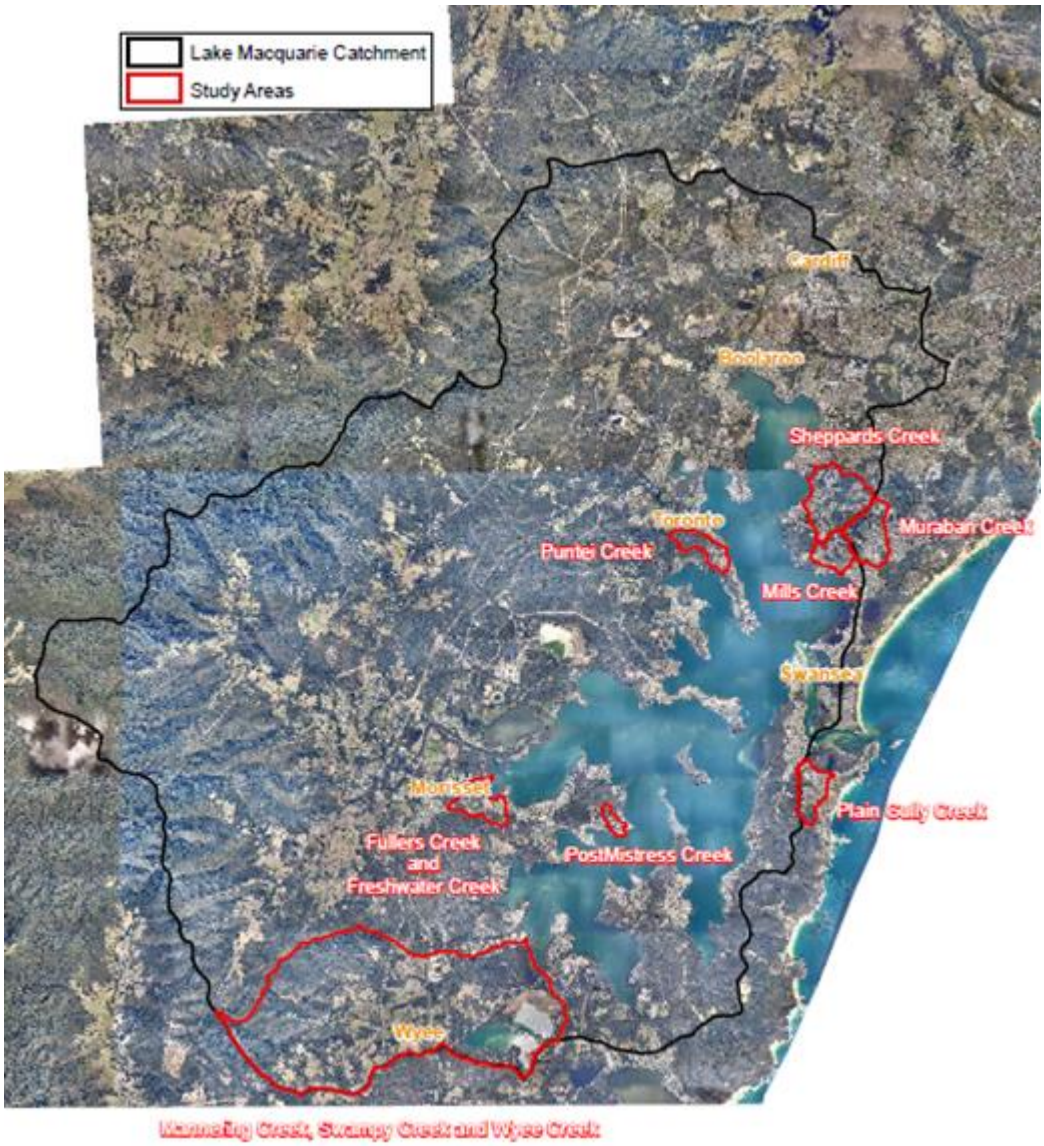
LAKE MACQUARIE CITY COUNCIL

# Flood Studies for Eight Residual Lake Macquarie Waterway Tributary Catchments

FINAL REPORT




Mannaling Creek, Swampy Creek and Wyee Creek

wma water

**AUGUST, 2021**

Level 2, 160 Clarence Street
Sydney, NSW, 2000

Tel: 9299 2855
Fax: 9262 6208
Email: wma@wmawater.com.au
Web: www.wmawater.com.au

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**AUGUST, 2021**

| **Project** | **Project Number** |
|---|---|
| Flood Studies for Eight Residual Lake Macquarie Waterway Tributary Catchments | 119076 |
| **Client** | **Client's Representative** |
| Lake Macquarie City Council | G D Jones |
| **Author** | **Prepared by** |
| Fabien Joly<br>Rhys Hardwick Jones<br>Richard Dewar | Rhys Hardwick Jones |
| | |
| **Date** | **Verified by** |
| 23 August 2021 | Richard Dewar |

| Revision | Description | Distribution | Date |
|---|---|---|---|
| 1 | 1st Draft | LMCC | November 2020 |
| 2 | Draft for Public Exhibition | LMCC | February 2021 |
| 3 | Final Report | LMCC | August 2021 |

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# LIST OF ACRONYMS

| | |
|---|---|
| AEP | Annual Exceedance Probability |
| AHD | Australian Height Datum |
| ARR | Australian Rainfall and Runoff |
| ALS | Airborne Laser Scanning sometimes known as LiDAR |
| BoM | Bureau of Meteorology |
| DEM | Digital Elevation Model |
| DPIE | Department of Planning Industry and Environment |
| EY | Exceedances per Year |
| IFD | Intensity, Frequency and Duration of Rainfall |
| IPCC | Intergovernmental Panel on Climate Change |
| m | metre |
| $m^3/s$ | cubic metres per second (flow measurement) |
| m/s | metres per second (velocity measurement) |
| PMF | Probable Maximum Flood |
| TUFLOW | one-dimensional (1D) and two-dimensional (2D) flood and tide simulation software program (hydraulic computer model) |
| WBNM | Watershed Bounded Network Model |

# FOREWORD

The NSW State Government's Flood Policy provides a framework to ensure the sustainable use of floodplain environments. The Policy is specifically structured to provide solutions to existing flooding problems in rural and urban areas. In addition, the Policy provides a means of ensuring that any 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 liable land remains the responsibility of local government. The State Government subsidises flood mitigation works to alleviate existing problems and provides specialist technical advice to assist Councils in the discharge of their floodplain management responsibilities.

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

***1. Flood Study***

- Determine the nature and extent of the flood problem.

***2. Floodplain Risk Management Study***

- Evaluates management options for the floodplain in respect of both existing and proposed development.

***3. Floodplain Risk Management Plan***

- Involves formal adoption by Council of a plan of management for the floodplain.

***4. Implementation of the Plan***

- Construction of flood mitigation works to protect existing development, use of Local Environmental Plans to ensure new development is compatible with the flood hazard.

This *Residual Lake Macquarie Waterway Tributary Catchments* Flood Study constitutes the first stage of the management process for the eight catchments to be investigated. This study has been prepared by WMAwater for Lake Macquarie City Council and was undertaken to establish a hydrologic and hydraulic modelling approach to determine design flood extents, levels and velocities within each of the eight study areas. The results provide the basis for future management of flood liable lands within these areas.

# EXECUTIVE SUMMARY

## Study Areas

Lake Macquarie City Council has previously completed Flood Studies for Lake Macquarie waterway as well as for all the major tributaries entering the lake (Stony Creek, LT Creek, South Creek, Dora Creek, Cockle Creek, North Creek, and Jewells Wetland). Council identified eight remaining smaller tributary catchments which have not been investigated in the above studies, and where information about flood risk was required. These eight smaller urbanised catchments are the subject of this Flood Study, namely:

**a)** Plains Gully Creek (Swansea / Caves Beach);
**b)** Sheppards Creek (Valentine);
**c)** Muraban Creek (Floraville/Belmont);
**d)** Mills Gully Creek (Belmont);
**e)** Puntei Creek (Carey Bay);
**f)** Fullers Creek and Freshwater Creek (Bonnells Bay);
**g)** Postmistress Creek (Sunshine);
**h)** Mannering Creek, Swampy Creek and Wyee Creek (Wyee).

## Flooding Mechanisms

Flooding in the eight study areas results from three mechanisms. Firstly, intense rainfall in the local catchment can cause local stormwater and overland flow flooding. These events can occur with rainfall durations of generally less than 2 hours (i.e. during intense localised storms) and overland flow flooding can occur even in steeper parts of the catchment that are substantially elevated above the lake. Overland flow flooding is known to occur relatively frequently in some of these catchments, and details are available from some specific events within the last 10 to 15 years, but no comprehensive historic record of the dates or impacts of these local stormwater events is available over the longer term.

The second key flood mechanisms occurs from heavy rainfall over the much larger Lake Macquarie catchment, causing the lake to rise and flood low-lying foreshore areas in the lower parts of the eight study areas. These lake flooding events have been well documented since the 1930s. The duration of rainfall and the response time of the water level in the lake to rainfall over the catchment can vary greatly between events. In June 2007 there was approximately 8 hours of intense rainfall and the lake rose to its peak approximately 10 hours after the rain ceased. However, in February 1990 the rainfall was over a longer duration and thus the water level in the lake rose much slower than in June 2007. Lake flooding events are usually accompanied by some localised overland flow flooding, but localised storm events can occur over only a small area and these can cause overland flow flooding without concurrent lake flooding.

The third flood mechanism is inundation from the Pacific Ocean due to a combination of high astronomic tides, storm surge in the ocean due to low barometric pressure, and wave setup and runup. Flooding from ocean inundation only affects the Plains Gully Creek catchment to any significant extent. Wave setup / runup are of lesser significance than the other factors due to the relatively sheltered nature of the creek entrance from the typical wave directions.

The three flooding mechanisms are not mutually exclusive phenomena and can occur in conjunction with one another. For example, the coinciding of storm surge and wave setup / runup with intense rainfall occurred in June 2007 and May 1974. However, while a more intense rainfall was experienced in June 2007, the May 1974 event produced a greater sea level rise.

### Impacts from Flooding

Lake and local catchment flooding cause significant hardship which will likely worsen with climate change, resulting in increased tangible and intangible damages to the community. Consequently Lake Macquarie City Council has undertaken a program of studies to address the management of the flood problem in accordance with the 2005 NSW Floodplain Development Manual (Reference 1).

The present study was initiated by Lake Macquarie City Council to assess design flood levels and to incorporate sea level rise benchmarks based on predictions by the Intergovernmental Panel on Climate Change (IPCC) and the Commonwealth Scientific and Industrial Research Organisation (CSIRO) technical review for Australia, and also the potential increase in rainfall intensities due to climate change.

A summary of the tangible Average Annual Damages for each catchment is provided below.

| Catchment | Average Annual Damages (AAD) |
|---|---|
| Plains Gully | $361,000 |
| Sheppards | $291,000 |
| Muraban | $1,277,000 |
| Mills Gully | $354,000 |
| Puntei | $814,000 |
| Fullers and Freshwater | $119,000 |
| Postmistress | $59,000 |
| Mannering/Swampy/Wyee | $240,000 |

### Reasons for Undertaking the Flood Studies

The aim is to provide an understanding of, and information on, flood behaviour and associated risk to inform:

- relevant government information systems;
- government and strategic decision makers on flood risk;
- the community;
- flood risk management planning for existing and future development;
- emergency management planning for existing and future development, and strategic and development scale land-use planning to manage growth in flood risk;
- other key stakeholders (including utility providers and the insurance industry) on flood risk.

The outputs of the study may be able to assist this by:

- facilitating information sharing on flood risk across government and with the community.

- providing a better understanding of the:
  - variation in flood behaviour, flood function, flood hazard and flood risk in the study areas;
  - impacts and costs for a range of flood events or risks to the existing and future community
  - impacts of changes in development and climate on flood risk;
  - emergency response situation and limitations;
  - effectiveness of current management measures.

The flood models developed in this study are used to:

- map the current flood behaviour of each creek and their tributaries;
- produce information on flood levels, velocities and flows for a full range of flood events, under existing catchment and floodplain conditions for each study area.

### Adopted Hydrologic/Hydraulic Modelling Approach

The adopted approach was to establish a WBNM hydrologic model for each catchment, which calculates the amount of runoff that will occur from storms of various intensities. This model is used to provide inputs to a TUFLOW 1D/2D hydraulic model, which calculates the flood levels, velocities and extents produced by the runoff as it flows down through the catchment. TUFLOW is a computational model that is widely used throughout NSW for flood studies. The TUFLOW model includes the drainage conveyed within the stormwater pipe network as well as flowing over the ground surface. A comprehensive verification of the TUFLOW model for each catchment to historical peak height data was not possible due to the lack of suitable peak height data from past local catchment floods. However, a limited verification to historical data was undertaken where data was available. The accuracy of the modelling can only be improved upon with collection of suitable data from future events and subsequent modelling of those events.

### Local Catchment Design Flood Estimation

The TUFLOW modelling system was used to map local catchment design flood levels, flows and velocities based on the available design rainfall data using the Australian Rainfall and Runoff (ARR) 2019 approach which supersedes the previous ARR 1987 approach. Maps are provided indicating the peak water depths, contours, velocities and hazard for the range of design events from the 50% AEP (50% chance of occurring per year) to the Probable Maximum Flood (PMF, an extreme event with a very low probability of occurrence in any given year).

For this study, which is principally investigating local stormwater flooding, all design events for current climate conditions have assumed a 20% AEP lake level of 0.82 m AHD in the Lake Macquarie waterway, and a 20% AEP ocean level of 1.24 mAHD in Black Neds Bay at the mouth of Plains Gully Creek (assuming no wave run-up effects, due to the protected location of the creek mouth in the bay). Sensitivity analysis was undertaken to assess the effects of assuming a higher level in the Black Neds Bay and Lake Macquarie waterway as a result of increasing sea levels due to climate change (refer to Section 8.2). Thisa climate change sensitivity analysis looked at two scenarios for increased sea levels.

### Sensitivity Analysis, Blockage and Climate Change

Sensitivity analysis and blockage assessments were undertaken to assess the effects of varying key model parameters. In addition, the effects of a sea level rise elevating the adopted design water levels in Lake Macquarie waterway and an increase in design rainfall intensities were undertaken. See Sections 5.6.3 and 8 for results and discussion. Some communities around the lake edge are highly vulnerable to sea level rise, notably those residents situated at the bottom of Puntei Creek, Postmistress Creek and Sheppards Creek of the catchments assessed in this study.

### Historical Flood Data

The study areas are similar to many urban overland flow catchments in that there is very limited historical flood data. For this reason it is important that:

- greater emphasis should be placed on improving data collection and storage of the data from large wet weather events (supported by community feedback through the consultation process);
- following each future flood a report should be written documenting the available rainfall and flood height data together with photographs. A comparison should also be made with the peak levels from past historical events as well as the design events in this report to put the event into some perspective.

# 1. BACKGROUND

## 1.1. Study Area

Lake Macquarie City Council has previously completed Flood Studies for Lake Macquarie waterway as well as for all the major tributaries entering the lake (Stony Creek, LT Creek, South Creek, Dora Creek, Cockle Creek, North Creek, and Jewells Wetland). Council identified eight remaining smaller tributary catchments which have not been investigated in the above studies, and where information about flood risk was required. These eight smaller urbanised catchments are the subject of this Flood Study, namely:

**a)** Plains Gully Creek (Swansea / Caves Beach);
**b)** Sheppards Creek (Valentine);
**c)** Muraban Creek (Floraville/Belmont);
**d)** Mills Gully Creek (Belmont);
**e)** Puntei Creek (Carey Bay);
**f)** Fullers Creek and Freshwater Creek (Bonnells Bay);
**g)** Postmistress Creek (Sunshine);
**h)** Mannering Creek, Swampy Creek and Wyee Creek (Wyee).

*note: where applicable, figures are labelled as per the letters above. For example Figure 2 shows the study area for each catchment, labelled Figure 2a to Figure 2h respectively.*

The Lake Macquarie waterway catchment and the eight tributary creek catchments, the subject of this Flood Study are shown on Figure 1. A detailed description of each tributary catchment is provided in Section 2 with Figure 2 (a to h) describing the study area. Figure 3 (a to h) shows the topography and Figure 4 (a to h) the TUFLOW hydraulic model extent within each catchment.

## 1.2. The Flood Problem

Many catchments entering the Lake Macquarie waterway experience poor drainage due to a combination of flat terrain, densely developed areas which can restrict flow paths, restricted openings under road or rail crossings, the presence of localised sag points that are not drained adequately, and/or periodically elevated lake levels. Localised problems also arise due to the age, design and maintenance of urban drainage systems. These problems will likely be exacerbated as ocean and lake levels rise as a result of projected sea level rise or rainfall increase due to anthropomorphic climate change.

Historical records started in the 1930s show that lake flooding has occurred in the urban areas surrounding Lake Macquarie waterway periodically in response to heavy rainfall over the Lake Macquarie waterway catchment. Lake flooding has resulted in inundation of urban lands and occasionally of building floors in the areas surrounding Lake Macquarie waterway. Via resident complaints, Council is aware of properties that have been subject to flood damage and above floor inundation caused by local catchment flooding in the various parts of the eight local catchments modelled in this study.

Most recently, significant damage and risk to life occurred in the February 1990, June 2007 and April 2015 events in the Lake Macquarie waterway and Newcastle regions.

Flooding in the study area occurs due to three key mechanisms:

1. Intense rainfall over the local catchment which exceeds the capacity of the urban stormwater (pit and pipe network) and or creek system and flows overland to Lake Macquarie waterway.
2. Elevated levels in Lake Macquarie waterway and the Swansea Channel due to intense widespread rainfall over the Lake Macquarie catchment.
3. Elevated ocean levels due to high astronomic tides, storm surge and wave setup and runup. These conditions can occur in combination with rainfall but the magnitude of the rainfall can vary greatly and thus may not always produce local catchment flooding. Ocean levels will largely only affect the Plains Gully Creek catchment, which drains to the Lake Entrance downstream of Swansea Channel.

Peak lake flood levels occur some 8 to 12 hours (or longer) after the peak rainfall over the lake catchment, while peak local catchment flood levels will typically occur within an hour or two after the peak rainfall in the local catchment. This means that even in large rainfall events, the two peaks are unlikely to coincide and will not necessarily coincide with the peak elevated ocean level.

Whilst the above mechanisms can occur together, stormwater flooding in the local catchments is more frequent, with storms and nuisance local stormwater flooding often reported several times a year. High astronomic tides also occur annually causing inundation of land below 1.1m AHD in the Plains Gully Creek catchment. Intense rainfall over the local catchment can occur due to a thunderstorm with no appreciable rise in the water level in Lake Macquarie waterway, as happened in January 2016. Widespread lake flooding sufficient to inundate low-lying foreshore land is less frequent, with records of lake levels exceeding 0.7 metres AHD (sufficient to flood some foreshore areas) indicating only 12 events since 1930 (see following section).

## 1.3. Overview of Flood Records

No prior hydrologic or hydraulic modelling study has been undertaken for overland flow within the eight study areas although the 2012 Lake Macquarie Waterway Flood Study (Reference 2) provided design flood levels for Lake Macquarie waterway and along the Swansea Channel. There are water level recorders at Belmont and at Swansea Bridge (Figure 1) with records back to 1986 and 1996 respectively (refer Reference 2). Historical rainfall data (Figure 1) are available from the Bureau of Meteorology (BoM) daily rainfall stations and over 15 pluviometers (which continuously record rainfall) installed in the Newcastle/Lake Macquarie region in the late 1980's by Hunter Water. The Hunter Water pluviometer gauges are primarily installed for monitoring the wastewater system, as well as inflows to water supply dams.

Lake Macquarie City Council has maintained a comprehensive database of peak lake flood levels in Lake Macquarie waterway since the 1930's but they have no flood record database from local catchment flooding within the eight study areas or along the Swansea Channel.

The dates and approximate peak lake levels of all known significant lake floods in Lake Macquarie waterway are shown in Table 1. According to the 2012 *Lake Macquarie Waterway Flood Study* (Reference 2) the February 1990, June 2007 long weekend and April 2015 events were all smaller than a 5% (1 in 20 year level of 1.23 m AHD) AEP event in Lake Macquarie waterway. It should be noted that the design magnitude of a historical flood will vary across a region. For example, near Newcastle the June 2007 long weekend event exceeded a 1% (1 in 100 year) AEP event but was a much smaller event at Swansea and on the western and southern sides of Lake Macquarie waterway.

Table 1: Significant Flood Events on Lake Macquarie Waterway

| Date (in order of severity) | Approximate Peak Lake Level (m AHD) |
|---|---|
| **18 June 1949** | 1.25 |
| **April 1946** | 1.20 |
| **11 June 1930** | 1.10 |
| **9 June 2007** | 1.05 |
| **22 April 2015** | 1.01 |
| **2 May 1964** | 1.00 |
| **4 February 1990** | 1.00 |
| **1953** | 0.90 |
| **1926/27** | 0.80 |
| **25 February 1981** | 0.80 |
| **May 1974** | 0.80 |
| **4 March 1977** | 0.70 |

**Notes:** Data (apart from April 2015) obtained from the 2012 Lake Macquarie Waterway Flood Study - Reference 2.
Levels are an average of several recorded heights.
It is likely that several lake floods prior to 1970 may not have been recorded.

The most recent event resulting in elevated levels in Lake Macquarie waterway occurred on 22 April 2015 where the peak level reached just over 1.0 m AHD, which was very similar to the peak level in February 1990 and June 2007. No significant rise in the water level in Lake Macquarie waterway occurred in the local catchment events in August 2019 and February 2020.

There are no water level recorder gauges in the study areas and no comprehensive record of the extent or depth in past local flooding events in the catchments.

## 1.4. Changes to the Catchment

Since the first European settlement there have been many changes to the landforms and building outlines on the floodplain (extensions to existing houses, new houses) as well as other significant developments on the floodplain, including installation of bridges and the pit and pipe network, road construction and mining activities. Development and upgrades to the pit and pipe network have also occurred. No chronological details of these changes are available.

Some of the changes to the floodplain may be temporary and others permanent. It is likely that

these developments on the floodplain will have affected the runoff regime as well as the extent of local catchment flooding. It is impossible to accurately account for these changes over the years due to the lack of detailed information.

## 1.5. Lake Macquarie Waterway Flood Study, June 2012 (Reference 2)

The 2012 *Lake Macquarie Waterway Flood Study* was initiated by Council to research and update the prior 1998 Lake Macquarie Flood Study, to incorporate predicted impacts of climate change. It is of relevance to the present study as it provides design flood levels within Lake Macquarie waterway.

The 2012 *Lake Macquarie Waterway Flood Study* included modelling of the June 2007 long weekend event and incorporated detailed bathymetric survey within the Swansea Channel. The study established a hydrologic model (WBNM) and hydraulic model (TUFLOW), which were calibrated and validated to the February 1990 and June 2007 long weekend events. The following conditions were adopted for the design lake flood analysis:

- 0.1 m AHD initial water level in the Lake Macquarie waterway (average lake level);
- 48 hour critical rainfall storm duration inflows (for all design events except the PMF) in conjunction with the respective ocean tides;
- design ocean levels based on the design levels in Fort Denison/Sydney Harbour plus a wave setup component (0.2 m assumed for the 1% (1 in 100 year) AEP event);
- all design tides assume the “shape” of the tidal hydrograph of the May 1974 east coast low event as recorded at Fort Denison in Sydney Harbour. This tidal hydrograph approximates the 1% (1 in 100 year) AEP design ocean event;
- the wave setup component was assumed to increase linearly to peak at the same time as the ocean peak;
- the peak ocean level was coincided with the peak rainfall burst in the 48 hour duration event.

Peak ocean levels and peak catchment runoff are unlikely to coincide. The 2012 *Lake Macquarie Waterway Flood Study* (Reference 2) used an envelope (i.e. whichever event produced the highest level) of the:

- 1% AEP catchment flood (“rain dominated event”) in conjunction with a 5% AEP (1 in 20 year) elevated ocean level (“ocean dominated event”); and
- 5% AEP catchment flood (“rain dominated event”) in conjunction with a 1% AEP (1 in 100 year) elevated ocean level (“ocean dominated event”),

to establish the 1% AEP design flood level for the lake. A similar approach was used for the other design events.

Design lake flood levels in Lake Macquarie waterway from the 2012 *Lake Macquarie Waterway Flood Study* (Reference 2) are reproduced in Table 2 and are based on ARR 1987 rainfall data. Climate change scenarios were analysed for the 20% (1 in 5 year), 5% (1 in 20 year) and 1% (1 in 100 year) AEP events and are also summarised in Table 2. The lake flood levels shown in Table 2 exclude wave runup on the foreshore areas within the lake or adjoining the Swansea Channel.

Table 2: Design Lake Flood Levels from Lake Macquarie Waterway Flood Study (Reference 2)

| | Peak Lake Level (m AHD) | | | | | |
|---|---|---|---|---|---|---|
| | | Sea Level Rise | | Rainfall Increase | | |
| Event (AEP) | Existing | + 0.4m | + 0.9m | 10% | 20% | 30% |
| 50% (1 in 2 year) | 0.65 | 1.04 | 1.54 | 0.71 | 0.77 | 0.83 |
| 20% (1 in 5 year) | 0.82 | 1.21 | 1.71 | 0.88 | 0.94 | 1.00 |
| 10% (1 in 10 year) | 0.94 | 1.32 | 1.81 | 1.03 | 1.11 | 1.19 |
| 5% (1 in 20 year) | 1.23 | 1.61 | 2.10 | 1.32 | 1.40 | 1.49 |
| 2% (1 in 50 year) | 1.38 | 1.74 | 2.20 | 1.50 | 1.61 | 1.72 |
| 1% (1 in 100 year) | 1.50 | 1.86 | 2.32 | 1.62 | 1.73 | 1.84 |
| 0.5% (1 in 200 year) | 1.69 | 2.05 | 2.51 | 1.81 | 1.92 | 2.03 |
| 0.2% (1 in 500 year) | 1.87 | 2.23 | 2.69 | 1.99 | 2.10 | 2.21 |
| PMF | 2.45 | 2.81 | 3.27 | 2.57 | 2.68 | 2.79 |

**Note:** Underlined levels have been derived from interpolation from model results rather than actual modelling

It should be noted that the application of the 2019 revision of ARR will change the design flood levels shown in Table 2.

## 1.6. Terminology

Engineers Australia as part of the team who developed the 2019 version of Australian Rainfall and Runoff (ARR) have produced a set of guidelines for appropriate terminology when referring to the probability of floods.

AEP is expressed using percentage probability. It expresses the probability that an event of a certain size or larger will occur in any one year, thus a 1% AEP event has a 1% chance of being equalled or exceeded in any one year.

The use of ARI, the Average Recurrence Interval, which indicates the long term average number of years between events, is now discouraged. It can incorrectly lead people to believe that because a 100-year ARI (1% AEP) event occurred last year it will not happen for another 99 years. For example there are several instances of 1% AEP events occurring within a short period, for example the 1949 and 1950 events at Kempsey.

Levels in this report are in metres to Australian Height Datum (AHD). 0 mAHD approximates mean sea level. Appendix A provides a glossary of commonly used terms and acronyms.

## 1.7. Accuracy of Flood Modelling

The accuracy of all model results provided in this report is dependent on the accuracy of the input data sets and the ability of the modelling approach to accurately replicate recorded historical flood data. As modelling approaches improve over time and additional local catchment flood data becomes available from future local flood events, the accuracy of the results will improve. To capture high quality flood data is difficult as the event passes very quickly (generally less than 4 hours). However, it is imperative that actions are taken to visit, interview and photograph immediately following any event (or collect from residents who have taken pictures during the

event) debris marks or similar that could be used for model verification.

A key input data set is the ALS (Airborne Laser Scanning) topographic information available for use in this study. The topographic information was derived with an estimated accuracy of ± 0.15m in cleared areas, such as car parks or on roads. In locations with more complex terrain, such as vegetated areas, the accuracy is likely to be much lower and could significantly vary, by up to ± 1m. It is cost prohibitive to obtain detailed field survey throughout the entire study area and the ALS is assumed to be correct. However, due to these potential accuracy limitations, some of the local catchment flood extents, depth estimates and design local flood levels may change if more accurate field survey is obtained. It is estimated that an order of accuracy of the local catchment design flood levels is ± 0.3m.

A limitation of the use of ALS is that it can show artificial small depressions in what is a uniformly graded structure, such as a road. These should be ignored and have no significant impact on the modelling results.

The results from the present study incorporate best practice in design flood estimation at this time but it is acknowledged that changes in approach in the future will cause changes to design flood levels. A good example of this is the collection of rainfall data which forms the basis of design local stormwater flood estimation. As more and more rainfall data are collected and analysed (and particularly from continuously read gauges termed pluviometers) the Bureau of Meteorology (BoM) will update estimates of design rainfalls over NSW. The recent 2019 updated version of the 1987 edition of Australian Rainfall and Runoff (ARR87, Reference 3) has introduced new approaches and guidelines, in addition updated Intensity, Frequency and Duration (IFD) rainfall data have been released by the BoM.

# 2. DESCRIPTION OF STUDY AREAS

## 2.1. Plains Gully Creek (Swansea / Caves Beach)

Diagram 1: Plains Gully Creek Catchment Locality (SIX maps)

Plains Gully Creek (1.87 km$^2$ catchment area) is located in the suburb of Caves Beach, lying between the coast and the Pacific Highway (Diagram 1 and Figure 2a). It drains in a south to north direction and enters Black Neds Bay via a culvert under Bowman Street. The creek is tidal to upstream of Bowman Street.

Photo 1: King tides in 2017 and 2018 (source: Lake Macquarie City Council)

King Tide 6 December 2017

A : Bowman Street Swansea opposite Gray Street looking east

King Tide 3 January 2018

B : Pacific Highway, Main Street of Swansea

C : Wood Street, Swansea at entrance

D : Bowman Street intersection with Plains Gully Creek and Black Neds Bay

During periods of high tides or storm surge activity Bowman Street is inundated from Black Neds Bay. As part of a previous community consultation program organised by Council the above photographs (Photo 1) were obtained. These were taken during the king tide events of 6th December 2017 and 3rd January 2018. Unfortunately, these photographs only indicate

depressions where water ponds due to poor drainage / infiltration and as such these cannot be used for rigorous verification of the modelling process of flooding from local rainfall. However, they indicate the inconvenience caused by an annually occurring ocean event in this area.

Photo 2: Plains Gully Creek crossings at Bowman Street (top left), Braemar Road (top right) and Strathmore Road (bottom) (source: Google Maps)

The creek crosses under Bowman Street, Braemar Road and Strathmore Road (Photo 2).

Upstream of Strathmore Road the creek is in a semi natural state surrounded by fairly dense vegetation. At Rea Street there is no open channel within the grounds of Swansea High School and smaller more frequent flows are contained in a piped drainage system. At Silky Oak Drive there is a wide grassed area to the west of Palm Tree Crescent across which overland flows will travel.

## 2.2. Sheppards Creek (Valentine)

Sheppards Creek (4.60 km$^2$ catchment area) is located in the suburb of Croudace Bay and exits to Lake Macquarie waterway via a 10m to 15m wide channel at Valentine Bowling Club (Photo 3). From downstream of Macquarie Drive / Croudace Bay Rd the creek has houses on both banks

with the house owners' boats moored on the banks of the creek (Photo 3).

Photo 3: Sheppards Creek upstream of Valentine Bowling Club

The creek passes under Macquarie Drive through a bridge (Photo 4) and upstream the creek becomes a semi-natural creek system surrounded by native bush.

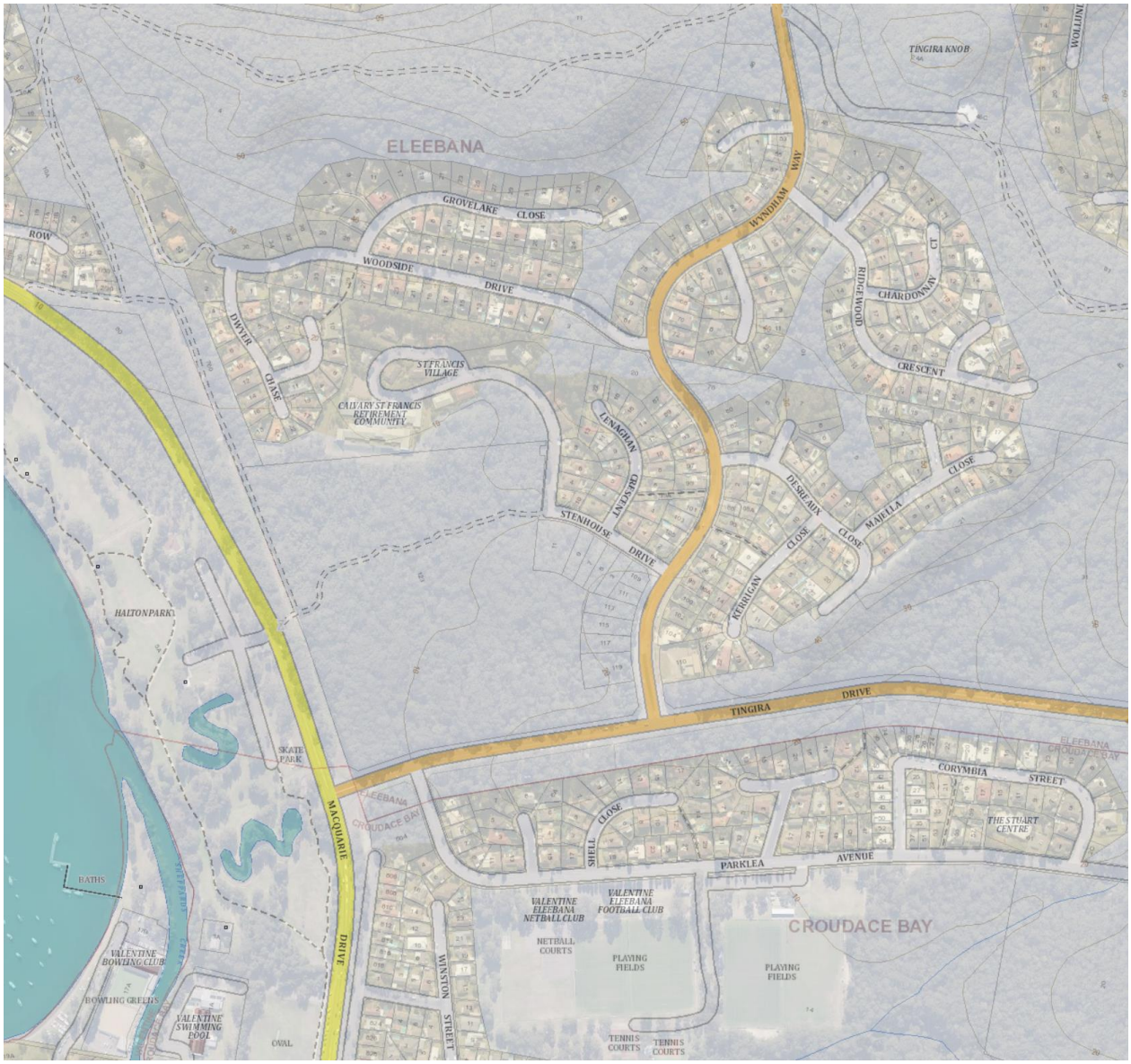
Photo 4: Sheppards Creek crossing of Macquarie Drive and looking upstream

In the upstream reaches of the southern part of the catchment there is a detention basin located within the Valentine Dog Exercise Area (Diagram 2), off Ruston Avenue. This basin is drained via an open swale reserve to the north, and drains into Sheppards Creek just upstream of Macquarie Drive via a culvert across Regal Way (the Regal Way sub-catchment).

Diagram 2: Valentine Detention Basin and Swale Location (SIX maps)

A significant part of the northern catchment drains into Sheppards Creek just upstream of the outlet to Croudace Bay. One subcatchment drains across Tingira Drive and Parklea Avenue, with overland flow occurring across the Valentine-Eleebana playing fields, which have been filled, and then through residential property around Winston Street and Shaw Street. In the north of the catchment, there is residential development in the upstream areas along Wyndham Way and Woodside Drive, Eleebana. These areas drain towards a semi-natural floodplain between Tingira Drive and Macquarie Drive, across Macquarie Drive and into Sheppards Creek at Halton Park (Diagram 3).

Diagram 3: Sheppards Creek northern floodplain (SIX Maps)




LMC Consulting undertook a previous hydraulic study of this creek to assess the effects of encroachment and construction of illegal structures on the performance of the creek in the 400m reach downstream of Croudace Bay Road / Macquarie Drive. The study concluded that Hec-Ras modelling indicated "*little towards affecting the flood behaviour of the creek.*" The modelling prepared for the present study would provide a more suitable tool for assessing the impacts of such encroachment, since two-dimensional effects will be important in this location and will be better captured by the TUFLOW model than by the HEC-RAS model prepared previously.

## 2.3. Muraban Creek (Floraville/Belmont)

Muraban Creek (2.82 km$^2$ catchment area to the wetland downstream of the Pacific Highway) is located in the suburbs of Floraville and Belmont. The creek exits into the extensive wetland area located between the Pacific Ocean and Belmont which drains either by infiltration or into Belmont Lagoon and then to Lake Macquarie waterway via Cold Tree Creek. The main branches of the creek include:

- the Floraville Road Branch (Diagram 4), approximately 500m in length from the Floraville

Road detention basin in Belmont North, to the swamp area downstream of the commercial warehouses on the Pacific Highway, south of Patrick Street,

- the main Muraban Creek branch, which runs in a north-south direction for approximately 2 km and is primarily an engineered open channel, with some semi-natural creek in the upper reaches at Floraville, and
- the Belmont branch, which drains the south-western part of the catchment rising up towards Hill Street, and which runs generally along Macquarie Drive, across the Pacific Highway near Belstone Avenue and Cobbin Parade, and then along an open concrete lined channel parallel to Cobbin Parade.

Diagram 4: Floraville Road Branch of Muraban Creek (SIX Maps)

The Floraville Road detention basin (Photo 5) is approximately 200m in length and 40m wide. It is a Declared Dam under the *Dams Safety Act 2015* (NSW). Dams Safety NSW is the independent regulator responsible for auditing compliance with dam safety regulations, and has the power to compel owners of declared dams to comply with these regulations and the Act.

The basin drains via a grated inlet and a twin 0.825 m diameter pipe and there is no formal spillway other than the crest of the clay-fill earthen embankment. A "traffic light" flood warning system was installed in 2020 (Council communication).

Downstream of the basin there are twin 1.8 m by 0.75 m box culverts under Floraville Road which discharge the runoff into an approximately 10 m wide grass lined open channel, with a single 1.05 m diameter pipe below. This channel runs from Floraville Road to the intersection of York Crescent and the Pacific Highway with the final 70 m comprising an open concrete channel.

Photo 5: Floraville Road detention basin

Downstream of the Pacific Highway the Floraville Road basin channel joins with a concrete lined channel that runs on the eastern side of the Pacific Highway entering from the west side midway between Vincent Street and Wommara Avenue. This is the main Muraban Creek branch which rises to the north near the intersection of Violet Street and Floraville Road, and runs generally between Floraville Road and the Pacific Highway.

Photo 6: Open channel alongside warehouses (left) and basin immediately upstream (right)

Muraban Creek exits to the wetland on the south side of the large warehouse (operated as a Bunnings at the time of writing) as an open channel. There is a partially filled (Photo 6) concrete lined basin at the upstream end of the channel which was full of water at the time of inspection in December 2019 and presumably had a blocked exit pipe. There is an additional concrete lined channel further south (from the Belmont Branch), running parallel to the channel shown in Photo 6. The channels in the lower sections of the main Muraban branch and the Belmont Branch are in close proximity to each other, running either side of the warehouses north of Cobbin Parade. It is likely that prior to development of this area, the natural creek ran through the area now occupied by the industrial development.

### 2.3.1. Floraville Road Detention Basin Hydrology Study

A report on the Floraville Road Detention Basin was undertaken by Hunter H20 in September 2015 (Reference 4). Key details of the basin are provided in Table 3 and results from the study in Table 4. At the time of writing, the basin is scheduled by Dams Safety NSW as a "declared dam," mainly due to the potential for loss of life downstream in the event of a basin failure. As such, the dam owner should meet the normal requirements under the *Dams Safety Act 2015* (NSW), whilst being aware that they are ultimately responsible for the safety of their dam and will be liable if the dam fails. The study was undertaken to determine the frequency of overtopping and concluded that:

- *The basin embankment is overtopped in events greater than the 0.38% annual exceedance probability event, or an event that occurs on average once every 260 years. This is well short of the requirements of the DSC for significant consequence category dams, which should be designed to safely pass the 1 in 10,000 annual exceedance probability event.*
- *During the 1 in 10,000 annual exceedance probability event, the embankment overtops by approximately 270 mm for approximately 72 minutes.*
- *Although the hydrological model for the Floraville Road Detention Basin is uncalibrated, based on the results it is reasonable to assume that the capacity of the basin does not meet the requirements of the DSC to safely pass the 1 in 10,000 annual exceedance probability event. It is therefore recommended that Council investigate options to increase the spilling capacity of the basin.*

Table 3: Floraville Road Detention Basin Details (Reference 4)

| Basin Component | Characteristic / Value |
|---|---|
| **General** | |
| Year Completed | 1992 |
| Designed | Sinclair Knight & Partners |
| Embankment Type | Homogenous Earth Fill |
| Catchment Area | 0.72 km² |
| Storage Capacity at Dam Crest Level | 22 ML (1) |
| **Embankment** | |
| Length of Crest | 250 m |
| Embankment Crest Level | RL 19.3 m AHD |
| Maximum Height of Embankment | 2.6 m |
| Freeboard above Spillway Level | 0.38 m |
| **Basin Outlet Works** | |
| Outlet Type | Pit |
| Pit Invert Level | RL 15.0 m AHD |
| Outlet Conduits | Dual 825 mm Circular Reinforced Concrete Pipes |
| **Spillway** | |
| Spillway Type | Broad-Crested Weir – Reinforced Grass Lined |
| Spillway Level | RL 18.92 m AHD |
| Spillway Width | 15 m |

Table 4: Floraville Road Detention Basin Peak Flows and Water Levels (Reference 4)

| AEP | Peak Inflow ($m^3/s$) | Peak Outflow ($m^3/s$) | Peak Water Level (m AHD) | Critical Duration (hours) |
|---|---|---|---|---|
| 50% | 3.2 | 4.3 | 16.81 | 24 |
| 20% | 5.7 | 4.6 | 17.13 | 12 |
| 10% | 6.9 | 4.9 | 17.42 | 12 |
| 5% | 8.2 | 5.1 | 17.76 | 12 |
| 2% | 9.5 | 5.6 | 18.37 | 6 |
| 1% | 11.5 | 6.1 | 18.93 | 6 |
| 0.5% | 18.4 | 11.3 | 19.27 | 2 |
| 0.38% | 19.3 | 12.2 | 19.30 | 2 |
| 0.2% | 24.1 | 19.3 | 19.37 | 2 |
| 0.1% | 31.6 | 28.5 | 19.43 | 2 |
| 1 in 10,000 | 57.7 | 57.5 | 19.57 | 2 |
| 1 in 10,000,000 | 157.1 | 156.4 | 19.90 | 0.5 |

## 2.4. Mills Gully Creek (Belmont)

Mills Gully Creek (1.59 km$^2$ catchment area) is located in the suburb of Belmont and drains into Lake Macquarie waterway under Ross Street at Laughlin Reserve and the Belmont 16ft Sailing Club (Diagram 5). Upstream the creek is largely confined to an incised channel and is surrounded by semi natural forest, thus there are no flooding issues affecting urban development apart from at the road crossings.

Diagram 5: Mills Gully Creek catchment (SIX Maps)

There are only two road crossing of the creek at Ross Street and at Spinnaker Ridge Way (Photo 7).

Photo 7: Mills Gully Creek crossing at Ross Street (left) and at Spinnaker Ridge Way (right)

There is a reasonably large flood detention basin in the western part of the catchment, at the end of Topgallant Way. This basin drains into a semi-natural creek tributary that crosses Ross Street via a culvert and joins the main branch of Mills Creek near Lewers Street. The creek channel is generally steeply incised, and although there are several private properties that back onto the creek reserve, they are generally steeply graded, with the buildings positioned on the higher parts of the lot away from the street.

## 2.5. Puntei Creek (Carey Bay)

Diagram 6: Puntei Creek catchment (SIX Maps)

Puntei Creek (1.52 km$^2$ catchment area) is located in the suburb of Carey Bay and drains into Lake Macquarie waterway across Excelsior Parade (Diagram 6).

Photo 8: Puntei Creek – Jarrett Street road crossing

The mid to upper part of the catchment, upstream of Jarrett Street, comprises a heavily vegetated valley with no urban development near to the creek. The creek crosses Jarrett Street via twin 2.4 m by 0.9 m box culverts (Photo 8). There are several houses on the downstream side of the Jarrett Street road crossing which potentially may have over road runoff entering properties, as the low point in the road crest is not aligned directly above the culvert location.

Photo 9: Puntei Creek – Open Swale

Photo 10: Puntei Creek –Excelsior Parade road crossing

Downstream of Jarrett Street, Puntei Creek is largely confined to a grass lined man made drainage swale with a debris collection structure at the upstream end, and several commercial and residential properties backing onto the reserve (Photo 9). The creek crosses under Excelsior Parade via triple 1.5 m by 0.75 m box culverts (Photo 10).

The road crest is very low-lying (1.4 mAHD to 1.5 mAHD), which is below the 1% AEP Lake Macquarie flood level. It is likely that Puntei Creek runoff will produce significant inundation across the road, particularly if there are coincident elevated water levels in the Lake Macquarie waterway downstream. Some of the houses in the downstream part of this catchment have floor levels less than 1.5 mAHD.

## 2.6. Fullers Creek and Freshwater Creek (Bonnells Bay)

Fullers and Freshwater Creeks (combined catchment area of 2.10 $km^2$) are located in the western part of the suburb of Bonnells Bay, and drain into Lake Macquarie waterway at Bonnells Bay (Diagram 7).

Diagram 7: Fullers Creek and Freshwater Creek catchments (SIX Maps)

The Lakeside Retirement Village lies between the two creeks in the lower catchment. Fullers Creek is surrounded by semi native dense forest and there are few urban structures affected by flooding, apart from the road crossings at Marconi Road, Ironbark Road and Inglewood Street. Freshwater Creek has a narrow corridor of remnant vegetation but is more closely abutted by residential development at the lower ends of Macquarie Street, Amos Street, Harbord Street and St Clair Street (Photo 11). The main road crossing of Freshwater Creek is at Station Street.

Photo 11: Station, Amos and Macquarie Streets on Freshwater Creek (Google Maps)

## 2.7. Postmistress Creek (Sunshine)

Postmistress Creek (0.51 km$^2$ catchment area) is located in the suburb of Sunshine and drains into Lake Macquarie waterway across Waterside Avenue (Diagram 8). The catchment is largely unoccupied by urban development, except on the catchment perimeter along Hillcrest and Cessnock Roads, and at the lower end of the catchment at Waterside Avenue bordering the lake.

Diagram 8: Postmistress Creek catchment (SIX Maps)

The road crossing at Waterside Avenue (Photo 12) has triple 2.7 m by 0.9 m culverts, below the road crest which is at approximately 1.1 mAHD to 1.2 mAHD. As the road is so low lying, the bottom of the culverts sit below the normal water level in the lake, and are therefore susceptible to sediment accumulation. There are also some utility/service pipes that cross the culvert opening on the downstream side and which will obstruct flow to some degree (Photo 12) and will be overtopped in times of flood and elevated water levels in Lake Macquarie waterway.

Some of the properties along Waterside Avenue are situated on very low-lying land, below 1.0 mAHD in some cases. This is below the 5% AEP lake flood level. It is therefore likely that the lower parts of this catchment around Waterside Avenue will be subject to relatively frequent inundation from both local overland flow and lake flooding, particularly if a localised storm occurs coincidentally with elevated lake levels.

Photo 12: Postmistress Creek at Waterside Avenue

## 2.8. Mannering Creek, Swampy Creek, Wyee Creek (Wyee)

The Mannering Creek, Swampy Creek and Wyee Creek catchments (combined catchment area of 51.1 km$^2$) are located in the suburb of Wyee and drain into Lake Macquarie waterway under Ruttleys Road (Diagram 9). Wyee Creek enters Swampy Creek downstream of the railway line which then combines with the Wyee Channel. The latter receives runoff from Mannering Creek and also from Mannering Lake Ash Dam which serves as the ash dam for the Vales Point power station.

The catchments flow to the Lake Macquarie waterway via twenty-four 1.8 m culverts (one set of eight, and one set of 16) under Ruttleys Road (see Photo 13).

The majority of the catchment adjoining the creek system is semi natural vegetation with no significant urban developments. The Mannering Lake Ash Dam is a significant feature of the catchment, and the catchment area to the dam is 6.2 km$^2$ or 12.1% of the total. The dam is designed to store the ash from the power station but will also act as a detention basin for some flood events, as it will temporarily store runoff in times of heavy rainfall.

Diagram 9: Mannering Creek, Swampy Creek and Wyee Creek catchment (SIX Maps)

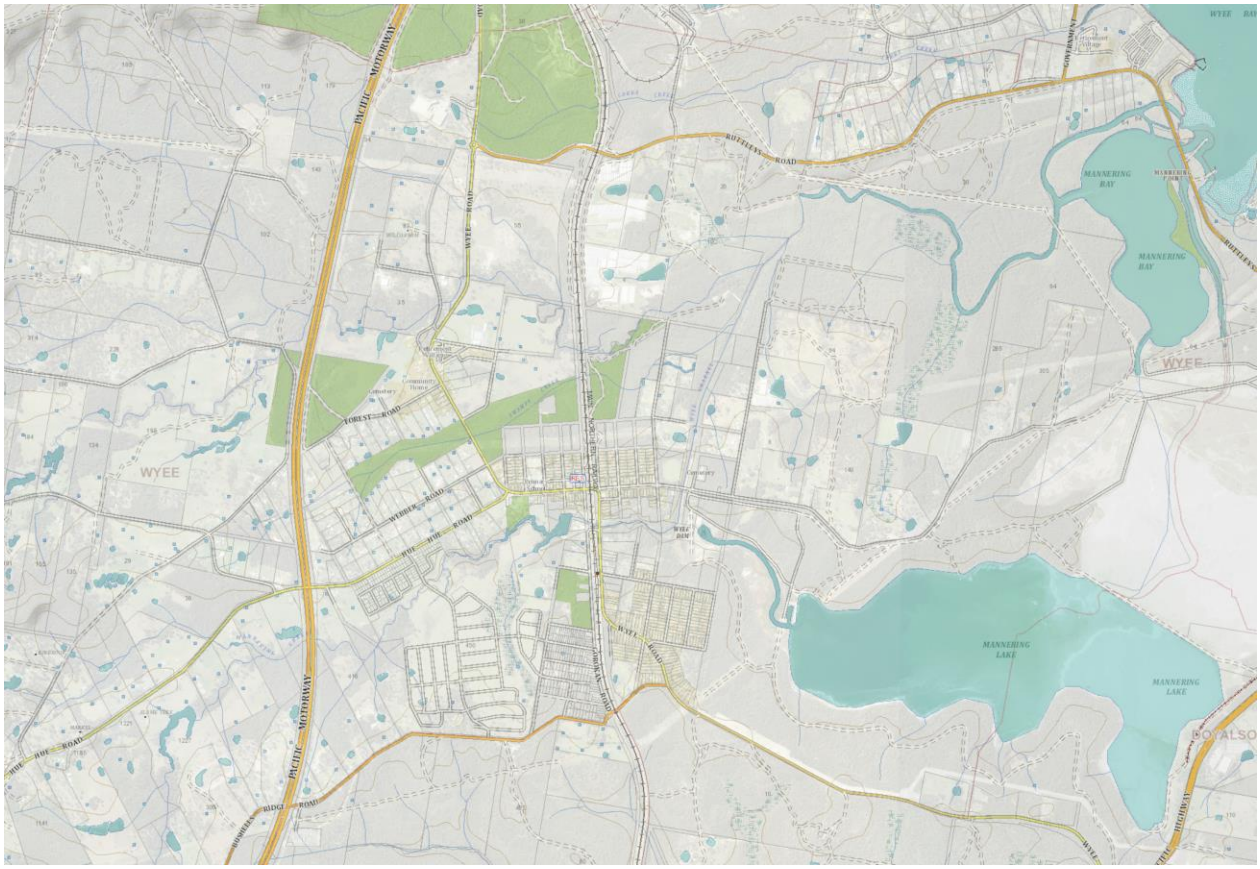



Photo 13: Wyee Creek culverts under Ruttleys Road

The Vales Point power station and colliery were in operation from 1961 to 2002 and then recommenced operations in 2005. Reference 5 has limited information about the design flood hydrology of the dam and the spillway. It states that:

*Delta Electricity [the dam owner] undertakes ongoing review and revision of flood*

*design level to ensure the VPAD meets current guidelines as set out by the NSW Dam Safety Committee. The current flooding status for VPAD is summarised in the Vales Point Ash Dam Management Plan 2015-2020 and reproduced below.*

*"A detailed flood study based on final estimated Probable Maximum Precipitation (PMP) values supplied by the Bureau of Meteorology was carried out in June 1998. A calibrated hydrological model (RORB) was used to estimate the inflow and outflow hydrographs for the storage. A range of storm durations were analysed for Annual Exceedance Probabilities (AEP) up to the Probable Maximum Flood (PMF).*

*The results showed that the flood spillway can safely pass the PMF event without overtopping the dam wall. The maximum flood level was determined to be 17.7 m, which is 0.8 m below the Wyee Dam crest level of 18.5 m and 1.3 m below the crest of the dry ash embankment.*

*Although the methodology for calculating extreme floods has been reviewed since this flood study was completed it is unlikely that there would be any significant change in the magnitude of the PMF, when calculated by the currently recommended methods. In any event, the excess spillway capacity will more than handle any increase in the design flood. Consequently, no additional flood studies to examine the PMF have been recommended at this stage."*

WMAwater requested more information about the flood hydrology from Delta, via Council, but this information was not provided. The outflows from the dam during a storm event will depend heavily on additional considerations beyond the intensity of the rainfall, particularly the initial level in the dam prior to the event. This would require a complex joint probability assessment to assess fully, which WMAwater cannot complete without provision of operational information from Delta. For this study, it has been assumed that the dam catchment discharges directly into the Wyee Channel without any attenuation or reduction in flow, for the full range of events modelled.

# 3. AVAILABLE DATA

## 3.1. Topographic Survey

ALS of the catchment topography (Figure 3a to h) for Lake Macquarie was acquired and processed by the NSW Spatial Services branch of the Land and Property Information Department in September 2014. It was downloaded from the federal government ICSM repository[1] for use in this study. This type of survey provides ground levels at approximately 1 metre spacing across the entire catchment. The accuracy of these levels is approximately ± 0.15 m on "hard" surfaces. On "soft" surfaces such as vegetated areas the accuracy is much less and if heavily vegetated no ground level may be provided due to the dense vegetation cover.

For the hydraulic modelling and mapping in this study the regular gridded Digital Elevation Models (DEMs) from the ALS repository (1 m by 1 m resolution) were used.

## 3.2. Pit and Pipe Network

Council provided a digital copy of the pit and pipe system within each catchment. Where possible this was checked against the information collected on the site inspection. Overall there was good agreement between the digital and observed data. Any significant / key differences that would have a large impact on the results was addressed through further field inspection and measurements by Council.

Council officers undertook additional field trips for some key structures where there was no existing survey information, such as detention basins and culverts/bridges at various road crossings. These locations were identified by WMAwater after the initial data review process.

## 3.3. Floor Level Survey

Building floor levels are required in order to undertake an assessment of potential flood damage and to estimate Average Annual Damages (AAD). Lake Macquarie Council previously completed a survey of floor levels for properties at or below 3 mAHD around the lake edge. It was necessary to supplement this survey with additional floor level data for properties in the upper parts of the study catchments that may be subject to overland flow.

A database of estimated building floor levels was produced for all properties (residential and commercial) that were potentially subject to flood damage based on the modelling results. Floor levels were compiled by using LiDAR to estimate ground levels at each building and adding a height-above-ground estimate for floor level heights above ground. These height-above-ground estimates were determined via visual inspection using techniques such as counting the number of bricks or steps from ground level to floor level, or other approximation methods – this technique provides a sufficient level of accuracy for undertaking flood damages. Google StreetView, in conjunction with photographs taken during a site visit, were used to estimate the height of the floor above ground.

1 https://elevation.fsdf.org.au/ accessed 31st January 2020.

Table 5 summarises the number of properties for which floor level information was either provided by Council, or obtained by the estimation procedure described above. The locations are shown on Figure 2 (a to h).

Table 5: Availability of floor level survey and estimates for each catchment

| Catchment | Number of floor levels from Council survey | Number of floor levels from WMAwater estimates | Total |
|---|---|---|---|
| **Plains Gully** | 174 | 172 | 346 |
| **Sheppards** | 105 | 263 | 368 |
| **Mills Gully** | 24 | 208 | 232 |
| **Muraban** | 13 | 411 | 424 |
| **Puntei** | 58 | 105 | 163 |
| **Fullers and Freshwater** | 37 | 157 | 194 |
| **Postmistress** | 0 | 35 | 35 |
| **Mannering / Swampy / Wyee** | 0 | 95 | 95 |
| **Total** | 411 | 1446 | 1857 |

## 3.4. Rainfall

### 3.4.1. Historical Rainfall Data

Rainfall data from past flood events are required for the verification of hydrologic and hydraulic models. Whilst daily rainfall is important to understand total rainfall amounts across an area, this information provides no indication of the peak intensities within the 24 hour period. For flood modelling of local catchment flow the sub-daily temporal pattern is essential and this is available from pluviometers, which are gauges that continuously record the rainfall. The availability of pluviometer data is therefore a critical factor in determining which historical events can be used for model verification.

The available rainfall data sites in the Lake Macquarie waterway catchment are shown on Figure 1. This indicates that the majority of the suitable gauges are in the north east part of the catchment with very few in the west and south. This is because the gauges are predominantly operated by Hunter Water and are located near their assets in the urbanised areas.

The two largest rainfall events in the Lake Macquarie waterway catchment that caused both elevated lake levels and local catchment flooding are the February 1990 and June 2007 events. However, there are no recorded peak levels for the February 1990 event in the study areas (there are elsewhere in the Lake Macquarie waterway catchment). It should be noted that there is considerable variation between the recorded rainfall at different locations for both these events. The rainfall recorded even a few kilometres apart can differ significantly, thus what was recorded at a gauge may not reflect the magnitude of the recorded flood in a nearby area or elsewhere

within the Lake Macquarie waterway catchment area.

Figure 6 to Figure 9 provides rainfall isohyets over the Lake Macquarie catchment for the June 2007, April 2015, August 2019 and February 2020 events, showing the spatial variation in the total rainfall amounts for these events. In addition to the spatial variation, the timing of the rainfall can also vary significantly and is equally as important in the effect on flooding. In the Lake Macquarie area, as with most catchments, there are insufficient numbers of rainfall gauges to get a comprehensive measurement of this spatial and temporal variation during the localised storms that produce flash flooding and overland flow. This uncertainty in the rainfall measurements must be taken into account when assessing the match of the modelled flood levels to the recorded information.

### 3.4.2. Design IFD Rainfall Data

Council's stormwater pit and pipe network systems and building floors levels are designed by engineers to meet a certain risk level. These risk levels are known as "design" standards and are quantified by the likelihood of occurrence in a given year (AEP, see Section 1.6). Typical standards include the 20% AEP or 10% AEP design standard for pipe drainage and the 1% AEP standard for floor levels. Floor level requirements usually incorporating an additional freeboard or safety factor of an additional 0.5m.

Design flood levels corresponding to a given standard are often estimated by assuming that rainfall of a given AEP will produce a flood of a similar AEP. The "design" standard rainfall data from the Bureau of Meteorology is used as an input to the hydrologic and hydraulic models to determine flood levels and extents. This assumption was adopted for this study. It is an implicit assumption in the rainfall-runoff modelling technique that was used.

A key consideration in this process is the intensity and duration of the design rainfall. On a large catchment such as Lake Macquarie waterway catchment the storm durations that must be considered are 12 hours or more as a shorter duration event will have little impact on lake levels. For the much smaller eight study area catchments the durations that will cause the most intense local flooding are the short duration events of approximately 4 hours or less. This question of the critical storm duration is discussed further in Section 5.7.1.

Design rainfall data is expressed in terms of its Intensity, Frequency and Duration (IFD). Design IFD rainfall data was obtained from the BoM website[2] for each catchment. Data for the Plains Gully Creek is provided as an example in Table 6. The design rainfall data varies for each study area, although is generally quite consistent around Lake Macquarie and does not vary significantly within each of the study area catchments.

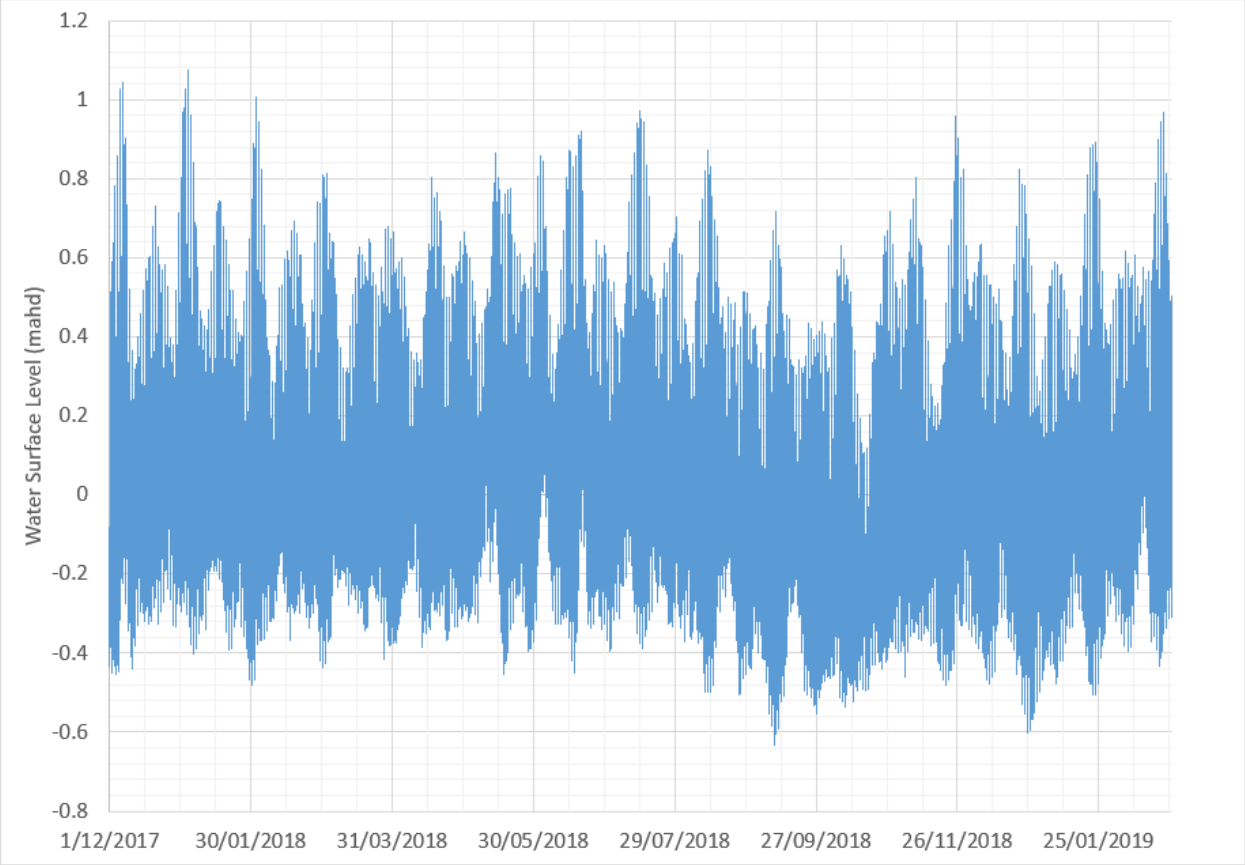
2 http://www.bom.gov.au/water/designRainfalls/revised-ifd/

Table 6: Design Intensity Frequency Duration Rainfall Data in mm/h (Plains Gully Creek)

| DURATION (minutes) | 1 EY | 50% AEP | 20% AEP | 10% AEP | 5% AEP | 1% AEP |
|---|---|---|---|---|---|---|
| 1 | 134 | 153 | 219 | 268 | 320 | 458 |
| 2 | 112 | 129 | 184 | 226 | 269 | 378 |
| 3 | 104 | 119 | 170 | 208 | 248 | 350 |
| 4 | 97.8 | 112 | 160 | 196 | 233 | 331 |
| 5 | 92.5 | 106 | 151 | 185 | 220 | 314 |
| 10 | 73.3 | 83.8 | 119 | 146 | 175 | 251 |
| 15 | 61.2 | 69.9 | 99.8 | 122 | 146 | 210 |
| 30 | 42 | 48.1 | 68.8 | 84.3 | 101 | 145 |
| 60 | 27.3 | 31.3 | 44.9 | 54.9 | 65.6 | 93.5 |
| 90 | 21 | 24.1 | 34.5 | 42.2 | 50.3 | 71.5 |
| 120 | 17.4 | 20 | 28.6 | 35 | 41.7 | 59.1 |
| 180 | 13.4 | 15.4 | 22 | 26.9 | 32 | 45.3 |
| 360 | 8.67 | 9.94 | 14.2 | 17.3 | 20.6 | 29.2 |

## 3.5. Tidal Analysis

Diagram 10: Swansea Channel Gauge Record (Dec 2017 to Feb 2019)




Water level gauge data are available for Lake Macquarie at Belmont and Marmong Point (Figure 1) and indicate a typical tidal range of only ± 0.05m in the lake itself. Thus, for seven of the eight study areas (with Plains Gully Creek being the exception) the influence of the tide can

be ignored. There is a greater tidal range within the Swansea Channel which affects the outlet of Plains Gully Creek. This this is illustrated in Diagram 10 with data from the Swansea Channel gauge for the period from December 2017 until February 2019 (14 months).

A frequency analysis (Table 7) shows that for 281 days (60%) of the period from Dec 2017 to Feb 2019 the peak tide reached between 0.4mAHD and 0.7mAHD. The analysis also shows that the peak tide exceeded 0.8mAHD on 56 days and exceeded 1mAHD on 5 days.

Table 7 : Frequency / Peak Tidal Level at Swansea Channel Gauge (Dec 2017 to Feb 2019)

| Peak Level (mAHD) | Number of days exceeded | Percentage of record |
|---|---|---|
| < 0.1 | 0 | 0% |
| 0.1 - 0.2 | 5 | 2.7% |
| 0.2 - 0.3 | 12 | 13.1% |
| 0.3 - 0.4 | 59 | 18.8% |
| 0.4 - 0.5 | 85 | 25.2% |
| 0.5 - 0.6 | 114 | 18.1% |
| 0.6 - 0.7 | 82 | 8.6% |
| 0.7 - 0.8 | 39 | 8.2% |
| 0.8 - 0.9 | 37 | 3.1% |
| 0.9 - 1 | 14 | 1.1% |
| >1.0 | 5 | 1.1% |

## 3.6. Community Consultation

### 3.6.1. Newsletter and Questionnaire

The accuracy of any design event modelling process is partially reliant on the quality and quantity of the available local flood height data with which the model results can be compared. However as there are no water level recorders or recorded historical flood levels in any of the eight study areas, the only available information about historical flooding was via community consultation. The initial consultation phase for the study included distribution of newsletters to residents accompanied with a questionnaire that asked about their experiences with flooding.

The newsletter/questionnaire was prepared by WMAwater and distributed by Council to addresses in the vicinity of the creeks. The properties included in the survey were identified as follows:

- WMAwater delineated the main creek and drainage lines in each study area catchment.
- Properties within 20 m of the creek lines, or below a level of 3 mAHD, were selected for consultation.
- Council-owned properties such as recreational spaces were excluded.
- Additional properties in Wyee were included based on analysis of the LIDAR and the vicinity to the creek.

A total of 730 targeted newsletters were distributed across the eight study catchments using the selection criteria above, and 74 responses were received. This response rate of 10% is relatively

high for studies on this nature, reflecting that the community has had recent experiences with flooding and the flooding is a significant concern for some residents.

The responses to the consultation program are summarised on Figure 10, Figure 11 and Figure 12, with notable outcomes including:

- Approximately half of the respondents (36 responses) had experienced some flooding of their property.
- 6 respondents had experienced above floor flooding.

Some of the respondents were able to provide photographs or descriptions of flooding that were suitable for use in the model verification process (see Section 5.6 for details). This information, along with rainfall data availability, was one of the primary drivers in determining which historical events to model for the verification process.

### 3.6.2. Public Exhibition of Report

A draft version of this report was presented to Council by WMAwater, and Council placed the draft report on public exhibition from 31 May 2021 to 28 July 2021. Residents affected by the outcomes of the study were directly notified by mail, and information about the study was placed on Council's website with directions for providing a response. Affected residents and the broader community were encouraged to respond with comments or feedback about the report.

Ten formal submissions were received from members of the public. Where relevant and appropriate, WMAwater made amendments to the report to clarify the information herein, or to address issues raised. However this process did not result in any substantive changes to the design flood modelling or other key outcomes from the study. Council indicated to WMAwater that it would provide a response to each submission received, and WMAwater provided information to Council to assist with the response where relevant.

Subsequent to the completion of this exhibition phase, WMAwater provided a final version of the report to Council along with all data and model files created during the study.

# 4. HYDROLOGIC MODELLING

## 4.1. Background

A hydrologic model is a tool for estimating the amount of runoff that flows from a catchment for a given amount of rainfall, and the timing of this runoff flow. Stream gauges (which measure water level in a stream) are a way of directly measuring the amount of runoff that occurs at one location in the creek, but they are expensive to setup and maintain. They also require a long record (several decades) to be of most use for flood estimation for rarer events. Most of the smaller creeks in NSW are not gauged, and there are no stream gauges in the eight creek catchments investigated here. In such cases, using a computer-based hydrologic model is the best practice method for determining how much flow occurs, using rainfall information (which is more widely available from rain gauges) to calculate the amount of flow that would occur in the creeks. This type of hydrologic model is referred to as a runoff-routing model.

There are several runoff-routing hydrologic modelling techniques and software packages available as described in ARR 2019 (Reference 6). These models allow the rainfall to vary in both space and time over the catchment and will calculate the runoff generated by each subcatchment.

In this study, the WBNM hydrologic runoff-routing software was used to determine flows from each sub-catchment. The WBNM model has a relatively simple but well supported method, where the routing behaviour of the catchment is primarily assumed to be correlated with the catchment area. If flow data is available at a stream gauge, then the WBNM model can be calibrated to this data through adjustment of various model parameters including the stream lag factor, storage lag factor, and/or rainfall infiltration into the soil.

The generated flow hydrographs can be used serve as inputs at the boundaries of the hydraulic model (discussed further in Section 5.2), which provides details about flood levels and velocities. In this study, WMAwater developed a hydrological model for each of the eight catchments, and used it to calculate the flows for each individual sub-catchment and tributary creek as inflow boundaries to the TUFLOW hydraulic model.

## 4.2. Sub-catchment delineation

The sub-catchment delineation for each of the eight catchments is shown in Figure 3 (a to h). The sub-catchments were derived from LiDAR topographic data and consideration of hydraulic controls such as bridge crossings and road/rail embankments, and the stormwater drainage network of pits, pipes and channels.

## 4.3. Impervious Surface Area

Runoff from connected impervious surfaces such as roads, gutters, roofs or concrete surfaces occurs significantly faster than from vegetated surfaces. This results in a faster concentration of flow within the downstream area of the catchment, and increased peak flow in some situations. This is less important in rural studies as they consist of relatively few impervious areas, and those areas are typically not hydraulically connected to the waterway (i.e. the water flows across

pervious areas on the route between the impervious surface and the receiving waterway).

The assumed effective imperviousness of each sub-catchment varied from 5% to 60%, depending on the land use. A large majority of the catchment is undeveloped and has a very low effective imperviousness. Slightly higher values were applied where there was low-density development, whilst higher imperviousness percentages were applied in the denser urban areas.

WMAwater used the Mannings layers (discussed in Section 5.3) and aerial photographs to assign one of three land use categories for the effective impervious surface area for each sub-catchment as per Table 8.

Table 8: Assumed percentage of effective impervious surface area by land use

| Type | Effective Percent Impervious |
|---|---|
| **Natural catchment or open space recreation** | 5% |
| **Moderate urbanization (low density)** | 20% |
| **Full urbanization (medium density)** | 60% |

## 4.4. Rainfall Losses

Methods for modelling the proportion of rainfall that is "lost" to infiltration are outlined in ARR 2019 (Reference 6). The methods are of varying degrees of complexity, with the more complex options only suitable if sufficient data is available. The method most typically used for design flood estimation is to apply an initial and continuing loss to the rainfall. The initial loss represents the wetting of the catchment prior to runoff starting to occur and the filling of localised depressions, and the continuing loss represents the ongoing infiltration of water into the saturated soils while rainfall continues. The initial/continuing loss method was adopted for this study.

## 4.5. Adopted Hydrologic Model Parameters

The model input parameters for each sub-catchment are:

- A lag factor (termed C), which can be used to accelerate or delay the runoff response to rainfall;
- A stream flow routing factor, which can accelerate or decelerate in-channel flows occurring through each sub-catchment;
- An impervious area lag factor;
- An areal reduction factor;
- The percentage of catchment area with a pervious/impervious surface; and
- Rainfall losses calculated by initial and continuing losses to represent infiltration.

The calibration for lake flooding in found that a value of 2.3 for the lag factor 'C' hydrologic model parameter was generally appropriate for the tributary catchments that produce runoff into the lake (Reference 2). There is insufficient additional localised information to warrant varying this parameter for the assorted tributary catchments in this study. The percentage of the impervious area is discussed in more detail in Section 4.3. A stream flow routing value of 1.0 was adopted,

which is the typical value for natural channels (this parameter is only relevant for Mannering/Swampy/Wyee Creeks (MSWC), as this is the only catchment in the study with significant stream length modelled in the hydrologic model, upstream of the hydraulic model area). Due to the relatively small size of the catchments in this study, areal reduction factors were not used.

# 5. HYDRAULIC MODELLING

## 5.1. Background

Hydraulic modelling is the simulation of how floodwaters move through and across the terrain. A hydraulic model can estimate the flood levels, depths, velocities and extents across the floodplain. It also provides information about how the flooding changes over time. The hydraulic model can simulate floodwater both within the creek banks, and when it breaks out and flows overland, including flows through structures (such as pipes, bridges and culverts), over roads and around buildings.

Two dimensional (2D) hydraulic modelling is currently the best practice standard for flood modelling. It requires high resolution information about the topography, which is available for this study from the ALS aerial survey. Various 2D software packages are available (SOBEK, TUFLOW, MIKE FLOOD, and others). The TUFLOW package was adopted as it meets requirements for best practice as outlined in Reference 7, and is currently the most widely used model of this type in Australia for riverine flood modelling.

The TUFLOW modelling package includes a finite difference or finite volume numerical model for the solution of the depth averaged shallow water equations in two dimensions. The TUFLOW software has been widely used for a range of similar floodplain projects both internationally and within Australia and is capable of dynamically simulating complex overland flow regimes.

The TUFLOW model version used in this study was 2018-03-AD-iSP-w64 (using the finite volume HPC solver), and further details regarding TUFLOW software can be found in the User Manual (Reference 8).

In TUFLOW the ground topography is represented as a grid of uniform-sized cells (1 m by 1 m for this study) with a ground elevation and Mannings ‘n’ roughness value assigned to each grid cell. The size of grid is determined as a balance between the model result definition required and the computer processing time needed to run the simulations. The greater the definition (i.e. the smaller the grid size) the greater the processing time need to run the simulation. Equations of flow are used to determine how water in one grid cell moves into a downstream grid cell. Open channels and the underground stormwater pipe network are also represented using 1 Dimensional (1D) elements. In this way the topography and drainage elements of the catchment are represented in the model (refer Figure 4 and Figure 5).

## 5.2. Applying Inflows to the Model

The runoff emanating from rainfall over the catchment can be incorporated into the TUFLOW model in two broad approaches. In the traditional approach a hydrologic model is used to generate runoff from the rainfall and the runoff is entered into TUFLOW at various locations. The alternative is the "rainfall on the grid" or the "direct rainfall" approach.

There are various advantages and disadvantages of each of the two runoff approaches which must be weighed up in light of the size of the catchment, the nature of the runoff and the required

outcomes of the study. For the present study the traditional hydrologic / hydraulic modelling approach has been adopted for the following reasons:

- the terrain in most catchments has significant grade and defined open channels, thus there are obvious locations to include runoff from a hydrologic model;
- some of the catchments are relatively large and this means that by including the entire catchment using a relatively small grid size would make model run times unreasonable;
- where appropriate buildings can be easily "blocked out" in the model grid with no need to adjust the rainfall amounts;
- the approach eliminates the various disadvantages of the direct rainfall approach such as the need to filter the results to exclude shallow depths of flow.

For sub-catchments within the TUFLOW model domain, local runoff hydrographs were extracted from the WBNM model. These were applied to the downstream end of the sub-catchments within the 2D domain of the hydraulic model. External inflows from outside of the hydraulic model domain (e.g. the upper Mannering and Wyee creek catchments) were applied to the edge boundary of the model. The inflow boundaries are shown in Figure 4 (a to h).

## 5.3. Effect of Vegetation and Ground Surface on Flow

The speed at which runoff crosses a surface will depend upon the surface type (grass, concrete lined, road, dense bush etc.) and the slope of the surface. The slope is accounted for in the model by the change in ground levels of each grid cell obtained from the ALS and the friction loss from the surface is accounted for by a Manning's "n' parameter (refer Reference 6). A listing of the adopted Manning's "n' factors based on judgement, recommended texts and past studies is shown on Table 9. The spatial distribution of these values is shown on Figure 5 (a to h).

Table 9: Adopted Manning's "n" values – TUFLOW model

| Land Use / Surface | Manning's "n" |
|---|---|
| Open space (grass/park/recreation) | 0.04 |
| Vegetated (forest) | 0.08 |
| Channel – minimal vegetation | 0.025 |
| Channel - vegetated | 0.045 |
| Residential Lots | 0.05 |
| Commercial and Industrial Lots | 0.06 |
| Waterway with grass or typically underwater | 0.025 |
| Waterway vegetated | 0.045 |
| Concrete Open Channel and Pipes | 0.015 |
| Roads and asphalt / Rock-lined channel | 0.02 |
| Buildings | Null cell (flow blocked) |

## 5.4. Road Crests and Gutters

Roads in urban areas often function as significant overland flow paths, and kerb/gutters are designed to efficiently convey flow due to their steep slope and the use of relatively smooth concrete. To capture the efficiency of these features in a 2D flood model with a 1 m grid it is usually necessary to modify the raw aerial survey information to represent a continuous surface

along the road gutters and crests. The TUFLOW model topography was refined by schematising the road crests and gutters as “breaklines,” which means that the levels along these longitudinal features were directly schematised into the model, rather than relying on LIDAR grid sampling of these areas, to provide a more accurate representation of the levels. These features are displayed in Figure 4 (a to h).

## 5.5. Model Schematisation Methodology for Hydraulic Structures

### 5.5.1. Bridges

Photo 14: Macquarie Drive Bridge at Sheppards Creek

Large bridges, such as the Macquarie Drive Bridge over Sheppards Creek (shown in Photo 14) were modelled in the 2D domain. The purpose of this was to maintain continuity in the model, and because the 1 m resolution was generally sufficient to resolve the waterway area beneath the larger bridges accurately. The energy loss parameter values caused by the obstruction of the bridges to flow were based on the geometrical properties of the structure and previous experience modelling similar structures.

### 5.5.2. Culverts

Smaller culverts (pipes and box culverts) where the creeks cross under roads were modelled using 1D elements. The modelling parameter values for these culverts were based on the geometrical properties of the structure and previous experience modelling similar structures. For several of the culverts, invert levels had to be estimated from LiDAR information due to lack of

available detailed survey data or plans.

### 5.5.3. Stormwater Pipes and Inlet Pits

The road culverts were modelled using one dimensional (1D elements) in accordance with typical best practice, using the automated default routines in TUFLOW for assessing the pipe/culvert flow regime and energy losses at pits. The modelling parameter values for the culverts/bridges were based on the geometrical properties of the structure, which were obtained from measurements and photographs taken during site inspections and previous experience modelling similar structures.

For several of the culverts, invert levels had to be estimated from LiDAR information due to lack of available detailed survey data or plans. For the stormwater pits and pipes, invert information was generally not available from Council's asset database. The pits were assumed to have a depth of 1.5 m below the ground surface, and this was adjusted where necessary to ensure that the pipes sloped in a downhill direction in the model.

### 5.5.4. Buildings

Buildings within the floodplain were removed from the computational grid ("blocked out"). As such, it was assumed that all the buildings would not provide any storage during a flood event, and that they could be treated as obstructions to floodwaters. This is in line with guidance from Reference 7, which found that the flow paths through built up areas were more accurately resolved by using the "block out" method, than by alternative mechanisms where flow through the buildings is assumed.

## 5.6. Modelling of Historical Events

### 5.6.1. Model Verification Event Selection and Methodology

Modelling of historical events is undertaken to "test" or verify the model results (peak levels or depths) versus the observed information received from residents. However due to the lack of suitable data a rigorous model calibration / verification (where model parameters are adjusted to more closely match the observed behaviour) could not be undertaken for any of the eight study areas. Verification of the TUFLOW modelling was undertaken by comparing peak water levels observed in past events (provided by the community and Council, see Section 3.6) to the results obtained from modelling those events in TUFLOW using the recorded rainfall for that event.

The choice of events for model verification depends on the availability of peak height and rainfall data for the event. Preferably the models would be verified with an extensive record of peak height and rainfall data (pluviometer - continuously recording rain gauge), but in urban flash flood areas there is usually limited information available

Whilst there is a reasonably comprehensive record of peak water levels in Lake Macquarie waterway since the 1930s (Table 1) there is no comprehensive record for local flooding in the eight study area catchments. On larger creek systems (for example on other catchments entering

Lake Macquarie waterway such as Winding Creek or Dora Creek) an approximate historical record can be construed from newspapers, resident recollections or the limited measurements available.

Unfortunately this is not possible for the eight study area catchments as no such data exists, and this is generally because the issues are generally localised flash flooding that does not generate significant mainstream media coverage. Often the events occur at night or while people are avoiding the rain indoors, and they do not necessarily observe the extent of flooding in roadways or even through their properties if it does not affect the house. Residents can usually recollect events within the last 20+ years but cannot state with any accuracy the relative magnitude of each event or the actual height they reached. Anecdotal information suggests that there has been some above house floor inundation caused by local runoff, however elevated water levels in Lake Macquarie waterway have inundated the low lying areas fronting Lake Macquarie waterway area and may have inundated floor levels.

It appears from anecdotal information (Section 3.6) that the June 2007 storm was the largest event in recent times and is remembered by many. Other events may be remembered more clearly by some residents (April 2015, February 2019, and February 2020) but this is generally because the event was associated with some other specific detail and not the magnitude of the event.

The following events were selected for the verification process based on the availability of anecdotal flood information and suitable rainfall data for the storm:

1. June 2007, Plains Gully Creek,
2. June 2007, Sheppards Creek,
3. June 2007, Muraban Creek,
4. June 2007, Mills Gully Creek,
5. June 2007, Puntei Creek,
6. April 2015, Puntei Creek,
7. February 2019, Fullers and Freshwater Creeks,
8. February 2020, Fullers and Freshwater Creeks,
9. April 2015, Postmistress Creek,
10. February 2020, Postmistress Creek, and
11. June 2007, Mannering, Swampy and Wyee Creeks.

The spatial rainfall grids for each event (see Section 3.4) were used to determine the total rainfall depths in each catchment. The temporal pattern from the closest pluviometer to each catchment was adopted for the modelling of the event.

### 5.6.2. Model Verification Results

Mapping of the modelled flood depths for each of the verification events is provided in Figure B1 to Figure B11, corresponding to the list of events/catchments above. On each map, the locations of the flood marks from residents (see Section 3.6) are shown, along with either the observed flood depth at the location or the qualitative description of flooding.

A summary of the modelling match to the observed flood marks is provided in Table 10, and comparison to qualitative descriptions of flooding in Table 11.

Table 10: Model Verification – Comparison of results with observed flood depths/levels

| Location ID | Catchment | Peak flood depth (m) – Obs=Observed | | | | | | | | | | | | Flood Mark Description |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | 2007 | | | 2015 | | | 2019 | | | 2020 | | | |
| | | Obs | Model | Error | Obs | Model | Error | Obs | Model | Error | Obs | Model | Error | |
| LMT_007 | Sheppards Creek | 1.0 | 1.11 | 0.11 | - | - | - | - | - | - | - | - | - | 2007 At rear of boundary it was about 1m above ground level |
| LMT_018 | Sheppards Creek | 0.7 - 0.8 | 0.62 | -0.18 | - | - | - | - | - | - | - | - | - | 2007, backyard flooded up to back porch steps. 700-800mm on own property. No.9 on slab (house inundated) |
| LMT_021 | Sheppards Creek | 0.45 | 0.44 | -0.01 | - | - | - | - | - | - | - | - | - | 2007 our property was flooded up to top of 3 steps |
| LMT_038 | Sheppards Creek | 0.15 | 0.35 | 0.20 | - | - | - | - | - | - | - | - | - | 2007 - Garage had approximately 15cm of water level |
| LMT_045 | Sheppards Creek | 1.0 | 0.77 | -0.23 | - | - | - | - | - | - | - | - | - | 2007 1 meter on back fence and inside garage |
| LMT_048 | Sheppards Creek | 0.2 | 0.24 | 0.04 | - | - | - | - | - | - | - | - | - | 8/06/2007 - Inside house, garage, main street and yard. Excessive volume from Ruston Street. 4ft at the shed, few inches above floor level, on 5inch concrete slab |
| LMT_063 | Sheppards Creek | - | - | - | - | - | - | - | - | - | - | - | - | 2007 250mm above floor level |
| LMT_070 | Sheppards Creek | 0.5 | 0.94 | 0.44 | - | - | - | - | - | - | - | - | - | Approximatively 0.5 m at back fence from picture |
| LMT_074 | Sheppards Creek | 0.2 - 0.3 | 0.28 | -0.02 | - | - | - | - | - | - | - | - | - | 2007 0.2m - 0.3m on street |
| LMT_074 | Sheppards Creek | 0.4 - 0.5 | 0.51 | 0.01 | - | - | - | - | - | - | - | - | - | 2007 0.4m - 0.5m on adjacent property |
| LMT_015 | Muraban Creek | 0.5 | 0.77 | 0.27 | - | - | - | - | - | - | - | - | - | 2007 Flooding to 0.5m at rear Western wall seeped through blockwork fire rated wall |
| LMT_046 | Muraban Creek | 0.3 - 0.4 | 0.25 | -0.15 | - | - | - | - | - | - | - | - | - | 2007 300 to 400 mm. Tide mark on doors of garage and 400 mm inside |
| LMT_001 | Puntei Creek | 0.6 | 0.82 | 0.22 | - | - | - | - | - | - | - | - | - | 2007 : 600mm from the floor level of the shed |
| LMT_071 | Puntei Creek | 1.0 | 0.82 | -0.18 | - | - | - | - | - | - | - | - | - | 2007 The water level rose to approximately 1 m In the house |
| LMT_006 | Puntei Creek | - | - | - | 1.5 | 1.4 | -0.1 | - | - | - | - | - | - | 2015 Puntei Creek rose approximately 0.5 to 1m above its normal high tide height |

| Location ID | Catchment | Peak flood depth (m) – Obs=Observed | | | | | | | | | | | | Flood Mark Description |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | 2007 | | | 2015 | | | 2019 | | | 2020 | | | |
| | | Obs | Model | Error | Obs | Model | Error | Obs | Model | Error | Obs | Model | Error | |
| LMT_062 | Fullers and Freshwater | - | - | - | - | - | - | 0.80 | 0.0 | -0.8 | - | - | - | 2019 main street flooded 80cm on road. |
| LMT_013 | Fullers and Freshwater | - | - | - | - | - | - | - | - | - | 0.30 | 0.24 | -0.06 | February 2020, Neighbor's Shed flooded. Freshwater Creek backed up and took a short cut through 82 and 84 St Clair Street to the end of the road. During every rain, street has stormwater back up and overflow from gutters due to the street stormwater no |
| LMT_009 | Fullers and Freshwater | - | - | - | - | - | - | | - | - | 1.2 | 1.02 | -0.18 | Water flows through property to Freshwater Creek. Flooding in garage during rapid heavy rain events. 1.2m depth adjacent to property. |
| LMT_010 | Postmistress Creek | - | - | - | - | - | - | - | - | - | 0.10 | 0.11 | 0.01 | 2019, Feb 2020 from picture shallow depth 0.1m over property |
| LMT_022 | Postmistress Creek | - | - | - | - | - | - | - | - | - | 0.07 | 0.07 | 0.00 | 2020 (two weeks before survey). Run off flooding occurred 3 weeks ago during heavy rain from poor drainage from new housing development. 3-4 inches |

Table 11: Model Verification – Comparison of results with observed flood behaviour descriptions and extents

| Location ID | Catchment | Resident Description | Model Behaviour | Match |
|---|---|---|---|---|
| LMT_002 | Plains Gully Creek | Water crossed the roads, property affected by Bay | Overland flow crosses Bowman Street and follows Alexander Place into the bay. | Yes |
| LMT_019 | Plains Gully Creek | Peggy Street and Bowman Street flooded. | Peggy street and Bowman Street affected by floodwater. | Yes |
| LMT_031 | Plains Gully Creek | 2007: water reached footpath from middle of the road | Overland flow covers Bowman street including the footpath. | Yes |
| LMT_034 | Plains Gully Creek | Flooding across road in Peggy Street, driveway/footpath only. | Peggy street affected by flooding. The flood extent is limited to the road itself and the footpath. | Yes |
| LMT_008 | Sheppards Creek | 2007: Along nearby public spaces and street | Nearby street, Valerie crescent flood affected by up to 0.5m as well as park north of the Valerie crescent | Yes |
| LMT_068 | Muraban Creek | June 2007: Yard and garage, up to back fence | Flood extent reaches the garage as well as the back fence | Yes |
| LMT_037 | Mills Creek | June 2007: Unit was flooded, Water in backyard. | The Tudor street low point filled with floodwater, with significant depths at the entry of the unit. | Yes |
| LMT_036 | Puntei Creek | June 2007: flooding in home. Garage and laundry of the property | Floodwaters pound in front of the property | Yes |
| LMT_061 | Puntei Creek | Drive way and low lying parts of the yard. | Driveway and yard significantly flooded | Yes |
| LMT_067 | Puntei Creek | Water flows through property into lake. Flood reached back laundry. | Overland flow path passes through the lot, relatively shallow | Yes |
| LMT_053 | Fullers Creek and Freshwater Creeks | Flooding from creek near 79. Spill across the road in front 108, 110-112 Station St. | Significant flooding next to Number 79 station street. Road running in front of number 108,110-112 conveys flow from the street to the creek. | Yes |
| LMT_011 | Postmistress Creek | Flooding at Yard, ankles deep. | Yard flood affected by shallow overland flow (below 0.1 m) | Yes |
| LMT_073 | Postmistress Creek | Feb/March 2020, 2015 Water pools at the entry. | Overland flow overtops the kerb line and reach the property where it ponds at the entry | Yes |

The verification process indicates that the models do a reasonable job of reproducing the anecdotal flood information described by residents. The modelled depths are typically within ±0.25 m of the observations, which is an acceptable level of accuracy for urban overland flow flood modelling with currently available data and modelling technology. The main exception to the above is the observation from a resident that water ponded to 0.8 m depth over Station Street at Freshwater Creek in 2019. The street here is significantly higher than surrounding ground and a steep downstream slope. The road would act as a weir to overland flow, with relatively shallow flow across the road crest even in major floods (Photo 15). The modelling indicated ponding of up to 1 m just upstream of the road, so it may have been that the resident was referring to this location rather than the road itself.

Photo 15: Freshwater Creek culvert at Station Street (from upstream)

There are limits to the accuracy that can be achieved in this model verification process, since there are significant uncertainties in the estimated rainfall amounts and spatial/temporal distribution, as well as uncertainties associated with the flood marks and estimated depths, and reliability of the residents' memory of the event.

In order to provide a more rigorous calibration outcome and improved model accuracy, more comprehensive high quality flood level data (or any other flood related data) would need to be recorded from future large local stormwater flood events.

### 5.6.3. Sensitivity Results

A number of sensitivity analyses were undertaken to establish the variation in modelled flood levels and flow that may occur if different parameter assumptions were made. These sensitivity scenarios were undertaken during the model verification stage, to understand which parameters

were the most influential on the peak flood levels results. During this stage a preliminary assumption of 50% blockage of pipes and culverts was made, which was later revised after more detailed assessment for the design modelling stage (see Section 5.9). Therefore, the sensitivity results discussed in this section are relative to a baseline assumption of 50% blockage. The sensitivity scenarios investigated included:

- Blockage of pipes/bridges/culverts (25%, 75% and 100% compared to 50% baseline);
- Hydrologic catchment lag parameter (C) varied by ±25%;
- Rainfall losses varied by ±25%;
- Mannings roughness varied by ±25%;
- Rainfall intensities due to potential climate change;
- Downstream boundaries due to potential climate change.

The variation in peak flood level resulting from the above scenarios is mapped in Appendix B, with results presented by catchment as follows:

- Plains Gully Creek, Figure B12 to Figure B21
- Sheppards Creek, Figure B22 to Figure B31
- Muraban Creek, Figure B32 to Figure B41
- Mills Gully Creek, Figure B42 to Figure B51
- Puntei Creek, Figure B52 to Figure B71
- Fullers Creek and Freshwater Creek, Figure B72 to Figure B91
- Postmistress Creek, Figure B92 to Figure B111
- Mannering, Swampy and Wyee Creeks, Figure B112 to Figure B121

Additional climate change sensitivity scenarios were undertaken after the design flood modelling stage was completed. Changes in 1% AEP peak flood level at selected locations are tabulated below with the blockage sensitivity results. Refer to Section 8 for discussion.

Table 12: Model Verification – Peak flood level sensitivity results at selected locations

Plains Gully Creek

| ID Figure 2a | Location | Change in peak flood level (m) compared to baseline 1% AEP level with 50% blockage | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | Blockage 25% | Blockage 75% | Blockage 100% | 0.5% AEP event | 0.2% AEP event | Sea Level Rise 2050 | Sea Level Rise 2100 |
| PGC1 | Basin upstream Rea St | -0.04 | 0.04 | 0.06 | 0.04 | 0.10 | 0.00 | 0.00 |
| PGC2 | DS Park Ave | -0.06 | 0.03 | 0.06 | 0.16 | 0.36 | 0.00 | 0.00 |
| PGC3 | Crossing of Martha St and Macquarie Grove | -0.03 | 0.01 | 0.02 | 0.05 | 0.09 | 0.00 | 0.00 |
| PGC4 | Ups Strathmore Rd | -0.06 | 0.05 | 0.08 | 0.08 | 0.17 | 0.00 | 0.00 |
| PGC5 | Plain Gully Creek @ Braemar Rd | -0.01 | 0.01 | 0.03 | 0.04 | 0.10 | 0.01 | 0.11 |
| PGC6 | Ups Gray St | -0.04 | 0.08 | 0.15 | 0.03 | 0.07 | 0.10 | 0.50 |
| PGC7 | Ups Bowman St | -0.25 | 0.20 | 0.32 | 0.04 | 0.09 | 0.23 | 0.65 |
| PGC8 | Ups Pacific Highway | 0.00 | 0.00 | 0.00 | 0.02 | 0.05 | 0.05 | 0.55 |
| PGC9 | Ups Pacific Highway | 0.00 | 0.01 | 0.00 | 0.01 | 0.01 | 0.39 | 0.89 |

Sheppards Creek

| ID Figure 2b | Location | Change in peak flood level (m) compared to baseline 1% AEP level with 50% blockage | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | Blockage 25% | Blockage 75% | Blockage 100% | 0.5% AEP event | 0.2% AEP event | Sea Level Rise 2050 | Sea Level Rise 2100 |
| She1 | Ups Croudace Bay Road | -0.67 | 0.24 | 0.28 | 0.34 | 0.76 | 0.00 | 0.00 |
| She2 | Basin Ups Croudace Bay Road | -0.45 | 0.41 | 0.44 | 0.34 | 0.81 | 0.00 | 0.00 |
| She3 | crossing of Excalibur Ave and Cavalier Cres | 0.00 | 0.01 | 0.05 | 0.04 | 0.09 | 0.00 | 0.00 |
| She4 | Basin near Ruston Ave | 0.01 | 0.01 | 0.02 | 0.10 | 0.23 | 0.00 | 0.00 |
| She5 | Creek South of Regal Way | -0.09 | 0.07 | 0.12 | 0.10 | 0.21 | 0.00 | 0.00 |
| She6 | Ups Croudace Bay Rd Bridge | 0.06 | -0.04 | -0.03 | 0.24 | 0.51 | 0.01 | 0.07 |
| She7 | Crossing of Macquarie Dr and Shaw St | 0.00 | 0.02 | 0.03 | 0.01 | 0.04 | 0.00 | 0.00 |
| She9 | Basin near Tingira Dr | 0.00 | 0.02 | 0.08 | 0.08 | 0.21 | 0.14 | 0.47 |

| ID Figure 2b | Location | Change in peak flood level (m) compared to baseline 1% AEP level with 50% blockage | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | Blockage 25% | Blockage 75% | Blockage 100% | 0.5% AEP event | 0.2% AEP event | Sea Level Rise 2050 | Sea Level Rise 2100 |
| She10 | Ups Parklea Ave | -0.13 | 0.11 | 0.23 | 0.03 | 0.08 | 0.00 | 0.00 |
| She11 | Ups Regal Way | -1.31 | 0.31 | 0.40 | 0.11 | 0.24 | 0.00 | 0.00 |
| She8 | Sheppards creek @ bowling club carpark | 0.02 | -0.01 | -0.01 | 0.67 | 1.46 | 0.00 | 0.00 |

Muraban Creek

| ID Figure 2c | Location | Change in peak flood level (m) compared to baseline 1% AEP level with 50% blockage | | | | |
|---|---|---|---|---|---|---|
| | | Blockage 25% | Blockage 75% | Blockage 100% | 0.5% AEP event | 0.2% AEP event |
| Mur1 | Floraville Basin | -0.06 | 0.02 | 0.03 | 0.06 | 0.10 |
| Mur2 | Ups Patrick St | -0.08 | 0.08 | 0.11 | 0.03 | 0.07 |
| Mur3 | Ups Vincent St | -0.04 | 0.06 | 0.11 | 0.06 | 0.19 |
| Mur4 | Eastern Channel Ups Princess Hwy | -0.03 | 0.02 | 0.03 | 0.01 | 0.07 |
| Mur5 | Ups Pacific Hwy @ South-West flow path | -0.08 | 0.05 | 0.09 | 0.05 | 0.29 |
| Mur6 | Open Channel @ Bluebell St | 0.04 | -0.04 | -0.05 | 0.07 | 0.15 |
| Mur7 | Basin south of warehouses | 0.01 | 0.02 | 0.02 | 0.07 | 0.16 |
| Mur8 | Western open channel Ups Princess Hwy | 0.00 | 0.03 | 0.05 | 0.03 | 0.07 |
| Mur9 | Muraban creek u/s warehouses | -0.47 | 0.15 | 0.25 | 0.10 | 0.23 |
| Mur10 | Ups Park St | -0.02 | 0.09 | 0.18 | 0.25 | 0.69 |
| Mur11 | Eastern Open Channel | 0.02 | -0.01 | -0.02 | 0.02 | 0.04 |
| Mur12 | Park Royal Rd low point | -0.01 | 0.01 | 0.03 | 0.00 | 0.00 |
| Mur13 | Muraban creek near Griffiths Ave | 0.03 | 0.02 | 0.03 | 0.00 | 0.00 |
| Mur14 | North west Creek ups Floraville Rd | -0.64 | 0.23 | 0.31 | 0.00 | 0.00 |
| Mur15 | Creek south of Nyanda Av | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |

Mills Gully Creek

| ID Figure 2d | Location | Change in peak flood level (m) compared to baseline 1% AEP level with 50% blockage | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | Blockage 25% | Blockage 75% | Blockage 100% | 0.5% AEP event | 0.2% AEP event | Sea Level Rise 2050 | Sea Level Rise 2100 |
| Mil1 | Topgallant Way basin | -0.04 | 0.03 | 0.05 | 0.08 | 0.19 | 0.00 | 0.00 |
| Mil2 | Crown St Low point | -0.02 | 0.02 | 0.03 | 0.04 | 0.09 | 0.00 | 0.00 |
| Mil3 | Ups Croudace Bay Rd 3 | -0.03 | 0.03 | 0.05 | 0.05 | 0.12 | 0.00 | 0.00 |
| Mil4 | Ups Spinnaker Ridge Way | -0.01 | 0.01 | 0.05 | 0.03 | 0.08 | 0.00 | 0.00 |
| Mil5 | Ups Croudace Bay Rd 2 | -0.01 | 0.03 | 0.06 | 0.02 | 0.06 | 0.00 | 0.00 |
| Mil6 | Ups Croudace Bay Rd 1 | 0.00 | 0.00 | 0.00 | 0.01 | 0.03 | 0.00 | 0.00 |
| Mil7 | Ups Ross St | -0.03 | 0.03 | 0.04 | 0.05 | 0.12 | 0.00 | 0.00 |
| Mil8 | Tudor St Low point | -0.01 | 0.01 | 0.02 | 0.02 | 0.06 | 0.00 | 0.00 |
| Mil9 | Creek at Lewers St | 0.00 | 0.00 | 0.00 | 0.05 | 0.12 | 0.00 | 0.00 |

Puntei Creek

| ID Figure 2e | Location | Change in peak flood level (m) compared to baseline 1% AEP level with 50% blockage | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | Blockage 25% | Blockage 75% | Blockage 100% | 0.5% AEP event | 0.2% AEP event | Sea Level Rise 2050 | Sea Level Rise 2100 |
| Punt1 | Ups Excelsior Pde | -0.01 | 0.01 | 0.00 | 0.08 | 0.21 | 0.04 | 0.19 |
| Punt2 | Puntei creek @ Lake Macquarie | -0.01 | 0.01 | 0.00 | 0.09 | 0.23 | 0.10 | 0.47 |
| Punt3 | Ups Hampton St | -0.02 | 0.01 | 0.02 | 0.03 | 0.07 | 0.00 | 0.00 |
| Punt4 | Ups Jarrett St | -0.05 | 0.05 | 0.09 | 0.06 | 0.15 | 0.00 | 0.00 |
| Punt5 | Puntei Creek 1 | 0.00 | 0.00 | -0.03 | 0.08 | 0.21 | 0.00 | 0.00 |
| Punt6 | Puntei Creek 2 | 0.00 | 0.00 | -0.02 | 0.07 | 0.19 | 0.00 | 0.00 |
| Punt7 | Puntei Creek 3 | 0.00 | 0.00 | -0.01 | 0.07 | 0.16 | 0.01 | 0.07 |
| Punt8 | Puntei Creek 4 | -0.01 | 0.01 | 0.00 | 0.08 | 0.21 | 0.03 | 0.18 |

Fullers Creek and Freshwater Creek

| ID Figure 2f | Location | Change in peak flood level (m) compared to baseline 1% AEP level with 50% blockage | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | Blockage 25% | Blockage 75% | Blockage 100% | 0.5% AEP event | 0.2% AEP event | Sea Level Rise 2050 | Sea Level Rise 2100 |
| FFC1 | Ups Marconi Road | -0.03 | 0.03 | 0.05 | 0.05 | 0.10 | 0.00 | 0.00 |
| FFC2 | Ups Station Street | -0.03 | 0.03 | 0.06 | 0.03 | 0.08 | 0.00 | 0.00 |
| FFC3 | Freshwater creek @ Amos St | 0.01 | -0.01 | -0.01 | 0.07 | 0.15 | 0.06 | 0.32 |
| FFC4 | Freshwater creek @ Macquarie St | 0.00 | -0.01 | -0.01 | 0.04 | 0.09 | 0.23 | 0.70 |
| FFC5 | Ups Ironbark Road | 0.00 | 0.00 | 0.00 | 0.02 | 0.04 | 0.00 | 0.00 |
| FFC6 | Ups Campview Road | -0.01 | 0.01 | 0.01 | 0.02 | 0.05 | 0.00 | 0.00 |
| FFC7 | Ups Inglewood Street | 0.00 | 0.00 | 0.00 | 0.01 | 0.03 | 0.00 | 0.00 |
| FFC8 | Fullers Creek Downstream of Inglewood St | 0.00 | 0.00 | 0.00 | 0.01 | 0.04 | 0.37 | 0.86 |

Postmistress Creek

| ID Figure 2g | Location | Change in peak flood level (m) compared to baseline 1% AEP level with 50% blockage | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | Blockage 25% | Blockage 75% | Blockage 100% | 0.5% AEP event | 0.2% AEP event | Sea Level Rise 2050 | Sea Level Rise 2100 |
| PMC1 | Ups Waterside Ave | -0.10 | 0.11 | 0.20 | 0.07 | 0.15 | 0.15 | 0.51 |
| PMC2 | Postmistress Creek @ Lake Macquarie | 0.00 | 0.00 | -0.01 | 0.01 | 0.03 | 0.38 | 0.88 |
| PMC3 | Ups Sunshine Parade property | -0.01 | 0.01 | 0.01 | 0.01 | 0.02 | 0.00 | 0.00 |
| PMC4 | Upstream part of the Catchment | 0.00 | 0.00 | 0.00 | 0.02 | 0.04 | 0.00 | 0.00 |

Mannering Creek, Swampy Creek and Wyee Creek

| ID Figure 2h | Location | Change in peak flood level (m) compared to baseline 1% AEP level with 50% blockage | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | Blockage 25% | Blockage 75% | Blockage 100% | 0.5% AEP event | 0.2% AEP event | Sea Level Rise 2050 | Sea Level Rise 2100 |
| MSWC1 | Mannering Creek @ Upstream M1 | -0.31 | 0.15 | 0.21 | 0.45 | 0.75 | 0.00 | 0.00 |
| MSWC2 | Swampy creek @ Upstream M1 | -0.67 | 0.90 | 3.07 | 0.24 | 0.58 | 0.00 | 0.00 |
| MSWC3 | Wyee Creek @ Upstream M1 | -0.02 | 0.03 | 0.06 | 0.21 | 0.54 | 0.00 | 0.00 |
| MSWC4 | northern creek @ Upstream M1 | -0.32 | 0.28 | 0.43 | 0.19 | 0.43 | 0.00 | 0.00 |
| MSWC5 | Swampy creek @ UPSTREAM WYEE Road | -0.27 | 0.28 | 0.33 | 0.18 | 0.45 | 0.00 | 0.00 |
| MSWC6 | Swampy creek @ Downstream WYEE Road | 0.00 | -0.03 | -0.05 | 0.11 | 0.25 | 0.00 | 0.00 |
| MSWC7 | Swampy creek @ Downstream M1 | 0.02 | -0.09 | -0.26 | 0.01 | 0.04 | 0.00 | 0.00 |
| MSWC8 | Wyee Creek @ Downstream M1 | -0.01 | 0.02 | 0.04 | 0.10 | 0.23 | 0.00 | 0.00 |
| MSWC9 | northern creek @ Downstream M1 | 0.08 | -0.14 | -0.42 | 0.02 | 0.04 | 0.00 | 0.00 |
| MSWC10 | Mannering Creek @ Downstream M1 | 0.00 | -0.04 | -0.14 | 0.03 | 0.18 | 0.00 | 0.00 |
| MSWC11 | Downstream M1 180 m south of Mannering Creek | No longer flooded | 0.15 | 0.20 | - | - | - | - |
| MSWC12 | Mannering Creek @ Upstream WYEE Road | -0.18 | 0.18 | 0.28 | 0.04 | 0.21 | 0.00 | 0.00 |
| MSWC13 | Mannering Creek @ Downstream WYEE Road | -0.38 | 0.38 | 0.48 | 0.14 | 0.72 | 0.00 | 0.00 |
| MSWC14 | Wyee Channel | -0.05 | 0.20 | 0.28 | 0.25 | 0.59 | 0.00 | 0.00 |
| MSWC15 | Wyee Creek @ Upstream WYEE Road | -0.04 | 0.05 | 0.09 | 0.04 | 0.09 | 0.00 | 0.00 |
| MSWC16 | Wyee Creek @ Downstream WYEE Road | 0.04 | -0.07 | -0.18 | 0.04 | 0.09 | 0.00 | 0.00 |
| MSWC17 | Wyee Creek @ Upstream Railway | 0.00 | -0.03 | -0.05 | 0.12 | 0.27 | 0.00 | 0.00 |
| MSWC18 | Downstream Wyee Channel | -0.07 | 0.04 | 0.03 | 0.15 | 0.35 | 0.00 | 0.00 |
| MSWC19 | Wyee Creek Upstream Mannering Bay | -0.13 | 0.10 | 0.16 | 0.10 | 0.22 | 0.06 | 0.12 |
| MSWC20 | Mannering Bay | -0.13 | 0.10 | 0.17 | 0.08 | 0.17 | 0.05 | 0.12 |
| MSWC22 | Mannering Inlet | 0.00 | 0.01 | 0.00 | 0.00 | 0.00 | 0.40 | 0.90 |

Additional localised sensitivity of bridge energy losses was also undertaken for major structures, and this was found to not have a significant impact on the results within typical parameter ranges.

Generally, there was insufficient calibration data to warrant significant deviation away from typical modelling values based on experience from calibrated models in similar catchments in the region.

## 5.7. ARR 2019 Design Flood Modelling

Since the last edition of ARR was published in 1987, numerous technological developments and a larger set of recorded rainfall data has been available for updating the ARR guidelines on design rainfall depths and temporal patterns. This set of data includes a larger number of rainfall gauges which continuously record rainfall (pluviometers) and a longer record of storms (inclusion of events from approximately 1985 to 2015). Prior to this, the sub-daily rainfall records in many locations apart from capital city centres covered only a ten to fifteen year period from the 1970s.

Compared to ARR 1987, there are three major updates to the rainfall-runoff design flood method as follows:

1. The IFD rainfall data and the initial and continuing loss values across Australia have been updated using the additional 30 years of data;
2. There is information about the amount of rainfall likely to occur before the main storm burst;
3. The approach for assuming design temporal patterns and determining the critical duration has been significantly revised. ARR 2019 recommends that 10 temporal patterns should be analysed for each storm duration in order to determine the critical storm event. The critical storm event is not the event producing the maximum peak value for all the durations but the temporal pattern of the duration which produces the maximum average peak value from the 10 storms.

IFD rainfall data, initial loss and continual loss were obtained from the ARR Datahub.[3]

### 5.7.1. Critical Duration Analysis

The adoption of ARR 2019 has made a significant difference in critical duration analysis (the storm duration which produces the highest flood level at a given catchment location). Each AEP event may have a unique critical duration and critical storm on each catchment. The critical duration may vary throughout the catchment, with longer durations generally causing more severe flooding lower down in the catchment comparted to the upper, as the total contributing catchment area size increases. The details of the critical analysis are provided below.

### 5.7.2. Design Storm Temporal Patterns

Temporal patterns are a hydrologic tool that describe how rain falls over time and are used in hydrograph estimation. There are significant updates in the application of temporal patterns for design events in ARR 2019. Previously, with ARR 1987 guidelines a single temporal pattern was

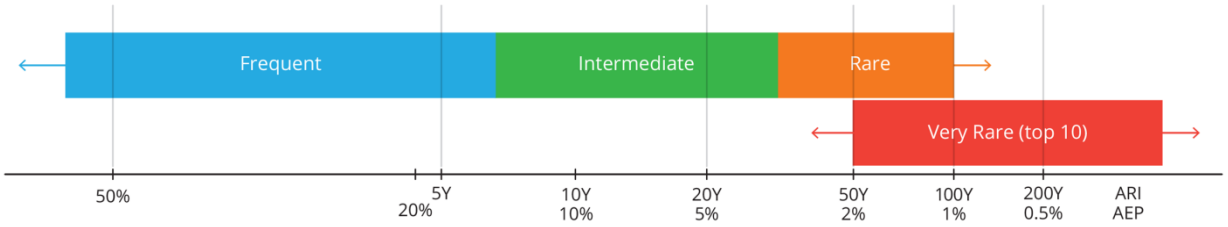
3 http://data.arr-software.org/

adopted for each rainfall event duration. However, ARR 2019 discusses the potential inaccuracies with adopting a single temporal pattern and recommends an approach where an ensemble of different temporal patterns is investigated. It is widely accepted that there are a large variety of temporal patterns possible for rainfall events of similar magnitude. This variation in temporal pattern can result in significant effects on the estimated peak flow. As such, the revised temporal patterns have adopted an ensemble of ten different temporal patterns for a particular design rainfall event. Given the rainfall-runoff response can be quite catchment specific, using an ensemble of temporal patterns attempts to produce the median catchment response.

ARR 2019 provides 30 patterns for each duration and are sub-divided into three temporal pattern bins based on the frequency of the events. Diagram 11 shows the three categories of bins (frequent, intermediate and rare) and corresponding AEP groups. The very rare bin is under the experimental stage and not used in this flood study. Thus there are ten temporal patterns for each AEP/duration in ARR 2019.

The adopted temporal pattern out of the 10 is the pattern which produces the peak flow (or peak flood level) just greater than the average of the 10 peak flows (or levels). Thus the temporal pattern adopted does not produce the largest peak flow (or level) for that storm duration. The critical storm duration is that which produces the maximum average peak flow (or level).

Diagram 11: Temporal Pattern Bins (Reference 6)




### 5.7.3. Rainfall Loss

In January 2019 (note ARR 2019 was released in May 2019) the NSW Office of Environment and Heritage released new guidance regarding the implementation of ARR 2016 methodologies in NSW specifically: *"Incorporating 2016 Australian Rainfall and Runoff in Studies Section 3.7.1 Initial and continuing losses, pre-burst and burst losses in NSW".* The new guidance was developed in response to a study that indicated that there is significant bias in the standard ARR 2016 design event method with default ARR 2016 losses and pre-burst, available from the ARR 2016/2019 Datahub. It identified that default continuing losses in ARR 2016 over-estimated losses and therefore should only be used where better information was not available. If default continuing losses from the ARR Datahub are to be used these should be used with a multiplier of 0.4 applied.

As per ARR 2019 modelling methodology, pre-burst rainfall (the portion of rainfall that precedes the critical burst of the storm event) is subtracted from the storm initial loss to calculate the burst initial loss. The burst loss is applied to the hydrological model. The formula for deriving the burst initial loss is as follows (with negative losses assumed to be zero):

Burst Initial Loss = Storm Initial Loss – Pre-Burst Depth

In the absence of the availability of calibrated losses (i.e. calibrated flow to a stream gauge), the factored ARR 2019 Datahub continuing loss rate has been applied for this study, in conjunction with Probability Neutral Burst Losses (available through the ARR 2019 Datahub and recommended in DPIE guidance).

Table 13: ARR 2019 Model Loss Values

| Loss | ARR 2019 Value |
|---|---|
| **Initial Loss (mm)** | Refer Table 14 |
| **Continuing Loss (mm/hr)** | 0.4 x 2.8 = 1.12 for Plains Gully<br>Varies between 1.08 and 1.20 for other catchments |

Table 14: Probability-Neutral Burst Initial Losses – Plains Gully Creek Catchment (mm)

| Burst Duration (hours) | AEP (%) | | | | | |
|---|---|---|---|---|---|---|
| | 50 | 20 | 10 | 5 | 2 | 1 |
| **1** | 16.6 | 11.4 | 11.4 | 11.9 | 12.2 | 9.1 |
| **1.5** | 16.6 | 12.7 | 12.8 | 13.3 | 13 | 9 |
| **2** | 16.5 | 12.7 | 12.7 | 12.4 | 13.3 | 7.4 |
| **3** | 18.2 | 13.7 | 13.5 | 12.2 | 11.6 | 6 |
| **6** | 14.6 | 10.5 | 10.4 | 9.5 | 11.3 | 3.9 |

Table 15: Probability-Neutral Burst Initial Losses – Mannering/Swampy/Wyee Catchment (mm)

| Burst Duration (hours) | AEP (%) | | | | | |
|---|---|---|---|---|---|---|
| | 50 | 20 | 10 | 5 | 2 | 1 |
| **1** | 27.2 | 13.8 | 14 | 15.3 | 16.7 | 16.7 |
| **1.5** | 30.4 | 16.7 | 16.5 | 17.7 | 16.6 | 13.3 |
| **2** | 27.1 | 16.3 | 16.2 | 17.4 | 17 | 14.1 |
| **3** | 30.3 | 18.7 | 17.4 | 17.6 | 15.8 | 11.4 |
| **6** | 27 | 17.2 | 16 | 14.1 | 13.7 | 7.9 |

Table 13 indicates the pervious surface loss values and the probability-neutral burst losses are shown in Table 14 for the Plains Gully Creek catchment, and Table 15 for the Mannering/Swampy/Wyee Creek catchment. The values for Plains Gully Creek are typical of the majority of the study area catchment around the lake. The losses are slightly higher for the Mannering/Swampy/Wyee Creek catchment since it extends further inland to the west, where the pre-burst rainfall values are lower and the soils have increased infiltration capacity.

Three land-use categories were adopted for the purposes of calculating catchment average rainfall losses. Within each category, an effective impervious area (EIA) proportion and was assumed, and for this proportion the initial loss was assumed to be 1 mm and continuing losses 0 mm/hr. For the remaining pervious fraction, the relevant losses as outlined above were assigned. The three categories and their relevant pervious fractions are summarised in Table 8 (Section 4.3).

### 5.7.4. Critical Duration Modelling and Representative Storm Selection

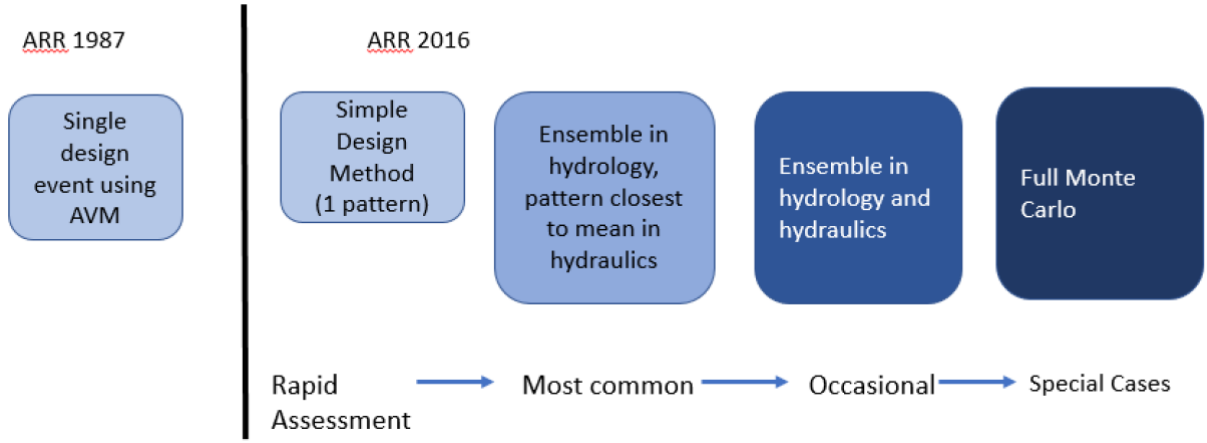
The critical duration is the temporal pattern and duration that best represents the flood behaviour (e.g. flow, level) for a specific design magnitude. It is generally related to the catchment size, as flow takes longer to concentrate at the outlet from a larger catchment, as well as other considerations like land use, shape, stream characteristics, etc.

With ARR2019 methodology, the critical duration is the storm duration that produces the highest mean flow or level at a point of interest (where the mean is calculated from the ensemble of ten temporal patterns for that duration). Where there are multiple locations of interest with different contributing catchment sizes, there can be multiple critical durations that need to be considered.

Once the critical duration is established, it is usually desirable to select a representative design storm temporal pattern that reproduces this behaviour for all points of interest. This representative storm can then be used for determining design flood behaviour and for future modelling to inform floodplain management decisions.

The potential methods for the ensemble modelling approach are outlined in Reference 9, reproduced in Diagram 12.

Diagram 12: Ensemble Hydrology Approaches in ARR2019




The “Most common” approach is to rely on a hydrologic model to determine the critical duration before proceeding with hydraulic modelling. For this study, due to the complex interactions between the hydrology and hydraulics, the relatively more complex “Occasional” approach was used where the full ensemble of temporal patterns were run in both the hydrologic and hydraulic models for a range of durations (depending on catchment size) as follows:

- 180 minutes to 1440 minutes for the Mannering, Swamp Creek and Wyee Creek catchment;
- 30 minutes to 540 minutes for the Muraban Creek catchment; and
- 30 minutes to 120 minutes for the remaining catchments.

For each duration, a grid of the mean peak level at each grid cell was calculated, and then a

maximum grid was calculated taking the highest peak mean level for each grid cell. The source of the peak mean level for each grid cell was mapped to show the variation in critical duration across the catchment (see Figure 13, a to h).

The process above indicated that the 30 minute to 45 minute durations are critical for the majority of the smaller catchments in the study, apart from some flood storage areas in lower catchment areas and open spaces such as parks, playing fields. Adopting a range of critical duration events across a catchment complicates the analysis as this may mean adopting different critical durations to represent the peak level, velocity or hazard. It also means that when undertaking sensitivity analysis or the modelling of options a multitude of durations must be run, increasing costs and time to use the modelling. Thus it is preferable to adopt a single representative storm that is similar to the critical duration behaviour for each AEP where possible.

Generally, there is very little variation in mean peak flood level (i.e. within ±0.05 m) between these different durations, and a representative pattern of either 45 minutes or 60 minutes was typically suitable for each of the smaller catchments. Figure 14 (a to h) shows the variation between the adopted representative pattern and the “true” critical duration peak mean result.

In the larger catchment of Mannering/Swampy/Wyee Creeks durations from 540 minutes to 1080 minutes (9 hours to 18 hours) are critical for the conveyance areas of the main creeks, and 1440 minutes (24 hours) is the critical duration for Mannering Bay and the adjacent wetlands. It was determined for this catchment and for Muraban Creek, that a combination of the representative patterns for two different durations was required to represent the catchment-wide peak flood behaviour within ±0.1 m for those two study areas.

The representative storm patterns selected for the design event modelling are summarised in Table 16:

Table 16: Selected Representative Design Storm Temporal Patterns

| AEP | Frequent<br>50% and 20% | Intermediate<br>10% and 5% | Rare<br>2%, 1%, 0.5% and 0.2% |
|---|---|---|---|
| **Plains Gully** | 120 min<br>TP4640 | 120 min<br>TP4625 | 90 min<br>TP4395 |
| **Sheppards** | 90 min<br>TP4602 | 60 min<br>TP4569 | 45 min<br>TP4528 |
| **Muraban<br>(2 durations)** | 45 min<br>TP4553 | 60 min<br>TP4573 | 45 min<br>TP4534 |
| | 270 min<br>TP2749 | 270 min<br>TP4700 | 120 min<br>TP4499 |
| **Mills** | 45 min<br>TP4552 | 45 min<br>TP4478 | 45 min<br>TP4534 |
| **Puntei** | 120 min<br>TP4643 | 90 min<br>TP4593 | 60 min<br>TP4463 |
| **Freshwater & Fullers** | 45 min<br>TP4553 | 60 min<br>TP4569 | 45 min<br>TP4528 |

| | | | |
|---|---|---|---|
| **Postmistress** | 90 min<br>TP4602 | 60 min<br>TP4565 | 45 min<br>TP4528 |
| **Mannering, Swampy and Wyee (2 durations)** | 720 min<br>TP4805 | 720 min<br>TP4794 | 540 min<br>TP4750 |
| | 1440 min<br>TP4883 | 1080 min<br>TP4830 | 1080 min<br>TP4748 |

For the PMF, the 30 minute storm was adopted as the critical duration. This was the case for all study catchments apart from Mannering/Swampy/Wyee Creeks, where a combination of the 180 minute and 360 minute PMF durations were adopted as critical.

## 5.8. Approach for Coincidence of Rainfall and Water Levels in Lake Macquarie Waterway

The peak water level in the Lake Macquarie waterway results from a combination of rainfall (ARR 1987) over the catchment and elevated ocean levels. Thus design flood levels in Lake Macquarie waterway in Reference 2 were determined using an envelope approach (i.e. the peak level from a range of scenarios) of:

- the 48 hour duration design inflow in combination with an elevated tide, taken as a synthetic tide oscillating between 0 m AHD and 1 m AHD in 12.5 hour cycles representing a normal tide with a 0.4 m anomaly added uniformly and,
- the design ocean level/tide in combination with a low inflow (20% AEP inflow).

These are termed the **rainfall induced** (design inflow event) and **ocean induced** (design ocean level) flooding mechanisms. Further details are provided in Reference 2.

Comparison of the above two flooding scenarios indicates that the rainfall-induced flood scenario produces the greater flood level in the Lake Macquarie waterway.

For the eight study areas local flooding is due to a localised rainfall event over each study area catchments and may or may not be associated with a similar rainfall event over the entire Lake Macquarie waterway catchment or an ocean induced event. The June 2007 event produced elevated lake levels (lake flooding) as well as local flooding in most of the study areas. However, the timing of the local catchment peak flood levels and the peak levels in Lake Macquarie waterway were not coincident. Typically peak local catchment flood levels occur within 1 to 2 hours of the most intense rainfall burst while the peak level in Lake Macquarie waterway occurs approximately 12 hours or even longer after the most intense rainfall burst. The latter occurs because it takes several hours for runoff to pass through the larger tributary catchments that provide most of the runoff volume (such as Dora Creek or Cockle Creek) and then fill Lake Macquarie waterway.

Typically in flood studies of larger tributary catchments surrounding Lake Macquarie waterway the 1% AEP runoff from the local catchment is coincided with the 5% AEP flood level in Lake Macquarie waterway. For smaller more frequent local runoff events a smaller coincident flood level in Lake Macquarie waterway is appropriate.

For this study, which is principally investigating local stormwater flooding, all design events have assumed a 20% AEP lake level of 0.82 m AHD in the Lake Macquarie waterway, and a 20% AEP ocean level of 1.24 mAHD in Black Neds Bay at the mouth of Plains Gully Creek (assuming no wave runup effects, due to the protected location of the creek mouth in the bay). Sensitivity analysis was undertaken to assess the effects of assuming a higher level in the Black Neds Bay and Lake Macquarie waterway (refer to Section 8.2).

## 5.9. Blockage

Design blockage for hydraulic structures was adopted in accordance with Reference 6. The debris availability, debris mobility and debris transportability was deemed to be in the Low to Medium categories for each of the catchments. The overall debris potential was classified as Low. With this classification, an inlet headwall blockage of 50% was applied to all road crossing culvert structures in the model with an opening size less than 1.5 m. Structures with a larger opening size had an assumed design debris blockage of 10% applied.

# 6. DESIGN FLOOD MODELLING RESULTS

## 6.1. Mapping of Results

The 50%, 20%, 10%, 5%, 2%, 1%, 0.5% AEP and PMF design flood events were simulated with the results provided as follows:

Appendix C: Plains Gully Creek (Swansea / Caves Beach);
Appendix D: Sheppards Creek (Valentine);
Appendix E: Muraban Creek (Floraville/Belmont);
Appendix F: Mills Gully Creek (Belmont);
Appendix G: Puntei Creek (Carey Bay);
Appendix H: Fullers Creek and Freshwater Creek (Bonnells Bay);
Appendix I: Postmistress Creek (Sunshine);
Appendix J: Mannering Creek, Swampy Creek and Wyee Creek (Wyee).

The figure numbers are the same for each catchment in the relevant appendix and are as follows:

- Peak depths, extents and contours on Figures 1 to 8;
- Peak velocities on Figures 9 to 16;
- Provisional flood hydraulic categorisation on Figures 17 to 24;
- Provisional hydraulic hazard on Figures 25 to 32;
- The impact of rainfall increase for the 1% AEP event (increase in peak level for the 0.2% and 0.5% events) on Figures 33 and 34;
- The impact of sea level rise on peak levels for the 1% AEP event on Figures 35 and 36 (not included for Appendix E – Muraban Creek);
- The impact of blockage for the 1% AEP event on Figures 37, 38 and 39;
- The impact of sea level rise on hydraulic hazard for the 1% AEP event on Figures 40 and 41 (not included for Appendix E – Muraban Creek).

## 6.2. Tabulation of Results

Tabulated peak flood level results for a range of AEPS are provided in Table 17 for selected locations in each catchment, using the following prefixes:

- Plains Gully Creek (PGC);
- Sheppards Creek (SC);
- Muraban Creek (MC);
- Mills Gully Creek (MGC);
- Puntei Creek (PC);
- Fullers Creek and Freshwater Creek (FFC);
- Postmistress Creek (PMC);
- Mannering Creek, Swampy Creek and Wyee Creek (MSWC).

The locations are shown on Figure 2 (a to h).

Table 17: Design flood modelling results – Peak flood levels at selected locations

Plains Gully Creek

| ID Figure 2a | Location | Peak flood level (m AHD) | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | 50% | 20% | 10% | 5% | 2% | 1% | 0.5% | 0.2% | PMF |
| PGC1 | Basin upstream Rea St | 9.89 | 10.23 | 10.45 | 10.62 | 10.78 | 10.87 | 10.91 | 10.96 | 11.29 |
| PGC2 | DS Park Ave | 2.51 | 2.88 | 3.04 | 3.21 | 3.46 | 3.73 | 3.89 | 4.09 | 4.67 |
| PGC3 | Crossing of Martha St and Macquarie Grove | 3.46 | 3.86 | 4.08 | 4.23 | 4.29 | 4.37 | 4.42 | 4.47 | 4.86 |
| PGC4 | Ups Strathmore Rd | 2.07 | 2.58 | 2.73 | 2.84 | 2.97 | 3.10 | 3.17 | 3.27 | 4.15 |
| PGC5 | Plain Gully Creek @ Braemar Rd | 1.67 | 1.87 | 1.95 | 2.03 | 2.09 | 2.16 | 2.20 | 2.25 | 2.62 |
| PGC6 | Ups Gray St | 1.39 | 1.48 | 1.52 | 1.57 | 1.61 | 1.65 | 1.68 | 1.72 | 2.02 |
| PGC7 | Ups Bowman St | 1.28 | 1.32 | 1.35 | 1.39 | 1.44 | 1.50 | 1.54 | 1.59 | 1.90 |
| PGC8 | Ups Pacific Highway | 1.40 | 1.47 | 1.51 | 1.54 | 1.56 | 1.59 | 1.61 | 1.64 | 1.81 |
| PGC9 | Plain Gully Creek @ Bay | 1.24 | 1.24 | 1.25 | 1.25 | 1.25 | 1.26 | 1.26 | 1.27 | 1.41 |

Sheppards Creek

| ID Figure 2b | Location | Peak flood level (m AHD) | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | 50% | 20% | 10% | 5% | 2% | 1% | 0.5% | 0.2% | PMF |
| She1 | Ups Croudace Bay Road | - | 20.02 | 20.41 | 20.78 | 21.28 | 21.76 | 22.11 | 22.53 | 22.85 |
| She2 | Basin Ups Croudace Bay Road | 26.79 | 27.10 | 27.26 | 27.45 | 27.91 | 28.32 | 28.66 | 29.14 | 29.48 |
| She3 | crossing of Excalibur Ave and Cavalier Cres | 12.77 | 12.90 | 12.96 | 13.01 | 13.06 | 13.11 | 13.15 | 13.20 | 13.79 |
| She4 | Basin near Ruston Ave | 9.17 | 9.43 | 9.55 | 9.66 | 9.79 | 9.92 | 10.02 | 10.16 | 10.70 |
| She5 | Creek South of Regal Way | 3.66 | 3.79 | 3.92 | 4.19 | 5.11 | 5.67 | 5.77 | 5.87 | 6.20 |
| She6 | Ups Croudace Bay Rd Bridge | 0.96 | 1.30 | 1.55 | 1.88 | 2.33 | 2.71 | 2.95 | 3.22 | 4.37 |
| She7 | Crossing of Macquarie Dr and Shaw St | 2.92 | 2.94 | 2.96 | 2.97 | 2.99 | 3.01 | 3.02 | 3.04 | 3.28 |
| She8 | Sheppards creek @ bowling club carpark | 0.86 | 0.93 | 0.98 | 1.07 | 1.17 | 1.29 | 1.38 | 1.50 | 2.14 |
| She9 | Basin near Tingira Dr | 33.31 | 33.79 | 34.02 | 34.15 | 34.20 | 34.26 | 34.29 | 34.34 | 34.64 |

| ID Figure 2b | Location | Peak flood level (m AHD) | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | 50% | 20% | 10% | 5% | 2% | 1% | 0.5% | 0.2% | PMF |
| She10 | Ups Parklea Ave | 20.25 | 20.56 | 20.75 | 21.15 | 21.43 | 21.63 | 21.74 | 21.87 | 22.61 |
| She11 | Ups Regal Way | 36.28 | 36.73 | 37.05 | 37.53 | 38.27 | 39.11 | 39.78 | 40.57 | 41.08 |

Muraban Creek

| ID Figure 2c | Location | Peak flood level (m AHD) | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | 50% | 20% | 10% | 5% | 2% | 1% | 0.5% | 0.2% | PMF |
| Mur1 | Floraville Basin | - | 17.69 | 18.13 | 18.69 | 18.92 | 19.23 | 19.28 | 19.32 | 19.48 |
| Mur2 | Ups Patrick St | 8.67 | 8.89 | 8.93 | 8.98 | 9.02 | 9.06 | 9.11 | 9.22 | 10.04 |
| Mur3 | Ups Vincent St | 9.37 | 9.93 | 10.25 | 10.32 | 10.39 | 10.45 | 10.51 | 10.63 | 10.95 |
| Mur4 | Eastern Channel Ups Princess Hwy | 11.57 | 11.69 | 11.75 | 11.80 | 11.83 | 11.87 | 11.90 | 11.93 | 12.11 |
| Mur5 | ups Pacific Hwy @ South-West flow path | 11.37 | 11.57 | 11.68 | 11.88 | 12.32 | 12.38 | 12.42 | 12.47 | 12.74 |
| Mur6 | Open Channel @ Bluebell St | 6.30 | 6.42 | 6.49 | 6.53 | 6.59 | 6.62 | 6.65 | 6.69 | 7.08 |
| Mur7 | Basin south of warehouses | 6.57 | 6.67 | 6.74 | 6.81 | 6.90 | 6.99 | 7.05 | 7.18 | 7.89 |
| Mur8 | Western open channel Ups Princess Hwy | 10.07 | 10.45 | 10.49 | 10.50 | 10.52 | 10.54 | 10.56 | 10.61 | 10.84 |
| Mur9 | Muraban creek u/s warehouses | 7.97 | 8.13 | 8.18 | 8.20 | 8.23 | 8.27 | 8.33 | 8.56 | 9.59 |
| Mur10 | Ups Park St | 14.29 | 14.54 | 14.74 | 14.84 | 14.95 | 15.04 | 15.11 | 15.20 | 15.75 |
| Mur11 | Eastern Open Channel | 12.35 | 12.63 | 12.79 | 12.90 | 13.01 | 13.11 | 13.19 | 13.28 | 13.85 |
| Mur12 | Park Royal Rd low point | 27.02 | 27.10 | 27.16 | 27.19 | 27.24 | 27.28 | 27.31 | 27.35 | 27.59 |
| Mur13 | Muraban creek near Griffiths Ave | 16.47 | 16.57 | 16.66 | 16.79 | 16.91 | 17.04 | 17.14 | 17.27 | 18.08 |
| Mur14 | North west Creek ups Floraville Rd | - | 38.17 | 38.41 | 38.60 | 38.83 | 39.05 | 39.30 | 39.74 | 40.20 |
| Mur15 | Creek south of Nyanda Av | 59.92 | 59.97 | 60.00 | 60.04 | 60.06 | 60.08 | 60.10 | 60.13 | 60.36 |

Mills Gully Creek

| ID Figure 2d | Location | Peak flood level (m AHD) | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | 50% | 20% | 10% | 5% | 2% | 1% | 0.5% | 0.2% | PMF |
| Mil1 | TopGallant Way basin | 17.11 | 17.46 | 17.55 | 17.67 | 17.85 | 17.95 | 18.03 | 18.14 | 18.58 |
| Mil2 | Crown St Low point | 20.56 | 20.71 | 20.83 | 20.88 | 20.92 | 20.97 | 21.00 | 21.06 | 21.49 |
| Mil3 | Ups Croudace Bay Rd 3 | 6.34 | 7.10 | 7.70 | 7.79 | 7.90 | 7.97 | 8.02 | 8.08 | 8.53 |
| Mil4 | Ups Spinnaker Ridge Way | 20.33 | 20.42 | 20.49 | 20.53 | 20.57 | 20.60 | 20.64 | 20.68 | 20.98 |
| Mil5 | Ups Croudace Bay Rd 2 | 35.79 | 35.97 | 36.01 | 36.08 | 36.16 | 36.19 | 36.21 | 36.24 | 36.45 |
| Mil6 | Ups Croudace Bay Rd 1 | 42.55 | 42.59 | 42.62 | 42.64 | 42.64 | 42.65 | 42.66 | 42.68 | 42.85 |
| Mil7 | Ups Ross St | 3.61 | 3.94 | 4.02 | 4.12 | 4.21 | 4.28 | 4.33 | 4.40 | 4.89 |
| Mil8 | Tudor St Low point | 19.07 | 19.14 | 19.20 | 19.23 | 19.23 | 19.26 | 19.28 | 19.31 | 19.59 |
| Mil9 | Creek at Lewers St | 12.15 | 12.36 | 12.45 | 12.56 | 12.70 | 12.77 | 12.82 | 12.88 | 13.27 |

Puntei Creek

| ID Figure 2e | Location | Peak flood level (m AHD) | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | 50% | 20% | 10% | 5% | 2% | 1% | 0.5% | 0.2% | PMF |
| Punt1 | Ups Excelsior Pde | 1.31 | 1.49 | 1.53 | 1.61 | 1.68 | 1.79 | 1.87 | 2.01 | 2.69 |
| Punt2 | Puntei creek @ Lake Macquarie | 0.85 | 0.93 | 1.00 | 1.10 | 1.18 | 1.30 | 1.39 | 1.53 | 2.26 |
| Punt3 | Ups Hampton St | 4.15 | 4.22 | 4.28 | 4.32 | 4.39 | 4.43 | 4.46 | 4.50 | 4.80 |
| Punt4 | Ups Jarrett St | 5.31 | 5.60 | 5.78 | 5.89 | 6.02 | 6.10 | 6.16 | 6.25 | 6.82 |
| Punt5 | Puntei Creek 1 | 3.83 | 3.97 | 4.07 | 4.19 | 4.34 | 4.45 | 4.54 | 4.66 | 5.43 |
| Punt6 | Puntei Creek 2 | 2.65 | 2.84 | 2.96 | 3.11 | 3.27 | 3.37 | 3.44 | 3.56 | 4.29 |
| Punt7 | Puntei Creek 3 | 1.55 | 1.73 | 1.81 | 1.91 | 2.00 | 2.10 | 2.16 | 2.26 | 2.91 |
| Punt8 | Puntei Creek 4 | 1.33 | 1.51 | 1.56 | 1.63 | 1.71 | 1.82 | 1.90 | 2.02 | 2.71 |

Fullers Creek and Freshwater Creek

| ID Figure 2f | Location | Peak flood level (m AHD) | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | 50% | 20% | 10% | 5% | 2% | 1% | 0.5% | 0.2% | PMF |
| FFC1 | Ups Marconi Road | 2.78 | 3.40 | 3.49 | 3.57 | 3.66 | 3.72 | 3.76 | 3.82 | 4.23 |
| FFC2 | Ups Station Street | 3.72 | 4.15 | 4.31 | 4.38 | 4.42 | 4.46 | 4.49 | 4.54 | 4.86 |
| FFC3 | Freshwater creek @ Amos St | 0.91 | 1.02 | 1.08 | 1.22 | 1.36 | 1.45 | 1.52 | 1.60 | 2.03 |
| FFC4 | Freshwater creek @ Macquarie St | 0.84 | 0.86 | 0.88 | 0.92 | 0.98 | 1.02 | 1.06 | 1.11 | 1.40 |
| FFC5 | Ups Ironbark Road | 5.71 | 5.76 | 5.77 | 5.79 | 5.81 | 5.83 | 5.85 | 5.87 | 6.05 |
| FFC6 | Ups Camp view Road | 12.84 | 12.90 | 12.93 | 12.95 | 12.98 | 13.00 | 13.02 | 13.06 | 13.27 |
| FFC7 | Ups Inglewood Street | 2.54 | 2.58 | 2.59 | 2.61 | 2.63 | 2.64 | 2.66 | 2.68 | 2.82 |
| FFC8 | Fullers Creek Downstream of Inglewood St | 0.82 | 0.83 | 0.83 | 0.83 | 0.85 | 0.86 | 0.88 | 0.90 | 1.59 |

Postmistress Creek

| ID Figure 2g | Location | Peak flood level (m AHD) | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | 50% | 20% | 10% | 5% | 2% | 1% | 0.5% | 0.2% | PMF |
| PMC1 | Ups Waterside Ave | 0.84 | 0.92 | 0.98 | 1.05 | 1.13 | 1.23 | 1.29 | 1.37 | 1.80 |
| PMC2 | Postmistress Creek @ Lake Macquarie | 0.82 | 0.82 | 0.83 | 0.83 | 0.83 | 0.84 | 0.85 | 0.87 | 1.20 |
| PMC3 | Ups Sunshine Parade property | 4.17 | 4.24 | 4.26 | 4.27 | 4.29 | 4.30 | 4.31 | 4.32 | 4.56 |
| PMC4 | Upstream part of the Catchment | 5.92 | 6.08 | 6.15 | 6.21 | 6.26 | 6.28 | 6.30 | 6.33 | 6.56 |

Mannering Creek, Swampy Creek and Wyee Creek

| ID Figure 2h | Location | Peak flood level (m AHD) | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | 50% | 20% | 10% | 5% | 2% | 1% | 0.5% | 0.2% | PMF |
| MSWC1 | Mannering Creek @ Upstream M1 | 25.53 | 26.32 | 27.06 | 27.44 | 28.07 | 28.52 | 28.97 | 29.27 | 29.95 |
| MSWC2 | Swampy creek @ Upstream M1 | 21.49 | 21.51 | 21.54 | 21.57 | 21.82 | 21.91 | 22.15 | 22.49 | 24.91 |
| MSWC3 | Wyee Creek @ Upstream M1 | 16.71 | 17.15 | 17.57 | 17.81 | 18.20 | 18.47 | 18.68 | 19.00 | 20.76 |
| MSWC4 | northern creek @ Upstream M1 | 21.44 | 21.60 | 21.80 | 21.91 | 22.27 | 22.50 | 22.70 | 22.93 | 23.72 |
| MSWC5 | Swampy creek @ UPSTREAM WYEE Road | 10.17 | 10.32 | 10.51 | 10.64 | 10.93 | 11.12 | 11.30 | 11.57 | 12.03 |
| MSWC6 | Swampy creek @ Downstream WYEE Road | 9.53 | 9.75 | 9.82 | 9.95 | 10.10 | 10.24 | 10.35 | 10.49 | 12.01 |
| MSWC7 | Swampy creek @ Downstream M1 | 20.44 | 20.47 | 20.50 | 20.54 | 20.59 | 20.60 | 20.60 | 20.63 | 20.73 |
| MSWC8 | Wyee Creek @ Downstream M1 | - | 16.31 | 16.59 | 16.77 | 17.01 | 17.15 | 17.24 | 17.38 | 18.25 |
| MSWC9 | northern creek @ Downstream M1 | 21.06 | 21.13 | 21.20 | 21.24 | 21.31 | 21.33 | 21.35 | 21.37 | 21.42 |
| MSWC10 | Mannering Creek @ Downstream M1 | 24.44 | 24.64 | 24.77 | 24.87 | 24.97 | 25.01 | 25.04 | 25.19 | 25.76 |
| MSWC11 | Downstream M1 180 m south of Mannering Creek | - | - | - | - | - | - | - | 26.92 | 27.53 |
| MSWC12 | Mannering Creek @ Upstream WYEE Road | 17.12 | 17.95 | 18.40 | 18.47 | 18.61 | 18.67 | 18.71 | 18.88 | 20.01 |
| MSWC13 | Mannering Creek @ Downstream WYEE Road | 13.67 | 13.94 | 14.16 | 14.30 | 14.71 | 14.91 | 15.05 | 15.64 | 18.04 |
| MSWC14 | Wyee Channel | 11.03 | 11.38 | 11.59 | 11.78 | 12.18 | 12.45 | 12.70 | 13.04 | 15.99 |
| MSWC15 | Wyee Creek @ Upstream WYEE Road | 12.81 | 13.18 | 13.56 | 13.68 | 13.77 | 13.82 | 13.86 | 13.91 | 14.38 |
| MSWC16 | Wyee Creek @ Downstream WYEE Road | 12.61 | 12.81 | 12.95 | 13.03 | 13.11 | 13.17 | 13.21 | 13.26 | 13.78 |
| MSWC17 | Wyee Creek @ Upstream Railway | 8.46 | 8.86 | 9.15 | 9.41 | 9.68 | 9.85 | 9.97 | 10.13 | 11.68 |
| MSWC18 | Downstream Wyee Channel | 3.06 | 3.59 | 3.86 | 4.10 | 4.47 | 4.68 | 4.83 | 5.03 | 6.67 |
| MSWC19 | Wyee Creek Upstream Mannering Bay | 1.07 | 1.33 | 1.55 | 1.79 | 2.24 | 2.42 | 2.52 | 2.64 | 3.65 |
| MSWC20 | Mannering Bay | 1.04 | 1.27 | 1.47 | 1.71 | 2.18 | 2.35 | 2.43 | 2.52 | 3.09 |
| MSWC22 | Mannering Inlet | 0.82 | 0.82 | 0.82 | 0.82 | 0.82 | 0.82 | 0.82 | 0.82 | 1.01 |

## 6.3. Hydraulic Classification

The NSW Government's Floodplain Development Manual 2005 (Reference 1) defines three hydraulic categories which could be applied to the study area, namely floodway, flood storage or flood fringe.

***Floodways***
*"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."*

***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.*"

***Flood fringe***
*"the remaining area of flood prone land after floodway and flood storage areas have been defined"*

There is no precise definition of floodway, flood storage and flood fringe or accepted approach to differentiate between these areas. In this Flood Study hydraulic categorisation was defined according to the following approach, namely:

*Floodway = Velocity * Depth > 0.25m$^2$/s AND Velocity > 0.25m/s OR Velocity > 1m/s*

The remainder of the floodplain outside the Floodway becomes either Flood Storage or Flood Fringe. Flood Storage was defined as the land outside the Floodway if the depth is greater than 0.2m and Flood Fringe if the depth is less than 0.2m. As noted in Reference 6 *"it is impossible to provide explicitly quantitative criteria for defining floodways and flood storage areas, as the significance of such areas is site specific"*.

Hydraulic classification areas were defined for each study area in the respective Appendix on Figures 17 to 24.

## 6.4. Flood Hazard

The risk to life and potential damages to buildings during floods varies both in time and place across the floodplain. In order to provide an understanding of the effects of a proposed development on flood behavior and the effects of flooding on development and people the floodplain can be sub-divided into hydraulic and hazard categories. This categorization should not be used for the assessment of development proposals on an isolated basis, rather they should be used for assessing the suitability of future types of land use and development in the formulation of a floodplain risk management plan.

Hazard classification plays an important role in informing floodplain risk management in an area. Previously, hazard classifications were binary – either Low or High Hazard as described in the Floodplain Development Manual (Reference 1). However, in recent years there has been a number of developments in the classification of hazard. *Managing the floodplain: a guide to best practice in flood risk management in Australia* (Reference 10) provides revised hazard classifications which add clarity to the hazard categories and what they mean in practice. The classification is divided into 6 categories, listed in Table 18, which indicate the restrictions on people, buildings and vehicles. The velocity/depth relationship for each of these categories is depicted in Diagram 13.

Diagram 13: Hazard Classifications (Reference 10)

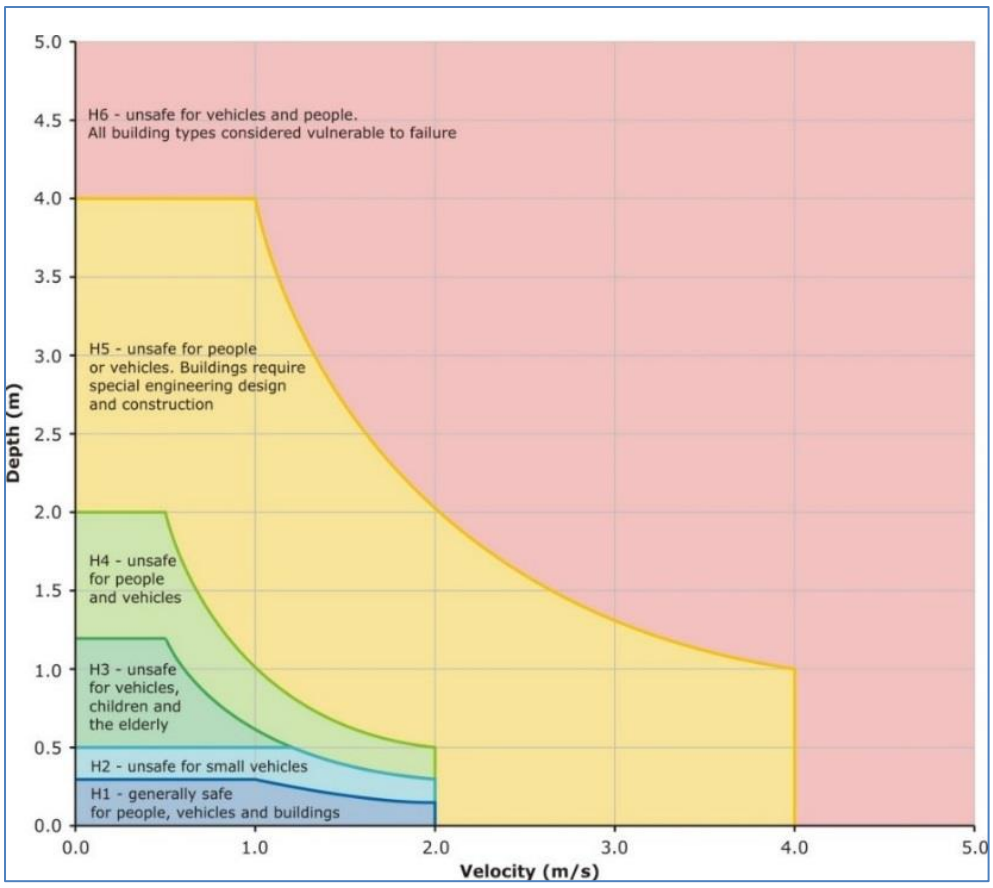



Table 18: Hazard Categories (Reference 10)

| Category | Constraint to people/vehicles | Building Constraints |
|---|---|---|
| **H1** | Generally safe | *No constraints* |
| **H2** | Unsafe for small vehicles | *No constraints* |
| **H3** | Unsafe for all vehicles, children and the elderly | *No constraints* |
| **H4** | Unsafe for vehicles and people. | *No constraints* |
| **H5** | Unsafe for vehicles and people. | All building types vulnerable to structural damage. Some less robust building types vulnerable to failure. |
| **H6** | Unsafe for people and vehicles | All building types considered vulnerable to failure |

The classifications only consider the hydraulic aspects of flood hazard, and not additional hazards arising from isolation. Hazard areas were defined for each study area in the respective Appendix on Figures 25 to 32 according to Diagram 13. It should be noted that these classifications only relate to local catchment flooding and do not include classifications based on flooding due to elevated water levels in Lake Macquarie waterway.

The *Floodplain Development Manual* (Reference 1) requires that other factors be considered in determining the "true" hazard such as size of flood, effective warning time, flood readiness, rate of rise of floodwaters, depth and velocity of flood waters, duration of flooding, evacuation problems, effective flood access, type of development within the floodplain, complexity of the stream network and the inter-relationship between flows.

## 6.5. Preliminary Flood Planning Area

### 6.5.1. Background

A key outcome of this study is the identification of land subject to flood-related development controls. The Lake Macquarie Local Environment Plan 2014 (the LEP, Reference 11) is applicable under clause 7.3(2) to "land that is shown as "Flood Planning Area" on the Flood Planning Map, and other land at or below the Flood Planning Level [defined as the 1% AEP level plus 0.5m freeboard]. Land subject to this clause must usually be identified as such on Section 10.7 planning certificates.

The Flood Planning Area (FPA) is relatively straightforward to define for mainstream flooding in ponded areas, such as in Lake Macquarie for example. It is the extent formed by using the 1% AEP flood level plus 0.5 m freeboard, stretched outwards where required at the fringe of the floodplain. In mainstream flow areas, the creek banks often rise by 0.5 m within a reasonably short distance of the 1% AEP flood extent, so the stretching process does not usually introduce major additional areas within the FPA. This method was found to be suitable for the majority of the study area floodplains along the main channels.

Where overland flow is being modelled however, the "standard" FPA definition (1% plus 0.5 m) will tend to include lots that are not in fact flooded, sometimes even in the PMF, or those subject to only nuisance inundation. This will tend to apply even if a reduced freeboard (for example 0.3 m) is used. When defining the FPA for an overland flow area, a variety of criteria for defining the FPA are best examined initially. The purpose of this work is to seek a method, based on a quantitative and repeatable criteria, that consistently produces a FPA that best reflects those properties requiring management by way of 10.7 certificates in regard to flood related development controls. This is separate to standard stormwater design considerations that will apply to all developments, and which are assumed to manage drainage at an intra-lot scale for small catchment areas.

The state government does not provide a prescriptive methodology for defining the FPA. WMAwater developed an FPA for this study using techniques specific to the catchment area, based on consideration of the flow behaviour and testing of several methods. The methodology is documented below.

### 6.5.2. Methodology

There are a range of alternative approaches for deriving the FPA. One approach, which aims to retain consistency with the LEP definition, is to add 0.5 m freeboard to the peak water level and attempt to “stretch” this surface across the terrain, as described above. Another technique is to identify cadastral lots affected by flooding, including consideration of the 1% AEP and possibly a larger event as a surrogate for the freeboard allowance, then identify the entire lot as within the FPA. This is often an appropriate technique for overland flow areas, but has the disadvantage that there is not a clearly defined spatial extent within the lot for inclusion on planning maps. This approach would not fit easily into Lake Macquarie’s existing framework for mapping the FPA.

For this study, the “add and stretch” technique was adopted with some modifications to filter out spurious results in overland flow areas. A summary of these steps is as follows:

1. The 1% AEP flood surface was filtered to identify “mainstream” flow based on a hazard classification of H3 or higher (see Section 6.4). This filtering identifies the main creek and overland flow paths and reduces the issues associated with attempting to add freeboard and stretch in minor overland flow areas.
2. 0.5 m freeboard was added to the surface obtained from step 1, and the surface was extrapolated outwards, and cut off where it intersected with the terrain.
3. The result was trimmed in some locations based on judgement that it would not be appropriate to stretch the extent beyond certain hydraulic controls, particularly some road crests and the embankments of detention basins.
4. Areas of overland flow with a depth greater than 0.15 m were then added back into the FPA extent derived above. These areas were filtered to remove isolated patches where it was assessed that these patches were artefacts of the data sample and modelling process rather than genuine overland flow paths.

### 6.5.3. Flood Planning Area Mapping

The Flood Planning Area result obtained using the above methodology is mapped on Figure 42 of the relevant appendix for each catchment. The areas designated as “mainstream” and incorporating the 0.5 m freeboard (steps 1 to 3 in the previous section) are identified by different shading on the maps to those areas identified as overland flow (step 4 in the previous section, which does not incorporate freeboard).

# 7. CONSEQUENCES OF FLOODING

## 7.1. Flood Damages

### 7.1.1. Background

The quantification of flood damages is an important part of the floodplain risk management process. It helps identify whether the benefits from various flood mitigation measures will outweigh the costs to implement those measures, and to prioritise which measures will be most cost-effective.

While flood damage assessment does not include all impacts or costs associated with flooding, it provides a basis for assessing the economic loss due to flooding, and also a non-subjective means of assessing the merit of flood mitigation works such as detention basins, levees, drainage enhancements, etc. By quantifying flood damages for a range of design events, appropriate management measures can be evaluated in terms of their benefits (reduction in flood damage) versus the cost of implementation.

The cost of flood damage and disruption to a community depends on a number of factors which include:

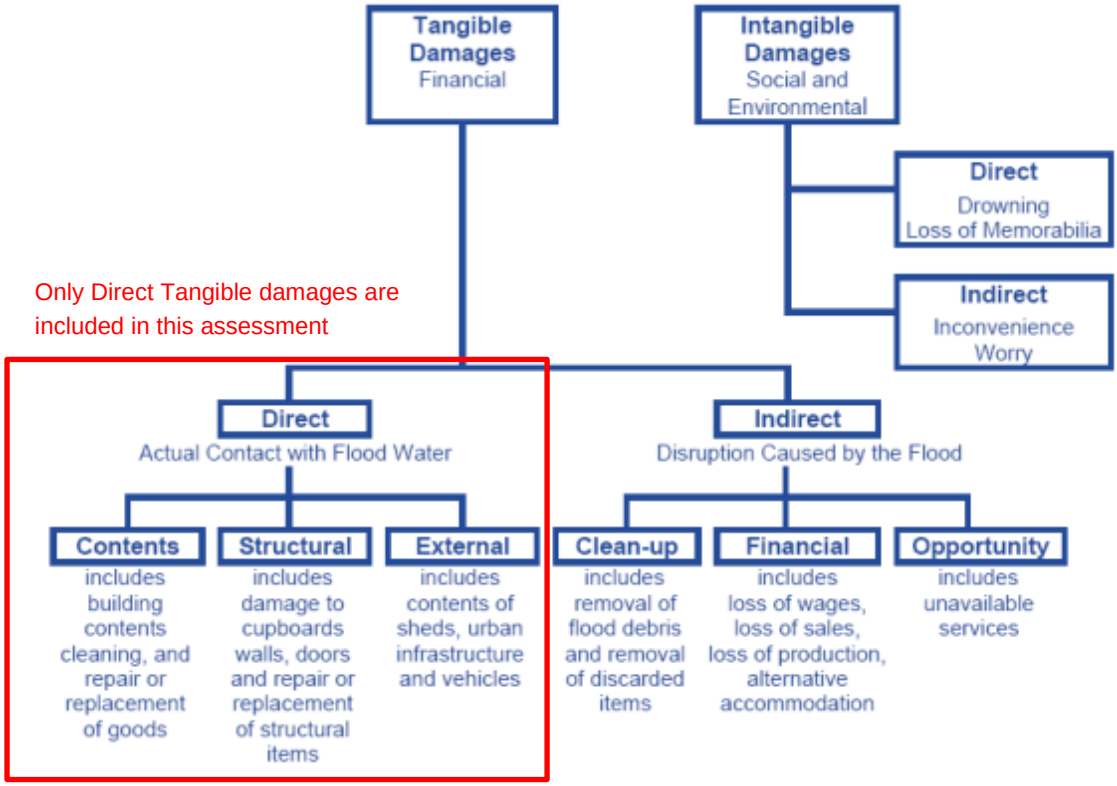
- Flood magnitude (depth, velocity and duration);
- Type of structures at risk and their susceptibility to damage;
- Nature of the development at risk (residential, commercial, industrial);
- Physical factors such as failure of services (e.g. utilities), flood borne debris, sedimentation, etc.;
- Awareness and readiness of the community to flooding;
- Effective warning times; and
- Availability of Evacuation Plans

The potential damage associated with a particular flood event can be divided into a number of components, which are grouped into two major categories;

- Tangible damages – financial costs of flooding quantified in monetary terms
- Intangible damages – social costs of flooding reflected in increased levels of mental stress, loss of sentimental items, inconvenience to people, injury or loss of life, etc.

Intangible damages are difficult to measure and impossible to meaningfully quantify in dollar terms. For this reason, intangible damages have not been assessed and the following damage assessment focuses on tangible damages only. Tangible damages can be further sub-divided into two categories, direct and indirect damages, as illustrated in Diagram 14.

Diagram 14: Types of flood damages (Source: Reference 1)




The total likely damages in any given flood event is difficult to quantify precisely, given the variable nature of flooding and the property and content values of houses affected. Design flood damages are estimated to obtain an indication of the magnitude of the flood problem and compare the economic effectiveness of proposed mitigation options. Understanding the total damages prevented over the life of a mitigation option in relation to current damages, or to an alternative option, can assist in the decision making process.

### 7.1.2. Approach

Flood damage estimation procedures have been formulated using data collected following real flood events. Information collected includes identification of properties flooded, the extent of flooding, depth of flooding experienced, flooding mechanism etc. This information can then be used to guide and calibrate models used to calculate flood damages for a particular area. One of the most thoroughly studied flood damage assessments was that undertaken at Nyngan, following the flood in 1990.

Estimation of flood damage has focussed on residential and community buildings in the study area using guidelines issued by the NSW Government (Reference 12) and recognised damage assessment methodologies. The most common approach to present flood damage data is in the form of flood-damage curves for a range of property types, i.e. residential, commercial, public property, public utilities etc. These relate flood damage to depth of flooding above a threshold level (usually floor level). The estimation of damage is based upon a flood level relative to the floor level of a property.

#### 7.1.2.1. Property Database

A property database was assembled as described in Section 3.3. The level of accuracy for the estimated floor heights is considered suitable for two reasons. Firstly, the estimation of property damage due to flooding is inherently difficult to estimate, given the large variation in building types, their contents, the duration of flooding and other factors, and so the accuracy of floor heights should be in line with the accuracy and applicability of the flood damage curves. Secondly, the economic damages assessment is only intended to be used as an estimate of the LGA-wide flood affectation and not on a per-property basis.

Flood levels were assigned to each property based on the modelled flood surface at the building. The database was used to determine the number and extent of properties inundated above protection level for the range of flood events modelled. No freeboard was included in these estimates.

#### 7.1.2.2. Residential Damage

Flood damage of residential buildings was calculated using a residential damage spreadsheet developed by the NSW Government in 2007. This includes a representative stage-damage curve derived for a typical house on a floodplain to estimate structural, contents and external damage. The amount of damage is based on the flood inundation depth for a given flood event. The AEP of the PMF event (primarily a function of the catchment size) was estimated to be 1 in $10^7$ for the purposes of damages assessment for these relatively small tributary catchments .

A number of input parameters are required to determine which stage-damage curve will be adopted. The key parameters used in this assessment are shown in Table 19.

Table 19: Parameters adopted for Residential Damages Assessment

| Parameter | Adopted Value | Comment |
|---|---|---|
| **Post Flood Inflation Factor** | 1.0 | Suggested range of 1.0 to 1.5 depending on the scale of impacts. Set to 1.0 to reflect that overland flow flooding in the tributary catchments is likely to be localised, and repairs would not significantly alter the demand for required trades in the region. |
| **Typical Duration of Immersion** | 2 hours | Short duration flooding. |
| **Building Damage Repair Limitation Factor** | 0.75 | Recommended for shorter periods of inundation (less than 12 hours). |
| **Contents Damage Repair Limitation Factor** | 0.75 | Recommended for shorter periods of inundation (less than 12 hours). |
| **Effective Warning Time (hrs)** | 0 | It is likely that no effective warning time would be given for residents for flash flooding. |
| **Level of flood awareness** | Low | Guidelines suggest ‘low’ is adopted unless ‘high’ can be justified. While flooding has been experienced in the catchments, it is assumed that the level of awareness of the extent of flooding for major flash flood events is low. |
| **House size** | 213m$^2$ | Based on a representative sample. |

The stage-damage curves within the NSW Government spreadsheet template are derived for late 2001, and have been updated using an Average Weekly Earnings (AWE) factor to November 2019. AWE is used to update residential flood damage curves rather than the inflation rate measured by the Consumer Price Index (CPI). A regional cost variation factor of 1.00 was applied for the Lake Macquarie region based on the value at Newcastle as presented in Rawlinson's Australian Construction Handbook (Reference 13). No damages were assumed to be incurred for the 1 EY event.

#### 7.1.2.3. Vehicle Damage

An estimation of vehicle damage has been excluded from this assessment. Significant damage can be attributed to vehicles, but these damages are difficult to quantify due to the mobility of the vehicles and the ability to remove them from the path of flood waters. The damages associated with vehicles can be highly variable depending on the time of day, flood warning times, and other factors. These may need to be considered for inclusion in the damages assessment if they are likely to affect assessment of flood mitigation measures for a subsequent Floodplain Risk Management Study and Plan.

### 7.1.3. Estimated Tangible Flood Damages

An estimation of the number of properties impacted (flooding occurring on the property up to the dwelling/building), number of properties with above floor flooding and total damage costs for each modelled flood event was undertaken. Residential external damages were assumed to start accumulating when floodwater is within 0.5m of the dwelling floor level for single storey buildings.

A typical measure used to estimate flood damages over a range of flood events is the Annual Average Damage (AAD). AAD represents the equivalent average damages that would be experienced by the community on an annual basis, by taking into account the probability of a flood occurrence over the long term. The AAD value is determined by multiplying the damages that can occur in a given flood by the probability of that flood actually occurring in a given year, and then summing across a range of floods. This method allows smaller floods, which occur more frequently to be given a greater weighting than the larger catastrophic floods that only occur rarely. The AAD for the existing case then provides a benchmark by which to assess the merit of flood management options.

A summary of the tangible flood damages for each of the study catchments is provided in Table 20. Dollar values are rounded to the nearest $1,000.

Table 20: Estimated Tangible Flood Damages for Each Catchment

Plains Gully Creek

| Event | No. Properties Affected | No. Flooded Above Floor Level | Total Damages for Event |
|---|---|---|---|
| **50%AEP** | 32 | 0 | $10,000 |
| **20% AEP** | 51 | 10 | $700,000 |
| **10% AEP** | 82 | 11 | $960,000 |
| **5% AEP** | 102 | 17 | $1,350,000 |
| **2% AEP** | 150 | 24 | $1,970,000 |
| **1% AEP** | 171 | 29 | $2,520,000 |
| **0.5% AEP** | 195 | 34 | $2,870,000 |
| **0.2% AEP** | 216 | 44 | $3,600,000 |
| **PMF** | 328 | 150 | $11,410,000 |
| **Average Annual Damages (AAD)** | | | $361,000 |

Sheppards Creek

| Event | No. Properties Affected | No. Flooded Above Floor Level | Total Damages for Event |
|---|---|---|---|
| **50%AEP** | 25 | 3 | $150,000 |
| **20% AEP** | 41 | 5 | $340,000 |
| **10% AEP** | 56 | 7 | $620,000 |
| **5% AEP** | 80 | 15 | $990,000 |
| **2% AEP** | 93 | 19 | $1,380,000 |
| **1% AEP** | 119 | 24 | $1,980,000 |
| **0.5% AEP** | 140 | 33 | $2,600,000 |
| **0.2% AEP** | 159 | 52 | $3,800,000 |
| **PMF** | 323 | 196 | $15,510,000 |
| **Average Annual Damages (AAD)** | | | $291,000 |

Muraban Creek

| Event | No. Properties Affected | No. Flooded Above Floor Level | Total Damages for Event |
|---|---|---|---|
| **50%AEP** | 83 | 9 | $1,090,000 |
| **20% AEP** | 148 | 15 | $1,760,000 |
| **10% AEP** | 181 | 23 | $2,370,000 |
| **5% AEP** | 224 | 34 | $3,200,000 |
| **2% AEP** | 247 | 42 | $4,290,000 |
| **1% AEP** | 274 | 55 | $5,240,000 |
| **0.5% AEP** | 283 | 62 | $6,130,000 |
| **0.2% AEP** | 300 | 84 | $7,390,000 |
| **PMF** | 389 | 213 | $17,530,000 |
| **Average Annual Damages (AAD)** | | | $1,277,000 |

Mills Gully Creek

| Event | No. Properties Affected | No. Flooded Above Floor Level | Total Damages for Event |
|---|---|---|---|
| **50%AEP** | 66 | 3 | $130,000 |
| **20% AEP** | 87 | 7 | $640,000 |
| **10% AEP** | 97 | 11 | $920,000 |
| **5% AEP** | 107 | 12 | $1,090,000 |

| Event | No. Properties Affected | No. Flooded Above Floor Level | Total Damages for Event |
|---|---|---|---|
| **2% AEP** | 119 | 15 | $1,290,000 |
| **1% AEP** | 124 | 18 | $1,590,000 |
| **0.5% AEP** | 129 | 25 | $1,910,000 |
| **0.2% AEP** | 140 | 32 | $2,510,000 |
| **PMF** | 198 | 97 | $7,580,000 |
| **Average Annual Damages (AAD)** | | | $354,000 |

Puntei Creek

| Event | No. Properties Affected | No. Flooded Above Floor Level | Total Damages for Event |
|---|---|---|---|
| **50%AEP** | 22 | 4 | $260,000 |
| **20% AEP** | 40 | 17 | $1,490,000 |
| **10% AEP** | 52 | 23 | $2,010,000 |
| **5% AEP** | 61 | 35 | $2,850,000 |
| **2% AEP** | 72 | 40 | $3,560,000 |
| **1% AEP** | 84 | 46 | $4,170,000 |
| **0.5% AEP** | 92 | 49 | $4,510,000 |
| **0.2% AEP** | 101 | 59 | $5,380,000 |
| **PMF** | 152 | 122 | $11,630,000 |
| **Average Annual Damages (AAD)** | | | $814,000 |

Fullers Creek and Freshwater Creek

| Event | No. Properties Affected | No. Flooded Above Floor Level | Total Damages for Event |
|---|---|---|---|
| **50%AEP** | 42 | 1 | $40,000 |
| **20% AEP** | 56 | 2 | $240,000 |
| **10% AEP** | 58 | 3 | $320,000 |
| **5% AEP** | 61 | 3 | $340,000 |
| **2% AEP** | 70 | 4 | $440,000 |
| **1% AEP** | 74 | 5 | $510,000 |
| **0.5% AEP** | 77 | 6 | $590,000 |
| **0.2% AEP** | 88 | 7 | $730,000 |
| **PMF** | 141 | 32 | $2,420,000 |
| **Average Annual Damages (AAD)** | | | $119,000 |

Postmistress Creek

| Event | No. Properties Affected | No. Flooded Above Floor Level | Total Damages for Event |
|---|---|---|---|
| **50%AEP** | 14 | 0 | $20,000 |
| **20% AEP** | 17 | 1 | $120,000 |
| **10% AEP** | 18 | 1 | $130,000 |
| **5% AEP** | 18 | 1 | $150,000 |
| **2% AEP** | 19 | 3 | $190,000 |
| **1% AEP** | 19 | 3 | $260,000 |
| **0.5% AEP** | 20 | 3 | $270,000 |
| **0.2% AEP** | 22 | 3 | $300,000 |
| **PMF** | 29 | 11 | $760,000 |
| **Average Annual Damages (AAD)** | | | $59,000 |

Mannering Creek, Swampy Creek and Wyee Creek

| Event | No. Properties Affected | No. Flooded Above Floor Level | Total Damages for Event |
|---|---|---|---|
| **50%AEP** | 3 | 0 | $0 |
| **20% AEP** | 10 | 5 | $390,000 |
| **10% AEP** | 15 | 10 | $810,000 |
| **5% AEP** | 17 | 13 | $1,020,000 |
| **2% AEP** | 21 | 18 | $1,580,000 |
| **1% AEP** | 21 | 19 | $1,710,000 |
| **0.5% AEP** | 24 | 19 | $1,770,000 |
| **0.2% AEP** | 25 | 22 | $1,960,000 |
| **PMF** | 55 | 52 | $5,110,000 |
| **Average Annual Damages (AAD)** | | | $240,000 |

### 7.1.4. Intangible Flood Damages

The intangible damages associated with flooding, by their nature, are inherently more difficult to estimate in monetary terms. In addition to the tangible damages discussed above, additional costs/damages are incurred by residents affected by flooding, such as stress, injury, loss of life, loss of sentimental items, etc. It is not possible to put monetary values on these intangible damages as they are likely to vary dramatically between each flood (from a negligible amount to significantly more than tangible damages) and depend on a range of factors such as size of flood, the individuals affected and community preparedness. However, it is still important that the consideration of intangible damages is included when assessing the impacts of flooding on a community.

Post flood damage surveys have linked flooding to stress, ill-health and trauma for residents. For example, the loss of memorabilia, pets, important documents and other items without fixed costs and of sentimental value may cause stress and subsequent ill-health. In addition, flooding may affect personal relationships and lead to stress in domestic and work situations. The actual flood event, resulting property damage, risk to life for the individuals or their family and the clean-up process can also add to the stress. In addition to the stress caused during an event, many residents who have experienced a major flood are fearful of the occurrence of another flood event and the associated damage and loss. The extent of stress depends on the individual and although the majority of flood victims recover, these effects can lead to a reduction in quality of life for the flood victims.

During any flood event, these is the potential for injury as well as loss of life due to causes such as drowning, floating debris or illness from polluted water. Generally, the higher the flood velocities and depths, the higher the risk. However, there will always be localised areas of high risk where flows may be concentrated around buildings or other structures within low hazard areas. The intangible damages for the study area catchments may be substantial, due to the lack of warning time for a typical flood event.

### 7.1.5. Damages Summary

A summary of the tangible AAD for each catchment is provided in Table 21.

Table 21: Summary of Tangible AAD for All Catchments

| Catchment | Average Annual Damages (AAD) |
|---|---|
| Plains Gully | $361,000 |
| Sheppards | $291,000 |
| Muraban | $1,277,000 |
| Mills Gully | $354,000 |
| Puntei | $814,000 |
| Fullers and Freshwater | $119,000 |
| Postmistress | $59,000 |
| Mannering/Swampy/Wyee | $240,000 |

While flood damage estimates are indicative only, they are useful in the evaluation of flood management options, aimed at reducing flood damage estimates while being economically viable to implement. It is recommended that these flood damage estimates be considered in the prioritisation of resources for investigating flood risk mitigation in the various catchments.

## 7.2. Summary of Property Subject to Inundation

A summary of the locations in each catchment with substantial concentration of flood-prone property is provided in Table 22. This summary is intended to identify the most at-risk areas, and is not a comprehensive list of every property in the study areas subject to flooding.

Table 22: Summary of Property Inundation "Hot Spots"

| Catchment | Description |
|---|---|
| **Plains Gully** | The most at-risk properties are those near the sag point at the intersection of Macquarie Grove and Martha Street, as well as the end of Farrington Close. Properties in these areas may be subject to over-floor inundation in approximately a 20% to 5% AEP event.<br><br>Properties in the lower part of the catchment around Bowman Street, Peggy Street, Gray Street and Northcote Avenue are affected by shallow overland flow for a range of flood magnitudes, and may be subject to above floor inundation in a 1% AEP event. These lower catchment areas will be particularly susceptible to increased flood risk from sea level rise in the future. |
| **Sheppards** | The principal areas of property flood risk in this catchment are:<br>• Adjacent to the main creek channel between Macquarie Drive and Croudace Bay,<br>• Along Shaw Street between Winston Street and Macquarie Drive, and<br>• Properties between Regal Way and Sheppards Creek at the bottom of Ruston Avenue.<br><br>Properties in these areas are potentially subject to above floor inundation in a 10% AEP event. In larger events the number of properties susceptible to inundation in these areas increases. Properties on Squire Close would potentially be subject to significant damage if the embankment of the detention basin immediately upstream was to fail during a flood event. |
| **Muraban** | The Muraban Creek catchment has the highest concentration of potential flood damages out of the catchments assessed in this study. The catchment is highly urbanised and the creeks have been contained either within pipes/overland flowpaths or relatively narrow concrete-lined channels. There are large areas of development potentially subject to inundation in relatively frequent events (i.e. around 10% AEP), including:<br>• Industrial/commercial areas between Cobbin Parade and Patrick Street,<br>• Residences on Patrick Street and Vincent Street,<br>• Residences between Park Street and Bell Street adjacent to the channel,<br>• Residences at the bottom of Griffiths Avenue<br>• Residences on Bell Street and Maxwell Avenue downstream of the Floraville Road detention basin, and<br>• Industrial/commercial premises on the Pacific Highway between York Street and Muraban Creek.<br><br>In larger events the number of properties susceptible to inundation in these areas increases. Properties downstream of the Floraville Road detention basin would potentially be subject to significant damage if the embankment of the detention basin |

| Catchment | Description |
|---|---|
| | was to fail during a flood event. |
| **Mills Gully** | Mills Gully Creek is sharply incised within the hillside and has a narrow floodplain, with relatively few properties at risk of inundation. The properties adjacent to the creek generally slope down from the street, with the buildings placed well above the flood extents. The most notable flood risk to property in this catchment is the Belmont 16-foot Sailing Club, which has been constructed over the top of the creek at the bottom of the catchment. Flooding of the car park and possibly the buildings can be expected to occur relatively frequently. |
| **Puntei** | Puntei Creek has similar characteristics to Mills Gully in the upper catchment areas, but in the mid- to lower-catchment there are a significant number of properties subject to flooding. Overland flow will occur through properties on Jarrett Street between the creek and Oakhampton Circuit when the capacity of the Jarrett Street culverts is exceeded, as the low point in the road crest is not aligned with the creek. Water that overtops the road will flow through these properties and return to the open grass swale further downstream.<br><br>The commercial/industrial properties on Excelsior Parade that back onto the creek are low lying and will experience relatively frequent overland flow inundation, with above floor inundation likely in a 1% AEP event.<br><br>Some of the residential properties in the lowest part of the catchment, bounded by Ambrose Street, Excelsior Parade and Laycock Street are below 1.5 mAHD, and will be affected by both Lake Macquarie flooding and local catchment flooding. Some of these properties will be inundated above floor level more frequently than a 10% AEP event. Flood risks for these properties will be exacerbated even further by Sea Level Rise, and may no longer be habitable with a rise of more than 0.5 m of the average lake level. |
| **Fullers / Freshwater** | Fullers Creek has a relatively small catchment area, and a low level of urbanisation. Flooding in this catchment is generally confined to the creek up to the 1% AEP event.<br><br>Freshwater Creek does not have a well-defined channel upstream of Station Street, and properties towards the bottom of St Clair Street or on Station Street near the creek are relatively low lying compared to the creek levels. Several properties in this areas will experience shallow overland flow in events more frequent than 10% AEP, with above floor inundation for a few properties. In larger events the number of properties susceptible to inundation in these areas increases, as well as additional properties in the lower parts of Amos Street and Macquarie Street. |
| **Postmistress Creek** | Postmistress Creek is sharply incised in a valley between Cessnock Road and Hillcrest Road, and flood risks are localised around the bottom of the catchment where the creek crosses Waterside Drive. Shallow overland flow is expected through properties on Waterside Drive and Norman Avenue in events up to the 10% AEP, with above floor flood affection for a few properties in larger events up to the 1% AEP. Sea level rise will significantly exacerbate the flood risk in this area. |
| **Mannering / Swampy / Wyee** | The lower part of this catchment is dominated by Mannering Bay wetland, the Vales Point Power Station and the associated collieries and dams. There appears to be no significant development at risk in this lower catchment area.<br><br>Further upstream, the land use remains largely rural or large-lot residential, and |

| Catchment | Description |
|---|---|
| | buildings are generally located above the 1% AEP flood extent. Some properties at the bottom of Jilliby Street and Gorokan Road are susceptible to flooding from Mannering Creek, possibly above floor level in a 1% AEP event.<br><br>Information about the flood risks and consequences of failure of the Wyee Dam (Mannering Lake) were not available to WMAwater during this study. Given the size of this lake and dam, properties along the Wyee Channel between Tuggerah Street and Rodgers Road may be subject to dramatically increased flood risk in the event of failure/collapse of the dam embankment during a flood event. |

## 7.3. Community and Emergency Facilities

A summary of community facilities affected either directly or indirectly by flooding is summarised in Table 23.

Table 23: Summary of Flood Prone Community Facilities

| Catchment | Facility | Description of Flood Affectation |
|---|---|---|
| **Plains Gully** | Swansea High School | Plains Gully Creek flows through the high school grounds, and reasonably frequent flooding can be expected, although the buildings are generally placed outside the 1% AEP extents. Risks to life, property or disruption to school activities are relatively low for all events modelled except the PMF, and evacuation would not generally be required in a flood event. The primary risk would be in the scenario of failure of the detention basin embankment upstream during a flood. |
| **Sheppards** | Valentine / Eleebana sports fields and Valentine Bowling Club | These facilities are affected by low hazard inundation in the 1% AEP event, and high hazard inundation in a PMF event. Evacuation is unlikely to be required, even in a PMF event, as there is either rising access or a suitable on-site refuge. |
| **Mills Gully** | Belmont 16-foot Sailing Club | This facility has been constructed over the top of the creek at the bottom of the catchment. Flooding of the car park and possibly the buildings can be expected to occur relatively frequently, with very high hazard flows (H5) across the car park and entrance in a 1% AEP event. Due to the siting of the building, it is likely that patrons will be trapped in the club building during a flood event due to the lack of any warning time. If the event escalates to a PMF level, occupants will likely be surrounding by extreme hazard flow (H6) that would potentially put the structural integrity of the building at risk. |
| **Puntei** | Carey Bay Dog Exercise Area | This area is subject to low hazard flooding in the 1% AEP, escalating to high hazard in the PMF. A combination of rising access and unpopularity for use during intense rain means risks to life are low. |
| **Puntei** | Paradise Palms Caravan Park | This facility is subject to low hazard flooding (H3 and below) in a 1% AEP event, escalating to high hazard (H4) during a PMF event. Rising egress is available from most locations in the site, so evacuation on foot will be feasible for mobile occupants. Occupants with limited mobility will be vulnerable to being trapped in hazardous flow in a PMF |

| Catchment | Facility | Description of Flood Affectation |
|---|---|---|
| | | event. |
| **Fullers and Freshwater** | Lakeside Retirement Village | This facility is located between Fullers and Freshwater Creek, and has generally been filled above the 1% AEP flood level. Risks to life and property are low up to the 1% AEP level. In a PMF event, some of the internal roads are subject to high hazard overland flow, primarily due to the velocity rather than depth of flow. The buildings are not subject to high hazard flow, even in a PMF event, and evacuation is unlikely to be required during a flood event except in the case of medical emergency. |

## 7.4. Inundation of Key Road Crossings

A summary of the overtopping depth at selected key road crossings is provided in Table 24. A positive value in the table indicates the road is inundated, and a negative value indicates the depth of the water level below the road crest on the upstream side of the road. Depths greater than 0.5 m are highlighted in red text to indicate a relatively high hazard level (H3 and above) for vehicles and pedestrians who attempt to traverse the floodwaters. Overtopping depths between 0.3 m and 0.5 m indicate at least moderate hazard (H2) to small vehicles and some vulnerable pedestrians.

Most of the reported locations are inundated by at least moderate hazard depth in a 5% AEP event. It is likely that during storms with rainfall intensity of 10% AEP or rarer for up to 2 hour duration would result in widespread disruption of access routes throughout the region.

The most notable areas of risk, where there are relatively high hazard levels in relatively frequent flood events, are:

- the Gorokan Road rail underpass in Wyee (although alternative access is available in the opposite direction via Gosford Road),
- Macquarie Grove at Caves Beach, where there is a trapped sag point where water can pond to significant depth but will not be fast flowing,
- Parklea Avenue in Sheppards Creek (alternative access via Tingira Drive), and
- Ross St near Evans Street in Mills Gully Creek.

Of these higher risk areas, the lower parts of Mills Gully Creek around the Belmont 16-foot sailing club and Macquarie Grove in Belmont appear to be the most likely locations where swift water rescue response may be required as a result of motorists attempting to traverse flooded roads.

Table 24: Road overtopping depths at key locations

Mannering Creek, Swampy Creek and Wyee Creek

| ID (Figure 15) | Location | Road Crest Level (m AHD) | Peak flood depth to crest (m) - Negative indicates road is not overtopped | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | 50% | 20% | 10% | 5% | 2% | 1% | 0.5% | 0.2% | PMF |
| 1 | Wyee Road South | 18.35 | - | 0.02 | 0.09 | 0.13 | 0.20 | 0.32 | 0.39 | 0.50 | 1.10 |
| 2 | Gorokan Road | 15.75 | 2.24 | 2.68 | 2.77 | 2.83 | 2.95 | 3.15 | 3.27 | 3.47 | 4.66 |
| 3 | Pacific Motorway North | 20.20 | -3.45 | -3.00 | -2.57 | -2.33 | -1.91 | -1.63 | -1.41 | -1.07 | 0.66 |
| 4 | Pacific Motorway South | 29.00 | - | -1.66 | -1.11 | -0.60 | 0.15 | 0.28 | 0.38 | 0.47 | 0.96 |
| 5 | Wyee Road | 11.70 | -1.44 | -1.19 | -0.90 | -0.71 | -0.38 | -0.18 | 0.00 | 0.11 | 0.34 |
| 6 | Wyee Road North | 13.60 | -0.59 | -0.07 | 0.11 | 0.16 | 0.24 | 0.28 | 0.30 | 0.34 | 0.80 |
| 7 | Access Road | 21.45 | 0.23 | 0.33 | 0.38 | 0.43 | 0.59 | 0.71 | 0.79 | 0.88 | 1.61 |
| 8 | Ruttleys Road | 1.90 | -0.83 | -0.60 | -0.38 | -0.13 | 0.30 | 0.46 | 0.53 | 0.60 | 1.05 |
| 16 | Railway bridge | 11.50 | -3.07 | -2.68 | -2.34 | -2.09 | -1.82 | -1.67 | -1.57 | -1.45 | -0.26 |

Plains Gully Creek

| | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 9 | Silky Oak road near Palm Tree Crescent | 18.20 | 0.08 | 0.15 | 0.20 | 0.23 | 0.28 | 0.30 | 0.32 | 0.35 | 0.54 |
| 10 | Park Avenue | 3.97 | -1.08 | -1.06 | -0.84 | -0.64 | -0.38 | -0.17 | -0.03 | 0.15 | 0.70 |
| 11 | Macquarie Grove | 3.15 | 0.70 | 1.03 | 1.11 | 1.16 | 1.24 | 1.27 | 1.30 | 1.34 | 1.70 |
| 12 | Northcote Avenue | 1.26 | 0.19 | 0.28 | 0.28 | 0.30 | 0.34 | 0.36 | 0.37 | 0.39 | 0.61 |
| 13 | Strathmore Road | 2.60 | -0.38 | 0.12 | 0.26 | 0.37 | 0.50 | 0.59 | 0.66 | 0.75 | 1.38 |
| 14 | Bowman Street | 1.42 | -0.54 | -0.42 | -0.28 | -0.15 | -0.03 | 0.09 | 0.15 | 0.21 | 0.55 |
| 15 | Gray Street | 1.25 | -0.08 | 0.13 | 0.24 | 0.30 | 0.36 | 0.41 | 0.44 | 0.49 | 0.80 |

Fullers Creek and Freshwater Creek

| | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 17 | Marconi Road | 3.17 | -0.28 | 0.32 | 0.39 | 0.45 | 0.52 | 0.57 | 0.62 | 0.67 | 1.07 |
| 18 | Station Street | 4.25 | -0.35 | 0.07 | 0.13 | 0.17 | 0.21 | 0.24 | 0.28 | 0.32 | 0.63 |
| 19 | Fishery Point Road | 31.00 | -0.03 | 0.11 | 0.10 | 0.11 | 0.12 | 0.13 | 0.13 | 0.16 | 0.25 |

Postmistress Creek

| ID (Figure 15) | Location | Road Crest Level (m AHD) | Peak flood depth to crest (m) - Negative indicates road is not overtopped | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | 50% | 20% | 10% | 5% | 2% | 1% | 0.5% | 0.2% | PMF |
| 20 | Waterside Avenue | 1.30 | -0.44 | -0.29 | -0.18 | -0.08 | 0.00 | 0.06 | 0.11 | 0.17 | 0.55 |
| Puntei Creek | | | | | | | | | | | |
| 21 | Jarrett Street | 5.66 | -0.10 | 0.18 | 0.27 | 0.33 | 0.44 | 0.51 | 0.56 | 0.64 | 1.17 |
| 22 | Excelsior Parade | 1.45 | -0.05 | 0.06 | 0.11 | 0.17 | 0.24 | 0.35 | 0.43 | 0.56 | 1.24 |
| Sheppards Creek | | | | | | | | | | | |
| 23 | Macquarie Drive | 2.80 | 0.12 | 0.15 | 0.16 | 0.18 | 0.20 | 0.22 | 0.23 | 0.27 | 0.57 |
| 24 | Croudace Bay Road | 2.95 | -2.01 | -1.70 | -1.48 | -1.24 | -0.89 | -0.51 | -0.29 | 0.11 | 1.37 |
| 25 | Crossing of Regal Way and Ruston Ave | 3.50 | 0.30 | 0.33 | 0.36 | 0.38 | 0.42 | 0.50 | 0.56 | 0.66 | 1.69 |
| 26 | Tingira Drive | 33.80 | -0.49 | -0.01 | 0.22 | 0.35 | 0.41 | 0.46 | 0.50 | 0.54 | 0.86 |
| 27 | Parklea Avenue | 19.20 | 1.12 | 1.50 | 1.71 | 2.22 | 2.41 | 2.56 | 2.65 | 2.77 | 3.47 |
| Muraban Creek | | | | | | | | | | | |
| 28 | Pacific Highway near Wommara Avenue | 11.36 | 0.24 | 0.36 | 0.42 | 0.47 | 0.51 | 0.54 | 0.56 | 0.60 | 0.79 |
| 29 | Patrick street | 9.00 | -0.33 | -0.09 | 0.00 | 0.03 | 0.07 | 0.12 | 0.17 | 0.24 | 1.04 |
| 30 | Vincent street | 10.10 | -0.21 | 0.22 | 0.28 | 0.33 | 0.37 | 0.43 | 0.50 | 0.59 | 0.85 |
| 31 | Pacific Highway near warehouse district | 9.75 | 0.11 | 0.14 | 0.16 | 0.18 | 0.20 | 0.22 | 0.24 | 0.26 | 0.48 |
| 32 | Park Street | 14.63 | -0.32 | 0.11 | 0.22 | 0.30 | 0.37 | 0.44 | 0.50 | 0.60 | 1.14 |
| 33 | Nyanda Avenue | 54.25 | 0.18 | 0.31 | 0.35 | 0.38 | 0.42 | 0.46 | 0.48 | 0.51 | 0.70 |
| 34 | Park Royal Drive | 26.85 | 0.20 | 0.28 | 0.33 | 0.37 | 0.41 | 0.45 | 0.48 | 0.51 | 0.75 |
| Mills Gully Creek | | | | | | | | | | | |
| 35 | Spinnaker Ridge Way | 20.10 | 0.24 | 0.34 | 0.41 | 0.45 | 0.48 | 0.52 | 0.54 | 0.59 | 0.89 |
| 36 | Croudace Bay Road | 7.50 | -0.67 | 0.25 | 0.31 | 0.37 | 0.45 | 0.51 | 0.55 | 0.61 | 1.06 |
| 37 | Ross Street near Evans Street | 3.15 | 0.74 | 0.92 | 0.97 | 1.04 | 1.12 | 1.18 | 1.23 | 1.29 | 1.60 |

## 7.5. Flood Emergency Management Considerations

It is necessary to consider questions of flood access, evacuation and flood readiness, which are relevant to the SES as part of the organisation's oversight of emergency preparedness, response and recovery in NSW.

The flood risk is of the form colloquially known as "flash flooding" for each of the catchments investigated in this study. This includes urban overland flow along roadways, when rainfall exceeds the capacity of the local stormwater network, as well as rapidly rising channelized flow in either natural creeks or engineered waterways. Flooding will generally occur quite quickly in response to very heavy rain. Generally the most effective way to mitigate flood risk to human life in this environment is to ensure that buildings are built to withstand flood forces to enable people to remain indoors during the intense storm events, and to discourage people from attempting to drive through floodwaters. This is best achieved by effective siting and design of buildings to ensure they remain flood free without requiring active measures such as the deployment of barriers or flood gates, so that people can remain on site until flooding has subsided. Since flooding around the buildings will be of short duration (typically minutes rather than hours for the flood peak to pass), the risks arising from isolation during flooding are relatively low.

Discussion is provided below about emergency management and evacuation considerations for the study area catchments.

### 7.5.1. Existing Flood Warnings

The Bureau of Meteorology issues quantitative flood warnings for specified forecast locations including expected flood class (major, moderate, minor) and timing of flooding. The Bureau does not provide quantitative flash-flood warnings, defined as rain-to-flood times of less than six hours. The response times for all of the study area catchments is less than six hours, and as such The Bureau does not issue quantitative warnings for these catchment.

The Bureau of Meteorology issues severe weather warnings whenever severe weather is occurring in an area or expected to develop or move into an area. This includes very heavy rain that may lead to flash flooding. The warnings describe the area under threat and the expected hazards. Warnings are issued with varying lead-times, depending on the weather situation, and can be from one hour to a day or more. The Bureau also issues severe thunderstorm warnings that include the locations of thunderstorms producing heavy rainfall which may cause flash flooding.

### 7.5.2. Preparedness and Response

The SES is the legislated Combat Agency for floods and is responsible for the control of flood operations. This includes the coordination of other agencies and organisations for flood management tasks. The SES Local Controller is responsible for dealing with floods as detailed in the State Flood Plan.

Given the flash flood nature of the catchments and the lack of warning time for flooding, as well

as the distance to each of the catchments from the relevant SES headquarters and access issues along the roads, the SES is unlikely to mobilise volunteers to any of these catchments in anticipation of flooding. The SES will generally only respond to specific calls for assistance in flash flood areas.

It will not be possible in real time during a flood to understand what the peak of the flood will be for the catchments. This is because:

- The time between the rainfall occurring and flooding occurring is short (generally less than an hour, and possibly as short as 15 minutes for local flash flooding in the road reserves);
- The location of the most intense rainfall bursts for flood-producing storms in small catchments such as this cannot be predicted accurately ahead of time; and
- As a result of the above, there are no formal flood warning systems in place for the catchments.

There will likely be very little warning of flooding, apart from very heavy local rainfall. General warnings about severe storms will be available for the Sydney Metropolitan region provided by the Bureau of Meteorology (BoM) but these will not provide specific information for these catchments. Generally across each of the study area catchments, existing buildings are not subject to high hazard flow even in a PMF event. The only exceptions to this are the Belmont 16-foot sailing club, and possibly the Valentine Bowling Club (both discussed in more detail in Section 7.3).

Apart from these locations, risk to life during floods will be low if people remain inside buildings while flooding is occurring, and avoid driving through floodwaters if they are in vehicles.

## 7.6. Advice on Land-Use Planning Considering Flooding

The NSW flood prone land policy permits land use and development on flood prone land, provided it is compatible with the nature of flooding in a particular area. For example, it is wise to limit use and development of land that is classified as floodway, since these are areas of conveyance and not only pose significant risks to humans, but any development in these areas can shift flood risks to other areas.

Lake Macquarie City Council implements flood-related planning controls via the Local Environment Plan (LEP) and Development Control Plan (DCP). The LEP specifies that land is subject to flood-related restrictions on development if it is

- shown as “Flood planning area” on the Flood Planning Map [in the LEP], or
- other land at or below the flood planning level [defined in the LEP to be the 1% AEP flood level plus 0.5 m freeboard].

The LEP outlines the nature of these restrictions, and more detailed requirements are specified in the DCP for different land uses. The LEP and DCP refer to mapping outputs that have been produced as part of this and other flood studies undertaken for Council.

This is a typical approach for consideration of flooding in land use planning, although WMAwater recommends that Council consider the following refinements:

- The time required to modify mapping in the LEP is significant, due to the consultation and exhibition requirements, and the approval requirements from state government departments. This means that the flood maps in the LEP will sometimes not reflect studies that have been recently undertaken. Council should therefore consider revising the LEP so that mapping of the Flood Planning Area (FPA) is either provided in the DCP, or via some other method (for example by referring to a mapped Flood Planning Area from any flood study adopted by Council). The preliminary FPA is provided in Figure 42 of the relevant appendix for each catchment.
- Flooding in the catchments assessed in this study comprises both mainstream (relatively deep and fast flowing) and overland (generally shallow flow but can be fast flowing) flooding. This is slightly different to previous flood studies undertaken by Council which have focused either on lake flooding or major creek flooding (such as Dora Creek or Cockle Creek). Many Councils develop different or modified controls for these different flooding regimes. For example, with shallow overland flow depth inundation a 0.5m freeboard may be considered too severe if such a level is well above the PMF level for the property. Overland flow is also more affected by local structures, such as fencing, than mainstream flooding where generally the majority of flow follows a well-defined path. Consideration might be given to having development controls that address these local issues with new development applications. These considerations will need to extend to other flood-prone areas of the LGA.

In urban areas with a short critical duration (say <2 hours) the safe evacuation of residents either before or during a flood is not possible and can present a greater risk than remaining in the house / building. Flooding in the overland flow parts of the study area may occur rapidly with no effective and reliable warning. Thus the flood is upon residents before they are aware of the problem (it could occur at night). All new buildings placed within flood extents should therefore be designed to be structurally sound (certified by a structural engineer) during a flood up to 0.5m above the 1% AEP and with a floor at that level. Residents will therefore be able to shelter in place until the flood passes (<1 hour). In a life threatening emergency residents should call the SES or police for rescue rather than attempt to drive or walk through floodwaters.

It is also recommended that Council consider provisions in the LEP to allow imposition of flood planning controls above the 1% AEP level for vulnerable or critical uses. For example, the Gosford LEP has a typical Flood Planning clause (7.2) applying to land below the “Flood Planning Area,” defined as the 1% AEP flood level plus 0.5m freeboard, but contains an additional clause as follows to address evacuation and emergency response (i.e. risks to life) up to the PMF. An example clause is provided below.

*7.3 Floodplain risk management*

*(1) The objectives of this clause are as follows—*

*(a) in relation to development with particular evacuation or emergency response issues, to enable evacuation of land subject to flooding in events exceeding the flood planning level,*

*(b) to protect the operational capacity of emergency response facilities and critical infrastructure during extreme flood events.*

*(1)* ***This clause applies to land between the flood planning level and the level of a***

***probable maximum flood**,*

*(2) Development consent must not be granted to development for the following purposes on land to which this clause applies unless the consent authority is satisfied that the development will not, in flood events exceeding the flood planning level, affect the safe occupation of, and evacuation from, the land—*

*(a) caravan parks,*

*(b) correctional facilities,*

*(c) emergency services facilities,*

*(d) group homes,*

*(e) hospitals,*

*(f) residential care facilities,*

*(g) tourist and visitor accommodation,*

*(h) critical community infrastructure.*

*(3) A word or expression used in this clause has the same meaning as it has in the Floodplain Development Manual (ISBN 0 7347 5476 0) published by the NSW Government in April 2005, unless it is otherwise defined in this clause.*

# 8. CLIMATE CHANGE

## 8.1. Background

The 2005 Floodplain Development Manual (Reference 1) requires that Flood Studies consider the impacts of climate change on flood behaviour.

Since the 1980s current best practice for considering the impacts of climate change (ocean level rise and rainfall increase) has been evolving rapidly. In October 2009 the NSW Government issued its *Policy Statement on Sea Level Rise* (Reference 14) which states: "*Over the period 1870-2001, global sea levels rose by 20 cm, with a current global average rate of increase approximately twice the historical average. Sea levels are expected to continue rising throughout the twenty-first century and there is no scientific evidence to suggest that sea levels will stop rising beyond 2100 or that the current trends will be reversed.*

*Sea level rise is an incremental process and will have medium to long-term impacts. The best national and international projections of sea level rise along the NSW coast are for a rise relative to 1990 mean sea levels of 40 cm by 2050 and 90 cm by 2100. However, the 4th Intergovernmental Panel on Climate Change in 2007 also acknowledged that higher rates of sea level rise are possible*".

In November 2009 the NSW State Government Department of Environment, Climate Change and Water exhibited the following:

- Draft Flood Risk Management Guide: Incorporating sea level rise benchmarks in flood risk assessments,
- Draft Coastal Risk Management Guide: Incorporating sea level rise benchmarks in coastal risk assessments,

The Department of Planning also exhibited the Draft NSW Coastal Planning Guideline: Adapting to Sea Level Rise. In August 2010 the NSW State Government Department of Environment, Climate Change and Water issued the following:

- Flood Risk Management Guide (Reference 15): Incorporating sea level rise benchmarks in flood risk assessments.

In addition an accompanying document *Derivation of the NSW Government's sea level rise planning benchmarks* (Reference 16) provided technical details on how the sea level rise assessment was undertaken.

In October 2012 the NSW Government advised that the 2009 Sea Level Rise Policy was now not NSW Government policy and Councils should rely upon their own sea level rise projections.

The Lake Macquarie Waterway Flood Risk Management Study (Reference 17) and Coastal Zone Hazards and Risk Assessment applied the best advice from international, national and state scientific organisations that sea levels on the east coast of Australia will rise by approximately 0.9 metres by about the year 2100.

Since these studies were completed the IPCC, BoM and CSIRO have completed a new assessment, including projected ice melt in their modelling. Lake Macquarie City Council reviewed the new levels in 2015 and resolved to continue using 0.9 metres, as it is reasonably close to the most recent reports and changing the planning levels too often would be unhelpful for owners, builders, developers and planners. Planning levels will be reviewed again when there is new scientific advice, or there is a change in government policy.

As a result of the information provided in the above and other documents, and to keep up-to-date with current best practice, this present study incorporates an assessment of climate change. However, it should be noted that climate change due to man-made or natural processes will still occur beyond the 2100 estimate.

There is currently no formal NSW Government Policy on increases in rainfall intensity due to climate change, and typical practice is to consider the sensitivity of changes of flood behaviour for rainfall increases in the order of 10% to 30%, consistent with Reference 18.

## 8.2. Sea Level Rise Results

Sea level rise was investigated for each study area, except Muraban Creek which is above sea level rise influence, with the results provided for each study area in their respective Appendix on Figures 35, 36 and 40, 41. The sea level rise scenarios incorporated an increase of 0.4 m and 0.9 m to the assumed tailwater levels.

## 8.3. Rainfall Increase Results

The Bureau of Meteorology has indicated that there is no intention at present to revise design rainfalls to take account of the impact of climate change, as the implications of temperature changes on extreme rainfall intensities are presently unclear, and there is uncertainty about whether the changes would in fact increase runoff for major flood producing storms.

Any increase in design flood rainfall intensities will increase the frequency, depth and extent of inundation across the catchment. It has also been suggested that the cyclone belt may move further southwards.

Projected increases to evaporation are also an important consideration because increased evaporation would lead to generally drier catchment conditions, resulting in lower runoff from rainfall. Mean annual rainfall is projected to decrease, which will also result in generally drier catchment conditions. This is a relatively minor consideration for the study area catchments which are urbanised and where initial rainfall losses are less relevant to flood behaviour.

It will be necessary to monitor updates in climate science and advice from the Bureau of Meteorology.

A comparison between the design rainfalls depths (for the critical 90 minute duration) at the Plains Gully Creek catchment is provided in Table 25.

Table 25: Comparison of different AEP design rainfalls to 1% AEP (Plains Gully catchment)

| Event | Percentage relative to 1% AEP |
|---|---|
| 0.2% AEP | 134% |
| 0.5% AEP | 113% |
| 2% AEP | 87% |
| 5% AEP | 70% |
| 10% AEP | 59% |
| 50% AEP | 48% |

The effect of rainfall intensity increase can be estimated by comparing the peak levels results from the 0.5% and 0.2% AEP events and the existing 1% AEP peak levels and results are provided for each study area in the respective Appendix on Figures 34 and 35. These comparisons reflect an increase of 13% and 34% to current climate rainfall intensities respectively, and serve as an approximate indication of the potential changes in flood affectation that may result from changes to rainfall climate in the next 30 to 70 years.

# 9. ACKNOWLEDGEMENTS

Lake Macquarie City Council has prepared this document with financial assistance from the NSW Government through its Floodplain Management Program. This document does not necessarily represent the opinions of the NSW Government or the Department of Planning, Industry and Environment. The assistance of the following in providing data and guidance to the study is gratefully acknowledged:

- Lake Macquarie City Council;
- NSW Government or the Department of Planning, Industry and Environment;
- Bureau of Meteorology;
- Hunter Water;
- Residents of the study areas of the eight catchments.

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# Figures

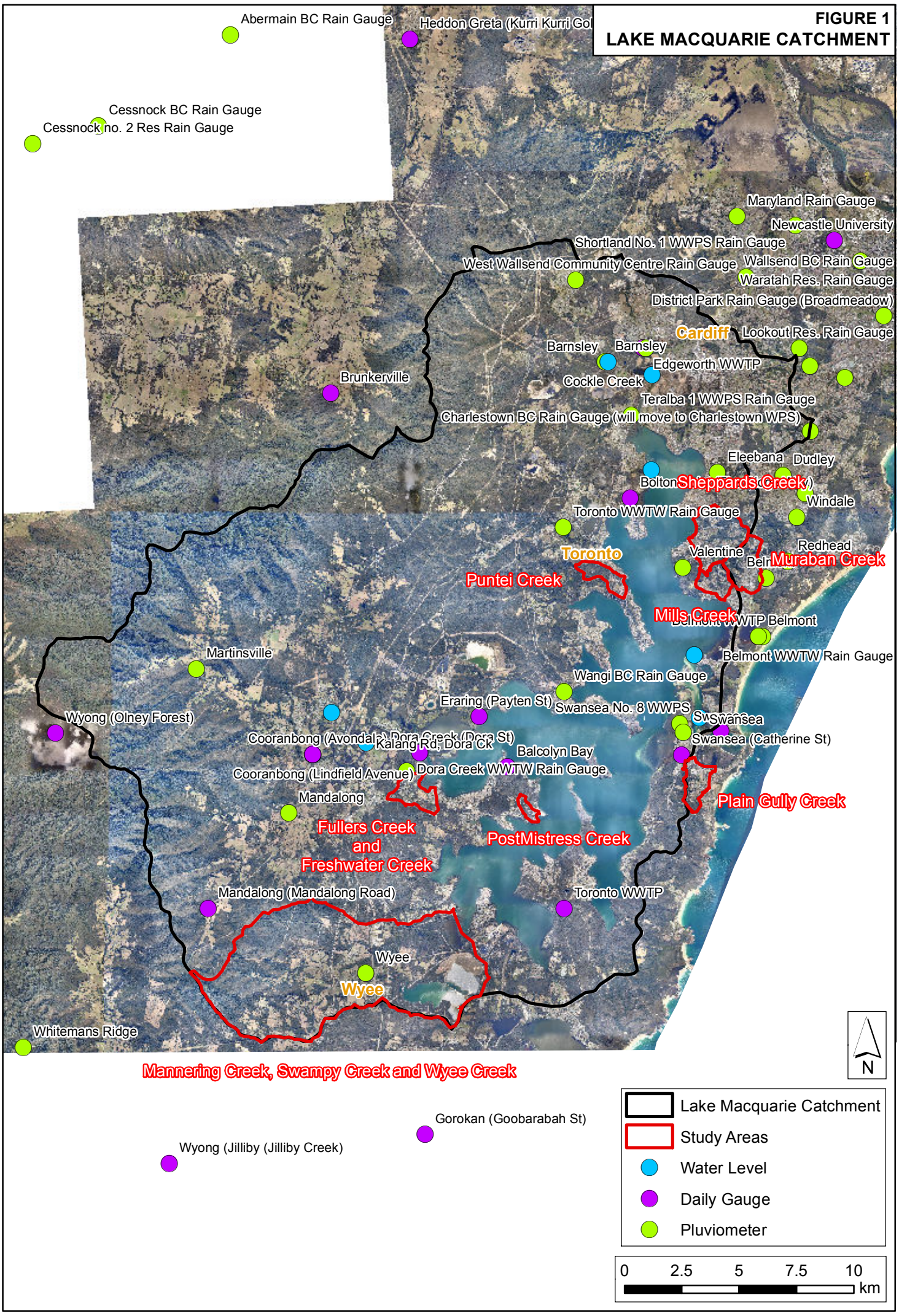
FIGURE 1
LAKE MACQUARIE CATCHMENT
Abermain BC Rain Gauge
Heddon Greta (Kurri Kurri Gol
Cessnock BC Rain Gauge
Cessnock no. 2 Res Rain Gauge
Maryland Rain Gauge
Newcastle University
Shortland No. 1 WWPS Rain Gauge
West Wallsend Community Centre Rain Gauge
Wallsend BC Rain Gauge
Waratah Res. Rain Gauge
District Park Rain Gauge (Broadmeadow)
Cardiff
Lookout Res. Rain Gauge
Barnsley
Barnsley
Edgeworth WWTP
Brunkerville
Cockle Creek
Teralba 1 WWPS Rain Gauge
Charlestown BC Rain Gauge (will move to Charlestown WPS)
Eleebana
Dudley
Bolton
Sheppards Creek
Windale
Toronto WWTW Rain Gauge
Toronto
Valentine
Redhead
Muraban Creek
Puntei Creek
Mills Creek
Belmont WWTP Belmont
Martinsville
Belmont WWTW Rain Gauge
Wangi BC Rain Gauge
Eraring (Payten St)
Swansea No. 8 WWPS
Wyong (Olney Forest)
Swansea
Cooranbong (Avondale) Dora Creek (Dora St)
Kalang Rd, Dora Ck
Swansea (Catherine St)
Balcolyn Bay
Cooranbong (Lindfield Avenue)
Dora Creek WWTW Rain Gauge
Plain Gully Creek
Mandalong
Fullers Creek
and
Freshwater Creek
PostMistress Creek
Mandalong (Mandalong Road)
Toronto WWTP
Wyee
Wyee
Whitemans Ridge
Mannering Creek, Swampy Creek and Wyee Creek
Gorokan (Goobarabah St)
Wyong (Jilliby (Jilliby Creek)
N
Lake Macquarie Catchment
Study Areas
Water Level
Daily Gauge
Pluviometer
0
2.5
5
7.5
10
km
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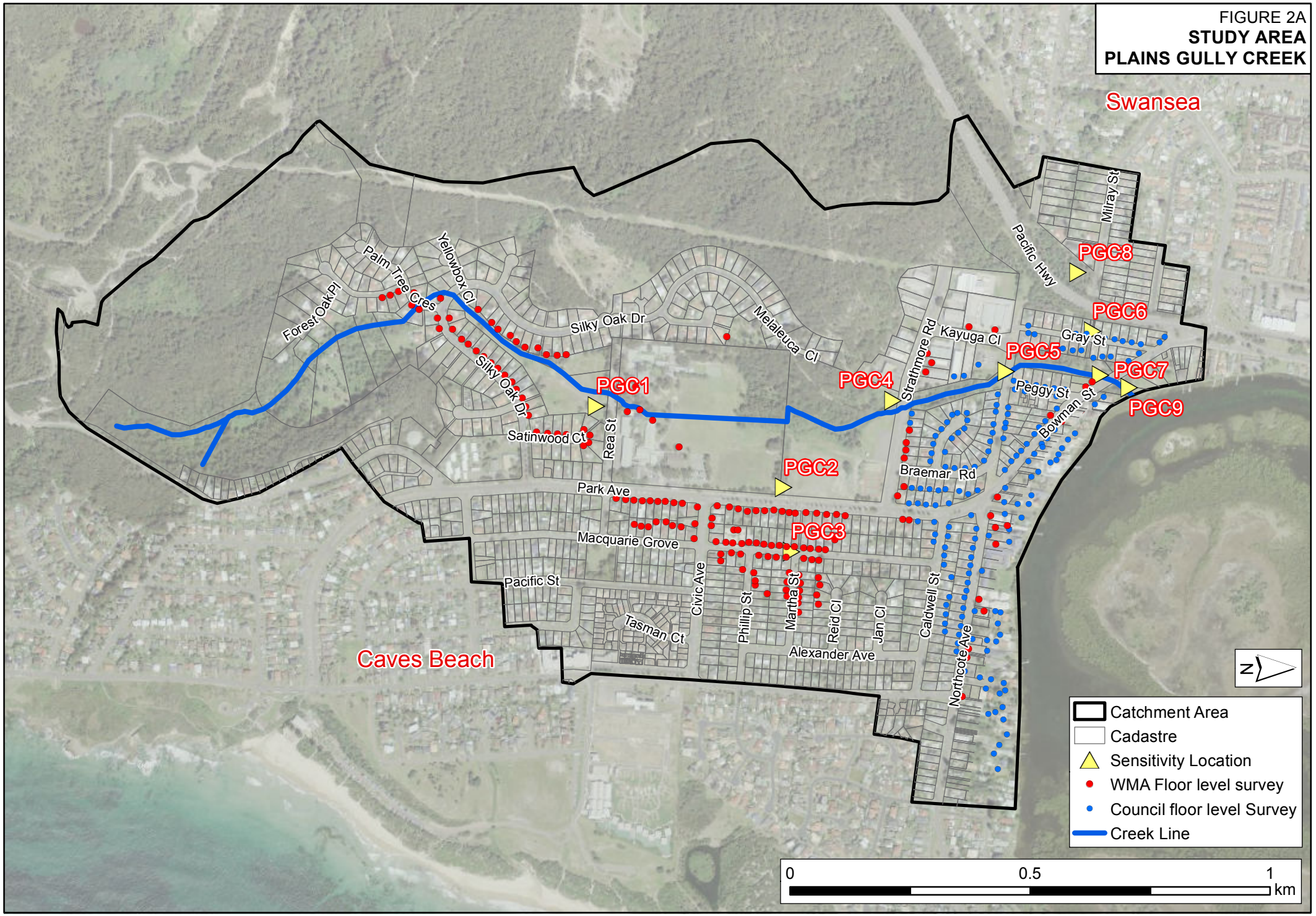


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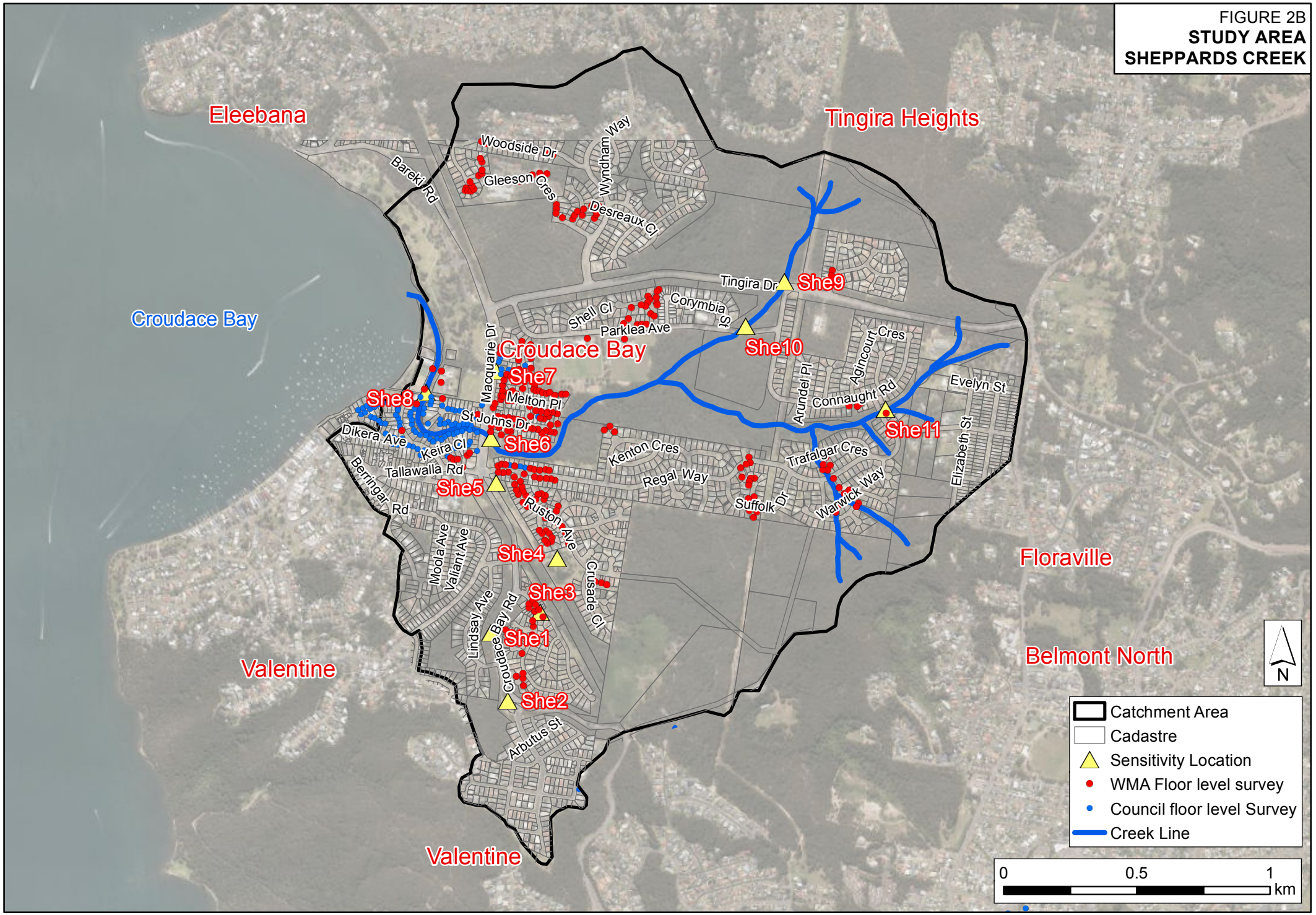
FIGURE 2B
STUDY AREA
SHEPPARDS CREEK
Eleebana
Tingira Heights
Croudace Bay
Floraville
Belmont North
Valentine
Valentine
Woodside Dr
Gleeson Cres
Wyndham Way
Desreaux Cl
Bareki Rd
Tingira Dr
She9
She10
She11
Shell Cl
Corymbia St
Parklea Ave
Agincourt Cres
Arundel Pl
Connaught Rd
Evelyn St
Elizabeth St
Macquarie Dr
Croudace Bay
She7
She8
Melton Pl
St Johns Dr
She6
Dikera Ave
Keira Cl
Tallawalla Rd
She5
Berringar Rd
Kenton Cres
Regal Way
Trafalgar Cres
Warwick Way
Suffolk Dr
Ruston Ave
She4
She3
She1
She2
Moola Ave
Valiant Ave
Lindsay Ave
Croudace Bay Rd
Crusade Cl
Arbutus St
N
Catchment Area
Cadastre
Sensitivity Location
WMA Floor level survey
Council floor level Survey
Creek Line
0
0.5
1
km
J:\Jobs\119076\ArcGIS\ArcMap\Report\Main_Report\Figure02_Study_Area\Figure02_B_Study_Areas_Sheppards_Creek.mxd

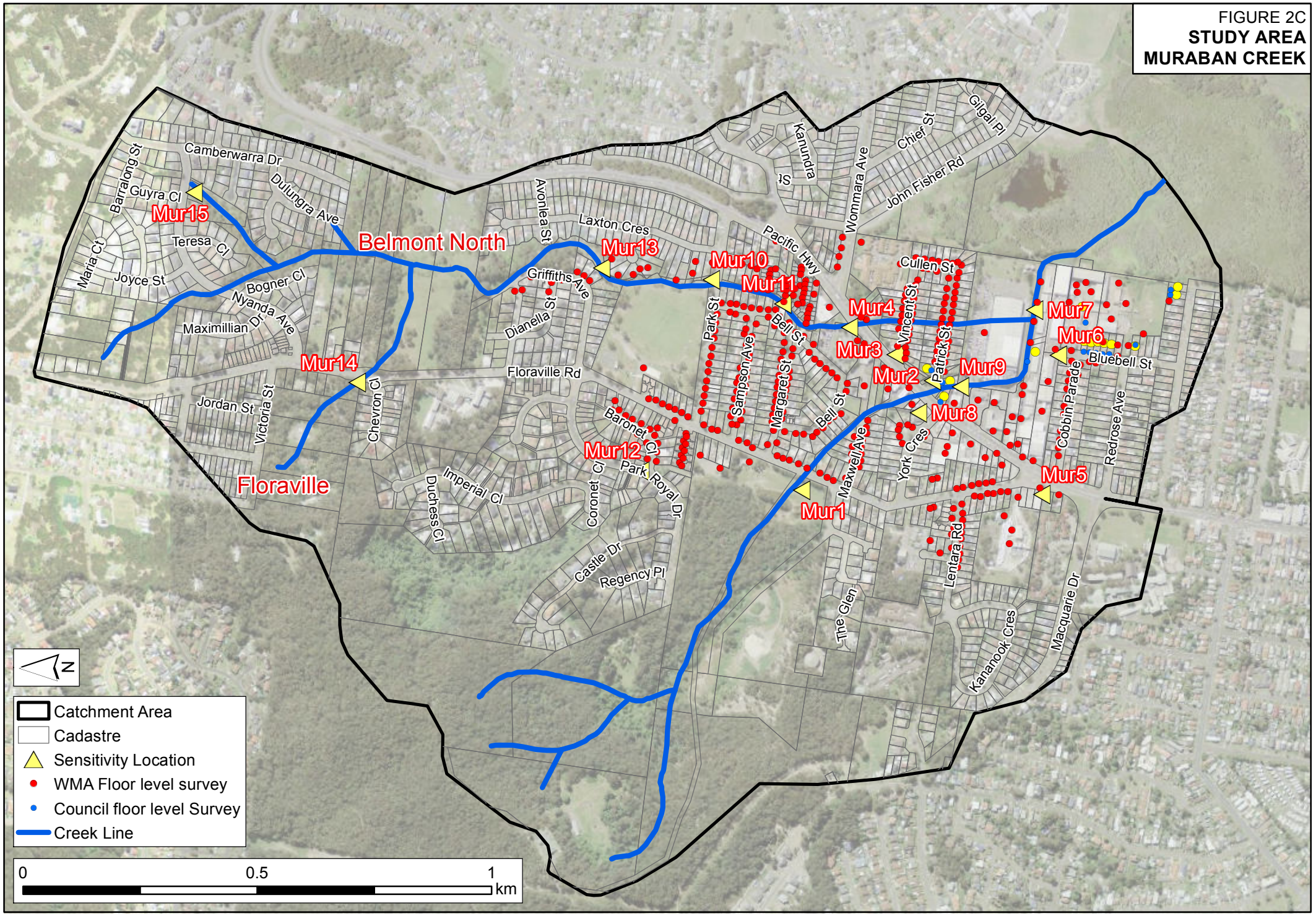
FIGURE 2C
STUDY AREA
MURABAN CREEK
Belmont North
Floraville
Mur1
Mur2
Mur3
Mur4
Mur5
Mur6
Mur7
Mur8
Mur9
Mur10
Mur11
Mur12
Mur13
Mur14
Mur15
Camberwarra Dr
Barralong St
Guyra Cl
Dulungra Ave
Teresa Cl
Maria Ct
Joyce St
Bogner Cl
Nyanda Ave
Maximillian Dr
Avonlea St
Laxton Cres
Griffiths Ave
Dianella St
Floraville Rd
Jordan St
Victoria St
Chevron Cl
Imperial Cl
Duchess Cl
Coronet Cl
Baronet Cl
Park Royal Dr
Castle Dr
Regency Pl
Kanundra
Wommara Ave
Chief St
Gilgai Pl
John Fisher Rd
Pacific Hwy
Park St
Sampson Ave
Margaret St
Bell St
Vincent St
Cullen St
Patrick St
Maxwell Ave
York Cres
Bluebell St
Cobbin Parade
Redrose Ave
Lentara Rd
The Glen
Kananook Cres
Macquarie Dr
N
Catchment Area
Cadastre
Sensitivity Location
WMA Floor level survey
Council floor level Survey
Creek Line
0
0.5
1
km
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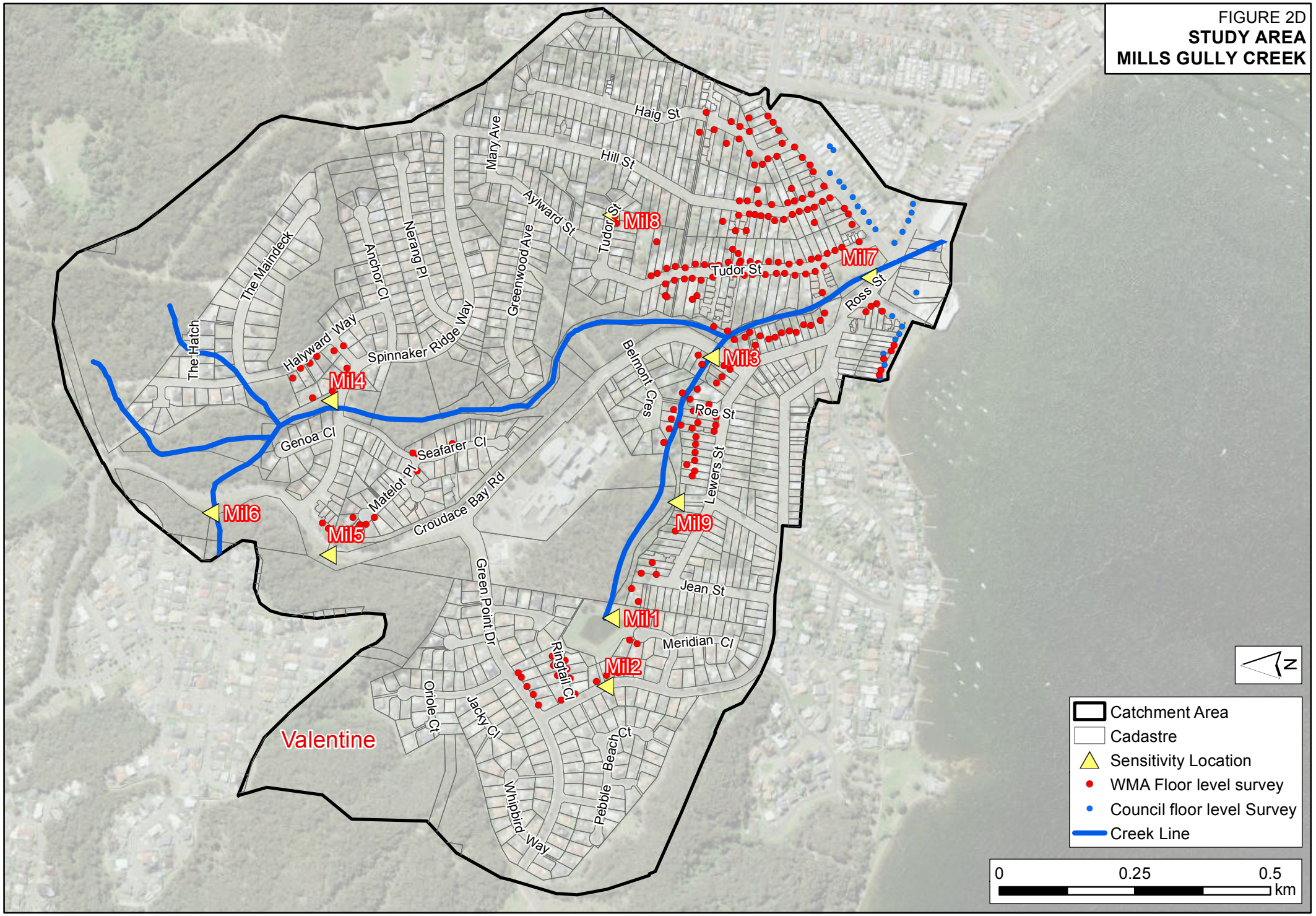
FIGURE 2D
STUDY AREA
MILLS GULLY CREEK
Haig St
Hill St
Mary Ave
Aylward St
Tudor St
Mil8
Mil7
Tudor St
Ross St
Greenwood Ave
The Maindeck
Anchor Cl
Nerang Pl
Spinnaker Ridge Way
Halyward Way
The Hatch
Mil4
Mil3
Belmont Cres
Roe St
Lewers St
Genoa Cl
Seafarer Cl
Mateiot Pl
Croudace Bay Rd
Mil6
Mil5
Mil9
Green Point Dr
Jean St
Mil1
Meridian Cl
Mil2
Ringtail Cl
Oriole Ct
Jacky Cl
Beach Ct
Pebble
Whipbird Way
Valentine
N
Catchment Area
Cadastre
Sensitivity Location
WMA Floor level survey
Council floor level Survey
Creek Line
0
0.25
0.5
km
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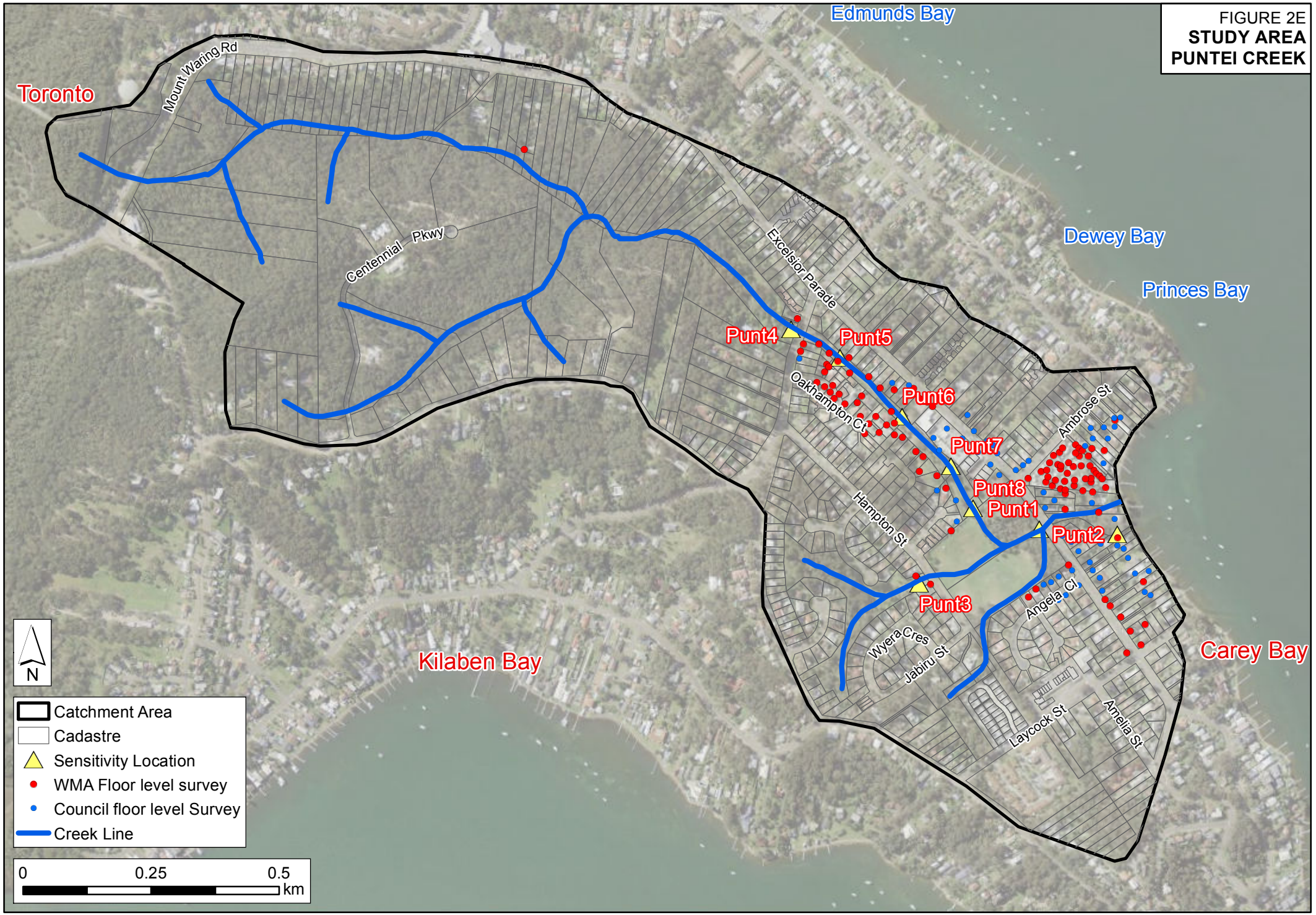
FIGURE 2E
STUDY AREA
PUNTEI CREEK
Edmunds Bay
Toronto
Mount Waring Rd
Centennial Pkwy
Excelsior Parade
Dewey Bay
Princes Bay
Punt4
Punt5
Punt6
Punt7
Punt8
Punt1
Punt2
Punt3
Oakhampton Ct
Hampton St
Ambrose St
Angela Cr
Wyera Cres
Jabiru St
Laycock St
Amelia St
Kilaben Bay
Carey Bay
N
Catchment Area
Cadastre
Sensitivity Location
WMA Floor level survey
Council floor level Survey
Creek Line
0
0.25
0.5
km
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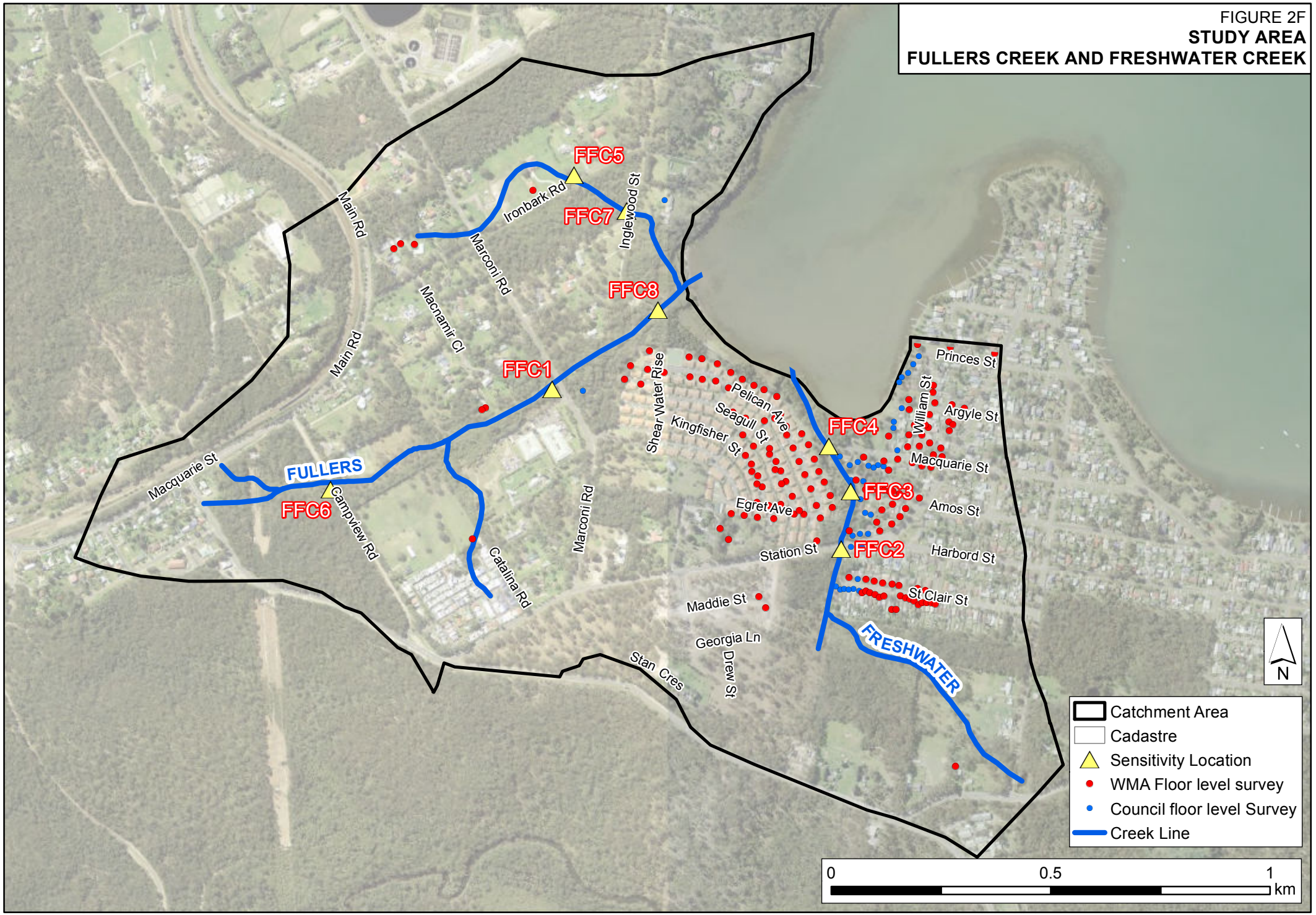
FIGURE 2F
STUDY AREA
FULLERS CREEK AND FRESHWATER CREEK
FFC5
FFC7
FFC8
FFC1
FFC6
FFC4
FFC3
FFC2
FULLERS
FRESHWATER
Main Rd
Ironbark Rd
Marconi Rd
Inglewood St
Macnamir Cl
Main Rd
Macquarie St
Campview Rd
Catalina Rd
Marconi Rd
Shear Water Rise
Pelican Ave
Seagull St
Kingfisher St
Egret Ave
Station St
Princes St
William St
Argyle St
Macquarie St
Amos St
Harbord St
St Clair St
Maddie St
Georgia Ln
Drew St
Stan Cres
N
Catchment Area
Cadastre
Sensitivity Location
WMA Floor level survey
Council floor level Survey
Creek Line
0
0.5
1
km
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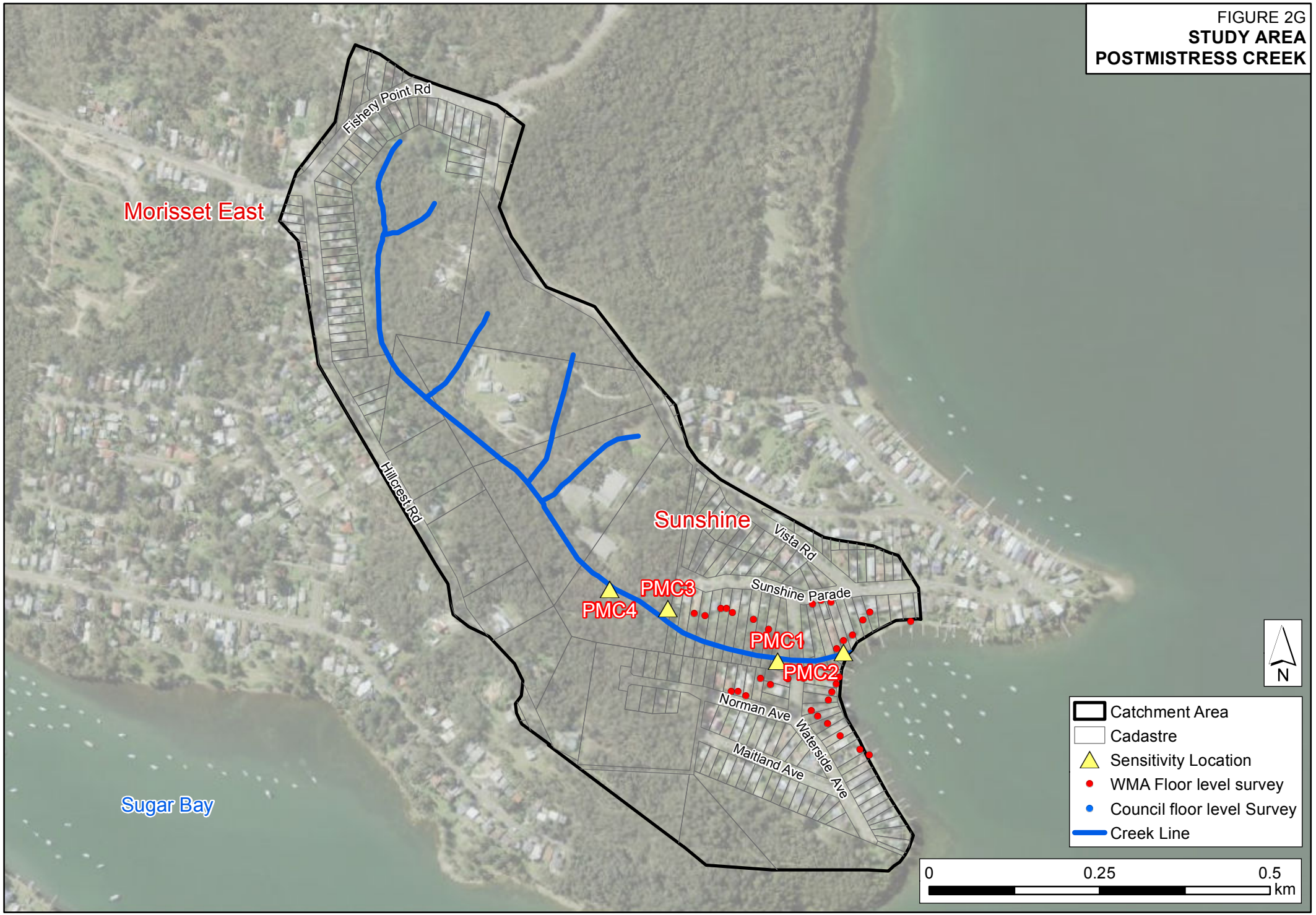
FIGURE 2G
STUDY AREA
POSTMISTRESS CREEK
Morisset East
Fishery Point Rd
Hillcrest Rd
Sunshine
Vista Rd
Sunshine Parade
PMC3
PMC4
PMC1
PMC2
Norman Ave
Waterside Ave
Maitland Ave
Sugar Bay
N
Catchment Area
Cadastre
Sensitivity Location
WMA Floor level survey
Council floor level Survey
Creek Line
0
0.25
0.5
km
J:\Jobs\119076\ArcGIS\ArcMap\Report\Main_Report\Figure02_Study_Area\Figure02_G_Study_Areas_Postmistress_Creek.mxd

FIGURE 2H

**STUDY AREA**

**MANNERING CREEK, SWAMPY CREEK AND WYEE CREEK**

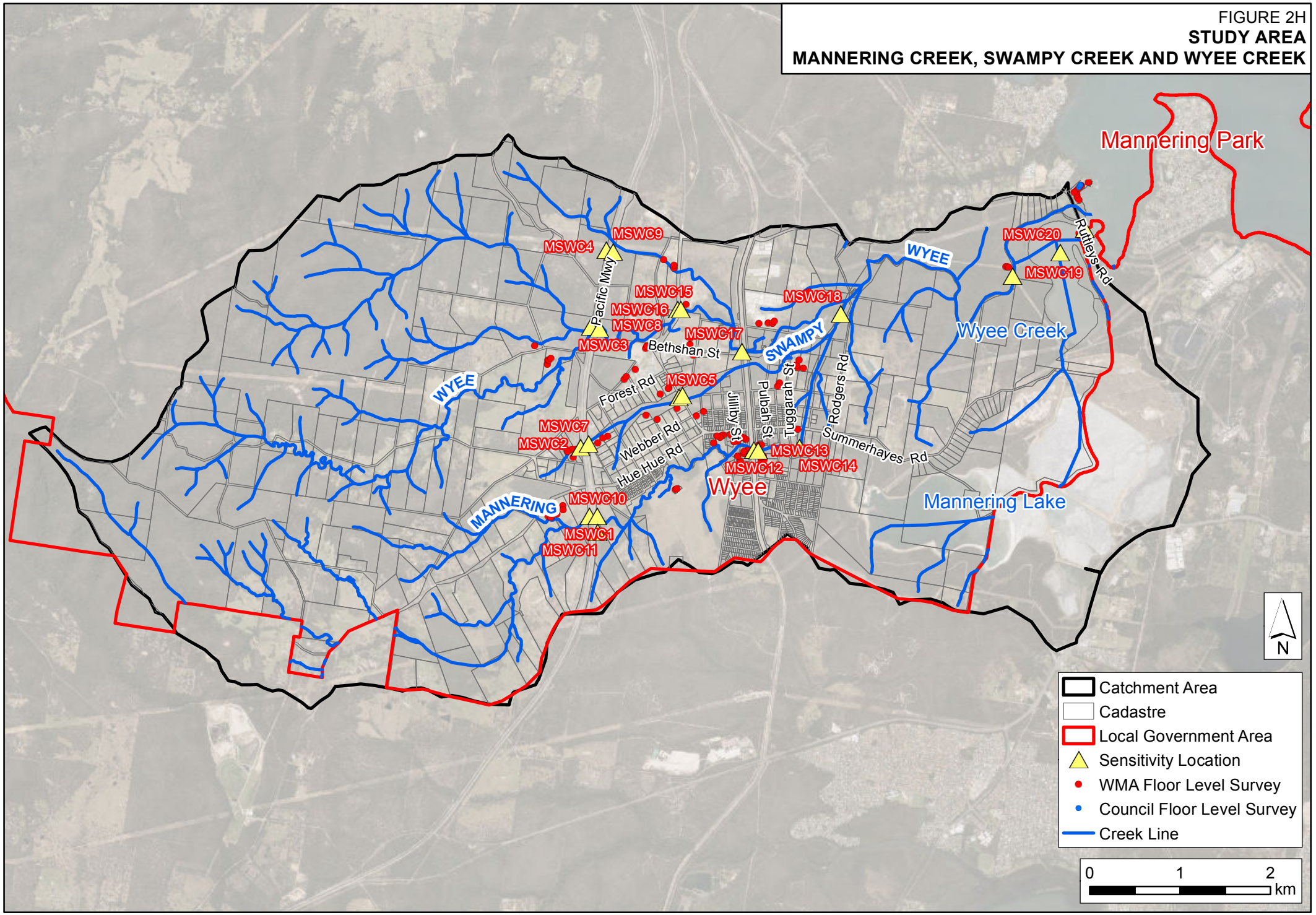


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FIGURE 3A

# TOPOGRAPHY AND SUBCATCHMENT LAYOUTS PLAINS GULLY CREEK

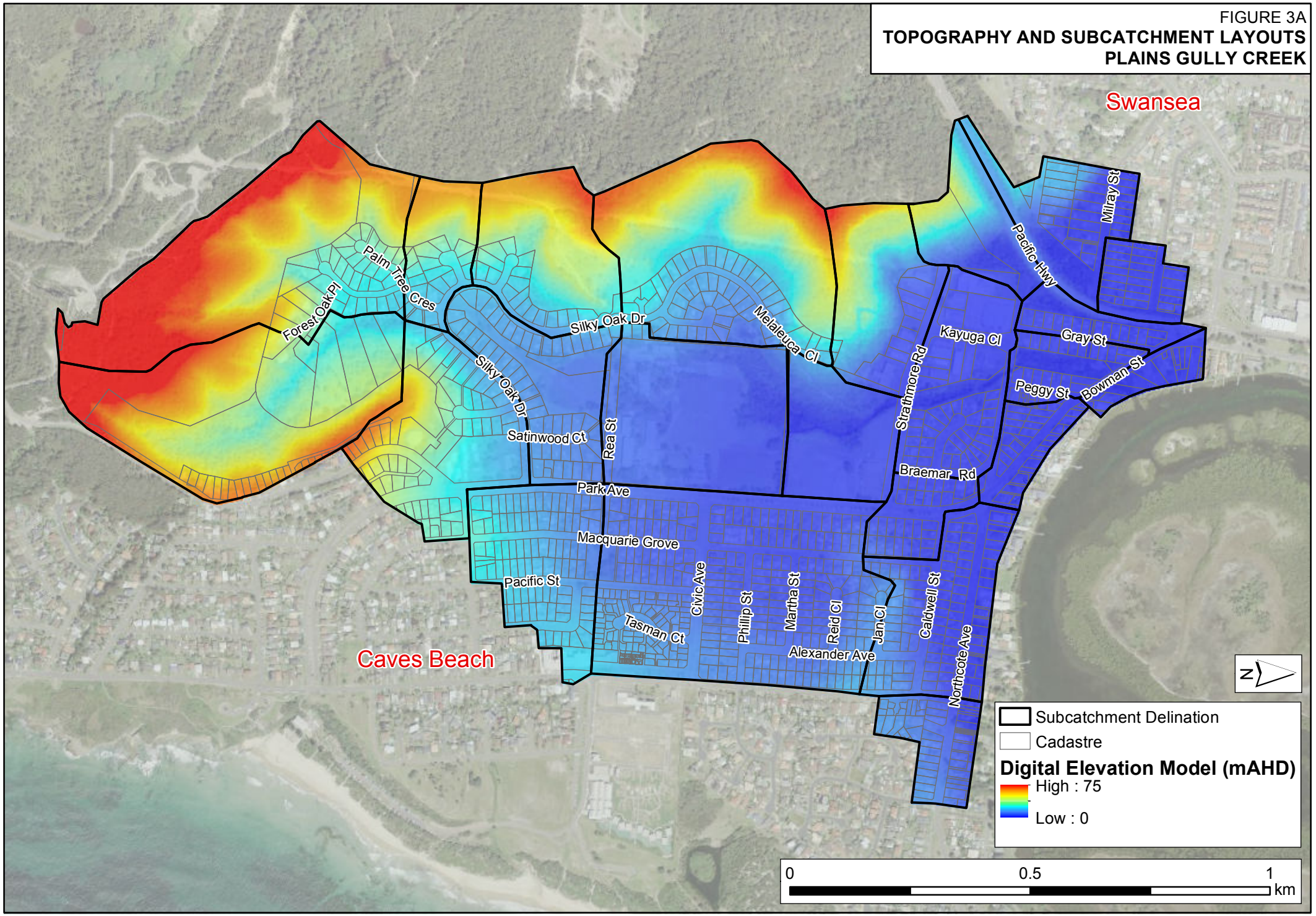


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FIGURE 3B

**TOPOGRAPHY AND SUBCATCHMENT LAYOUTS**
**SHEPPARDS CREEK**

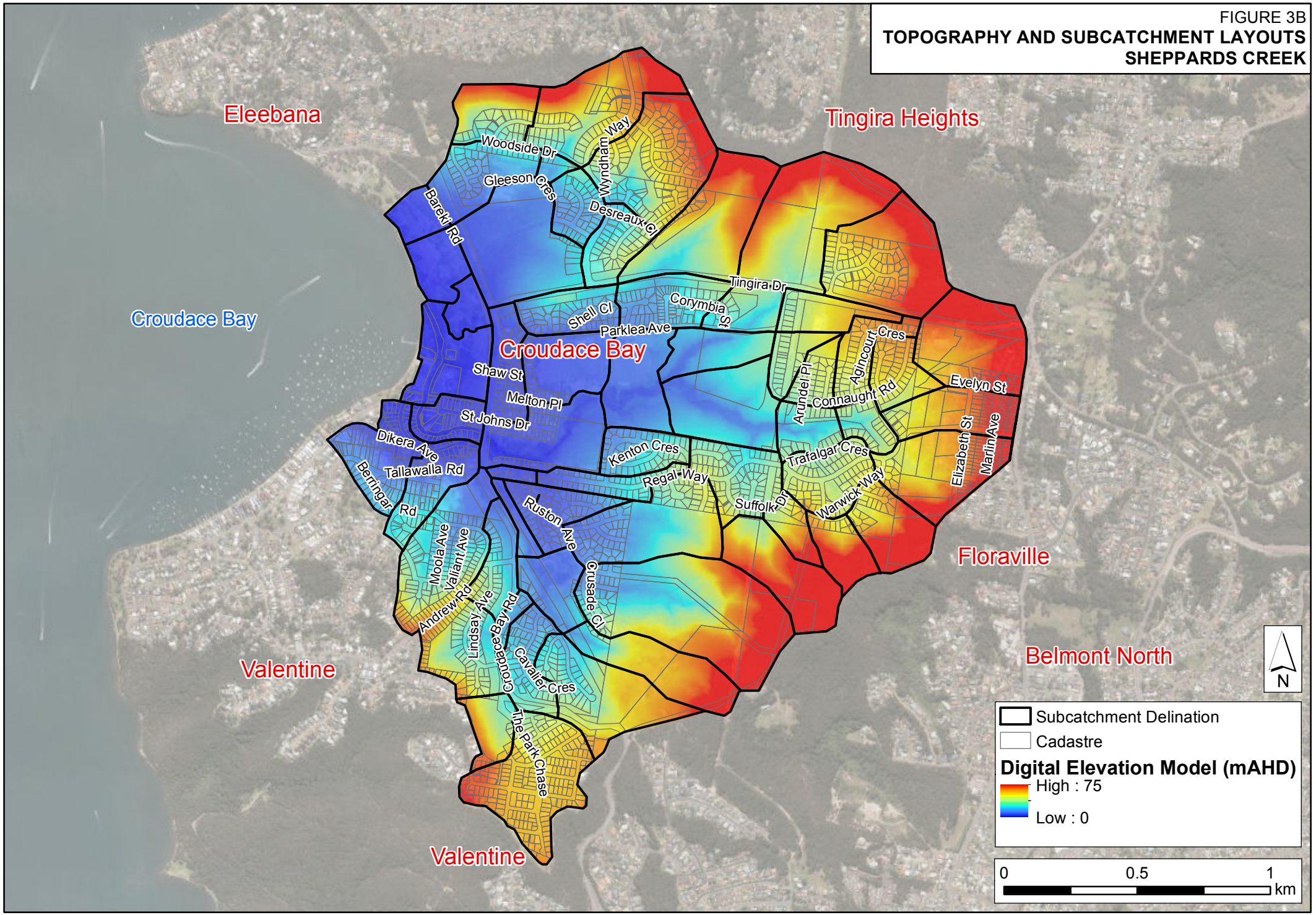


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FIGURE 3C

**TOPOGRAPHY AND SUBCATCHMENT LAYOUTS**
**MURABAN CREEK**

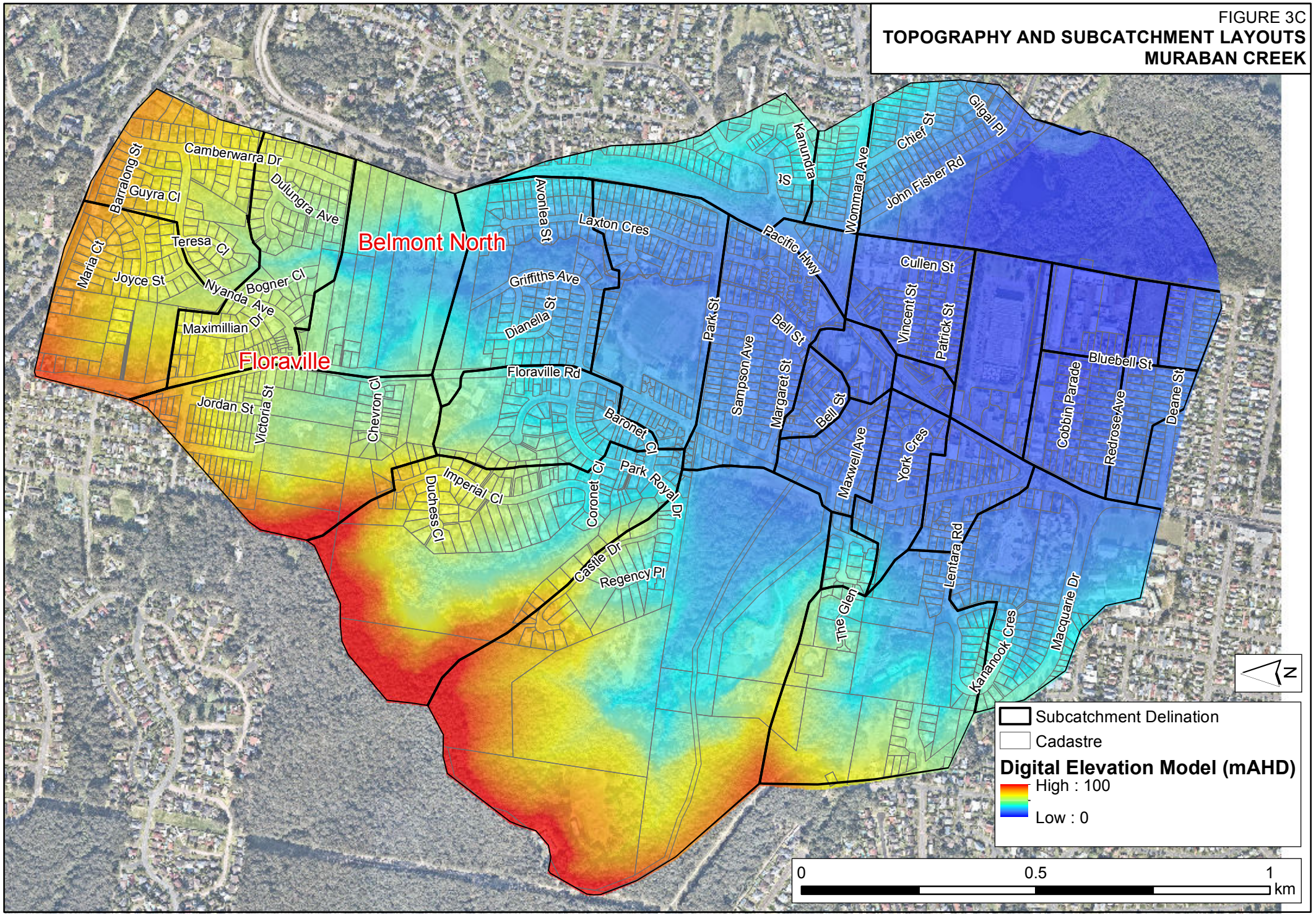


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FIGURE 3D

**TOPOGRAPHY AND SUBCATCHMENT LAYOUTS**
**MILLS GULLY CREEK**

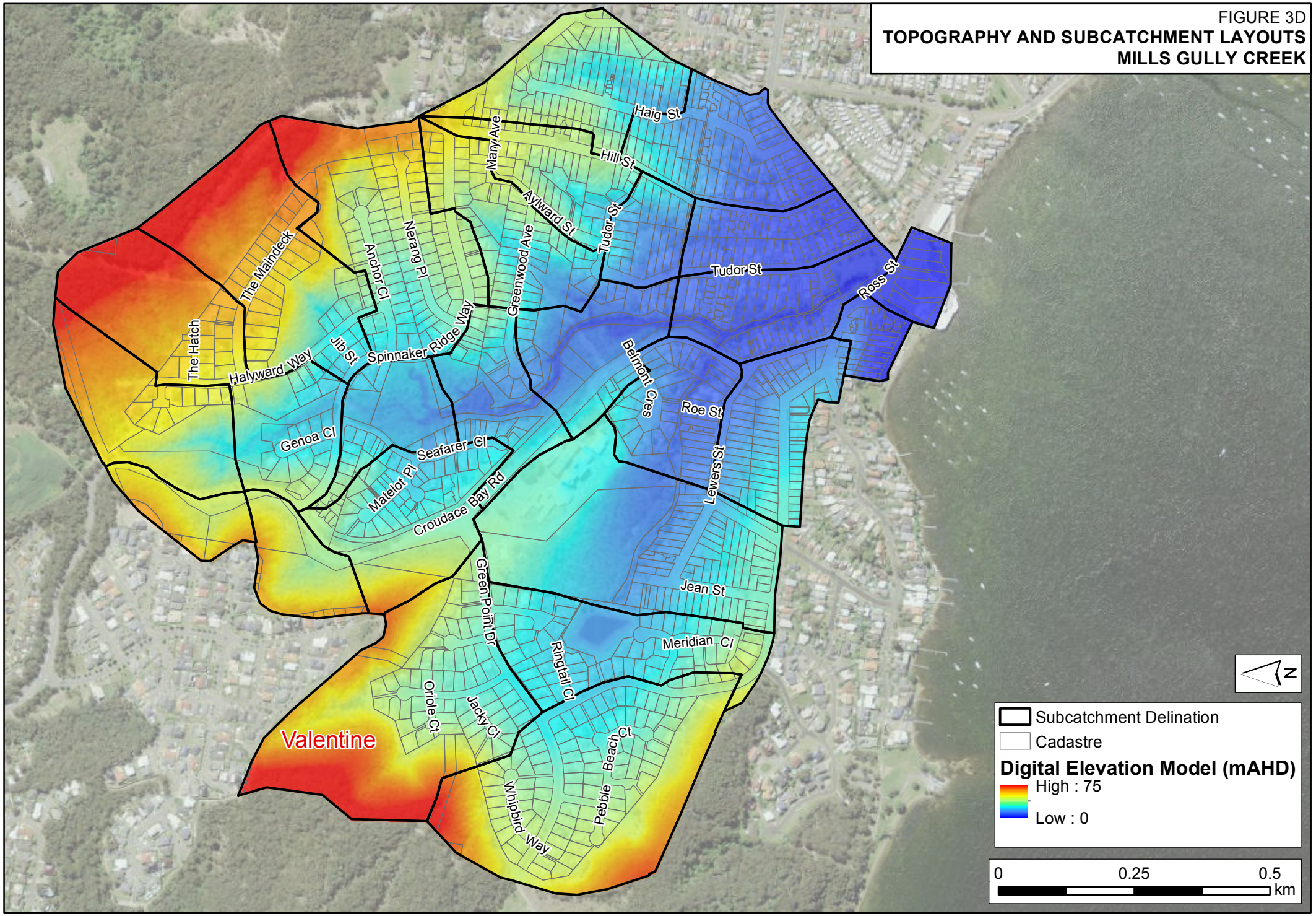


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FIGURE 3E

**TOPOGRAPHY AND SUBCATCHMENT LAYOUTS**
**PUNTEI CREEK**

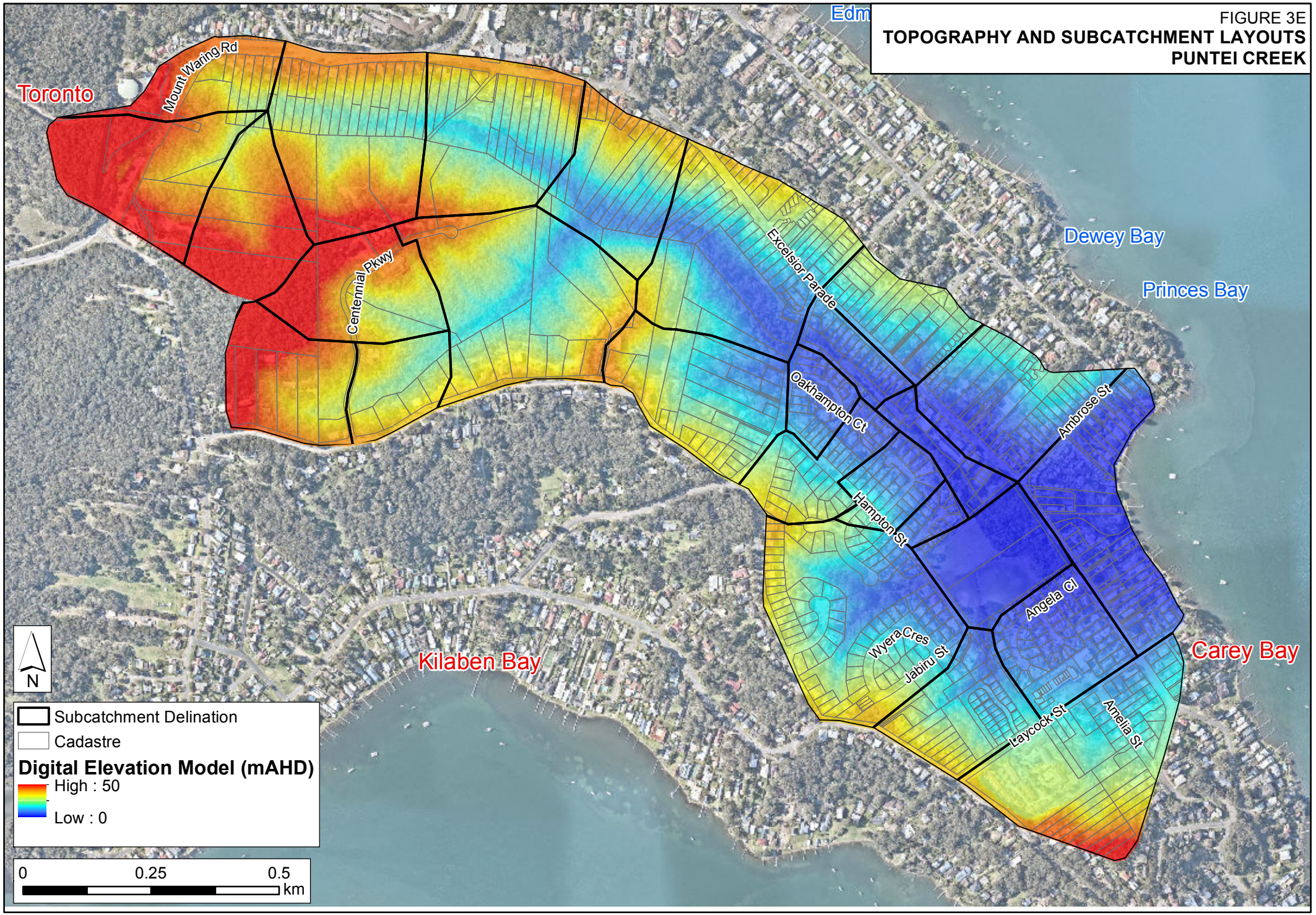


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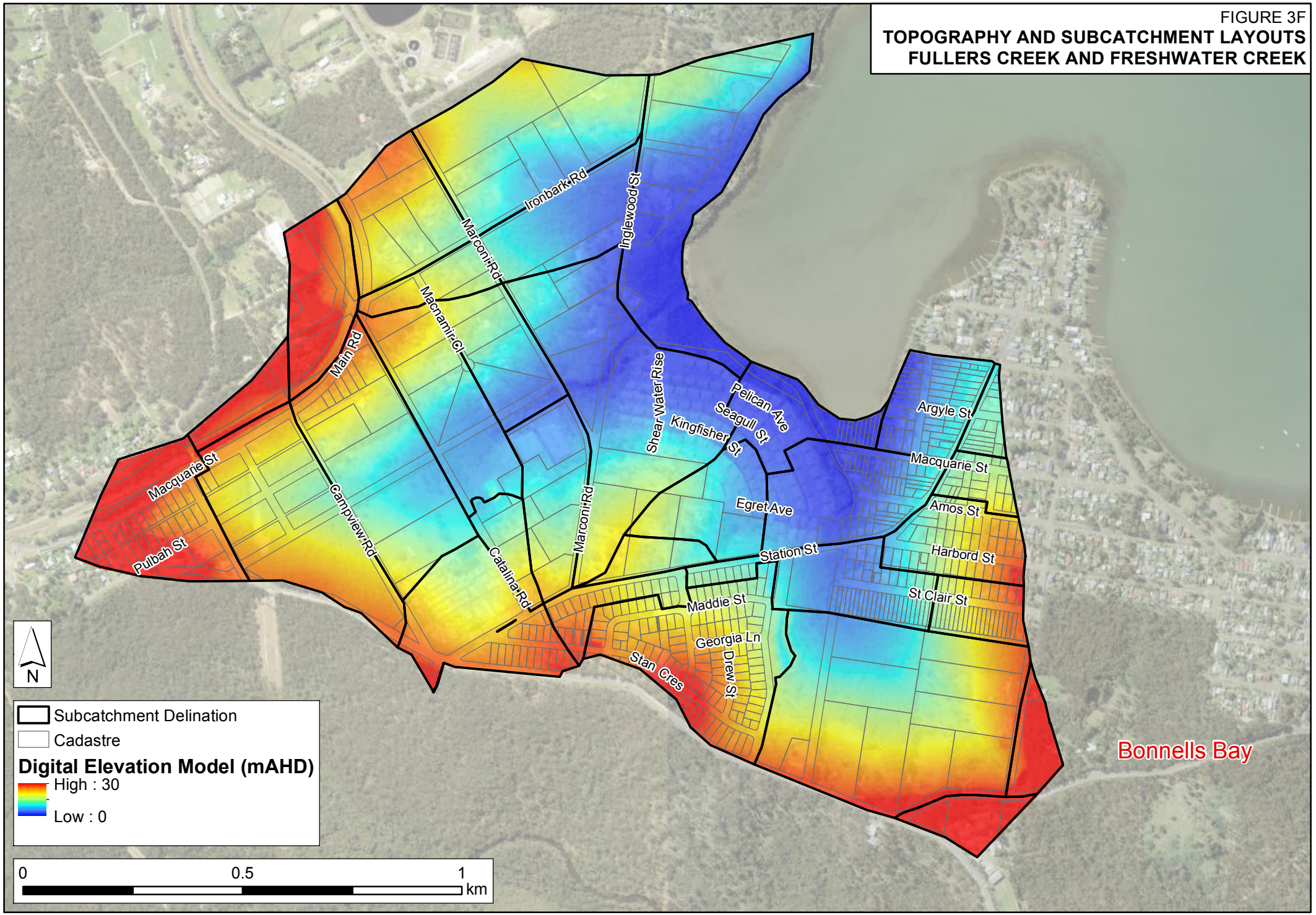
FIGURE 3F

**TOPOGRAPHY AND SUBCATCHMENT LAYOUTS**
**FULLERS CREEK AND FRESHWATER CREEK**

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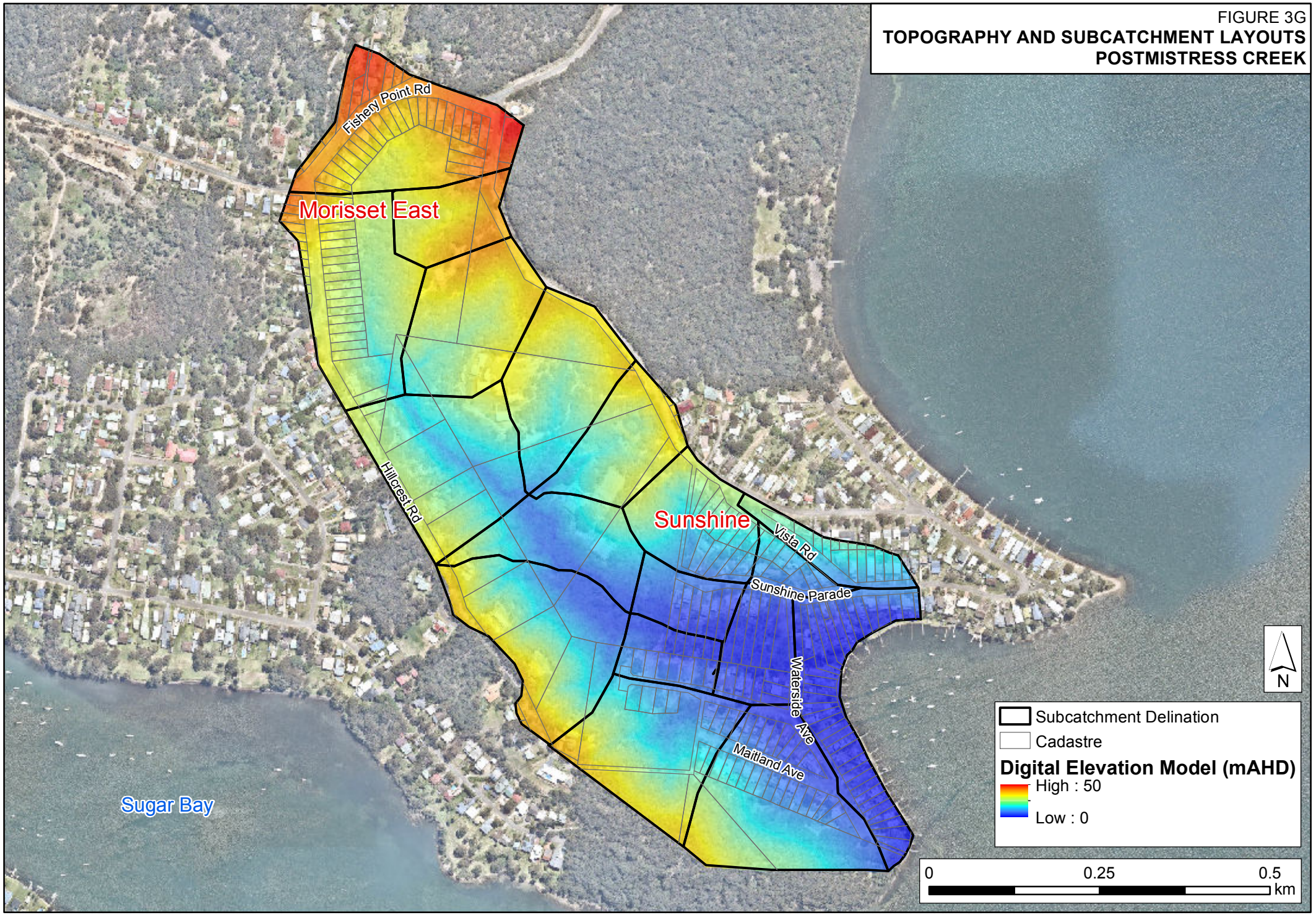
FIGURE 3G
TOPOGRAPHY AND SUBCATCHMENT LAYOUTS
POSTMISTRESS CREEK
Fishery Point Rd
Morisset East
Hillcrest Rd
Sunshine
Vista Rd
Sunshine Parade
Waterside Ave
Maitland Ave
Sugar Bay
N
Subcatchment Delination
Cadastre
Digital Elevation Model (mAHD)
High : 50
Low : 0
0
0.25
0.5
km
J:\Jobs\119076\ArcGIS\ArcMap\Report\Main_Report\Figure03_DEM_WBNM_Catchment\Figure03_G_Topography_and_Subcatchment_Layouts_Postmistress_Creek.mxd

FIGURE 3H

**TOPOGRAPHY AND SUBCATCHMENT LAYOUTS**
**MANNERING CREEK, SWAMPY CREEK AND WYEE CREEK**

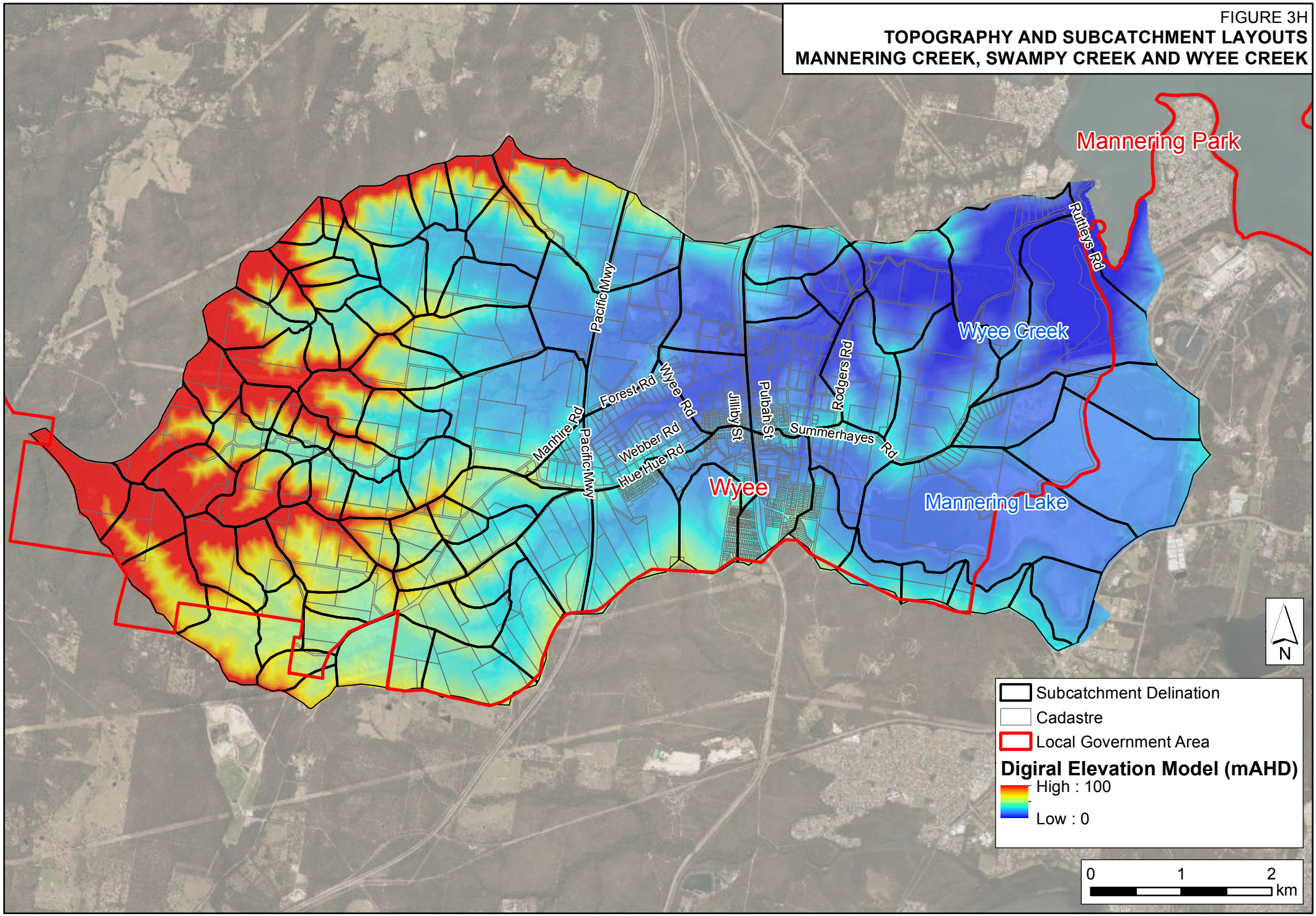


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FIGURE 4A

**HYDRAULIC MODEL LAYOUTS**
**PLAINS GULLY CREEK**

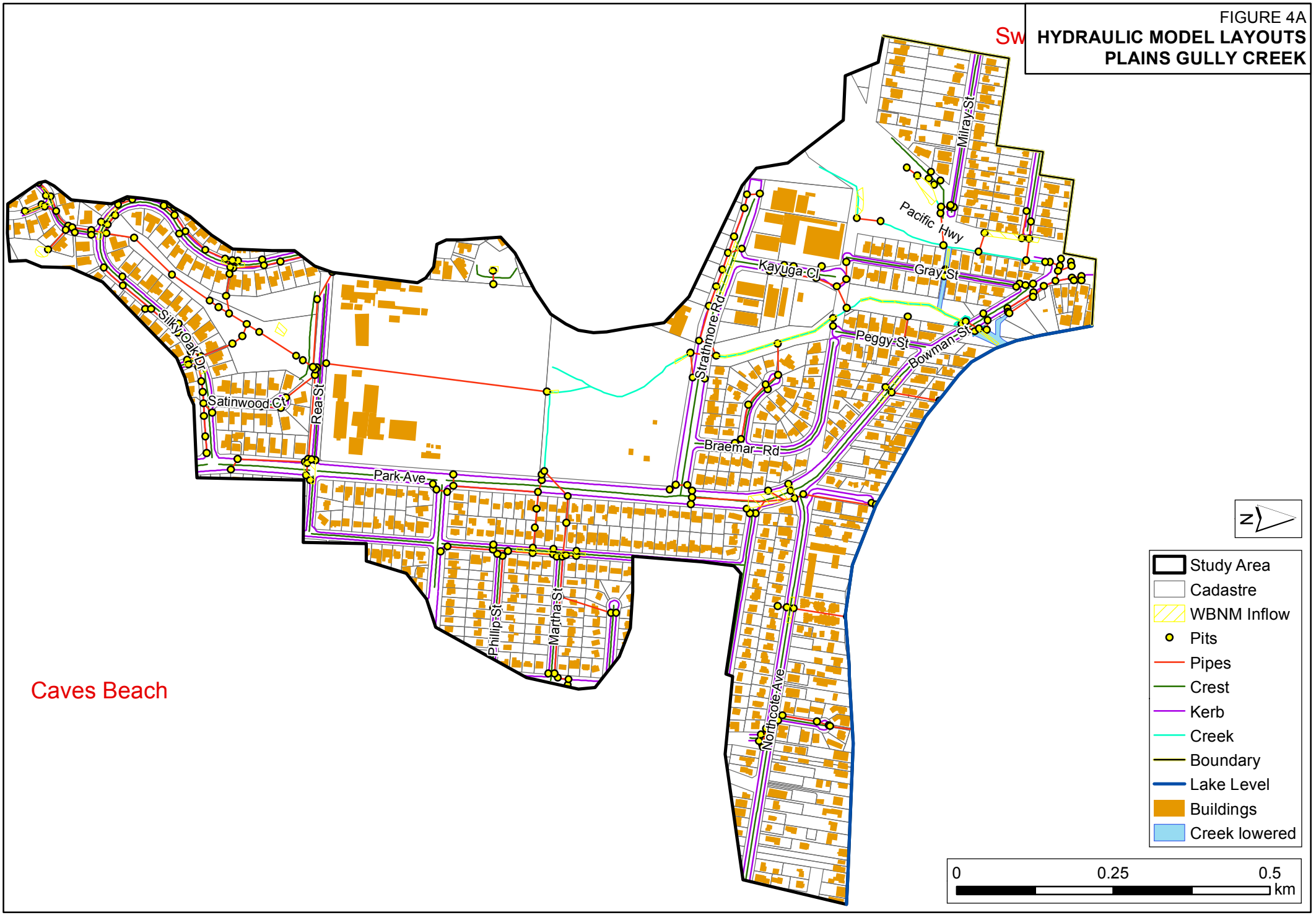


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FIGURE 4B
**HYDRAULIC MODEL LAYOUTS**
**SHEPPARDS CREEK**

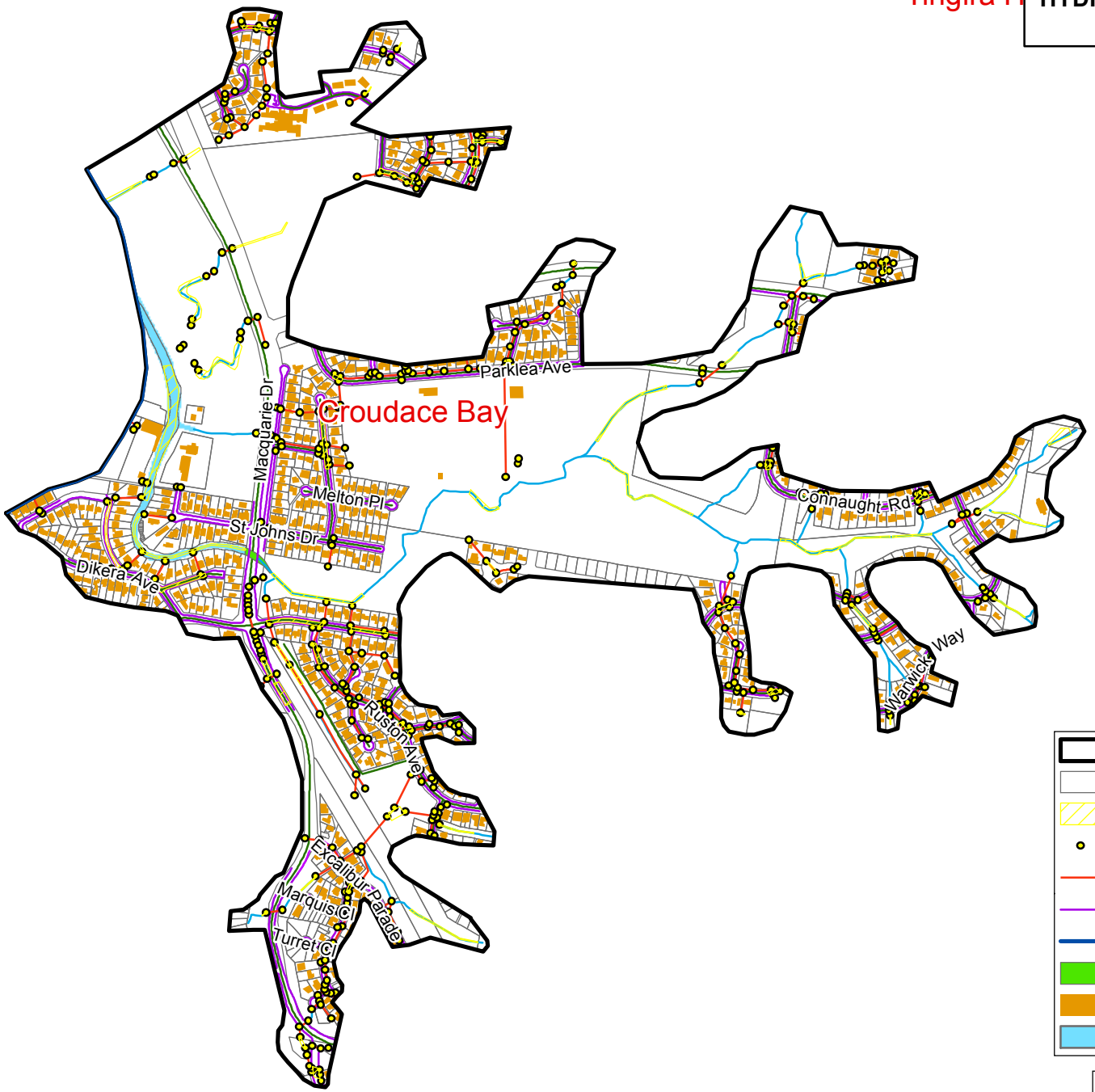


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FIGURE 4C
**HYDRAULIC MODEL LAYOUTS**
**MURABAN CREEK**

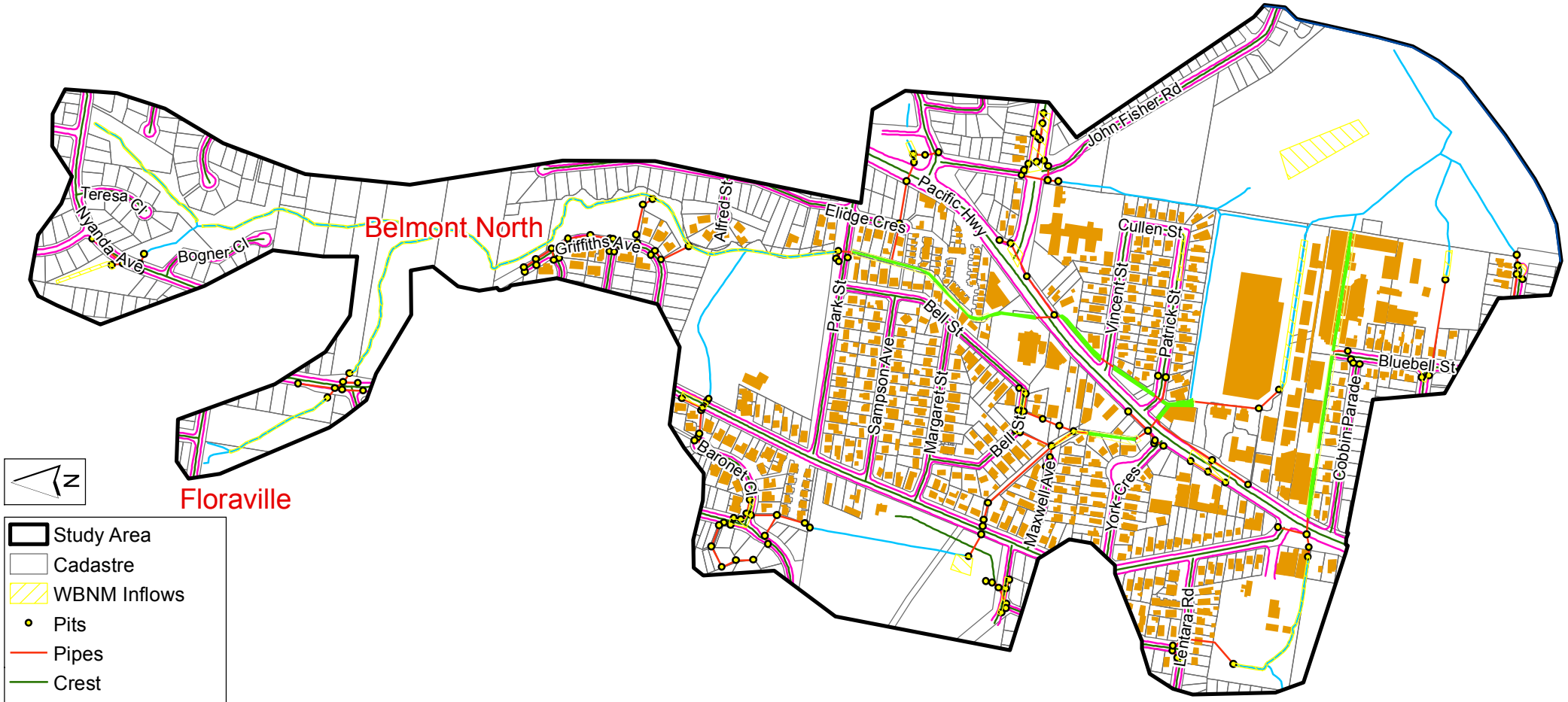


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FIGURE 4D
**HYDRAULIC MODEL LAYOUTS**
**MILLS GULLY CREEK**

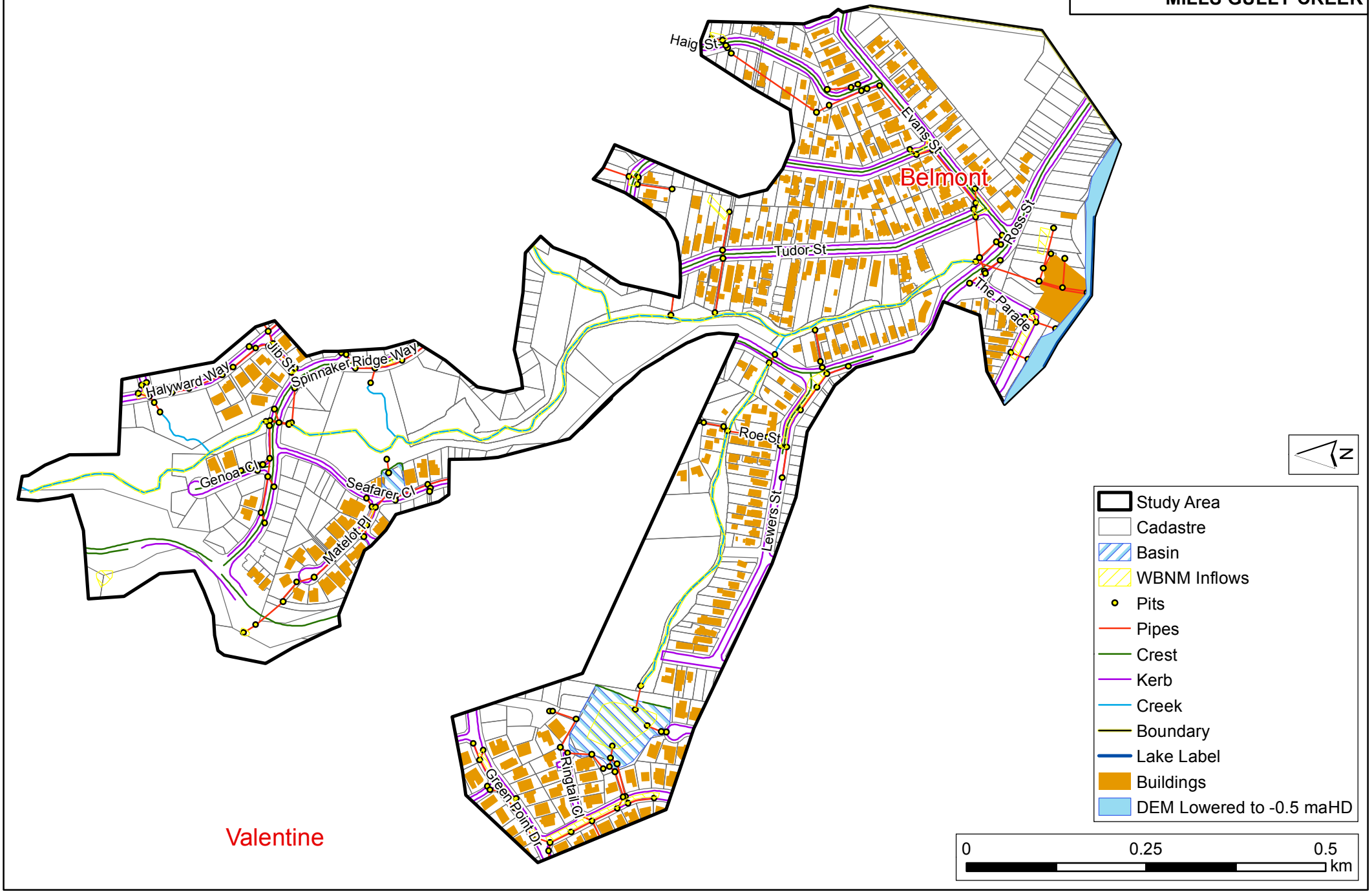


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FIGURE 4E
**HYDRAULIC MODEL LAYOUTS**
**PUNTEI CREEK**

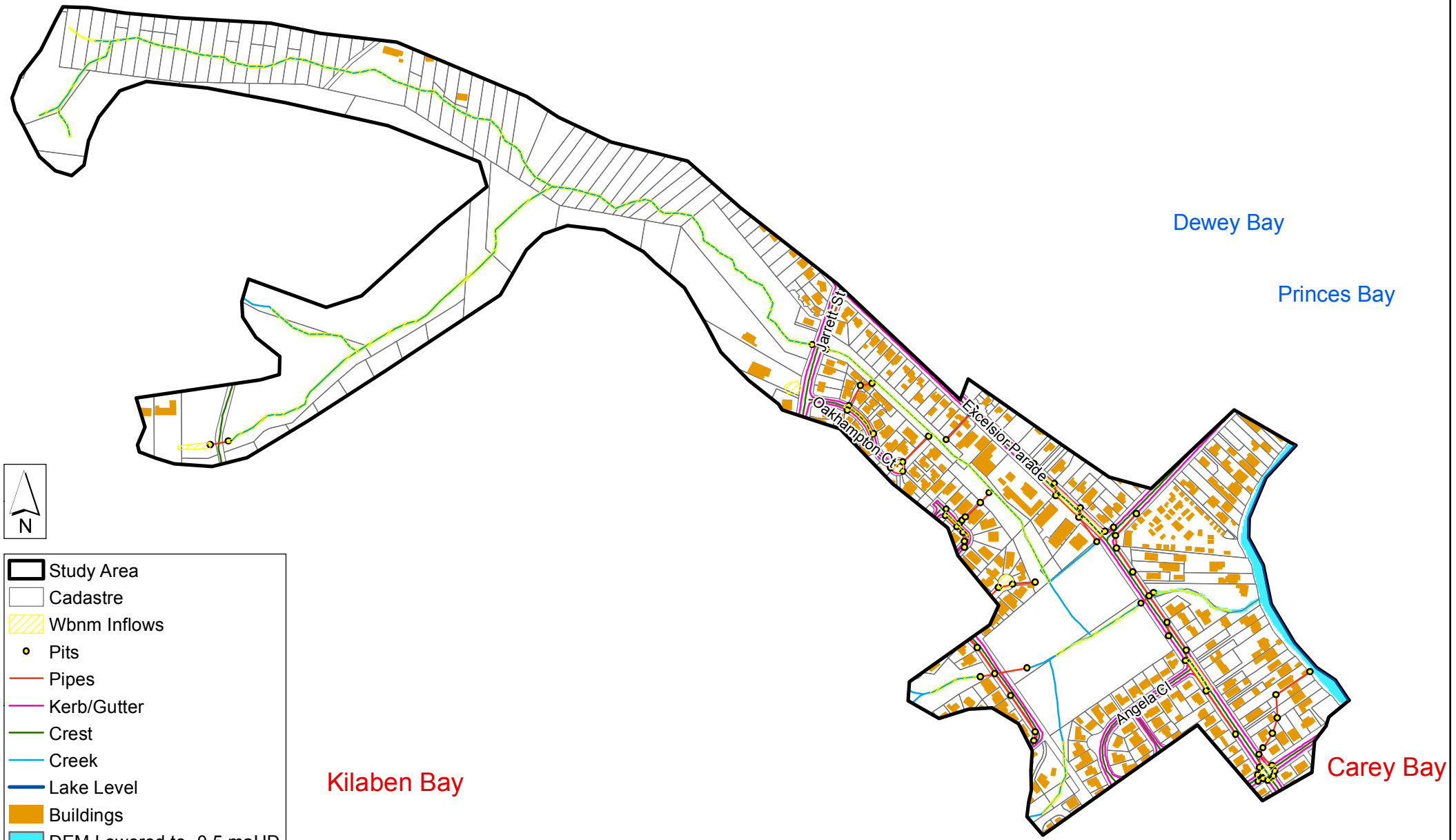


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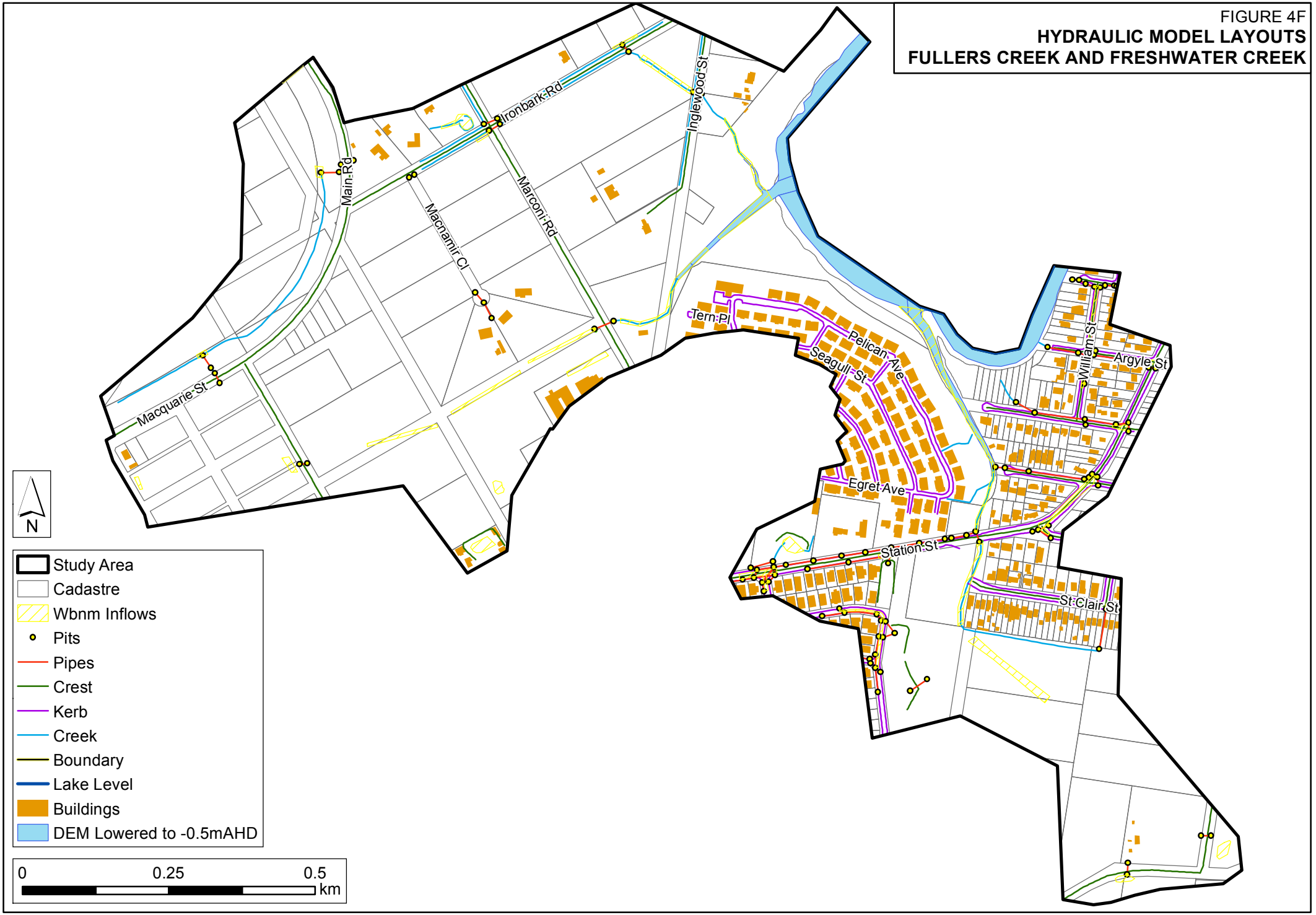
FIGURE 4F

# HYDRAULIC MODEL LAYOUTS
# FULLERS CREEK AND FRESHWATER CREEK




J:\Jobs\119076\ArcGIS\ArcMap\Report\Main_Report\Figure04_TUFLOW_model_Layout\Figure04_F_Hydraulic_Model_Layouts_Fullers_Creek_and_Freshwater_Creek.mxd

FIGURE 4G
**HYDRAULIC MODEL LAYOUTS**
**POSTMISTRESS CREEK**

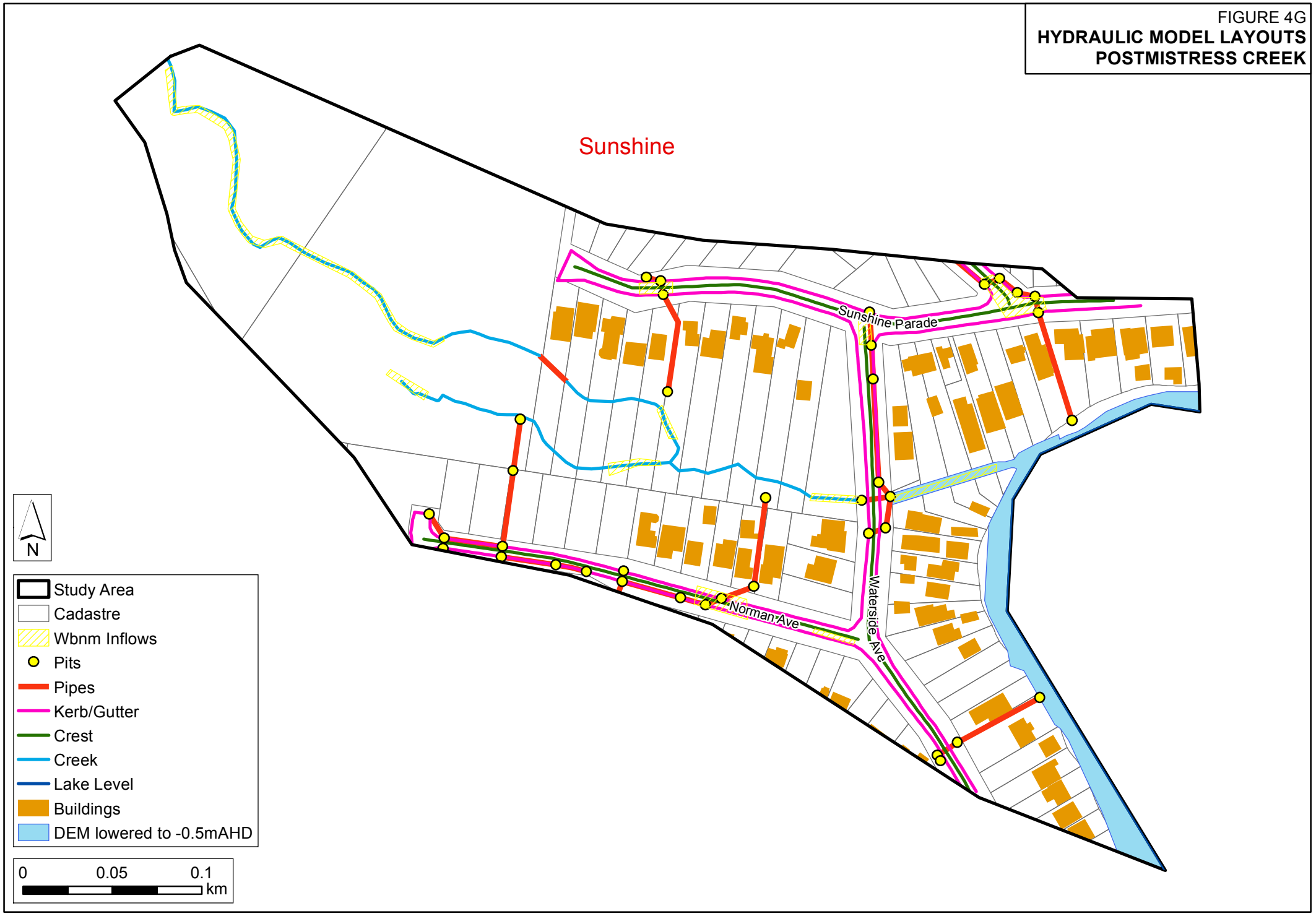



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FIGURE 4H

**HYDRAULIC MODEL LAYOUTS**

**MANNERING CREEK, SWAMPY CREEK AND WYEE CREEK**

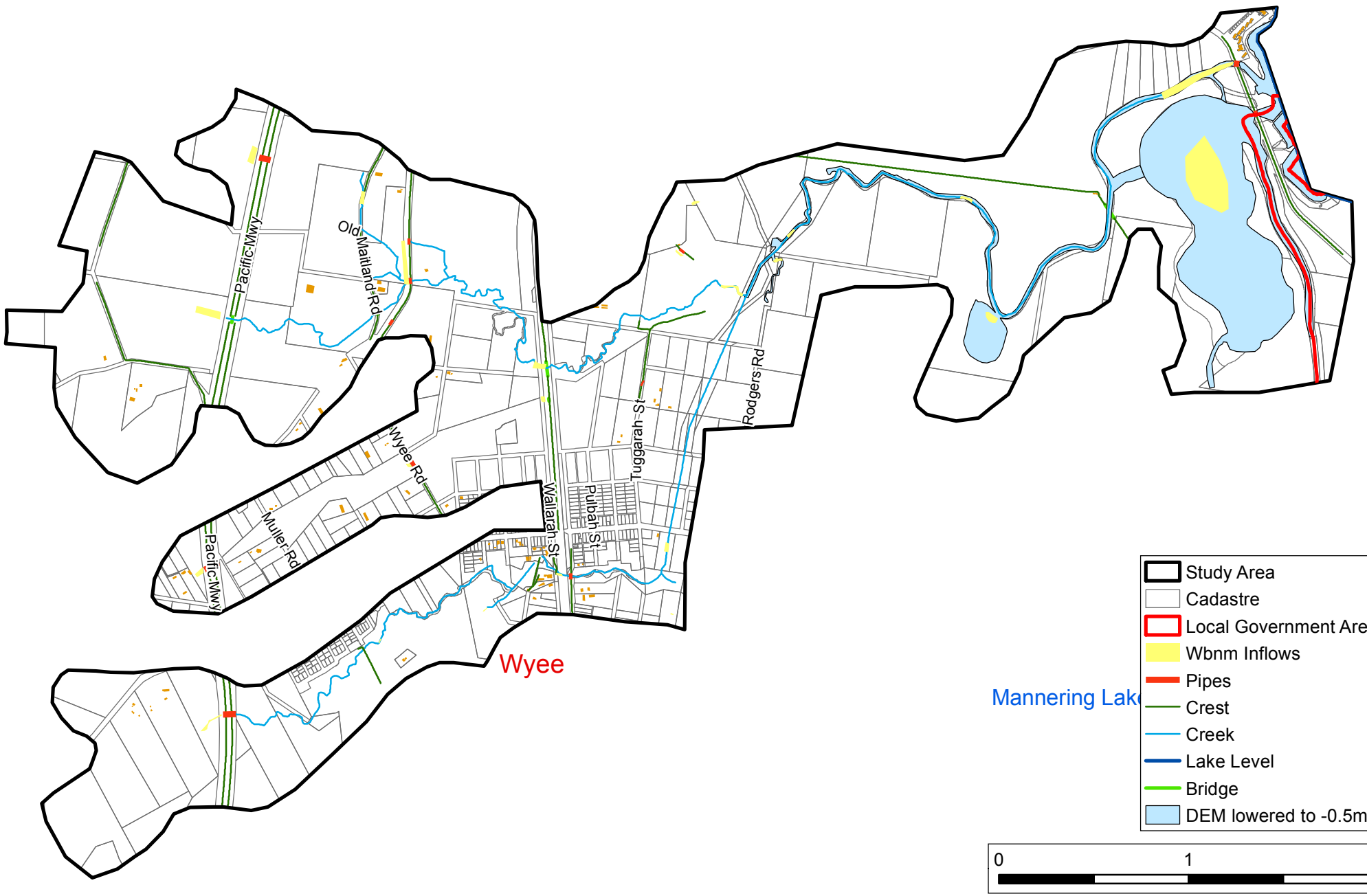


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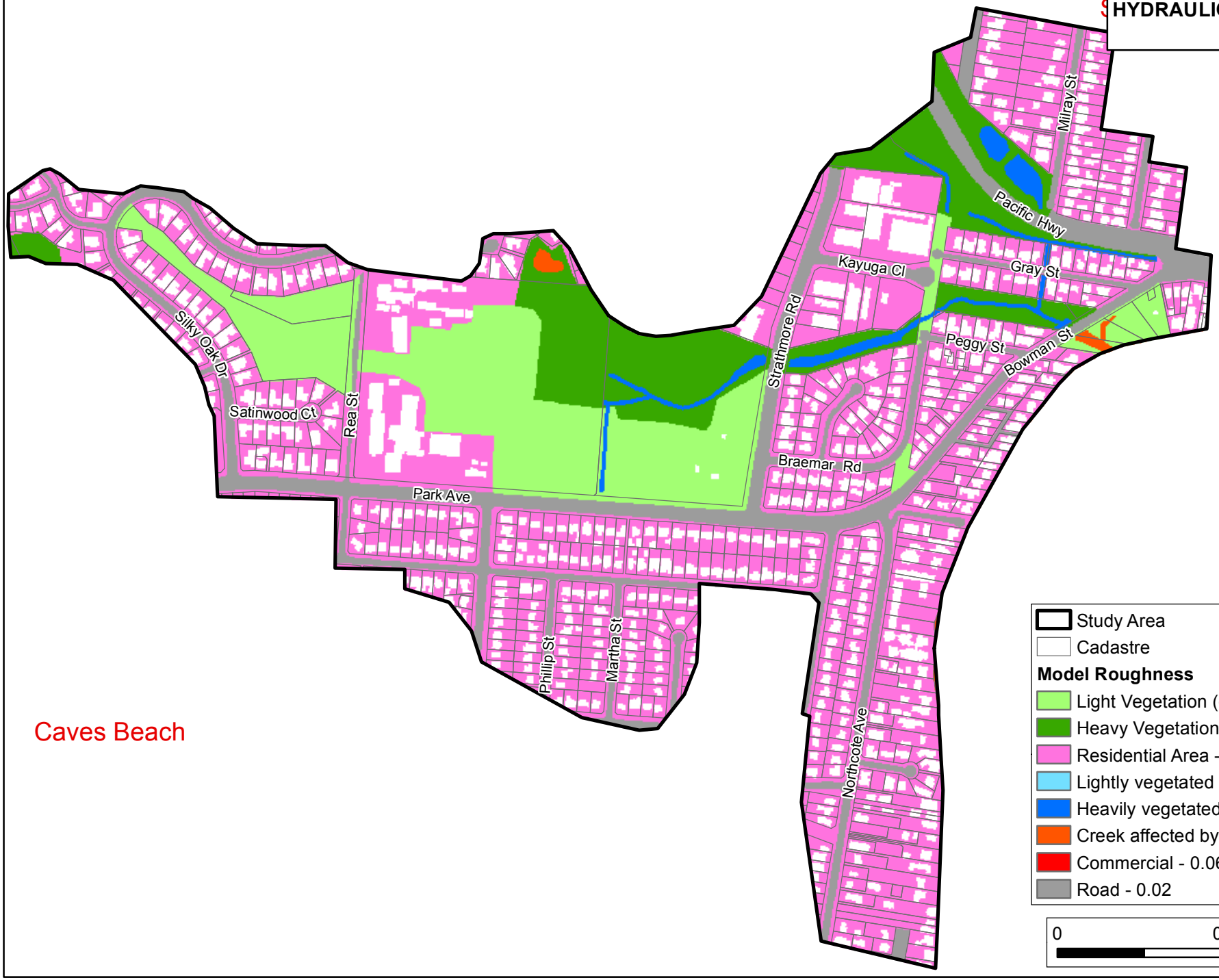
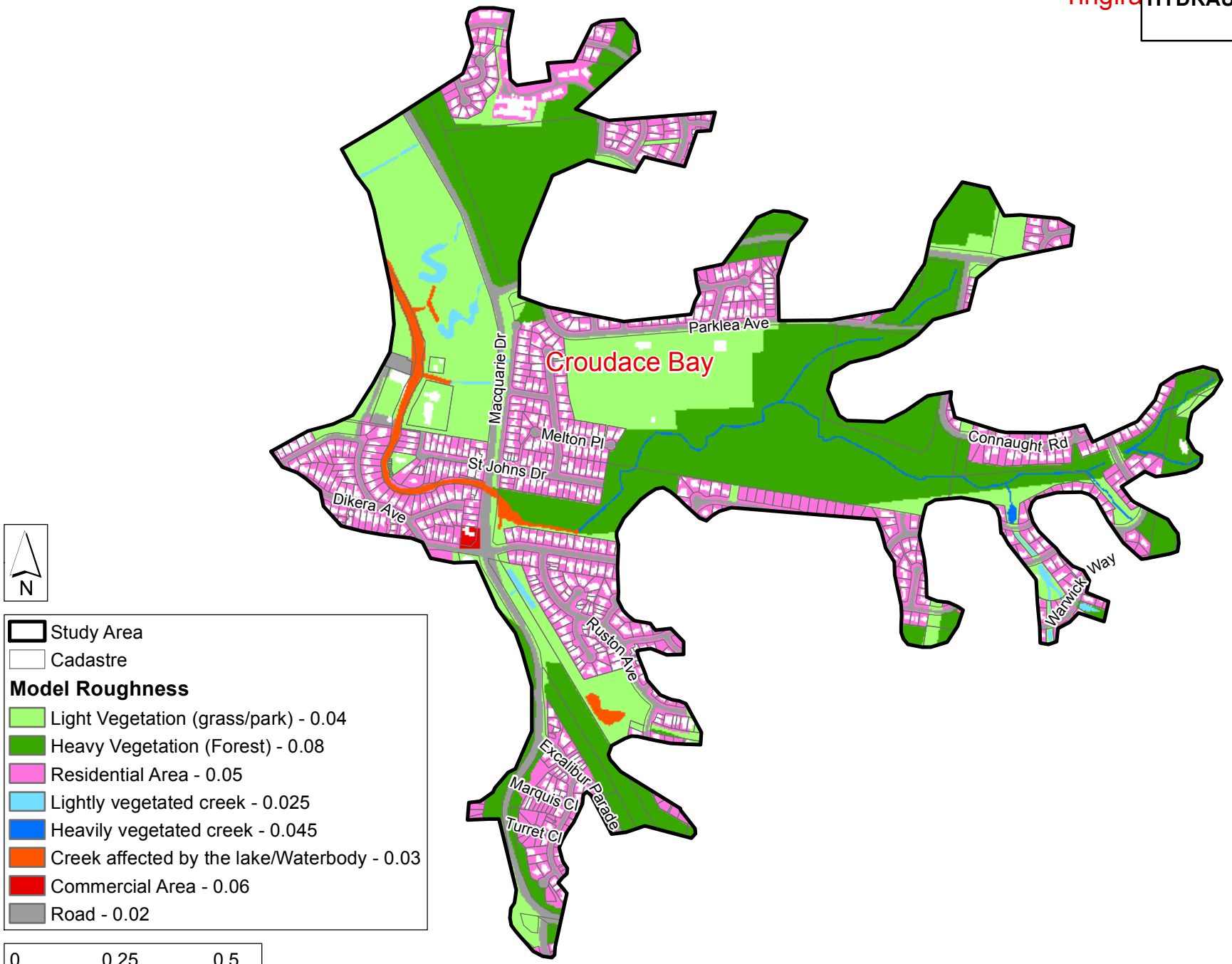
FIGURE 5A

**HYDRAULIC MODEL ROUGHNESS**
**PLAINS GULLY CREEK**




J:\Jobs\119076\ArcGIS\ArcMap\Report\Figure05_TUFLOW_roughness\Figure05_A2_Hydraulic_Model_Roughness_Plains_Gully_Creek.mxd

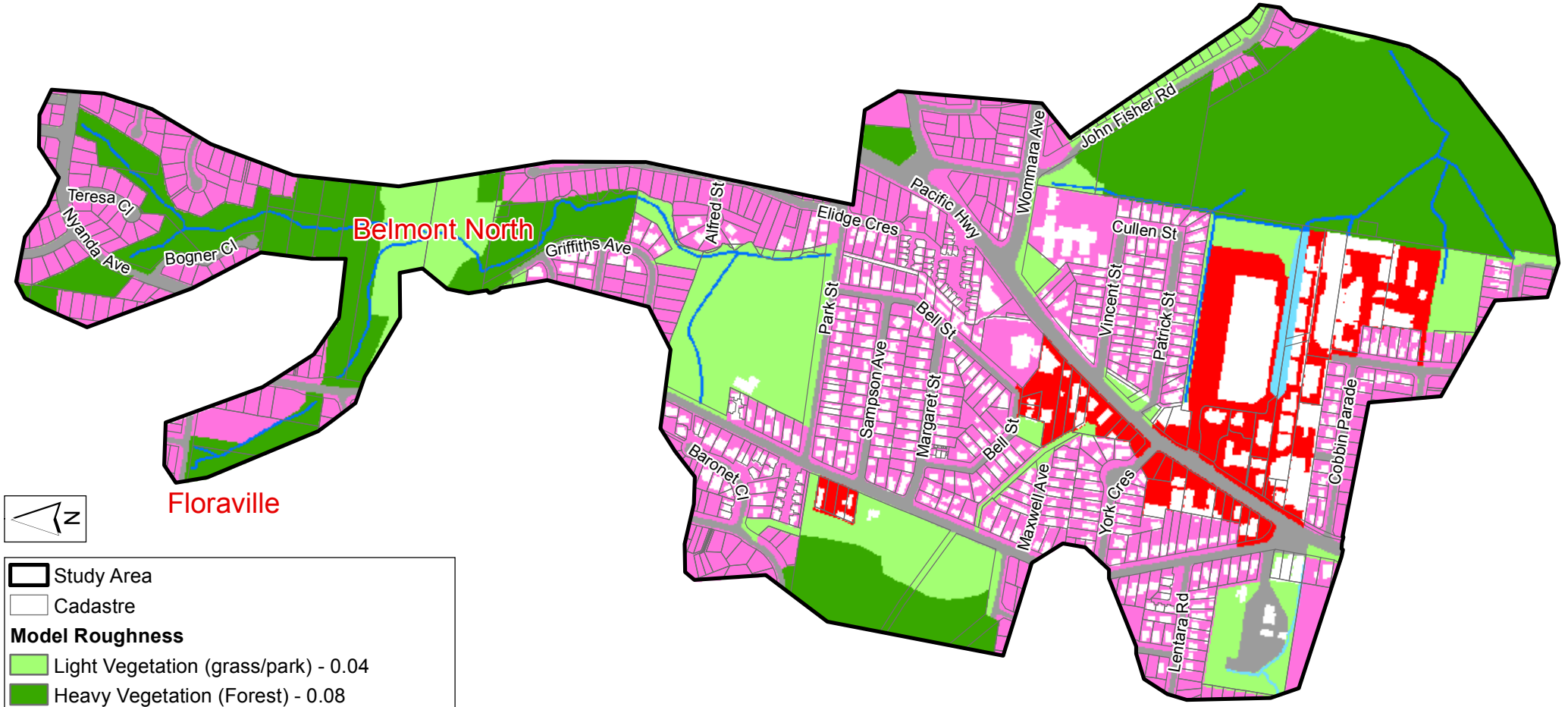
FIGURE 5B
**HYDRAULIC MODEL ROUGHNESS**
**SHEPPARDS CREEK**




J:\Jobs\119076\ArcGIS\ArcMap\Report\Figure05_TUFLOW_roughness\Figure05_B_Hydraulic_Model_Roughness_Sheppards_Creek.mxd

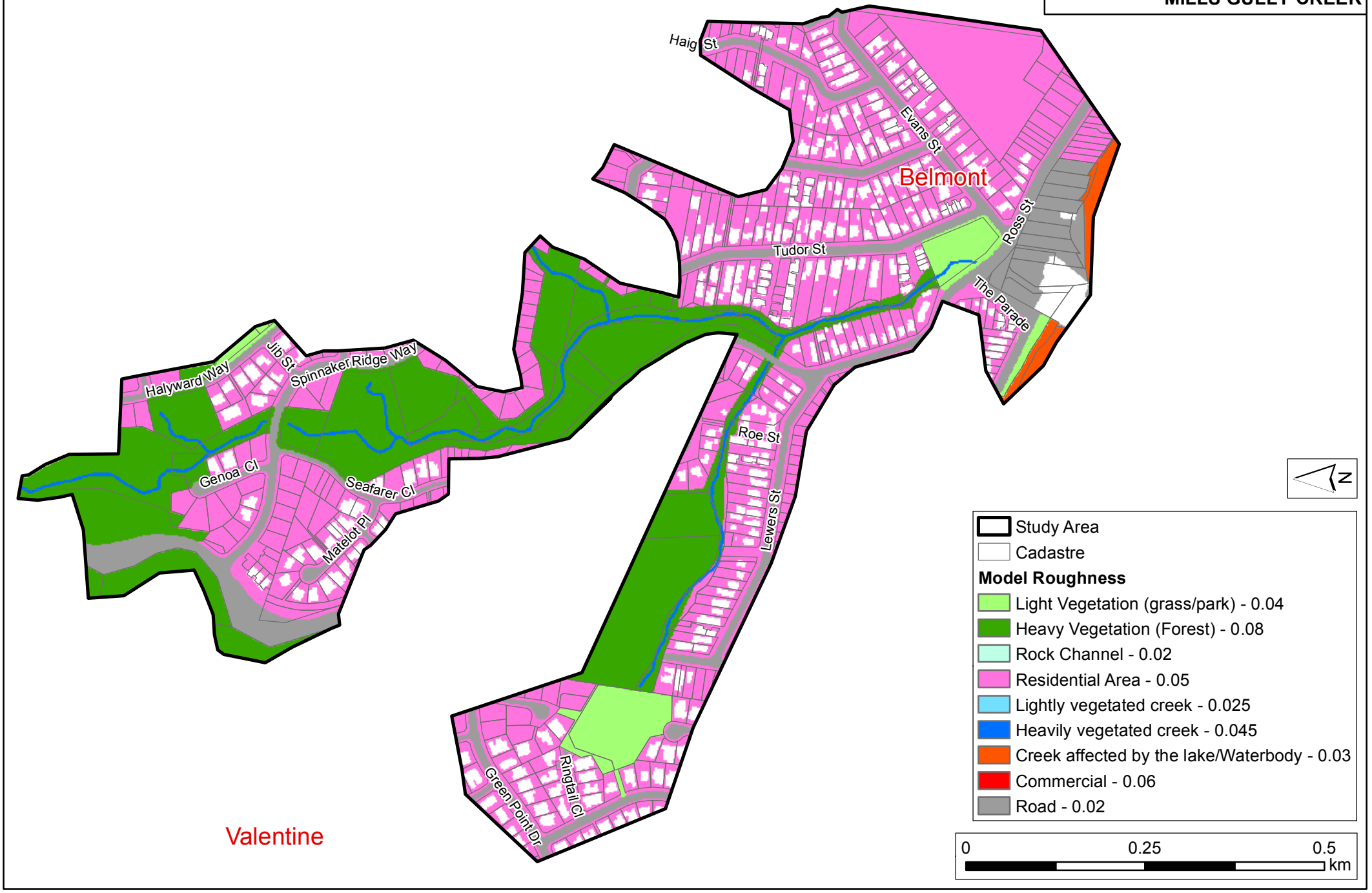
FIGURE 5C

**HYDRAULIC MODEL ROUGHNESS**
**MURABAN CREEK**




J:\Jobs\119076\ArcGIS\ArcMap\Report\Figure05_TUFLOW_roughness\Figure05_C_Hydraulic_Model_Roughness_Muraban_Creek.mxd

FIGURE 5D
**HYDRAULIC MODEL ROUGHNESS**
**MILLS GULLY CREEK**



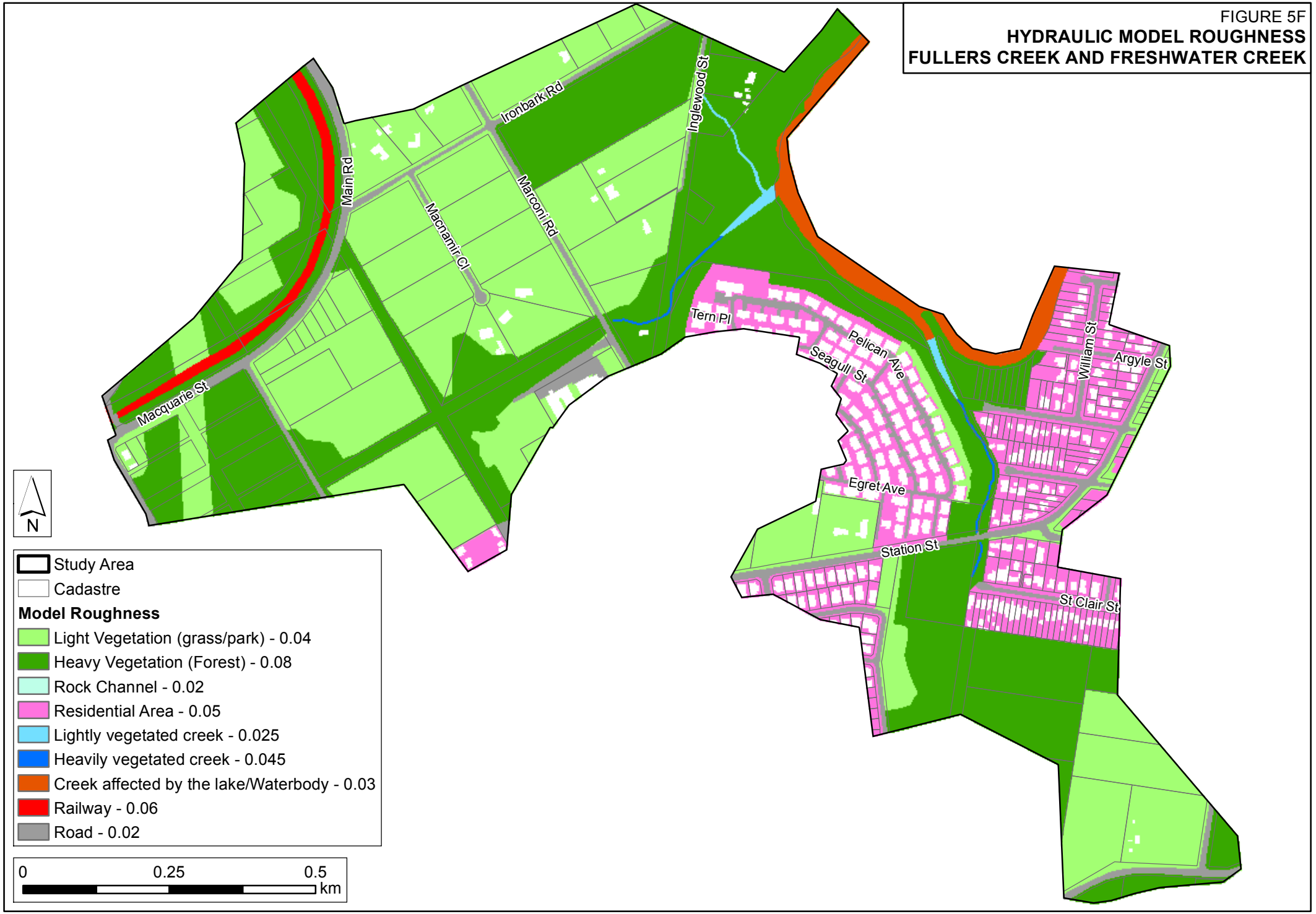

J:\Jobs\11907\6\ArcGIS\ArcMap\Report\Figure05_TUFLOW_roughness\Figure05_D_Hydraulic_Model_Roughness_Mills_Gully_Creek.mxd

FIGURE 5E
**HYDRAULIC MODEL ROUGHNESS**
**PUNTEI CREEK**

J:\Jobs\119076\ArcGIS\ArcMap\Report\Figure05_TUFLOW_roughness\Figure05_E_Hydraulic_Model_Roughness_Puntei_Creek.mxd

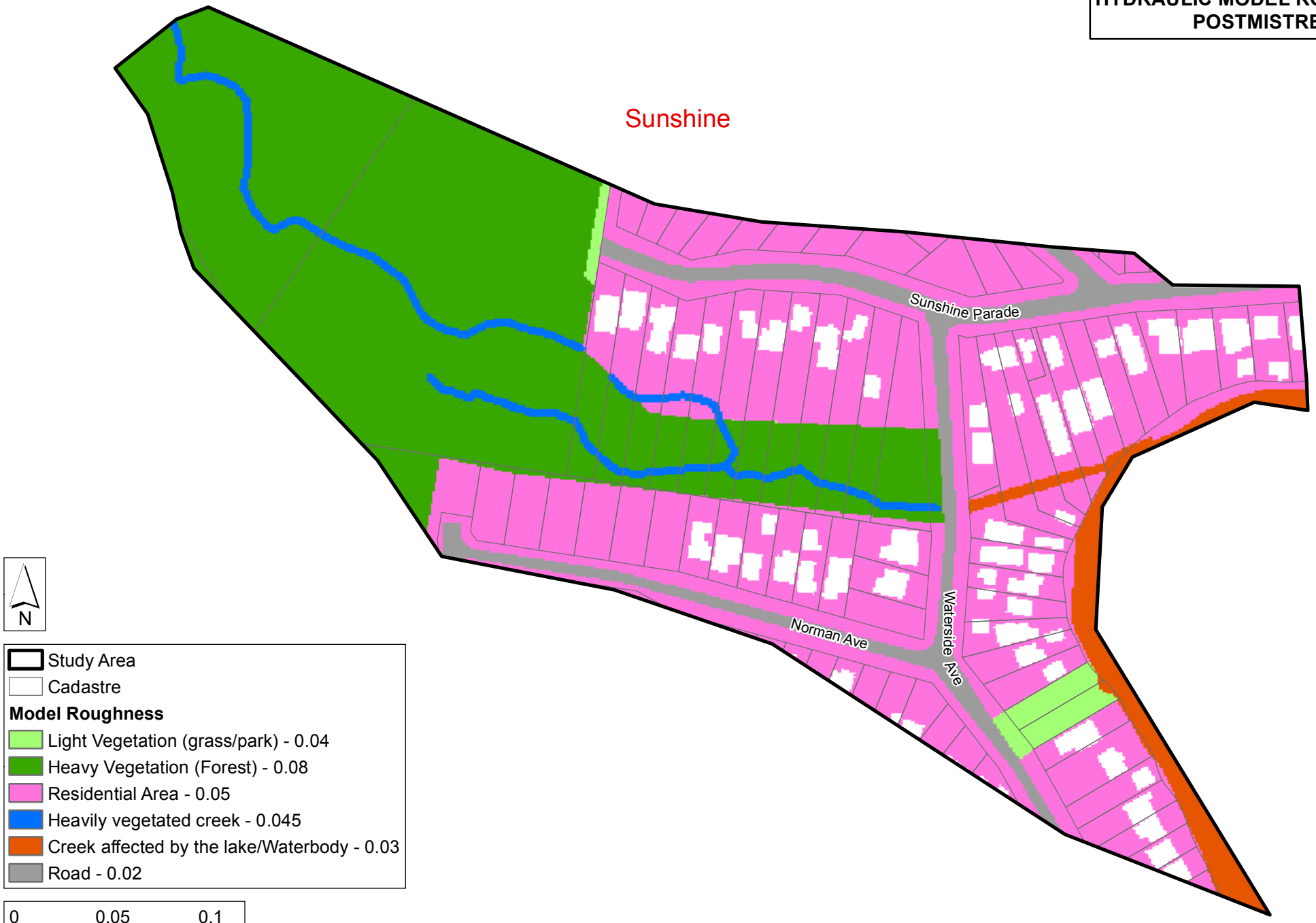
FIGURE 5F

# HYDRAULIC MODEL ROUGHNESS
# FULLERS CREEK AND FRESHWATER CREEK




J:\Jobs\119076\ArcGIS\ArcMap\Report\Main_Report\Figure05_TUFLOW_roughness\Figure05_F_Hydraulic_Model_Roughness_Fullers_Creek_and_Freshwater_Creek.mxd

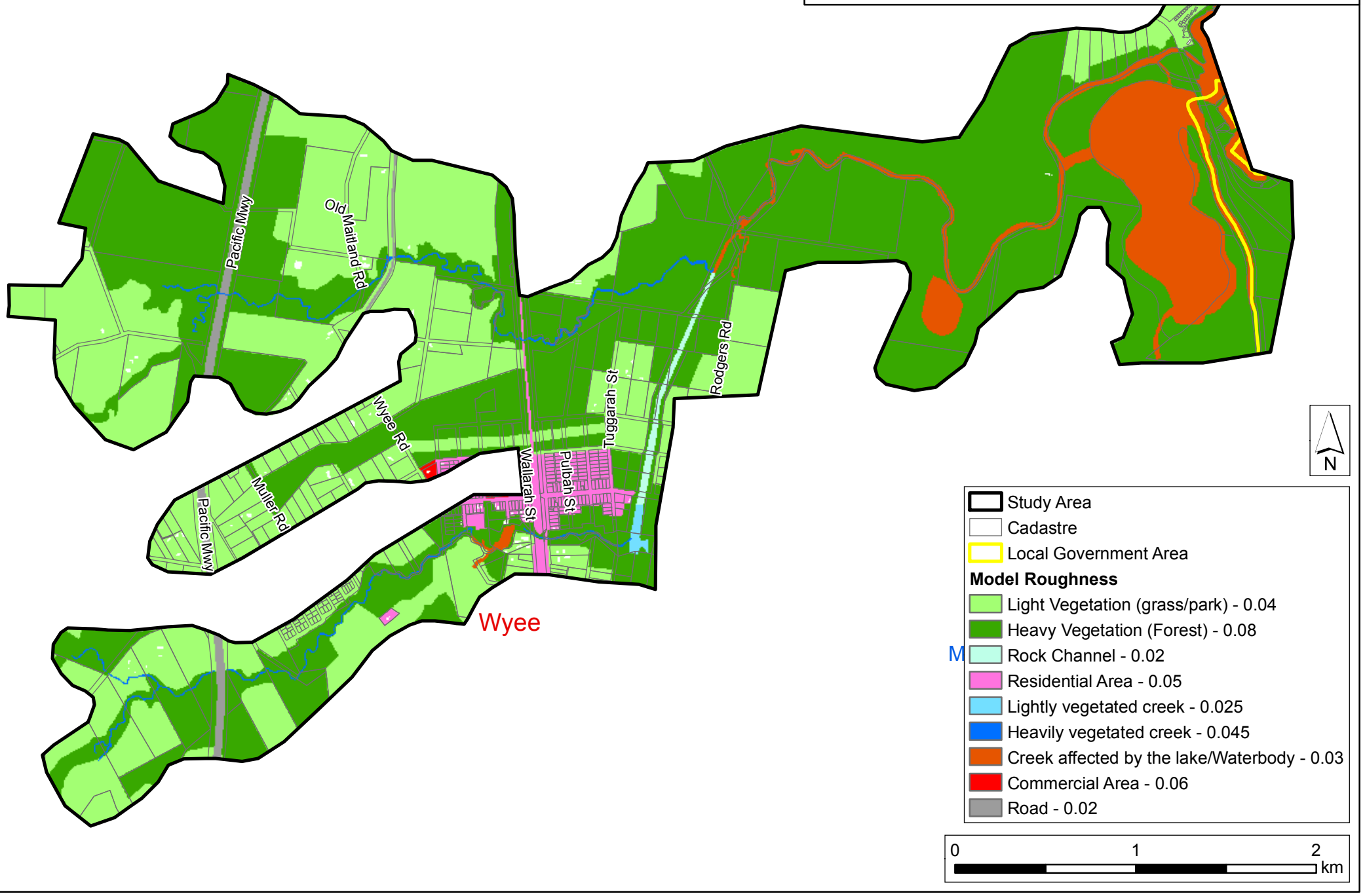
FIGURE 5G
**HYDRAULIC MODEL ROUGHNESS**
**POSTMISTRESS CREEK**




J:\Jobs\119076\ArcGIS\ArcMap\Report\Figure05_TUFLOW_roughness\Figure05_G_Hydraulic_Model_Roughness_Postmistress_Creek.mxd

FIGURE 5H

# HYDRAULIC MODEL ROUGHNESS
# MANNERING CREEK, SWAMPY CREEK AND WYEE CREEK

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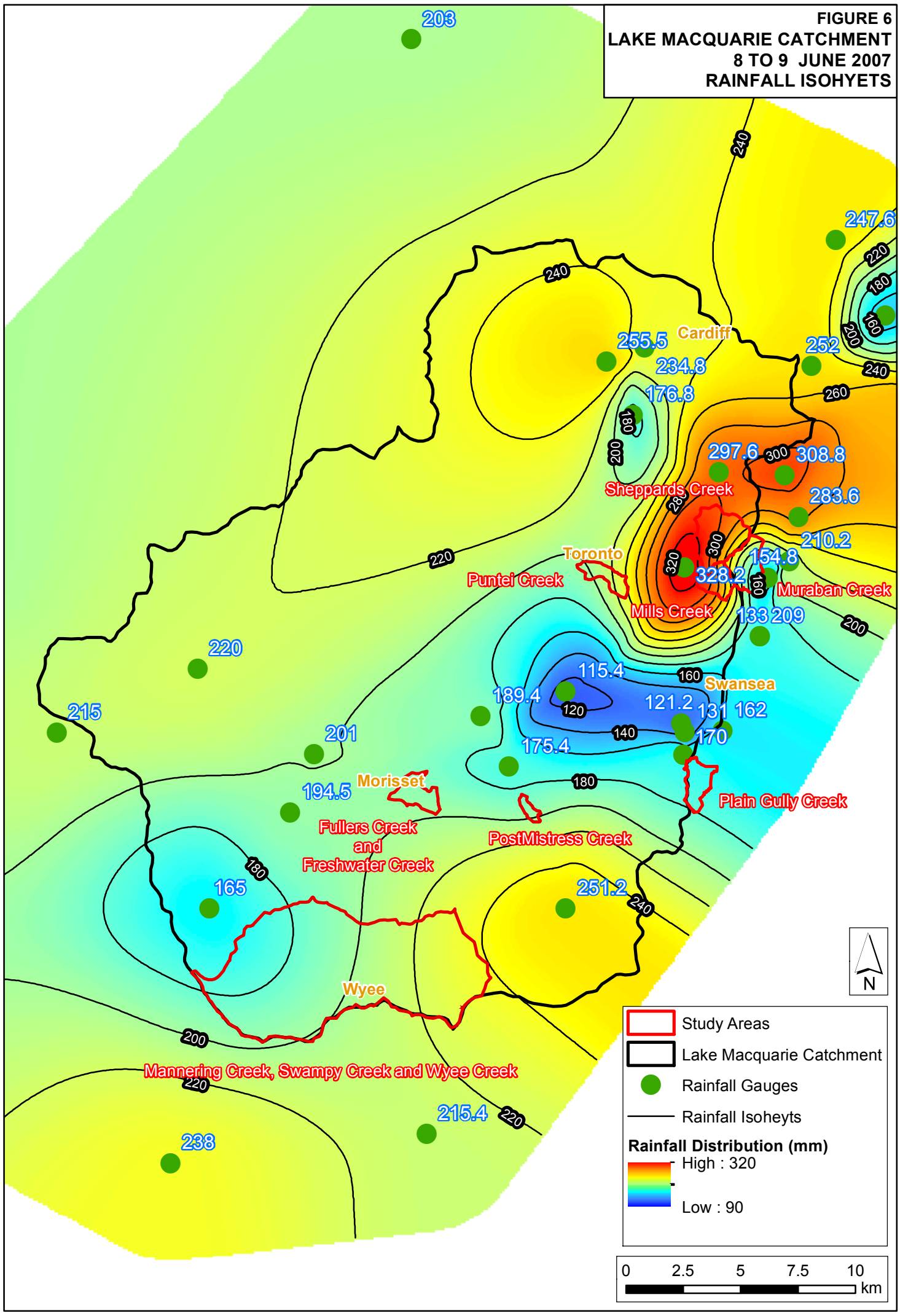


FIGURE 6
LAKE MACQUARIE CATCHMENT
8 TO 9 JUNE 2007
RAINFALL ISOHYETS
203
247.6
255.5
Cardiff
252
234.8
176.8
297.6
308.8
Sheppards Creek
283.6
210.2
Toronto
154.8
328.2
Puntei Creek
Muraban Creek
Mills Creek
133
209
220
215
201
115.4
189.4
121.2
131
162
Swansea
170
175.4
194.5
Morisset
Fullers Creek
and
Freshwater Creek
PostMistress Creek
Plain Gully Creek
165
251.2
Wyee
Mannering Creek, Swampy Creek and Wyee Creek
215.4
238
N
Study Areas
Lake Macquarie Catchment
Rainfall Gauges
Rainfall Isoheyts
Rainfall Distribution (mm)
High : 320
Low : 90
0
2.5
5
7.5
10
km
J:\Jobs\119076\ArcGIS\ArcMap\Report\Main_Report\Figure06_09_Isohyets\Figure06_2007_Isohyets.mxd

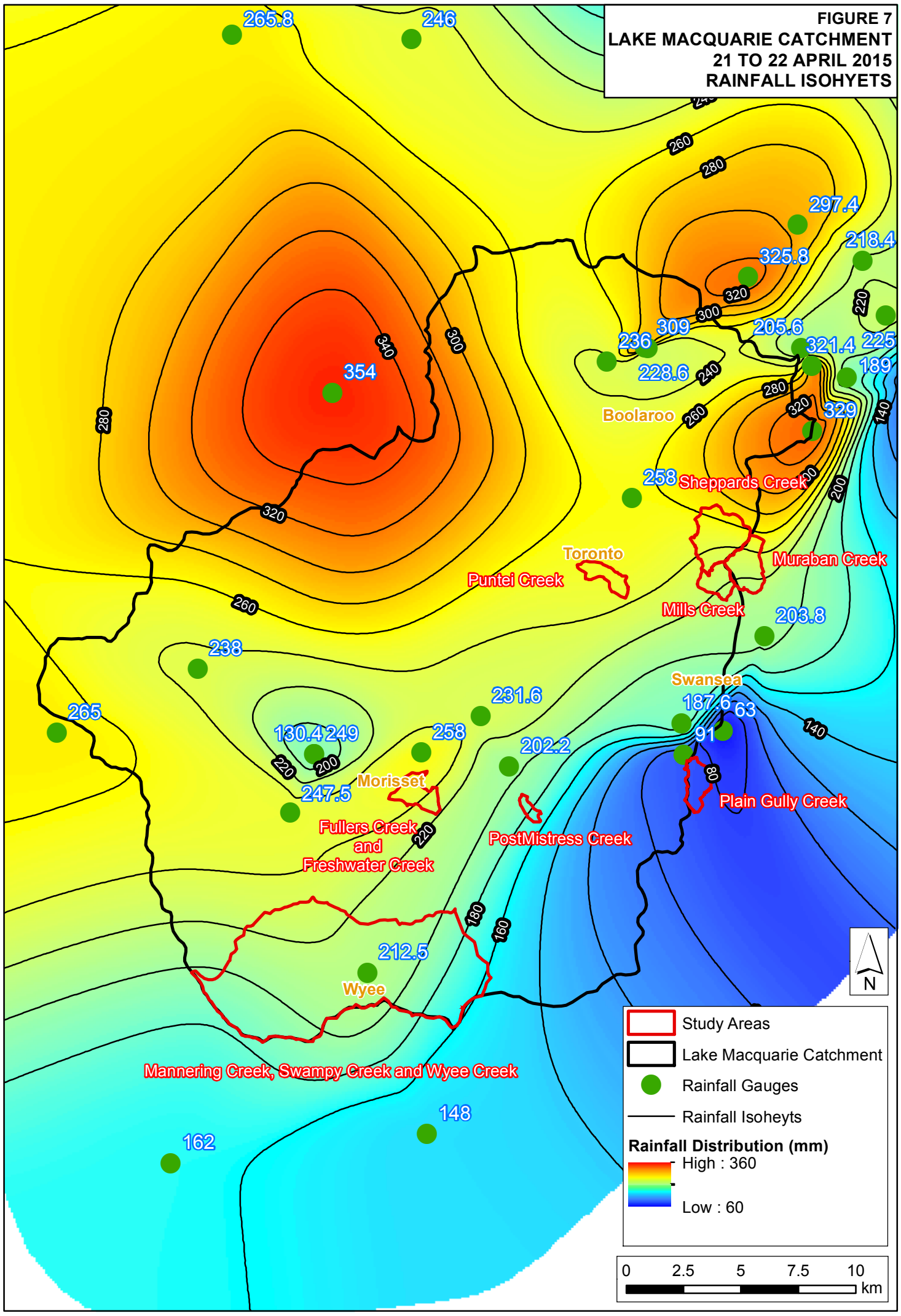
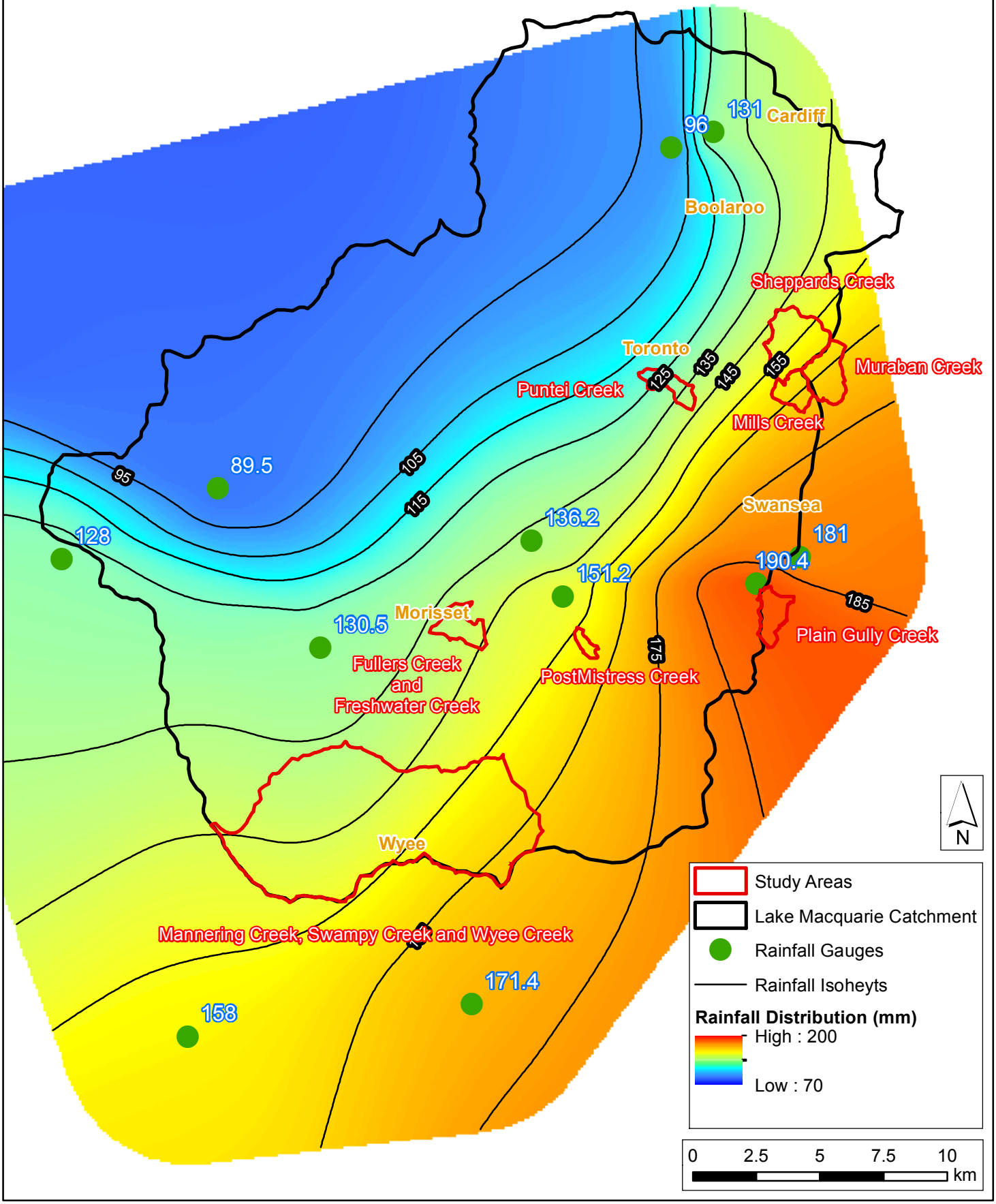


FIGURE 7
LAKE MACQUARIE CATCHMENT
21 TO 22 APRIL 2015
RAINFALL ISOHYETS
265.8
246
297.4
218.4
325.8
205.6
321.4
225
189
309
236
228.6
354
329
Boolaroo
258
Sheppards Creek
Toronto
Puntei Creek
Muraban Creek
Mills Creek
203.8
238
265
231.6
187.6
63
91
130.4
249
258
202.2
247.5
Morisset
Fullers Creek
and
Freshwater Creek
PostMistress Creek
Plain Gully Creek
212.5
Wyee
Mannering Creek, Swampy Creek and Wyee Creek
148
162
Swansea
N
Study Areas
Lake Macquarie Catchment
Rainfall Gauges
Rainfall Isoheyts
Rainfall Distribution (mm)
High : 360
Low : 60
0
2.5
5
7.5
10
km
J:\Jobs\119076\ArcGIS\ArcMap\Report\Figure06_09_Isohyets\Figure07_2015_Isohyets.mxd

**FIGURE 8**
**LAKE MACQUARIE CATCHMENT**
**30 TO 31 AUGUST 2019**
**RAINFALL ISOHYETS**

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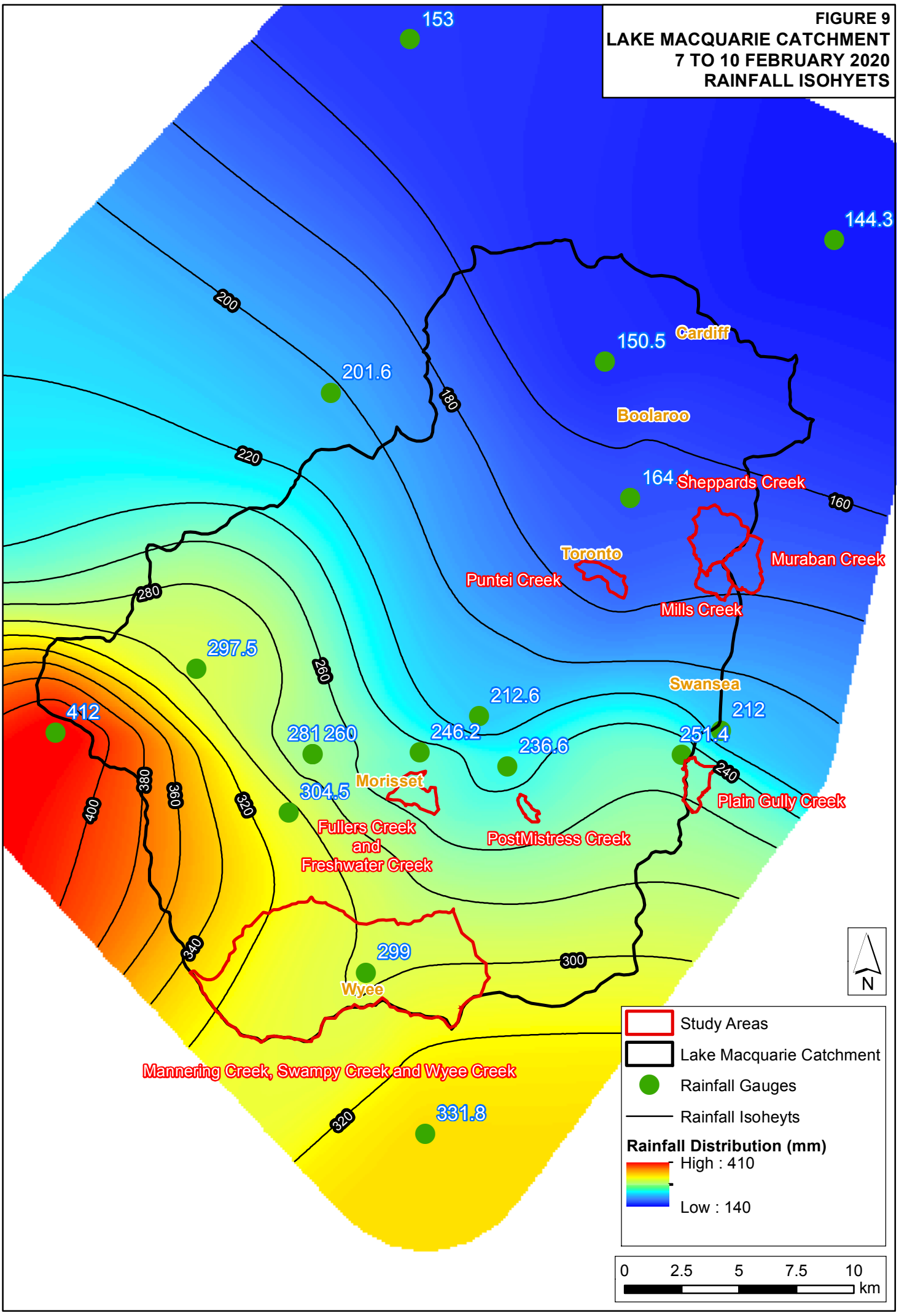
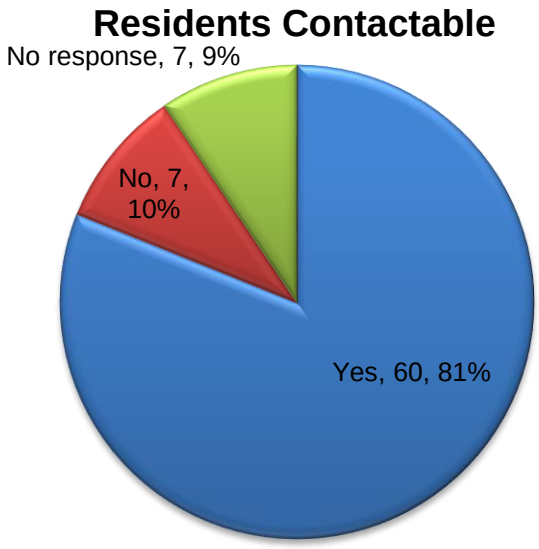
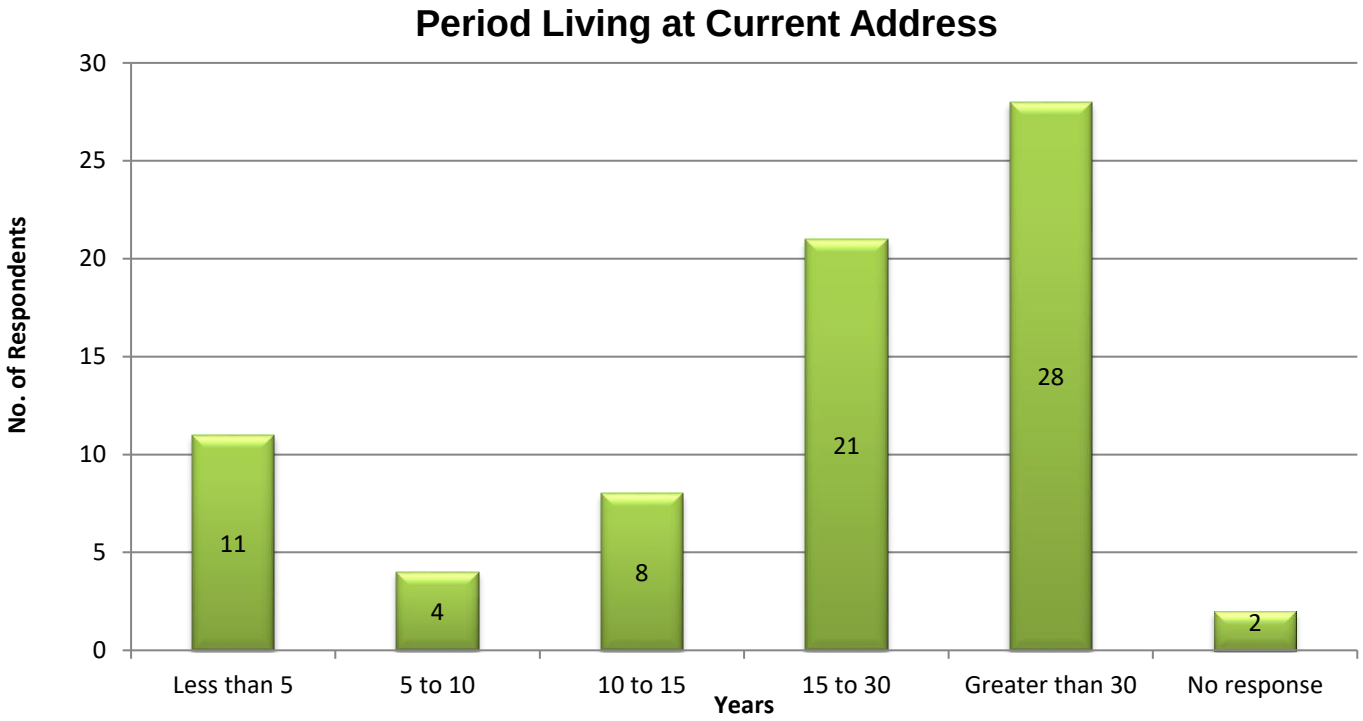


FIGURE 9
LAKE MACQUARIE CATCHMENT
7 TO 10 FEBRUARY 2020
RAINFALL ISOHYETS
153
144.3
150.5
Cardiff
201.6
Boolaroo
164.1
Sheppards Creek
Toronto
Muraban Creek
Puntei Creek
Mills Creek
297.5
Swansea
212.6
212
412
281
260
246.2
236.6
251.4
Morisset
304.5
Plain Gully Creek
Fullers Creek
and
Freshwater Creek
PostMistress Creek
299
Wyee
Mannering Creek, Swampy Creek and Wyee Creek
331.8
200
180
220
160
280
260
240
400
380
360
320
340
300
320
N
Study Areas
Lake Macquarie Catchment
Rainfall Gauges
Rainfall Isoheyts
Rainfall Distribution (mm)
High : 410
Low : 140
0
2.5
5
7.5
10
km
J:\Jobs\119076\ArcGIS\ArcMap\Report\Main_Report\Figure06_09_Isohyets\Figure09_2020_Isohyets.mxd

FIGURE 10
**COMMUNITY CONSULTATION RESPONSES**



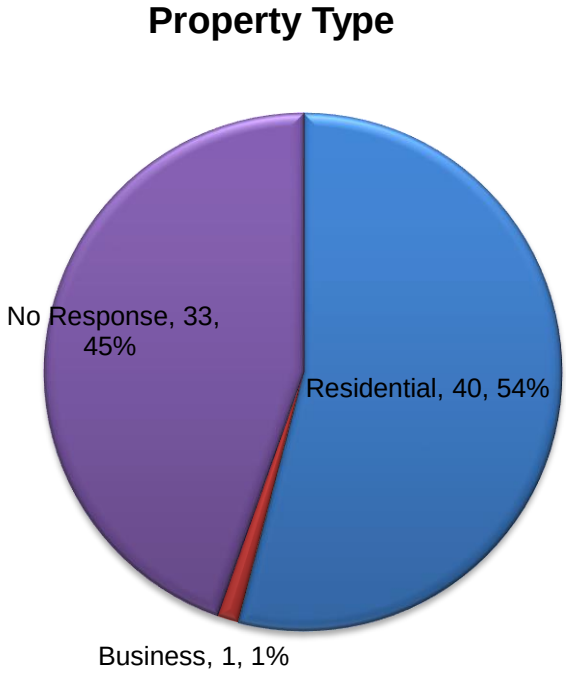
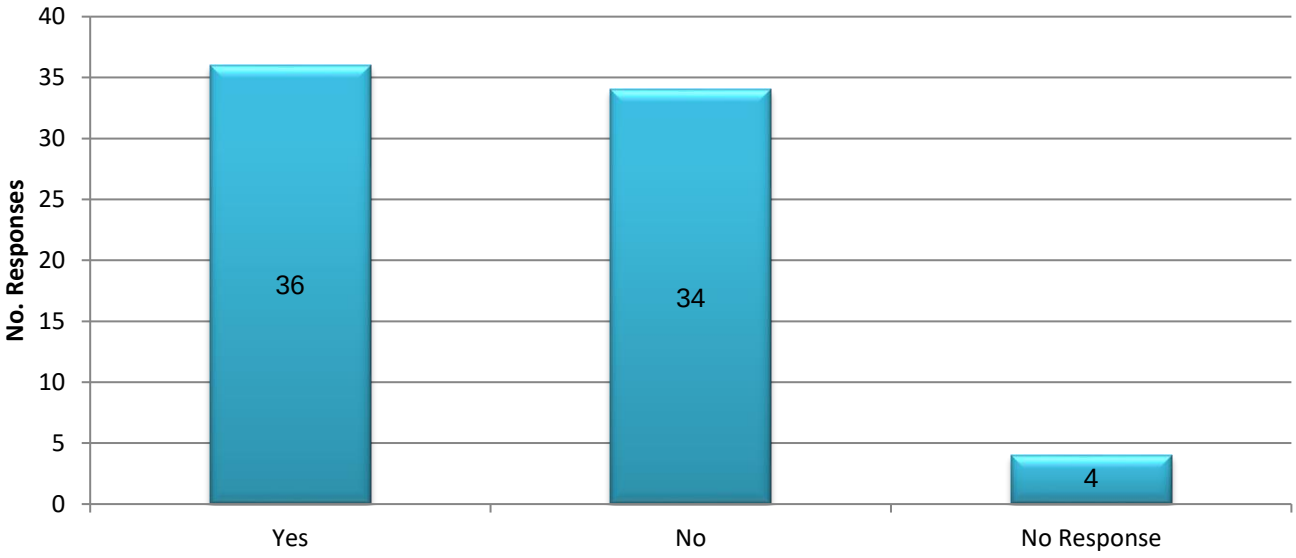
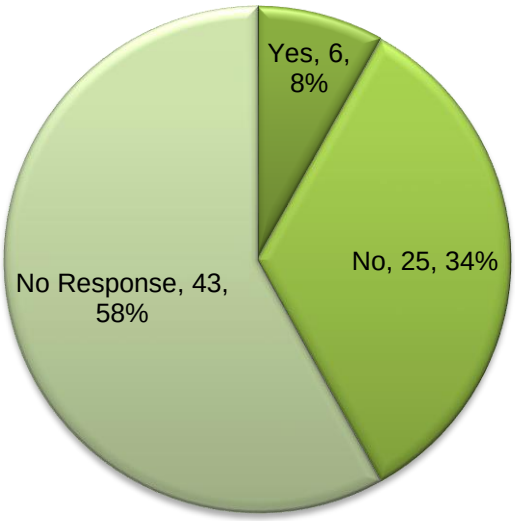



FIGURE 11
**COMMUNITY CONSULTATION RESPONSES**

## Properties Affected by Flooding




## Properties Flooded Above Floor Level




## Properties that Experienced Flood Damage

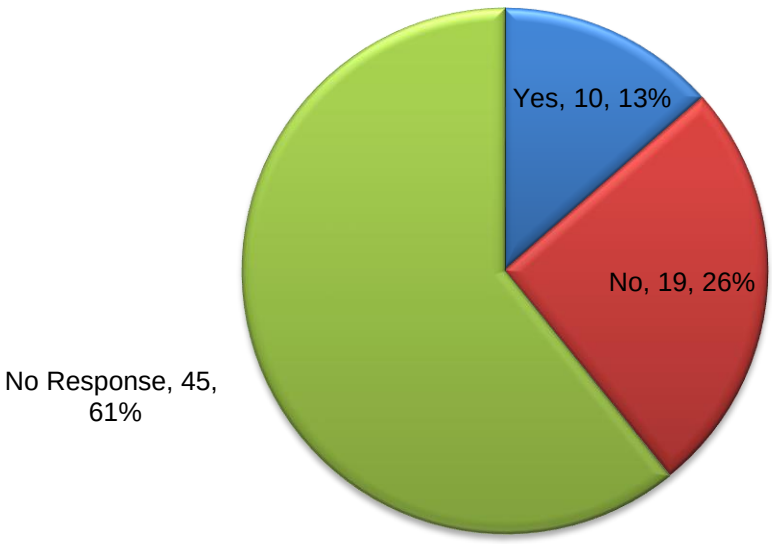
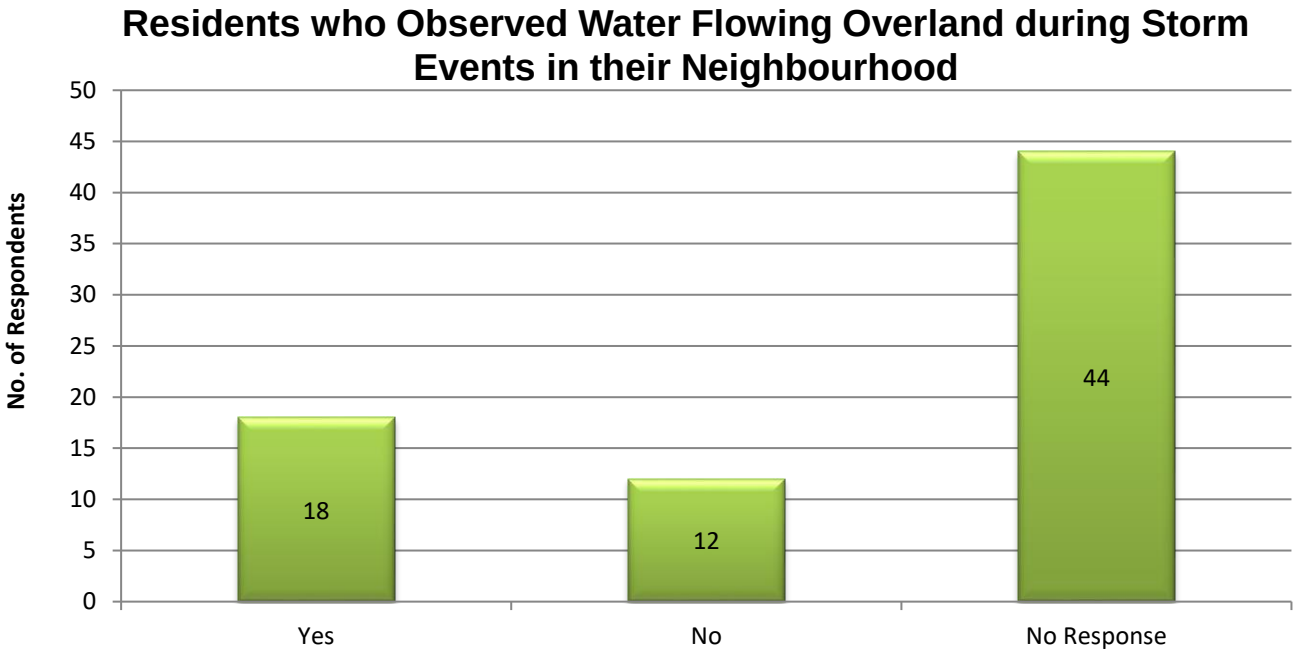
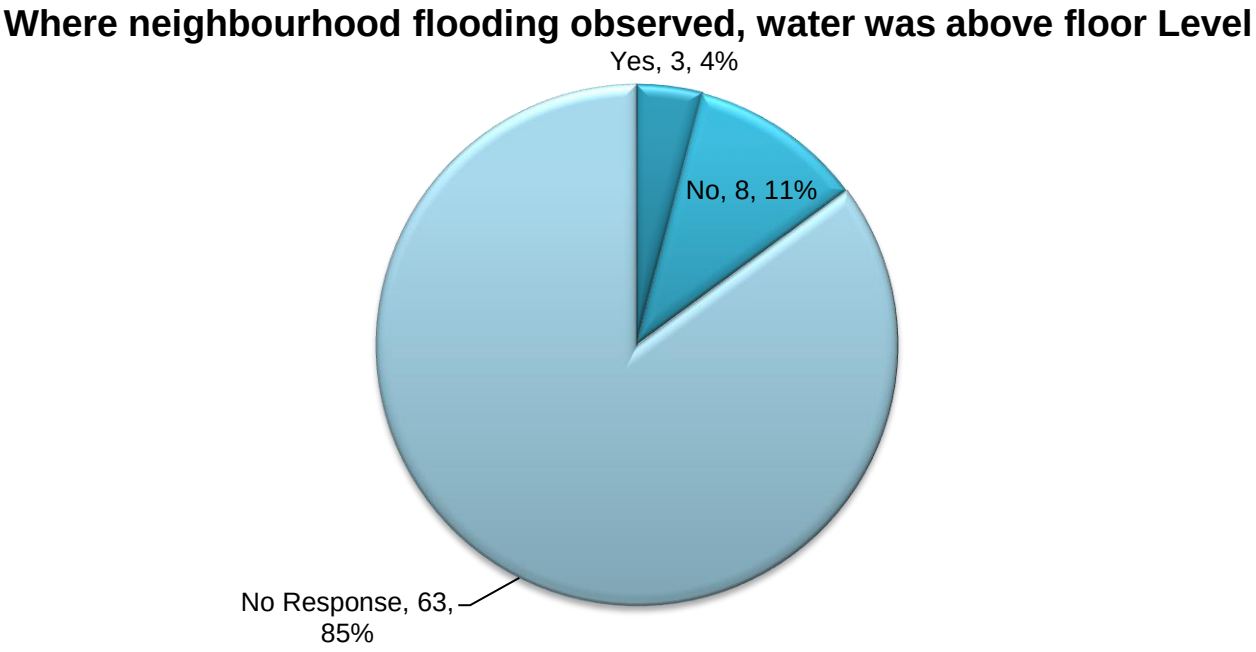


FIGURE 12
**COMMUNITY CONSULTATION RESPONSES**



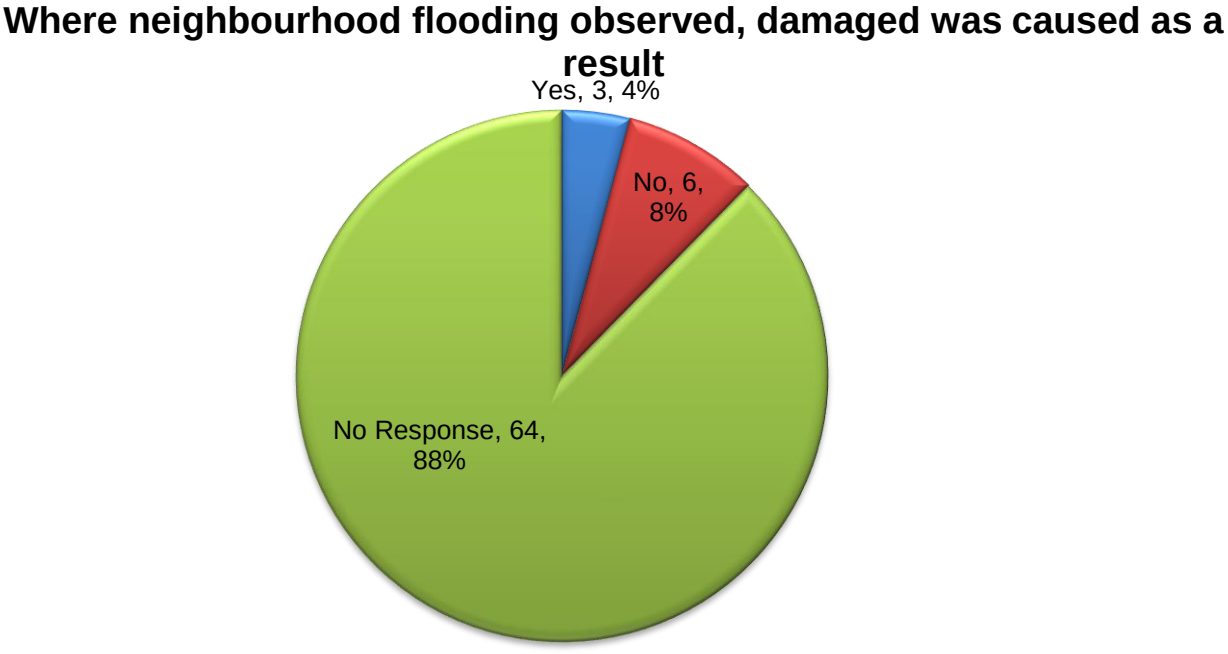
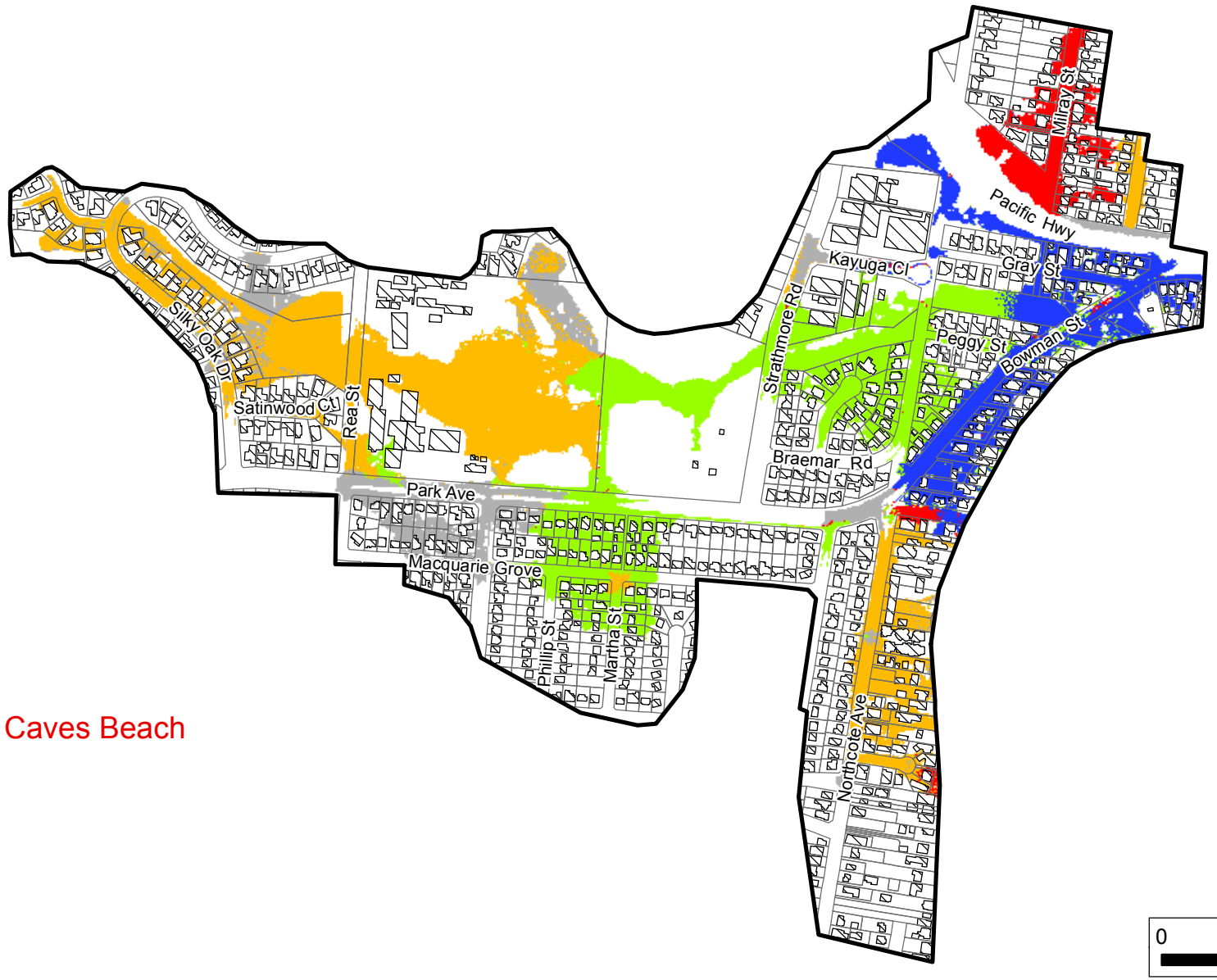
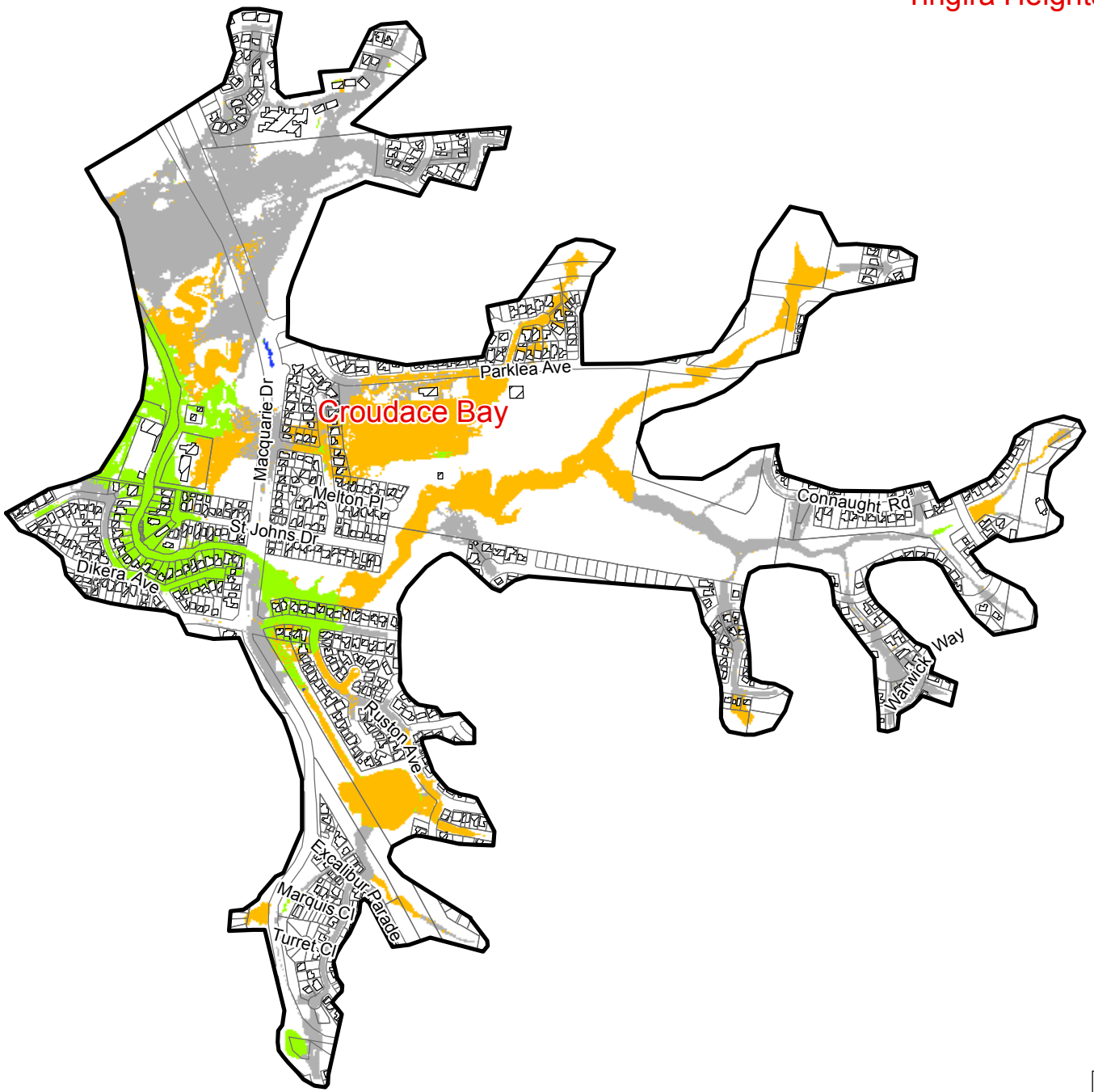



FIGURE 13A
**PLAINS GULLY CREEK**
**CRITICAL DURATION**
**1% AEP EVENT**



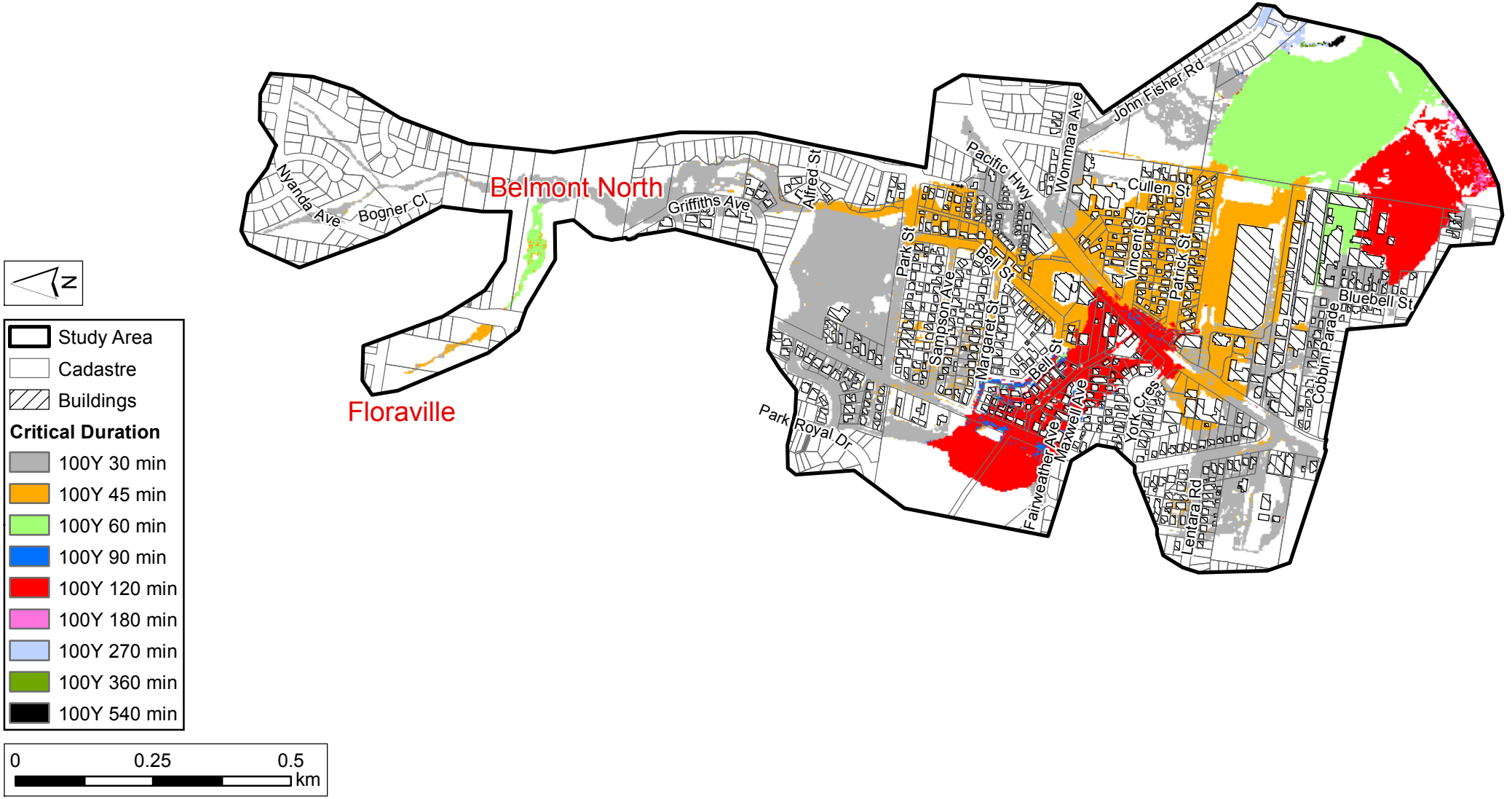

J:\Jobs\119076\ArcGIS\ArcMap\Report\Main_Report\Figure13_critical_duration_100Y\Figure13A_Plains_Gully_Creek_Critical_Duration_100Y.mxd

FIGURE 13B
**SHEPPARDS CREEK**
**CRITICAL DURATION**
**1% AEP EVENT**



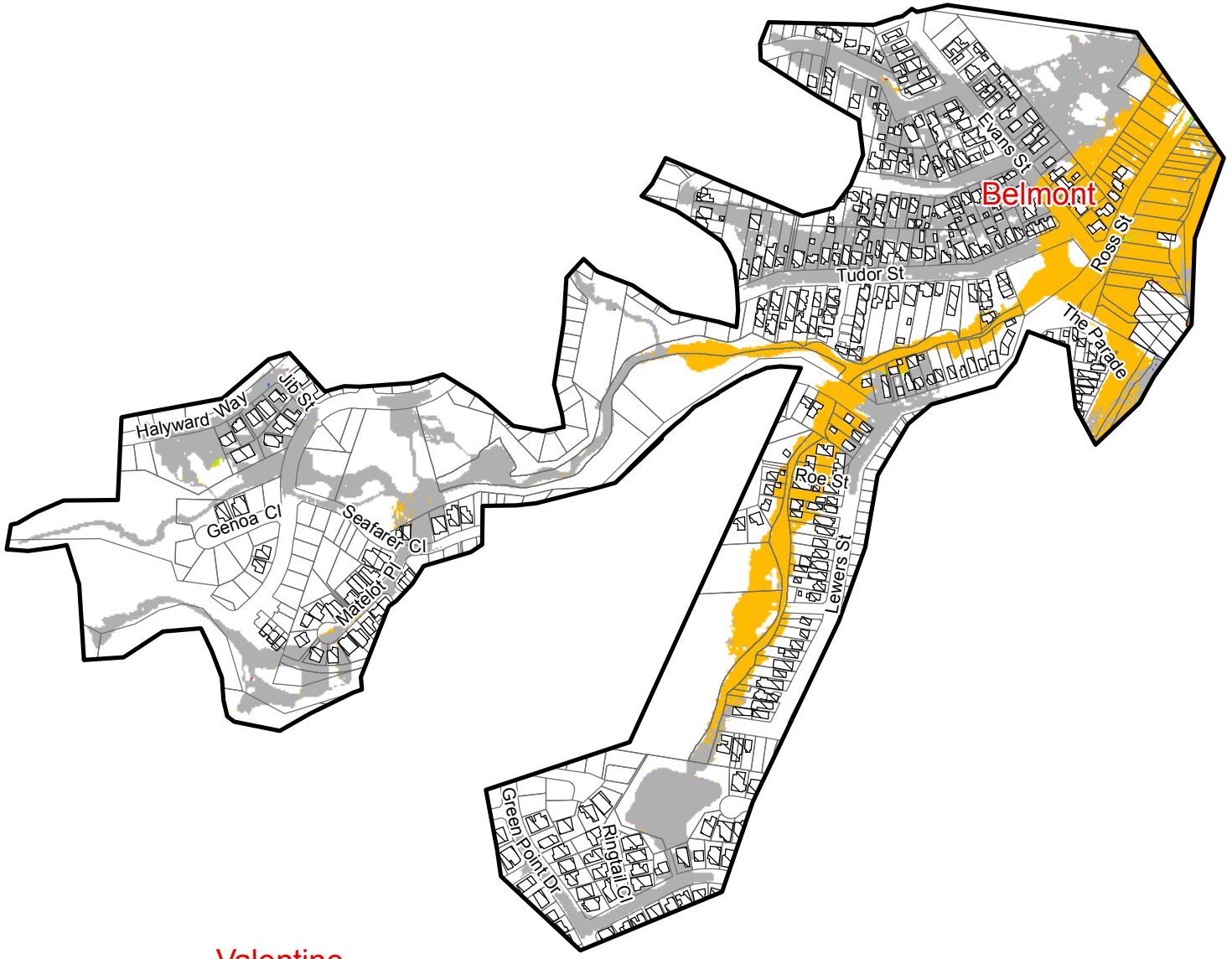

J:\Jobs\119076\ArcGIS\ArcMap\Report\Figure13_critical_duration_100Y\Figure13B_Sheppards_Creek_Critical_Duration_100Y.mxd

FIGURE 13C
**MURABAN CREEK**
**CRITICAL DURATION**
**1% AEP EVENT**




J:\Jobs\119076\ArcGIS\ArcMap\Report\Main_Report\Figure13_critical_duration_100Y\Figure13C_Muraban_Creek_Critical_Duration_100Y.mxd

FIGURE 13D
**MILLS CREEK**
**CRITICAL DURATION**
**1% AEP EVENT**




N

Study Area
Buildings
Cadastre

**Critical Duration**

100Y 30 min
100Y 45 min
100Y 60 min
100Y 90 min
100Y 120 min

0 0.25 0.5 km

J:\Jobs\119076\ArcGIS\ArcMap\Report\Main_Report\Figure13_critical_duration_100Y\Figure13D_Mills_Creek_Critical_Duration_100Y.mxd

FIGURE 13E
**PUNTEI CREEK**
**CRITICAL DURATION**
**1% AEP EVENT**

J:\Jobs\119076\ArcGIS\ArcMap\Report\Main_Report\Figure13_critical_duration_100Y\Figure13E_Puntei_Creek_Critical_Duration_100Y.mxd

FIGURE 13F

**FULLERS CREEK AND FRESHWATER CREEK**
**CRITICAL DURATION**
**1% AEP EVENT**

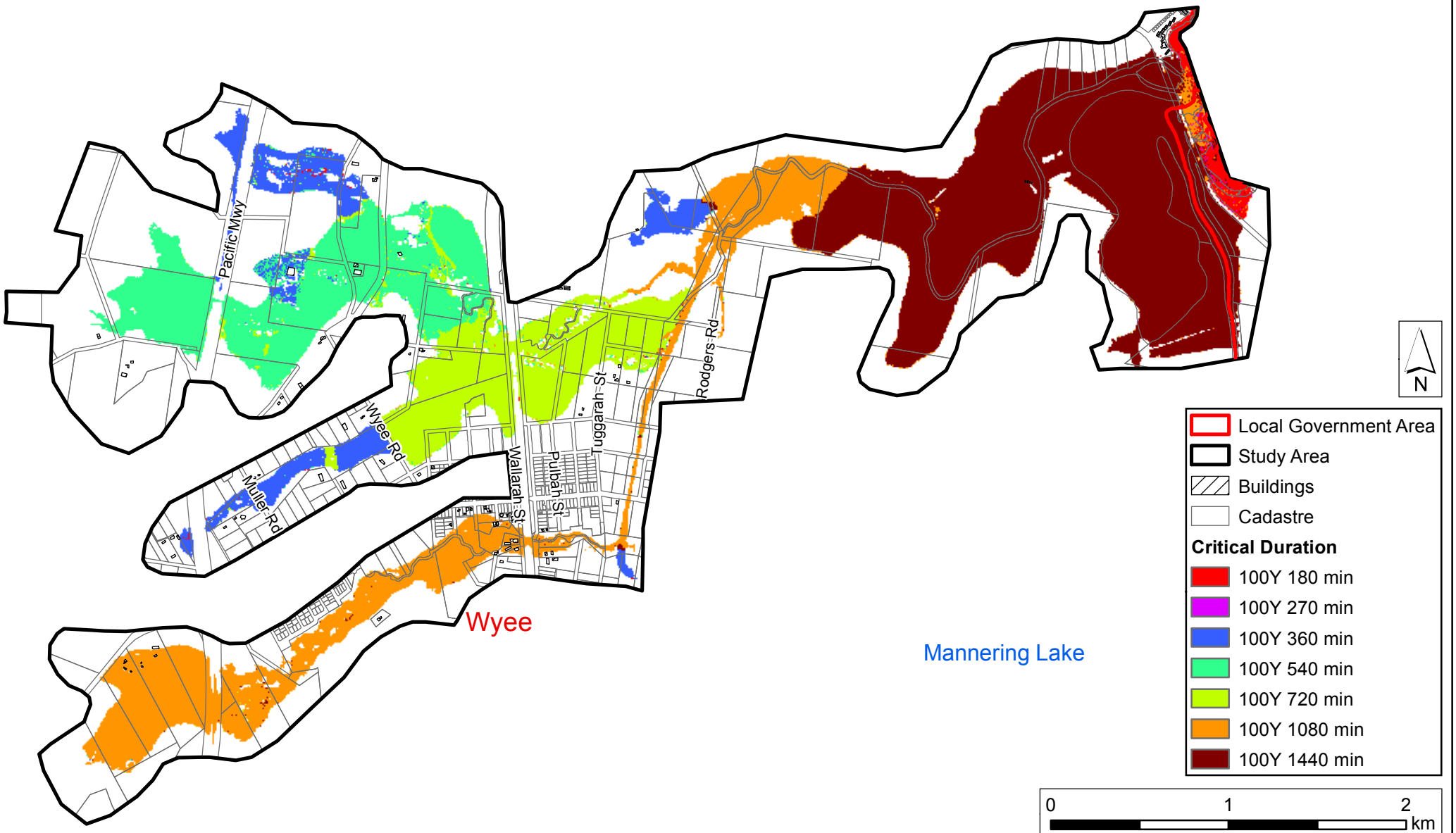
J:\Jobs\119076\ArcGIS\ArcMap\Report\Main_Report\Figure13_critical_duration_100Y\Figure13F_FFC_Critical_Duration_100Y.mxd

FIGURE 13G
**POSTMISTRESS CREEK**
**CRITICAL DURATION**
**1% AEP EVENT**

J:\Jobs\119076\ArcGIS\ArcMap\Report\Figure13_critical_duration_100Y\Figure13G_PMC_Critical_Duration_100Y.mxd

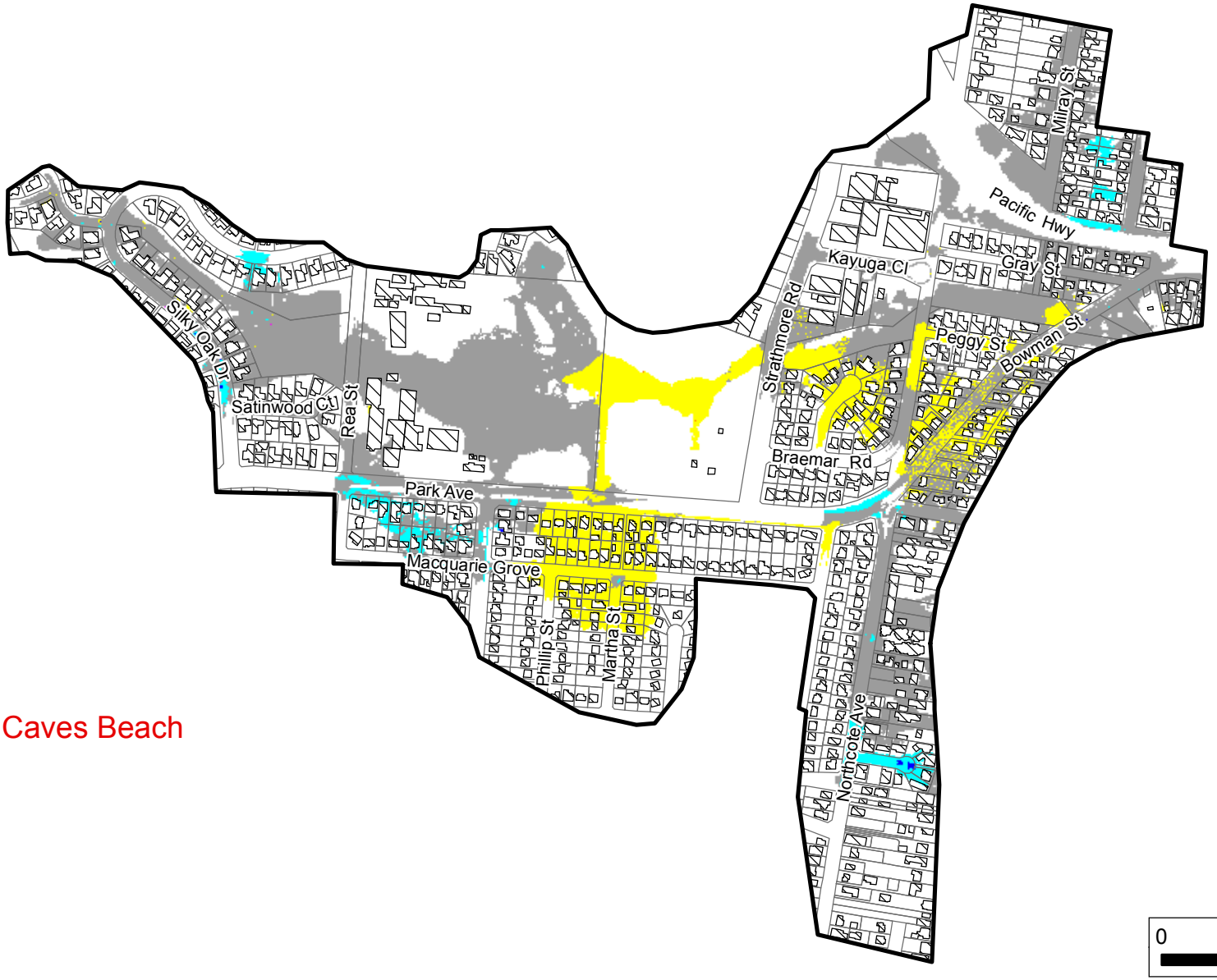
FIGURE 13H

**MANNERING CREEK, SWAMPY CREEK AND WYEE CREEK**
**CRITICAL DURATION**
**1% AEP EVENT**




J:\Jobs\119076\ArcGIS\ArcMap\Report\Main_Report\Figure13_critical_duration_100Y\Figure13H_MSWC_Critical_Duration_100Y.mxd

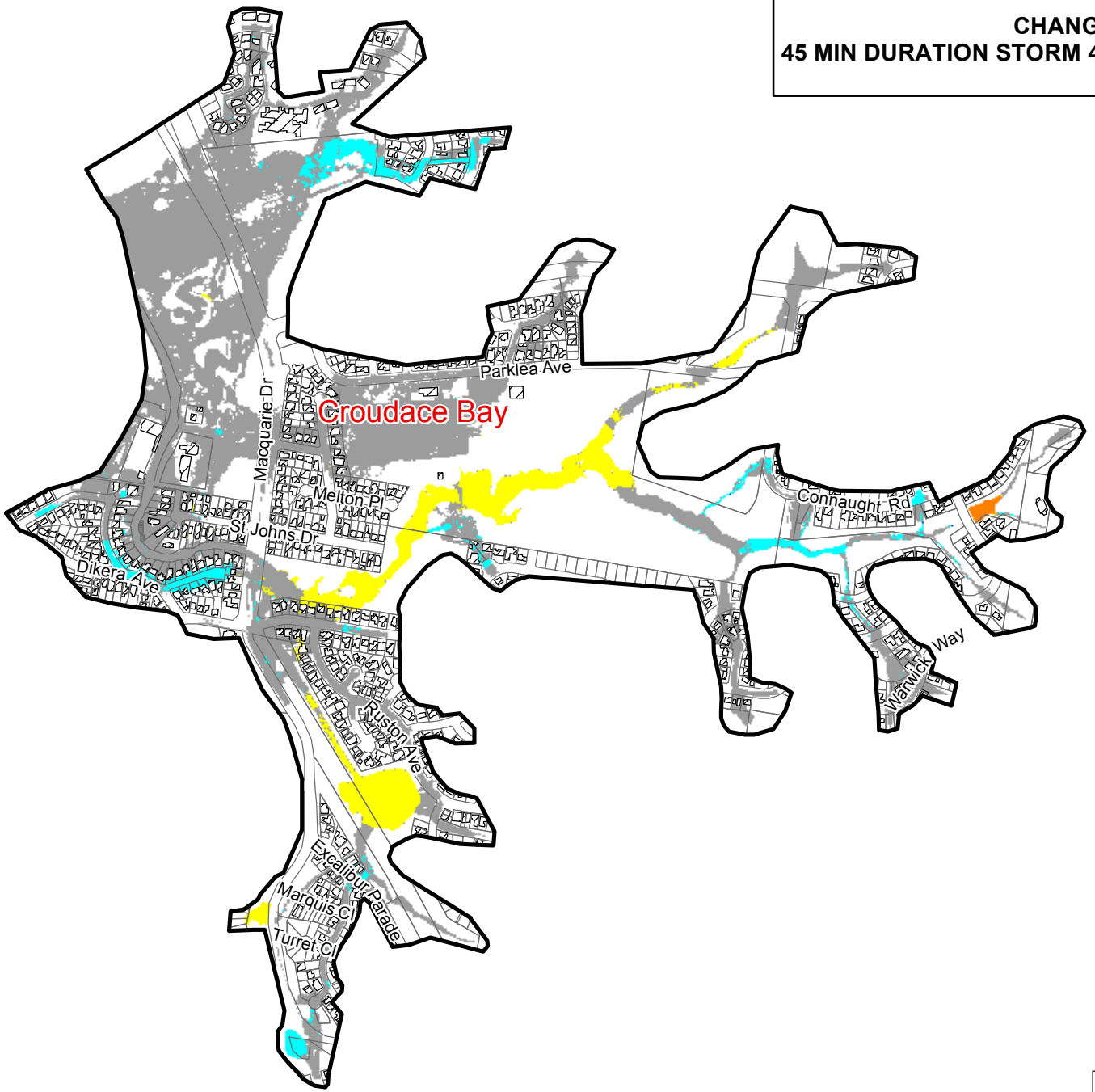
FIGURE 14A
**PLAINS GULLY CREEK**
**CHANGE IN PEAK FLOOD LEVEL**
**90 MIN DURATION STORM 4395 V MEANS ENVELOPE**
**1% AEP EVENT**




J:\Jobs\119076\ArcGIS\ArcMap\Report\Main_Report\Figure14_Impact_selected_pattern_V_ENV_Medians\Figure14A_Plains_Gully_Creek_impact_100Y_90min_4395VMean.mxd

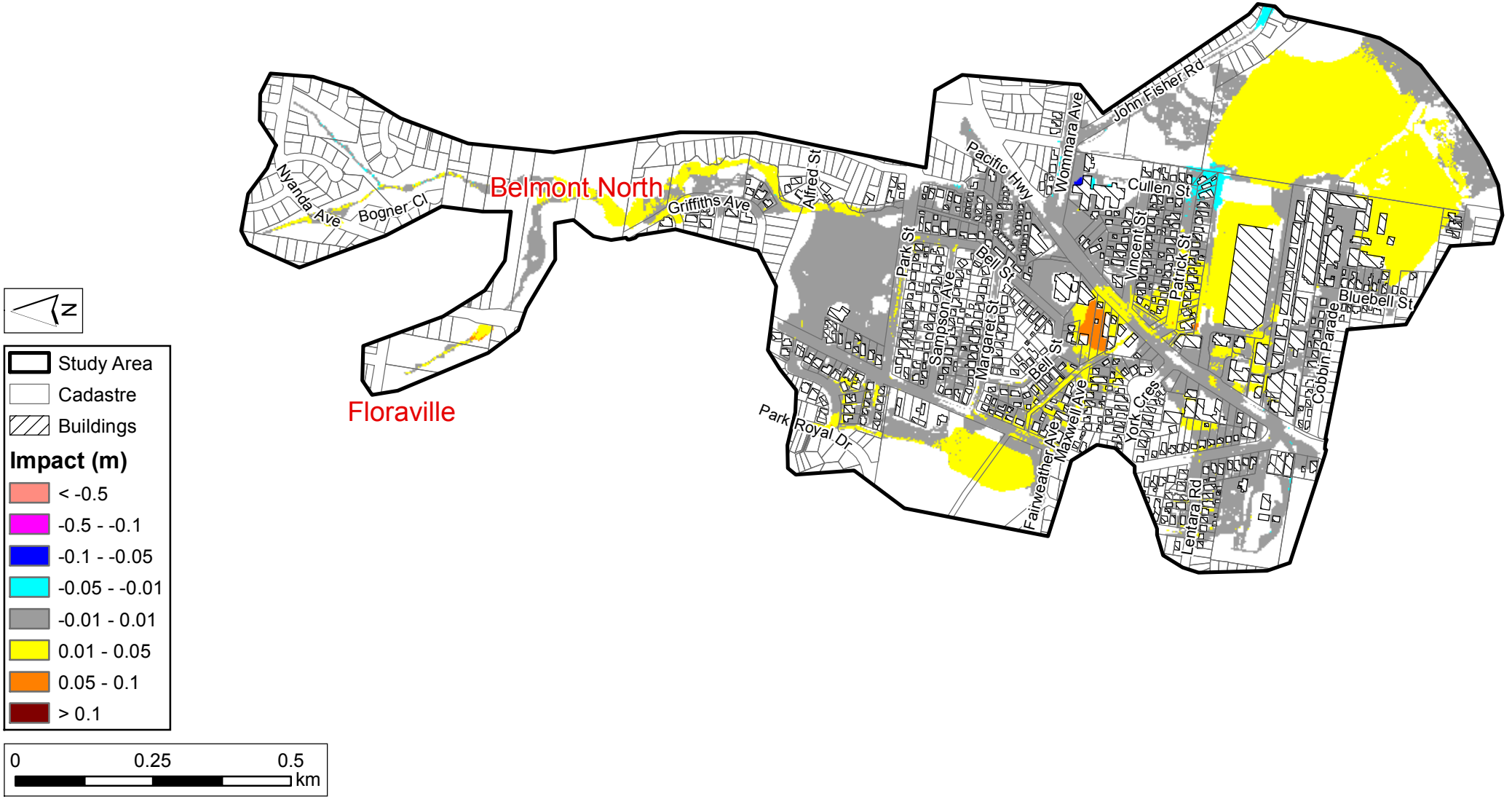
FIGURE 14B

**SHEPPARDS CREEK**
**CHANGE IN PEAK FLOOD LEVEL**
**45 MIN DURATION STORM 4528 V MEANS ENVELOPE**
**1% AEP EVENT**




J:\Jobs\119076\ArcGIS\ArcMap\Report\Figure14_Impact_selected_pattern_V_ENV_Medians\Figure14B_Sheppards_Creek_impact_100Y_45min_4528VMean.mxd

FIGURE 14C
**MURABAN CREEK**
**CHANGE IN PEAK FLOOD LEVEL**
**SELECTED PATTERNS V MEANS ENVELOPE**
**1% AEP EVENT**




J:\Jobs\119076\ArcGIS\ArcMap\Report\Main_Report\Figure14_Impact_selected_pattern_V_ENV_Medians\Figure14C_Muraban_Creek_Impact_100Y_45min_120_VMean.mxd

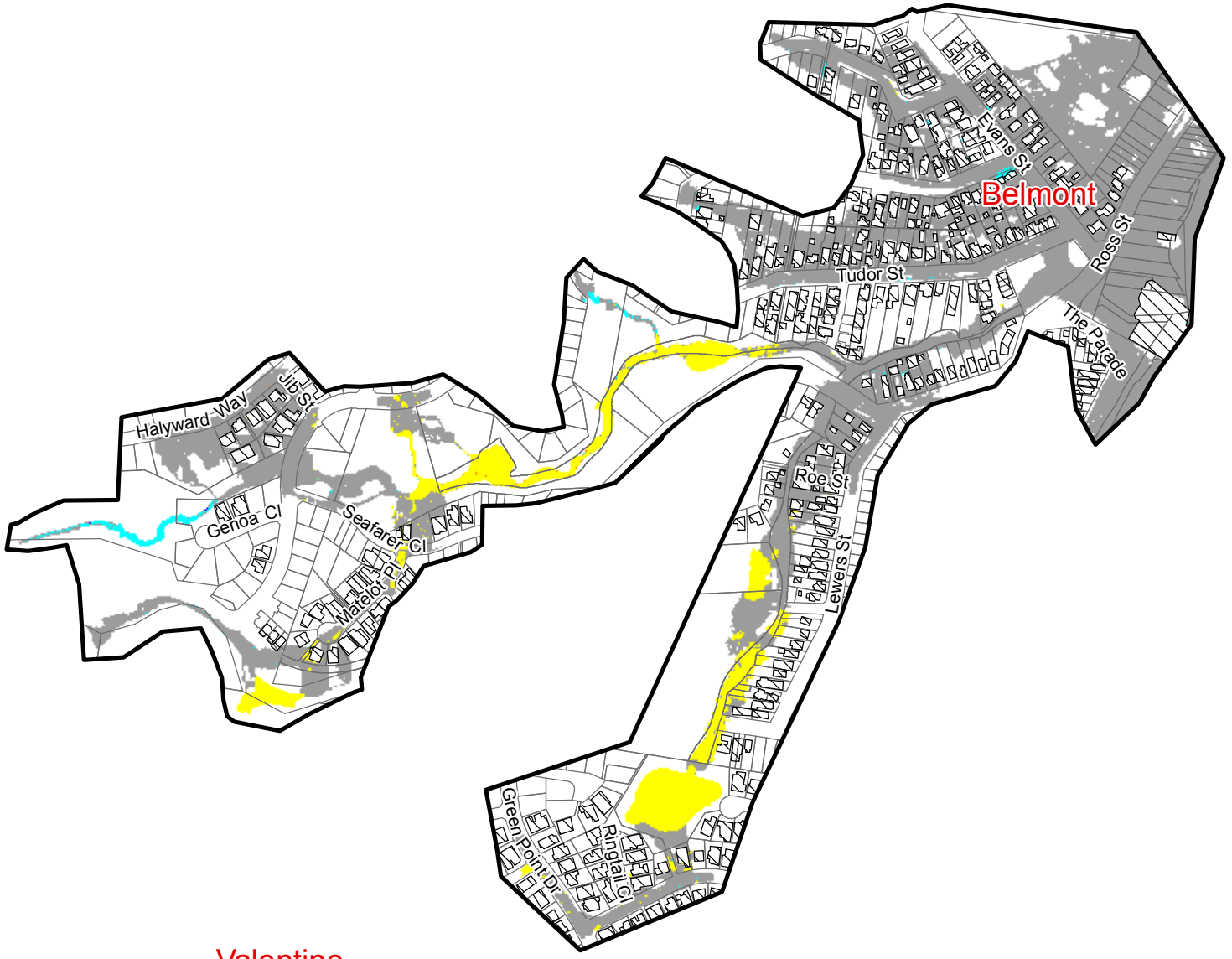
FIGURE 14D

**MILLS CREEK**

**CHANGE IN PEAK FLOOD LEVEL**

**45 MIN DURATION STORM 4534 V MEANS ENVELOPE**

**1% AEP EVENT**




N

Study Area

Buildings

Cadastre

**Imoact (m)**

< -0.5

-0.5 - -0.1

-0.1 - -0.05

-0.05 - -0.01

-0.01 - 0.01

0.01 - 0.05

0.05 - 0.1

> 0.1

0 0.25 0.5 km

J:\Jobs\1190776\ArcGIS\ArcMap\Report\Main_Report\Figure14_Impact_selected_pattern_V_ENV_Medians\Figure14D_Mills_Creek_impact_100Y_45min_4534VMean.mxd

FIGURE 14E

**PUNTEI CREEK**

**CHANGE IN PEAK FLOOD LEVEL**

**60 MIN DURATION STORM 4463 V MEANS ENVELOPE**

**1% AEP EVENT**

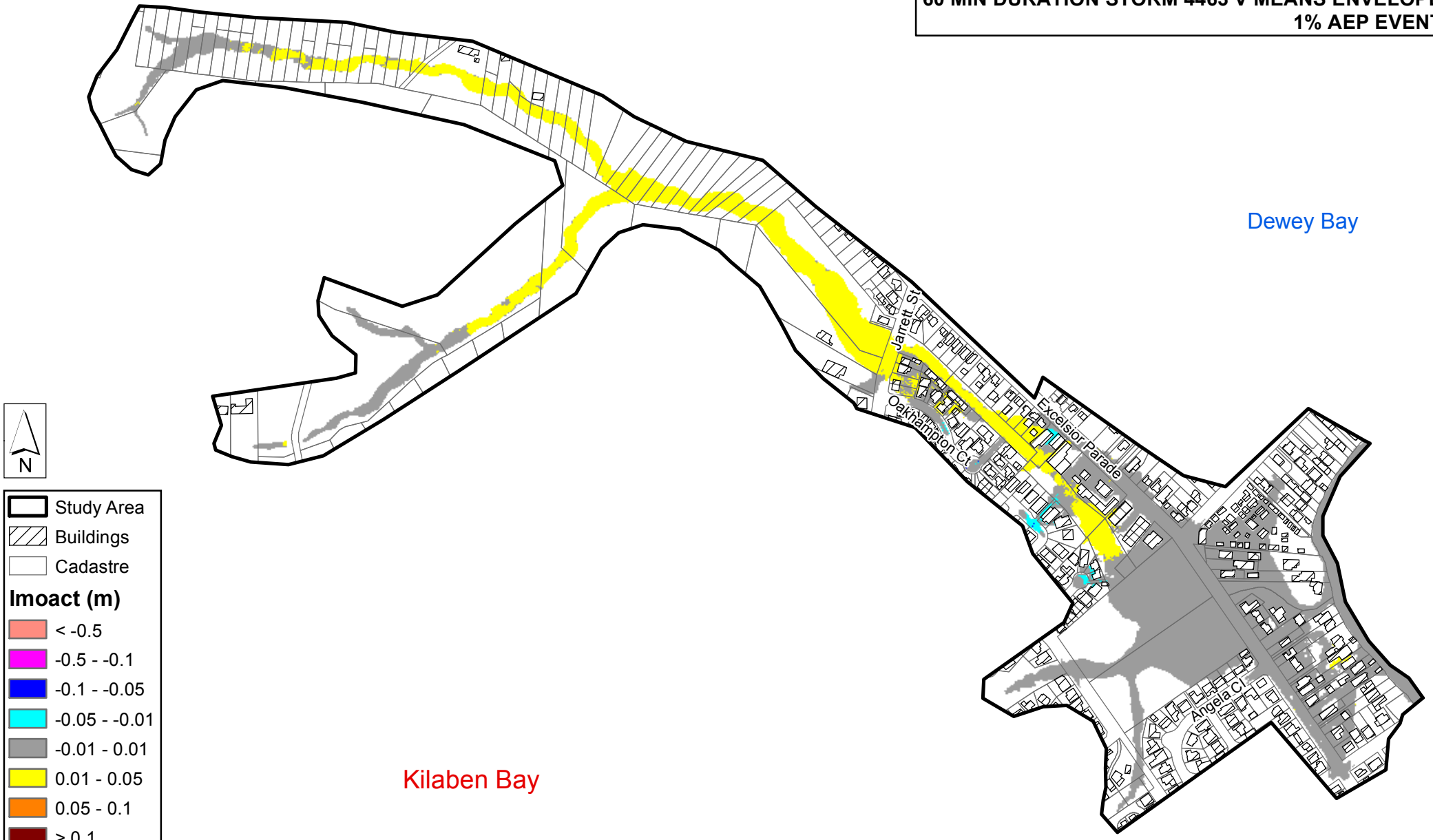



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FIGURE 14F

**FULLERS CREEK AND FRESHWATER CREEK**
**CHANGE IN PEAK FLOOD LEVEL**
**45 MIN DURATION STORM 4528 V MEANS ENVELOPE**
**1% AEP EVENT**

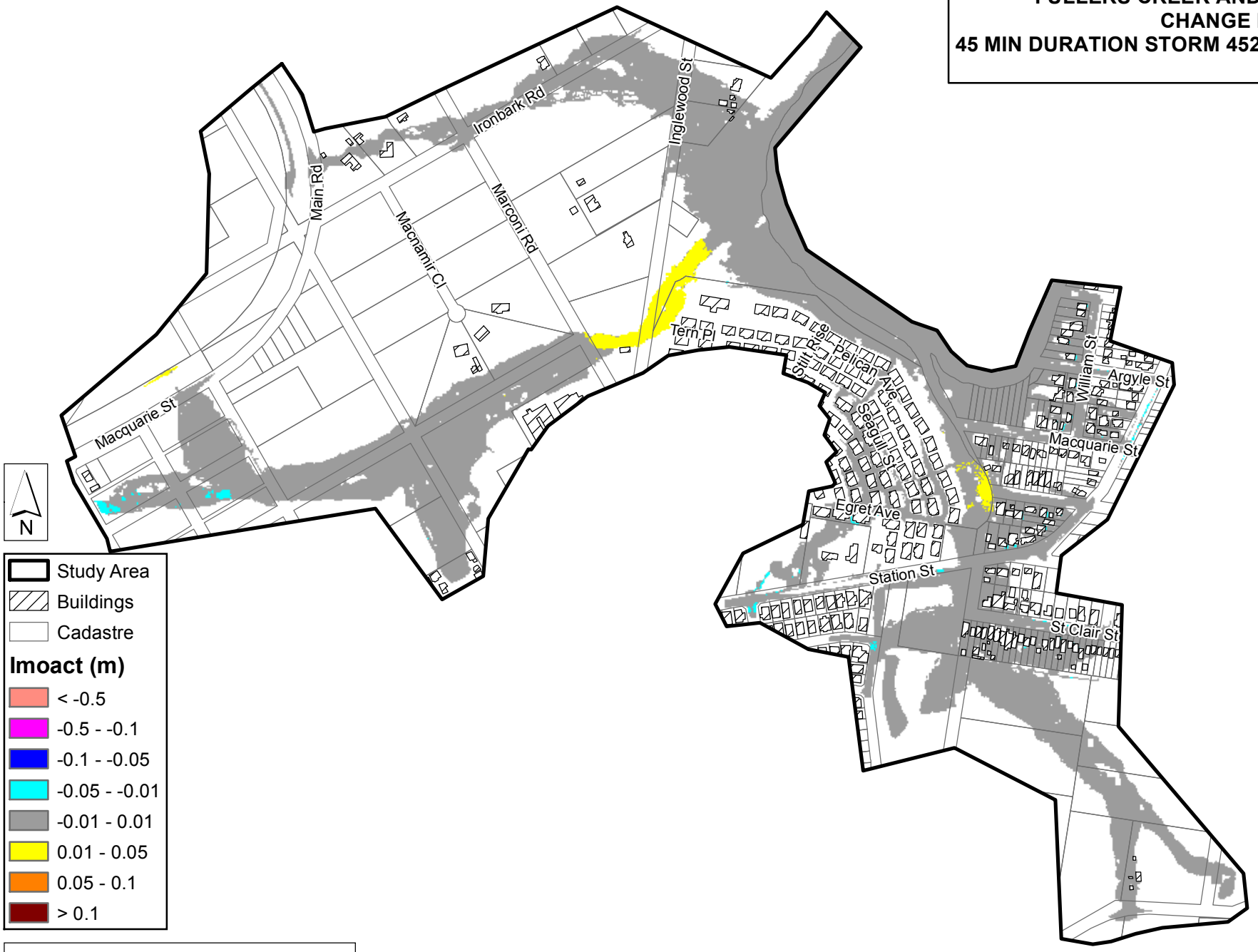


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FIGURE 14G
**POSTMISTRESS CREEK**
**CHANGE IN PEAK FLOOD LEVEL**
**45 MIN DURATION STORM 4528 V MEANS ENVELOPE**
**1% AEP EVENT**

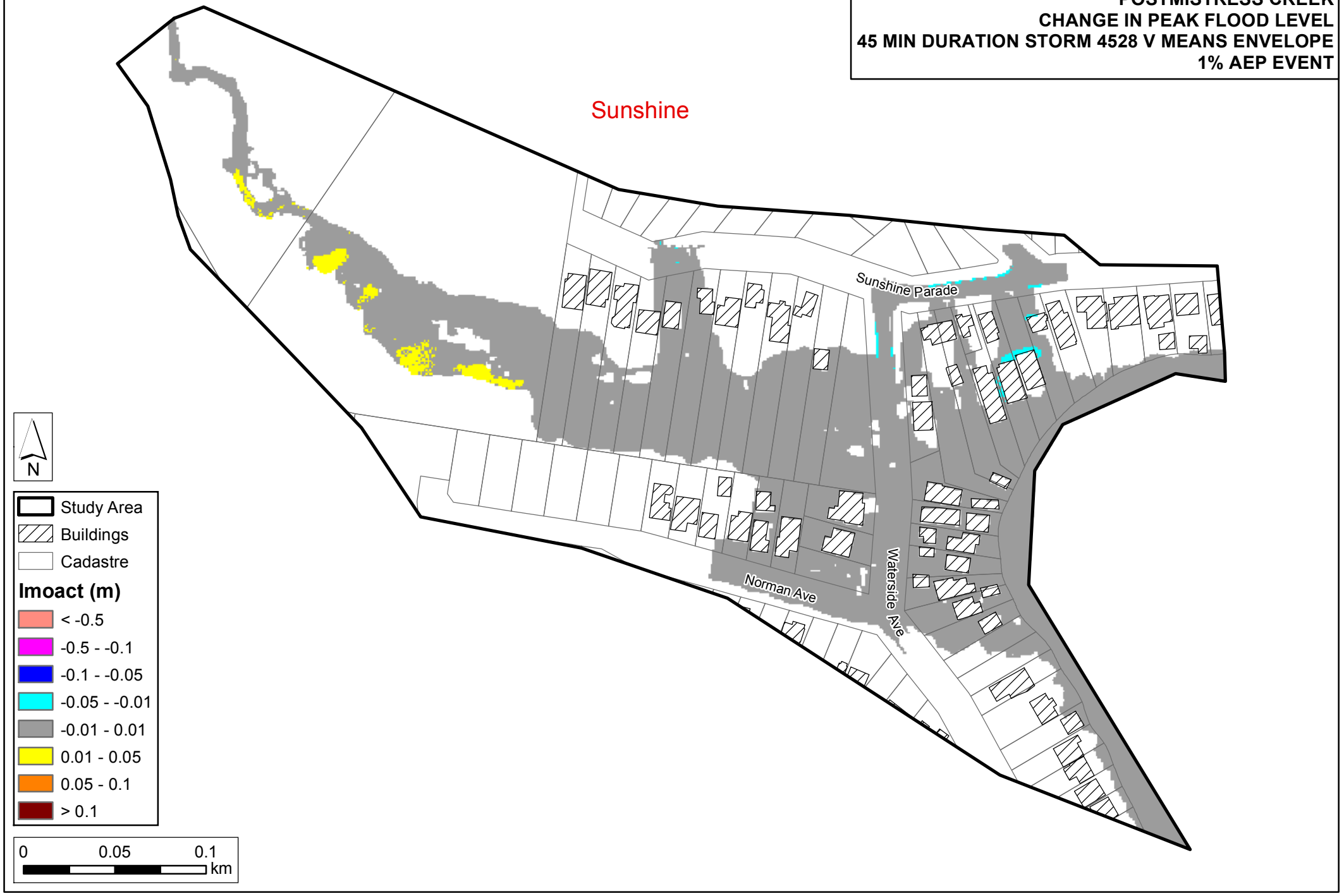


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FIGURE 14H

**MANNERING CREEK, SWAMPY CREEK AND WYEE CREEK**
**CHANGE IN PEAK FLOOD LEVEL**
**SELECTED PATTERNS V MEANS ENVELOPE**
**1% AEP EVENT**

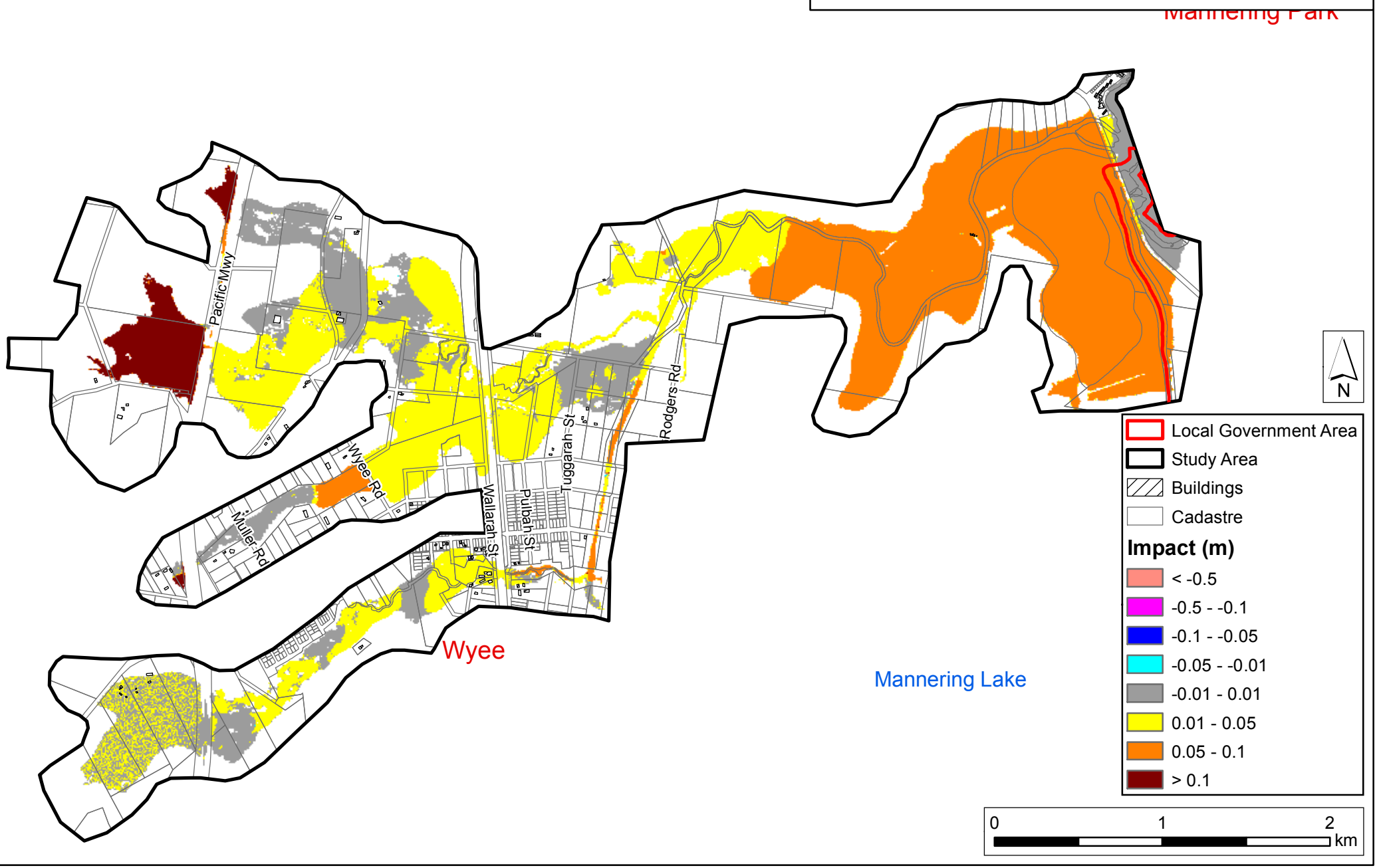


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FIGURE 15A
**PLAINS GULLY CREEK**
**LOCATIONS FOR ROAD OVERTOPPING RESULTS**
**1% AEP EVENT**

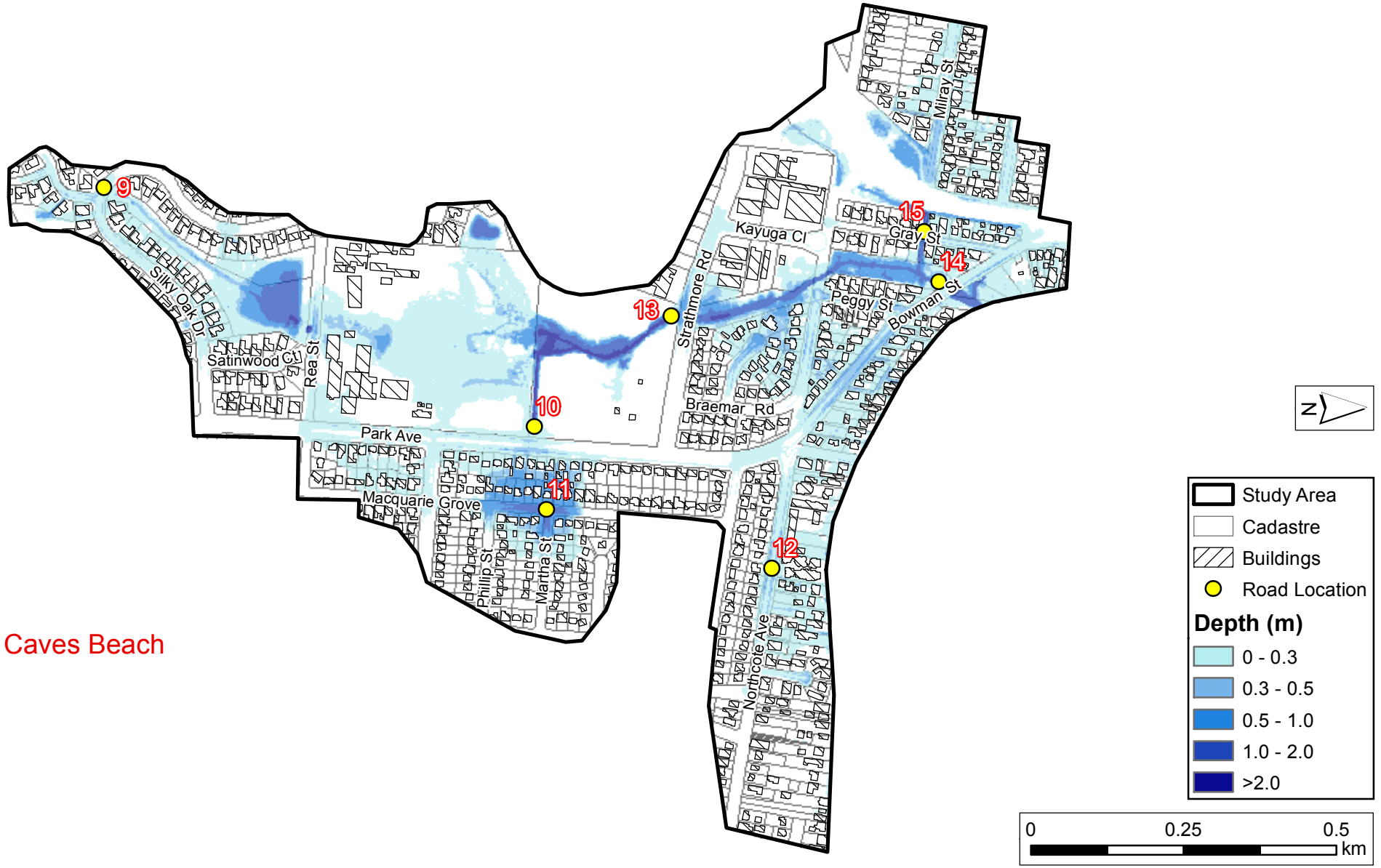


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FIGURE 15B
**SHEPPARDS CREEK**
**LOCATIONS FOR ROAD OVERTOPPING RESULTS**
**1% AEP EVENT**

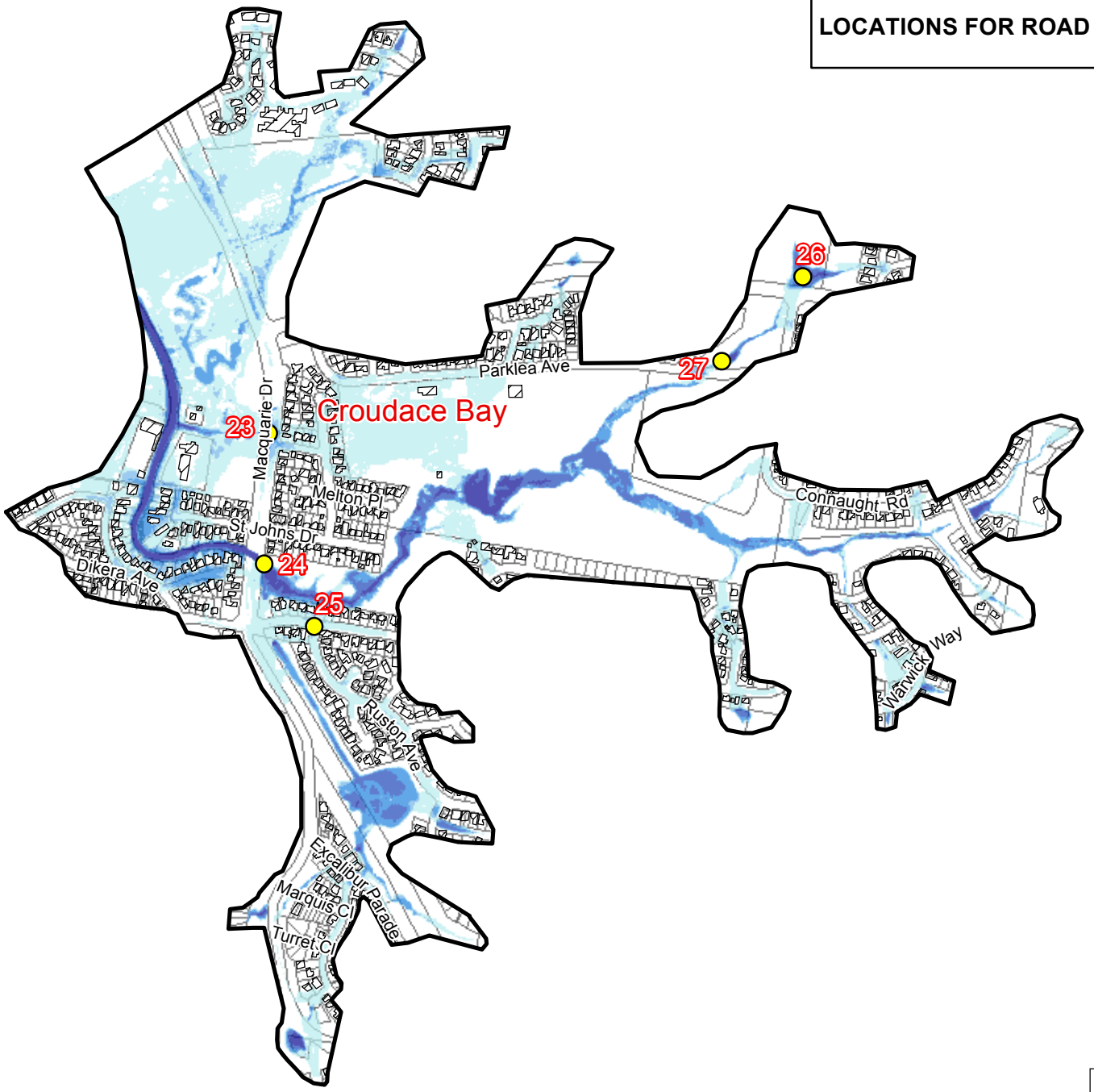


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FIGURE 15C
**MURABAN CREEK**
**LOCATIONS FOR ROAD OVERTOPPING RESULTS**
**1% AEP EVENT**

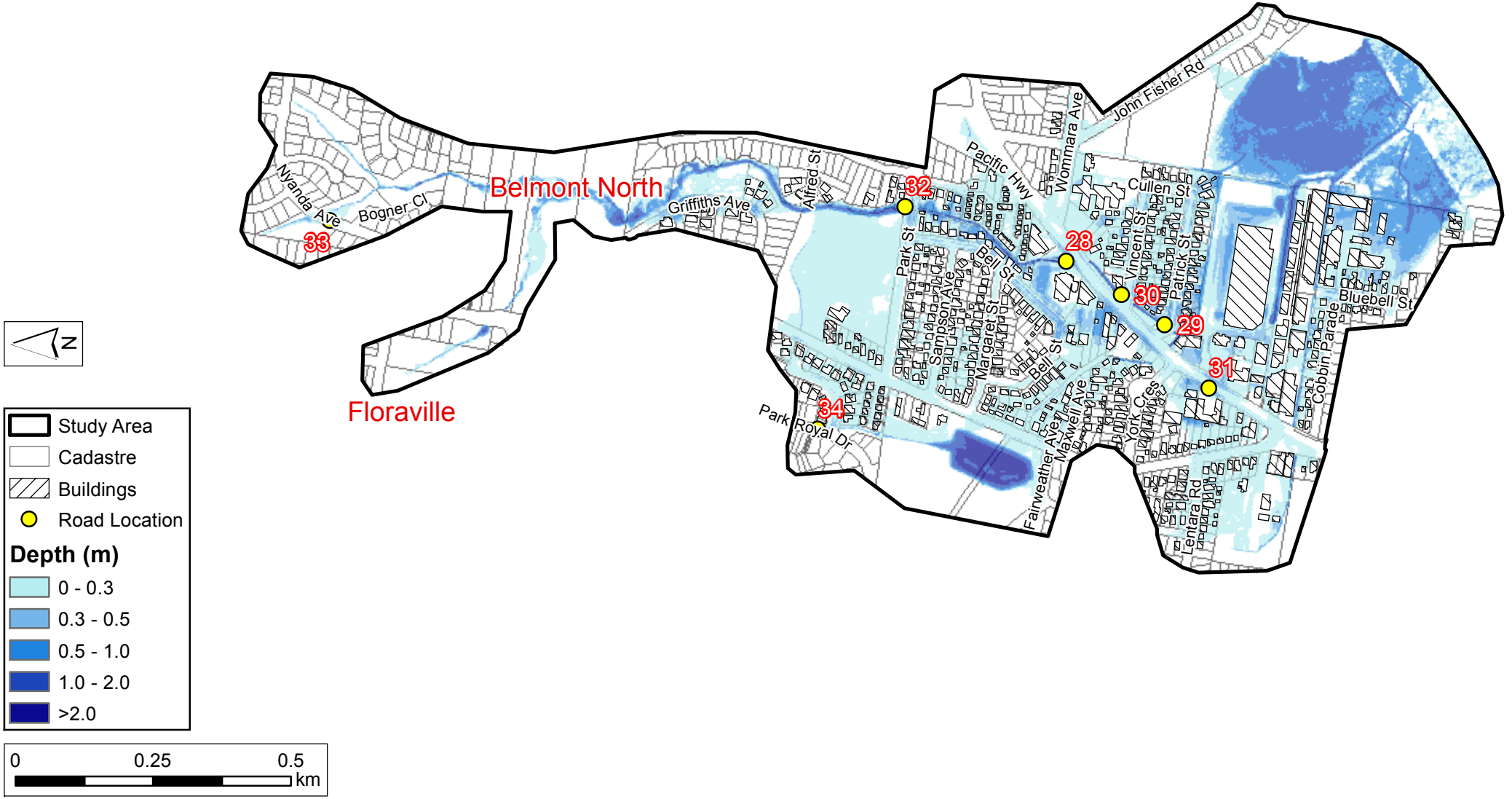


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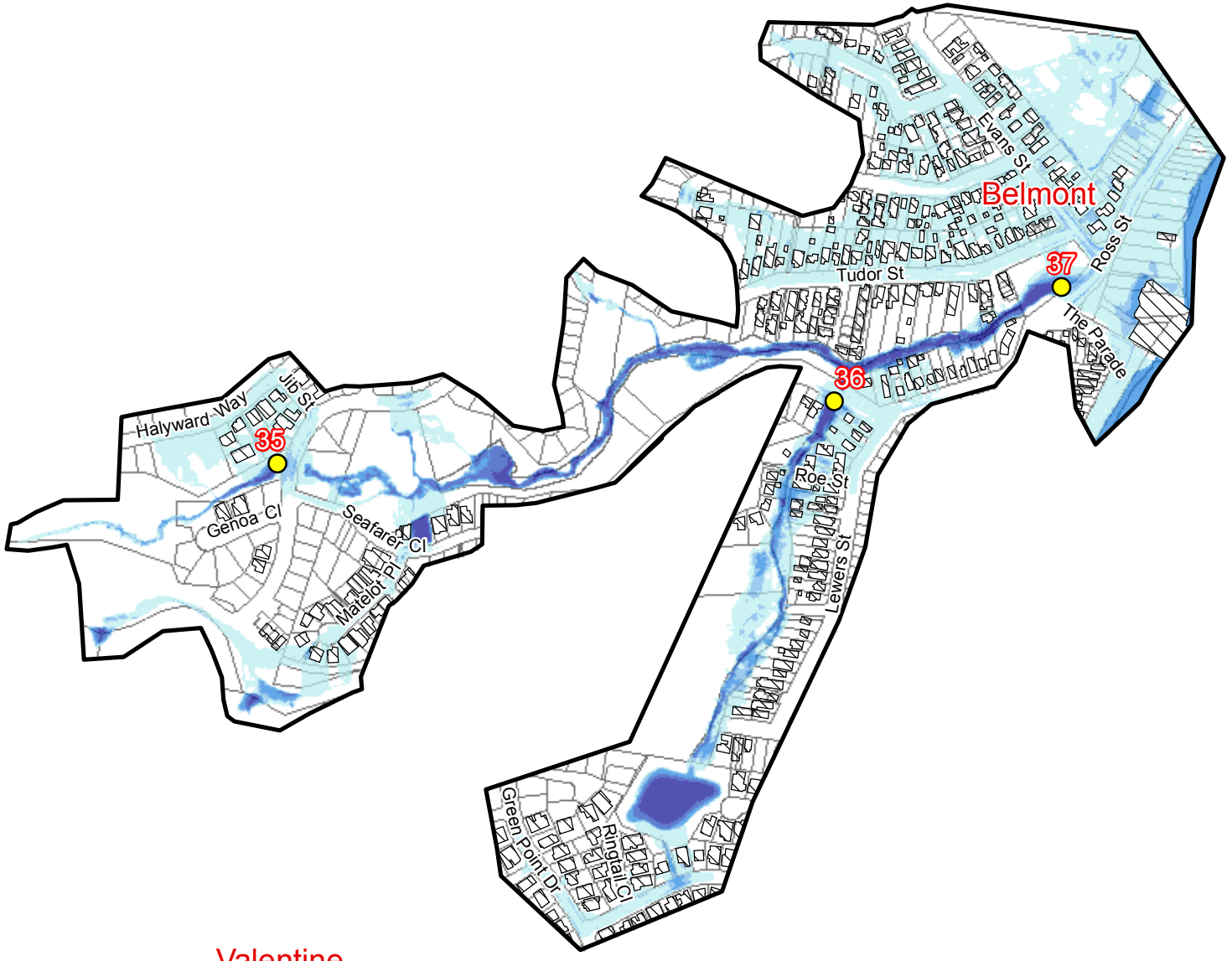
FIGURE 15D
**MILLS GULLY CREEK**
**LOCATIONS FOR ROAD OVERTOPPING RESULTS**
**1% AEP EVENT**




Study Area
Buildings
Cadastre
Road Location

**Depth (m)**
0 - 0.3
0.3 - 0.5
0.5 - 1.0
1.0 - 2.0
>2.0

0 0.25 0.5 km

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FIGURE 15E
**PUNTEI CREEK**
**LOCATIONS FOR ROAD OVERTOPPING RESULTS**
**1% AEP EVENT**

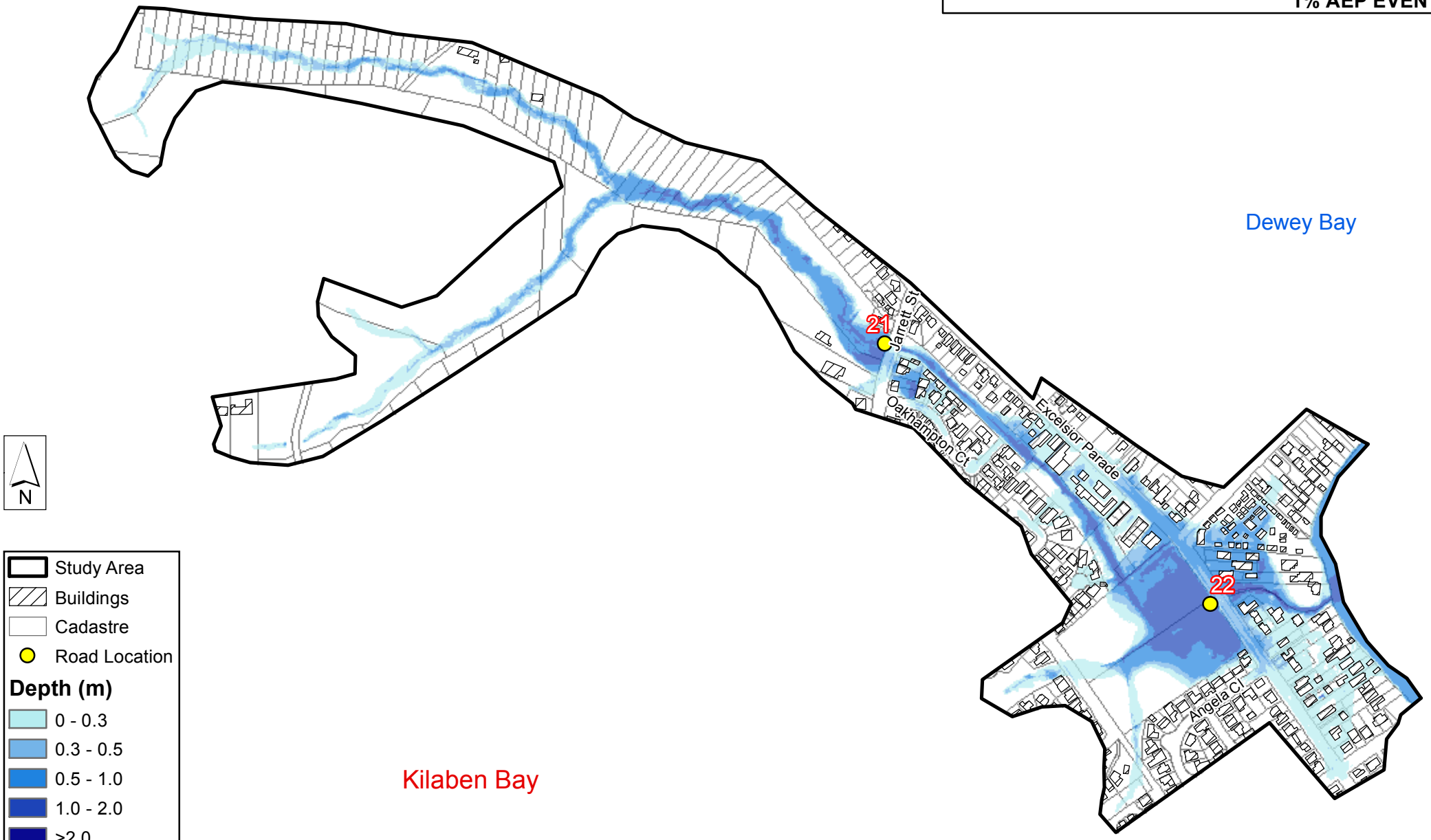


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FIGURE 15F

**FULLERS CREEK AND FRESHWATER CREEK**
**LOCATIONS FOR ROAD OVERTOPPING RESULTS**
**1% AEP EVENT**

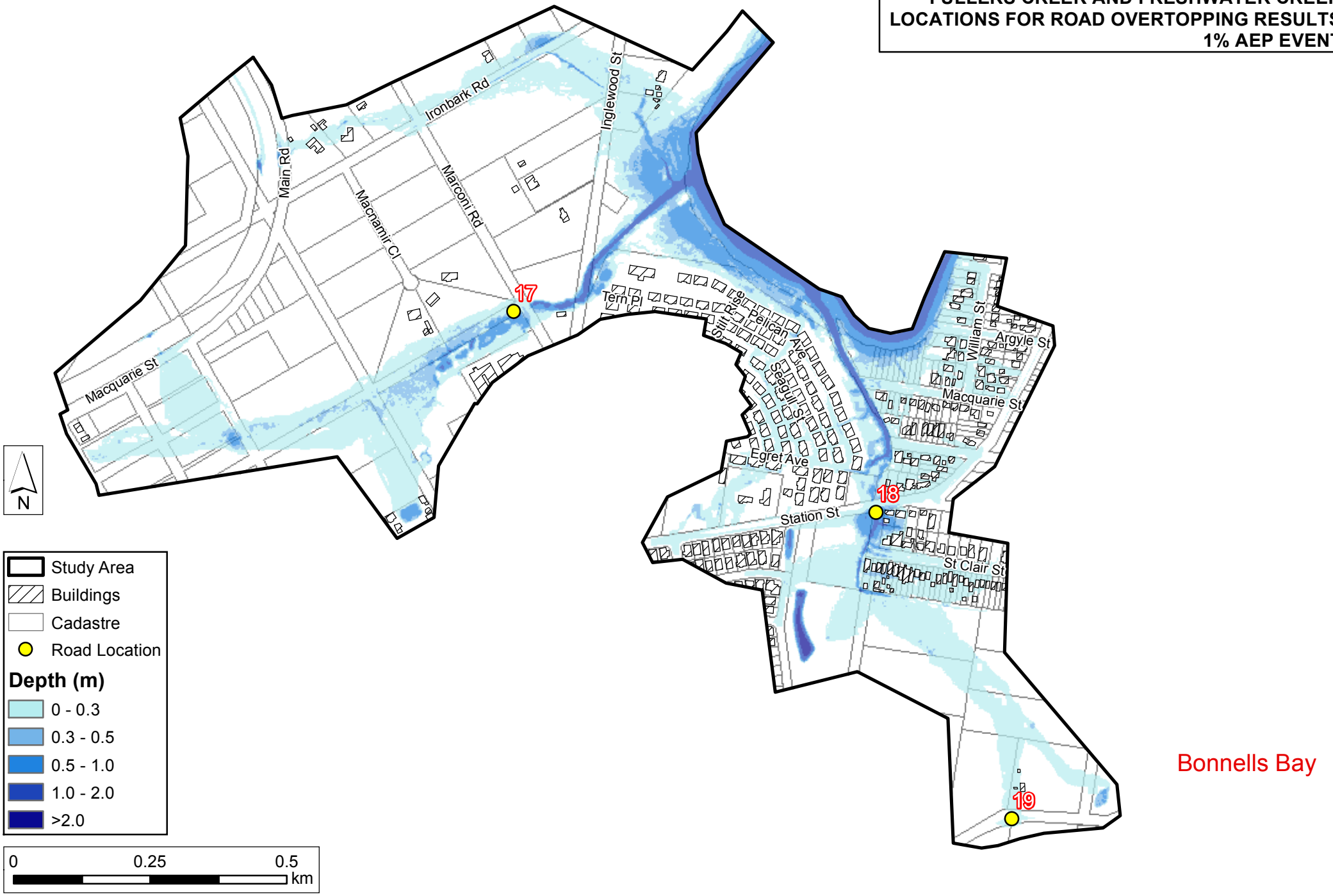


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FIGURE 15G
**POSTMISTRESS CREEK**
**LOCATIONS FOR ROAD OVERTOPPING RESULTS**
**1% AEP EVENT**

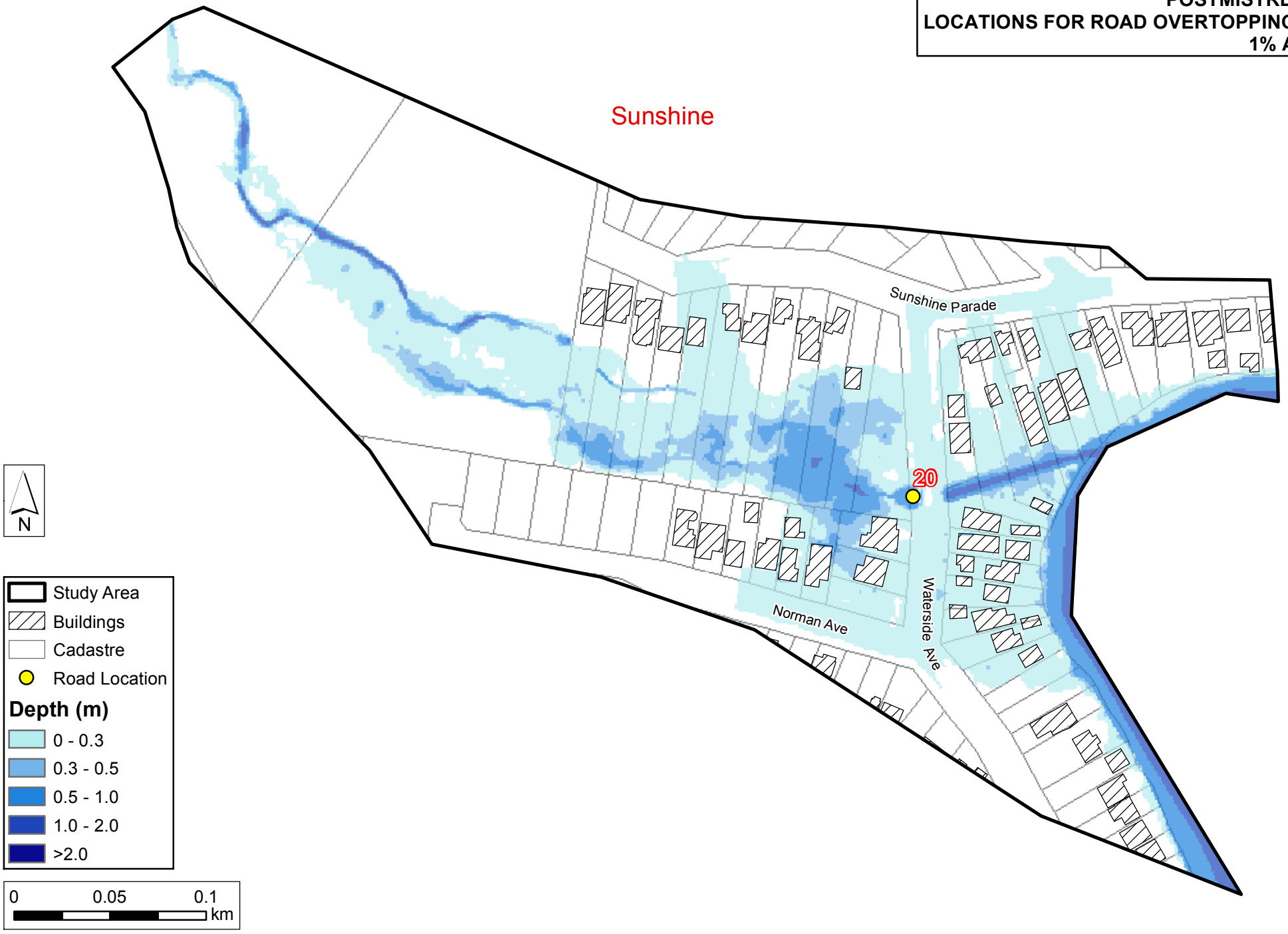


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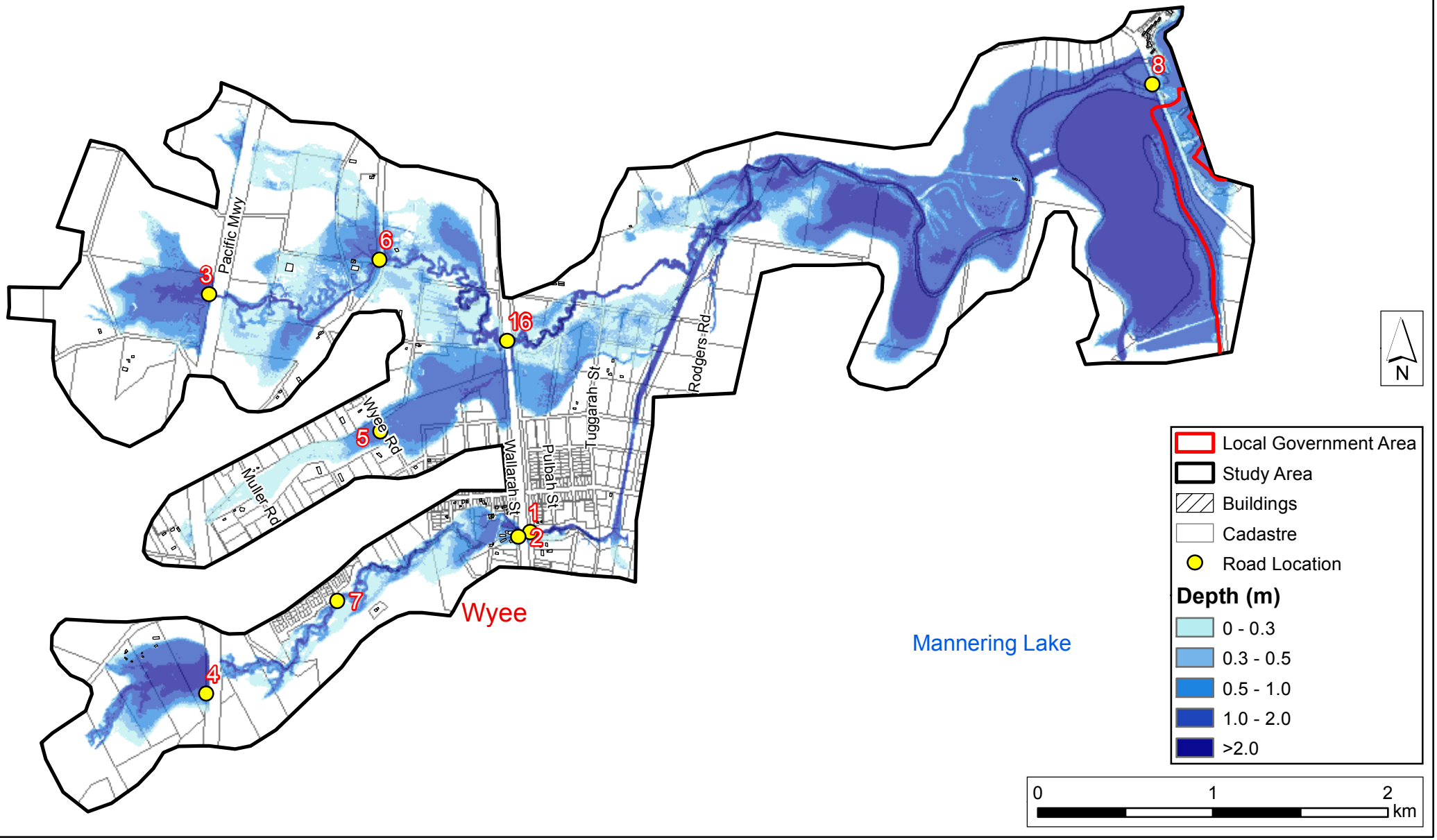
FIGURE 15H

**MANNERING CREEK, SWAMPY CREEK AND WYEE CREEK**
**LOCATIONS FOR ROAD OVERTOPPING RESULTS**
**1% AEP EVENT**

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# Appendix A

# APPENDIX A: GLOSSARY OF TERMS

Taken from the Floodplain Development Manual (April 2005 edition)

| | |
|---|---|
| **acid sulfate soils** | Are sediments which contain sulfidic mineral pyrite which may become extremely acid following disturbance or drainage as sulfur compounds react when exposed to oxygen to form sulfuric acid. More detailed explanation and definition can be found in the NSW Government Acid Sulfate Soil Manual published by Acid Sulfate Soil Management Advisory Committee. |
| **Annual Exceedance Probability (AEP)** | The chance of a flood of a given or larger size occurring in any one year, usually expressed as a percentage. For example, if a peak flood discharge of 500 $m^3/s$ has an AEP of 5%, it means that there is a 5% chance (that is one-in-20 chance) of a 500 $m^3/s$ or larger event occurring in any one year (see ARI). |
| **Australian Height Datum (AHD)** | A common national surface level datum approximately corresponding to mean sea level. |
| **Average Annual Damage (AAD)** | Depending on its size (or severity), each flood will cause a different amount of flood damage to a flood prone area. AAD is the average damage per year that would occur in a nominated development situation from flooding over a very long period of time. |
| **Average Recurrence Interval (ARI)** | The long term average number of years between the occurrence 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. |
| **caravan and moveable home parks** | Caravans and moveable dwellings are being increasingly used for long-term and permanent accommodation purposes. Standards relating to their siting, design, construction and management can be found in the Regulations under the LG Act. |
| **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. |
| **consent authority** | The Council, Government agency or person having the function to determine a development application for land use under the EP&A Act. The consent authority is most often the Council, however legislation or an EPI may specify a Minister or public authority (other than a Council), or the Director General of DIPNR, as having the function to determine an application. |
| **development** | Is defined in Part 4 of the Environmental Planning and Assessment Act (EP&A Act).<br><br>**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.<br>**new development:** refers to development of a completely different nature to that associated with the former land use. For example, the urban subdivision of an area previously used for rural purposes. New developments involve rezoning and typically require major extensions of existing urban services, such as roads, water supply, sewerage and electric power.<br>**redevelopment:** refers to rebuilding in an area. For example, as urban areas age, it may become necessary to demolish and reconstruct buildings on a relatively large scale. Redevelopment generally does not require either rezoning or major extensions to urban services. |
| **disaster plan (DISPLAN)** | A step by step sequence of previously agreed roles, responsibilities, functions, actions and management arrangements for the conduct of a single or series of connected emergency operations, with the object of ensuring the coordinated response by all agencies having responsibilities and functions in emergencies. |

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| **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). |
| **ecologically sustainable development (ESD)** | Using, conserving and enhancing natural resources so that ecological processes, on which life depends, are maintained, and the total quality of life, now and in the future, can be maintained or increased. A more detailed definition is included in the Local Government Act 1993. The use of sustainability and sustainable in this manual relate to ESD. |
| **effective warning time** | The time available after receiving advice of an impending flood and before the floodwaters prevent appropriate flood response actions being undertaken. The effective warning time is typically used to move farm equipment, move stock, raise furniture, evacuate people and transport their possessions. |
| **emergency management** | A range of measures to manage risks to communities and the environment. In the flood context it may include measures to prevent, prepare for, respond to and recover from flooding. |
| **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 defences excluding tsunami. |
| **flood awareness** | Flood awareness is an appreciation of the likely effects of flooding and a knowledge of the relevant flood warning, response and evacuation procedures. |
| **flood education** | Flood education seeks to provide information to raise awareness of the flood problem so as to enable individuals to understand how to manage themselves an their property in response to flood warnings and in a flood event. It invokes a state of flood readiness. |
| **flood fringe areas** | The remaining area of flood prone land after floodway and flood storage areas have been defined. |
| **flood liable land** | Is synonymous with flood prone land (i.e. land susceptible to flooding by the probable maximum flood (PMF) event). Note that the term flood liable land covers the whole of the floodplain, not just that part below the flood planning level (see flood planning area). |
| **flood mitigation standard** | The average recurrence interval of the flood, selected as part of the floodplain risk management process that forms the basis for physical works to modify the impacts of flooding. |
| **floodplain** | Area of land which is subject to inundation by floods up to and including the probable maximum flood event, that is, 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. |
| **floodplain risk management plan** | A management plan developed in accordance with the principles and guidelines in this manual. Usually includes both written and diagrammatic information describing how particular areas of flood prone land are to be used and managed to achieve defined objectives. |
| **flood plan (local)** | A sub-plan of a disaster plan that deals specifically with flooding. They can exist at State, Division and local levels. Local flood plans are prepared under the leadership of the State Emergency Service. |

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| **flood planning area** | The area of land below the flood planning level and thus subject to flood related development controls. The concept of flood planning area generally supersedes the "flood liable land" concept in the 1986 Manual. |
| **Flood Planning Levels (FPLs)** | FPL's are the combinations of flood levels (derived from significant historical flood events or floods of specific AEPs) and freeboards selected for floodplain risk management purposes, as determined in management studies and incorporated in management plans. FPLs supersede the "standard flood event" in the 1986 manual. |
| **flood proofing** | A combination of measures incorporated in the design, construction and alteration of individual buildings or structures subject to flooding, to reduce or eliminate flood damages. |
| **flood prone land** | Is land susceptible to flooding by the Probable Maximum Flood (PMF) event. Flood prone land is synonymous with flood liable land. |
| **flood readiness** | Flood readiness is an ability to react within the effective warning time. |
| **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.<br><br>**existing flood risk:** the risk a community is exposed to as a result of its location on the floodplain.<br>**future flood risk:** the risk a community may be exposed to as a result of new development on the floodplain.<br>**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 flows, or a significant increase in flood levels. |
| **freeboard** | 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. Freeboard is included in the flood planning level. |
| **habitable room** | **in a residential situation:** a living or working area, such as a lounge room, dining room, rumpus room, kitchen, bedroom or workroom.<br>**in an industrial or commercial situation:** an area used for offices or to store valuable possessions susceptible to flood damage in the event of a 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 hazard categories are provided in the Manual. |
| **hydraulics** | Term given to the study of water flow in waterways; in particular, the evaluation of flow parameters such as water level and velocity. |
| **hydrograph** | A graph which shows how the discharge or stage/flood level at any particular location varies with time during a flood. |

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| **hydrology** | Term given to the study of the rainfall and runoff process; in particular, the evaluation of peak flows, flow volumes and the derivation of hydrographs for a range of floods. |
| **local overland flooding** | Inundation by local runoff rather than overbank discharge from a stream, river, estuary, lake or dam. |
| **local drainage** | Are smaller scale problems in urban areas. They are outside the definition of major drainage in this glossary. |
| **mainstream flooding** | Inundation of normally dry land occurring when water overflows the natural or artificial banks of a stream, river, estuary, lake or dam. |
| **major drainage** | Councils have discretion in determining whether urban drainage problems are associated with major or local drainage. For the purpose of this manual major drainage involves:<br>• the floodplains of original watercourses (which may now be piped, channelised or diverted), or sloping areas where overland flows develop along alternative paths once system capacity is exceeded; and/or<br>• water depths generally in excess of 0.3 m (in the major system design storm as defined in the current version of Australian Rainfall and Runoff). These conditions may result in danger to personal safety and property damage to both premises and vehicles; and/or<br>• major overland flow paths through developed areas outside of defined drainage reserves; and/or<br>• the potential to affect a number of buildings along the major flow path. |
| **mathematical/computer models** | The mathematical representation of the physical processes involved in runoff generation and stream flow. These models are often run on computers due to the complexity of the mathematical relationships between runoff, stream flow and the distribution of flows across the floodplain. |
| **merit approach** | The merit approach weighs social, economic, ecological and cultural impacts of land use options for different flood prone areas together with flood damage, hazard and behaviour implications, and environmental protection and well being of the State's rivers and floodplains.<br><br>The merit approach operates at two levels. At the strategic level it allows for the consideration of social, economic, ecological, cultural and flooding issues to determine strategies for the management of future flood risk which are formulated into Council plans, policy and EPIs. At a site specific level, it involves consideration of the best way of conditioning development allowable under the floodplain risk management plan, local floodplain risk management policy and EPIs. |
| **minor, moderate and major flooding** | Both the State Emergency Service and the Bureau of Meteorology use the following definitions in flood warnings to give a general indication of the types of problems expected with a flood:<br><br>**minor flooding:** causes inconvenience such as closing of minor roads and the submergence of low level bridges. The lower limit of this class of flooding on the reference gauge is the initial flood level at which landholders and townspeople begin to be flooded.<br>**moderate flooding:** low-lying areas are inundated requiring removal of stock and/or evacuation of some houses. Main traffic routes may be covered.<br>**major flooding:** appreciable urban areas are flooded and/or extensive rural areas are flooded. Properties, villages and towns can be isolated. |
| **modification measures** | Measures that modify either the flood, the property or the response to flooding. Examples are indicated in Table 2.1 with further discussion in the Manual. |
| **peak discharge** | The maximum discharge occurring during a flood event. |

| | |
|---|---|
| **Probable Maximum Flood (PMF)** | 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 (PMP)** | 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 chance of flooding (see AEP). |
| **risk** | Chance of something happening that will have an impact. It is measured in terms of consequences and likelihood. In the context of the manual it is the likelihood of consequences arising from the interaction of floods, communities and the environment. |
| **runoff** | The amount of rainfall which actually ends up as streamflow, 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 at a particular location changes with time during a flood. It must be referenced to a particular datum. |
| **survey plan** | A plan prepared by a registered surveyor. |
| **water surface profile** | A graph showing the flood stage at any given location along a watercourse at a particular time. |

# APPENDIX B: CALIBRATION AND SENSITIVITY MAPS


Calibration Results
Figure B1: Plains Gully Creek, June 2007 Storm Event
Figure B2: Sheppards Creek, June 2007 Storm Event
Figure B3: Sheppards Creek, April 2015 Storm Event
Figure B4: Muraban Creek, June 2007 Storm Event
Figure B5: Mills Gully Creek, June 2007 Storm Event
Figure B6: Puntei Creek, June 2007 Storm Event
Figure B7: Fullers Creek and Freshwater Creek, February 2019 Storm Event
Figure B8: Fullers Creek and Freshwater Creek, February 2020 Storm Event
Figure B9: Postmistress Creek, April 2015 Storm Event
Figure B10: Postmistress Creek, February 2020 Storm Event
Figure B11: Mannering Creek, Swampy Creek and Wyee Creek, June 2007 Calibration Event

Sensitivity – Plains Gully Creek
Figure B12: June 2007 Calibration Event, Blockage Reduced to 25%
Figure B13: June 2007 Calibration Event, Blockage Increased to 75%
Figure B14: June 2007 Calibration Event, Lag Decreased by 25%
Figure B15: June 2007 Calibration Event, Lag Increased by 25%
Figure B16: June 2007 Calibration Event, Loss Decreased by 25%
Figure B17: June 2007 Calibration Event, Loss Increased by 25%
Figure B18: June 2007 Calibration Event, Mannings Reduced by 25%
Figure B19: June 2007 Calibration Event, Mannings Increased by 25%
Figure B20: June 2007 Calibration Event, Lake Level Increased by 0.5m
Figure B21: June 2007 Calibration Event, Lake Level Reduced by 0.5m

Sensitivity – Sheppards Creek
Figure B22: June 2007 Calibration Event, Blockage Reduced to 25%
Figure B23: June 2007 Calibration Event, Blockage Increased to 75%
Figure B24: June 2007 Calibration Event, Lag Decreased by 25%
Figure B25: June 2007 Calibration Event, Lag Increased by 25%
Figure B26: June 2007 Calibration Event, Loss Decreased by 25%
Figure B27: June 2007 Calibration Event, Loss Increased by 25%
Figure B28: June 2007 Calibration Event, Mannings Reduced by 25%
Figure B29: June 2007 Calibration Event, Mannings Increased by 25%
Figure B30: June 2007 Calibration Event, Lake Level Increased by 0.5m
Figure B31: June 2007 Calibration Event, Lake Level Reduced by 0.5m

Sensitivity – Muraban Creek
Figure B32: June 2007 Calibration Event, Blockage Reduced to 25%
Figure B33: June 2007 Calibration Event, Blockage Increased to 75%
Figure B34: June 2007 Calibration Event, Lag Decreased by 25%
Figure B35: June 2007 Calibration Event, Lag Increased by 25%
Figure B36: June 2007 Calibration Event, Loss Decreased by 25%
Figure B37: June 2007 Calibration Event, Loss Increased by 25%
Figure B38: June 2007 Calibration Event, Mannings Reduced by 25%
Figure B39: June 2007 Calibration Event, Mannings Increased by 25%
Figure B40: June 2007 Calibration Event, Lake Level Increased by 0.5m
Figure B41: June 2007 Calibration Event, Lake Level Reduced by 0.5m

Sensitivity – Mills Gully Creek
Figure B42: June 2007 Calibration Event, Blockage Reduced to 25%
Figure B43: June 2007 Calibration Event, Blockage Increased to 75%
Figure B44: June 2007 Calibration Event, Lag Decreased by 25%
Figure B45: June 2007 Calibration Event, Lag Increased by 25%
Figure B46: June 2007 Calibration Event, Loss Decreased by 25%
Figure B47: June 2007 Calibration Event, Loss Increased by 25%
Figure B48: June 2007 Calibration Event, Mannings Reduced by 25%
Figure B49: June 2007 Calibration Event, Mannings Increased by 25%
Figure B50: June 2007 Calibration Event, Lake Level Increased by 0.5m
Figure B51: June 2007 Calibration Event, Lake Level Reduced by 0.5m

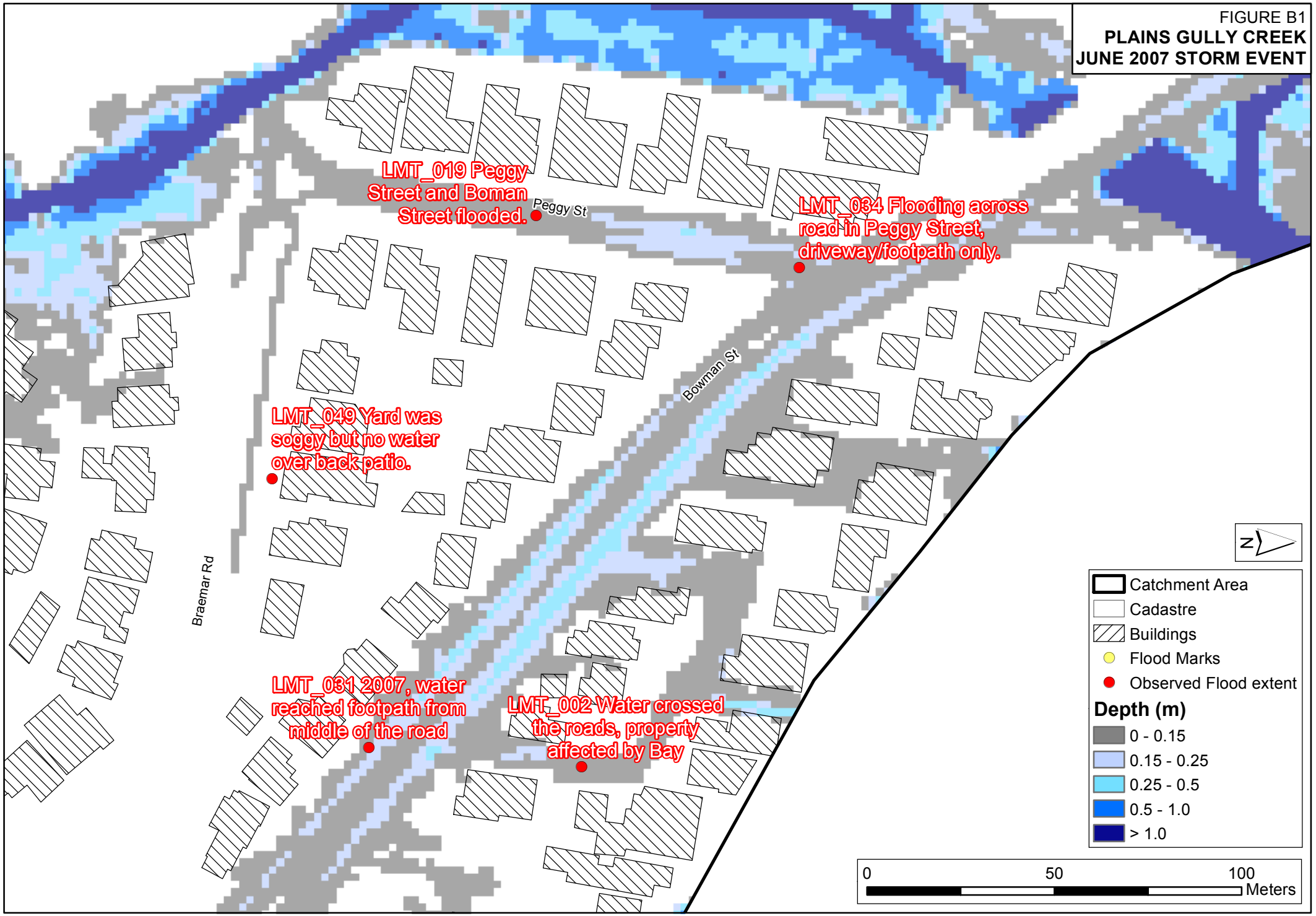
Sensitivity – Puntei Creek
Figure B52: June 2007 Calibration Event, Blockage Reduced to 25%
Figure B53: June 2007 Calibration Event, Blockage Increased to 75%
Figure B54: June 2007 Calibration Event, Lag Decreased by 25%
Figure B55: June 2007 Calibration Event, Lag Increased by 25%
Figure B56: June 2007 Calibration Event, Loss Decreased by 25%
Figure B57: June 2007 Calibration Event, Loss Increased by 25%
Figure B58: June 2007 Calibration Event, Mannings Reduced by 25%
Figure B59: June 2007 Calibration Event, Mannings Increased by 25%
Figure B60: June 2007 Calibration Event, Lake Level Increased by 0.5m
Figure B61: June 2007 Calibration Event, Lake Level Reduced by 0.5m
Figure B62: April 2015 Calibration Event, Blockage Reduced to 25%
Figure B63: April 2015 Calibration Event, Blockage Increased to 75%
Figure B64: April 2015 Calibration Event, Lag Decreased by 25%
Figure B65: April 2015 Calibration Event, Lag Increased by 25%
Figure B66: April 2015 Calibration Event, Loss Decreased by 25%
Figure B67: April 2015 Calibration Event, Loss Increased by 25%
Figure B68: April 2015 Calibration Event, Mannings Reduced by 25%
Figure B69: April 2015 Calibration Event, Mannings Increased by 25%
Figure B70: April 2015 Calibration Event, Lake Level Increased by 0.5m
Figure B71: April 2015 Calibration Event, Lake Level Reduced by 0.5m

Sensitivity – Fullers Creek and Freshwater Creek
Figure B72: February 2019 Calibration Event, Blockage Reduced to 25%
Figure B73: February 2019 Calibration Event, Blockage Increased to 75%
Figure B74: February 2019 Calibration Event, Lag Decreased by 25%
Figure B75: February 2019 Calibration Event, Lag Increased by 25%
Figure B76: February 2019 Calibration Event, Loss Decreased by 25%
Figure B77: February 2019 Calibration Event, Loss Increased by 25%
Figure B78: February 2019 Calibration Event, Mannings Reduced by 25%
Figure B79: February 2019 Calibration Event, Mannings Increased by 25%
Figure B80: February 2019 Calibration Event, Lake Level Increased by 0.5m
Figure B81: February 2019 Calibration Event, Lake Level Reduced by 0.5m
Figure B82: February 2020 Calibration Event, Blockage Reduced to 25%
Figure B83: February 2020 Calibration Event, Blockage Increased to 75%
Figure B84: February 2020 Calibration Event, Lag Decreased by 25%
Figure B85: February 2020 Calibration Event, Lag Increased by 25%
Figure B86: February 2020 Calibration Event, Loss Decreased by 25%
Figure B87: February 2020 Calibration Event, Loss Increased by 25%
Figure B88: February 2020 Calibration Event, Mannings Reduced by 25%
Figure B89: February 2020 Calibration Event, Mannings Increased by 25%
Figure B90: February 2020 Calibration Event, Lake Level Increased by 0.5m
Figure B91: February 2020 Calibration Event, Lake Level Reduced by 0.5m

Sensitivity – Postmistress Creek
Figure B92: April 2015 Calibration Event, Blockage Reduced to 25%
Figure B93: April 2015 Calibration Event, Blockage Increased to 75%
Figure B94: April 2015 Calibration Event, Lag Decreased by 25%
Figure B95: April 2015 Calibration Event, Lag Increased by 25%
Figure B96: April 2015 Calibration Event, Loss Decreased by 25%
Figure B97: April 2015 Calibration Event, Loss Increased by 25%
Figure B98: April 2015 Calibration Event, Mannings Reduced by 25%
Figure B99: April 2015 Calibration Event, Mannings Increased by 25%
Figure B100: April 2015 Calibration Event, Lake Level Increased by 0.5m
Figure B101: April 2015 Calibration Event, Lake Level Reduced by 0.5m
Figure B102: February 2020 Calibration Event, Blockage Reduced to 25%
Figure B103: February 2020 Calibration Event, Blockage Increased to 75%
Figure B104: February 2020 Calibration Event, Lag Decreased by 25%
Figure B105: February 2020 Calibration Event, Lag Increased by 25%
Figure B106: February 2020 Calibration Event, Loss Decreased by 25%
Figure B107: February 2020 Calibration Event, Loss Increased by 25%
Figure B108: February 2020 Calibration Event, Mannings Reduced by 25%
Figure B109: February 2020 Calibration Event, Mannings Increased by 25%
Figure B110: February 2020 Calibration Event, Lake Level Increased by 0.5m
Figure B111: February 2020 Calibration Event, Lake Level Reduced by 0.5m

Sensitivity – Mannering Creek, Swampy Creek and Wyee Creek
Figure B112: June 2007 Calibration Event, Blockage Reduced to 25%
Figure B113: June 2007 Calibration Event, Blockage Increased to 75%
Figure B114: June 2007 Calibration Event, Lag Decreased by 25%
Figure B115: June 2007 Calibration Event, Lag Increased by 25%
Figure B116: June 2007 Calibration Event, Loss Decreased by 25%
Figure B117: June 2007 Calibration Event, Loss Increased by 25%
Figure B118: June 2007 Calibration Event, Mannings Reduced by 25%
Figure B119: June 2007 Calibration Event, Mannings Increased by 25%
Figure B120: June 2007 Calibration Event, Lake Level Increased by 0.5m
Figure B121: June 2007 Calibration Event, Lake Level Reduced by 0.5m

FIGURE B1
**PLAINS GULLY CREEK**
**JUNE 2007 STORM EVENT**

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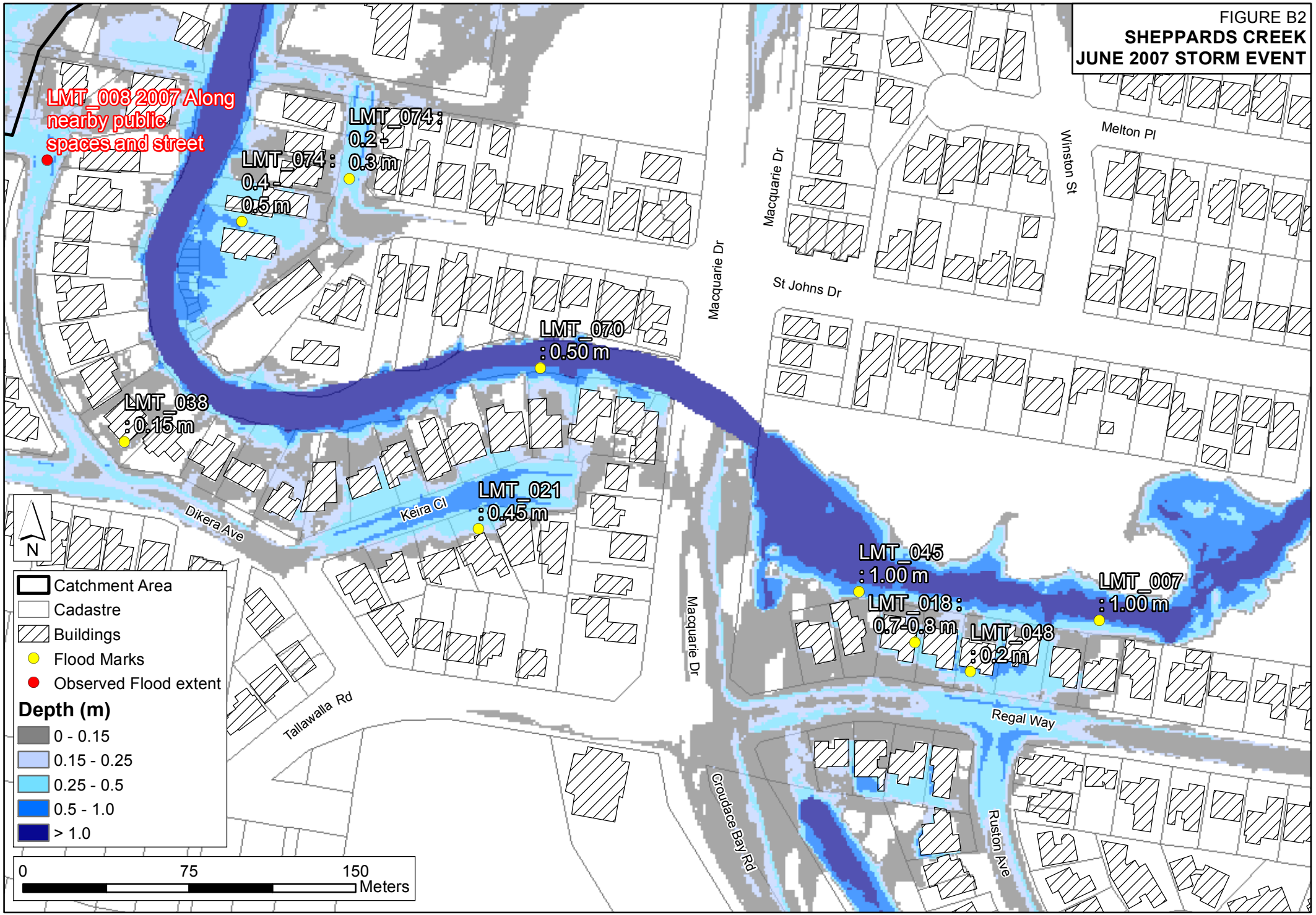
FIGURE B2
SHEPPARDS CREEK
JUNE 2007 STORM EVENT
LMT_008 2007 Along nearby public spaces and street
LMT_074 : 0.4 - 0.5 m
LMT_074 : 0.2 - 0.3 m
LMT_070 : 0.50 m
LMT_038 : 0.15 m
LMT_021 : 0.45 m
LMT_045 : 1.00 m
LMT_018 : 0.7-0.8 m
LMT_048 : 0.2 m
LMT_007 : 1.00 m
Macquarie Dr
Winston St
Melton Pl
St Johns Dr
Keira Cl
Dikera Ave
Tallawalla Rd
Regal Way
Croudace Bay Rd
Ruston Ave
N
Catchment Area
Cadastre
Buildings
Flood Marks
Observed Flood extent
Depth (m)
0 - 0.15
0.15 - 0.25
0.25 - 0.5
0.5 - 1.0
> 1.0
0
75
150
Meters
J:\Jobs\119076\ArcGIS\ArcMap\Report\AppendixB_Calibration\1to60\FigureB002_Sheppards_Creek_Calibration_2007_v1.mxd

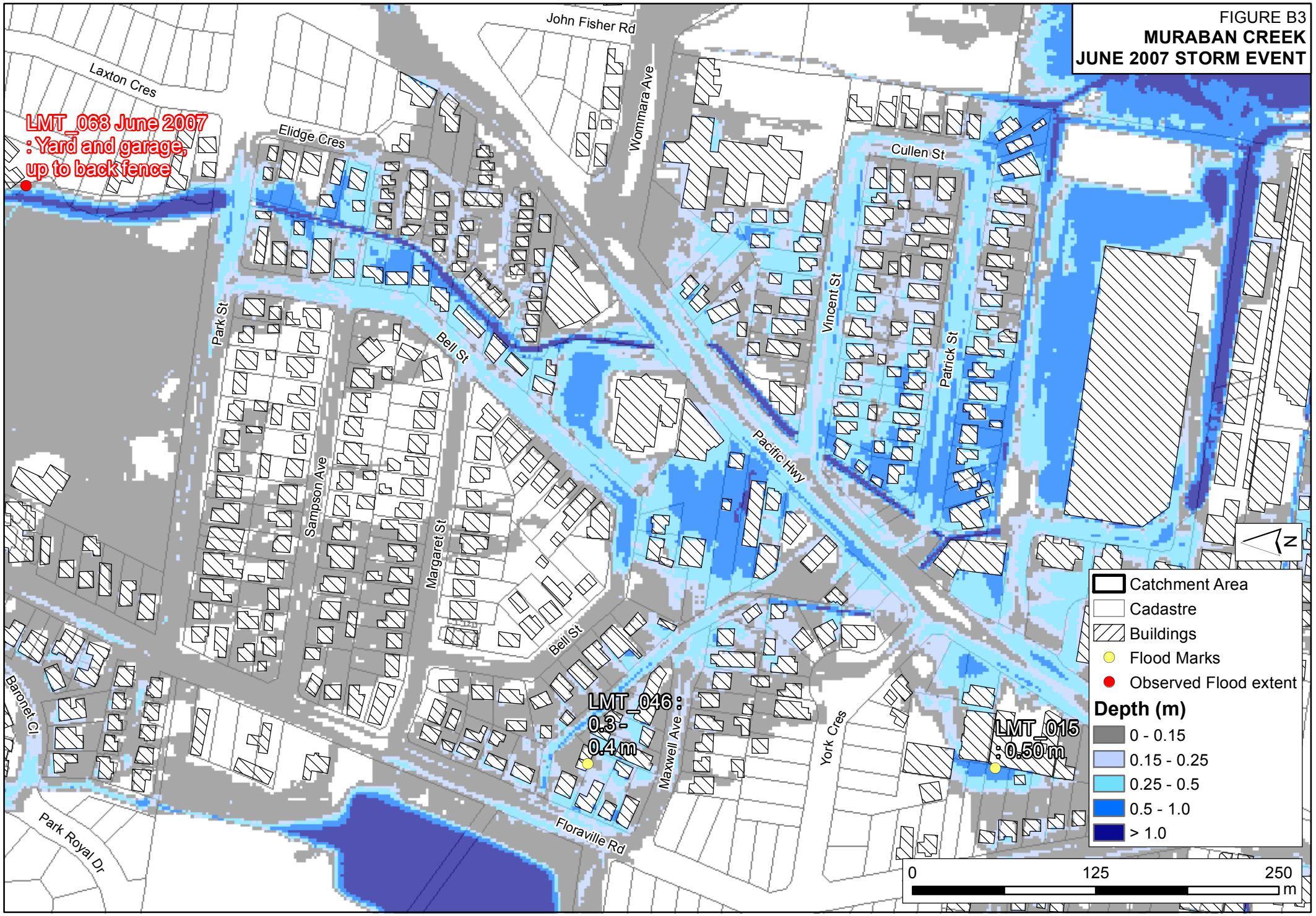
FIGURE B3
MURABAN CREEK
JUNE 2007 STORM EVENT
LMT_068 June 2007
: Yard and garage,
up to back fence
John Fisher Rd
Laxton Cres
Elidge Cres
Wommara Ave
Cullen St
Vincent St
Patrick St
Park St
Bell St
Pacific Hwy
Sampson Ave
Margaret St
Bell St
Baronet Cl
Maxwell Ave
York Cres
Park Royal Dr
Floraville Rd
LMT_046 :
0.3 -
0.4 m
LMT_015
: 0.50 m
N
Catchment Area
Cadastre
Buildings
Flood Marks
Observed Flood extent
Depth (m)
0 - 0.15
0.15 - 0.25
0.25 - 0.5
0.5 - 1.0
> 1.0
0
125
250
m
J:\Jobs\119076\ArcGIS\ArcMap\Report\AppendixB_Calibration\1to60\FigureB003_Muraban_Creek_Calibration_2007.mxd

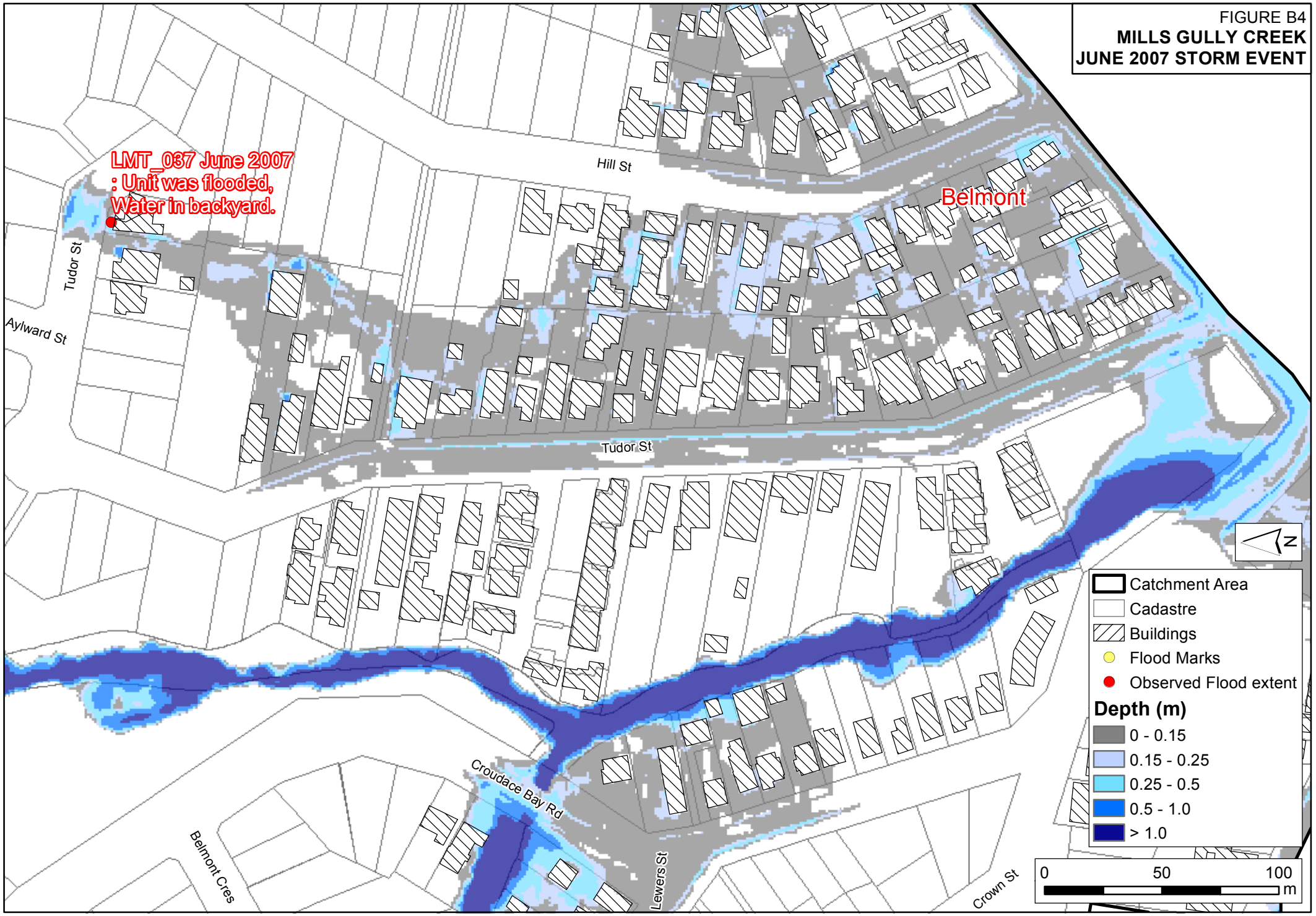
FIGURE B4
MILLS GULLY CREEK
JUNE 2007 STORM EVENT
LMT_037 June 2007
: Unit was flooded,
Water in backyard.
Belmont
Hill St
Tudor St
Aylward St
Tudor St
Croudace Bay Rd
Belmont Cres
Lewers St
Crown St
Catchment Area
Cadastre
Buildings
Flood Marks
Observed Flood extent
Depth (m)
0 - 0.15
0.15 - 0.25
0.25 - 0.5
0.5 - 1.0
> 1.0
0
50
100
m
J:\Jobs\119076\ArcGIS\ArcMap\Report\AppendixB_Calibration\1to60\FigureB004_Mills_Gully_Creek_Calibration_2007.mxd

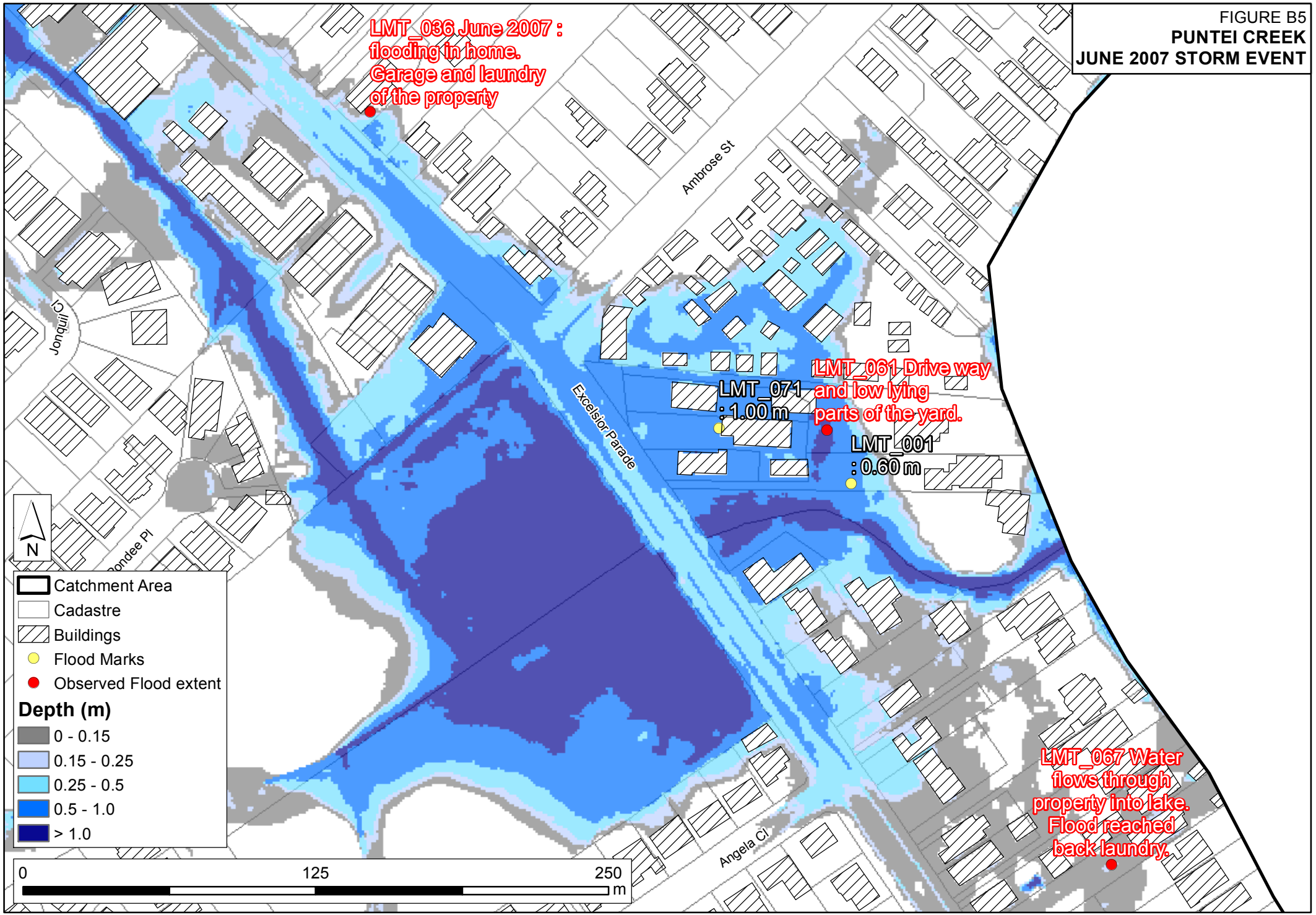
FIGURE B5
PUNTEI CREEK
JUNE 2007 STORM EVENT
LMT_036 June 2007 : flooding in home. Garage and laundry of the property
LMT_061 Drive way and low lying parts of the yard.
LMT_071 : 1.00 m
LMT_001 : 0.60 m
LMT_067 Water flows through property into lake. Flood reached back laundry.
Ambrose St
Excelsior Parade
Angela Cl
Jonquil Ct
Dundee Pl
N
Catchment Area
Cadastre
Buildings
Flood Marks
Observed Flood extent
Depth (m)
0 - 0.15
0.15 - 0.25
0.25 - 0.5
0.5 - 1.0
> 1.0
0
125
250
m
J:\Jobs\1190776\ArcGIS\ArcMap\Report\AppendixB_Calibration\1to60\FigureB005_Puntei_Creek_Calibration_2007.mxd

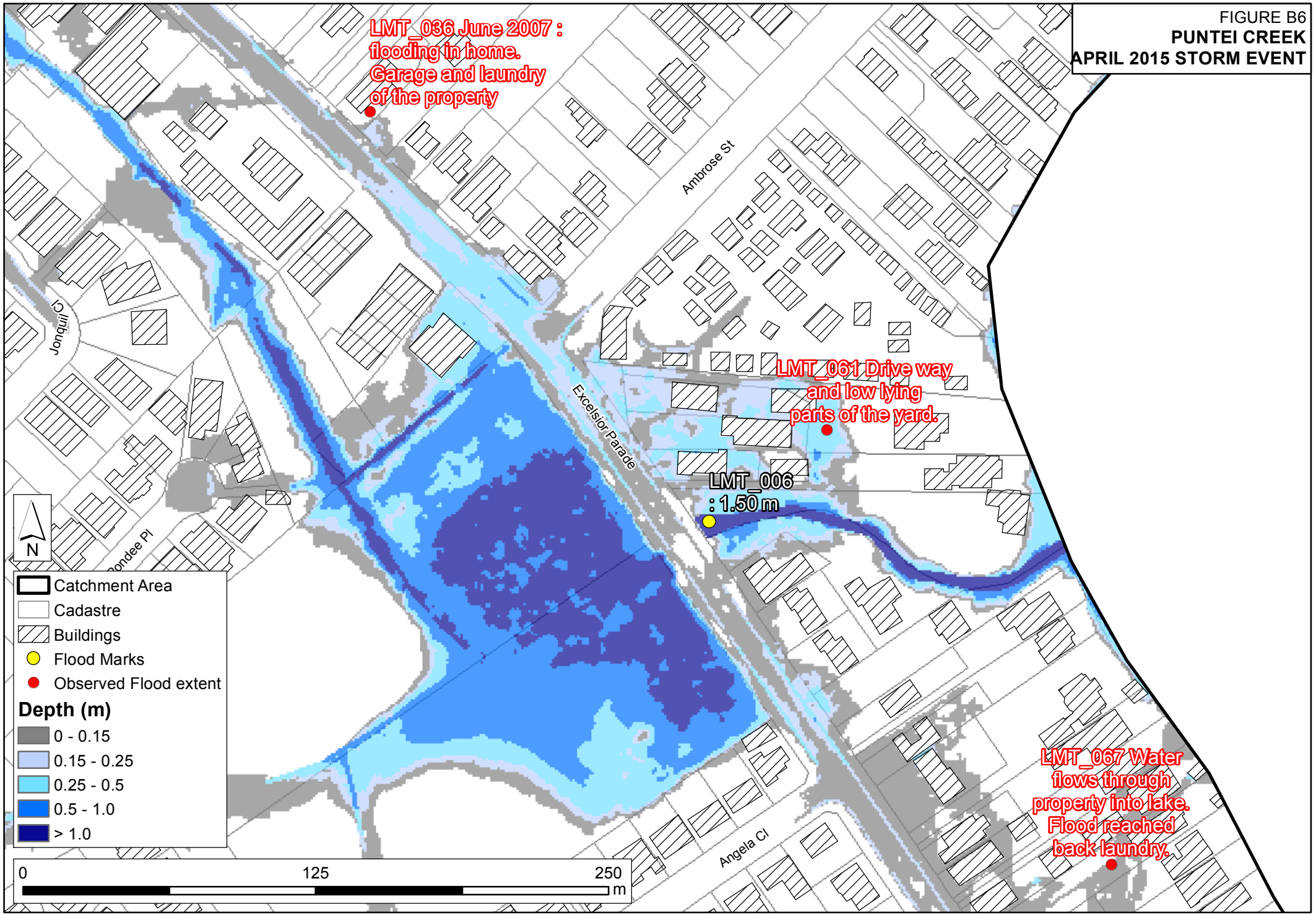
FIGURE B6
PUNTEI CREEK
APRIL 2015 STORM EVENT
LMT_036 June 2007 : flooding in home. Garage and laundry of the property
LMT_061 Drive way and low lying parts of the yard.
LMT_006 : 1.50 m
LMT_067 Water flows through property into lake. Flood reached back laundry.
Ambrose St
Excelsior Parade
Angela Cl
Jonquil Ct
Dundee Pl
N
Catchment Area
Cadastre
Buildings
Flood Marks
Observed Flood extent
Depth (m)
0 - 0.15
0.15 - 0.25
0.25 - 0.5
0.5 - 1.0
> 1.0
0
125
250
m
J:\Jobs\1190776\ArcGIS\ArcMap\Report\AppendixB_Calibration\1to60\FigureB006_Puntei_Creek_Calibration_2015.mxd

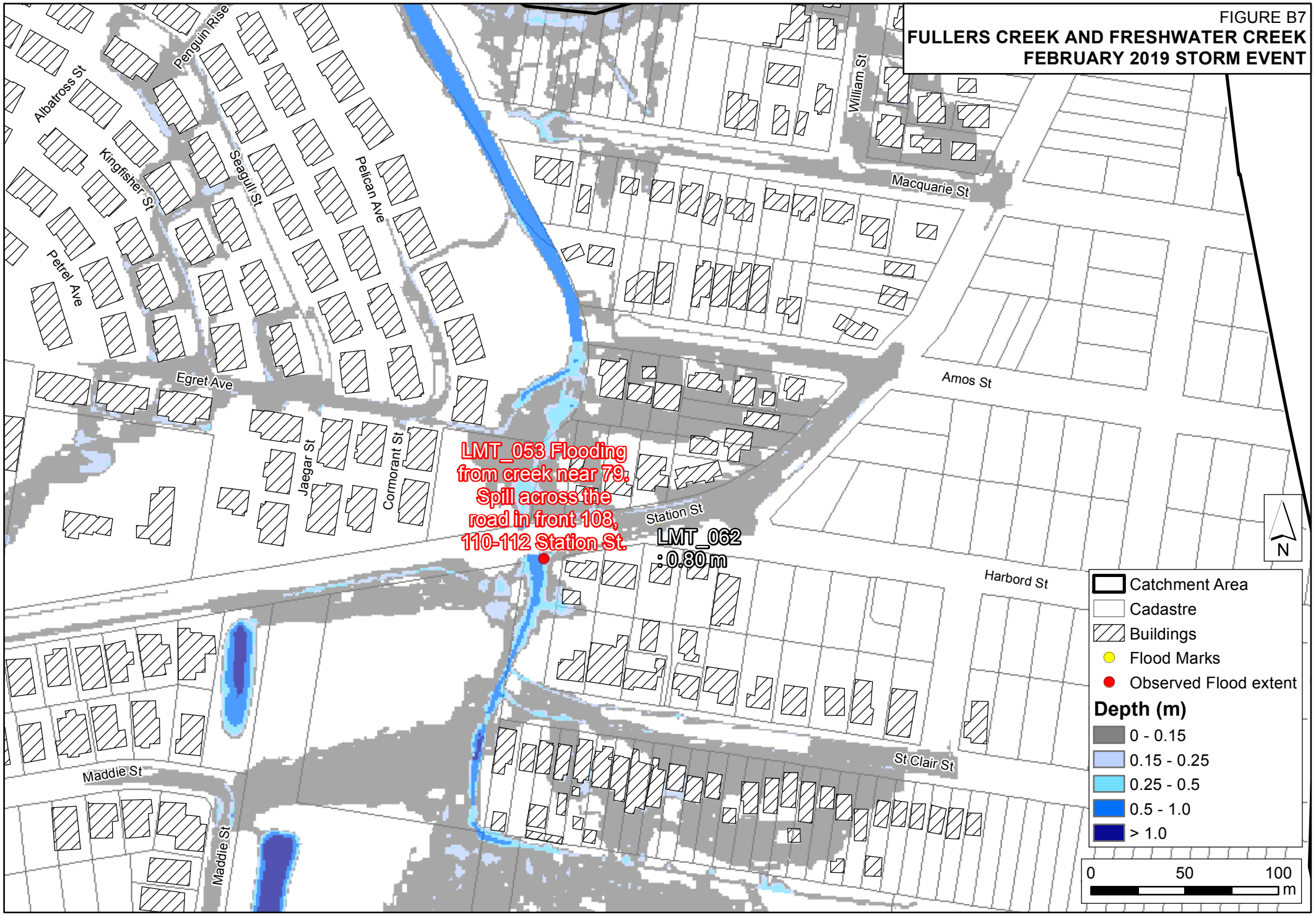
FIGURE B7
FULLERS CREEK AND FRESHWATER CREEK
FEBRUARY 2019 STORM EVENT
Albatross St
Penguin Rise
Kingfisher St
Seagull St
Pelican Ave
Petrel Ave
Egret Ave
Jaegar St
Cormorant St
William St
Macquarie St
Amos St
Station St
Harbord St
St Clair St
Maddie St
Maddie St
LMT_053 Flooding from creek near 79. Spill across the road in front 108, 110-112 Station St.
LMT_062
:0.80 m
N
Catchment Area
Cadastre
Buildings
Flood Marks
Observed Flood extent
Depth (m)
0 - 0.15
0.15 - 0.25
0.25 - 0.5
0.5 - 1.0
> 1.0
0
50
100
m
J:\Jobs\1190776\ArcGIS\ArcMap\Report\AppendixB_Calibration\1to60\FigureB007_Fullers_Creek_and_Freshwater_Creek_Calibration_2019.mxd

FIGURE B8

**FULLERS CREEK AND FRESHWATER CREEK**
**FEBRUARY 2020 STORM EVENT**

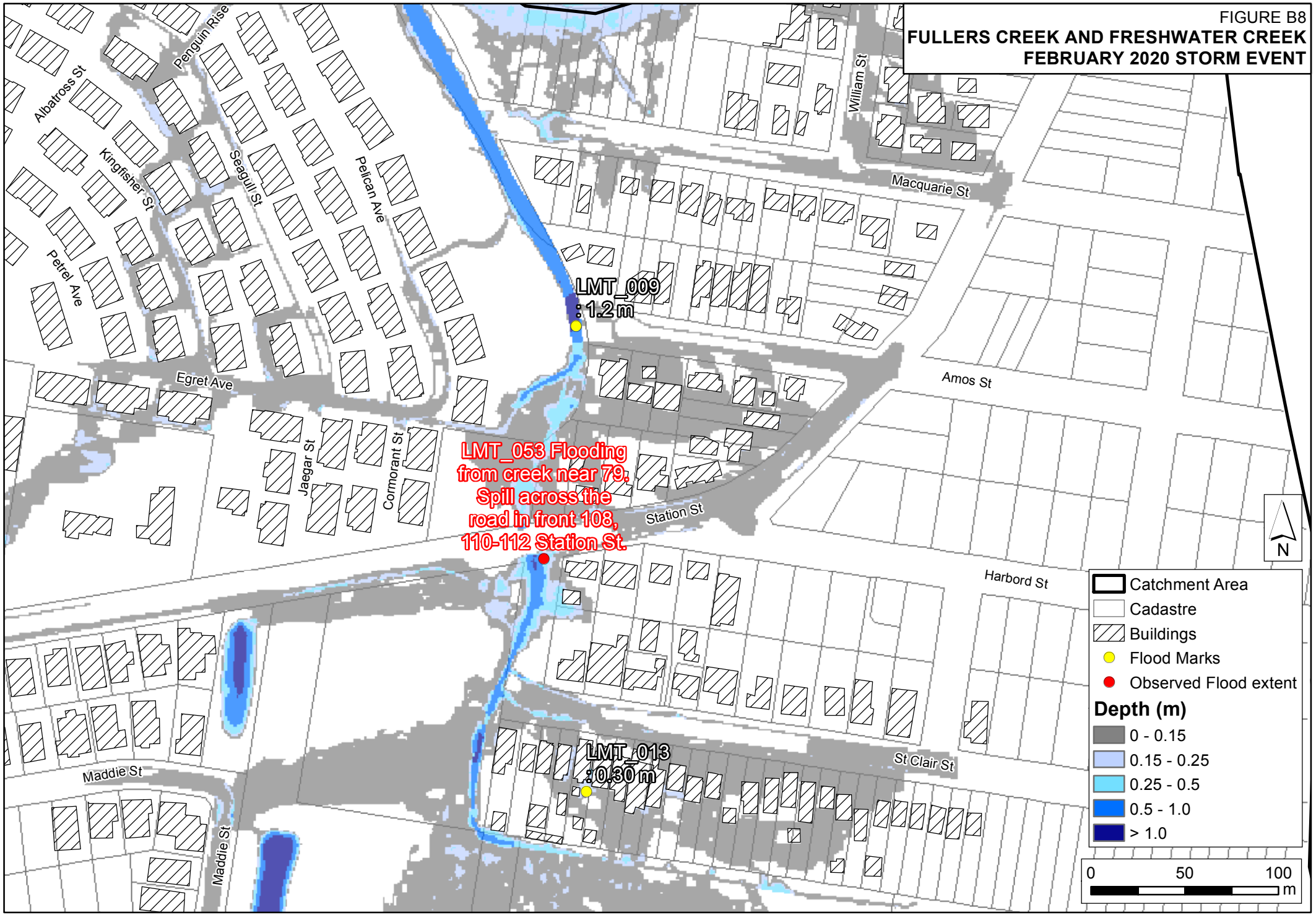


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FIGURE B9
**POSTMISTRESS CREEK**
**APRIL 2015 STORM EVENT**

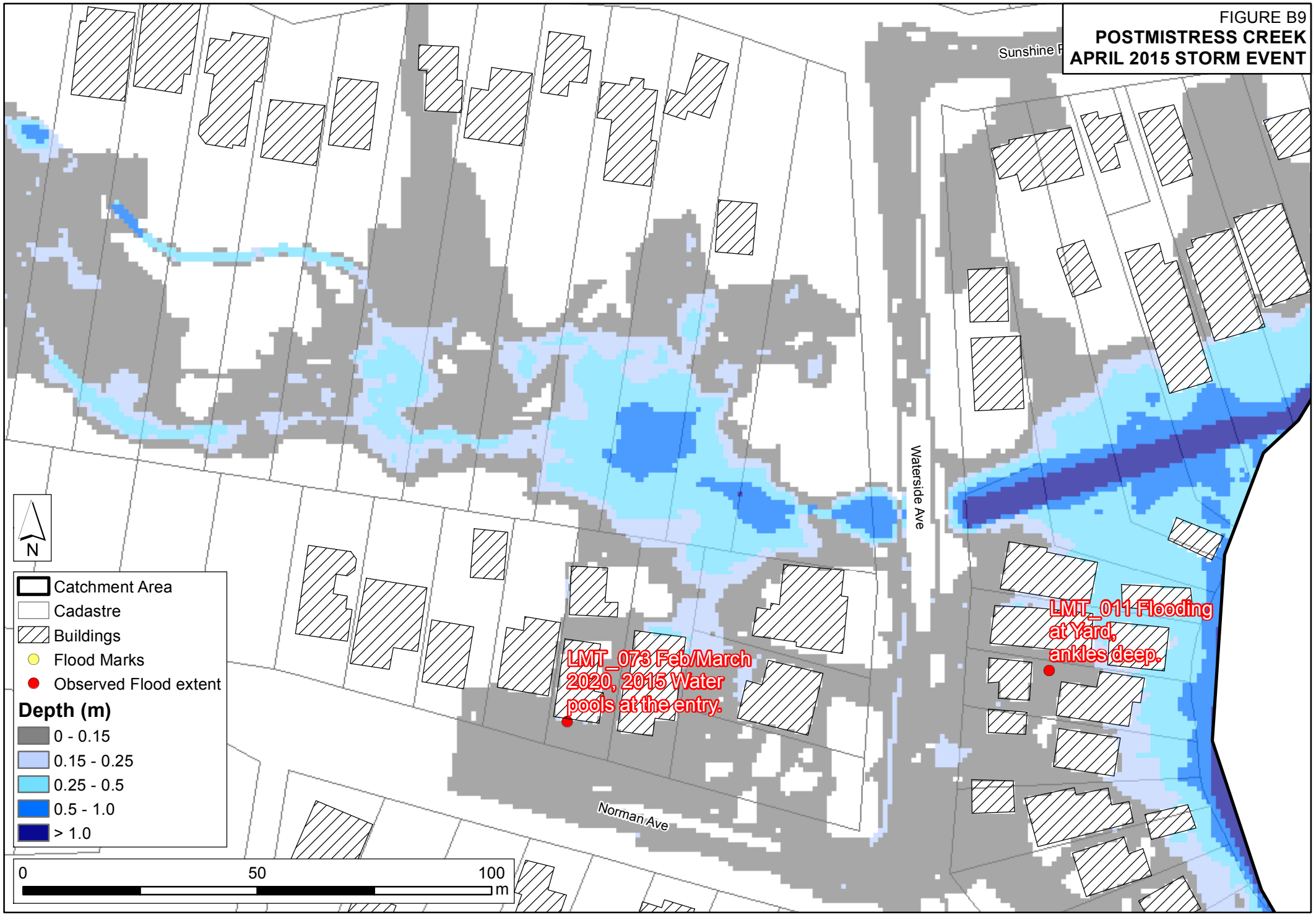


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FIGURE B10
**POSTMISTRESS CREEK**
**FEBRUARY 2020 STORM EVENT**

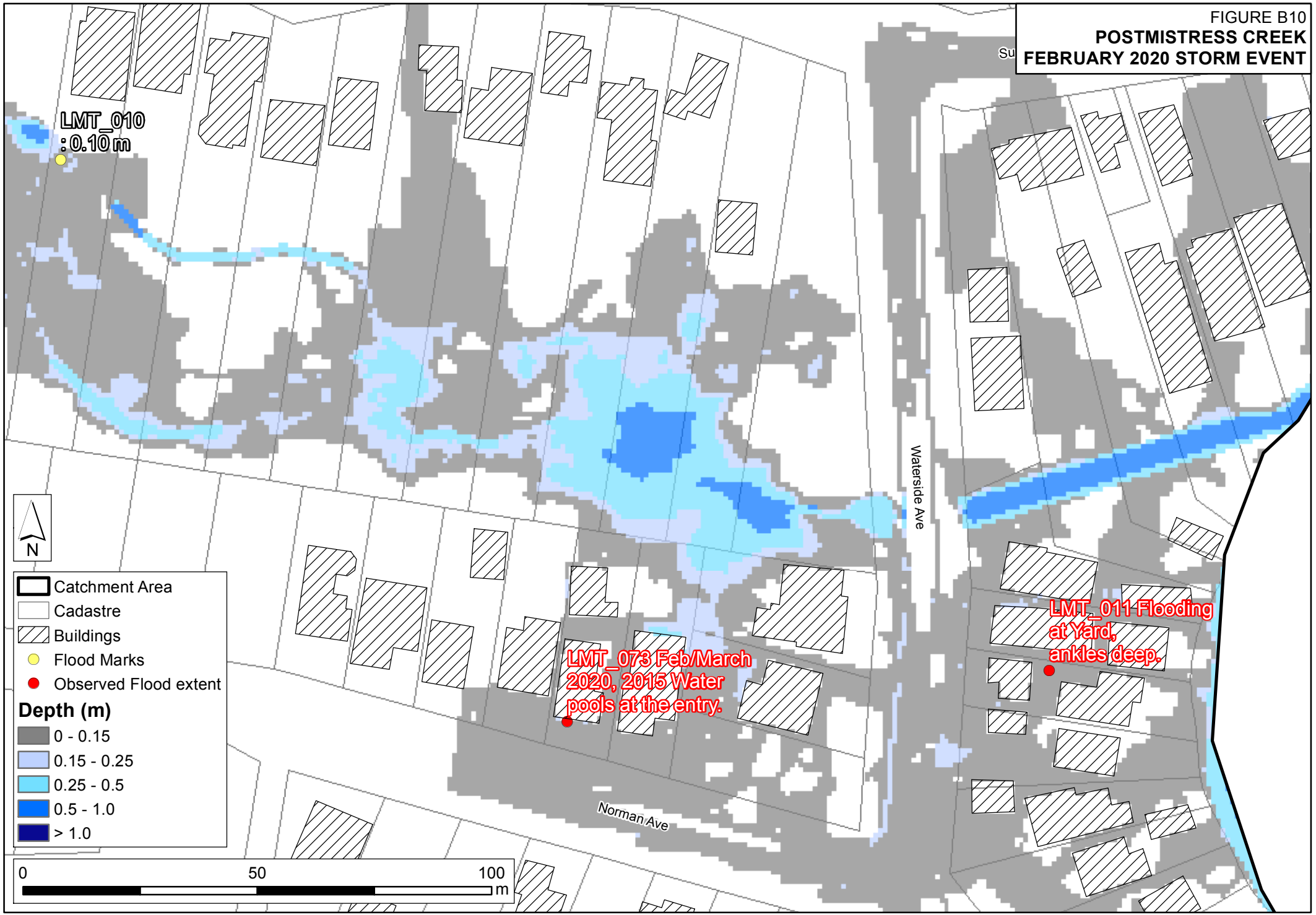


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FIGURE B11

**MANNERING CREEK, SWAMPY CREEK AND WYEE CREEK**
**2007 CALIBRATION EVENT**

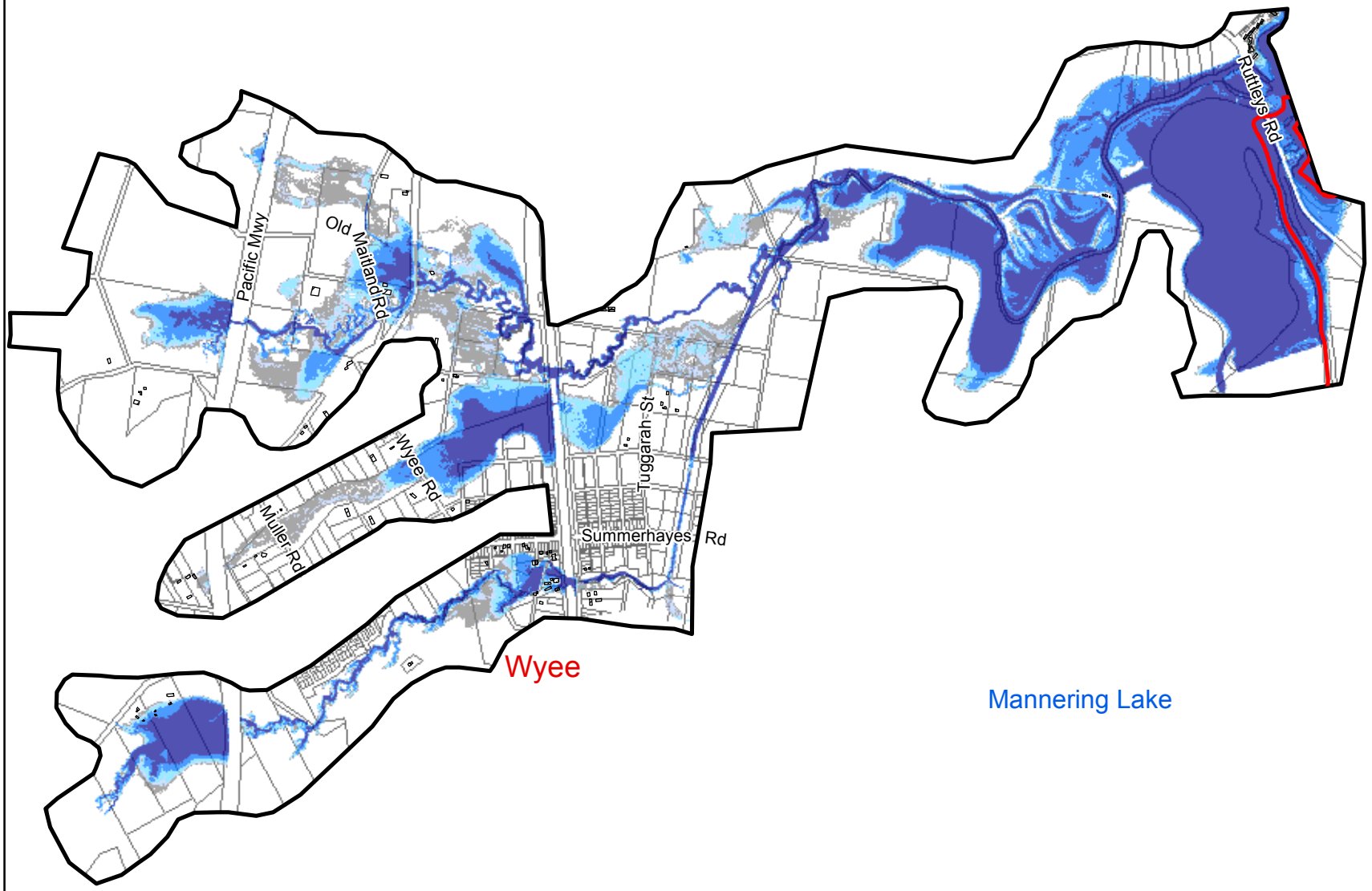


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FIGURE B12
**PLAINS GULLY CREEK**
**2007 CALIBRATION EVENT**
**BLOCKAGE REDUCED TO 25%**

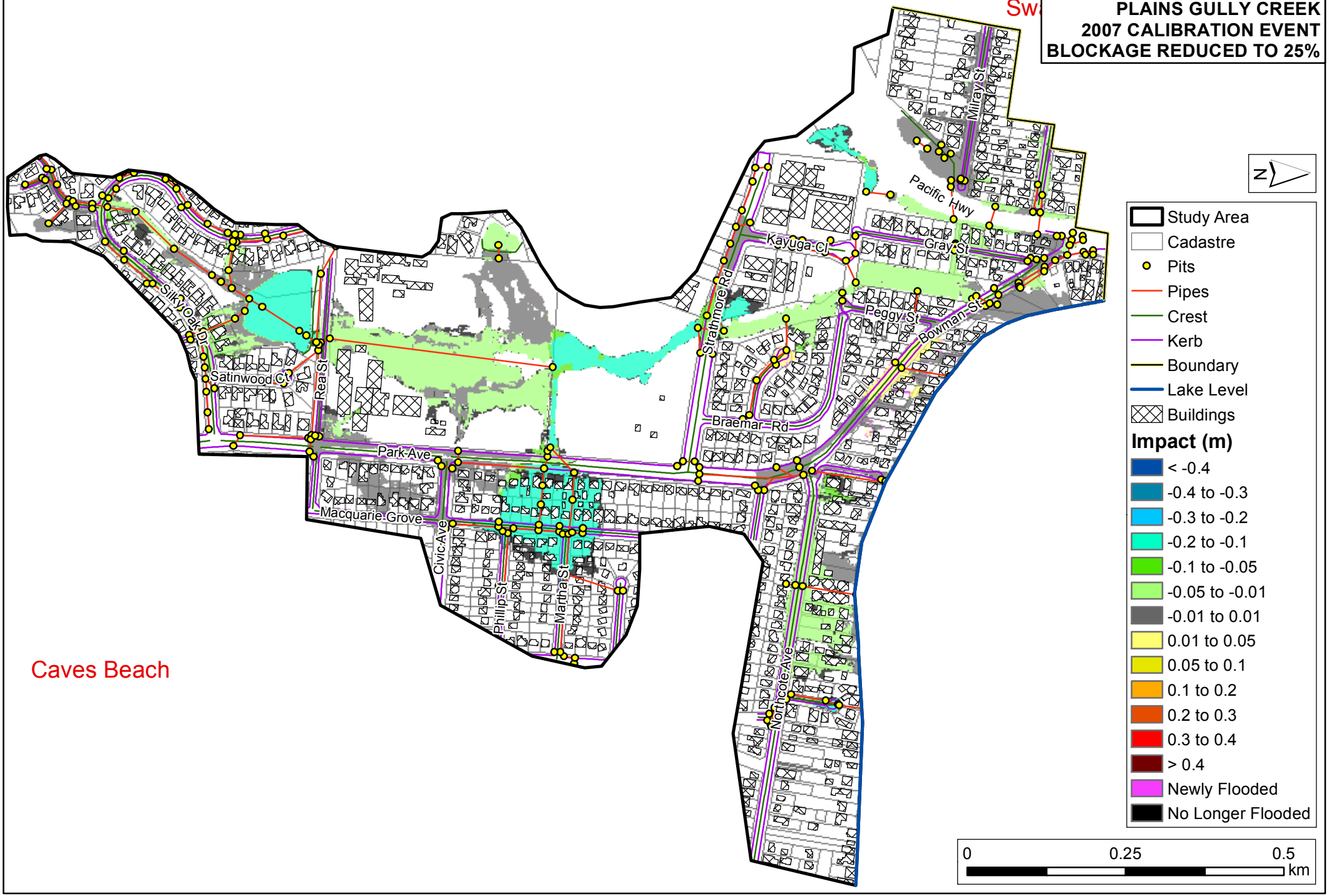


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FIGURE B13
**PLAINS GULLY CREEK**
**2007 CALIBRATION EVENT**
**BLOCKAGE INCREASED TO 75%**

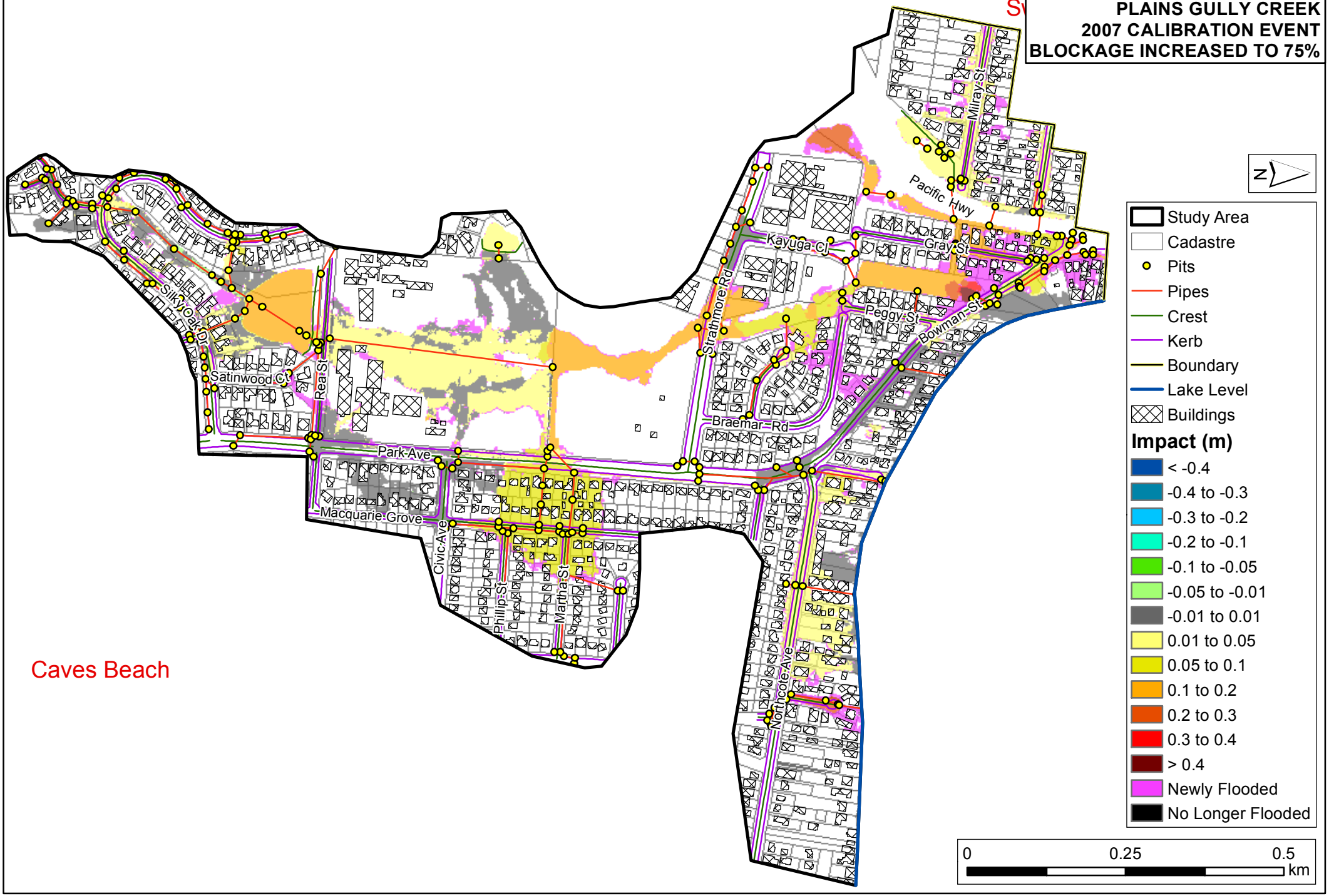


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FIGURE B14
**PLAINS GULLY CREEK**
**2007 CALIBRATION EVENT**
**LAG DECREASED BY 25%**

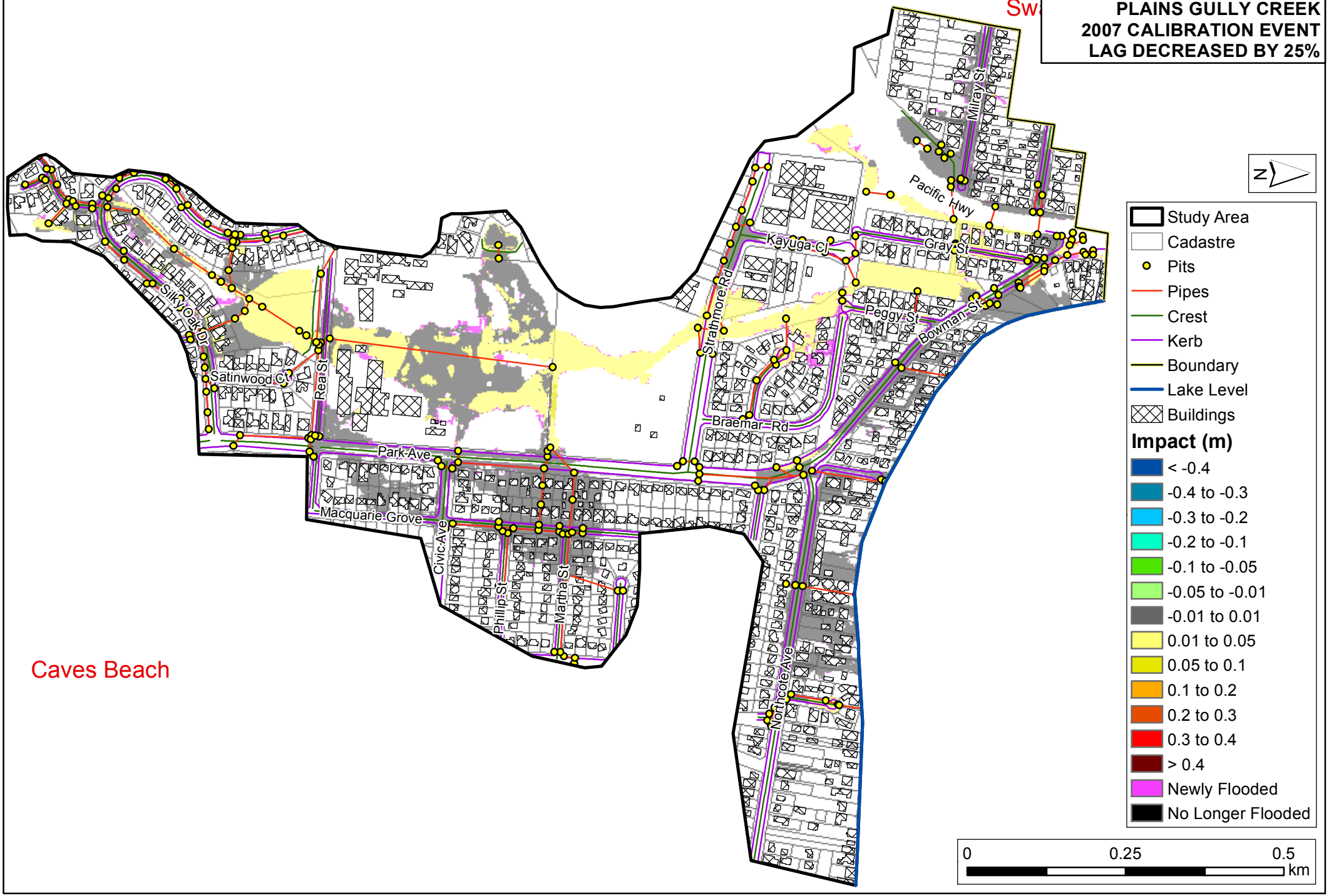


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FIGURE B15
**PLAINS GULLY CREEK**
**2007 CALIBRATION EVENT**
**LAG INCREASED BY 25%**

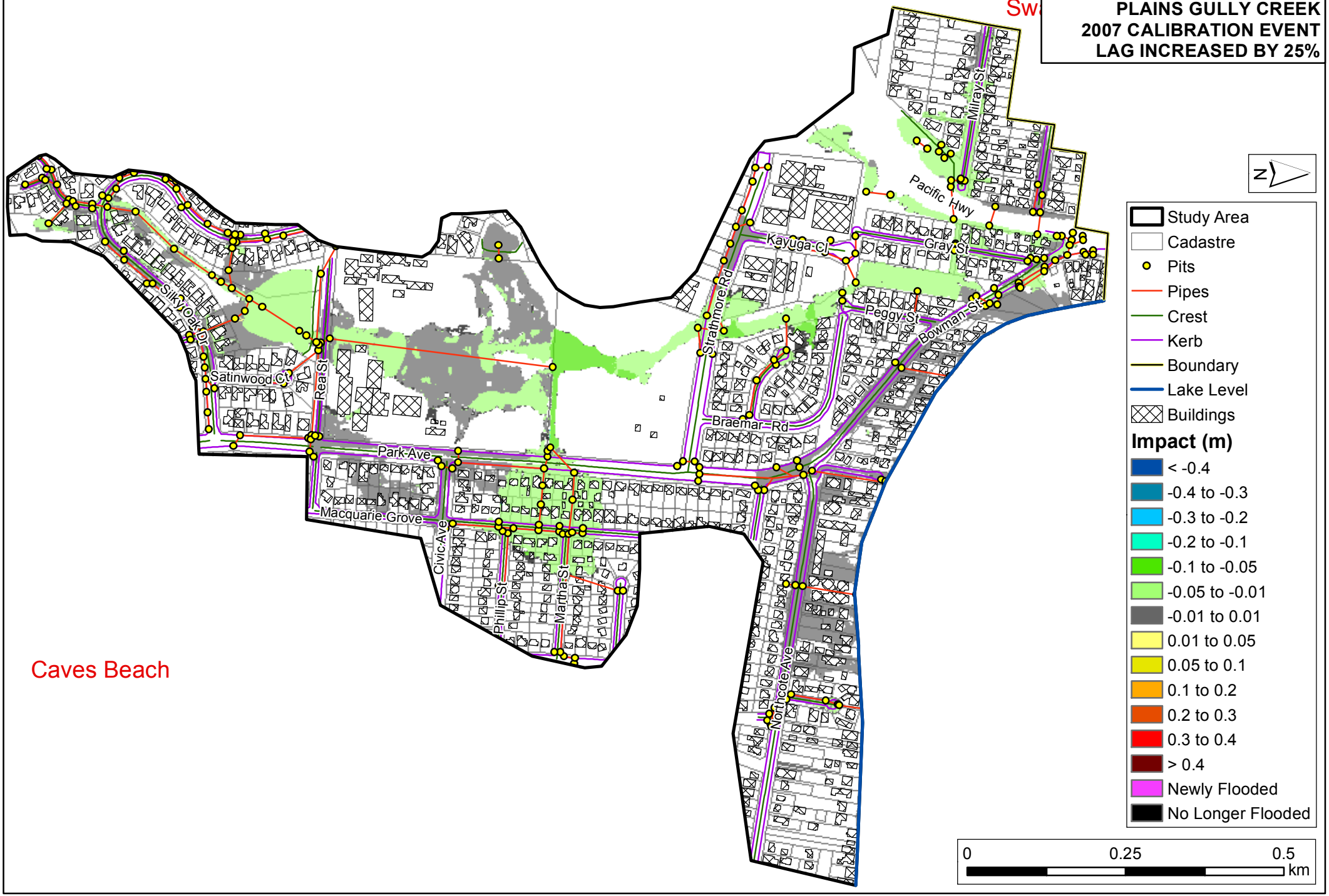


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FIGURE B16
**PLAINS GULLY CREEK**
**2007 CALIBRATION EVENT**
**LOSS DECREASED BY 25%**

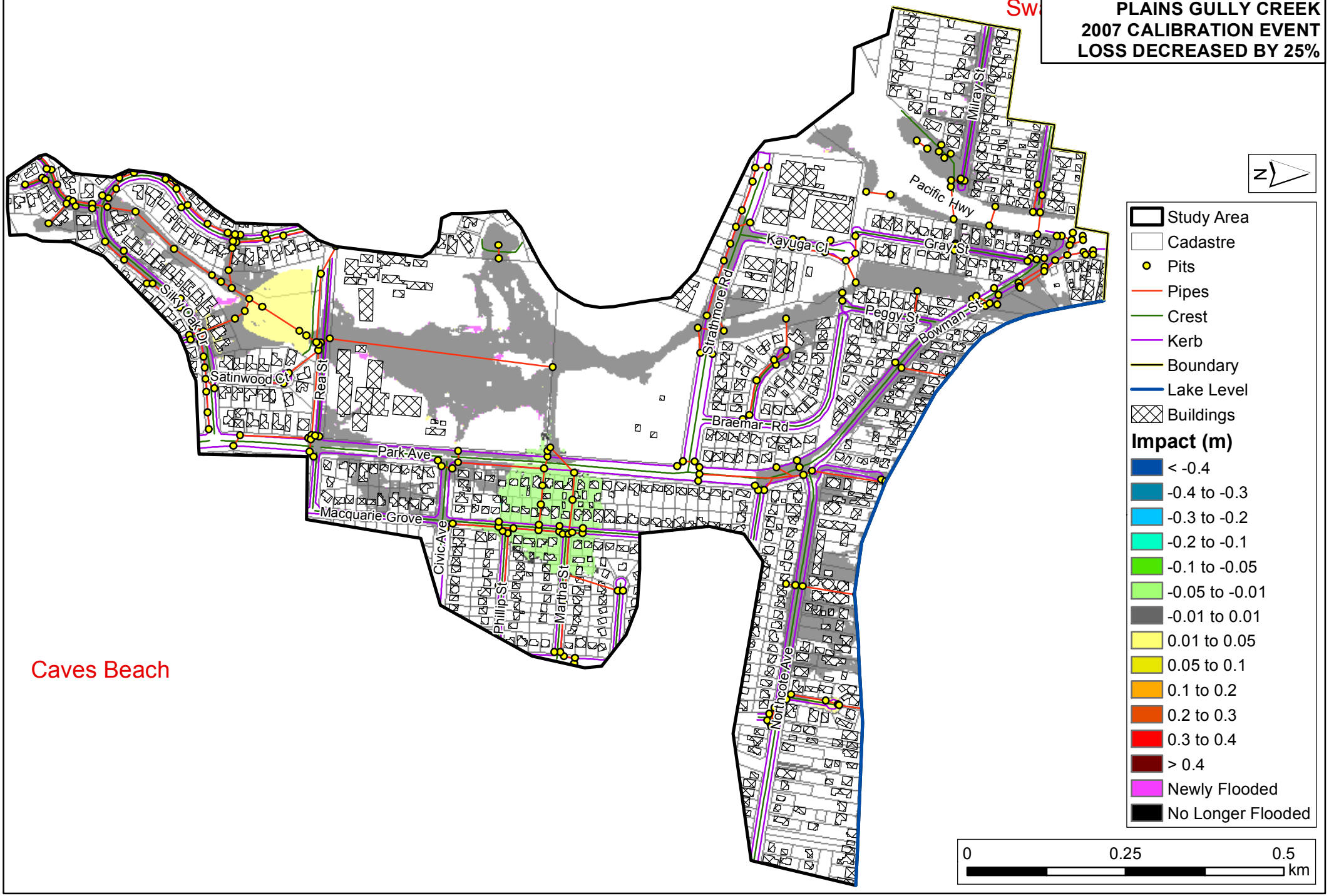


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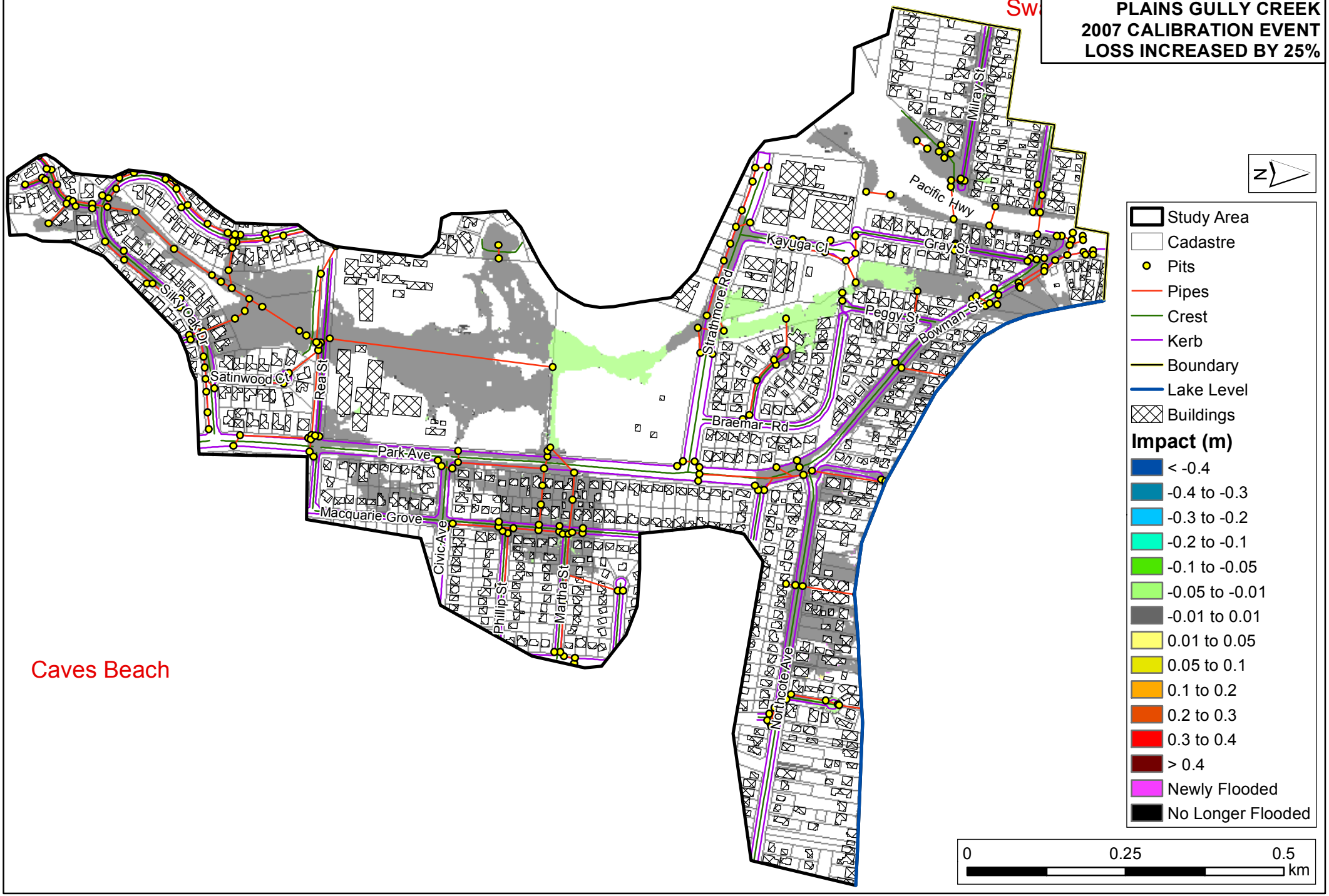
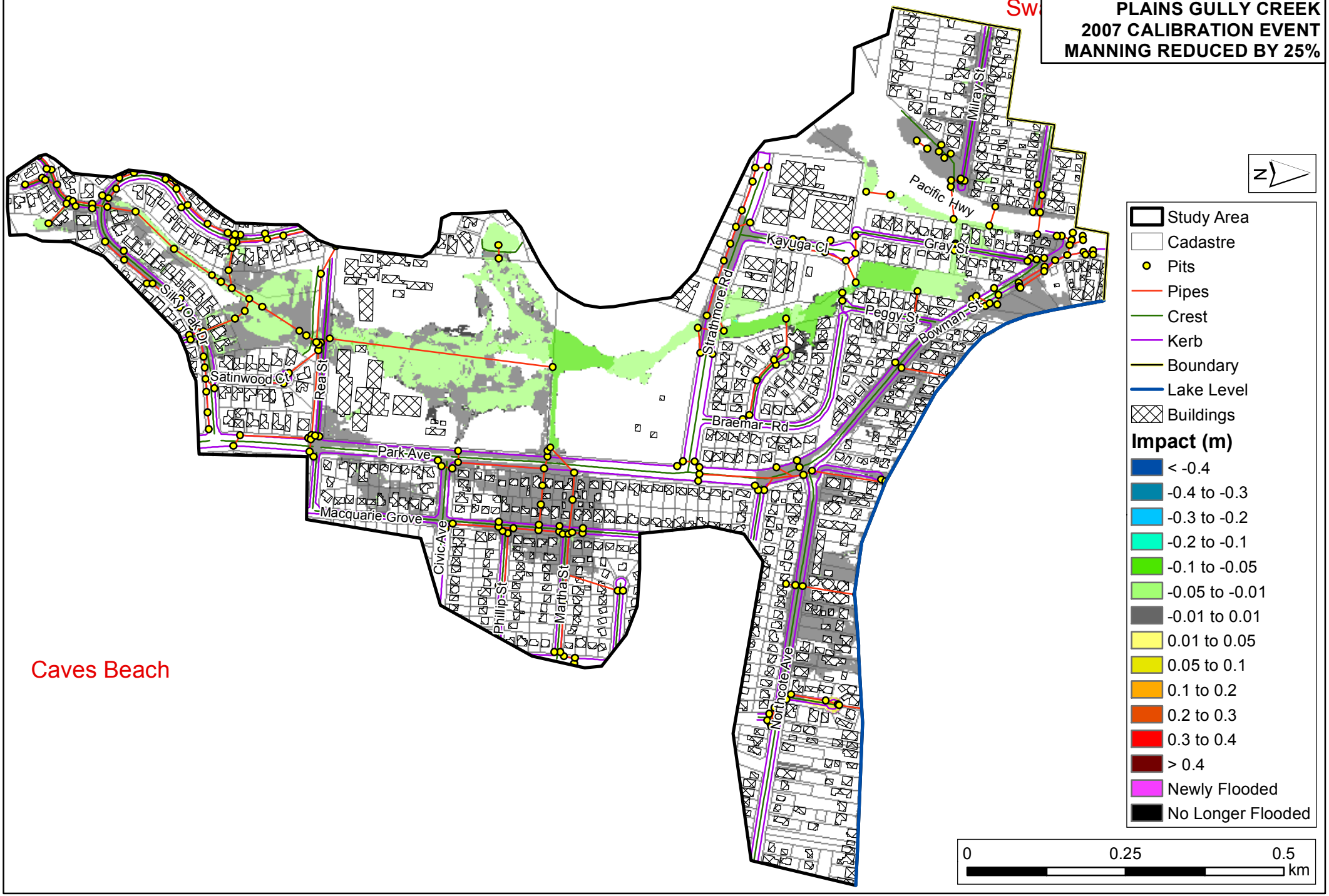
FIGURE B17
**PLAINS GULLY CREEK**
**2007 CALIBRATION EVENT**
**LOSS INCREASED BY 25%**



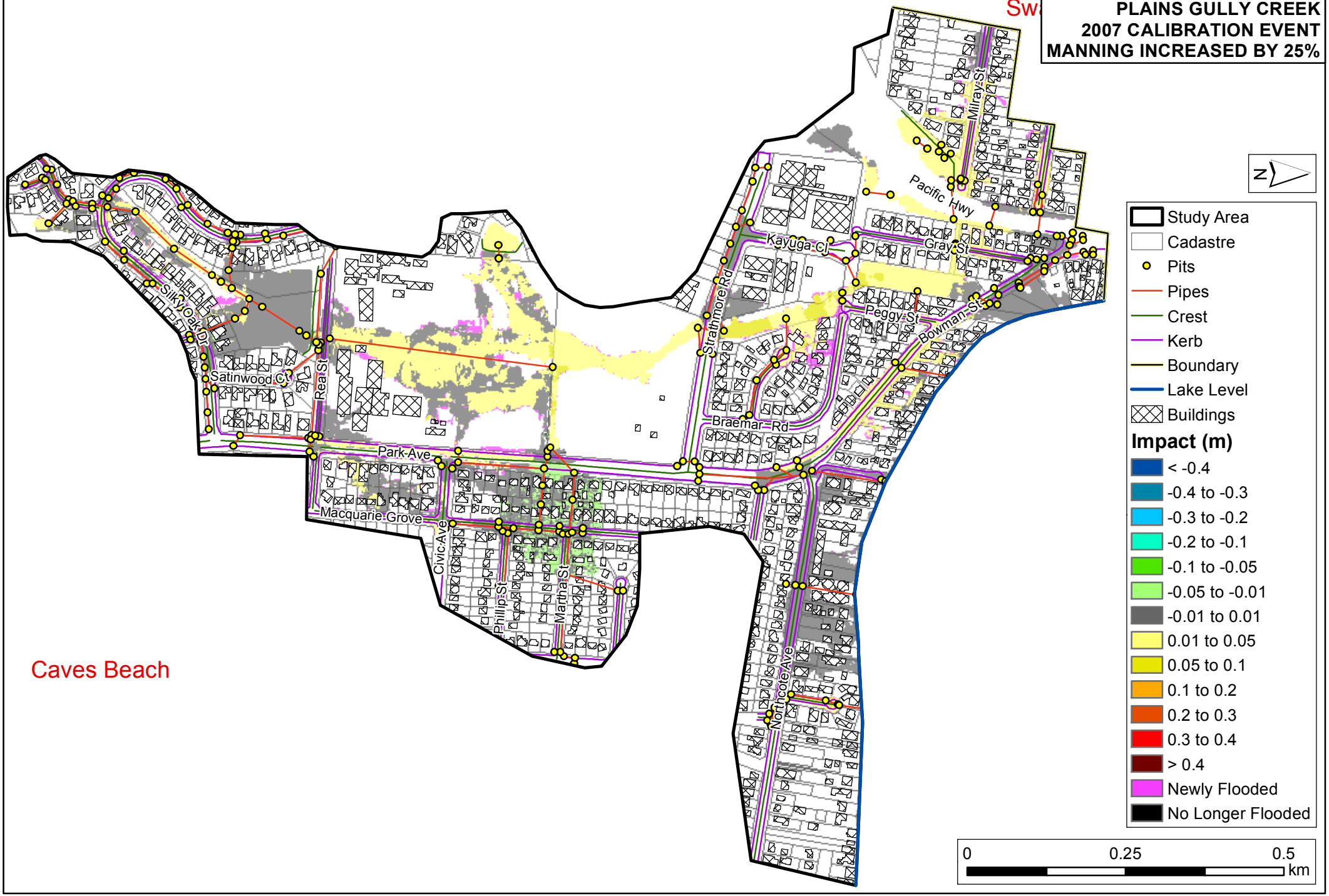

J:\Jobs\119076\ArcGIS\ArcMap\Report\AppendixB_Calibration\1to60\FigureB017_Plains_Gully_Creek_Impact_2007Swansea08_Calibration_DX1_Lossp25.mxd

FIGURE B18
**PLAINS GULLY CREEK**
**2007 CALIBRATION EVENT**
**MANNING REDUCED BY 25%**




J:\Jobs\119076\ArcGIS\ArcMap\Report\AppendixB_Calibration\1to60\FigureB018_Plains_Gully_Creek_Impact_2007Swansea08_Calibration_DX1_Mann25.mxd

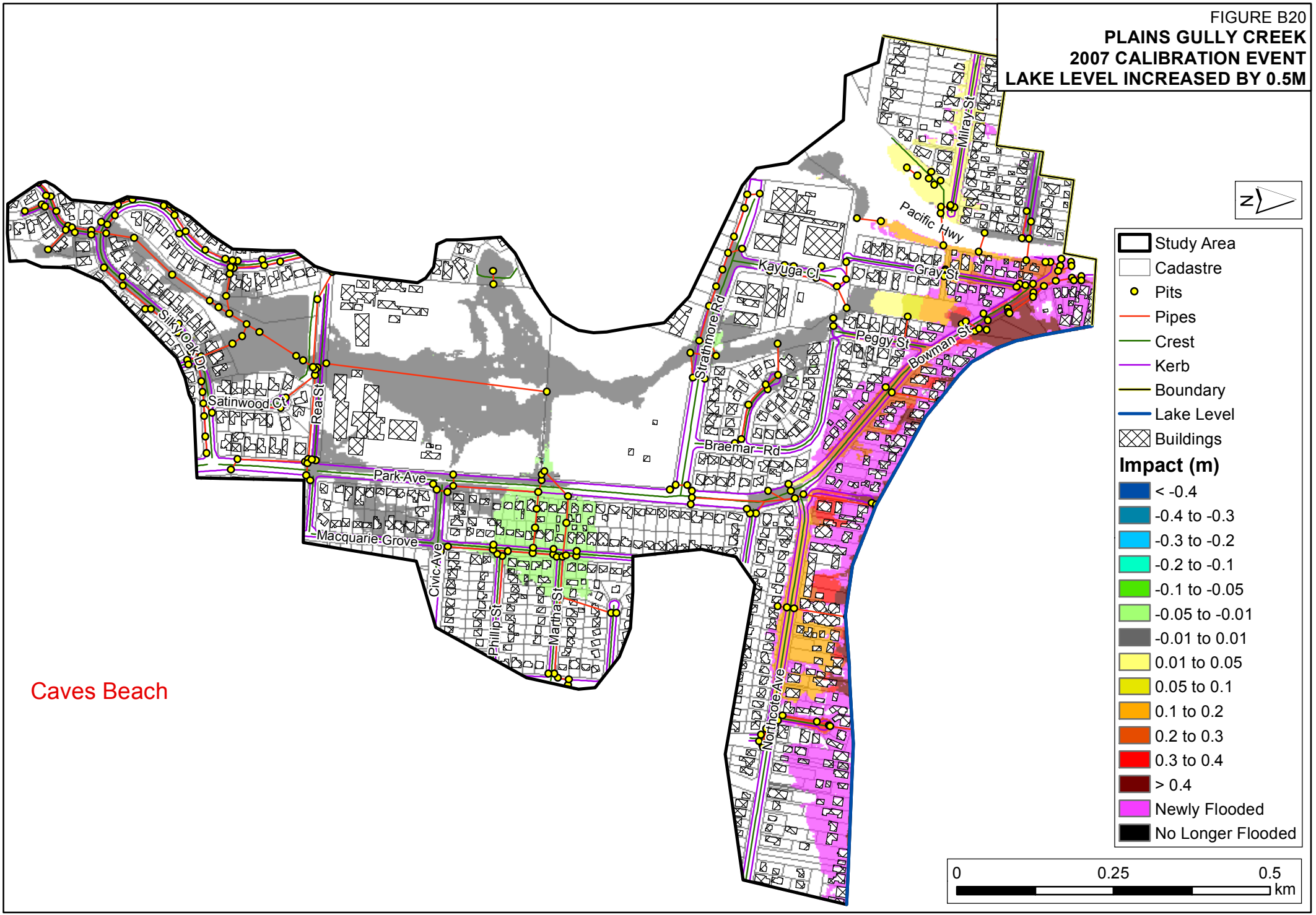
FIGURE B19
**PLAINS GULLY CREEK**
**2007 CALIBRATION EVENT**
**MANNING INCREASED BY 25%**




J:\Jobs\119076\ArcGIS\ArcMap\Report\AppendixB_Calibration\1to60\FigureB019_Plains_Gully_Creek_Impact_2007Swansea08_Calibration_DX1_Manp25.mxd

FIGURE B20

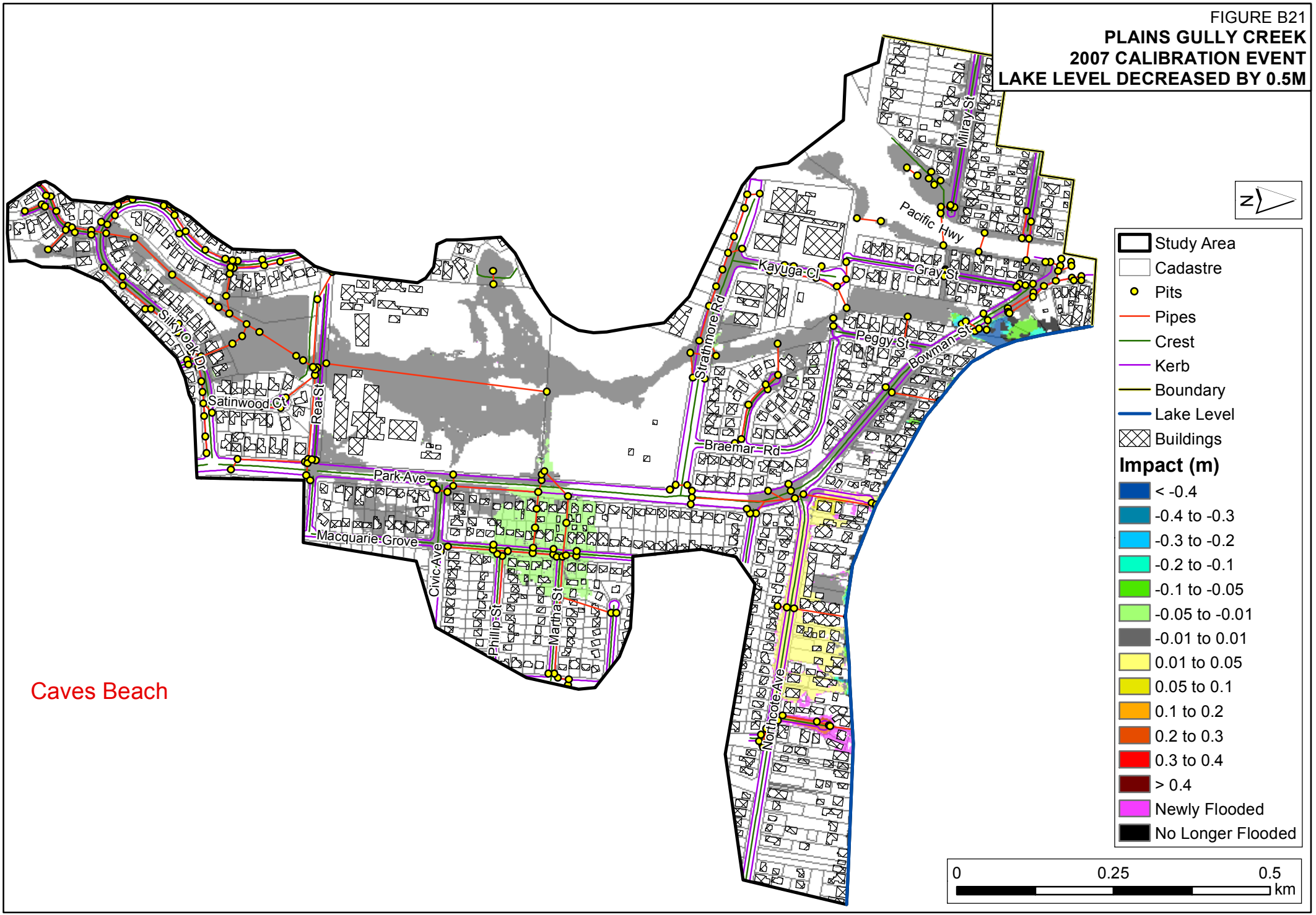
**PLAINS GULLY CREEK**
**2007 CALIBRATION EVENT**
**LAKE LEVEL INCREASED BY 0.5M**




J:\Jobs\119076\ArcGIS\ArcMap\Report\AppendixB_Calibration\1to60\FigureB020_Plains_Gully_Creek_Impact_2007Swansea08_Calibration_DX1_TWP500MM.mxd

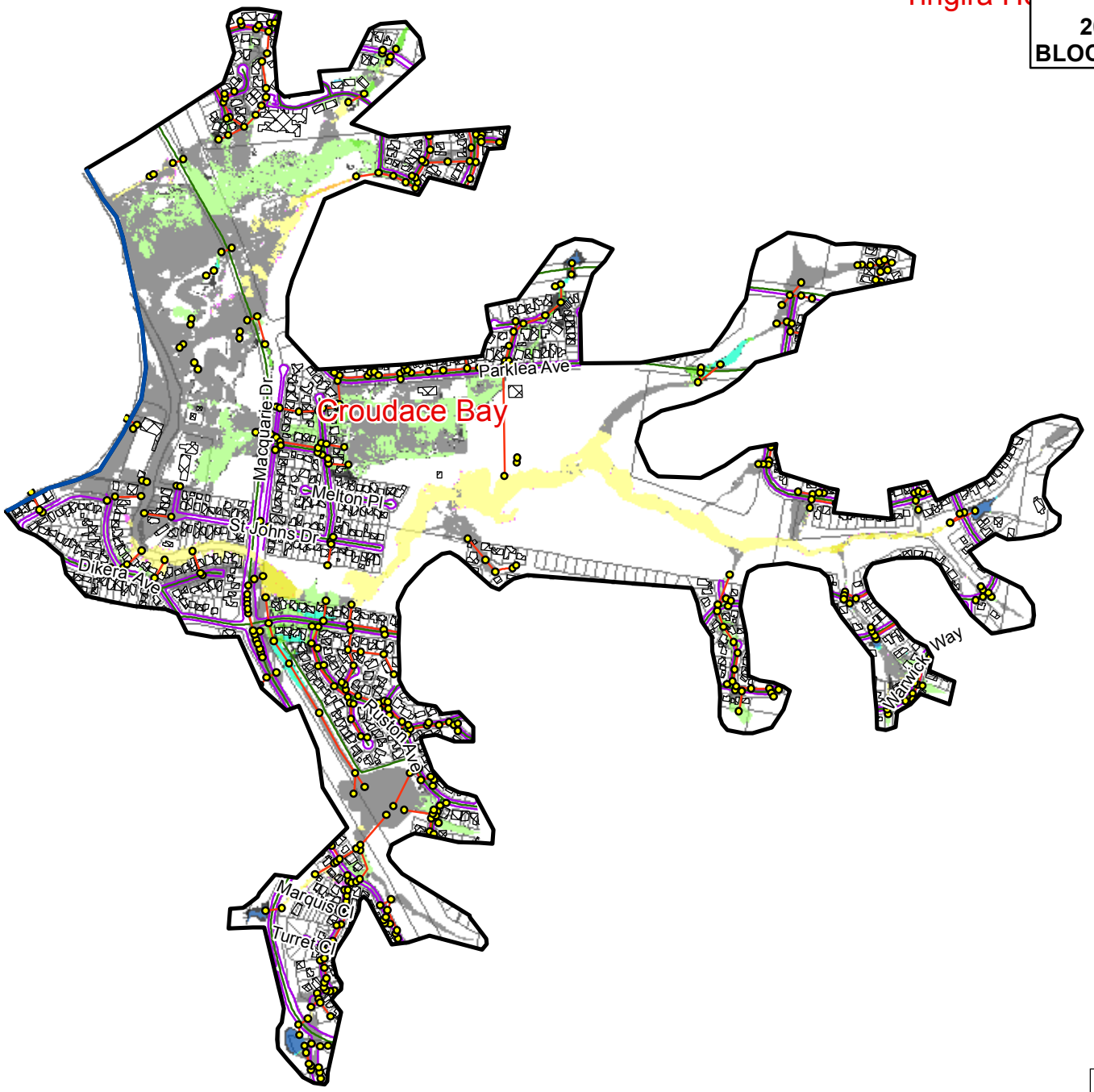
FIGURE B21

**PLAINS GULLY CREEK**
**2007 CALIBRATION EVENT**
**LAKE LEVEL DECREASED BY 0.5M**



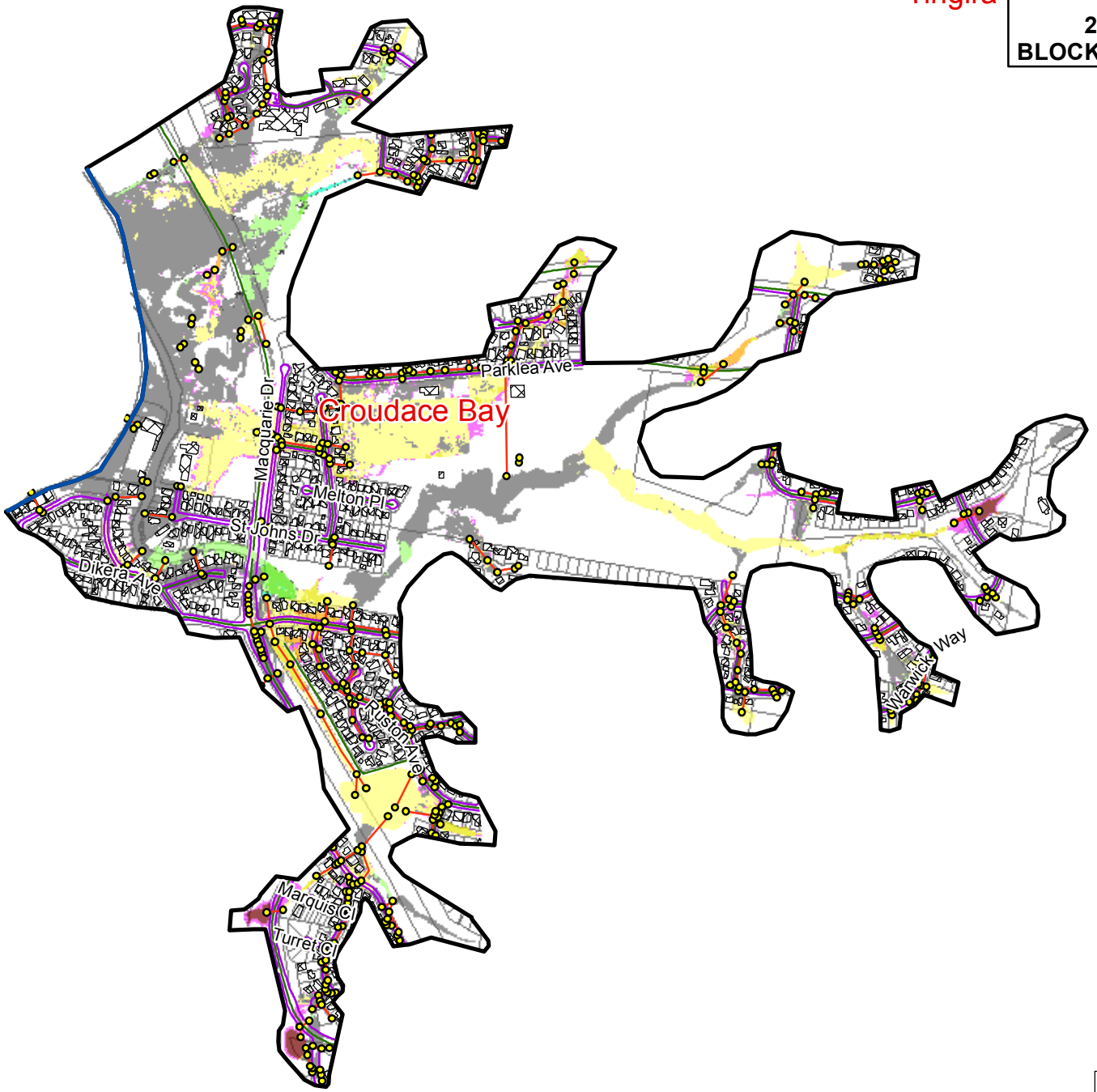

J:\Jobs\119076\ArcGIS\ArcMap\Report\AppendixB_Calibration\1to60\FigureB021_Plains_Gully_Creek_Impact_2007Swansea08_Calibration_DX1_TWM500MM.mxd

FIGURE B22
**SHEPPARDS CREEK**
**2007 CALIBRATION EVENT**
**BLOCKAGE REDUCED TO 25%**



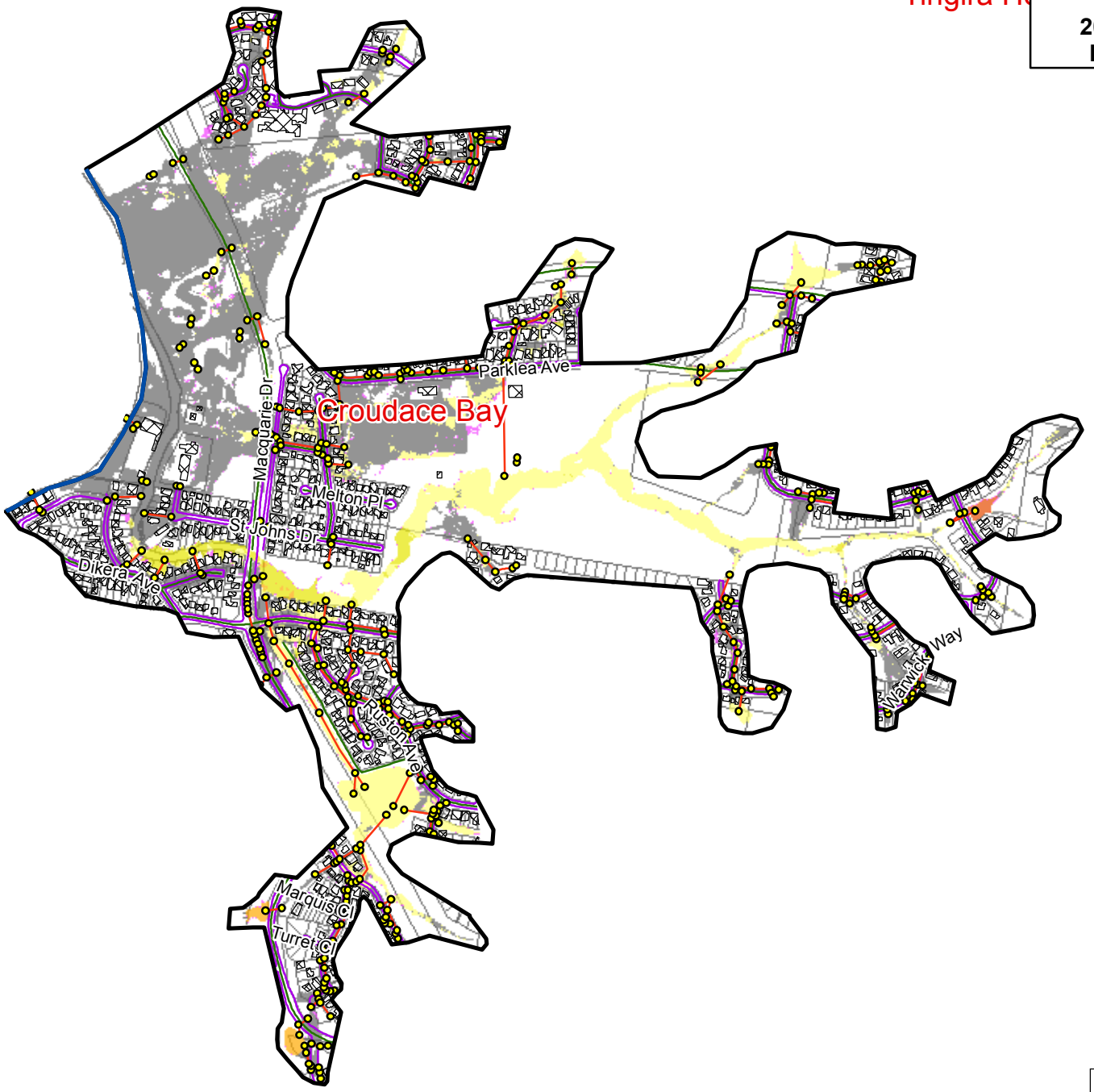

J:\Jobs\119076\ArcGIS\ArcMap\Report\AppendixB_Calibration\1to60\FigureB022_Sheppards_Creek_Impact_2007TR101_Calibration_DX1_blo025.mxd

FIGURE B23
**SHEPPARDS CREEK**
**2007 CALIBRATION EVENT**
**BLOCKAGE INCREASED TO 75%**



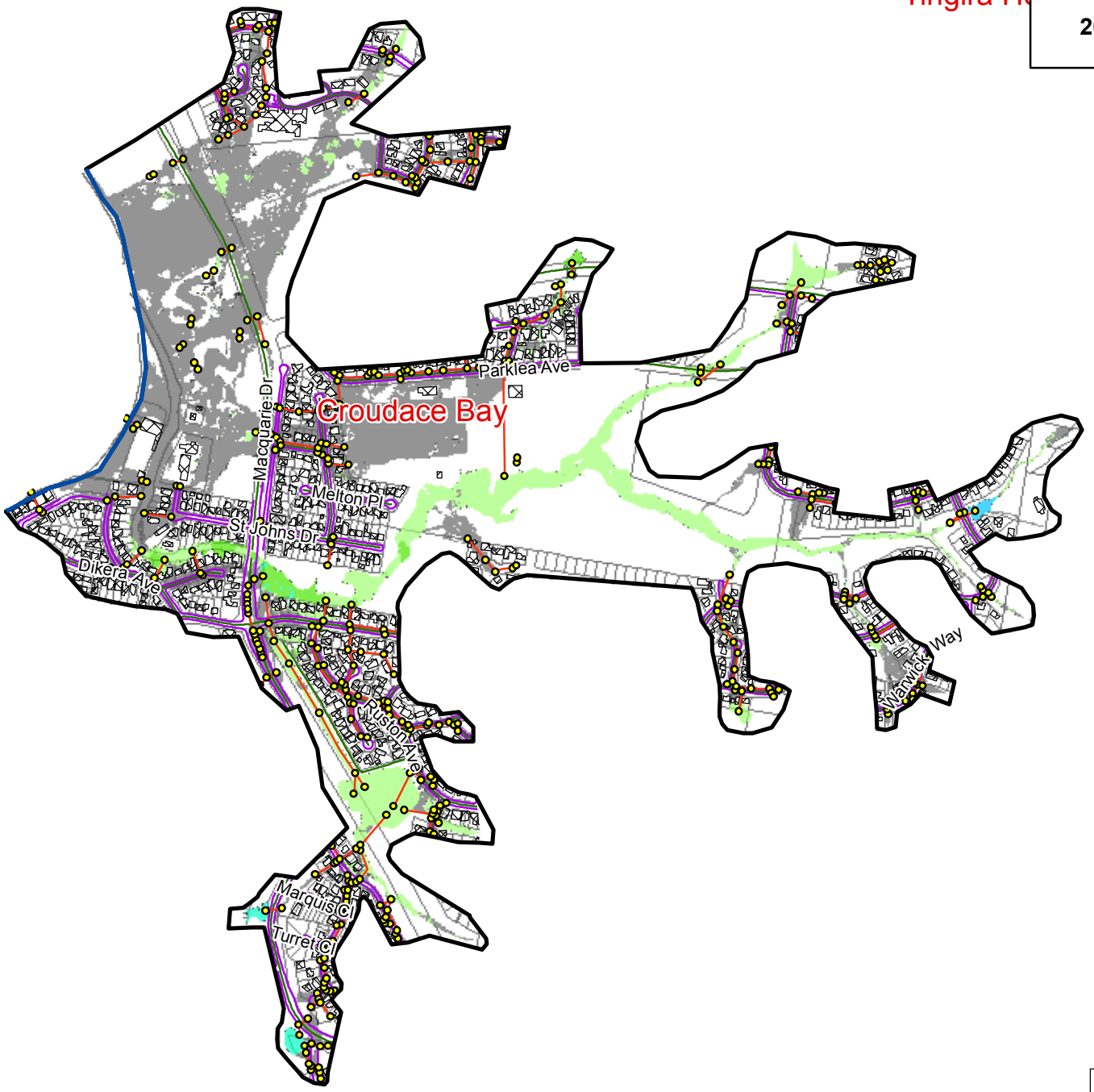

J:\Jobs\119076\ArcGIS\ArcMap\Report\AppendixB_Calibration\1to60\FigureB023_Sheppards_Creek_Impact_2007TR101_Calibration_DX1_blo075.mxd

FIGURE B24
**SHEPPARDS CREEK**
**2007 CALIBRATION EVENT**
**LAG DECREASED BY 25%**



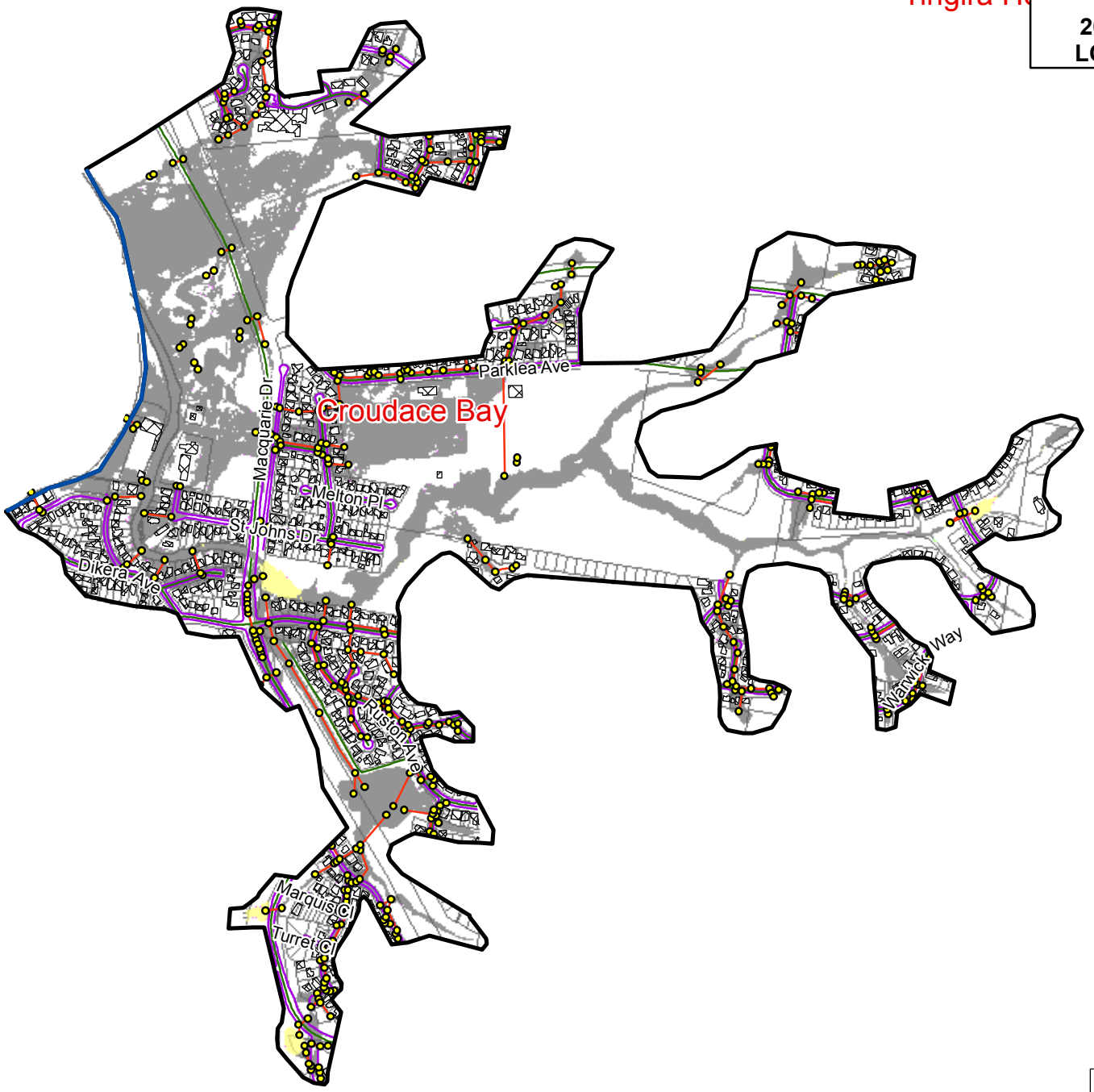

J:\Jobs\119076\ArcGIS\ArcMap\Report\AppendixB_Calibration\1to60\FigureB024_Sheppards_Creek_Impact_2007TR101_Calibration_DX1_LagM25.mxd

FIGURE B25
**SHEPPARDS CREEK**
**2007 CALIBRATION EVENT**
**LAG INCREASED BY 25%**




J:\Jobs\119076\ArcGIS\ArcMap\Report\AppendixB_Calibration\1to60\FigureB025_Sheppards_Creek_Impact_2007TR101_Calibration_DX1_LagP25.mxd

FIGURE B26
**SHEPPARDS CREEK**
**2007 CALIBRATION EVENT**
**LOSS DECREASED BY 25%**




J:\Jobs\119076\ArcGIS\ArcMap\Report\AppendixB_Calibration\1to60\FigureB026_Sheppards_Creek_Impact_2007TR101_Calibration_DX1_LossM25.mxd

FIGURE B27
**SHEPPARDS CREEK**
**2007 CALIBRATION EVENT**
**LOSS INCREASED BY 25%**

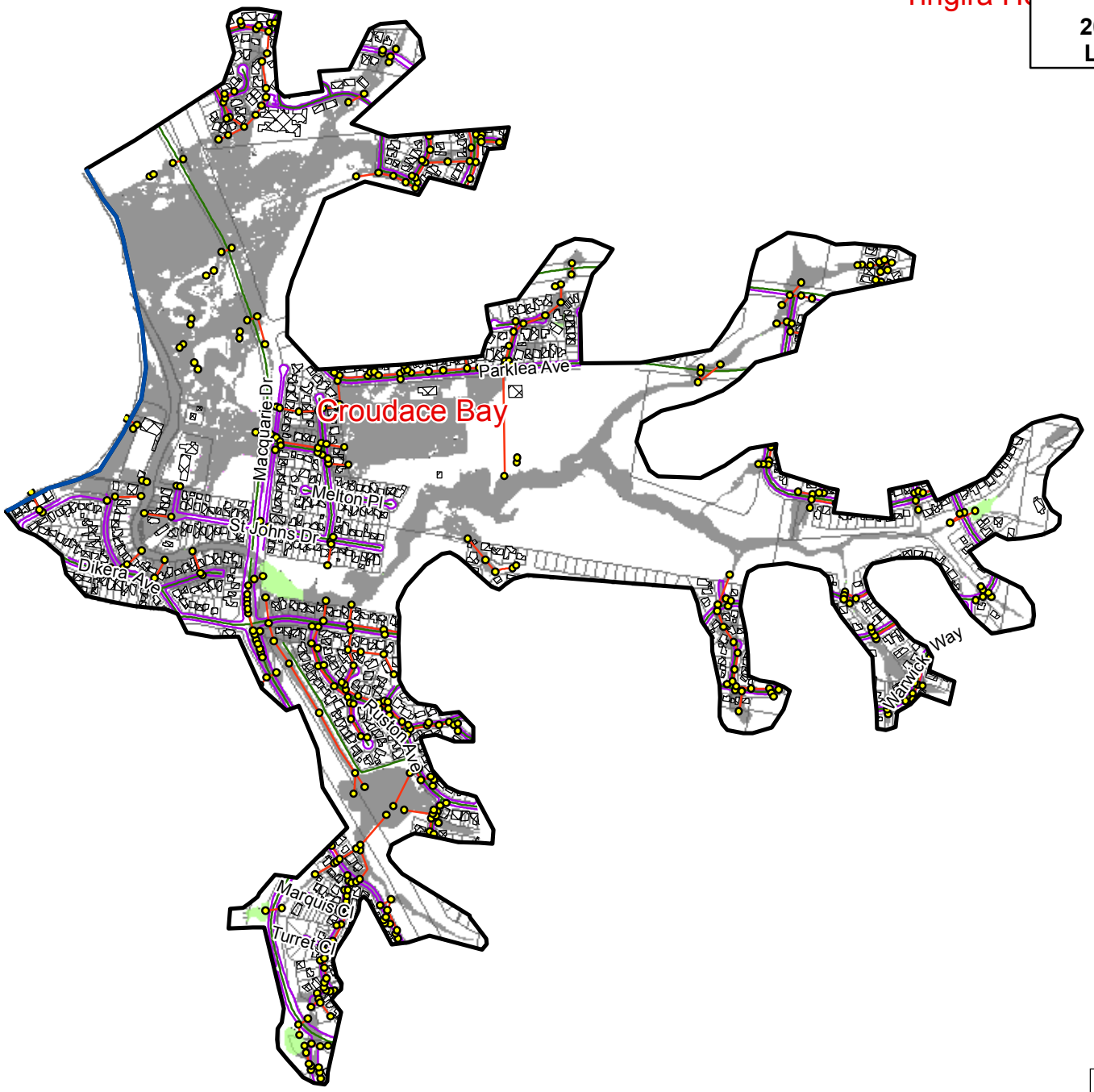



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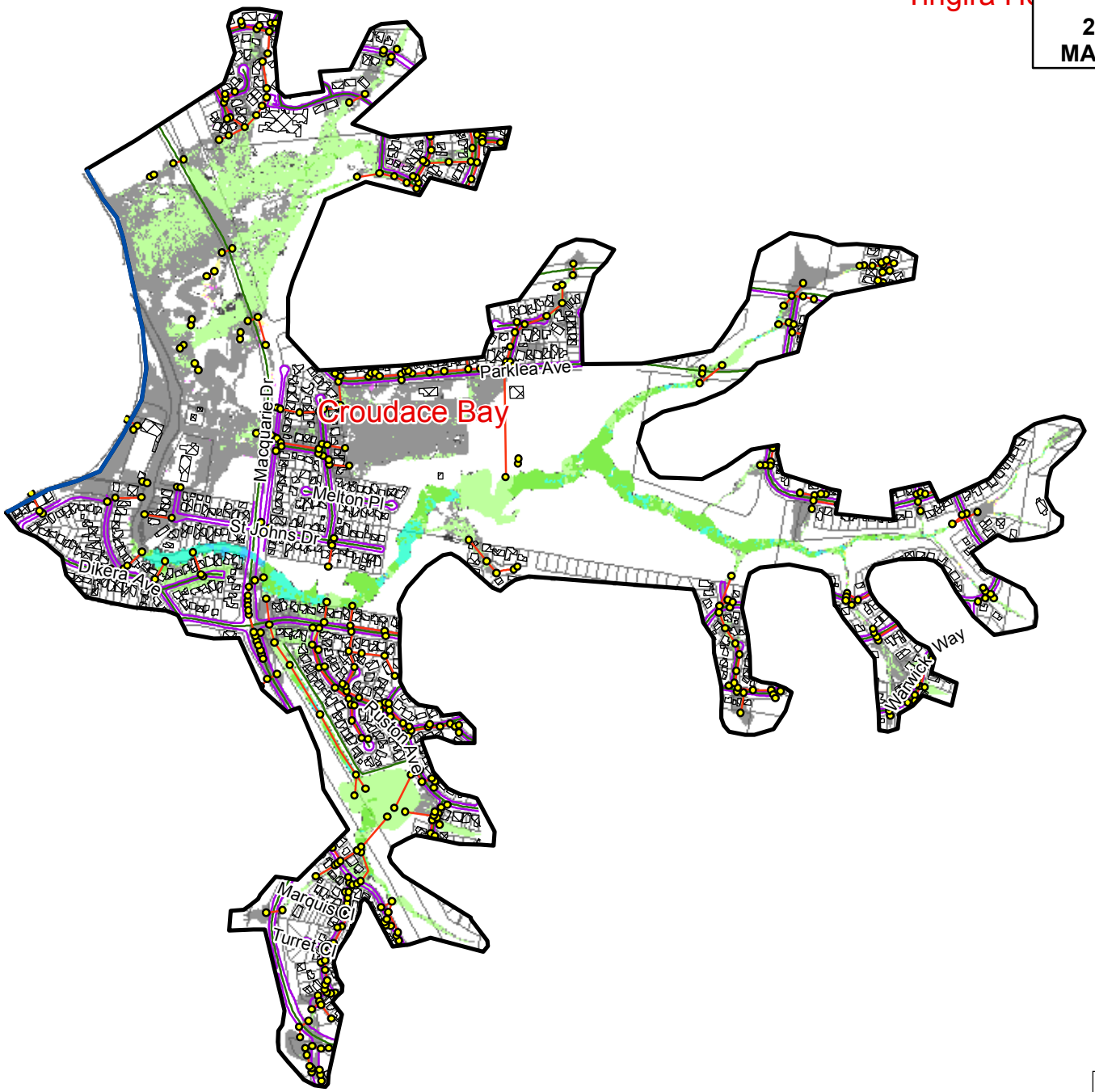
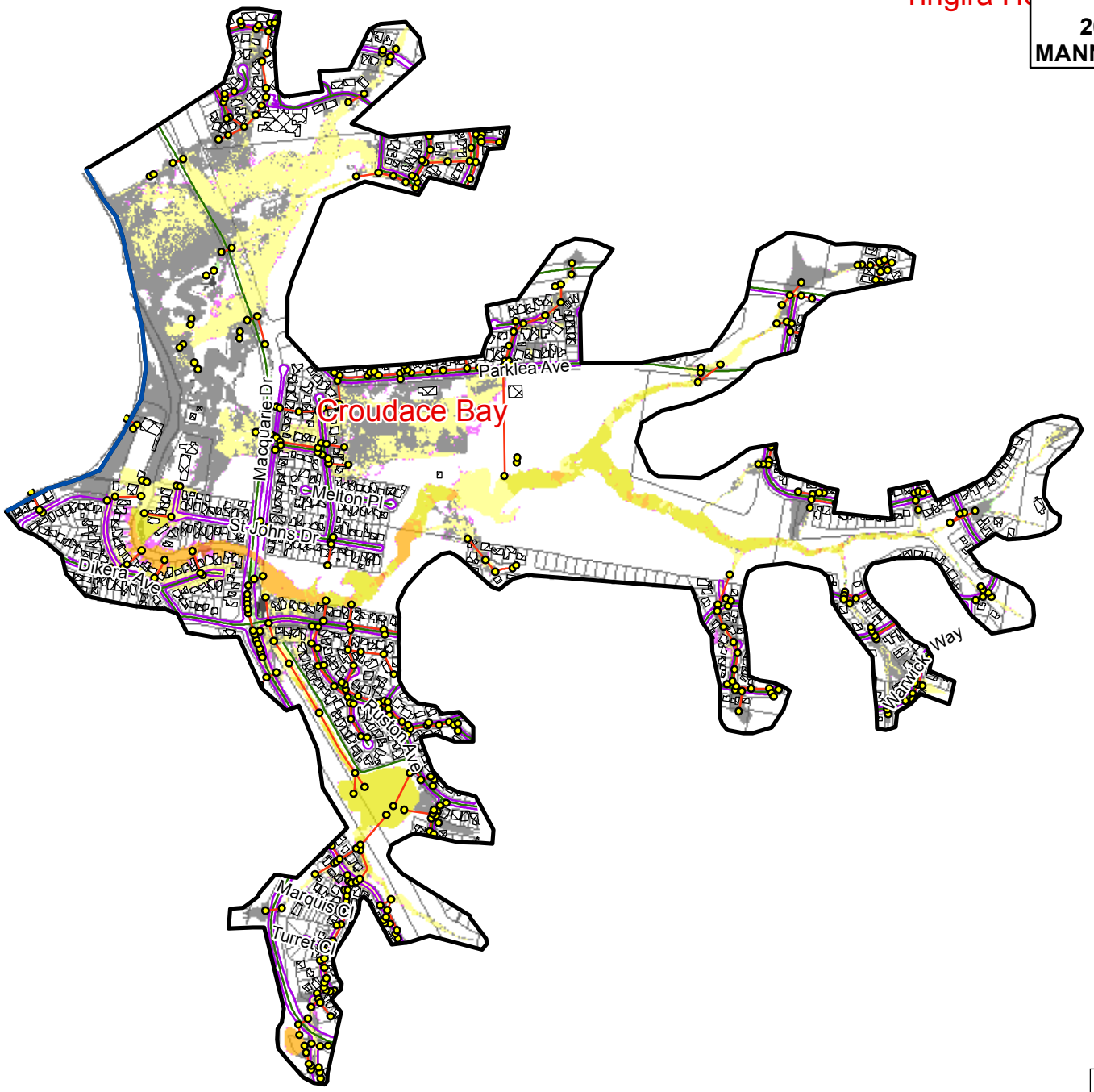
FIGURE B28
**SHEPPARDS CREEK**
**2007 CALIBRATION EVENT**
**MANNING REDUCED BY 25%**




J:\Jobs\1190776\ArcGIS\ArcMap\Report\AppendixB_Calibration\1to60\FigureB028_Sheppards_Creek_Impact_2007TR101_Calibration_DX1_manm25.mxd

FIGURE B29
**SHEPPARDS CREEK**
**2007 CALIBRATION EVENT**
**MANNING INCREASED BY 25%**




J:\Jobs\119076\ArcGIS\ArcMap\Report\AppendixB_Calibration\1to60\FigureB029_Sheppards_Creek_Impact_2007TR101_Calibration_DX1_manp25.mxd

FIGURE B30
**SHEPPARDS CREEK**
**2007 CALIBRATION EVENT**
**LAKE LEVEL INCREASED BY 0.5M**

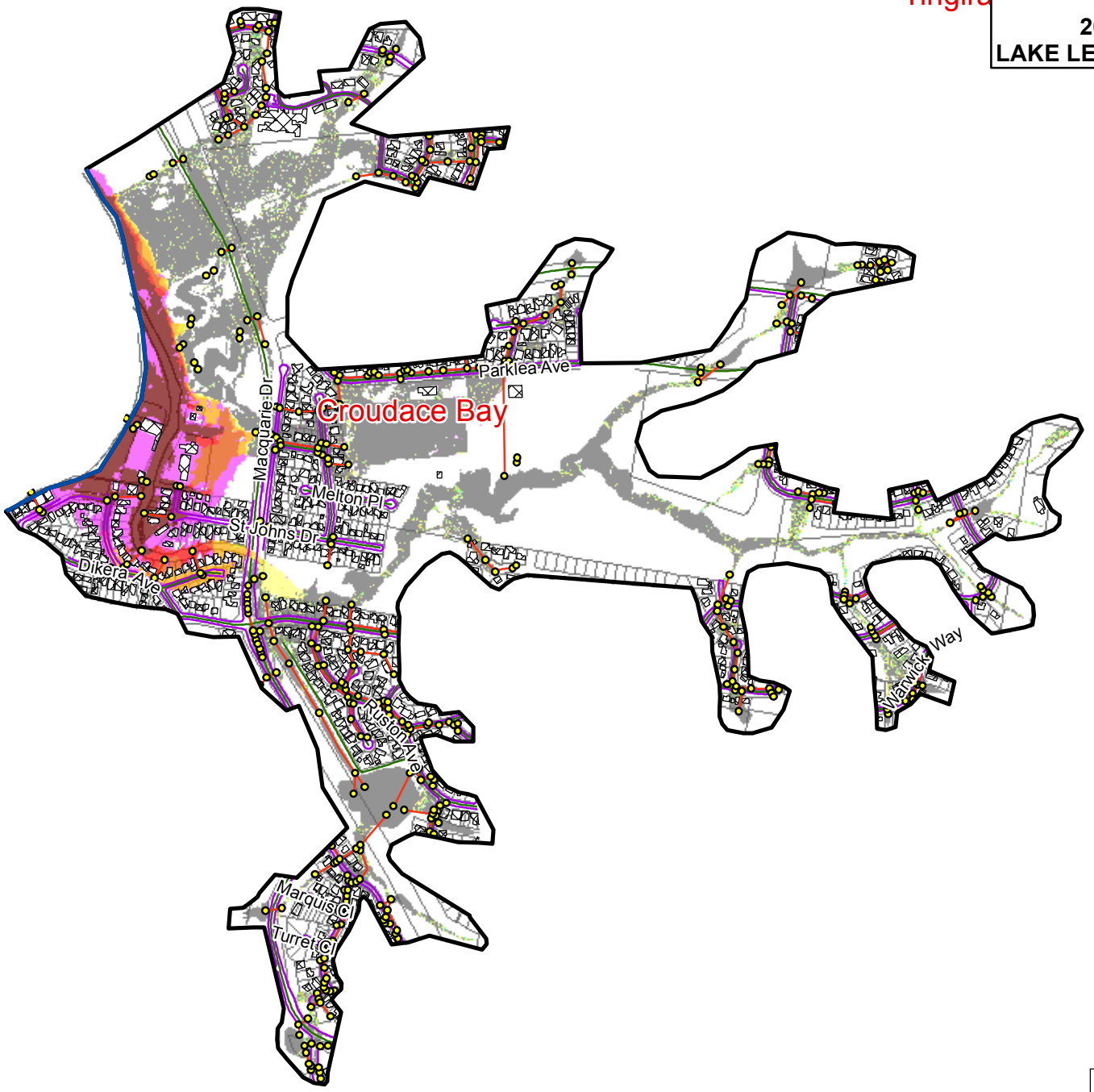



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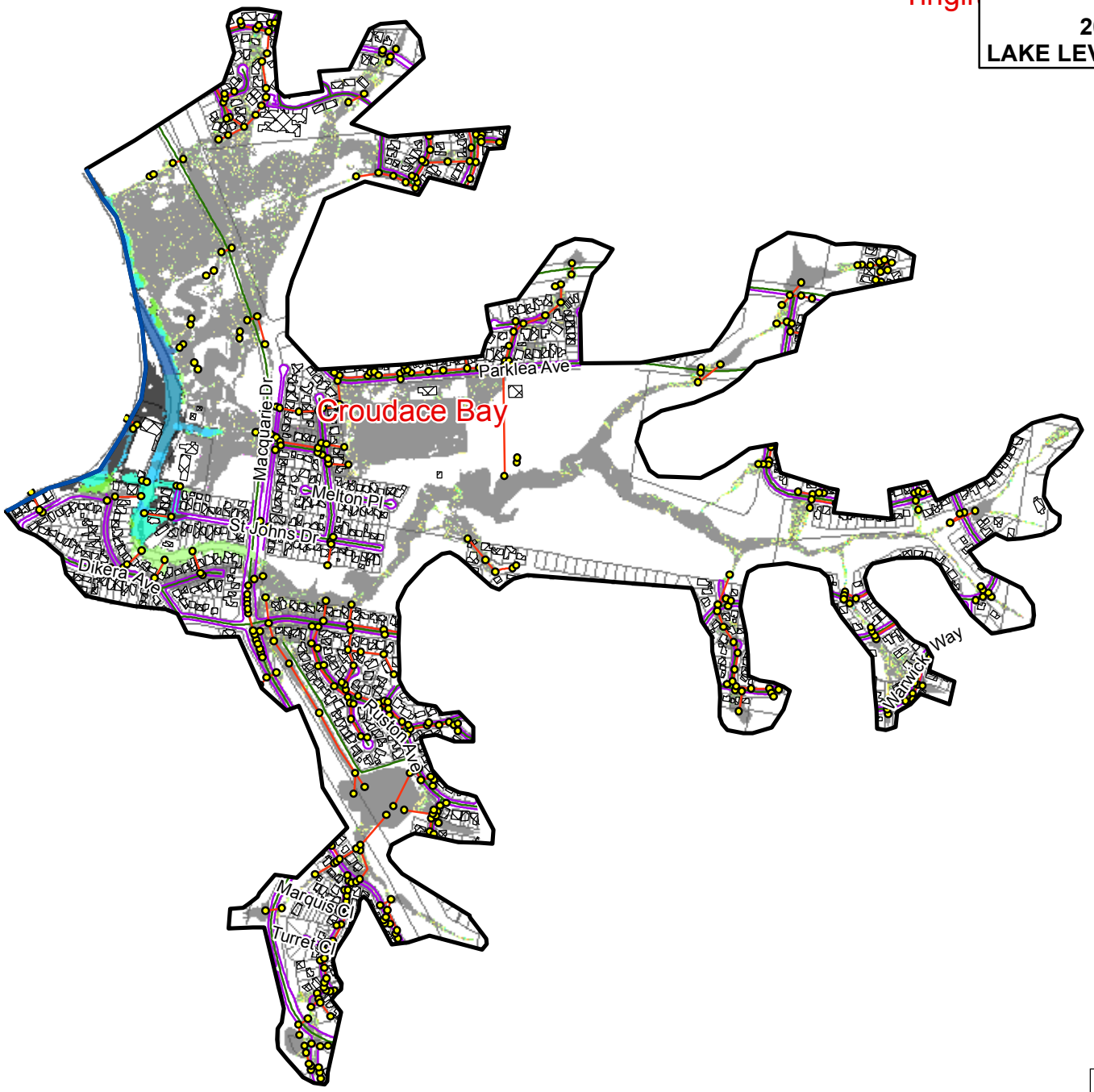
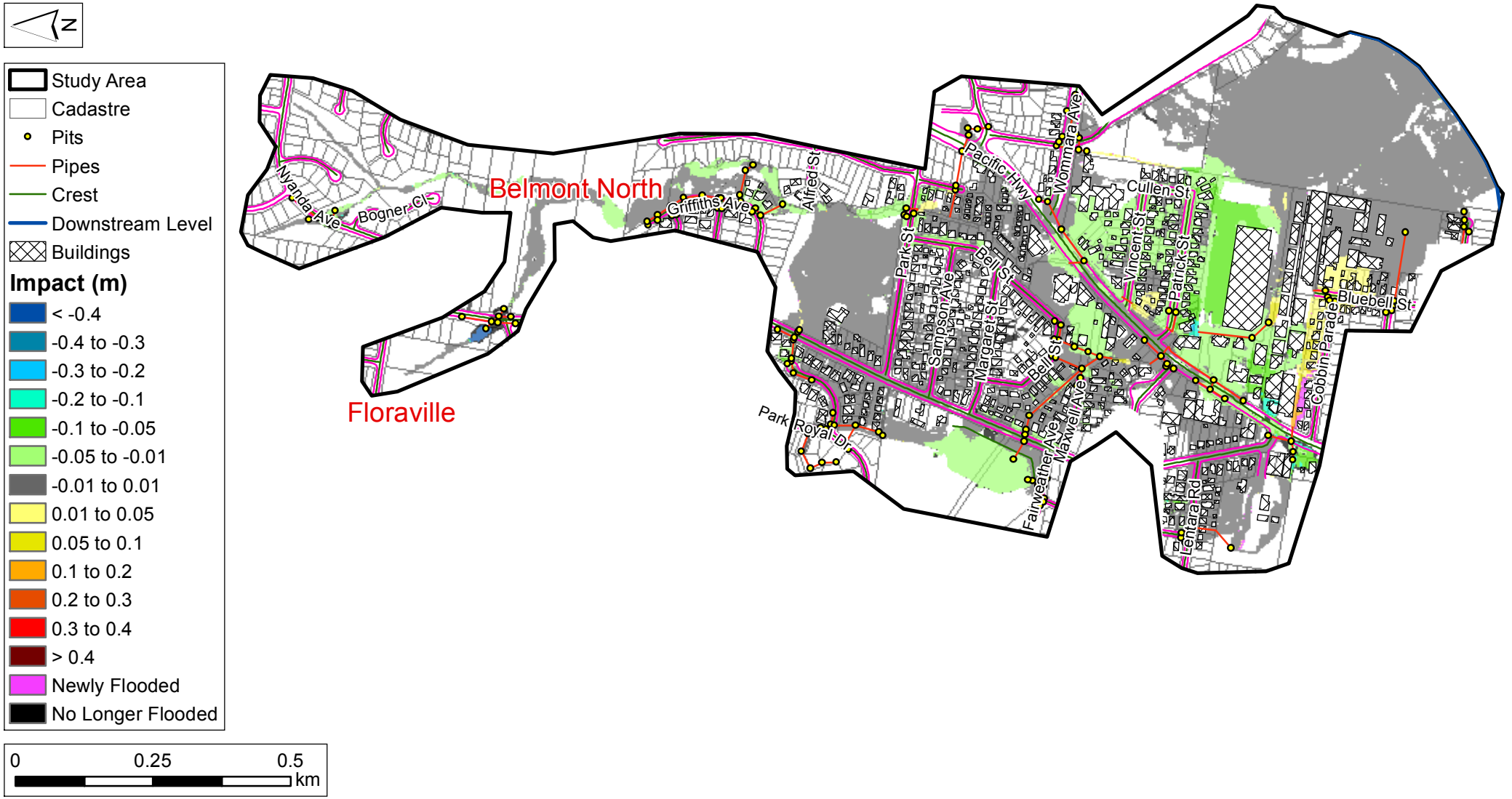
FIGURE B31
**SHEPPARDS CREEK**
**2007 CALIBRATION EVENT**
**LAKE LEVEL DECREASED BY 0.5M**



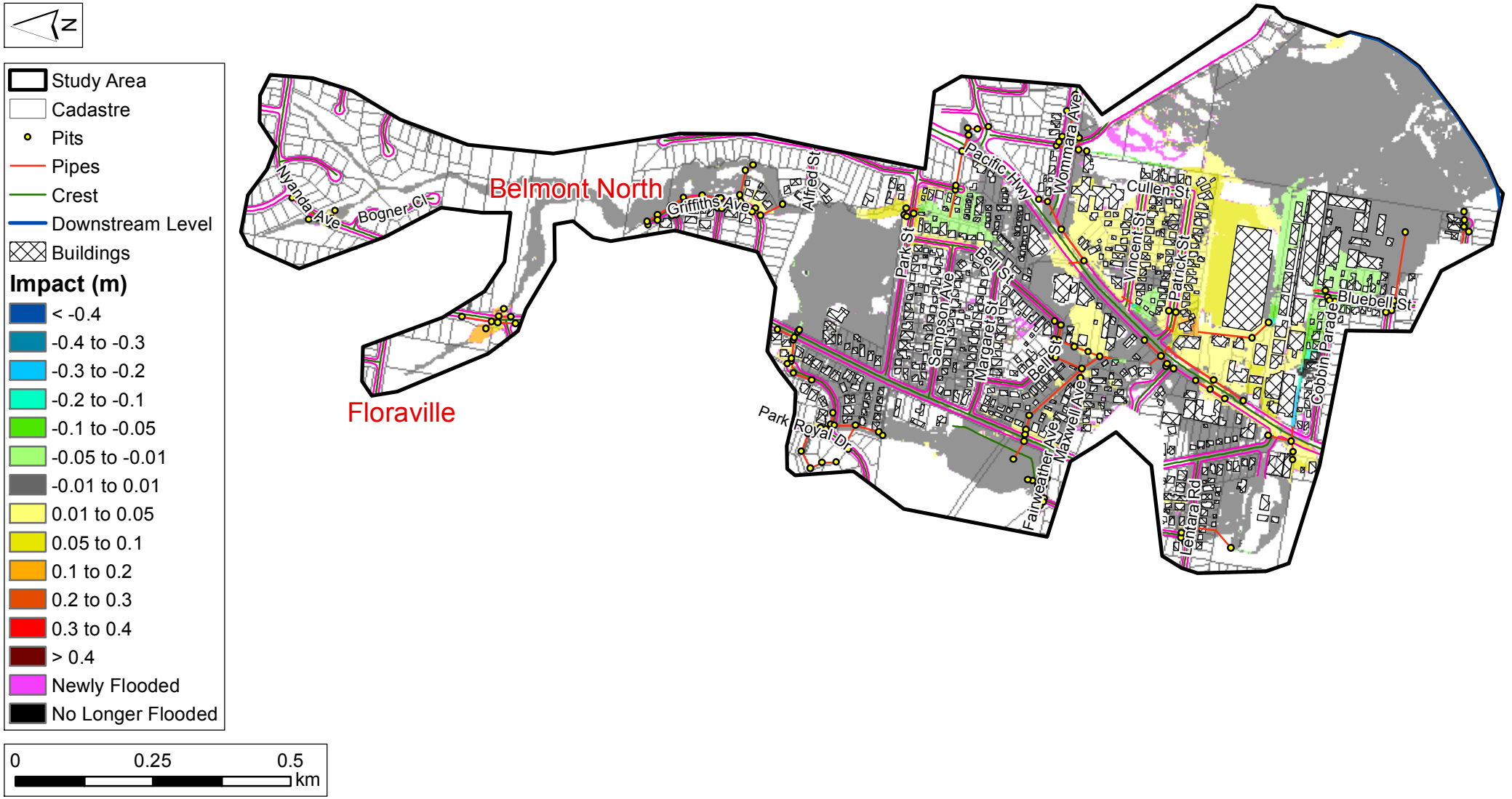

J:\Jobs\1190776\ArcGIS\ArcMap\Report\AppendixB_Calibration\1to60\FigureB031_Sheppards_Creek_Impact_2007TR101_Calibration_DX1_TWM500MM.mxd

FIGURE B32
**MURABAN CREEK**
**2015 CALIBRATION EVENT**
**BLOCKAGE REDUCED TO 25%**




J:\Jobs\119076\ArcGIS\ArcMap\Report\AppendixB_Calibration\1to60\FigureB032_Muraban_Creek_Impact_2007TR101_Calibration_DX1_blo025.mxd

FIGURE B33
**MURABAN CREEK**
**2007 CALIBRATION EVENT**
**BLOCKAGE INCREASED TO 75%**




J:\Jobs\119076\ArcGIS\ArcMap\Report\AppendixB_Calibration\1to60\FigureB033_Muraban_Creek_Impact_2007TR101_Calibration_DX1_bio075.mxd

FIGURE B34
**MURABAN CREEK**
**2007 CALIBRATION EVENT**
**LAG DECREASED BY 25%**

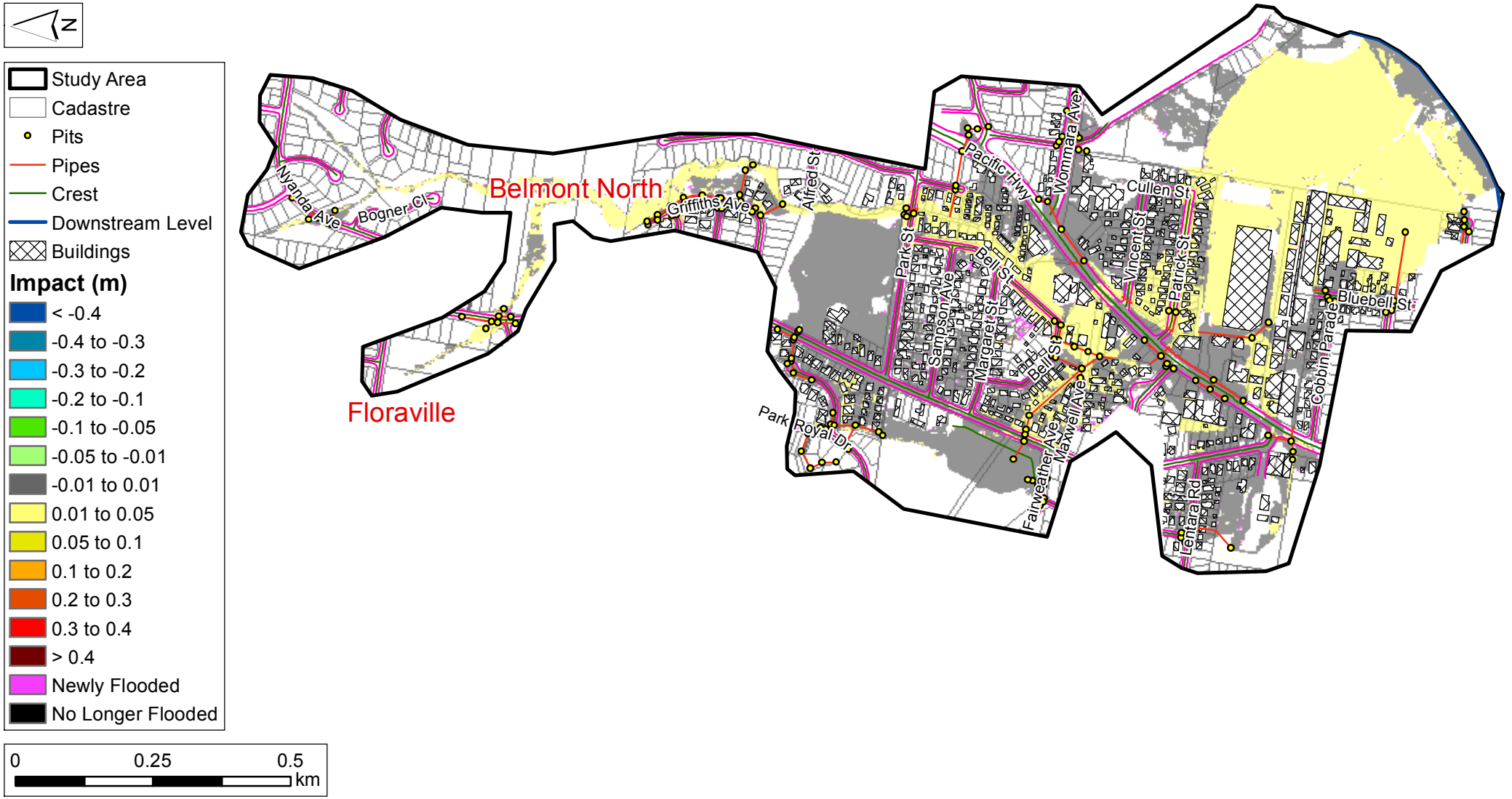



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FIGURE B35
**MURABAN CREEK**
**2007 CALIBRATION EVENT**
**LAG INCREASED BY 25%**

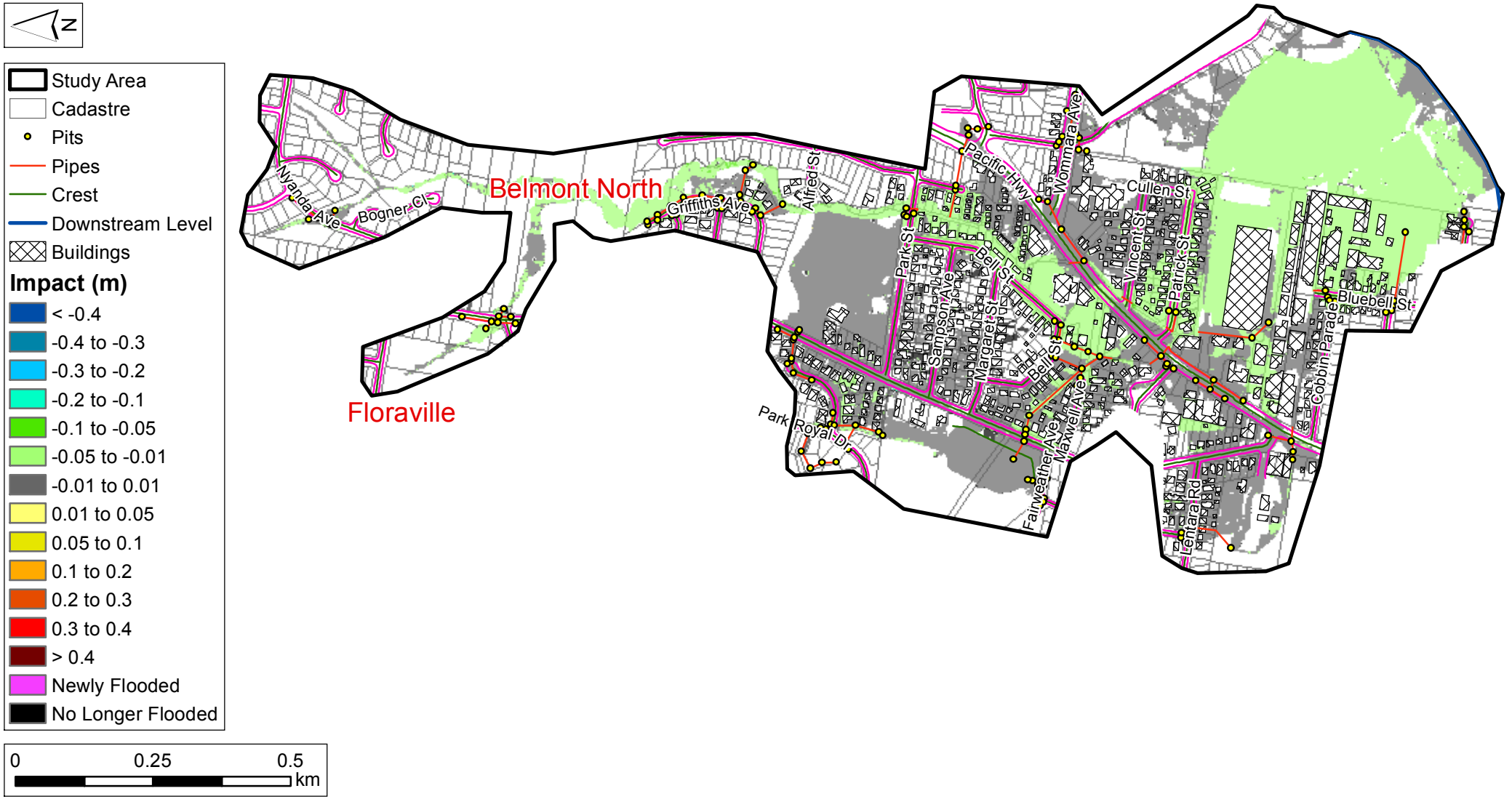


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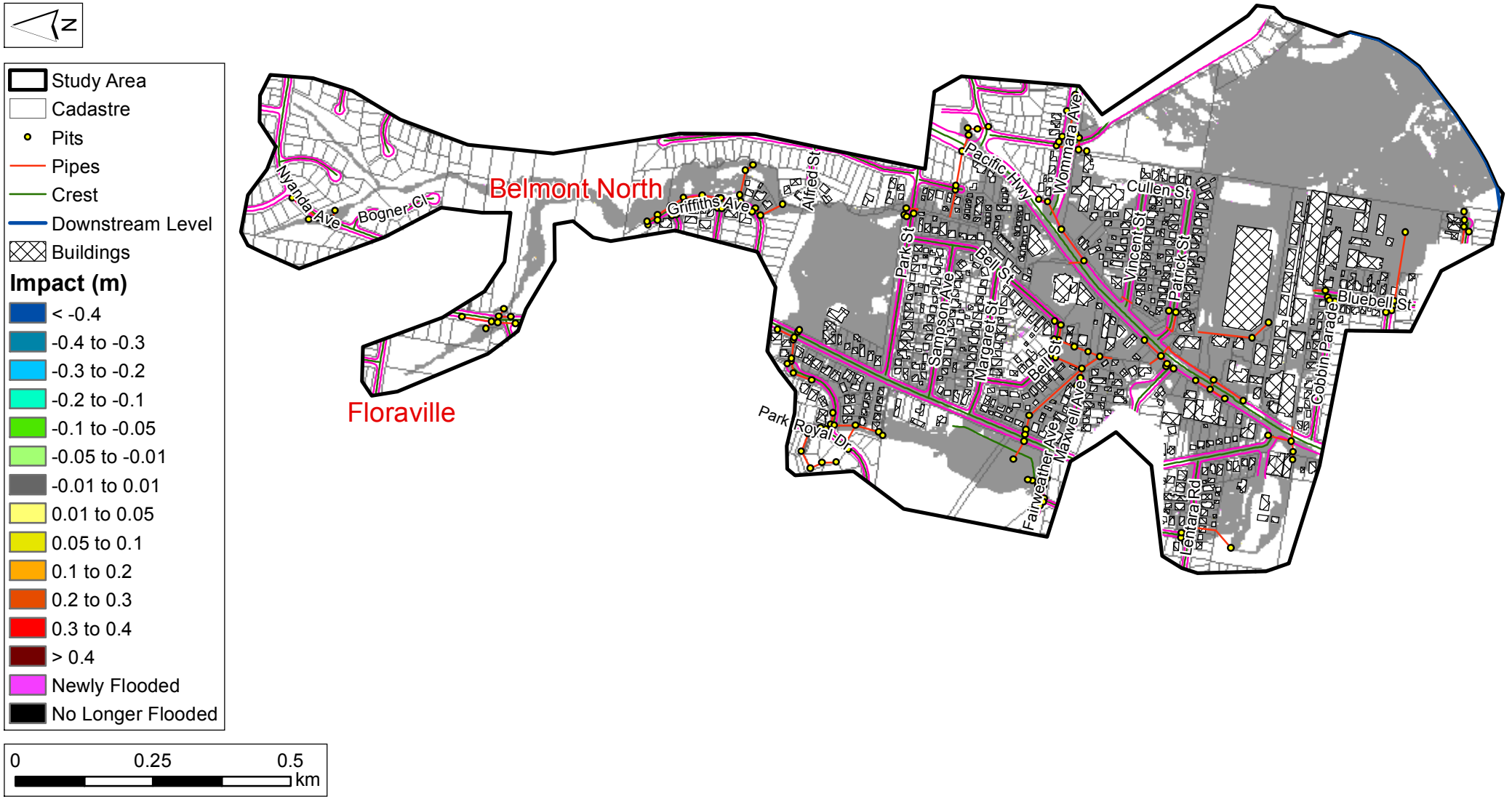
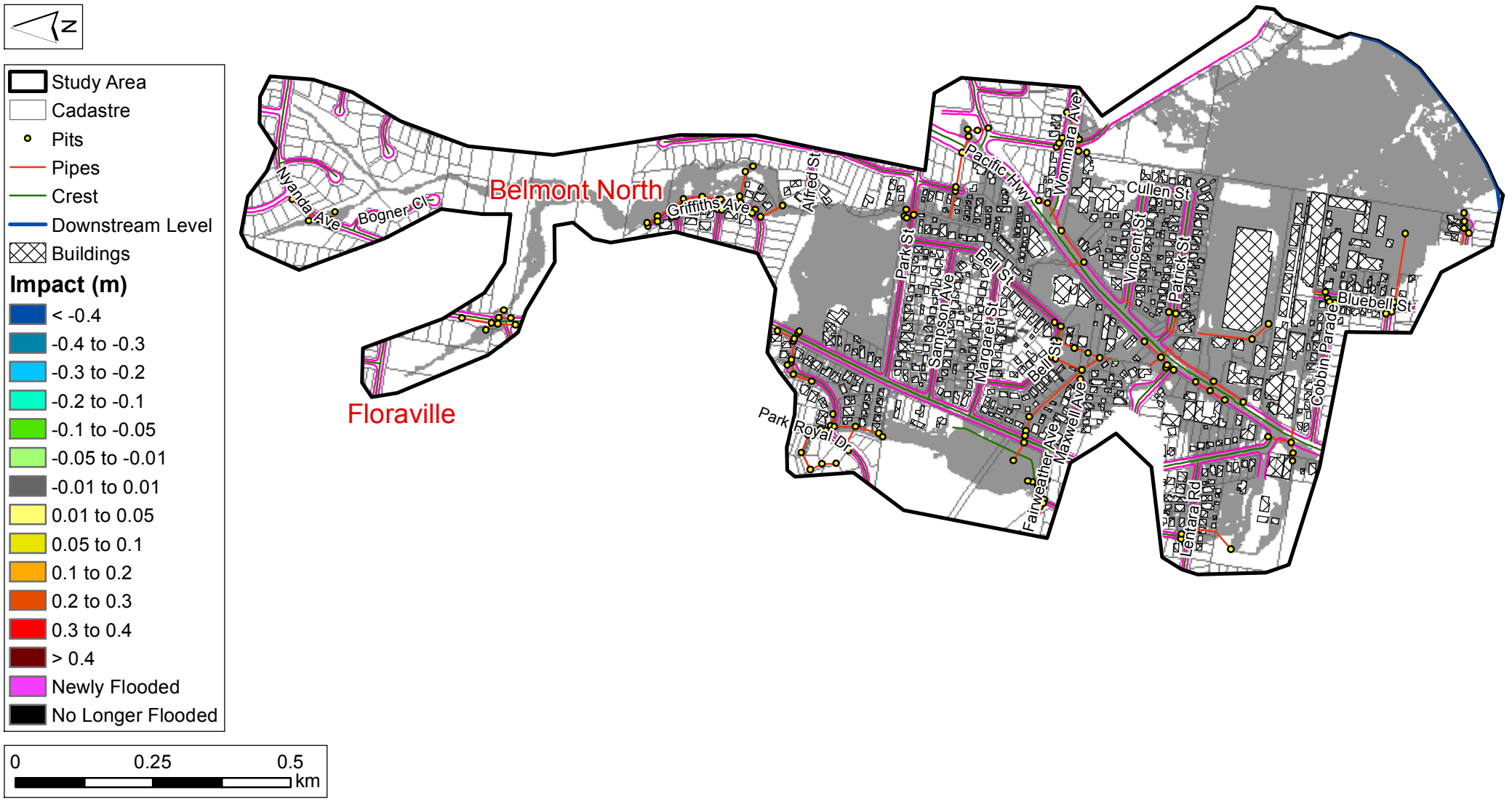
FIGURE B36
**MURABAN CREEK**
**2007 CALIBRATION EVENT**
**LOSS DECREASED BY 25%**



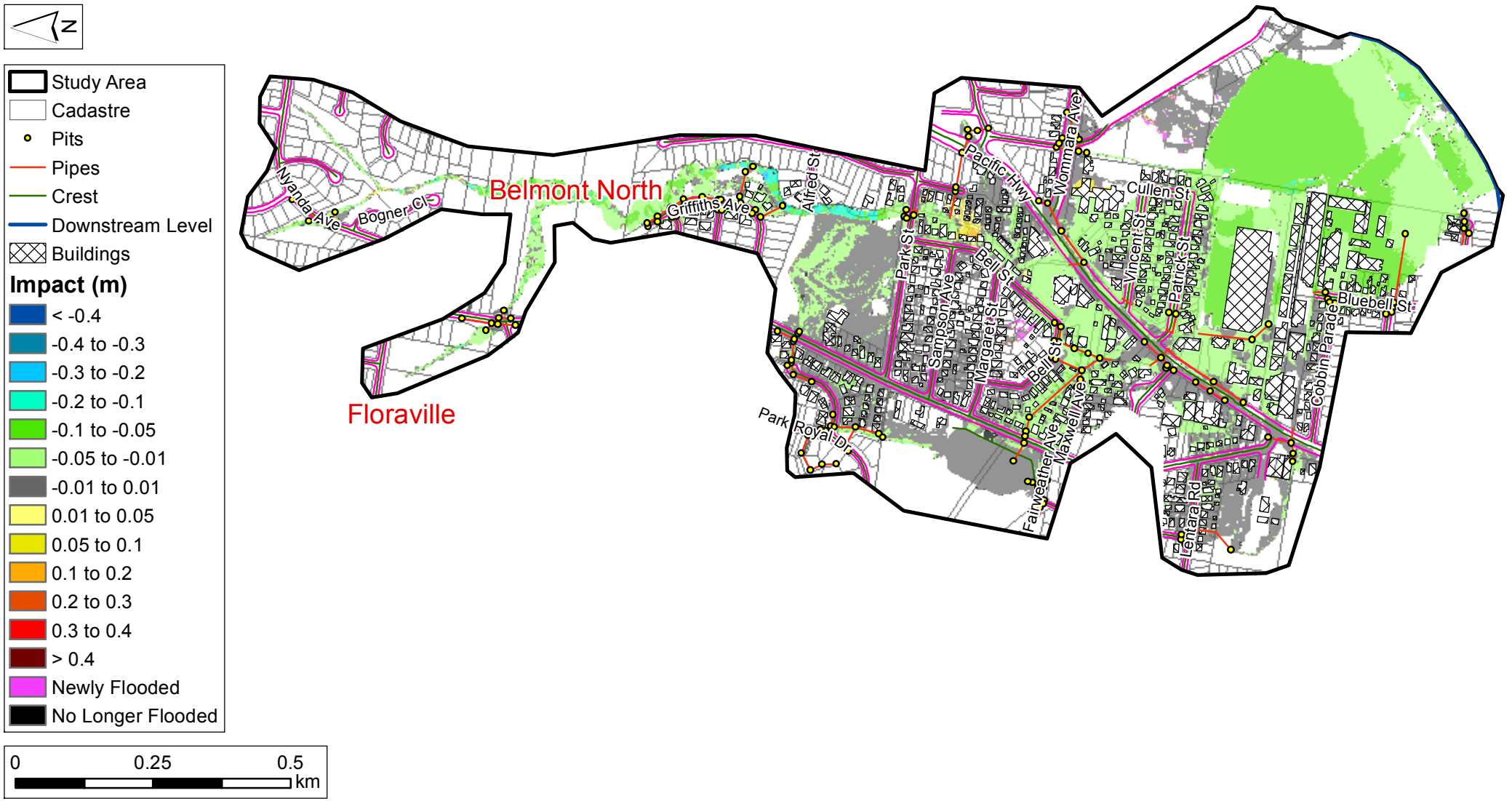

J:\Jobs\119076\ArcGIS\ArcMap\Report\AppendixB_Calibration\1to60\FigureB036_Muraban_Creek_Impact_2007TR101_Calibration_DX1_LossM25.mxd

FIGURE B37
**MURABAN CREEK**
**2007 CALIBRATION EVENT**
**LOSS INCREASED BY 25%**




J:\Jobs\119076\ArcGIS\ArcMap\Report\AppendixB_Calibration\1to60\FigureB037_Muraban_Creek_Impact_2007TR101_Calibration_DX1_Lossp25.mxd

FIGURE B38
**MURABAN CREEK**
**2007 CALIBRATION EVENT**
**MANNING REDUCED BY 25%**




J:\Jobs\119076\ArcGIS\ArcMap\Report\AppendixB_Calibration\1to60\FigureB038_Muraban_Creek_Impact_2007TR101_Calibration_DX1_manm25.mxd

FIGURE B39
**MURABAN CREEK**
**2007 CALIBRATION EVENT**
**MANNING INCREASED BY 25%**

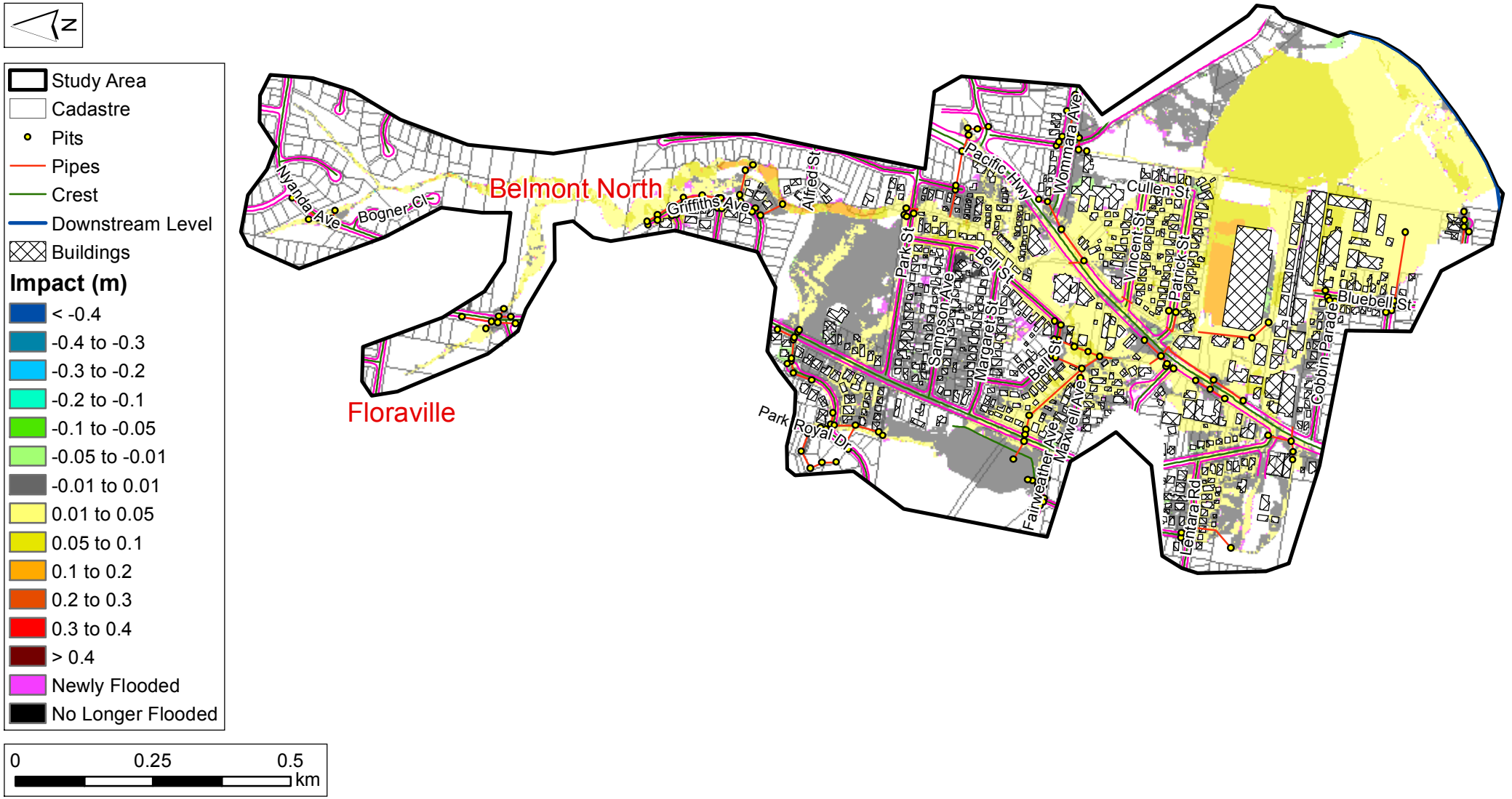



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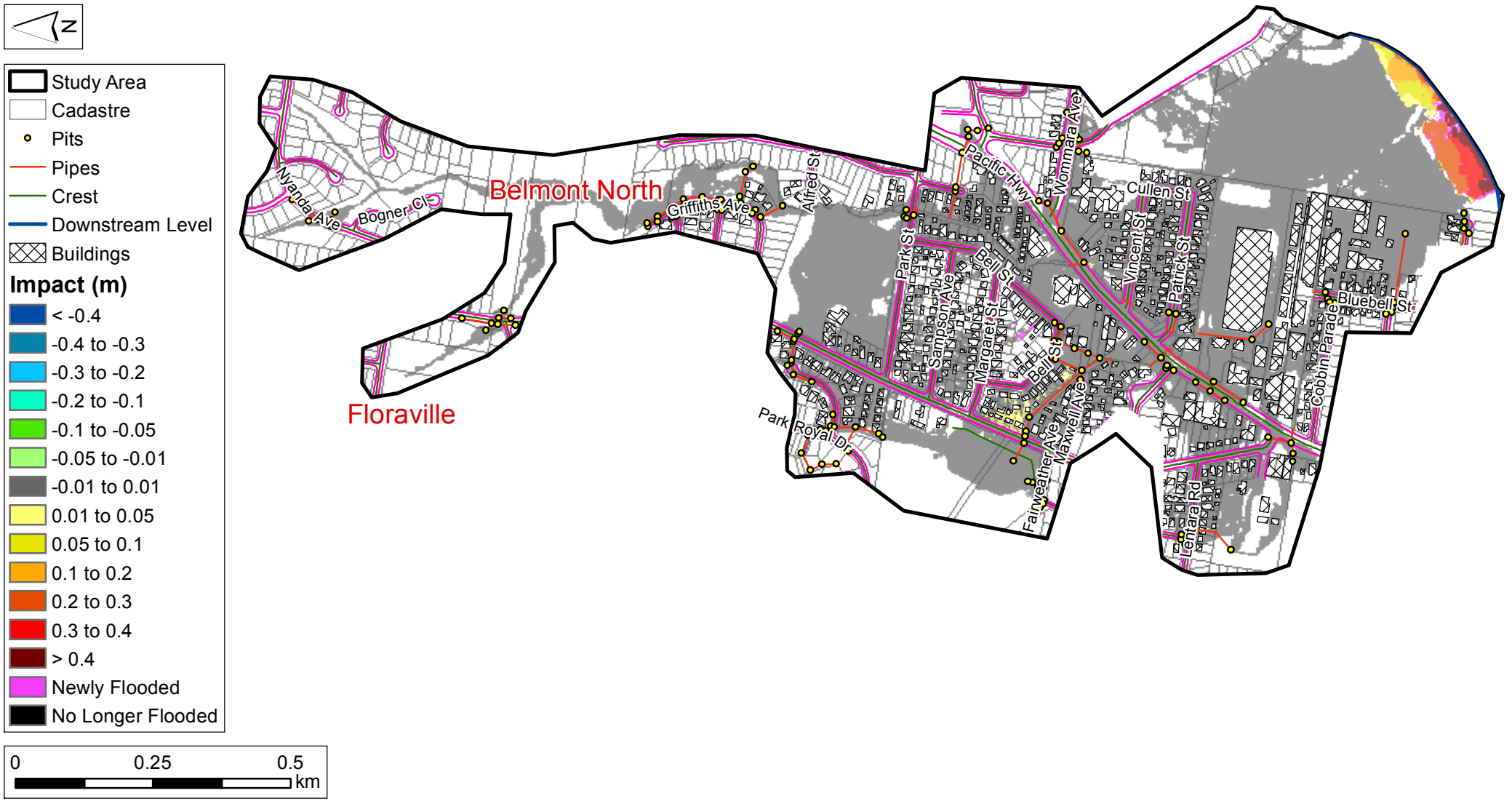
FIGURE B40
**MURABAN CREEK**
**2007 CALIBRATION EVENT**
**DS LEVEL INCREASED BY 0.5M**

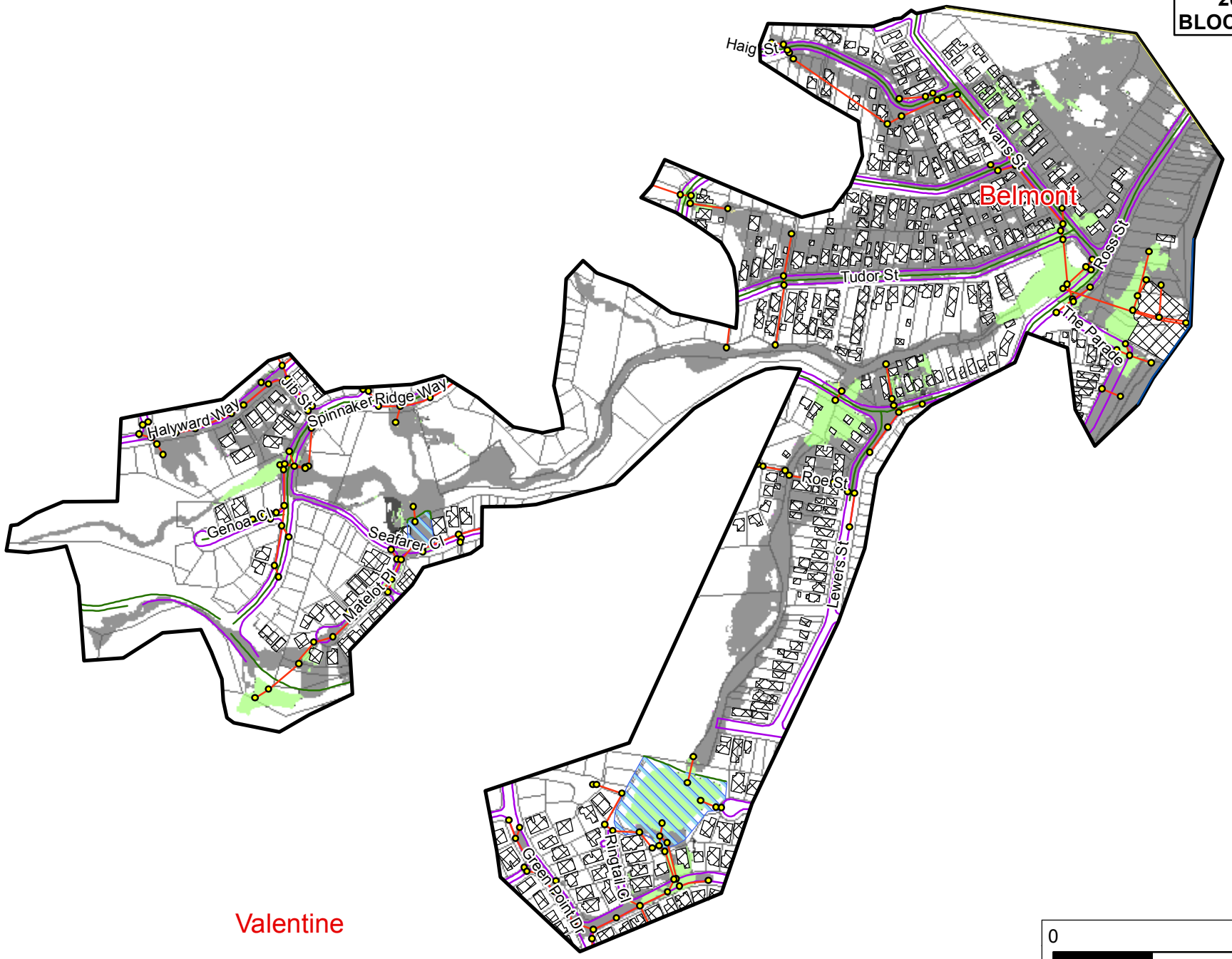



J:\Jobs\119076\ArcGIS\ArcMap\Report\AppendixB_Calibration\1to60\FigureB040_Muraban_Creek_Impact_2007TR101_Calibration_DX1_TWP500MM.mxd

FIGURE B41
**MURABAN CREEK**
**2007 CALIBRATION EVENT**
**DS LEVEL DECREASED BY 0.5M**

J:\Jobs\119076\ArcGIS\ArcMap\Report\AppendixB_Calibration\1to60\FigureB041_Muraban_Creek_Impact_2007TR101_Calibration_DX1_TWM500MM.mxd

FIGURE B42
**MILLS GULLY CREEK**
**2007 CALIBRATION EVENT**
**BLOCKAGE REDUCED TO 25%**




N

- Study Area
- Cadastre
- Basin
- Pits
- Pipes
- Crest
- Kerb
- Boundary
- Lake Label
- Buildings

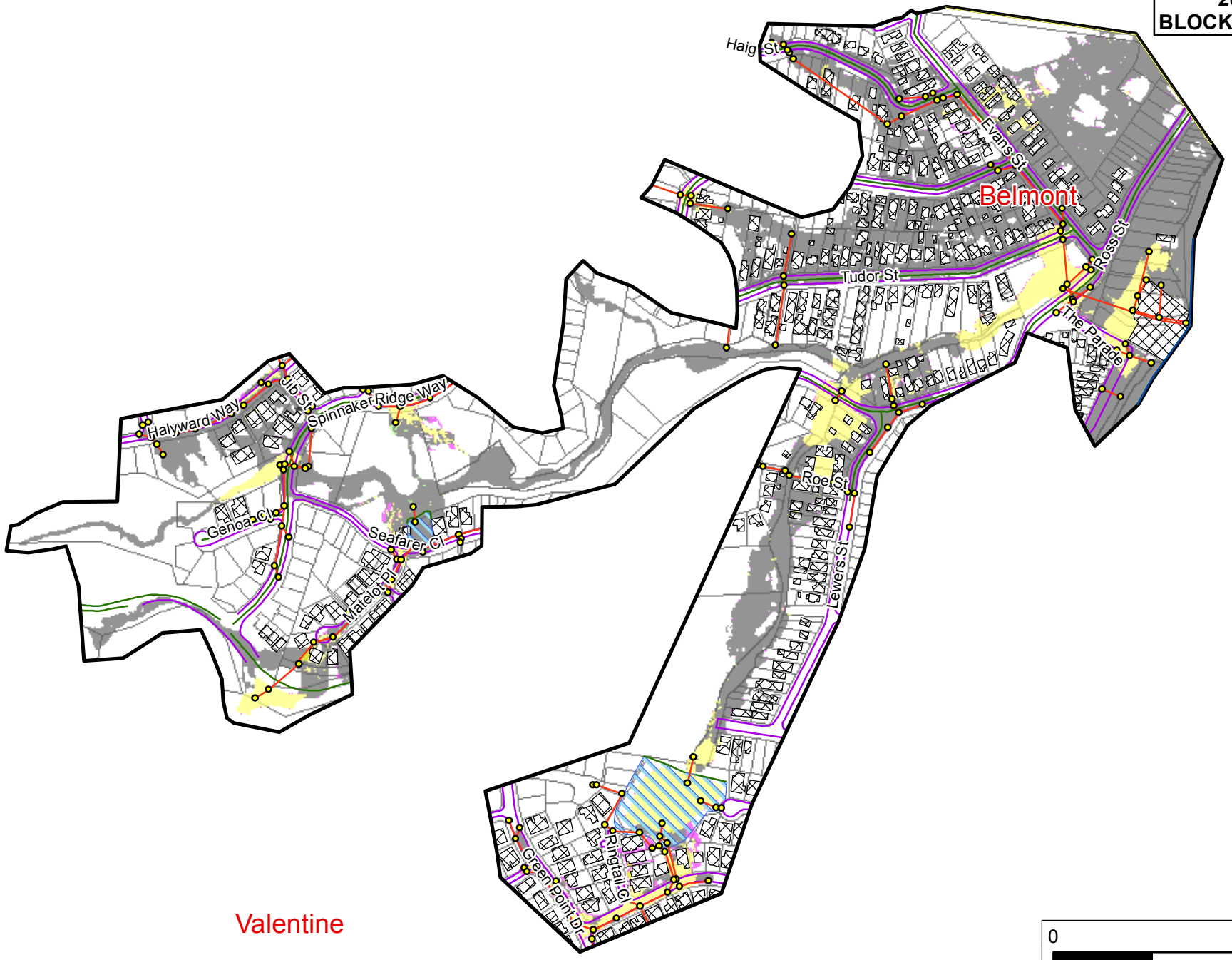
**Impact (m)**

- < -0.4
- -0.4 to -0.3
- -0.3 to -0.2
- -0.2 to -0.1
- -0.1 to -0.05
- -0.05 to -0.01
- -0.01 to 0.01
- 0.01 to 0.05
- 0.05 to 0.1
- 0.1 to 0.2
- 0.2 to 0.3
- 0.3 to 0.4
- > 0.4
- Newly Flooded
- No Longer Flooded

0 0.25 0.5 km

J:\Jobs\119076\ArcGIS\ArcMap\Report\AppendixB_Calibration\1to60\FigureB042_Mills_Gully_Creek_Impact_2007TR101_Calibration_DX1_blo025.mxd

FIGURE B43
**MILLS GULLY CREEK**
**2007 CALIBRATION EVENT**
**BLOCKAGE INCREASED TO 75%**




N

- Study Area
- Cadastre
- Basin
- Pits
- Pipes
- Crest
- Kerb
- Boundary
- Lake Label
- Buildings

**Impact (m)**

- < -0.4
- -0.4 to -0.3
- -0.3 to -0.2
- -0.2 to -0.1
- -0.1 to -0.05
- -0.05 to -0.01
- -0.01 to 0.01
- 0.01 to 0.05
- 0.05 to 0.1
- 0.1 to 0.2
- 0.2 to 0.3
- 0.3 to 0.4
- > 0.4
- Newly Flooded
- No Longer Flooded

0 0.25 0.5 km

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FIGURE B44

**MILLS GULLY CREEK**
**2007 CALIBRATION EVENT**
**LAG DECREASED BY 25%**

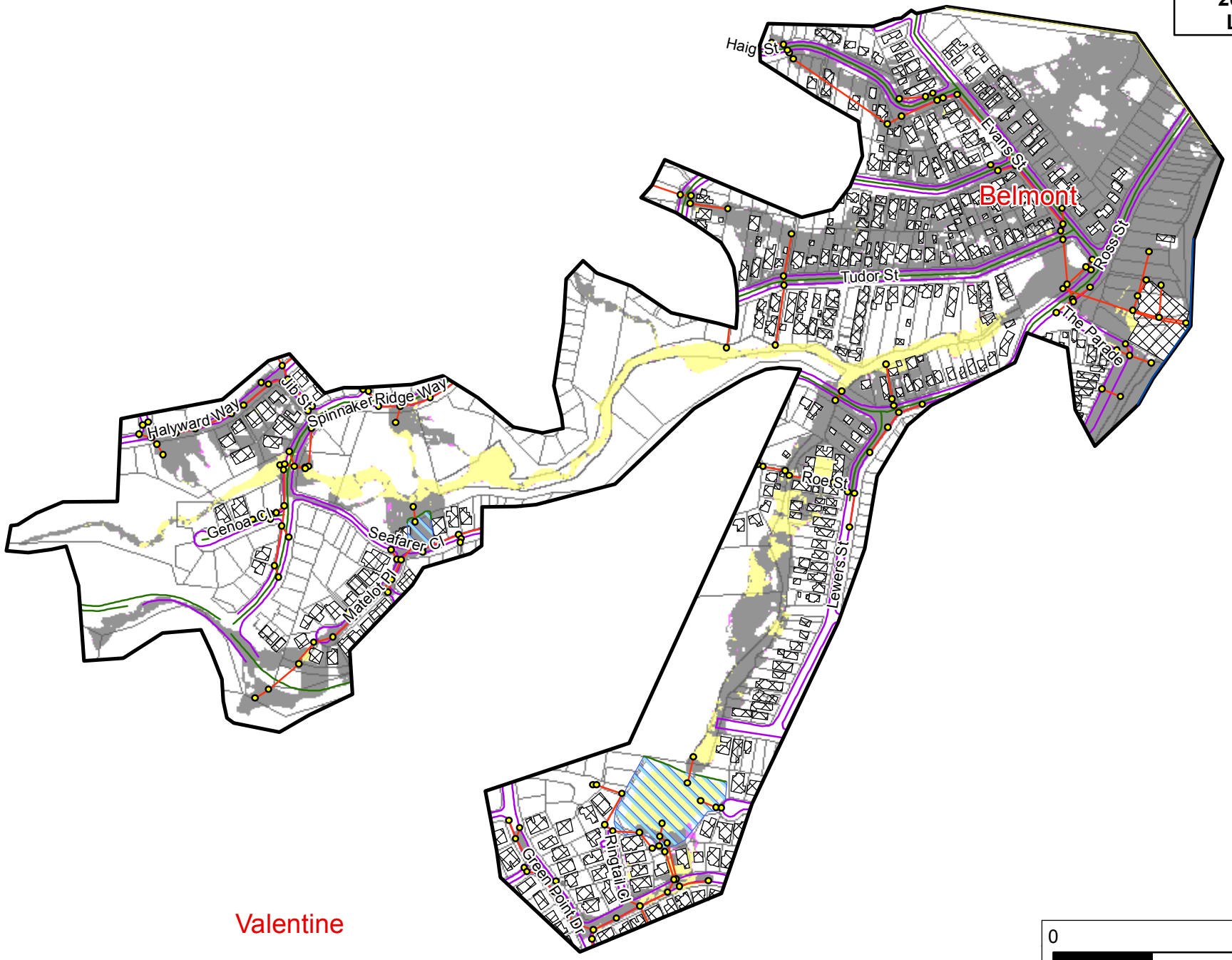


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FIGURE B45
**MILLS GULLY CREEK**
**2007 CALIBRATION EVENT**
**LAG INCREASED BY 25%**

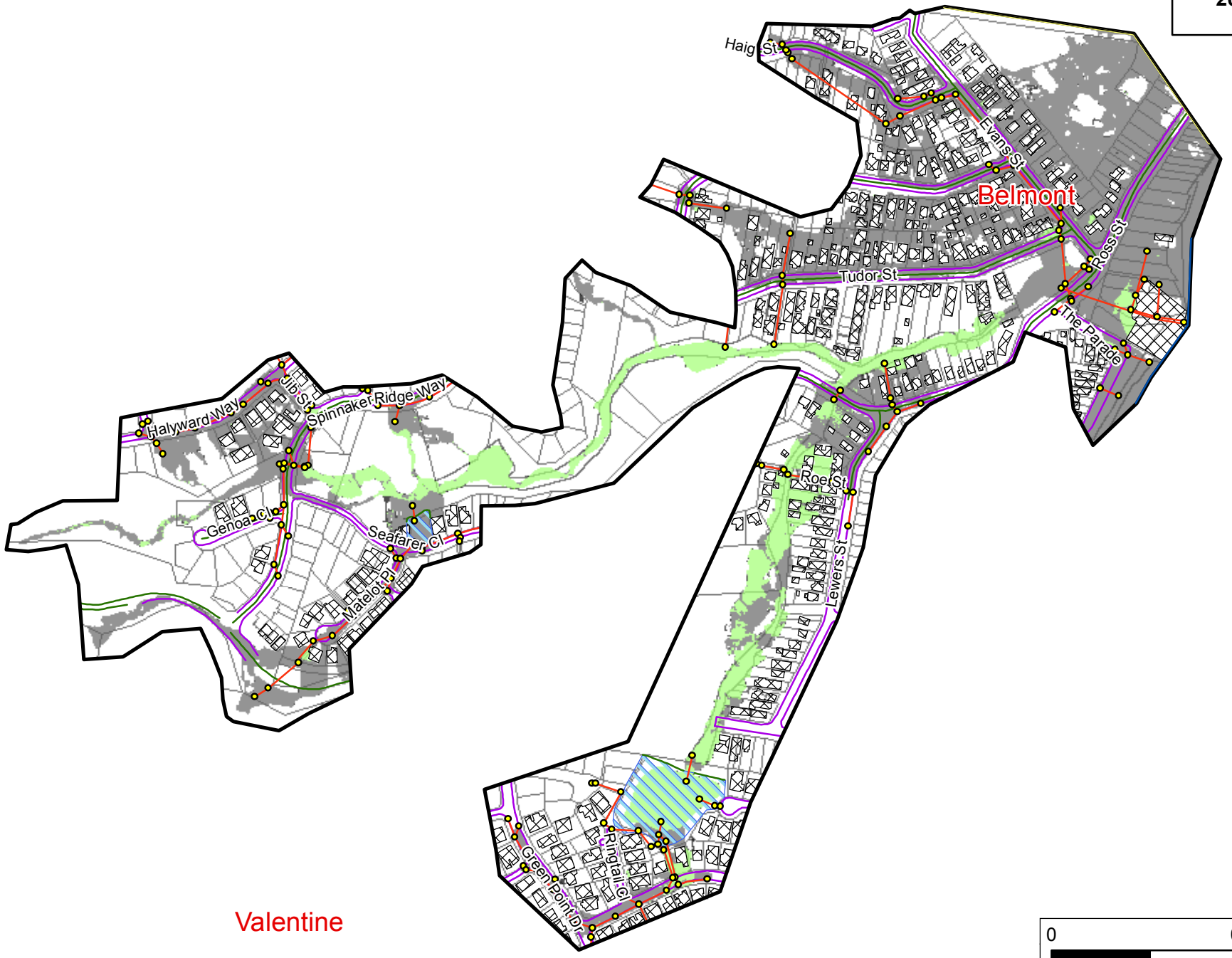


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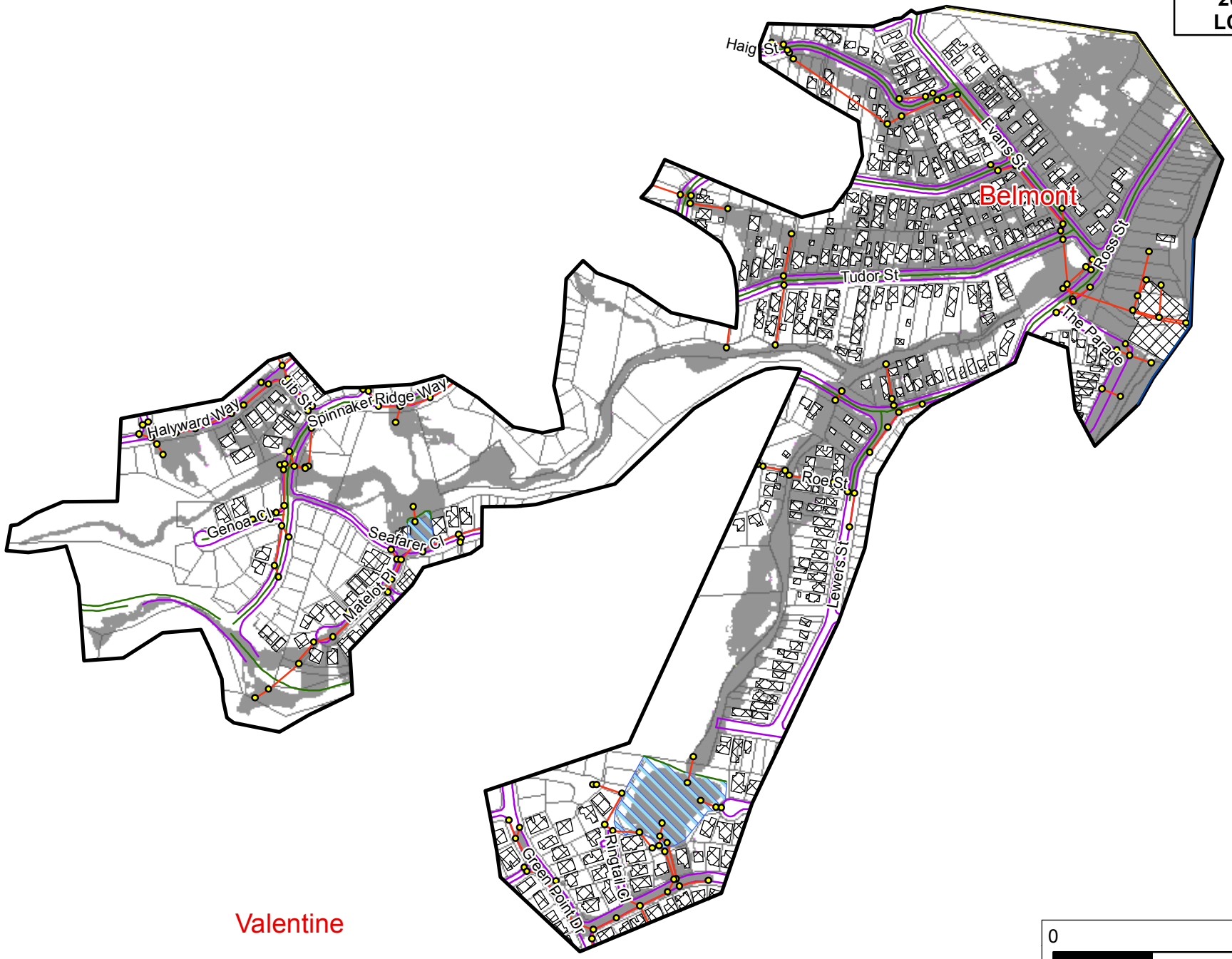
FIGURE B46
**MILLS GULLY CREEK**
**2007 CALIBRATION EVENT**
**LOSS DECREASED BY 25%**




N

- Study Area
- Cadastre
- Basin
- Pits
- Pipes
- Crest
- Kerb
- Boundary
- Lake Label
- Buildings

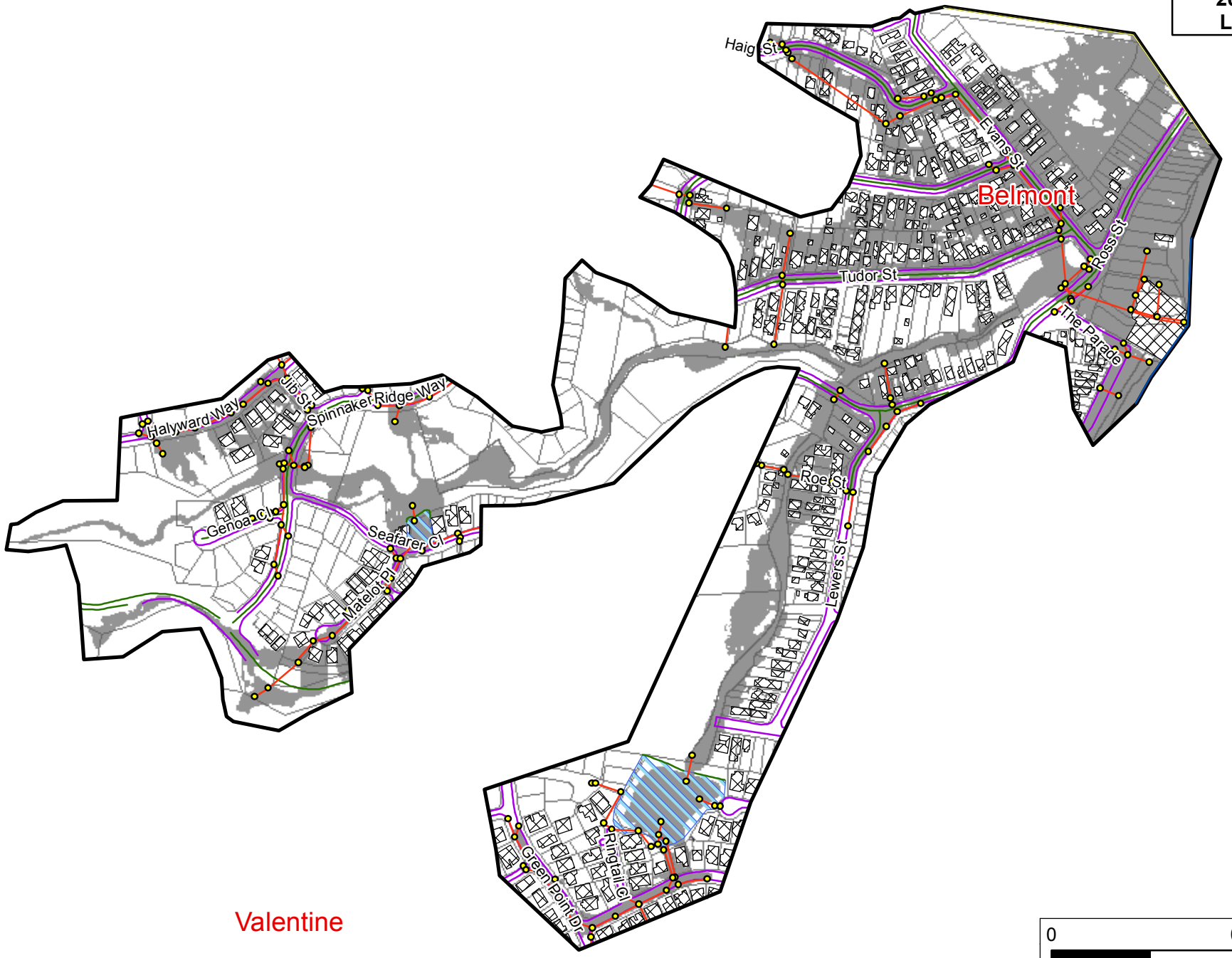
**Impact (m)**

- < -0.4
- -0.4 to -0.3
- -0.3 to -0.2
- -0.2 to -0.1
- -0.1 to -0.05
- -0.05 to -0.01
- -0.01 to 0.01
- 0.01 to 0.05
- 0.05 to 0.1
- 0.1 to 0.2
- 0.2 to 0.3
- 0.3 to 0.4
- > 0.4
- Newly Flooded
- No Longer Flooded

0 0.25 0.5 km

J:\Jobs\119076\ArcGIS\ArcMap\Report\AppendixB_Calibration\1to60\FigureB046_Mills_Gully_Creek_Impact_2007TR101_Calibration_DX1_LossM25.mxd

FIGURE B47
**MILLS GULLY CREEK**
**2007 CALIBRATION EVENT**
**LOSS INCREASED BY 25%**




N

- Study Area
- Cadastre
- Basin
- Pits
- Pipes
- Crest
- Kerb
- Boundary
- Lake Label
- Buildings

**Impact (m)**

- < -0.4
- -0.4 to -0.3
- -0.3 to -0.2
- -0.2 to -0.1
- -0.1 to -0.05
- -0.05 to -0.01
- -0.01 to 0.01
- 0.01 to 0.05
- 0.05 to 0.1
- 0.1 to 0.2
- 0.2 to 0.3
- 0.3 to 0.4
- > 0.4
- Newly Flooded
- No Longer Flooded

0 0.25 0.5 km

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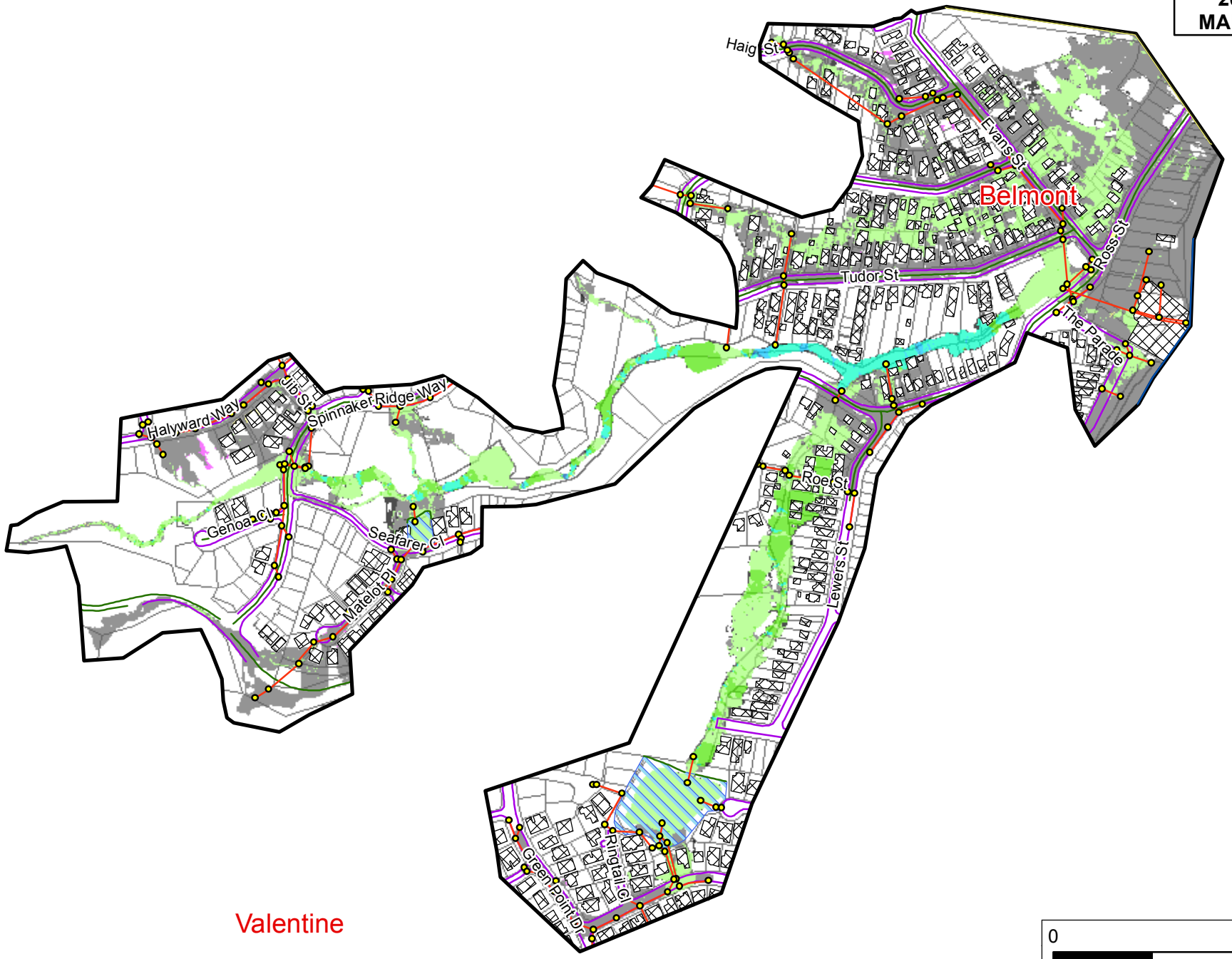
FIGURE B48

**MILLS GULLY CREEK**
**2007 CALIBRATION EVENT**
**MANNING REDUCED BY 25%**




N

- Study Area
- Cadastre
- Basin
- Pits
- Pipes
- Crest
- Kerb
- Boundary
- Lake Label
- Buildings

**Impact (m)**

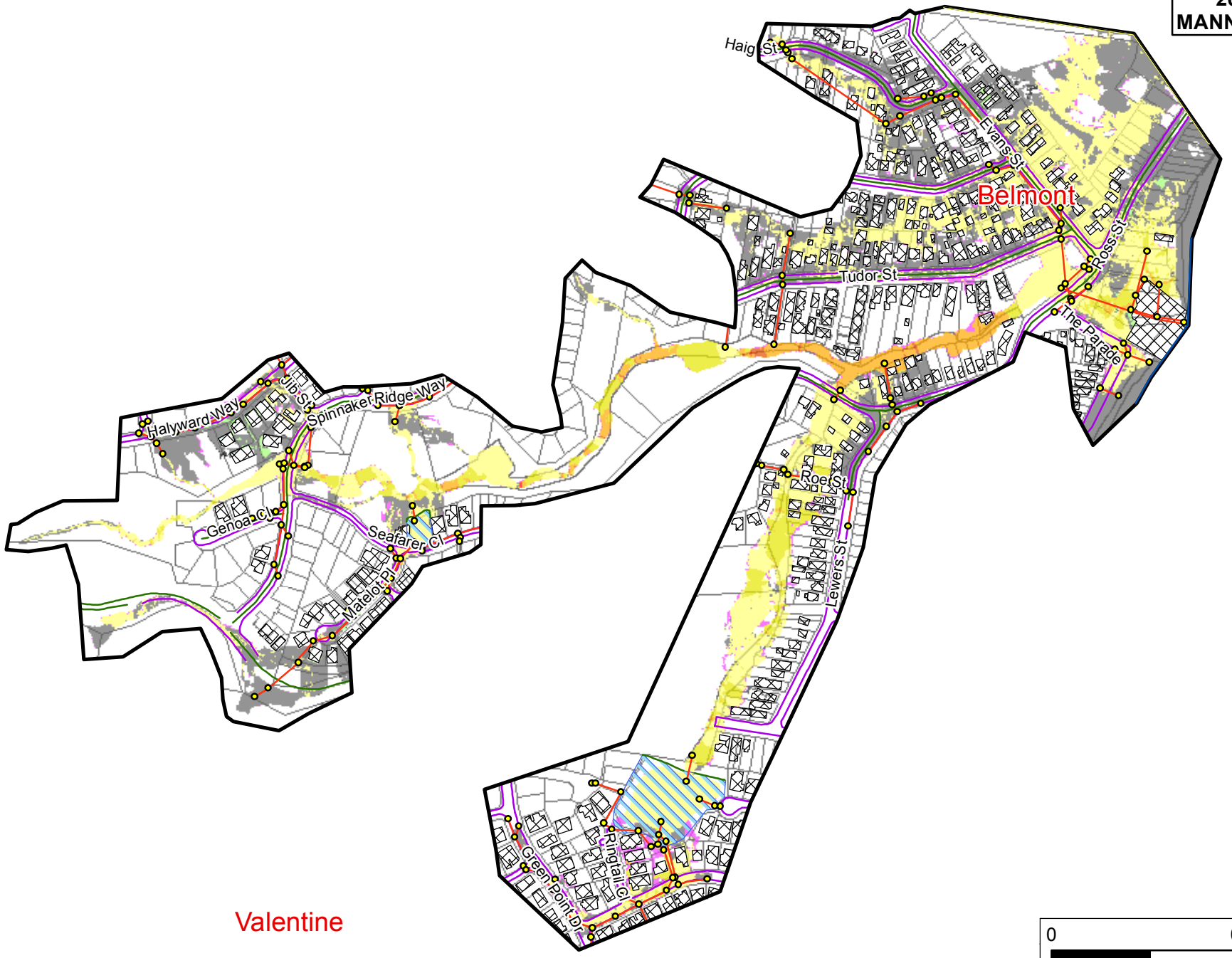
- < -0.4
- -0.4 to -0.3
- -0.3 to -0.2
- -0.2 to -0.1
- -0.1 to -0.05
- -0.05 to -0.01
- -0.01 to 0.01
- 0.01 to 0.05
- 0.05 to 0.1
- 0.1 to 0.2
- 0.2 to 0.3
- 0.3 to 0.4
- > 0.4
- Newly Flooded
- No Longer Flooded

0 0.25 0.5 km

J:\Jobs\119076\ArcGIS\ArcMap\Report\AppendixB_Calibration\1to60\FigureB048_Mills_Gully_Creek_Impact_2007TR101_Calibration_DX1_manm25.mxd

FIGURE B49

**MILLS GULLY CREEK**
**2007 CALIBRATION EVENT**
**MANNING INCREASED BY 25%**




N

- Study Area
- Cadastre
- Basin
- Pits
- Pipes
- Crest
- Kerb
- Boundary
- Lake Label
- Buildings

**Impact (m)**

- < -0.4
- -0.4 to -0.3
- -0.3 to -0.2
- -0.2 to -0.1
- -0.1 to -0.05
- -0.05 to -0.01
- -0.01 to 0.01
- 0.01 to 0.05
- 0.05 to 0.1
- 0.1 to 0.2
- 0.2 to 0.3
- 0.3 to 0.4
- > 0.4
- Newly Flooded
- No Longer Flooded

0 0.25 0.5 km

J:\Jobs\119076\ArcGIS\ArcMap\Report\AppendixB_Calibration\1to60\FigureB049_Mills_Gully_Creek_Impact_2007TR101_Calibration_DX1_manp25.mxd

FIGURE B50

**MILLS GULLY CREEK**
**2007 CALIBRATION EVENT**
**LAKE LEVEL INCREASED BY 0.5M**

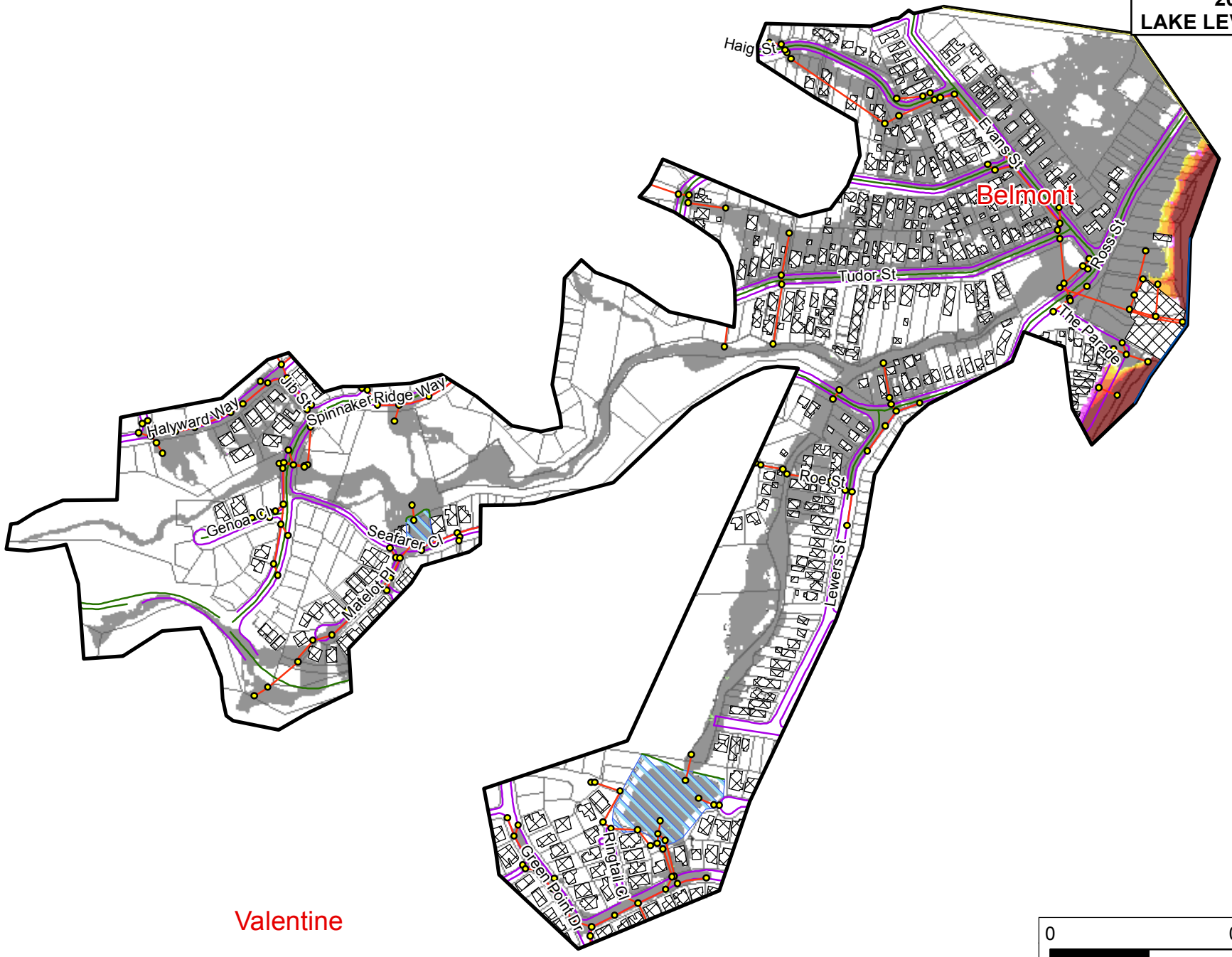



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FIGURE B51
**MILLS GULLY CREEK**
**2007 CALIBRATION EVENT**
**LAKE LEVEL DECREASED BY 0.5M**

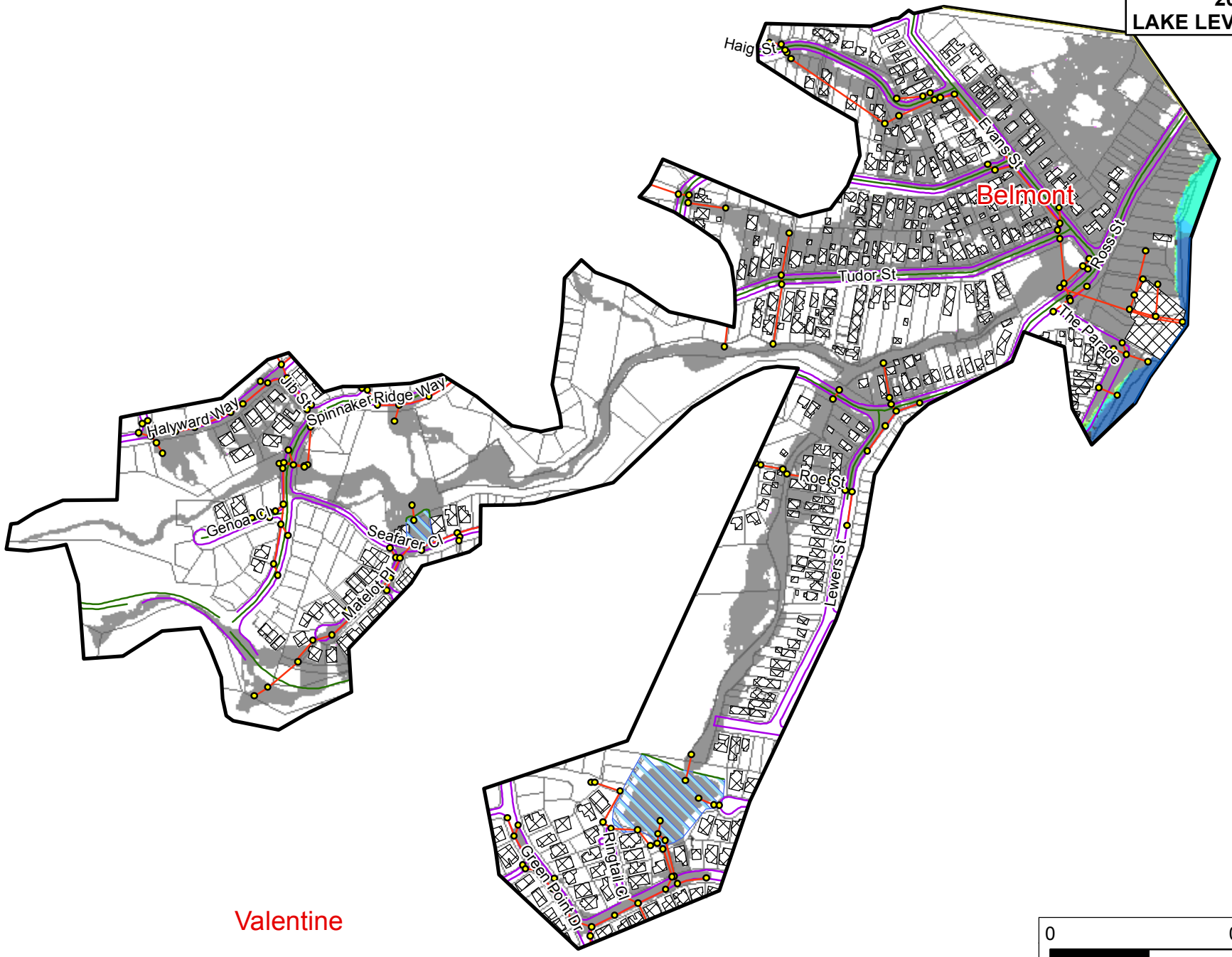


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FIGURE B52
**PUNTEI CREEK**
**2007 CALIBRATION EVENT**
**BLOCKAGE REDUCED TO 25%**

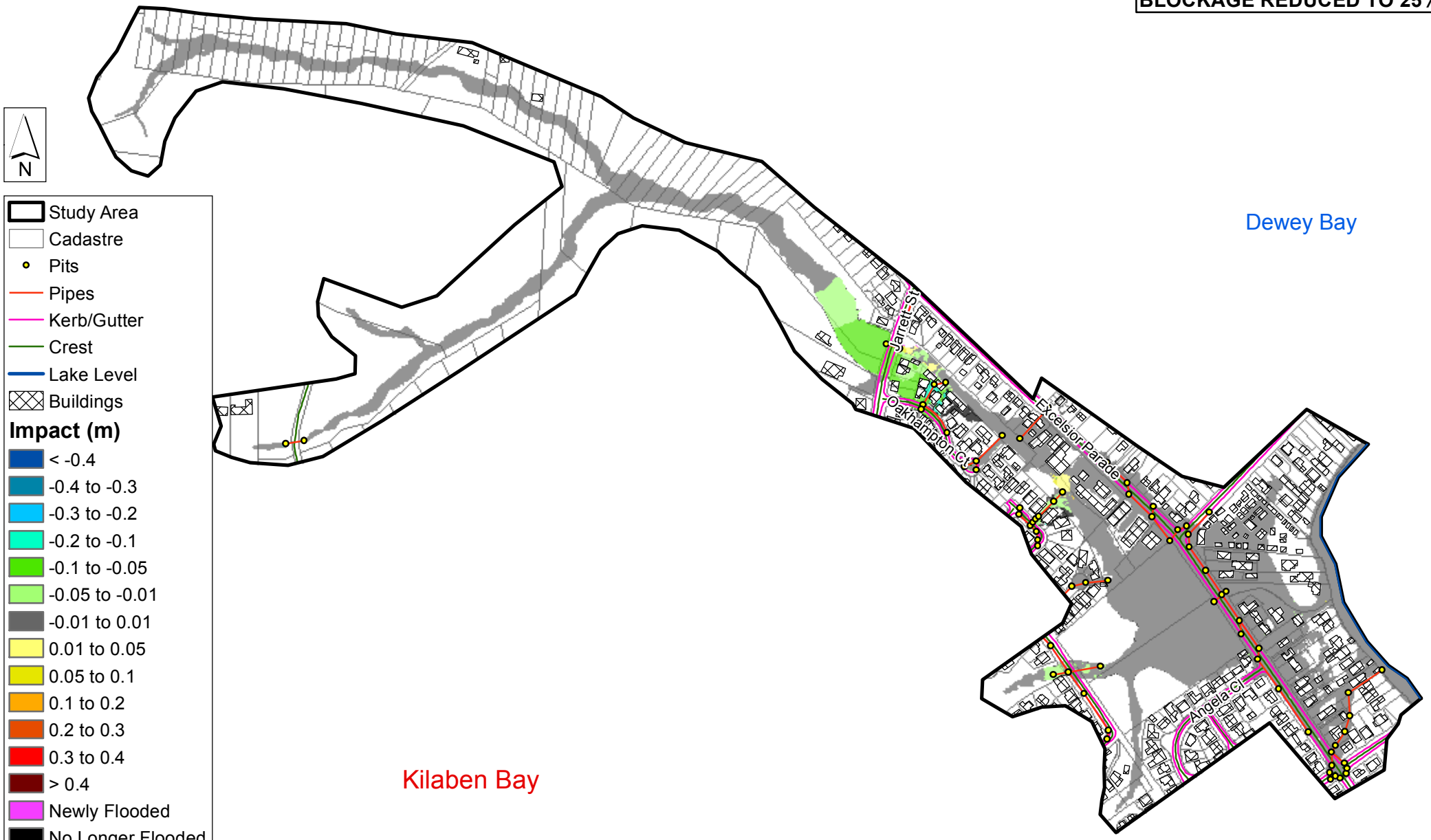


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FIGURE B53
**PUNTEI CREEK**
**2007 CALIBRATION EVENT**
**BLOCKAGE INCREASED TO 75%**

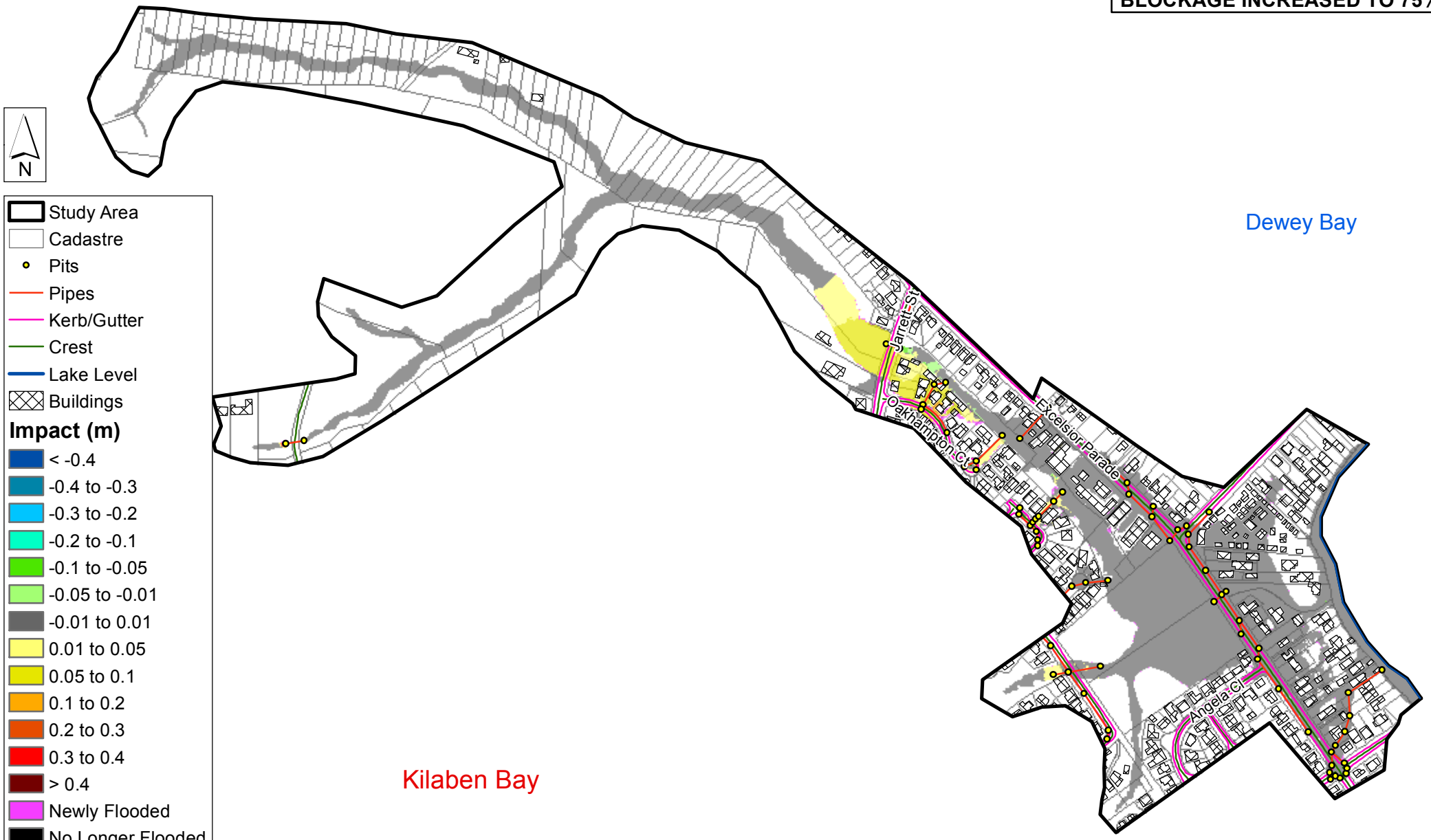


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FIGURE B54
**PUNTEI CREEK**
**2007 CALIBRATION EVENT**
**LAG DECREASED BY 25%**

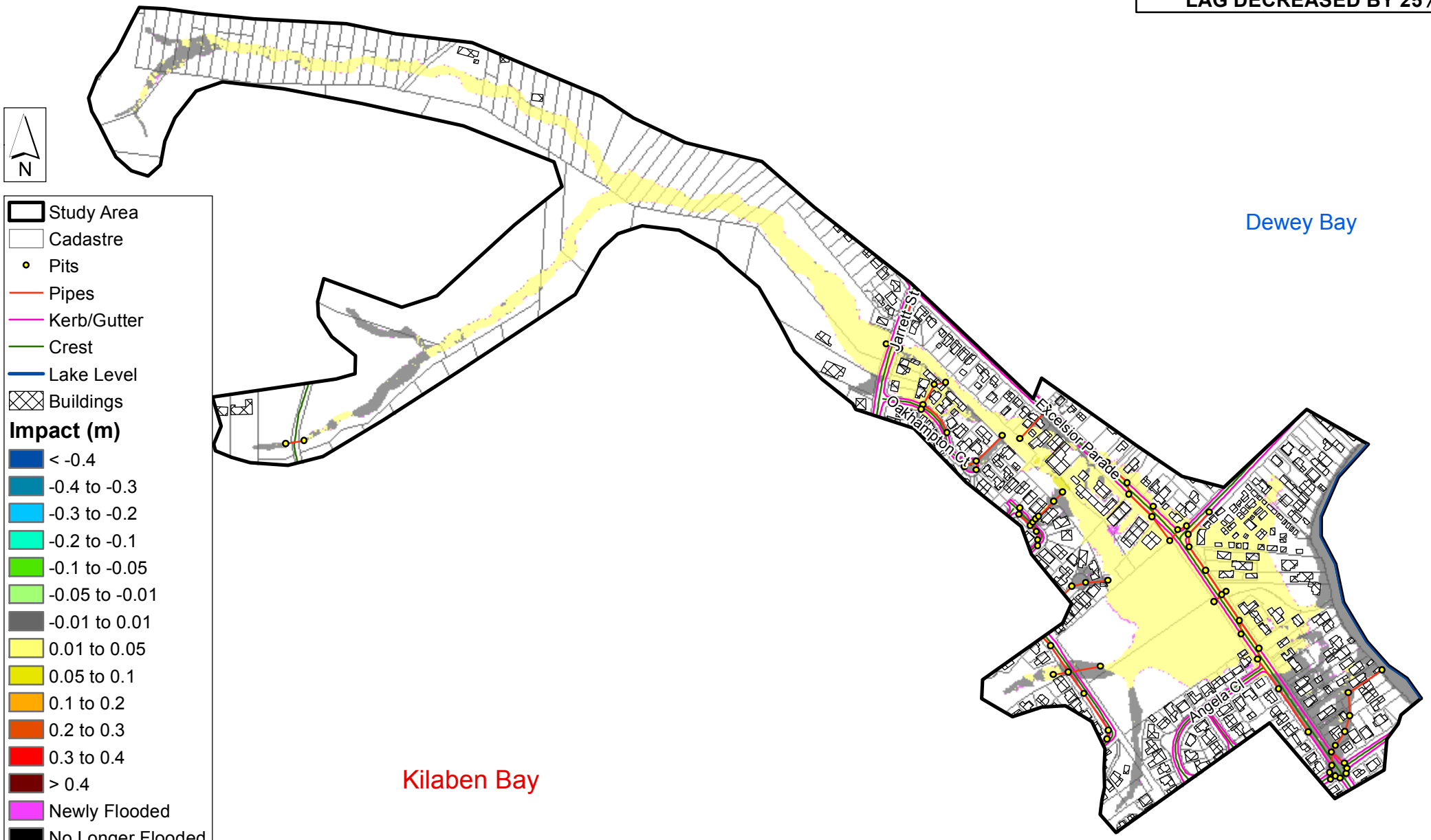


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FIGURE B55
**PUNTEI CREEK**
**2007 CALIBRATION EVENT**
**LAG INCREASED BY 25%**

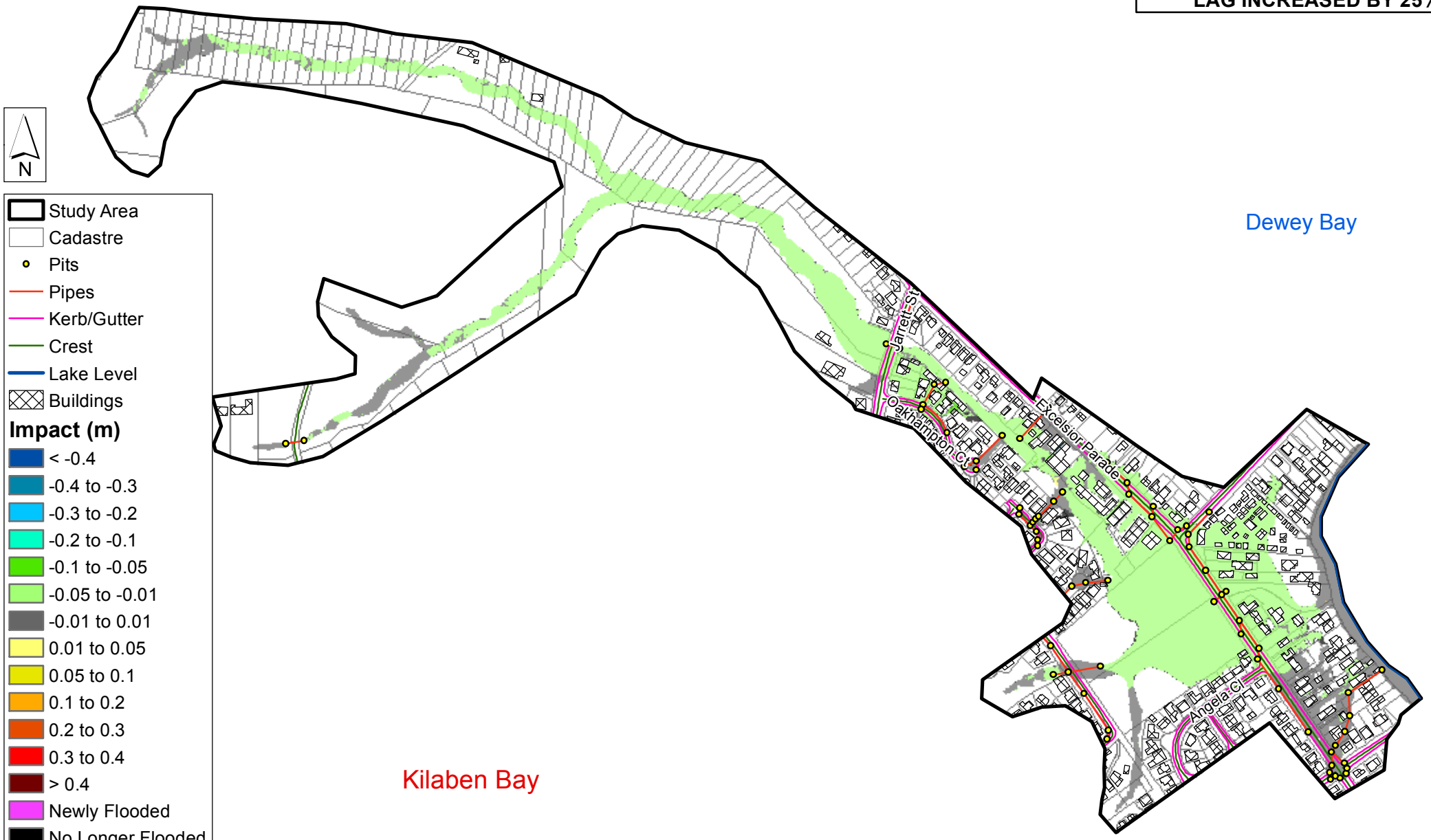


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FIGURE B56
**PUNTEI CREEK**
**2007 CALIBRATION EVENT**
**LOSS DECREASED BY 25%**

J:\Jobs\119076\ArcGIS\ArcMap\Report\AppendixB_Calibration\1to60\FigureB056_Puntei_Creek_Impact_2007TR101_Calibration_DX1_LossM25.mxd

FIGURE B57
**PUNTEI CREEK**
**2007 CALIBRATION EVENT**
**LOSS INCREASED BY 25%**

J:\Jobs\119076\ArcGIS\ArcMap\Report\AppendixB_Calibration\1to60\FigureB057_Puntei_Creek_Impact_2007TR101_Calibration_DX1_Lossp25.mxd

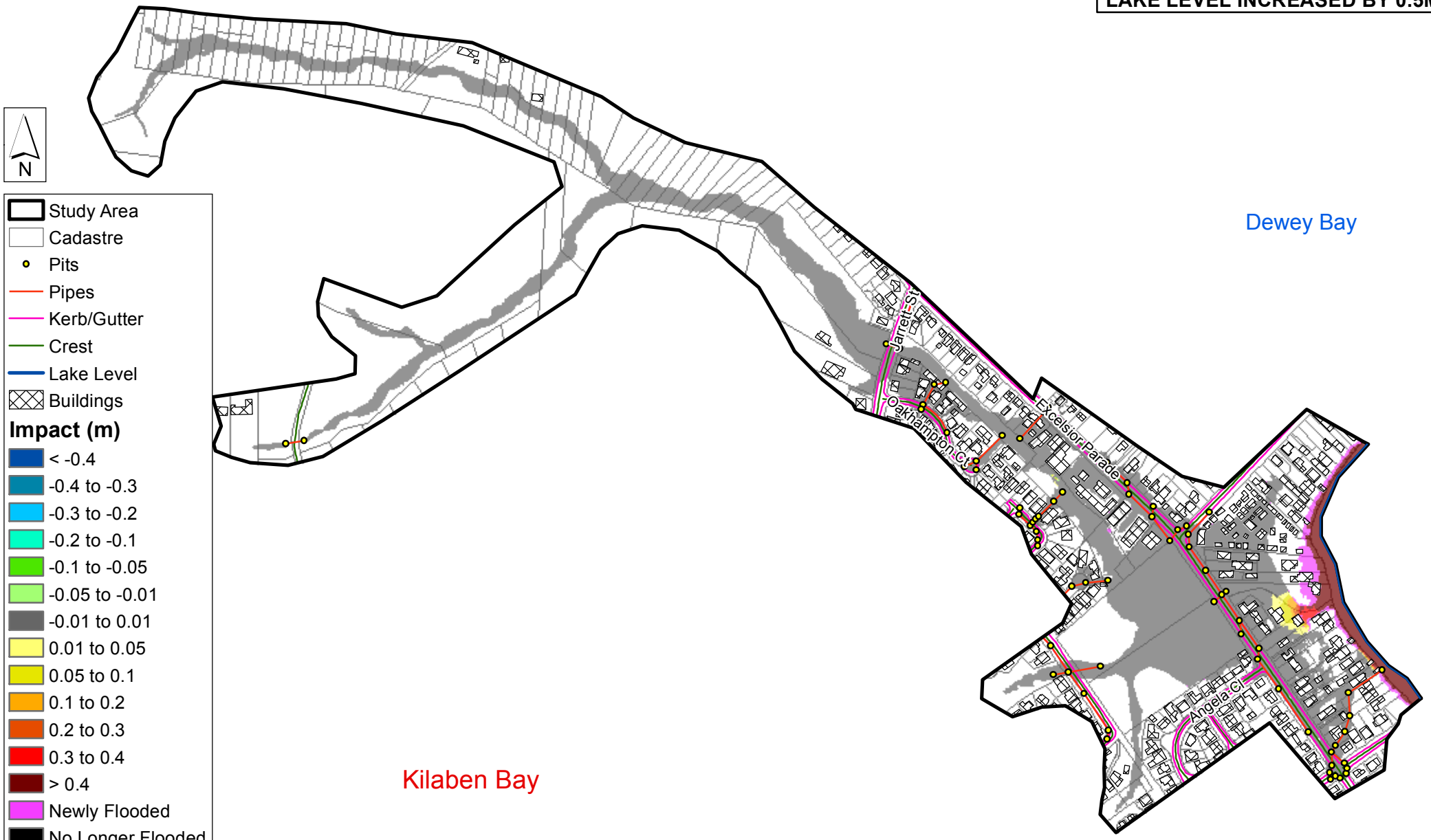
FIGURE B58
**PUNTEI CREEK**
**2007 CALIBRATION EVENT**
**MANNING REDUCED BY 25%**

J:\Jobs\119076\ArcGIS\ArcMap\Report\AppendixB_Calibration\1to60\FigureB058_Puntei_Creek_Impact_2007TR101_Calibration_DX1_manm25.mxd

FIGURE B59
**PUNTEI CREEK**
**2007 CALIBRATION EVENT**
**MANNING INCREASED BY 25%**

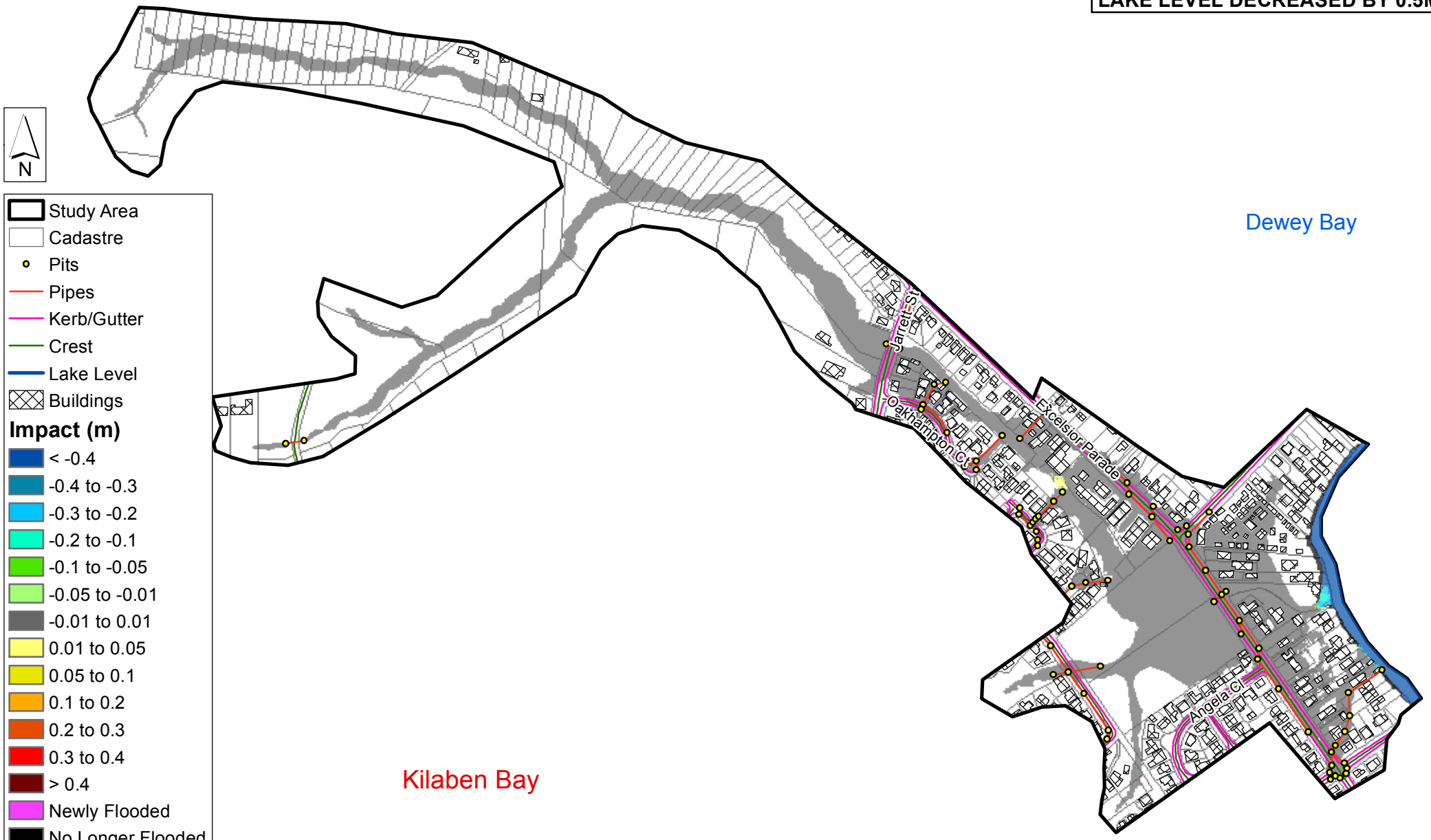
J:\Jobs\119076\ArcGIS\ArcMap\Report\AppendixB_Calibration\1to60\FigureB059_Puntei_Creek_Impact_2007TR101_Calibration_DX1_manp25.mxd

FIGURE B60
**PUNTEI CREEK**
**2007 CALIBRATION EVENT**
**LAKE LEVEL INCREASED BY 0.5M**



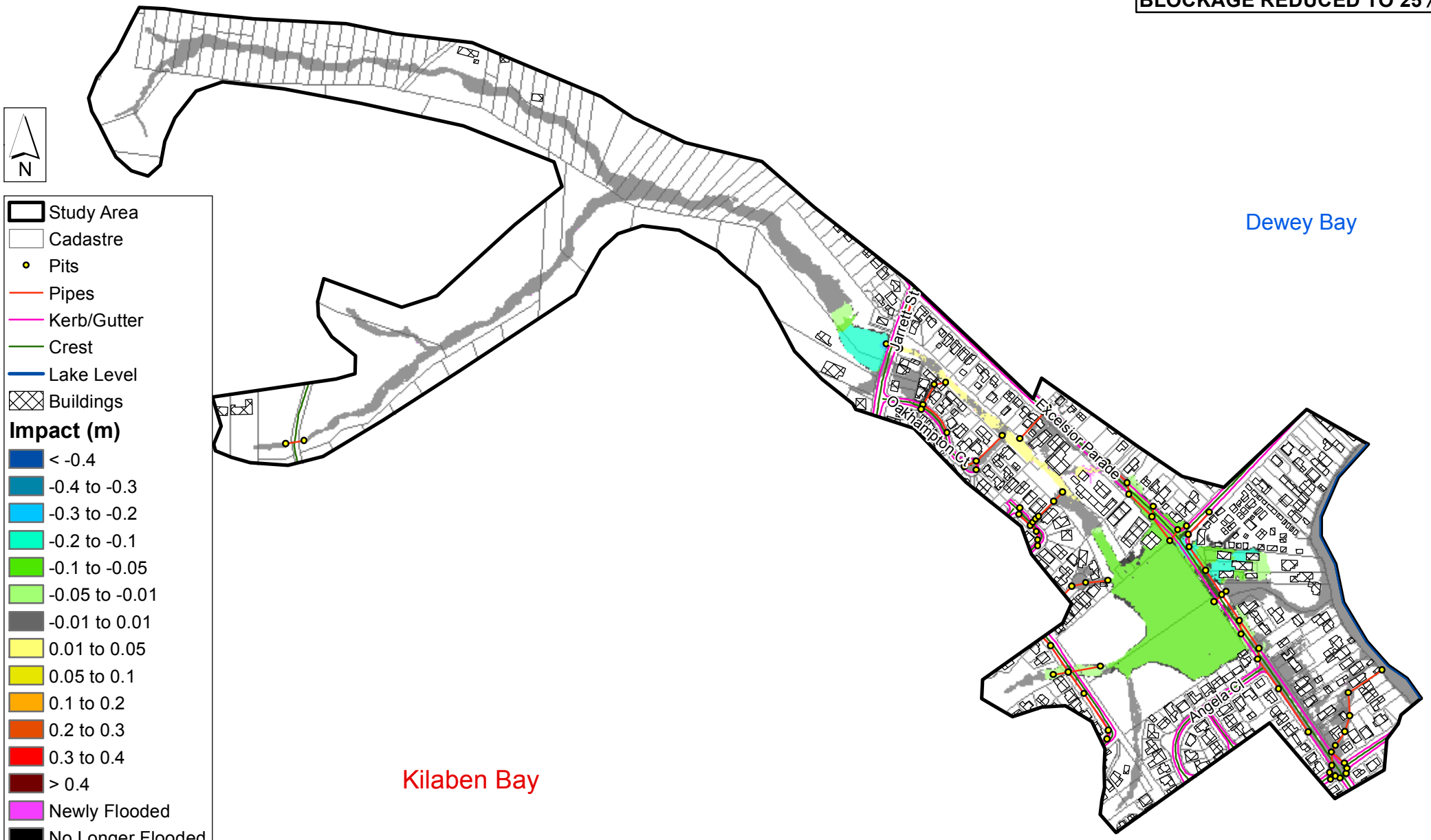

J:\Jobs\119076\ArcGIS\ArcMap\Report\AppendixB_Calibration\1to60\FigureB060_Puntei_Creek_Impact_2007TR101_Calibration_DX1_TWP500MM.mxd

FIGURE B61
**PUNTEI CREEK**
**2007 CALIBRATION EVENT**
**LAKE LEVEL DECREASED BY 0.5M**



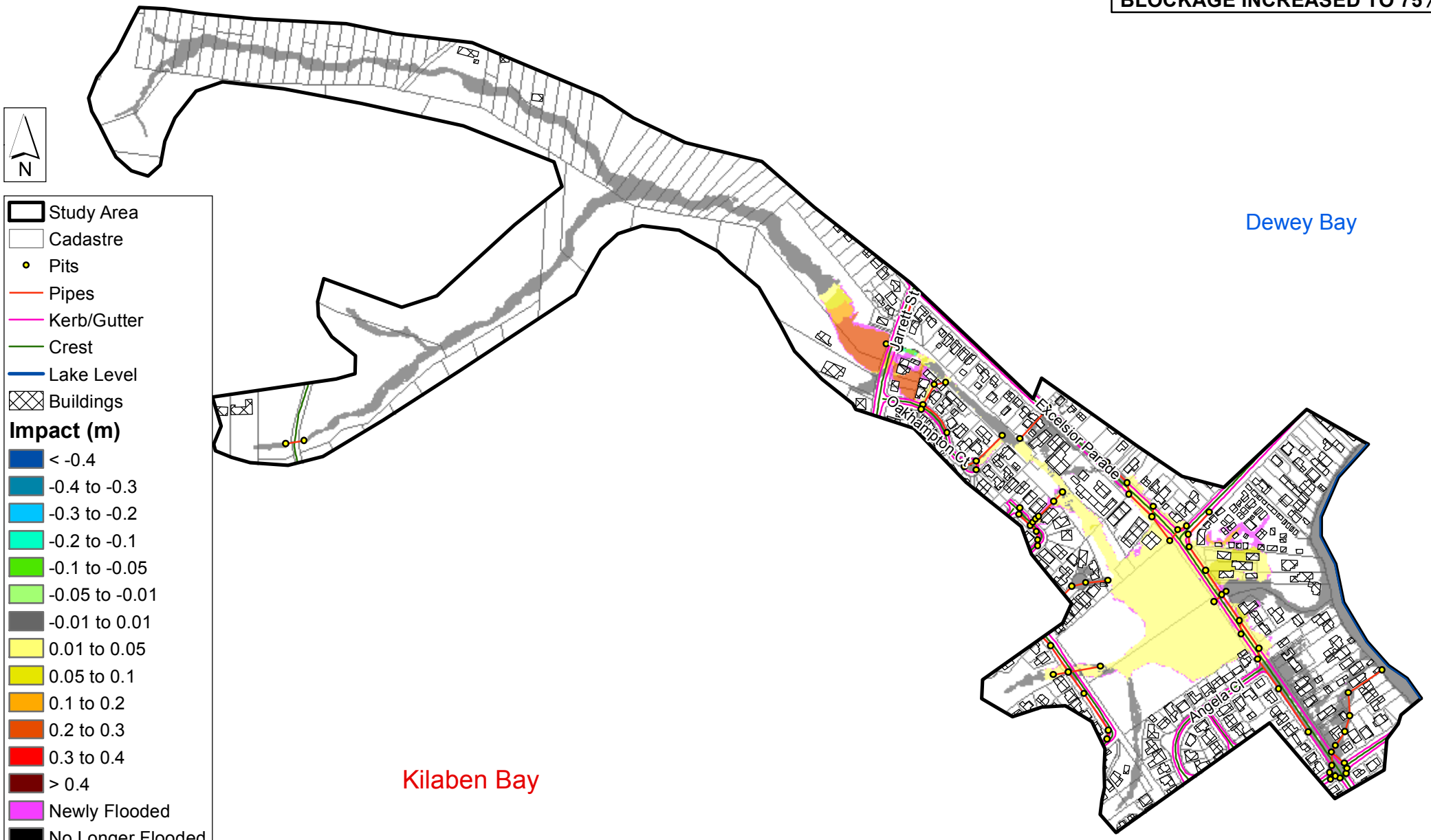

J:\Jobs\119076\ArcGIS\ArcMap\Report\AppendixB_Calibration\1to60\FigureB061_Puntei_Creek_Impact_2007TR101_Calibration_DX1_TWM500MM.mxd

FIGURE B62
**PUNTEI CREEK**
**2015 CALIBRATION EVENT**
**BLOCKAGE REDUCED TO 25%**



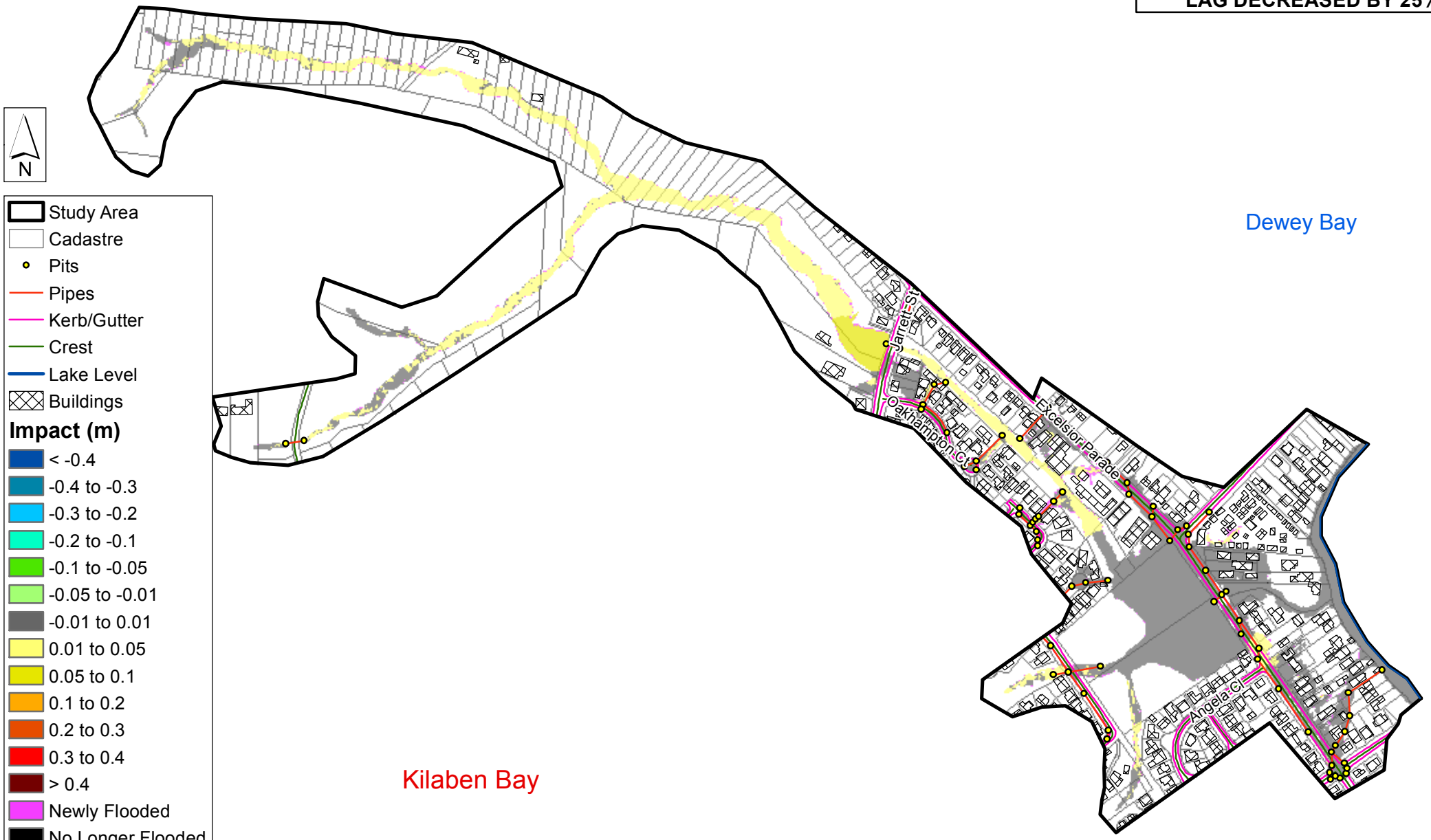

J:\Jobs\119076\ArcGIS\ArcMap\Report\AppendixB_Calibration\61to121\FigureB062_Puntei_Creek_2015_Impact_Calibration_DX1_blo025.mxd

FIGURE B63
**PUNTEI CREEK**
**2015 CALIBRATION EVENT**
**BLOCKAGE INCREASED TO 75%**



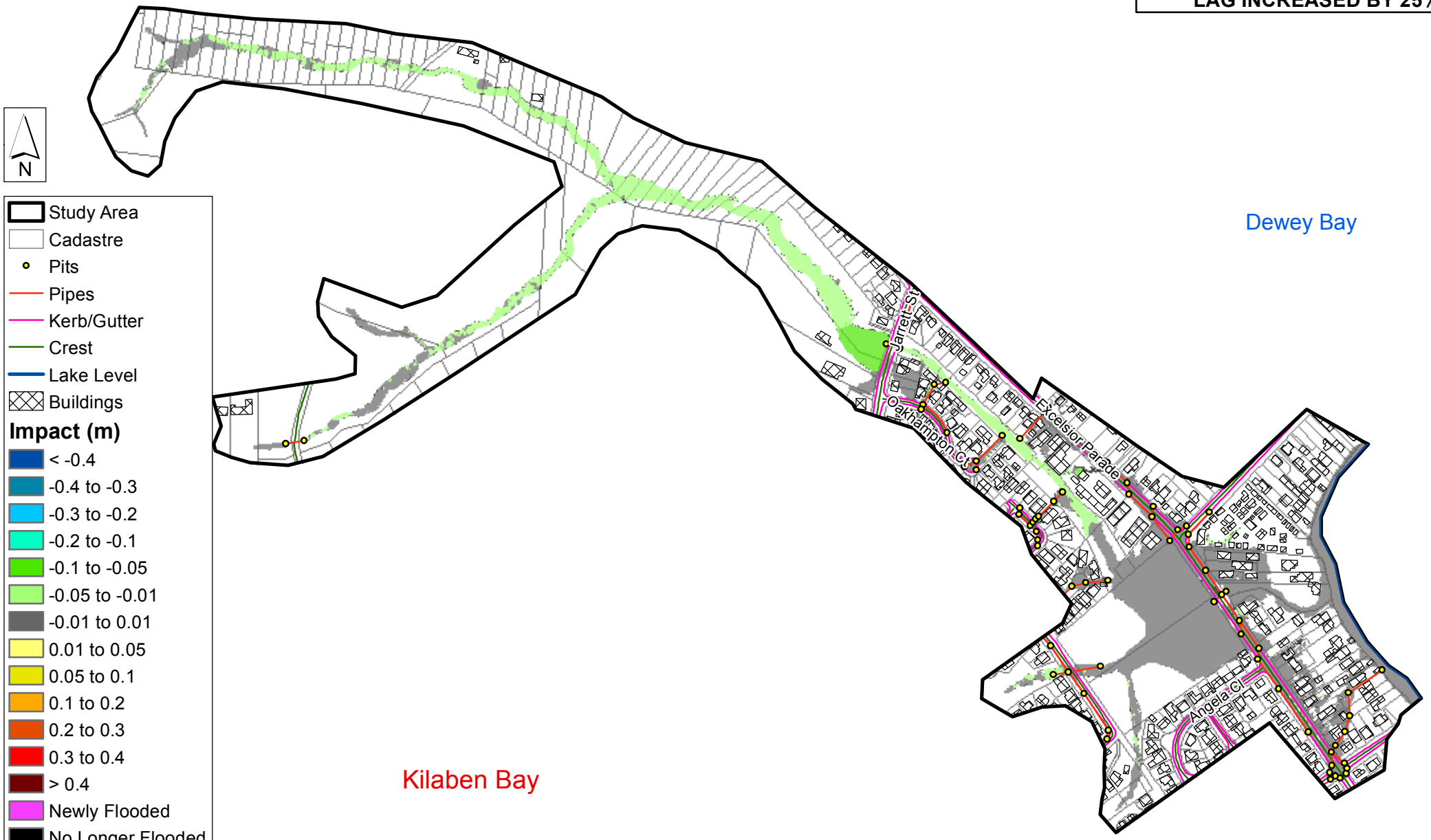

J:\Jobs\119076\ArcGIS\ArcMap\Report\AppendixB_Calibration\61to121\FigureB063_Puntei_Creek_2015_Impact_Calibration_DX1_blo075.mxd

FIGURE B64
**PUNTEI CREEK**
**2015 CALIBRATION EVENT**
**LAG DECREASED BY 25%**



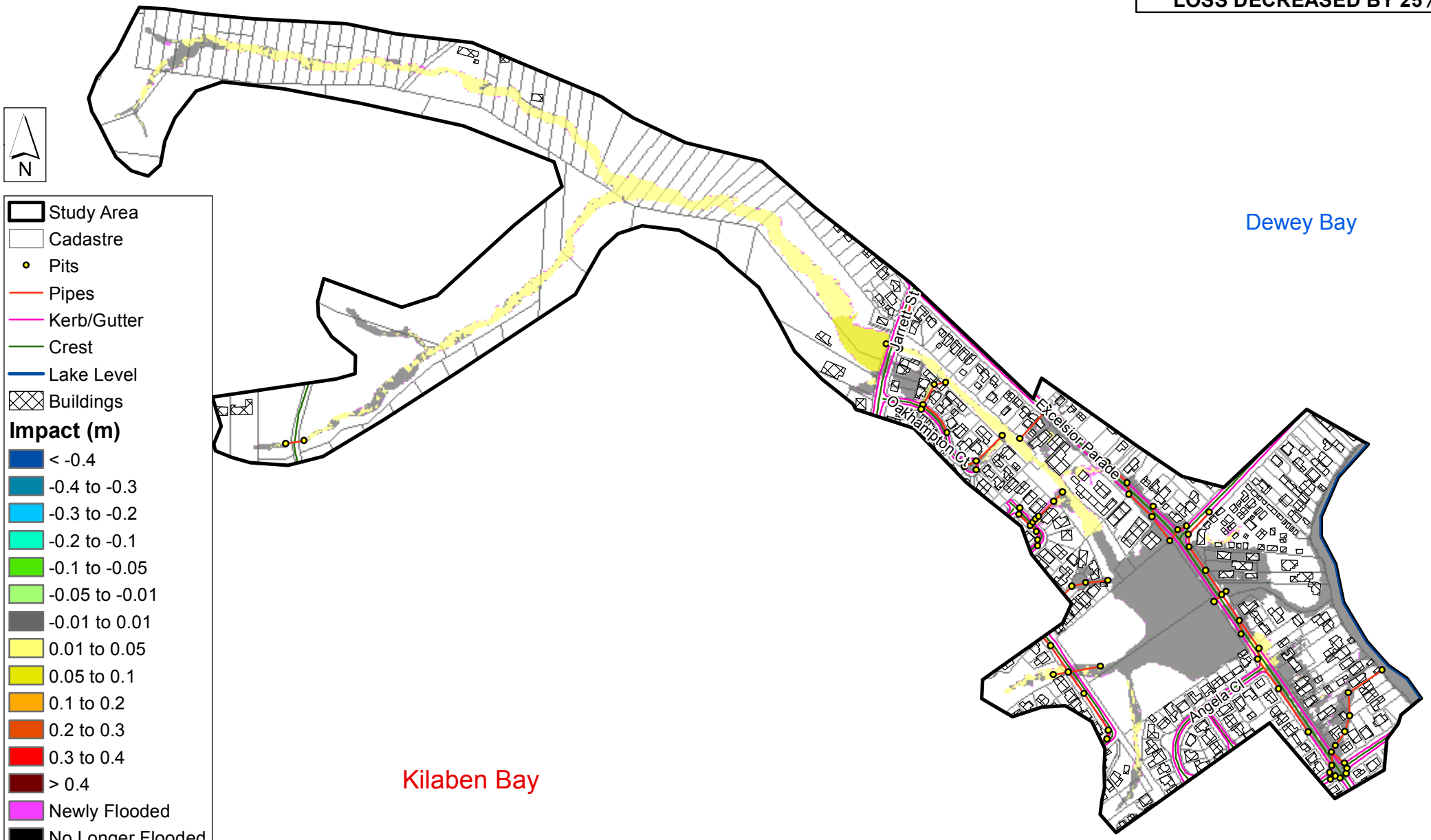

J:\Jobs\119076\ArcGIS\ArcMap\Report\AppendixB_Calibration\61to121\FigureB064_Puntei_Creek_2015_Impact_Calibration_DX1_LagM25.mxd

FIGURE B65
**PUNTEI CREEK**
**2015 CALIBRATION EVENT**
**LAG INCREASED BY 25%**



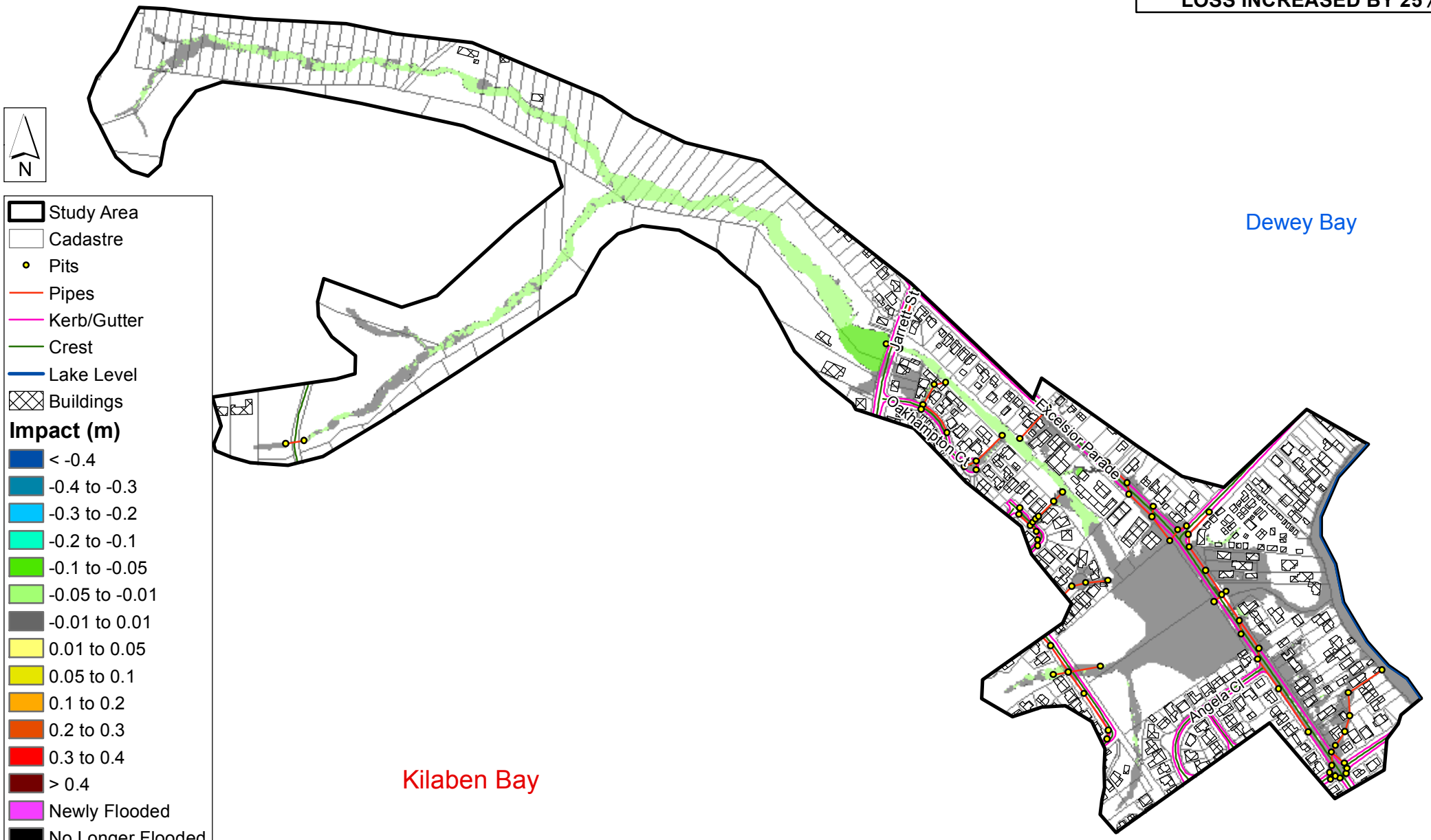

J:\Jobs\119076\ArcGIS\ArcMap\Report\AppendixB_Calibration\61to121\FigureB065_Puntei_Creek_2015_Impact_Calibration_DX1_LagP25.mxd

FIGURE B66
**PUNTEI CREEK**
**2015 CALIBRATION EVENT**
**LOSS DECREASED BY 25%**



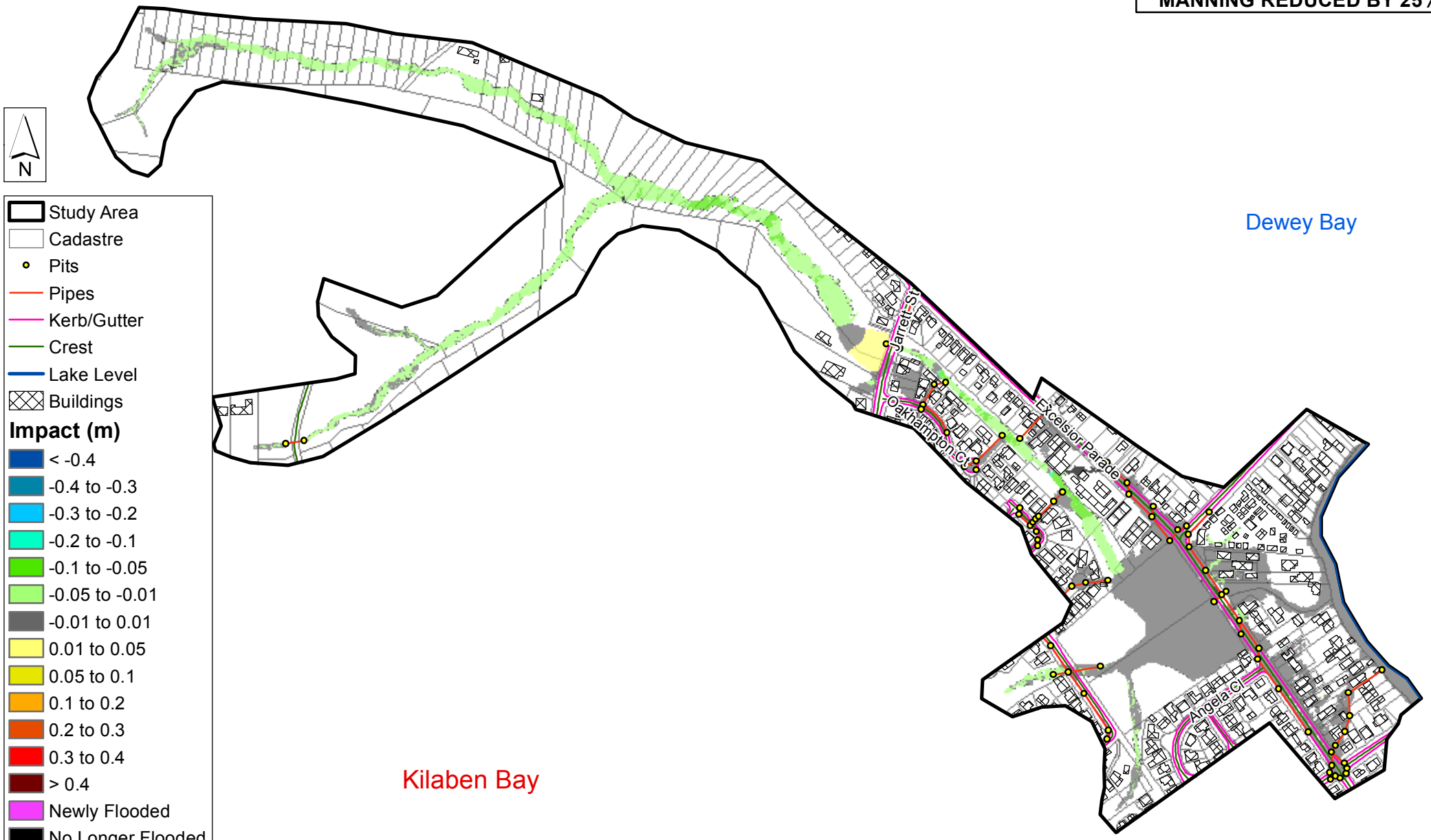

J:\Jobs\119076\ArcGIS\ArcMap\Report\AppendixB_Calibration\61to121\FigureB066_Puntei_Creek_2015_Impact_Calibration_DX1_LossM25.mxd

FIGURE B67
**PUNTEI CREEK**
**2015 CALIBRATION EVENT**
**LOSS INCREASED BY 25%**



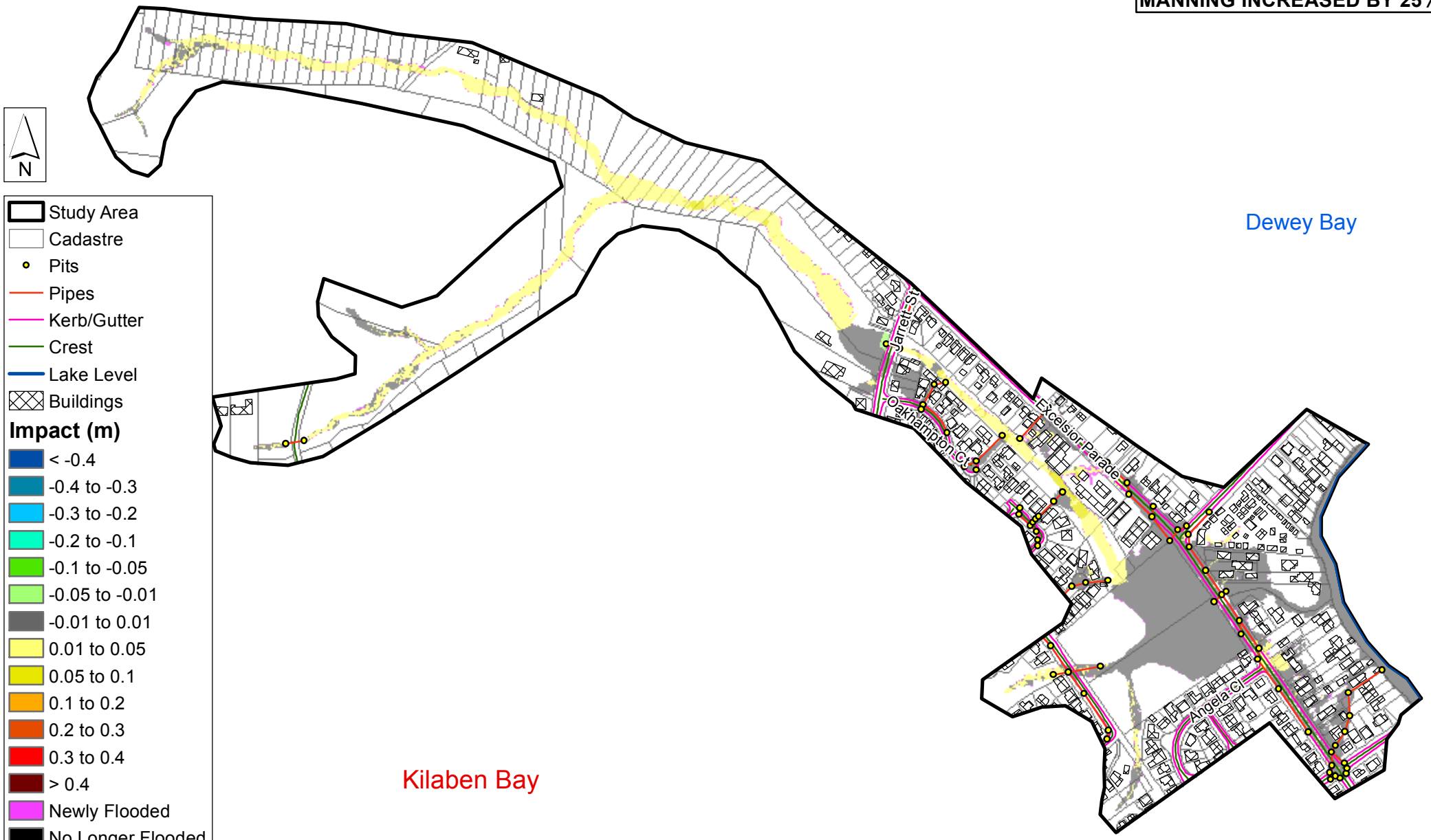

J:\Jobs\1119076\ArcGIS\ArcMap\Report\AppendixB_Calibration\611to1211\FigureB067_Puntei_Creek_2015_Impact_Calibration_DX1_Lossp25.mxd

FIGURE B68
**PUNTEI CREEK**
**2015 CALIBRATION EVENT**
**MANNING REDUCED BY 25%**



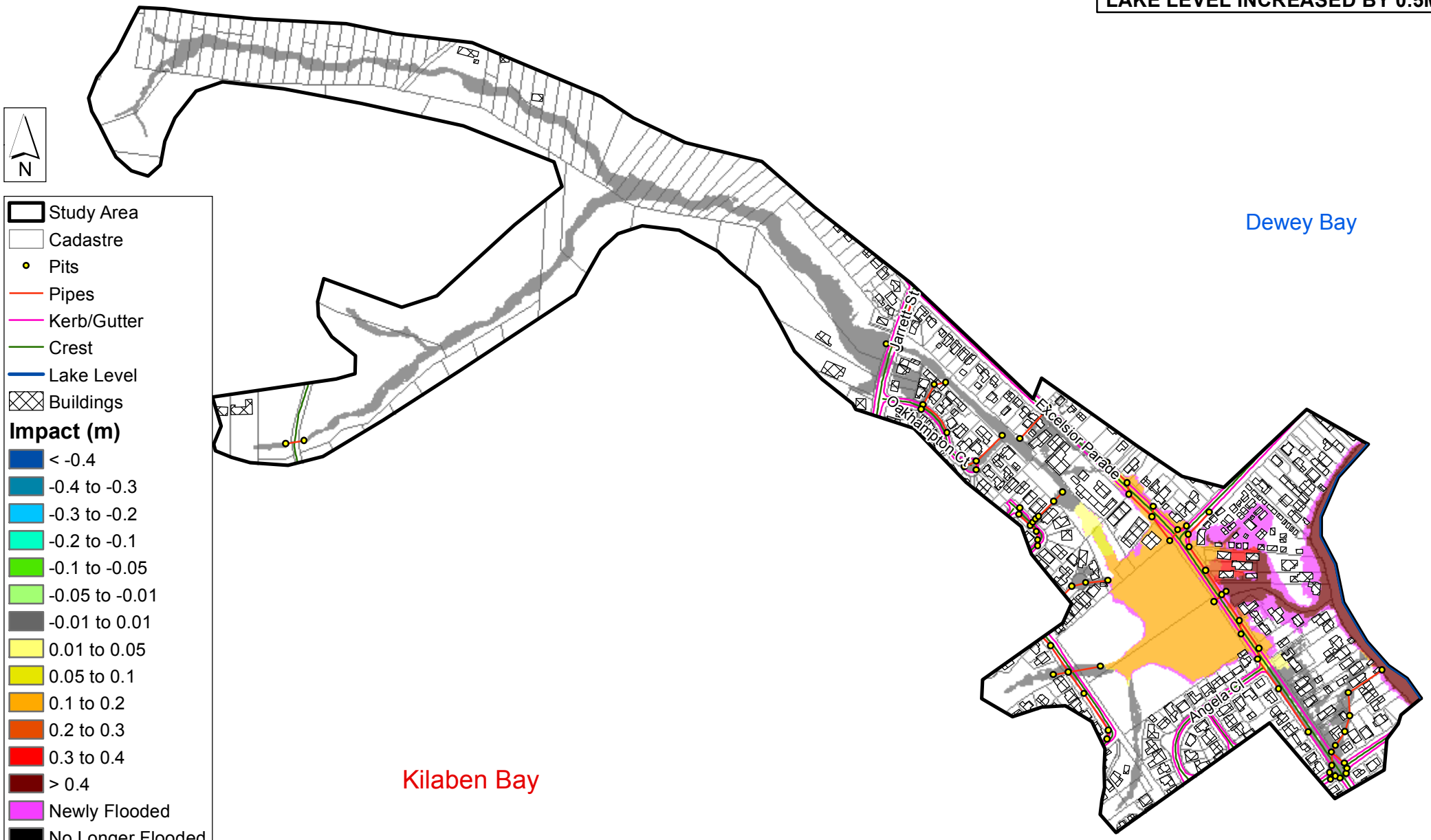

J:\Jobs\119076\ArcGIS\ArcMap\Report\AppendixB_Calibration\61to121\FigureB068_Puntei_Creek_2015_Impact_Calibration_DX1_mannn25.mxd

FIGURE B69
**PUNTEI CREEK**
**2015 CALIBRATION EVENT**
**MANNING INCREASED BY 25%**



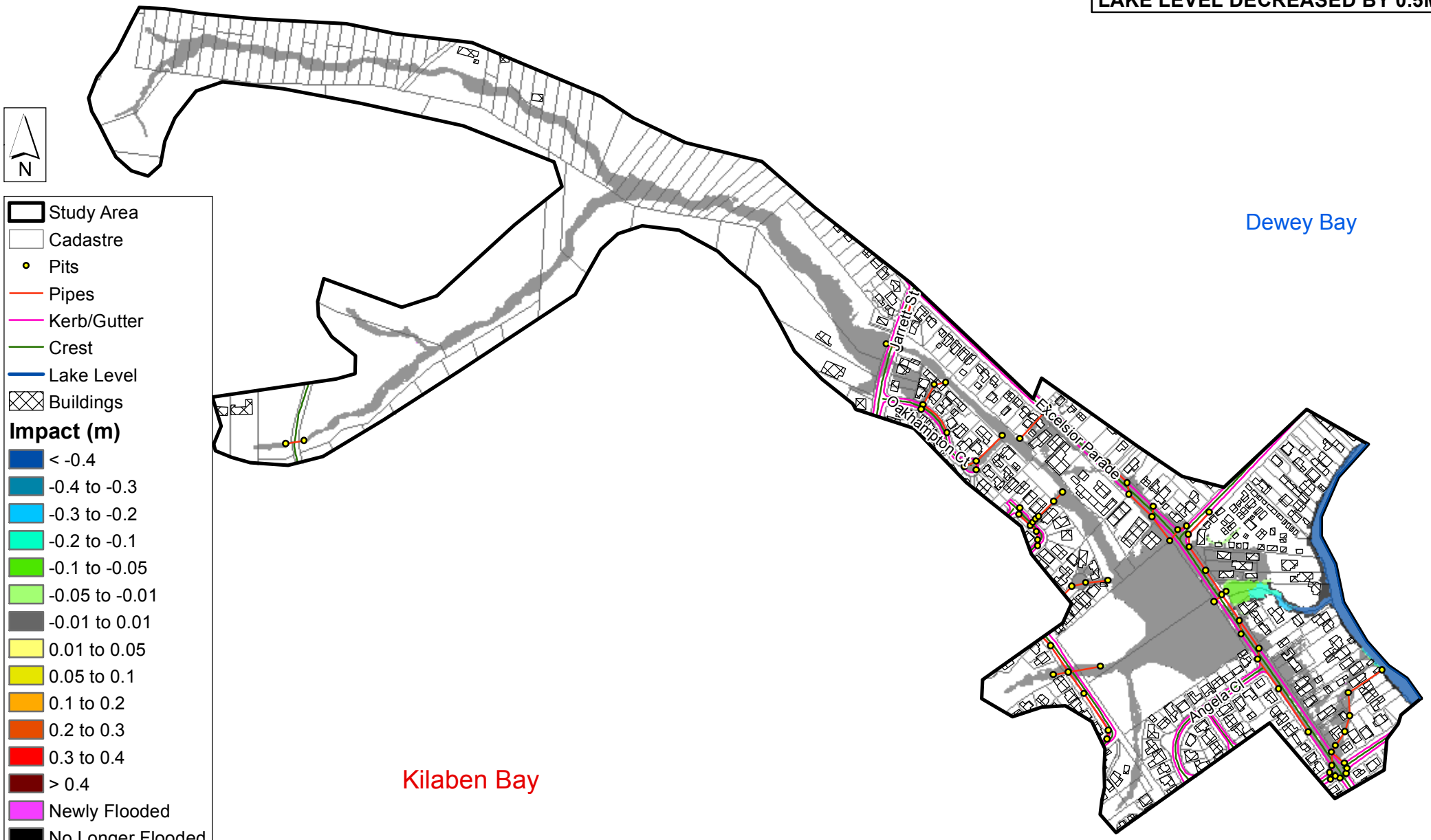

J:\Jobs\119076\ArcGIS\ArcMap\Report\AppendixB_Calibration\61to121\FigureB069_Puntei_Creek_2015_Impact_Calibration_DX1_manp25.mxd

FIGURE B70
**PUNTEI CREEK**
**2015 CALIBRATION EVENT**
**LAKE LEVEL INCREASED BY 0.5M**




J:\Jobs\119076\ArcGIS\ArcMap\Report\AppendixB_Calibration\61to121\FigureB070_Puntei_Creek_2015_Impact_Calibration_DX1_TWP500MM.mxd

FIGURE B71
**PUNTEI CREEK**
**2015 CALIBRATION EVENT**
**LAKE LEVEL DECREASED BY 0.5M**




J:\Jobs\119076\ArcGIS\ArcMap\Report\AppendixB_Calibration\61to121\FigureB071_Puntei_Creek_2015_Impact_Calibration_DX1_TWM500MM.mxd

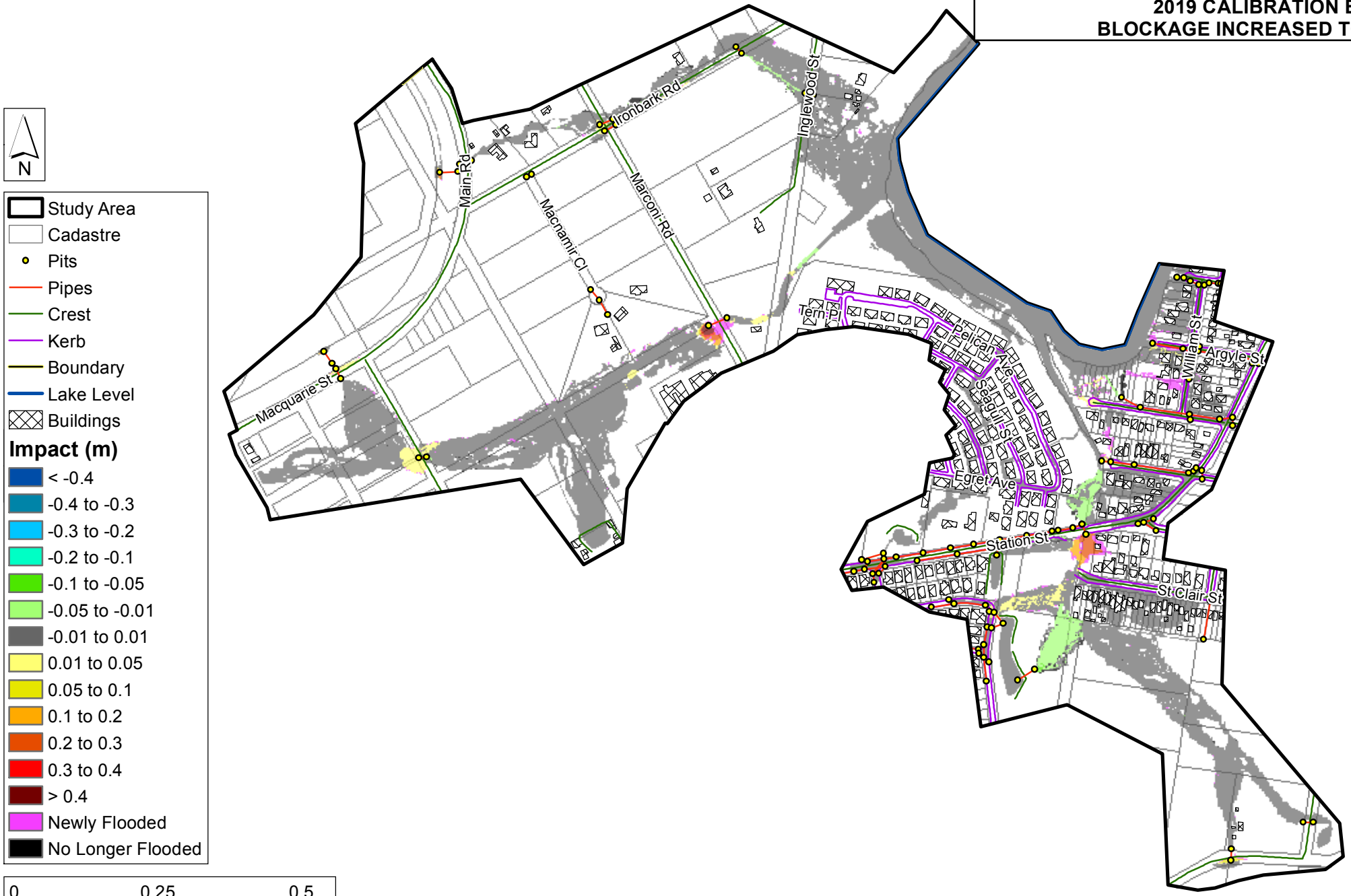
FIGURE B72

**FULLERS CREEK AND FRESHWATER CREEK**
**2019 CALIBRATION EVENT**
**BLOCKAGE REDUCED TO 25%**

J:\Jobs\119076\ArcGIS\ArcMap\Report\AppendixB_Calibration\61to121\FigureB072_FFC_Impact_2019DoraCreMan_Calibration_DX1_blo025.mxd

FIGURE B73

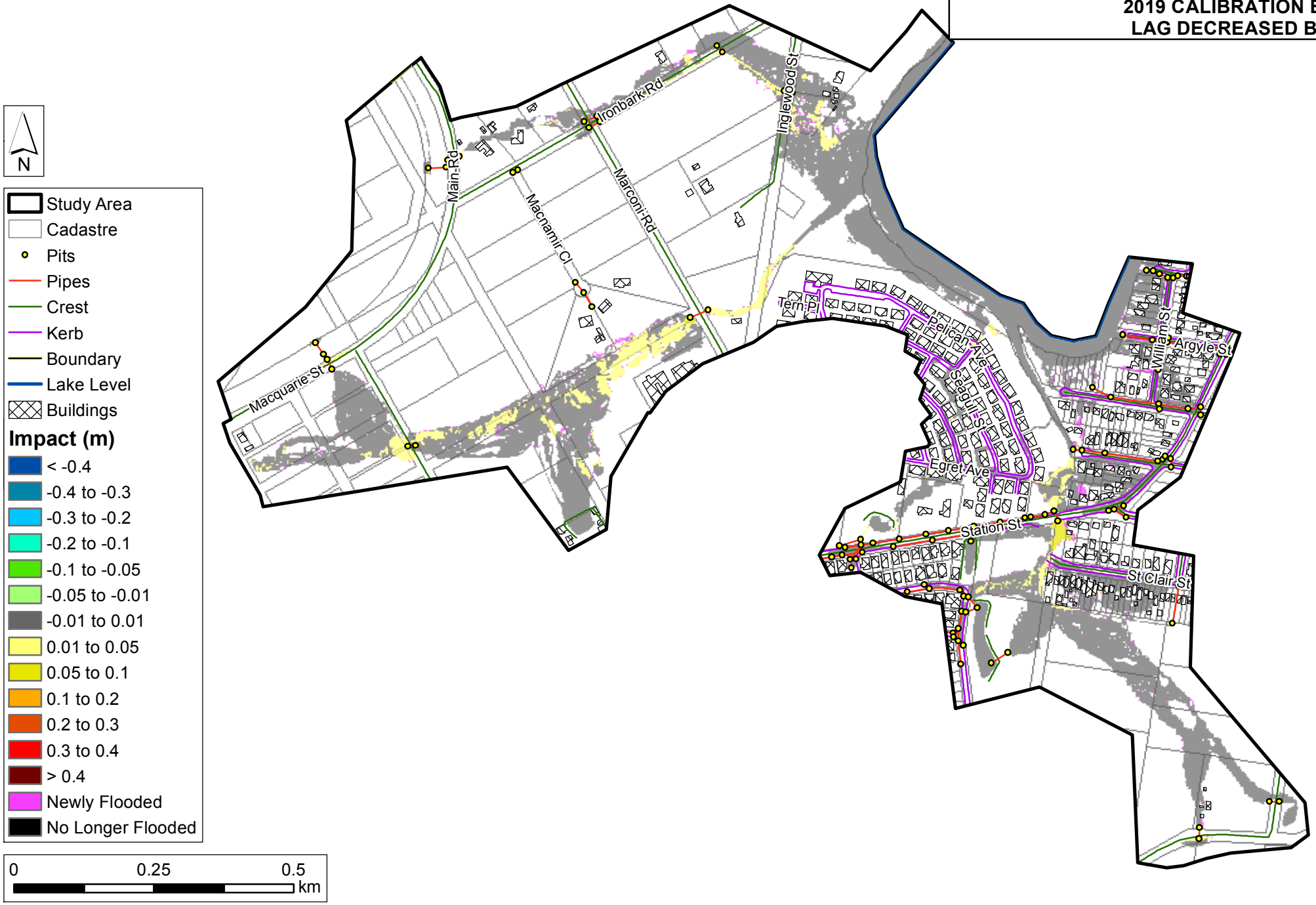
**FULLERS CREEK AND FRESHWATER CREEK**
**2019 CALIBRATION EVENT**
**BLOCKAGE INCREASED TO 75%**




J:\Jobs\119076\ArcGIS\ArcMap\Report\AppendixB_Calibration\61to121\FigureB073_FFC_Impact_2019DoraCreMan_Calibration_DX1_blo075.mxd

FIGURE B74

**FULLERS CREEK AND FRESHWATER CREEK**
**2019 CALIBRATION EVENT**
**LAG DECREASED BY 25%**




J:\Jobs\119076\ArcGIS\ArcMap\Report\AppendixB_Calibration\61to121\FigureB074_FFC_Impact_2019DoraCreMan_Calibration_DX1_LagM25.mxd

FIGURE B75

**FULLERS CREEK AND FRESHWATER CREEK**
**2019 CALIBRATION EVENT**
**LAG INCREASED BY 25%**

J:\Jobs\119076\ArcGIS\ArcMap\Report\AppendixB_Calibration\61to121\FigureB075_FFC_Impact_2019DoraCreMan_Calibration_DX1_LagP25.mxd

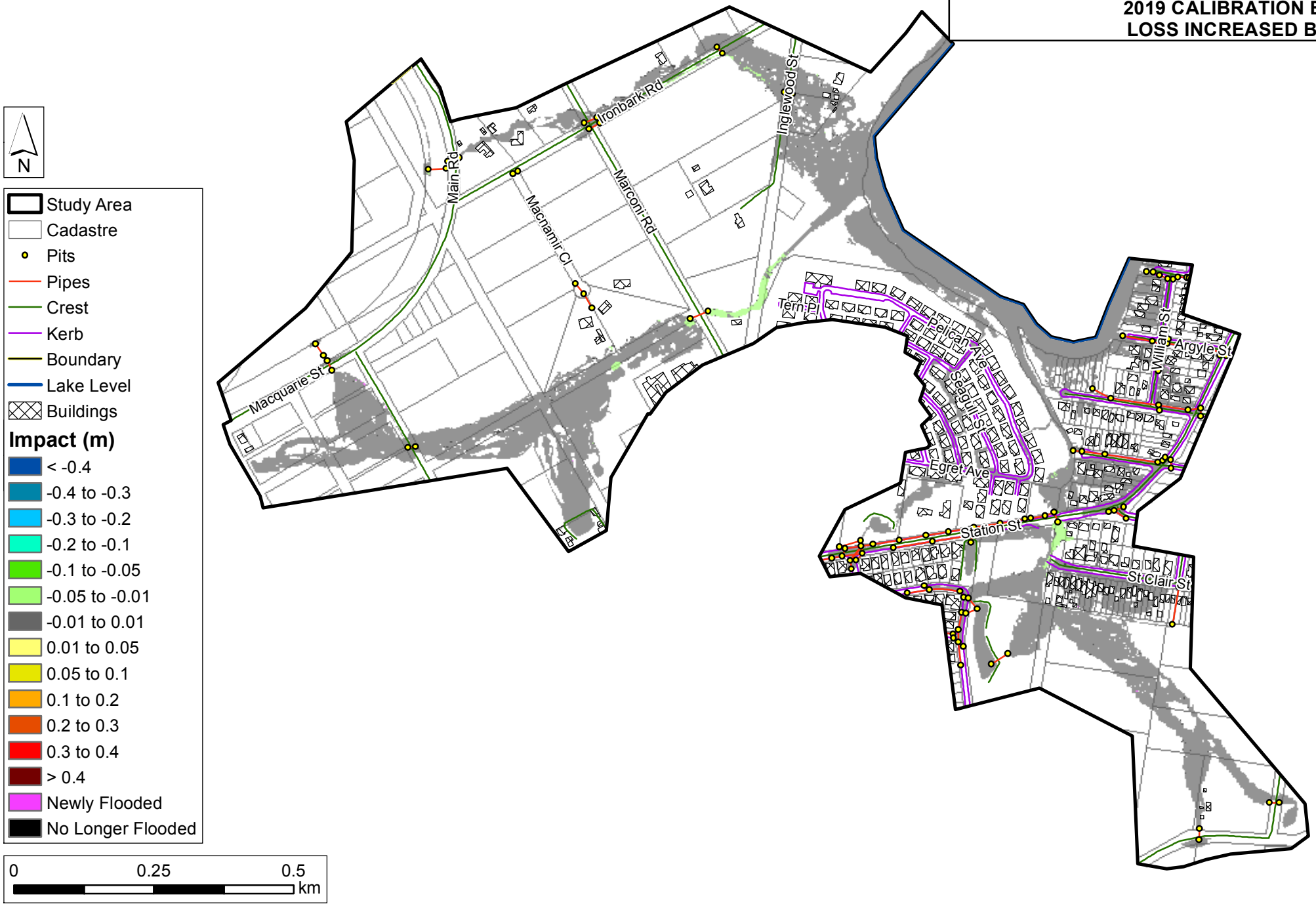
FIGURE B76

**FULLERS CREEK AND FRESHWATER CREEK**
**2019 CALIBRATION EVENT**
**LOSS DECREASED BY 25%**

J:\Jobs\119076\ArcGIS\ArcMap\Report\AppendixB_Calibration\61to121\FigureB076_FFC_Impact_2019DoraCreMan_Calibration_DX1_LossM25.mxd

FIGURE B77

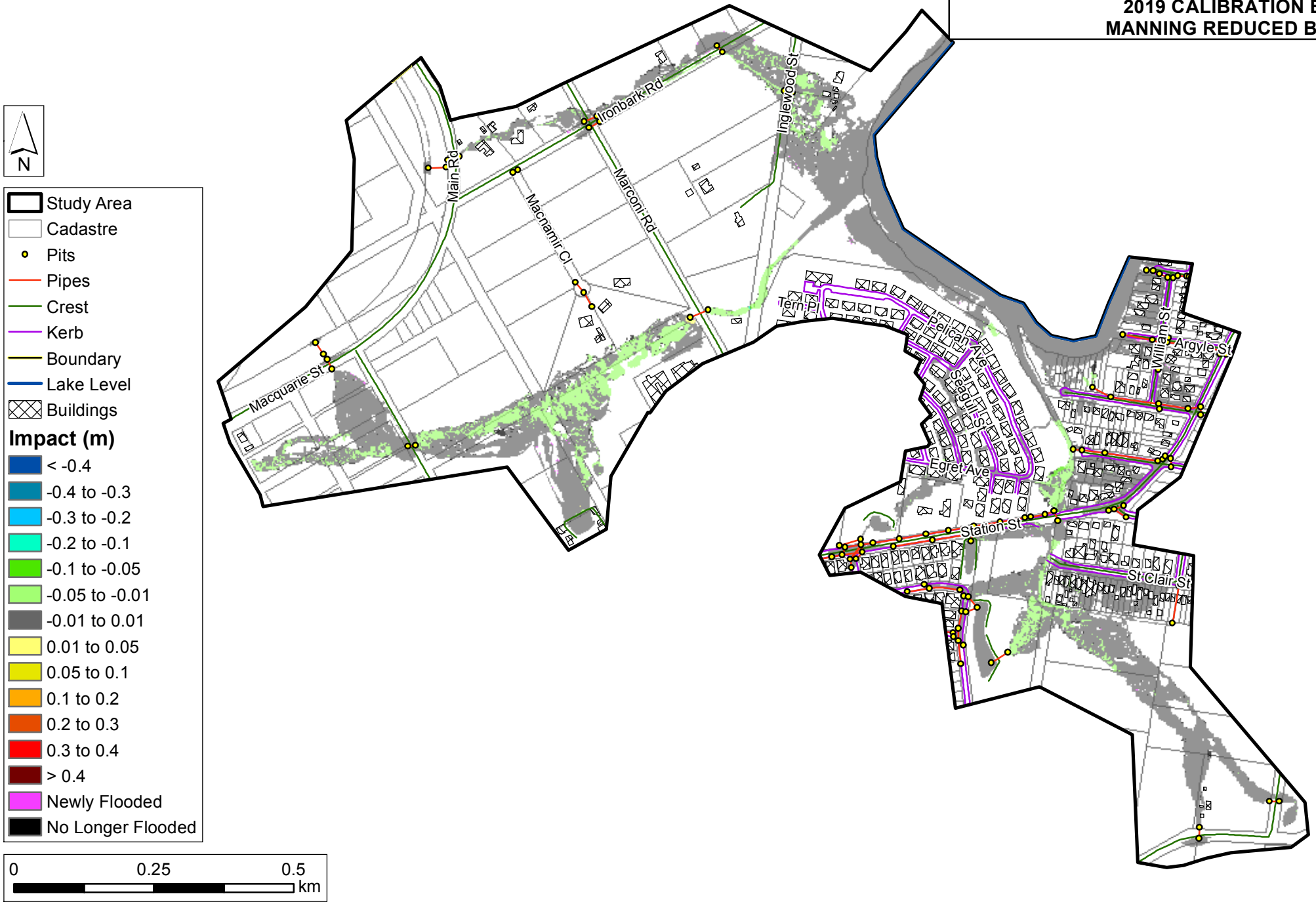
**FULLERS CREEK AND FRESHWATER CREEK**
**2019 CALIBRATION EVENT**
**LOSS INCREASED BY 25%**




J:\Jobs\119076\ArcGIS\ArcMap\Report\AppendixB_Calibration\61to121\FigureB077_FFC_Impact_2019DoraCreMan_Calibration_DX1_Lossp25.mxd

FIGURE B78

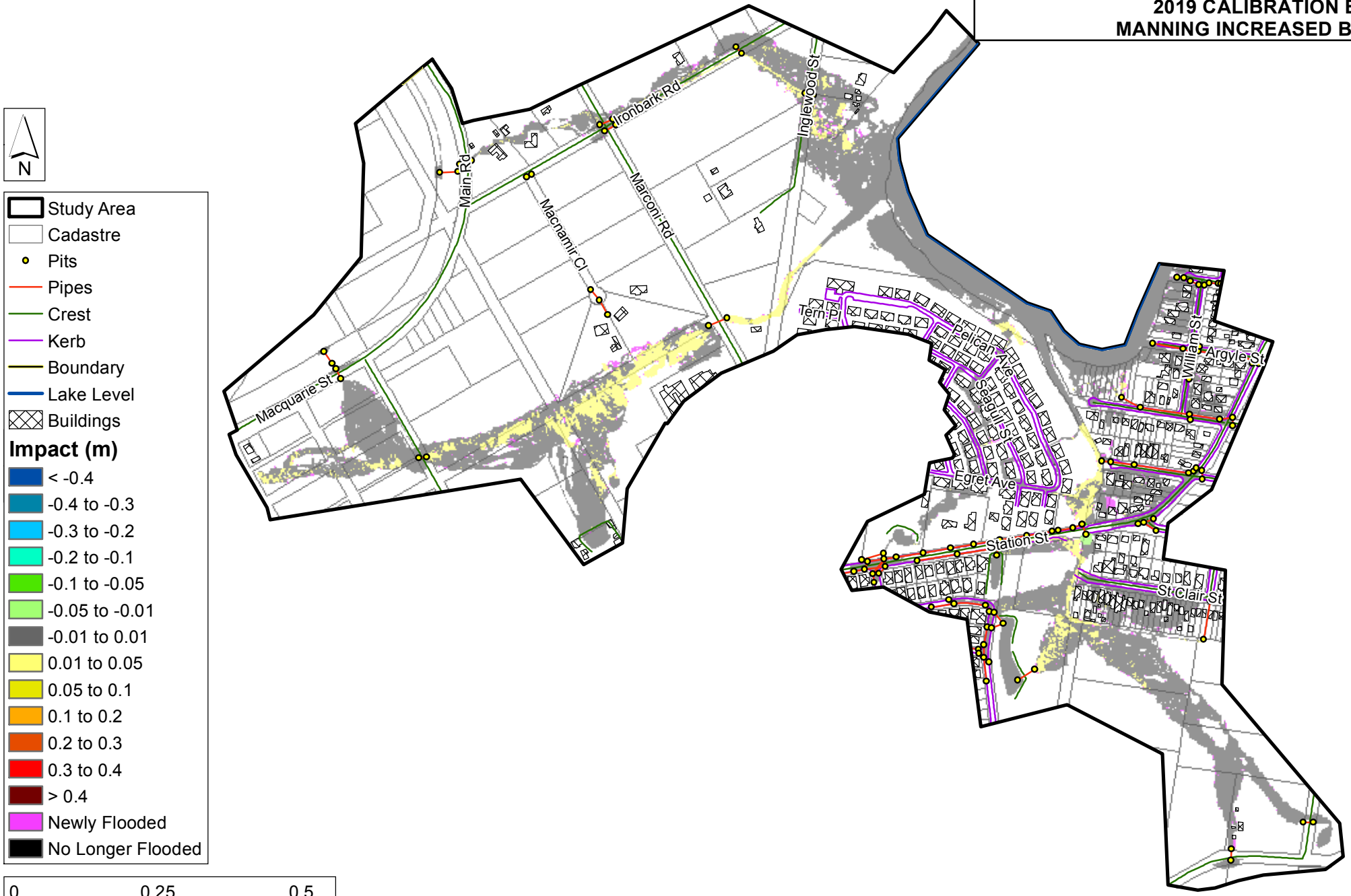
**FULLERS CREEK AND FRESHWATER CREEK**
**2019 CALIBRATION EVENT**
**MANNING REDUCED BY 25%**




J:\Jobs\119076\ArcGIS\ArcMap\Report\AppendixB_Calibration\61to121\FigureB078_FFC_Impact_2019DoraCreMan_Calibration_DX1_mann25.mxd

FIGURE B79

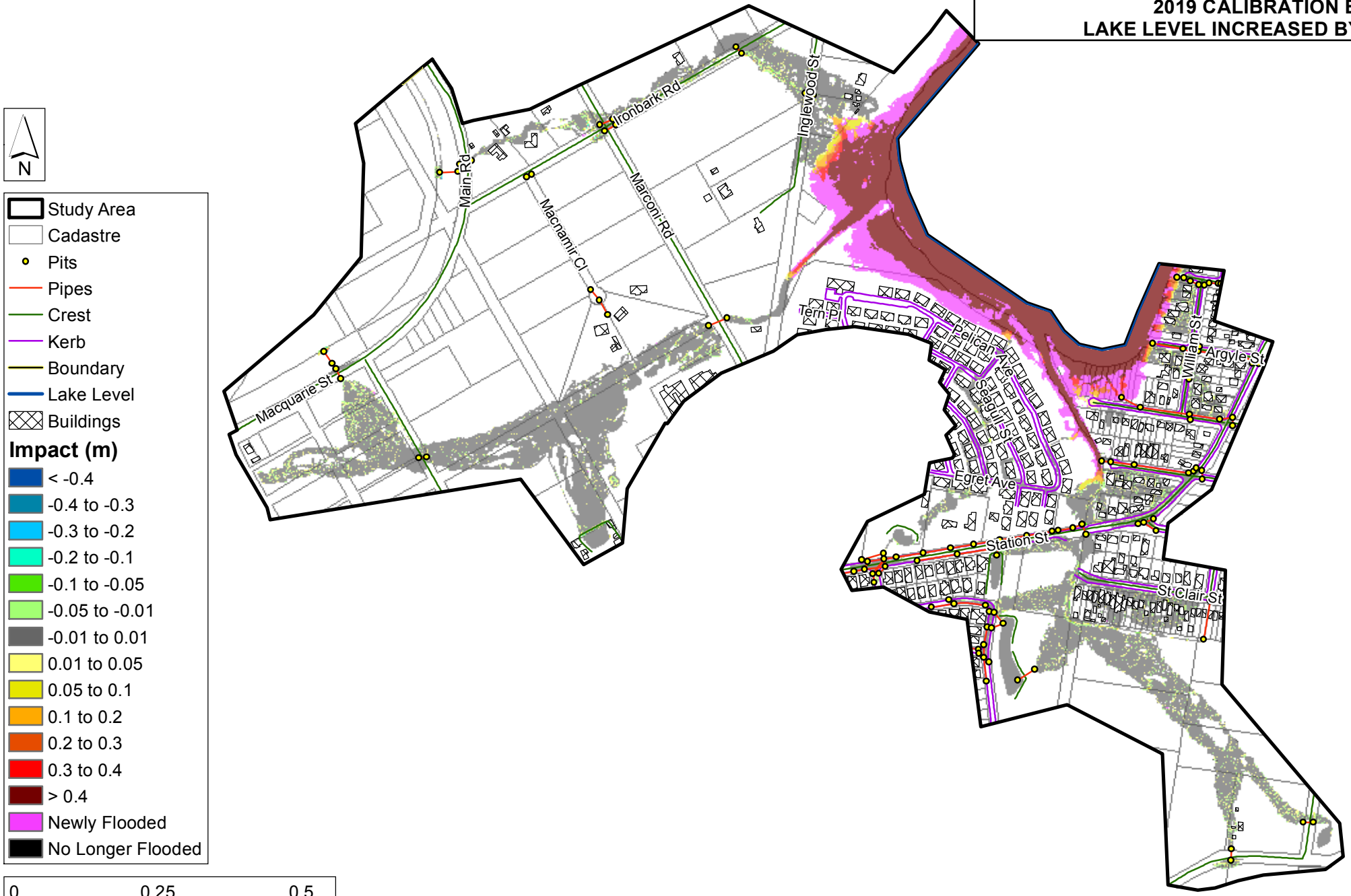
**FULLERS CREEK AND FRESHWATER CREEK**
**2019 CALIBRATION EVENT**
**MANNING INCREASED BY 25%**




J:\Jobs\119076\ArcGIS\ArcMap\Report\AppendixB_Calibration\61to121\FigureB079_FFC_Impact_2019DoraCreMan_Calibration_DX1_manp25.mxd

FIGURE B80

**FULLERS CREEK AND FRESHWATER CREEK**
**2019 CALIBRATION EVENT**
**LAKE LEVEL INCREASED BY 0.5M**




J:\Jobs\119076\ArcGIS\ArcMap\Report\AppendixB_Calibration\61to121\FigureB080_FFC_Impact_2019DoraCreMan_Calibration_DX1_TWP500MM.mxd

FIGURE B81

**FULLERS CREEK AND FRESHWATER CREEK**
**2019 CALIBRATION EVENT**
**LAKE LEVEL DECREASED BY 0.5M**

J:\Jobs\119076\ArcGIS\ArcMap\Report\AppendixB_Calibration\61to121\FigureB081_FFC_Impact_2019DoraCreMan_Calibration_DX1_TWm500MM.mxd

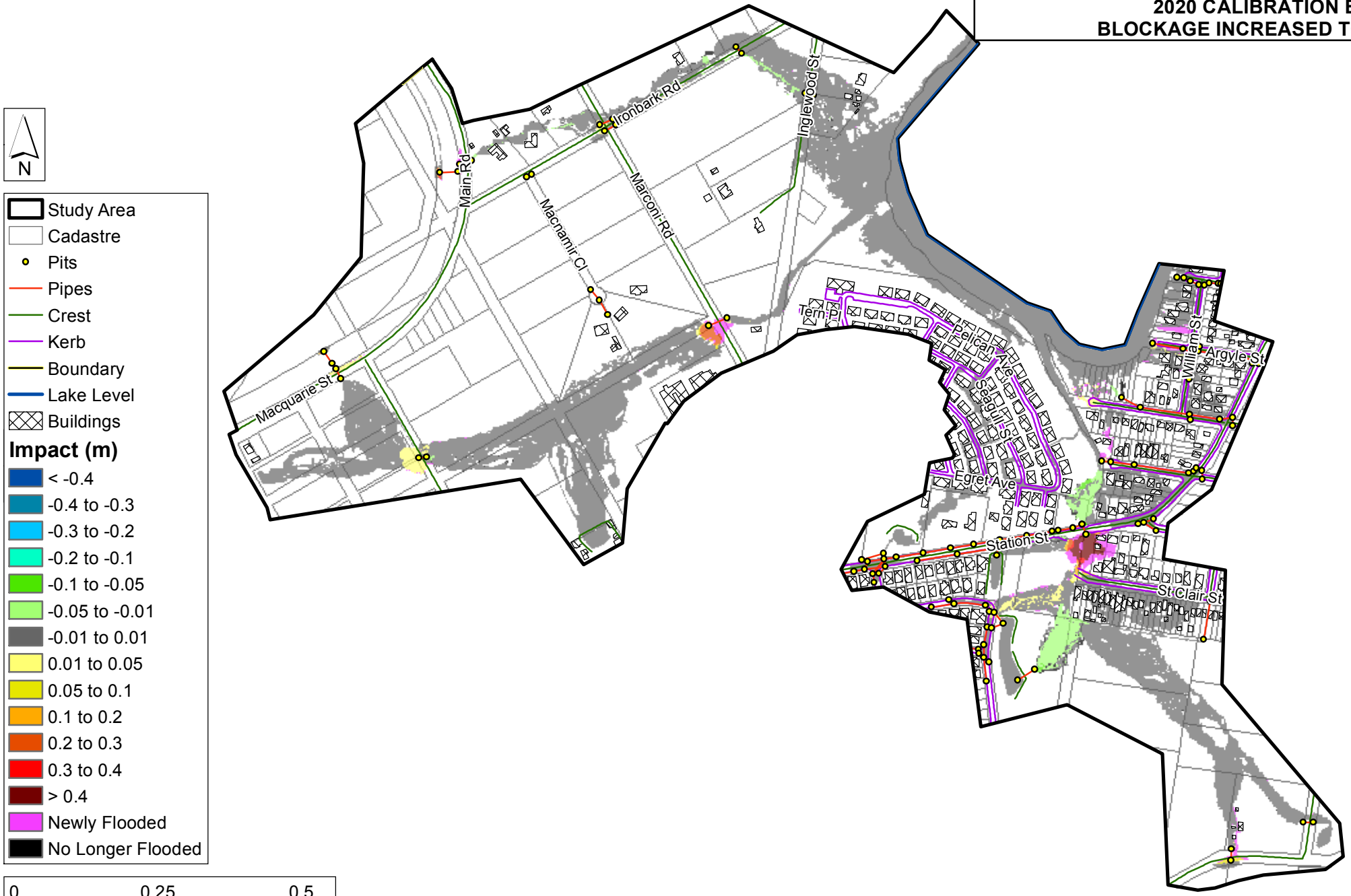
FIGURE B82

**FULLERS CREEK AND FRESHWATER CREEK**
**2020 CALIBRATION EVENT**
**BLOCKAGE REDUCED TO 25%**

J:\Jobs\119076\ArcGIS\ArcMap\Report\AppendixB_Calibration\61to121\FigureB082_FFC_Impact_2020DoraCreMan_Calibration_DX1_blo025.mxd

FIGURE B83

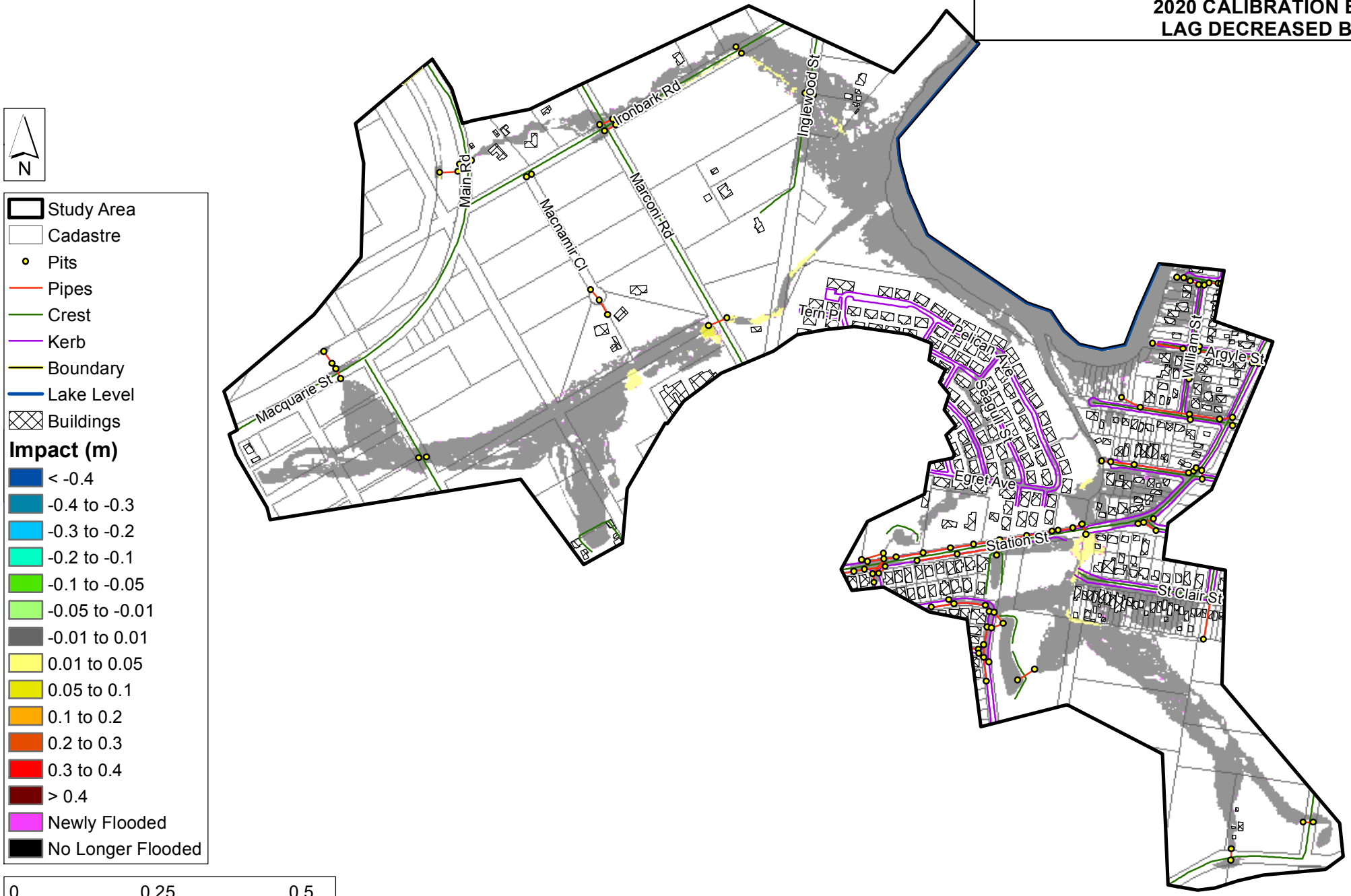
**FULLERS CREEK AND FRESHWATER CREEK**
**2020 CALIBRATION EVENT**
**BLOCKAGE INCREASED TO 75%**




J:\Jobs\119076\ArcGIS\ArcMap\Report\AppendixB_Calibration\61to121\FigureB083_FFC_Impact_2020DoraCreMan_Calibration_DX1_blo075.mxd

FIGURE B84

**FULLERS CREEK AND FRESHWATER CREEK**
**2020 CALIBRATION EVENT**
**LAG DECREASED BY 25%**




J:\Jobs\119076\ArcGIS\ArcMap\Report\AppendixB_Calibration\61to121\FigureB084_FFC_Impact_2020DoraCreMan_Calibration_DX1_LagM25.mxd

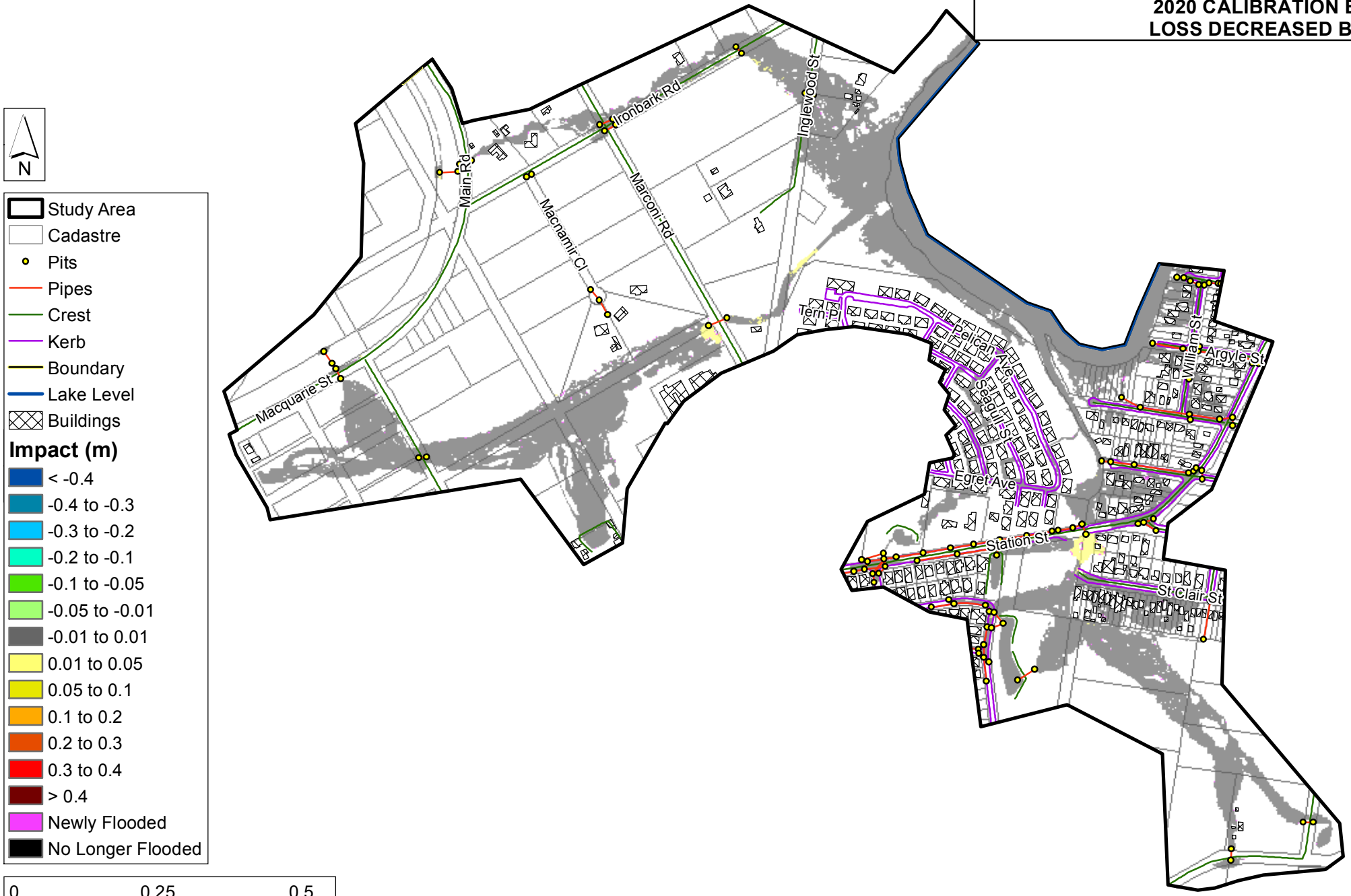
FIGURE B85

**FULLERS CREEK AND FRESHWATER CREEK**
**2020 CALIBRATION EVENT**
**LAG INCREASED BY 25%**

J:\Jobs\119076\ArcGIS\ArcMap\Report\AppendixB_Calibration\61to121\FigureB085_FFC_Impact_2020DoraCreMan_Calibration_DX1_LagP25.mxd

FIGURE B86

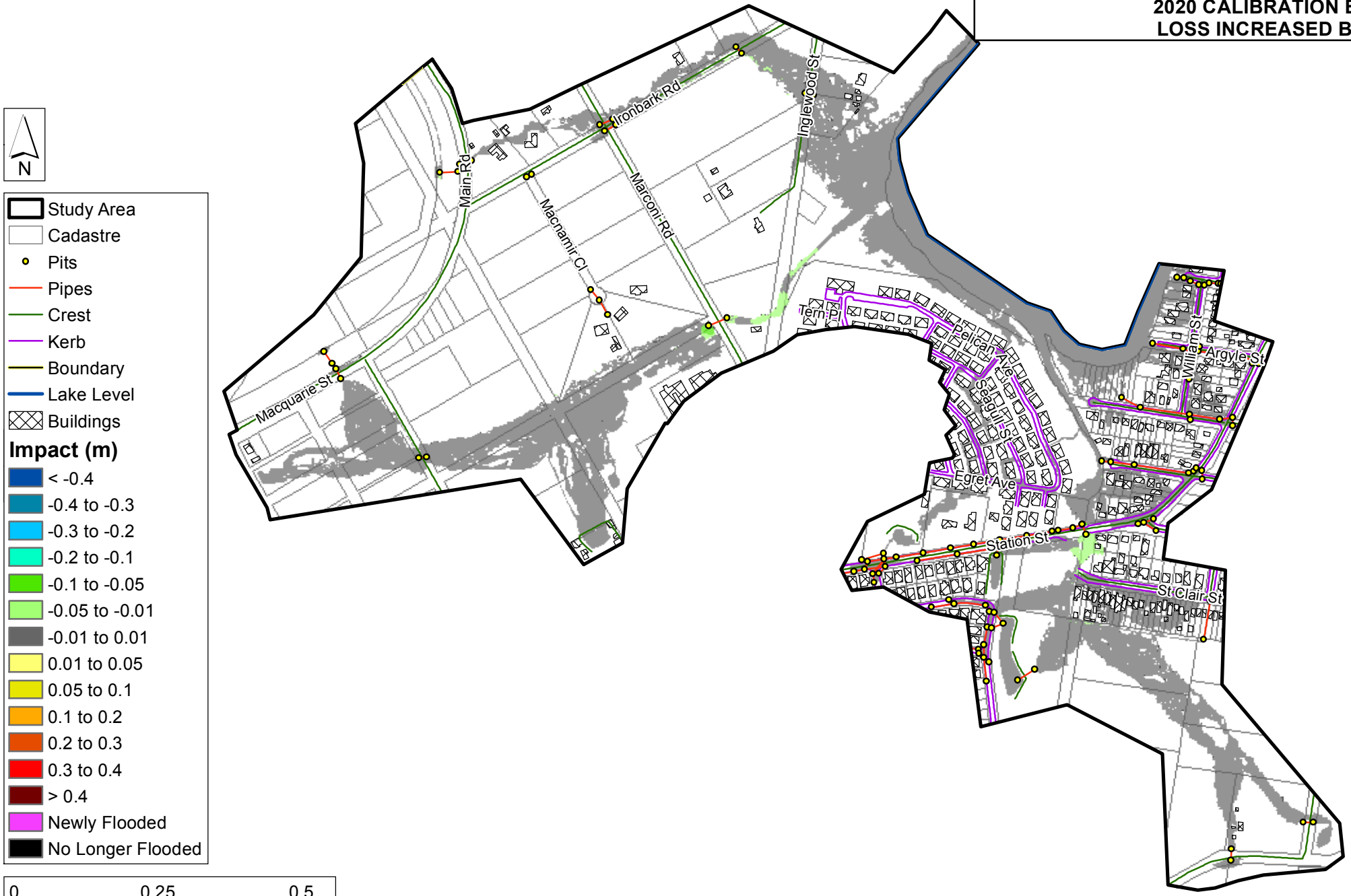
**FULLERS CREEK AND FRESHWATER CREEK**
**2020 CALIBRATION EVENT**
**LOSS DECREASED BY 25%**




J:\Jobs\119076\ArcGIS\ArcMap\Report\AppendixB_Calibration\61to121\FigureB086_FFC_Impact_2020DoraCreMan_Calibration_DX1_LossM25.mxd

FIGURE B87

**FULLERS CREEK AND FRESHWATER CREEK**
**2020 CALIBRATION EVENT**
**LOSS INCREASED BY 25%**




J:\Jobs\119076\ArcGIS\ArcMap\Report\AppendixB_Calibration\61to121\FigureB087_FFC_Impact_2020DoraCreMan_Calibration_DX1_Lossp25.mxd

FIGURE B898

**FULLERS CREEK AND FRESHWATER CREEK**
**2020 CALIBRATION EVENT**
**MANNING REDUCED BY 25%**

J:\Jobs\119076\ArcGIS\ArcMap\Report\AppendixB_Calibration\61to121\FigureB088_FFC_Impact_2020DoraCreMan_Calibration_DX1_manm25.mxd

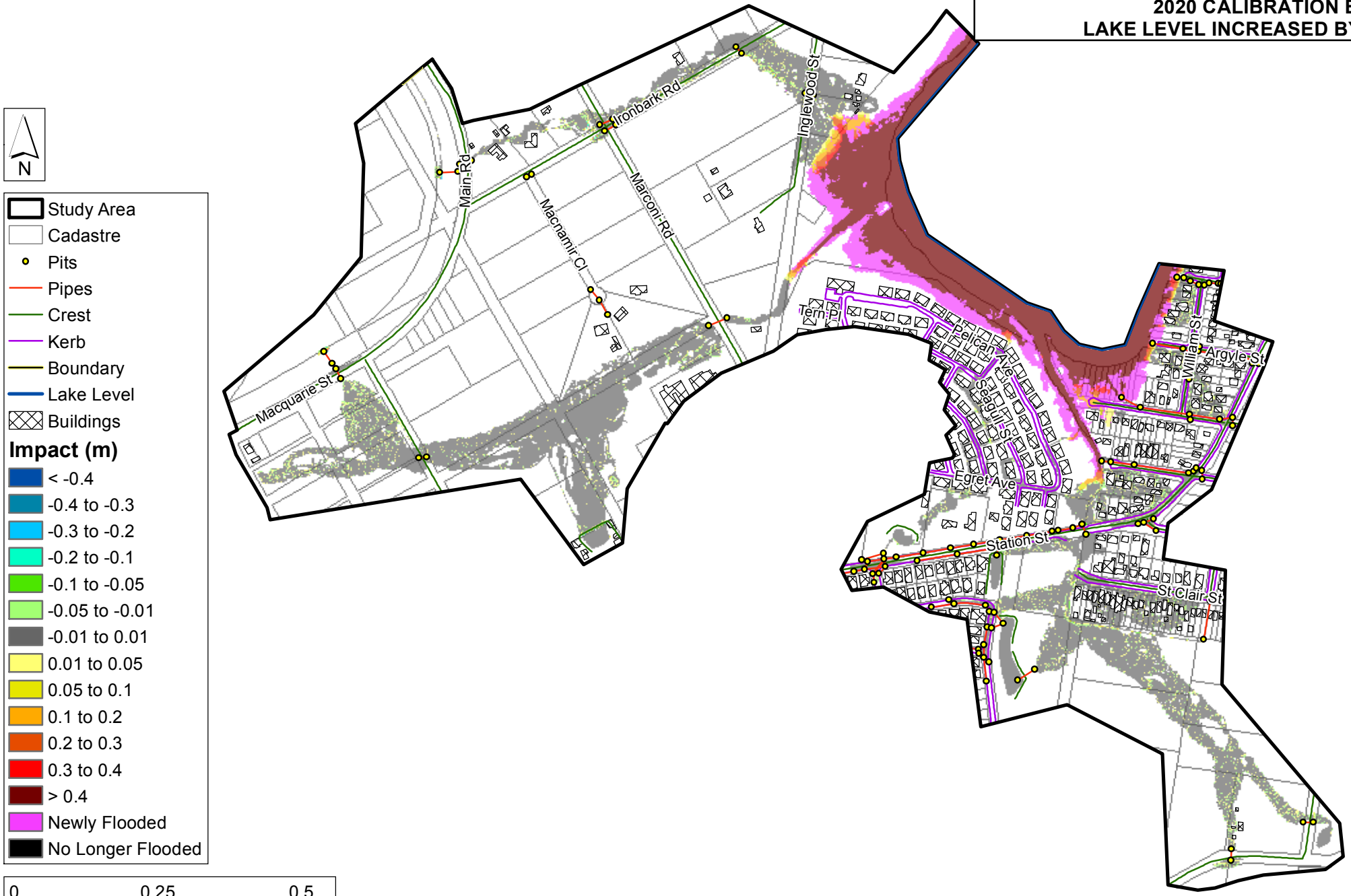
FIGURE B89

**FULLERS CREEK AND FRESHWATER CREEK**
**2020 CALIBRATION EVENT**
**MANNING INCREASED BY 25%**

J:\Jobs\119076\ArcGIS\ArcMap\Report\AppendixB_Calibration\61to121\FigureB089_FFC_Impact_2020DoraCreMan_Calibration_DX1_manp25.mxd

FIGURE B90

**FULLERS CREEK AND FRESHWATER CREEK**
**2020 CALIBRATION EVENT**
**LAKE LEVEL INCREASED BY 0.5M**



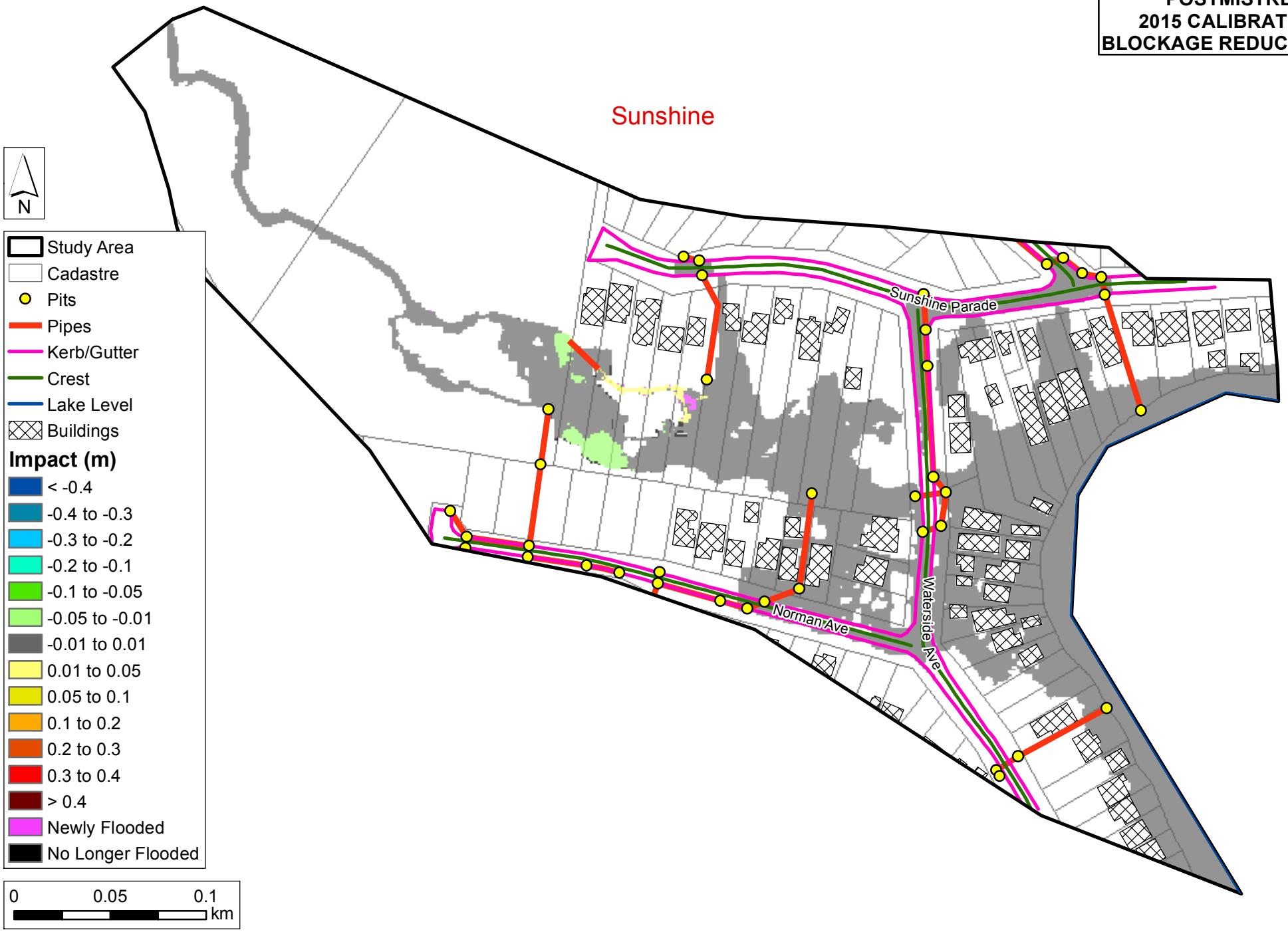

J:\Jobs\119076\ArcGIS\ArcMap\Report\AppendixB_Calibration\61to121\FigureB090_FFC_Impact_2020DoraCreMan_Calibration_DX1_TWP500MM.mxd

FIGURE B91

**FULLERS CREEK AND FRESHWATER CREEK**
**2020 CALIBRATION EVENT**
**LAKE LEVEL DECREASED BY 0.5M**

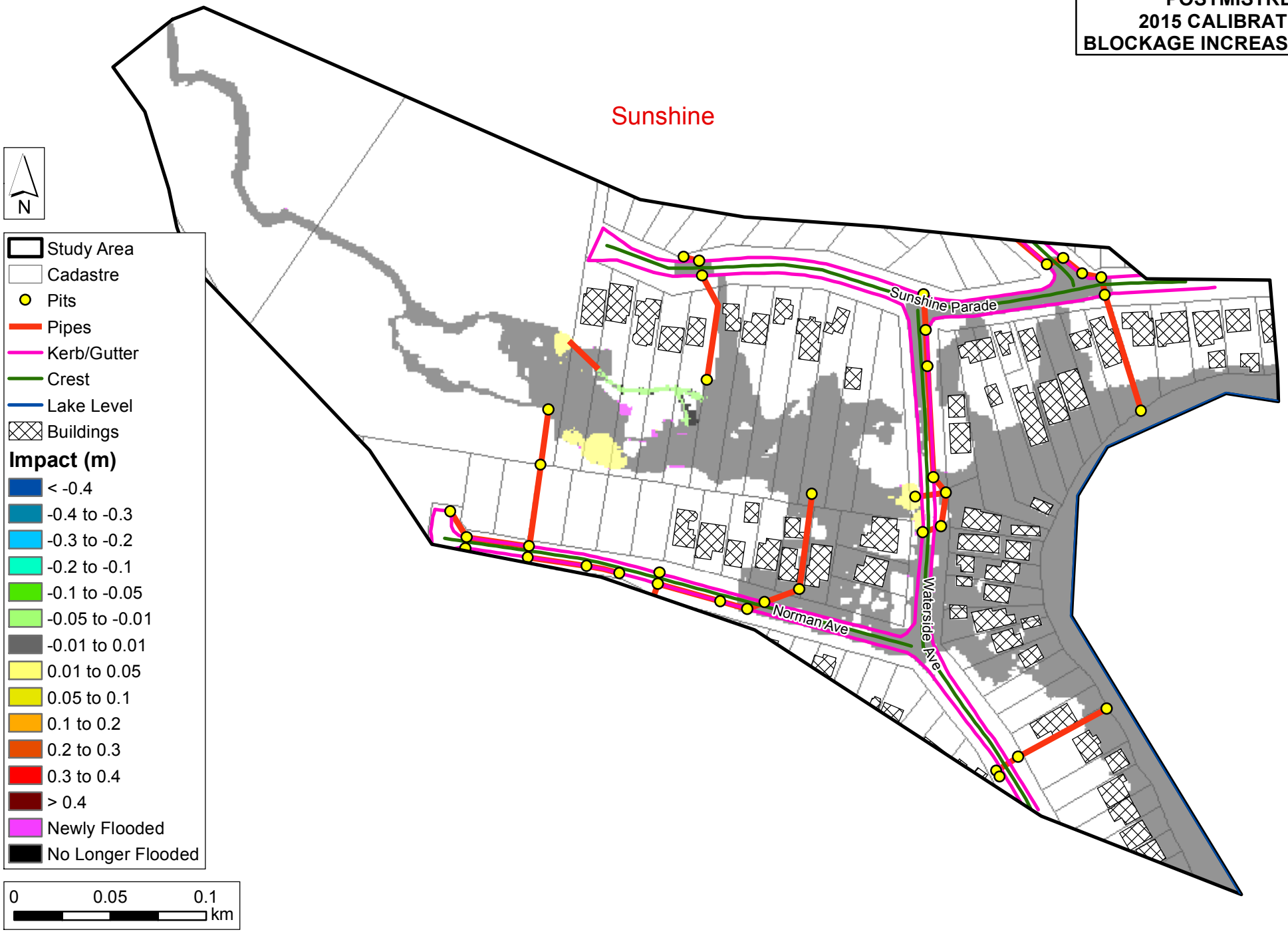
J:\Jobs\119076\ArcGIS\ArcMap\Report\AppendixB_Calibration\61to121\FigureB091_FFC_Impact_2020DoraCreMan_Calibration_DX1_TWm500MM.mxd

FIGURE B92
**POSTMISTRESS CREEK**
**2015 CALIBRATION EVENT**
**BLOCKAGE REDUCED TO 25%**



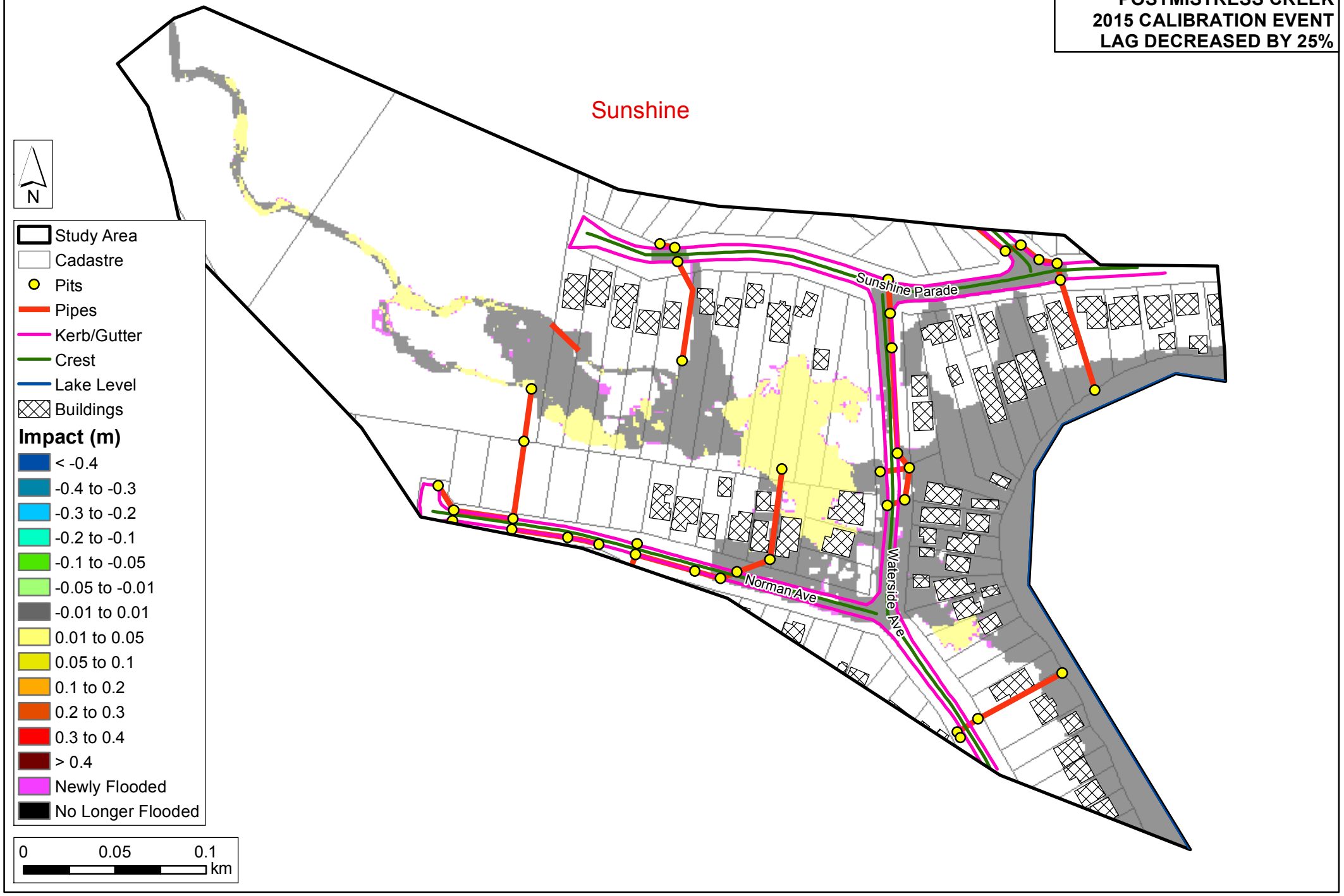

J:\Jobs\119076\ArcGIS\ArcMap\Report\AppendixB_Calibration\61to121\FigureB092_Postmistress_Creek_Impact_2015MandBa_Calibration_DX1_blo025.mxd

FIGURE B93
**POSTMISTRESS CREEK**
**2015 CALIBRATION EVENT**
**BLOCKAGE INCREASED TO 75%**



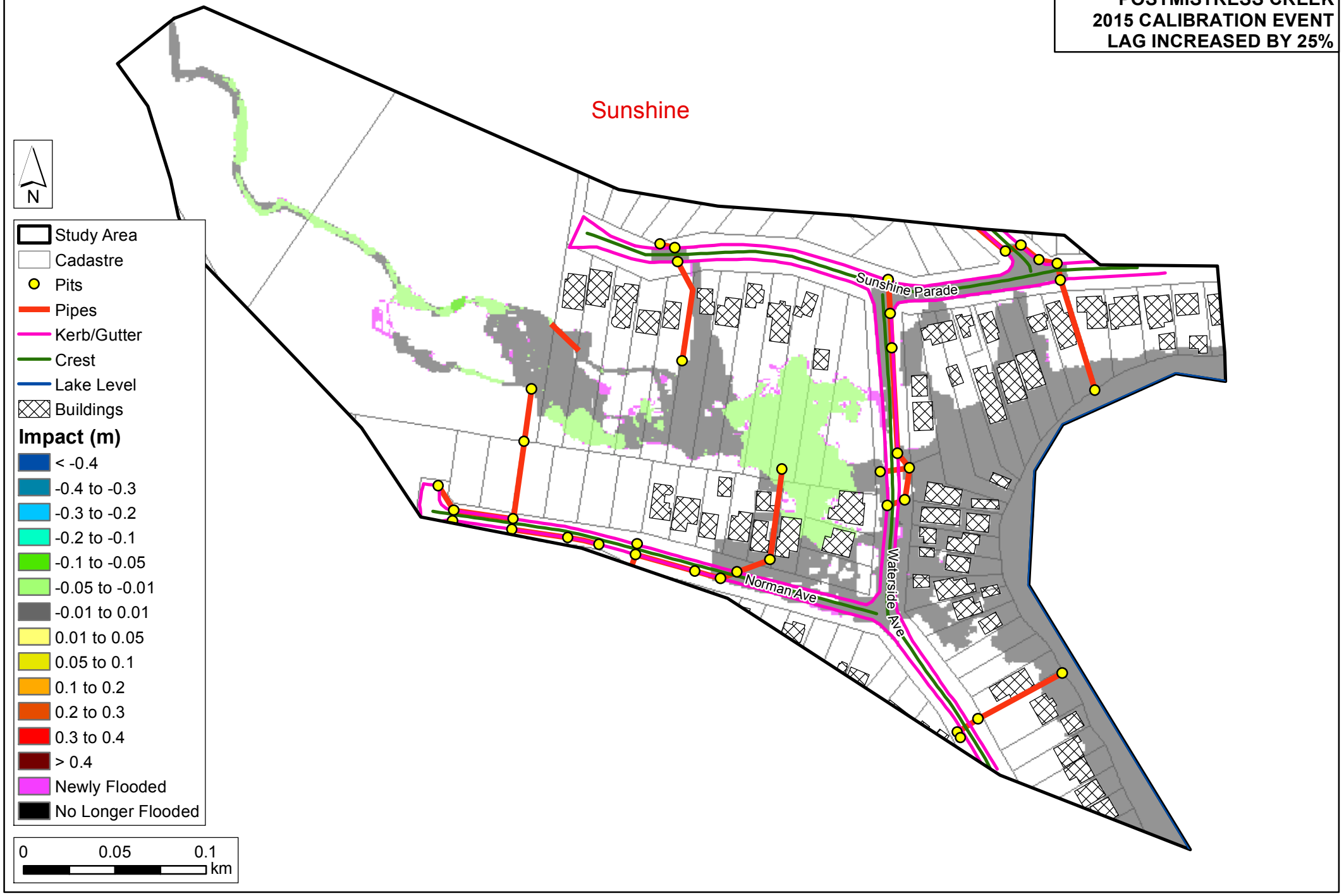

J:\Jobs\119076\ArcGIS\ArcMap\Report\AppendixB_Calibration\61to121\FigureB093_Postmistress_Creek_Impact_2015MandBa_Calibration_DX1_blo075.mxd

FIGURE B94
**POSTMISTRESS CREEK**
**2015 CALIBRATION EVENT**
**LAG DECREASED BY 25%**



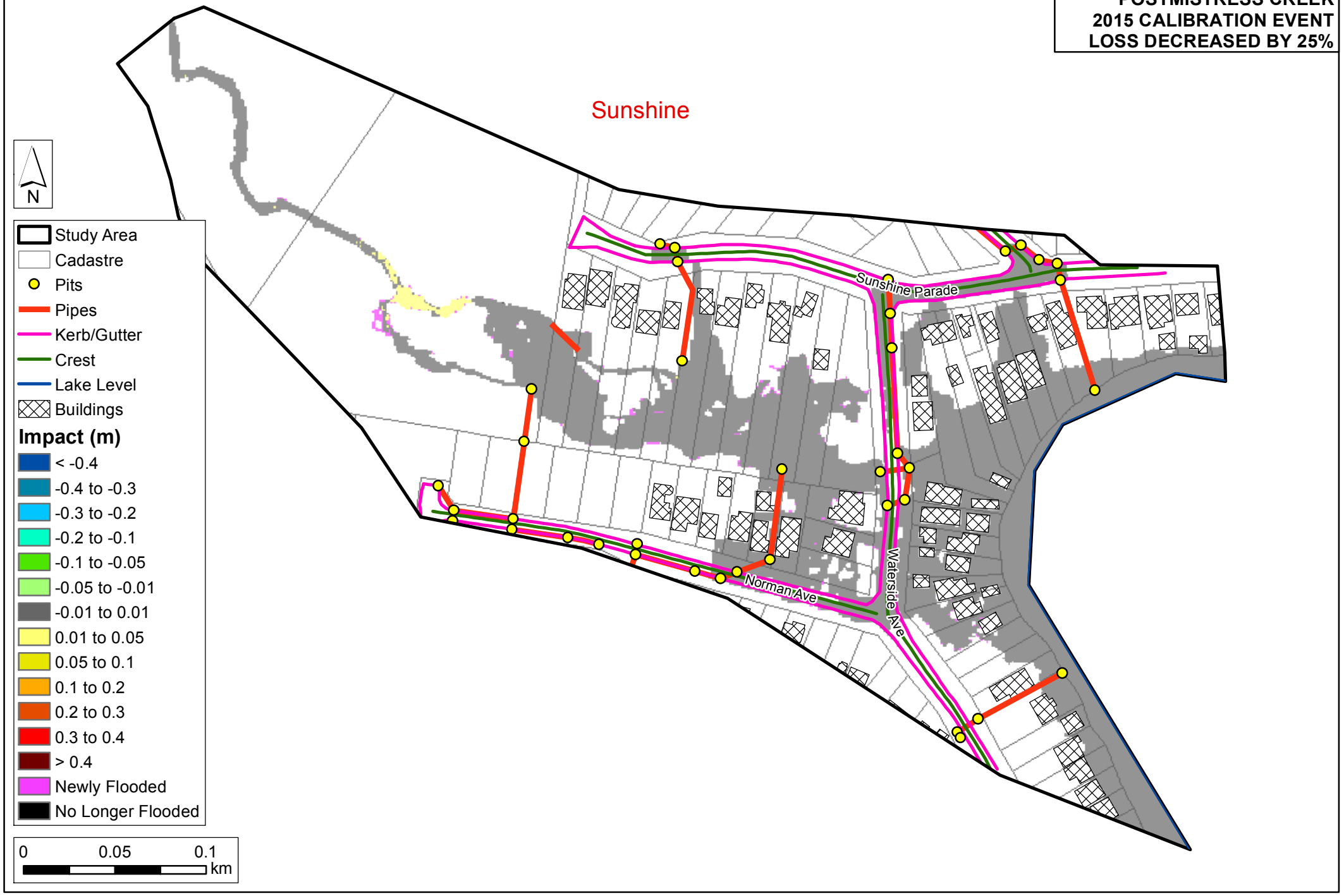

J:\Jobs\119076\ArcGIS\ArcMap\Report\AppendixB_Calibration\61to121\FigureB094_Postmistress_Creek_Impact_2015MandBa_Calibration_DX1_LagM25.mxd

FIGURE B95
**POSTMISTRESS CREEK**
**2015 CALIBRATION EVENT**
**LAG INCREASED BY 25%**



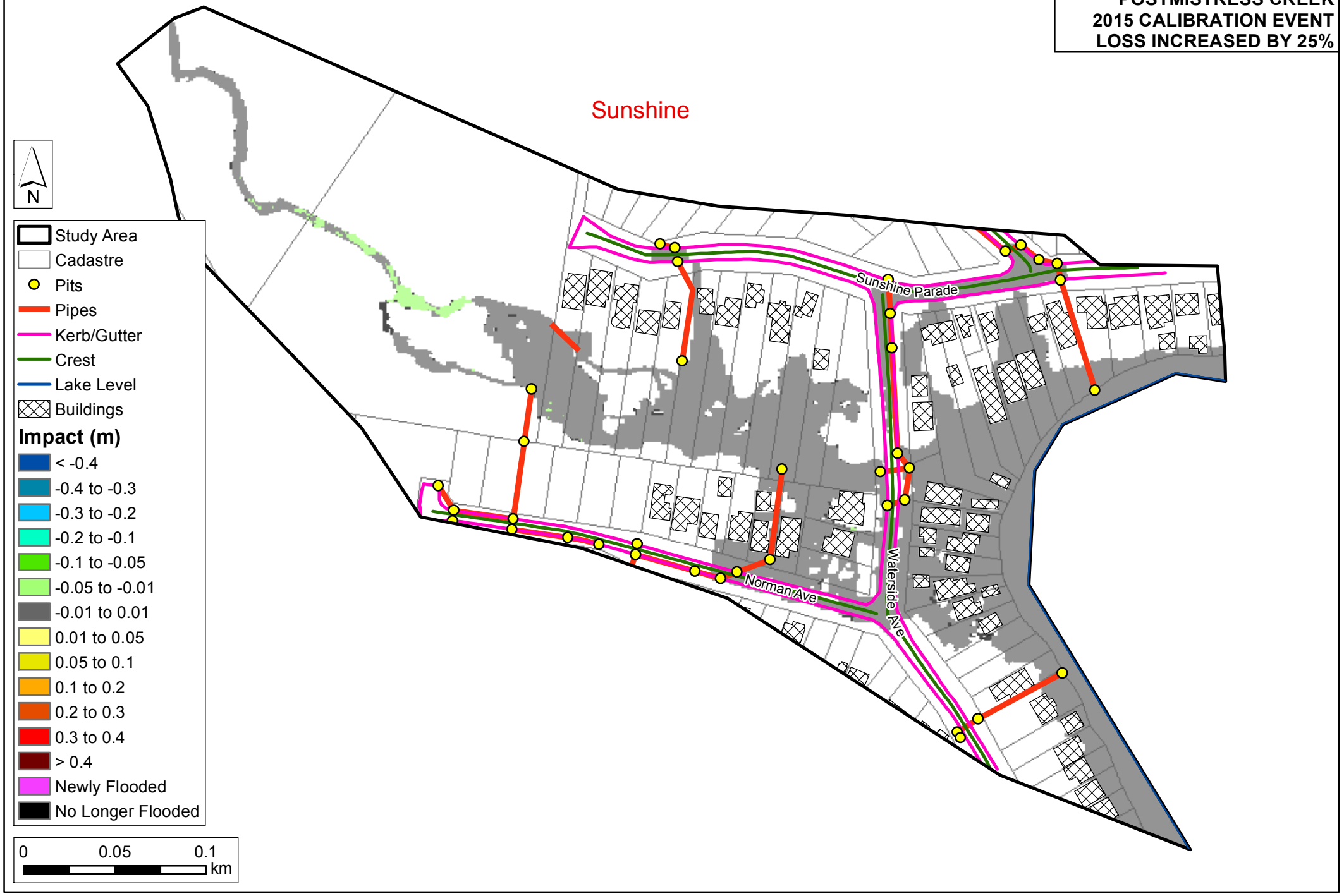

J:\Jobs\119076\ArcGIS\ArcMap\Report\AppendixB_Calibration\61to121\FigureB095_Postmistress_Creek_Impact_2015MandBa_Calibration_DX1_LagP25.mxd

FIGURE B106
**POSTMISTRESS CREEK**
**2015 CALIBRATION EVENT**
**LOSS DECREASED BY 25%**



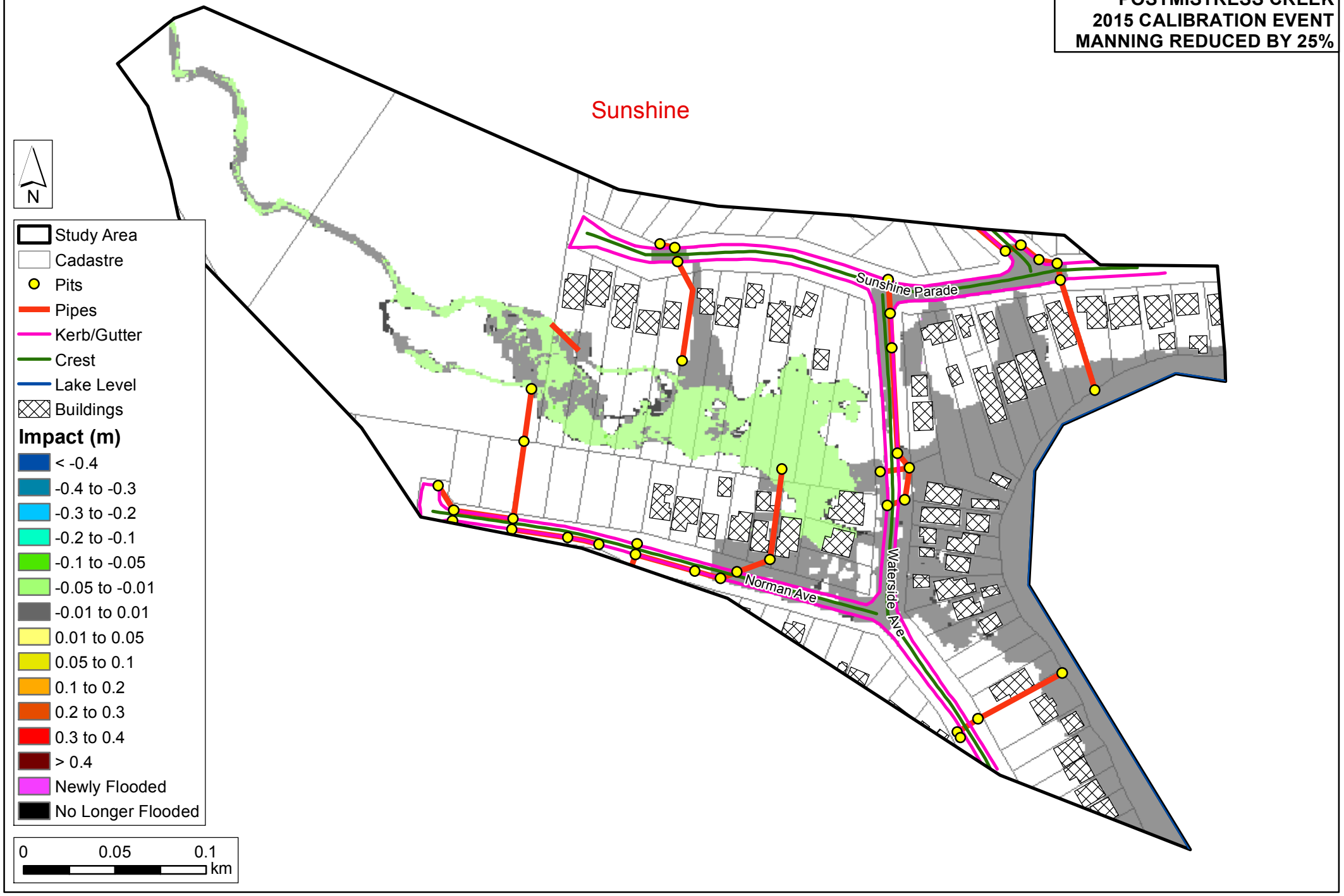

J:\Jobs\119076\ArcGIS\ArcMap\Report\AppendixB_Calibration\61to121\FigureB096_Postmistress_Creek_Impact_2015MandBa_Calibration_DX1_LossM25.mxd

FIGURE B97
**POSTMISTRESS CREEK**
**2015 CALIBRATION EVENT**
**LOSS INCREASED BY 25%**



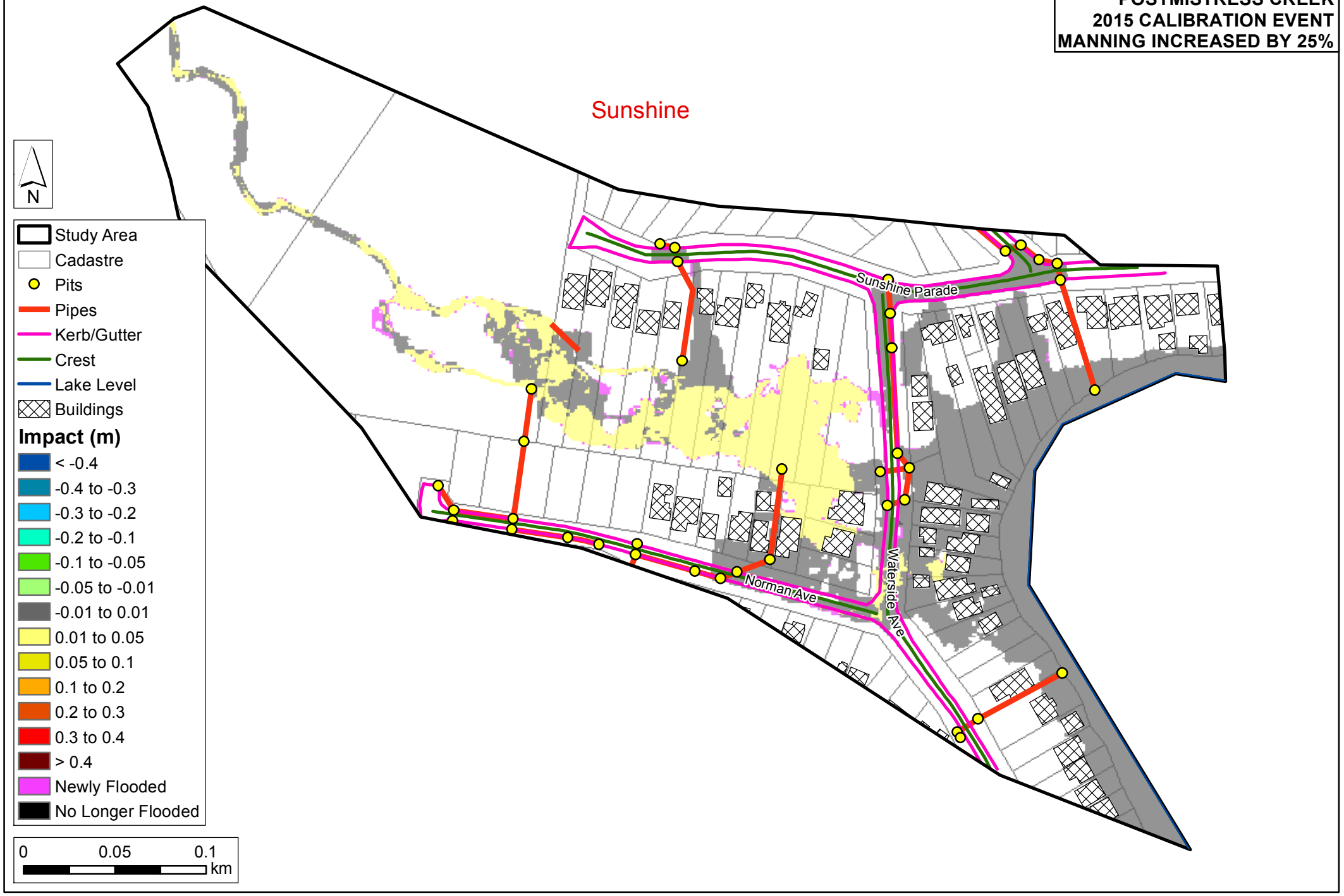

J:\Jobs\119076\ArcGIS\ArcMap\Report\AppendixB_Calibration\61to121\FigureB097_Postmistress_Creek_Impact_2015MandBa_Calibration_DX1_Lossp25.mxd

FIGURE B98
**POSTMISTRESS CREEK**
**2015 CALIBRATION EVENT**
**MANNING REDUCED BY 25%**



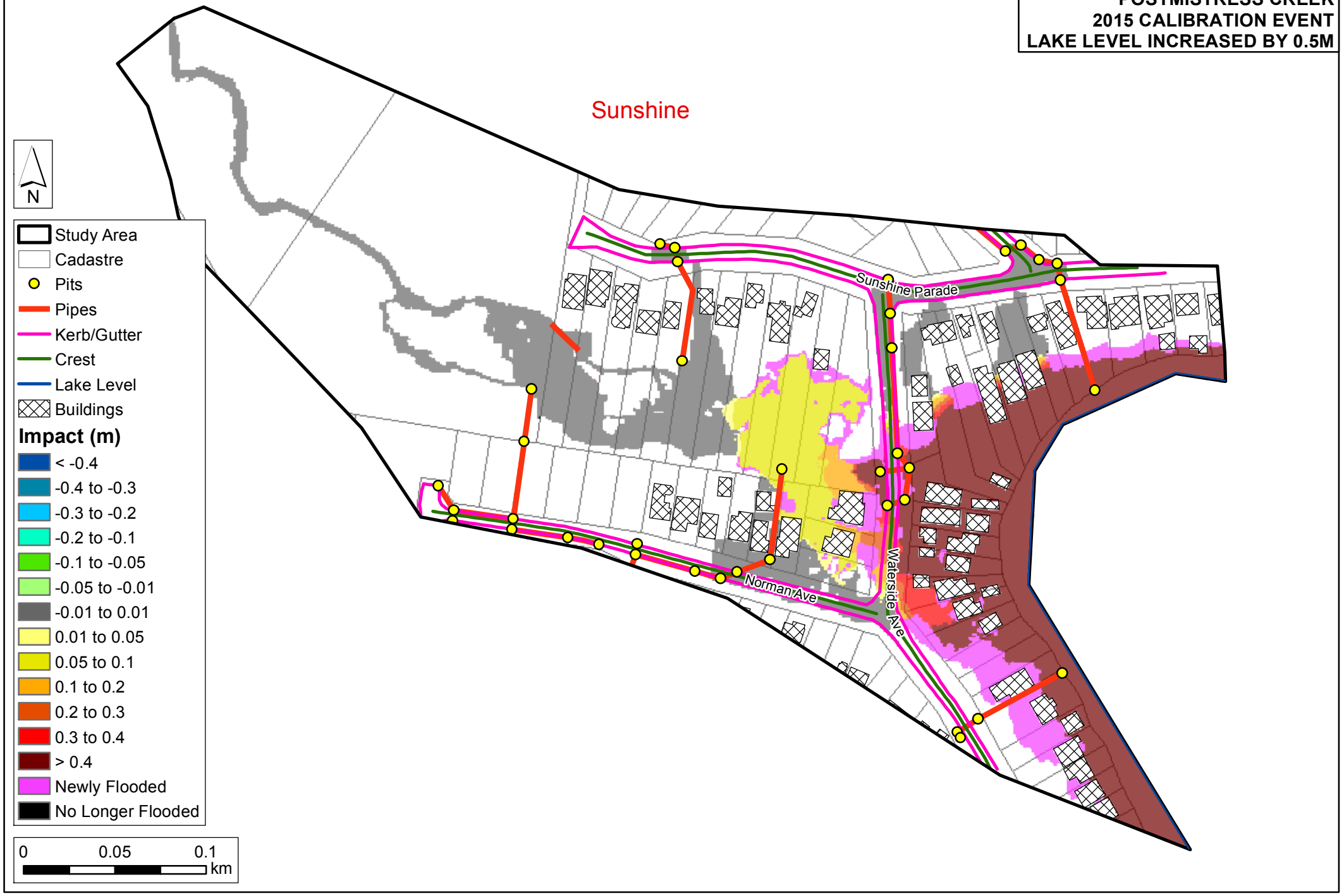

J:\Jobs\119076\ArcGIS\ArcMap\Report\AppendixB_Calibration\61to121\FigureB098_Postmistress_Creek_Impact_2015MandBa_Calibration_DX1_mann25.mxd

FIGURE B99
**POSTMISTRESS CREEK**
**2015 CALIBRATION EVENT**
**MANNING INCREASED BY 25%**




J:\Jobs\119076\ArcGIS\ArcMap\Report\AppendixB_Calibration\61to121\FigureB099_Postmistress_Creek_Impact_2015MandBa_Calibration_DX1_manp25.mxd

FIGURE B100
**POSTMISTRESS CREEK**
**2015 CALIBRATION EVENT**
**LAKE LEVEL INCREASED BY 0.5M**

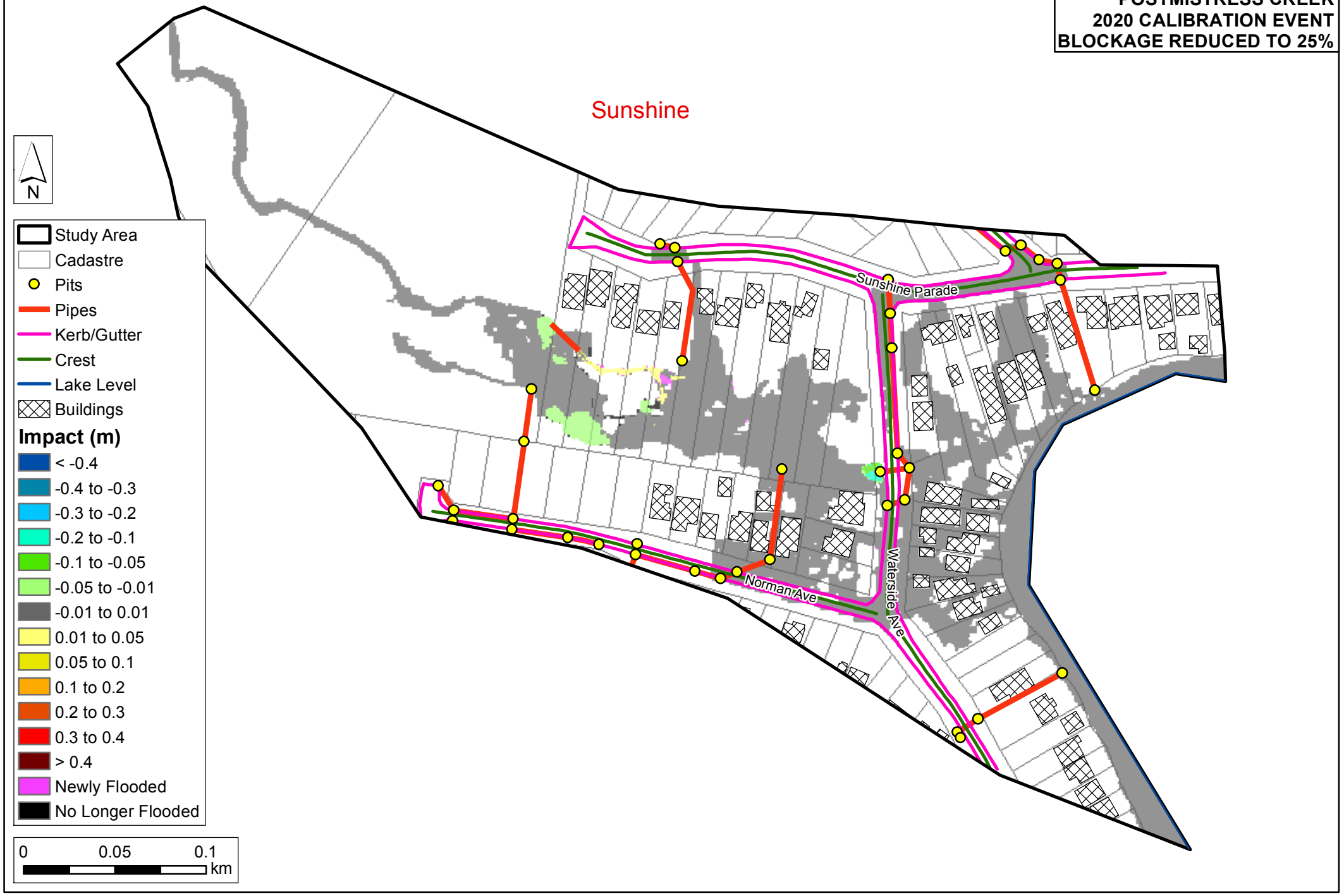



J:\Jobs\119076\ArcGIS\ArcMap\Report\AppendixB_Calibration\61to121\FigureB100_Postmistress_Creek_Impact_2015MandBa_Calibration_DX1_TWP500MM.mxd

FIGURE B101
**POSTMISTRESS CREEK**
**2015 CALIBRATION EVENT**
**LAKE LEVEL DECREASED BY 0.5M**

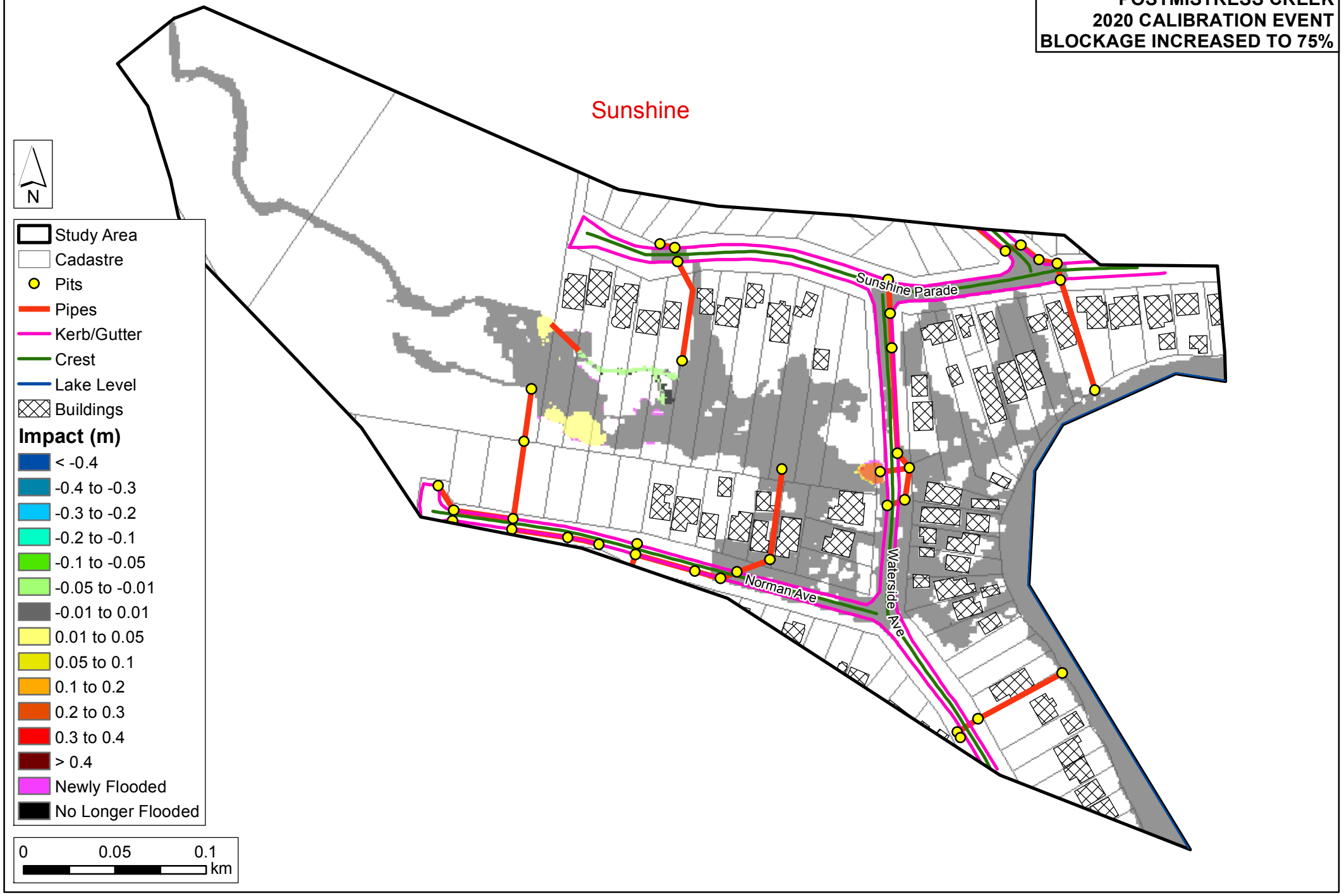
J:\Jobs\119076\ArcGIS\ArcMap\Report\AppendixB_Calibration\61to121\FigureB101_Postmistress_Creek_Impact_2015MandBa_Calibration_DX1_TWm500MM.mxd

FIGURE B102
**POSTMISTRESS CREEK**
**2020 CALIBRATION EVENT**
**BLOCKAGE REDUCED TO 25%**



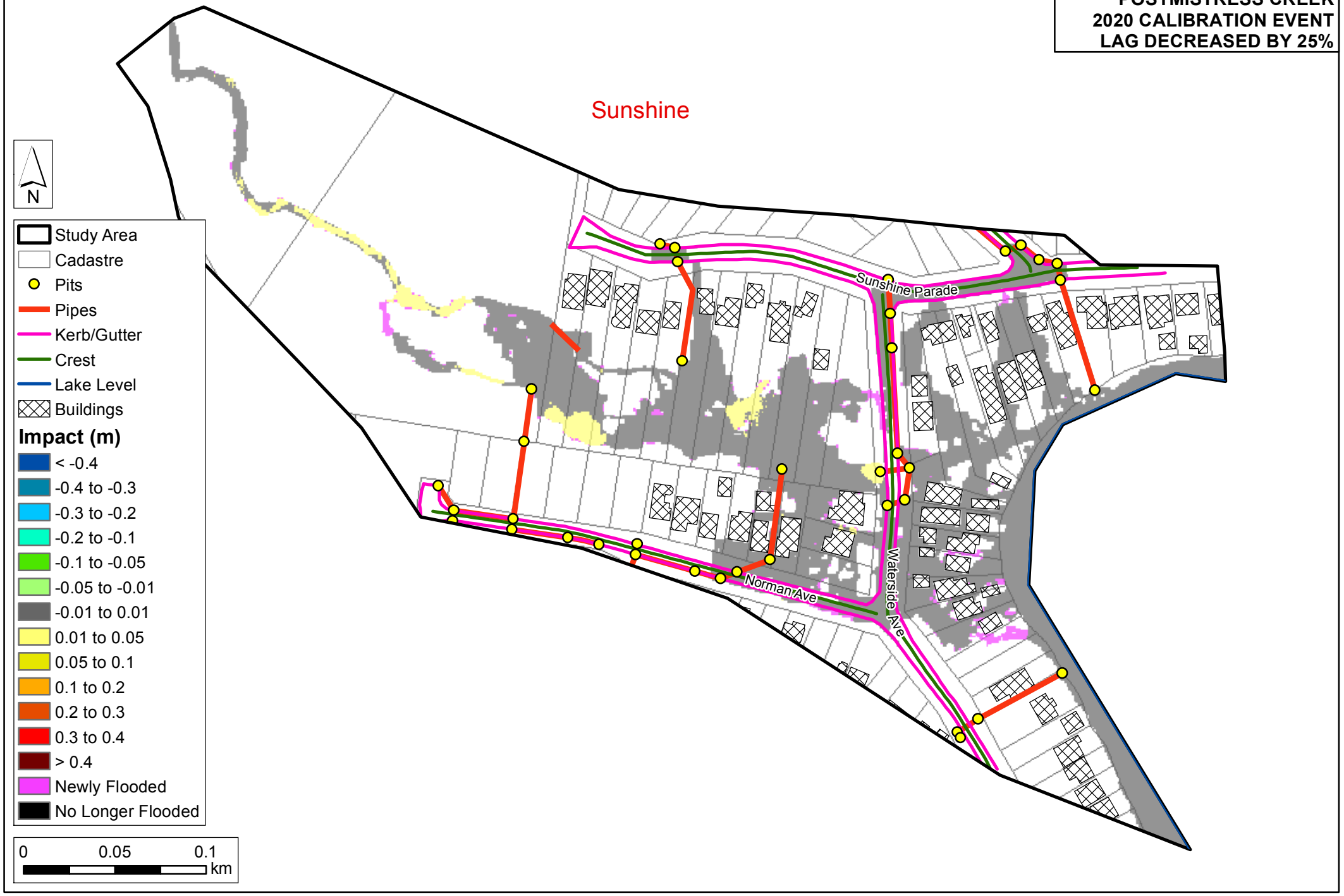

J:\Jobs\119076\ArcGIS\ArcMap\Report\AppendixB_Calibration\61to121\FigureB102_Postmistress_Creek_Impact_2020MandBa_Calibration_DX1_blo025.mxd

FIGURE B103
**POSTMISTRESS CREEK**
**2020 CALIBRATION EVENT**
**BLOCKAGE INCREASED TO 75%**



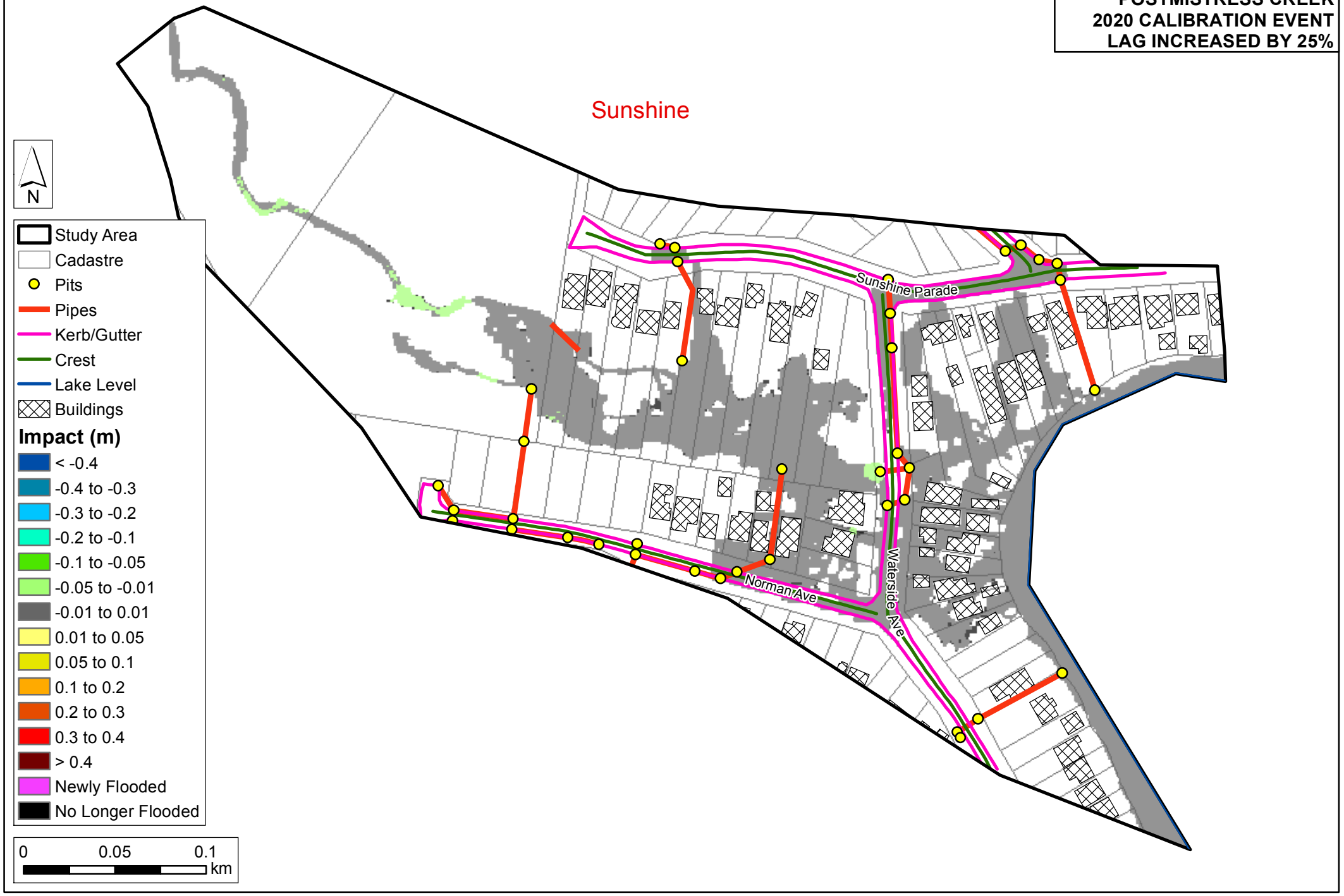

J:\Jobs\119076\ArcGIS\ArcMap\Report\AppendixB_Calibration\61to121\FigureB103_Postmistress_Creek_Impact_2020MandBa_Calibration_DX1_blo075.mxd

FIGURE B104
**POSTMISTRESS CREEK**
**2020 CALIBRATION EVENT**
**LAG DECREASED BY 25%**



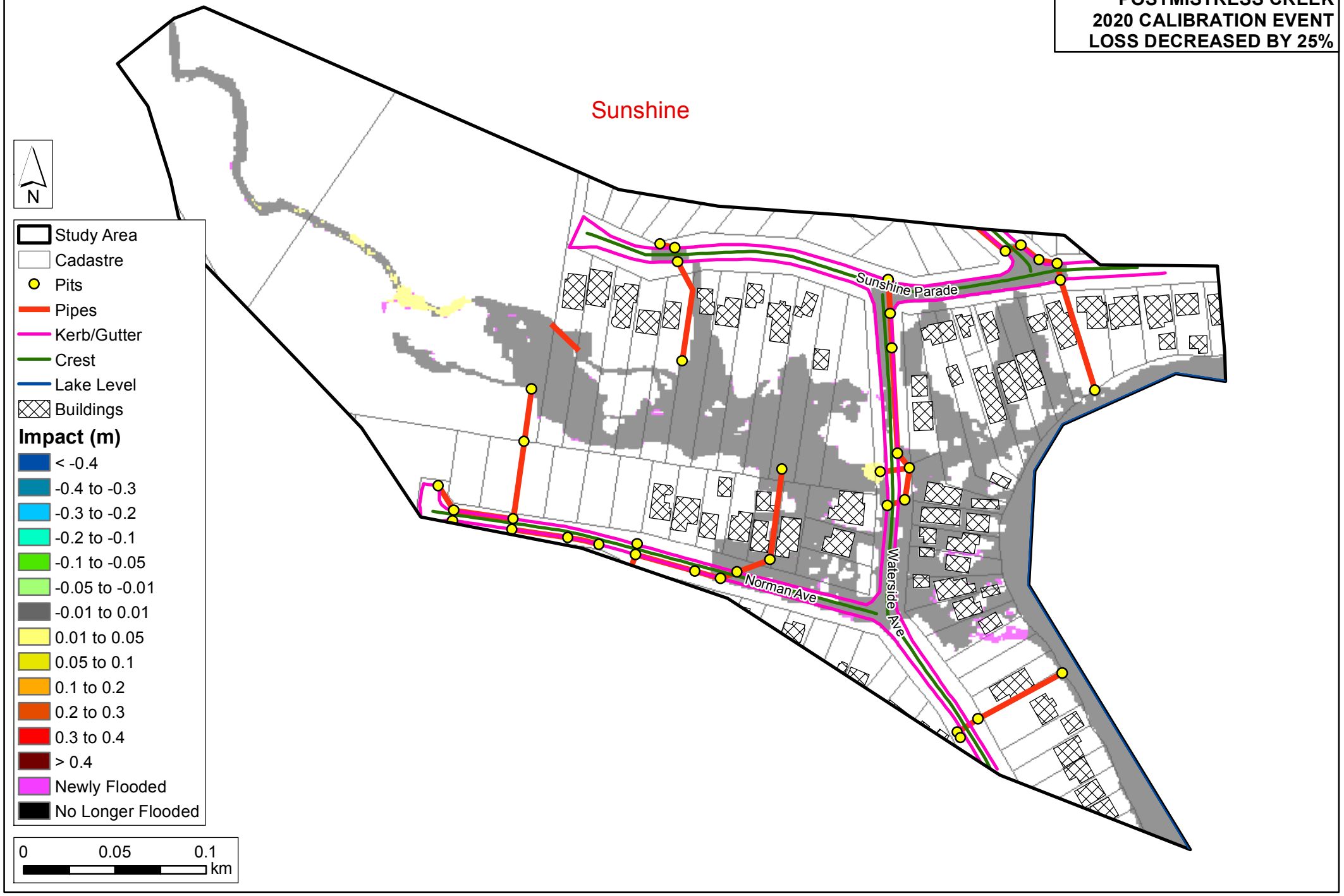

J:\Jobs\119076\ArcGIS\ArcMap\Report\AppendixB_Calibration\61to121\FigureB104_Postmistress_Creek_Impact_2020MandBa_Calibration_DX1_LagM25.mxd

FIGURE B105
**POSTMISTRESS CREEK**
**2020 CALIBRATION EVENT**
**LAG INCREASED BY 25%**



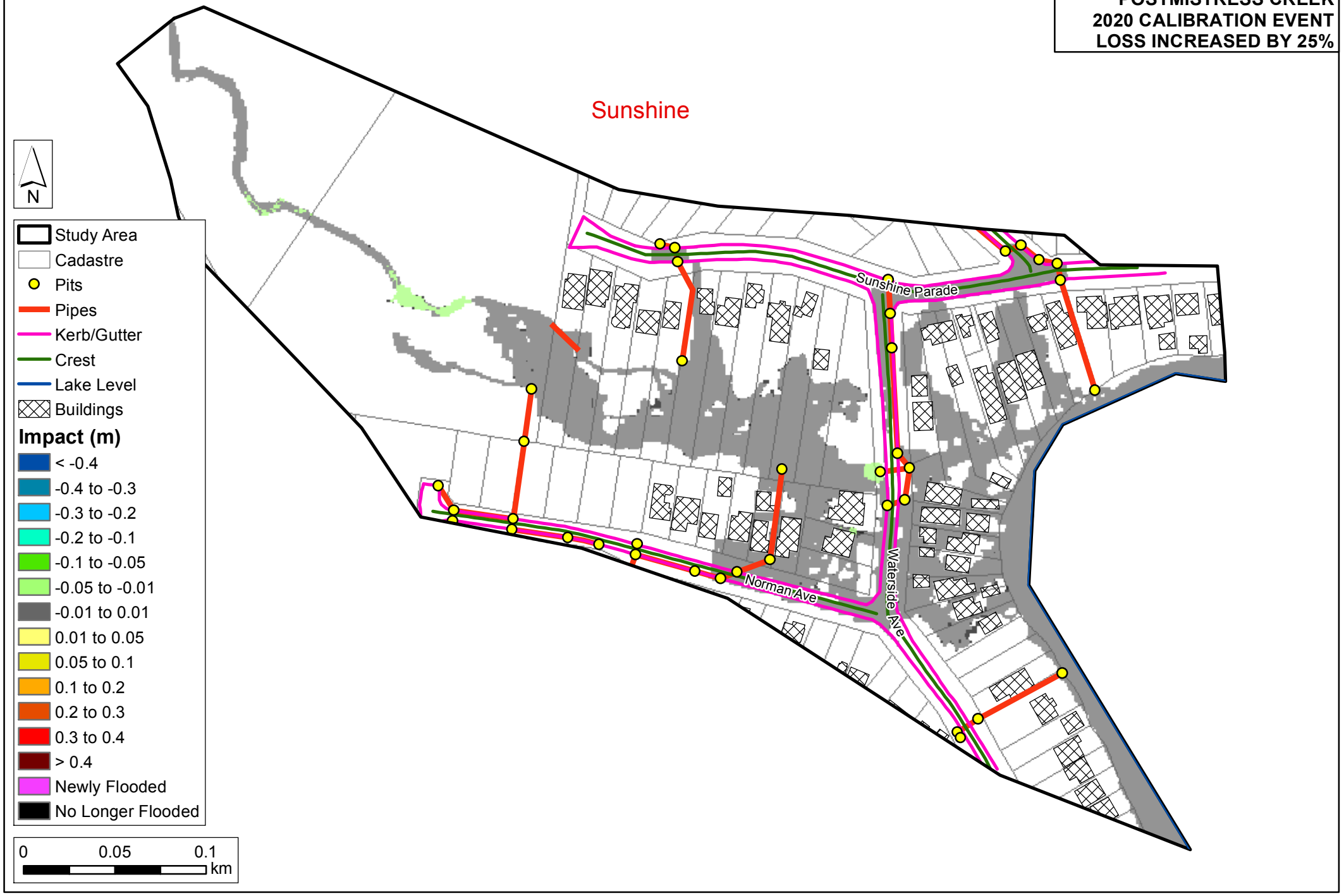

J:\Jobs\119076\ArcGIS\ArcMap\Report\AppendixB_Calibration\61to121\FigureB105_Postmistress_Creek_Impact_2020MandBa_Calibration_DX1_LagP25.mxd

FIGURE B106
**POSTMISTRESS CREEK**
**2020 CALIBRATION EVENT**
**LOSS DECREASED BY 25%**



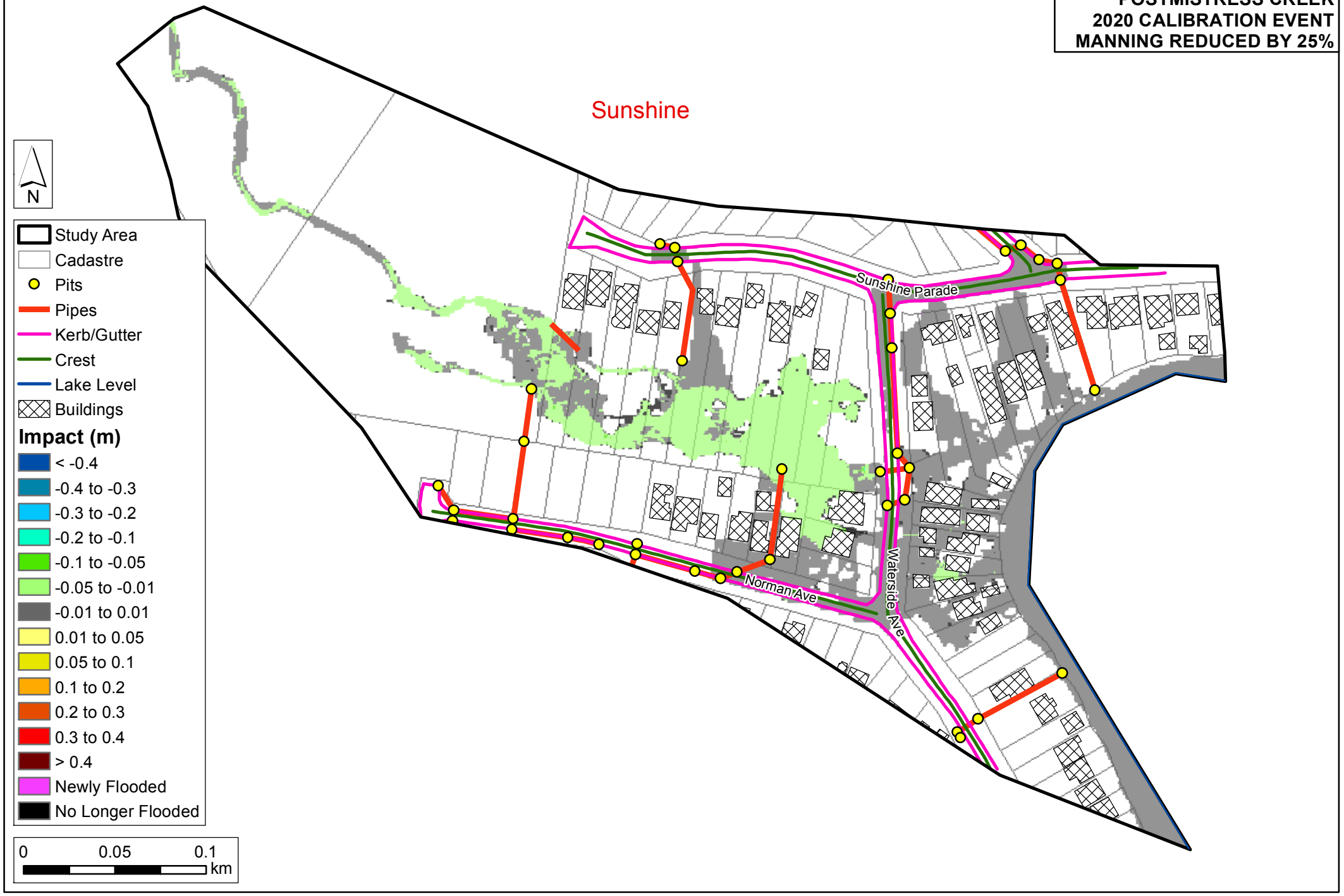

J:\Jobs\119076\ArcGIS\ArcMap\Report\AppendixB_Calibration\61to121\FigureB106_Postmistress_Creek_Impact_2020MandBa_Calibration_DX1_LossM25.mxd

FIGURE B107
**POSTMISTRESS CREEK**
**2020 CALIBRATION EVENT**
**LOSS INCREASED BY 25%**



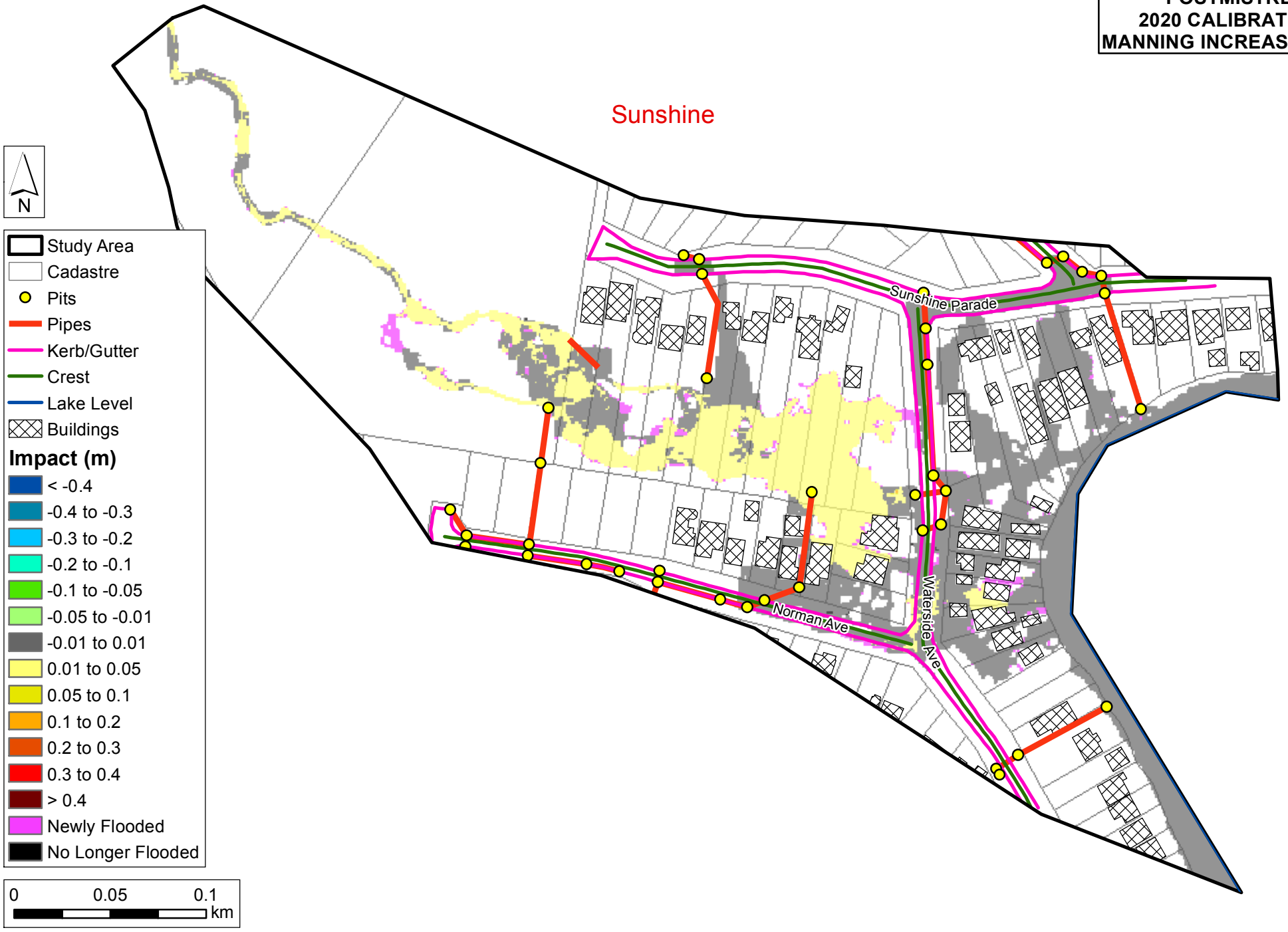

J:\Jobs\119076\ArcGIS\ArcMap\Report\AppendixB_Calibration\61to121\FigureB107_Postmistress_Creek_Impact_2020MandBa_Calibration_DX1_Lossp25.mxd

FIGURE B108
**POSTMISTRESS CREEK**
**2020 CALIBRATION EVENT**
**MANNING REDUCED BY 25%**




J:\Jobs\119076\ArcGIS\ArcMap\Report\AppendixB_Calibration\61to121\FigureB108_Postmistress_Creek_Impact_2020MandBa_Calibration_DX1_mann25.mxd

FIGURE B109
**POSTMISTRESS CREEK**
**2020 CALIBRATION EVENT**
**MANNING INCREASED BY 25%**

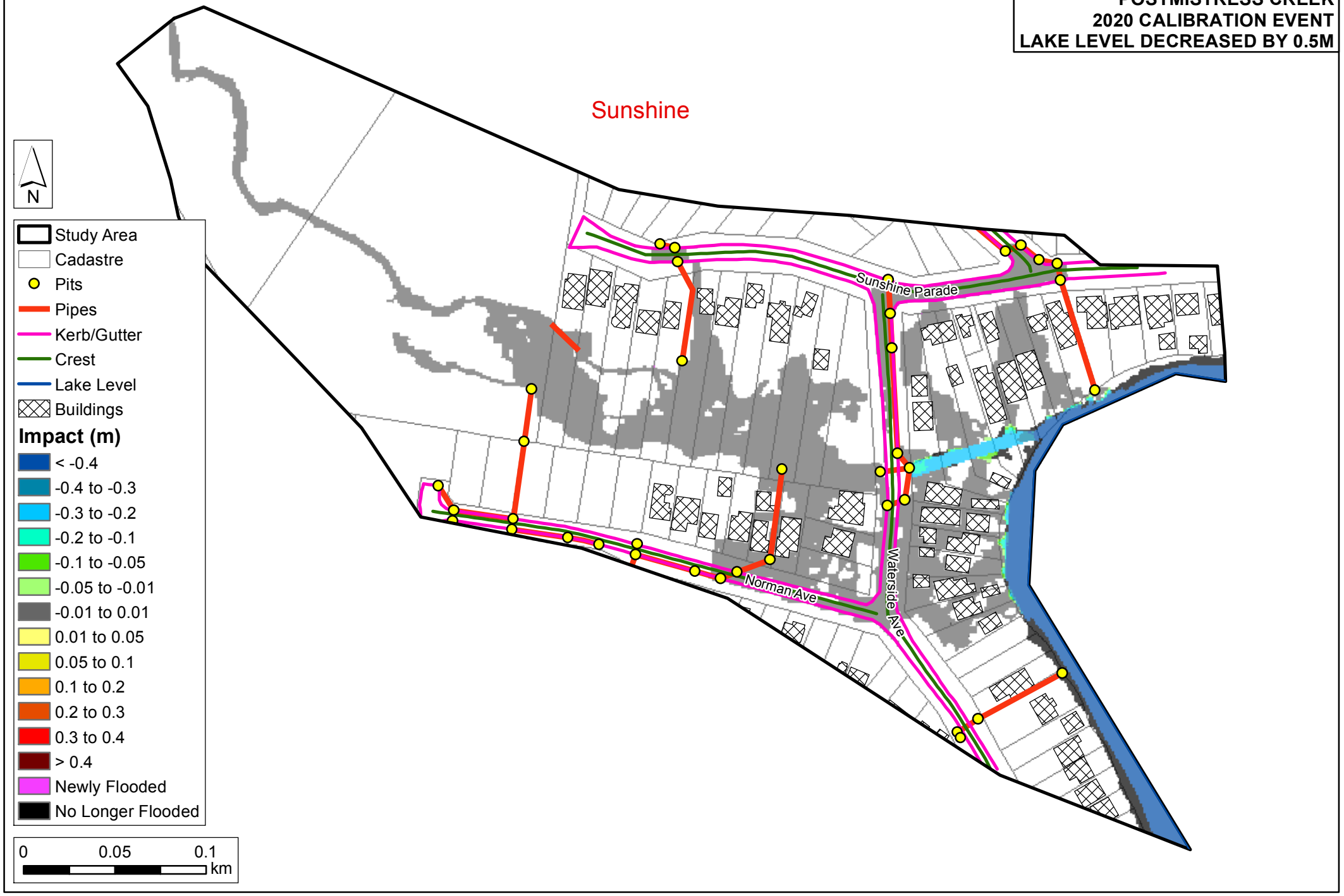



J:\Jobs\119076\ArcGIS\ArcMap\Report\AppendixB_Calibration\61to121\FigureB109_Postmistress_Creek_Impact_2020MandBa_Calibration_DX1_manp25.mxd

FIGURE B110
**POSTMISTRESS CREEK**
**2020 CALIBRATION EVENT**
**LAKE LEVEL INCREASED BY 0.5M**

J:\Jobs\119076\ArcGIS\ArcMap\Report\AppendixB_Calibration\61to121\FigureB110_Postmistress_Creek_Impact_2020MandBa_Calibration_DX1_TWP500MM.mxd

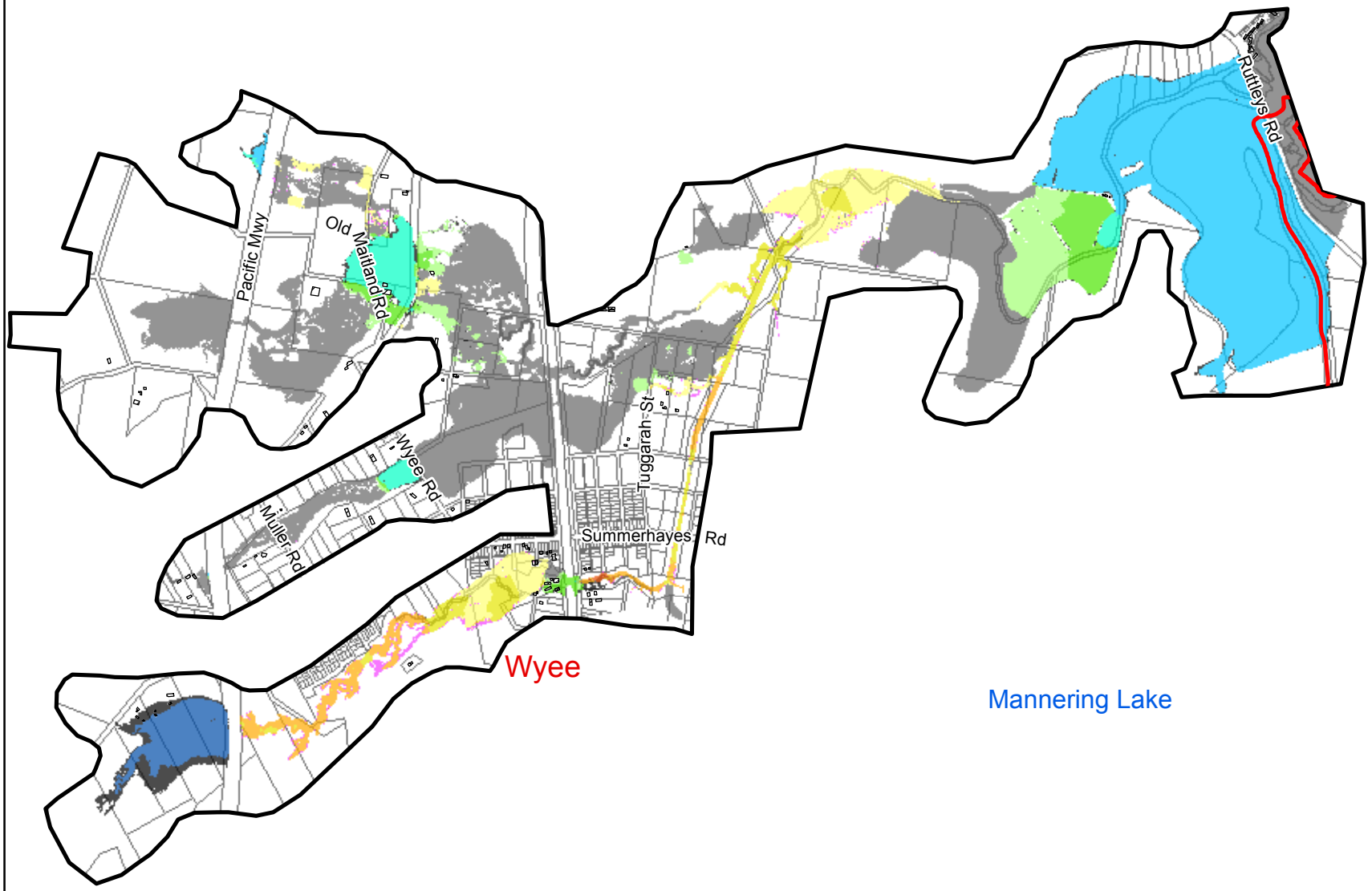
FIGURE B111
**POSTMISTRESS CREEK**
**2020 CALIBRATION EVENT**
**LAKE LEVEL DECREASED BY 0.5M**




J:\Jobs\119076\ArcGIS\ArcMap\Report\AppendixB_Calibration\61to121\FigureB111_Postmistress_Creek_Impact_2020MandBa_Calibration_DX1_TWm500MM.mxd

FIGURE B112

**MANNERING CREEK, SWAMPY CREEK AND WYEE CREEK**
**2007 CALIBRATION EVENT**
**BLOCKAGE REDUCED TO 25%**




N

Local Government Area
Study Area
Buildings
Cadastre

**Impact (m)**

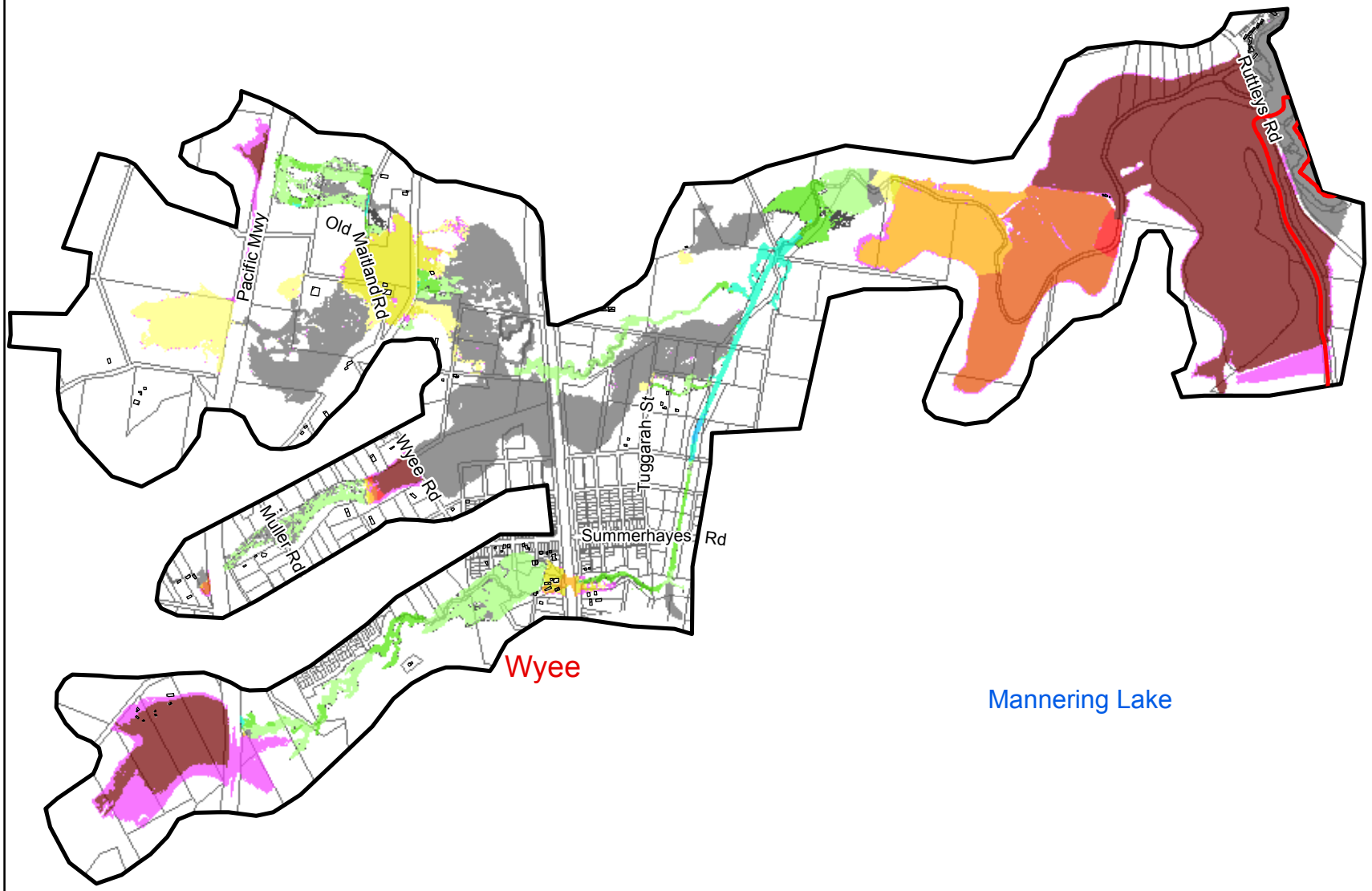
< -0.4
-0.4 to -0.3
-0.3 to -0.2
-0.2 to -0.1
-0.1 to -0.05
-0.05 to -0.01
-0.01 to 0.01
0.01 to 0.05
0.05 to 0.1
0.1 to 0.2
0.2 to 0.3
0.3 to 0.4
> 0.4
Newly Flooded
No Longer Flooded

0 1 2 km

J:\Jobs\119076\ArcGIS\ArcMap\Report\AppendixB_Calibration\61to121\FigureB112_MSWC_Impact_2007_Calibration_DX2_blo025.mxd

FIGURE B113

**MANNERING CREEK, SWAMPY CREEK AND WYEE CREEK**
**2007 CALIBRATION EVENT**
**BLOCKAGE INCREASED TO 75%**




N

- Local Government Area
- Study Area
- Buildings
- Cadastre

**Impact (m)**

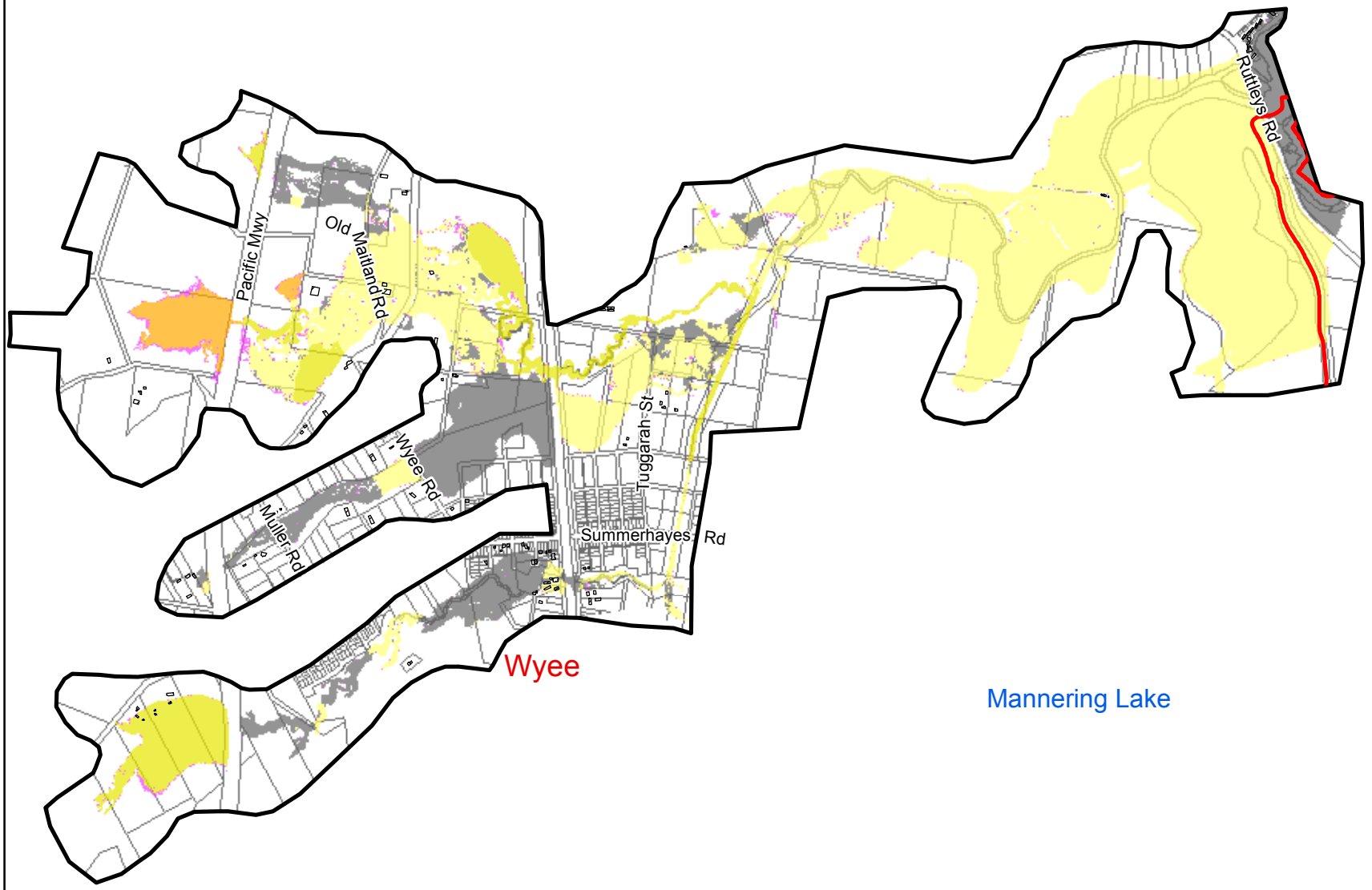
- < -0.4
- -0.4 to -0.3
- -0.3 to -0.2
- -0.2 to -0.1
- -0.1 to -0.05
- -0.05 to -0.01
- -0.01 to 0.01
- 0.01 to 0.05
- 0.05 to 0.1
- 0.1 to 0.2
- 0.2 to 0.3
- 0.3 to 0.4
- > 0.4
- Newly Flooded
- No Longer Flooded

0 1 2 km

J:\Jobs\119076\ArcGIS\ArcMap\Report\AppendixB_Calibration\61to121\FigureB113_MSWC_Impact_2007_Calibration_DX2_blo075.mxd

FIGURE B114

**MANNERING CREEK, SWAMPY CREEK AND WYEE CREEK**
**2007 CALIBRATION EVENT**
**LAG DECREASED BY 25%**




N

Local Government Area
Study Area
Buildings
Cadastre

**Impact (m)**

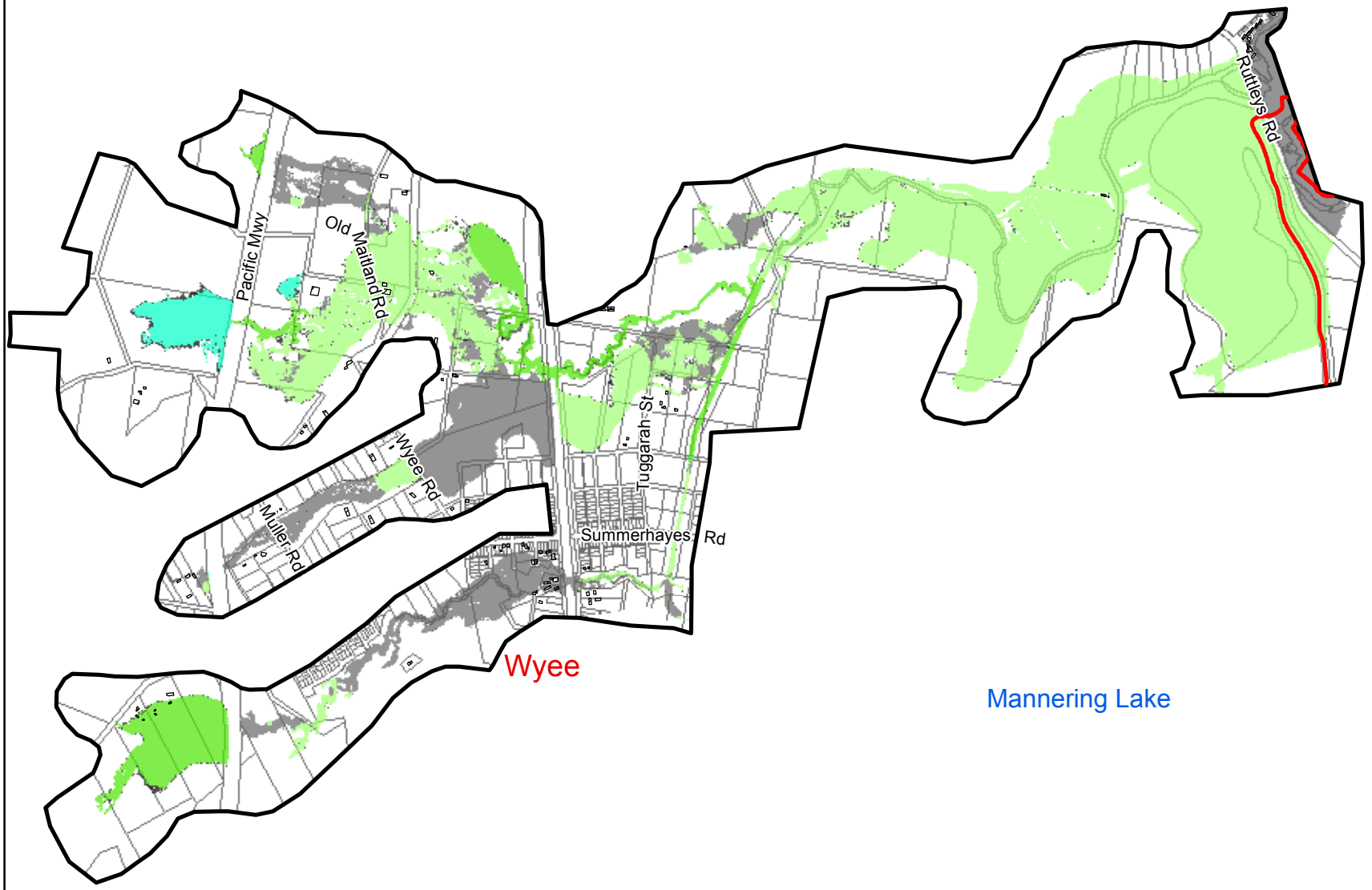
- < -0.4
- -0.4 to -0.3
- -0.3 to -0.2
- -0.2 to -0.1
- -0.1 to -0.05
- -0.05 to -0.01
- -0.01 to 0.01
- 0.01 to 0.05
- 0.05 to 0.1
- 0.1 to 0.2
- 0.2 to 0.3
- 0.3 to 0.4
- > 0.4
- Newly Flooded
- No Longer Flooded

0 1 2 km

J:\Jobs\119076\ArcGIS\ArcMap\Report\AppendixB_Calibration\61to121\FigureB114_MSWC_Impact_2007_Calibration_DX2_LagM25.mxd

FIGURE B115

**MANNERING CREEK, SWAMPY CREEK AND WYEE CREEK**
**2007 CALIBRATION EVENT**
**LAG INCREASED BY 25%**




N

Local Government Area
Study Area
Buildings
Cadastre

**Impact (m)**

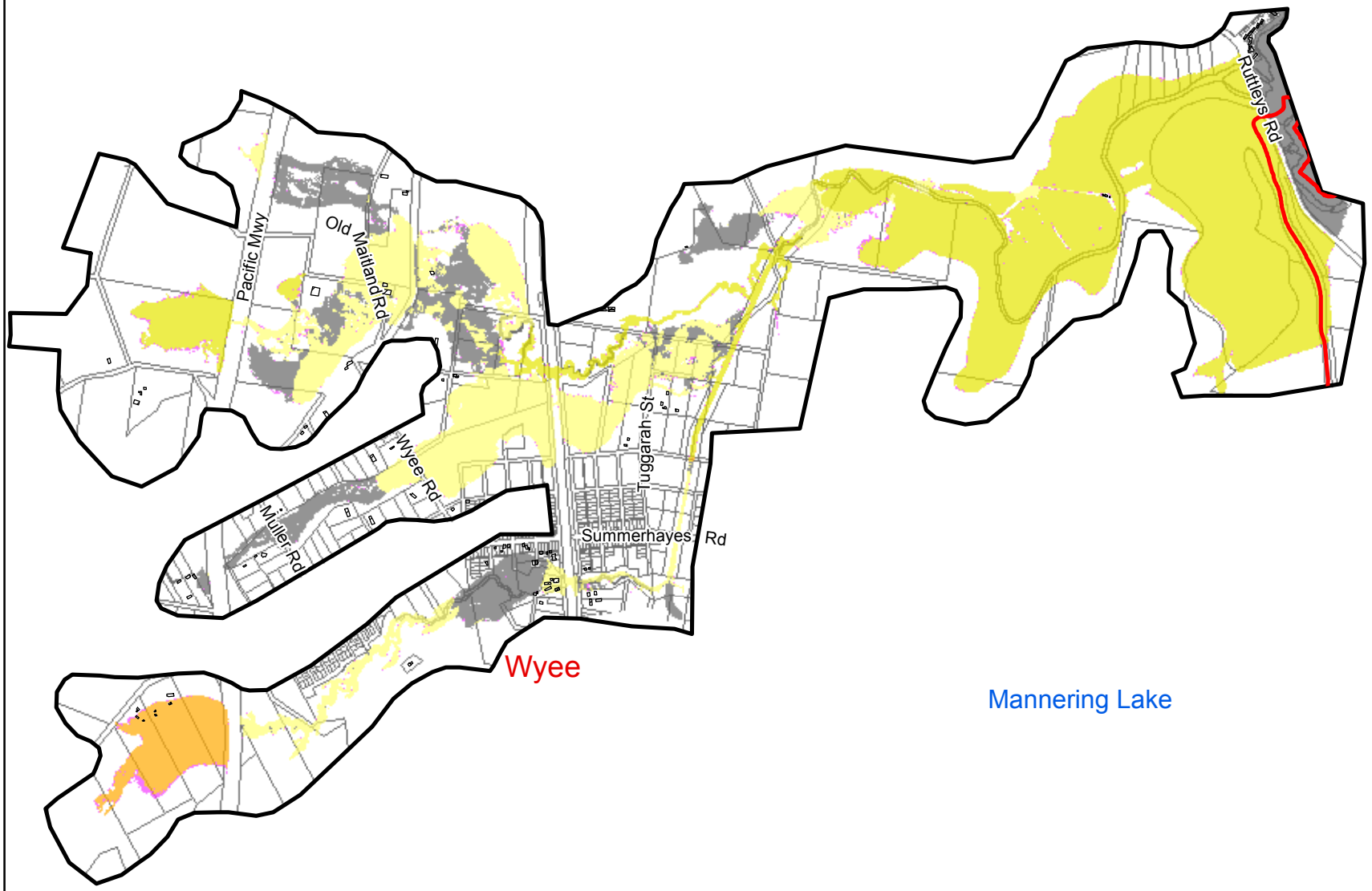
- < -0.4
- -0.4 to -0.3
- -0.3 to -0.2
- -0.2 to -0.1
- -0.1 to -0.05
- -0.05 to -0.01
- -0.01 to 0.01
- 0.01 to 0.05
- 0.05 to 0.1
- 0.1 to 0.2
- 0.2 to 0.3
- 0.3 to 0.4
- > 0.4
- Newly Flooded
- No Longer Flooded

0 1 2 km

J:\Jobs\119076\ArcGIS\ArcMap\Report\AppendixB_Calibration\61to121\FigureB115_MSWC_Impact_2007_Calibration_DX2_LagP25.mxd

FIGURE B116

**MANNERING CREEK, SWAMPY CREEK AND WYEE CREEK**
**2007 CALIBRATION EVENT**
**LOSS DECREASED BY 25%**




N

Local Government Area
Study Area
Buildings
Cadastre

**Impact (m)**

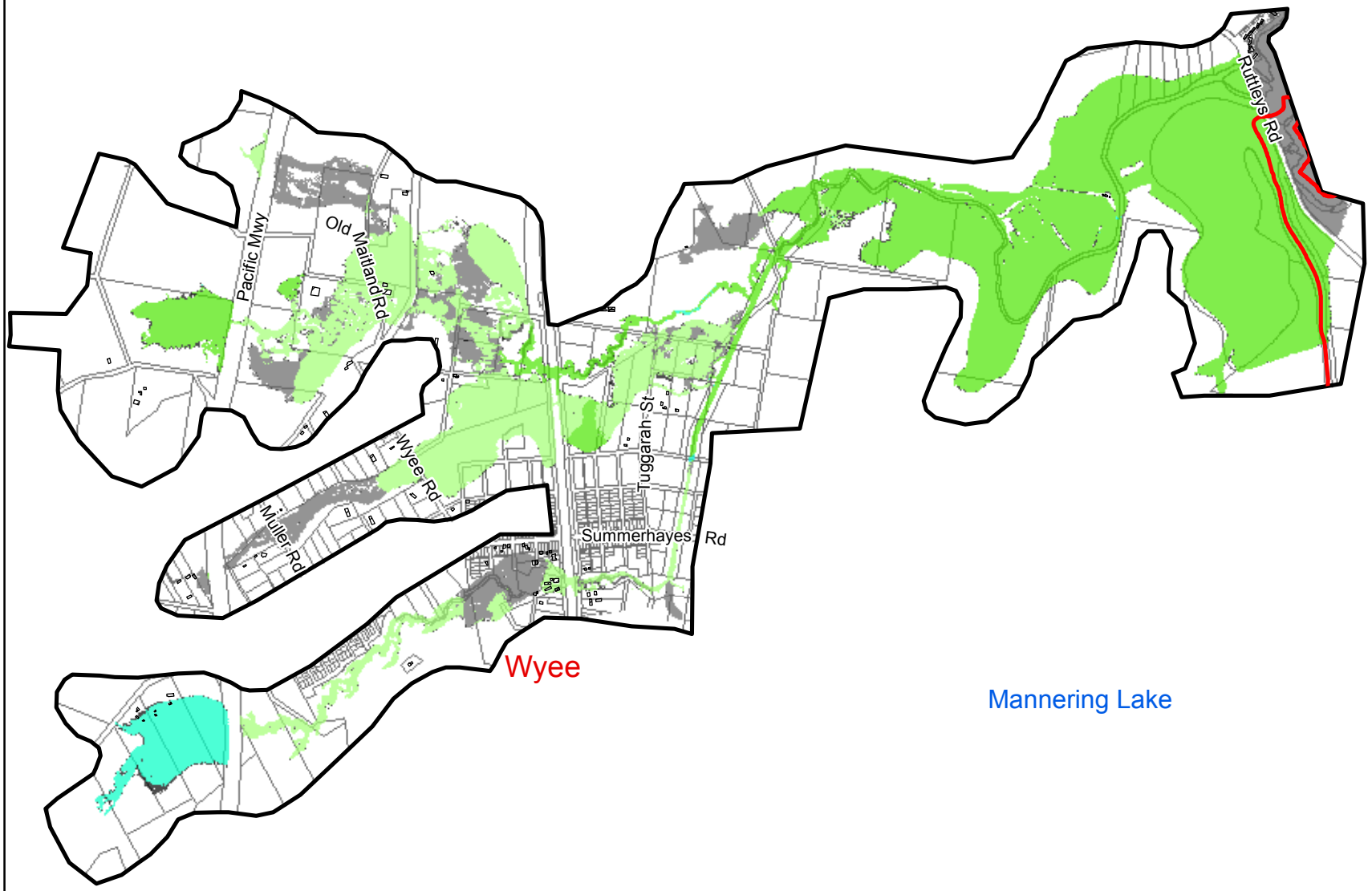
- < -0.4
- -0.4 to -0.3
- -0.3 to -0.2
- -0.2 to -0.1
- -0.1 to -0.05
- -0.05 to -0.01
- -0.01 to 0.01
- 0.01 to 0.05
- 0.05 to 0.1
- 0.1 to 0.2
- 0.2 to 0.3
- 0.3 to 0.4
- > 0.4
- Newly Flooded
- No Longer Flooded

0 1 2 km

J:\Jobs\119076\ArcGIS\ArcMap\Report\AppendixB_Calibration\61to121\FigureB116_MSWC_Impact_2007_Calibration_DX2_LossM25.mxd

FIGURE B117

**MANNERING CREEK, SWAMPY CREEK AND WYEE CREEK**
**2007 CALIBRATION EVENT**
**LOSS INCREASED BY 25%**




N

Local Government Area
Study Area
Buildings
Cadastre

**Impact (m)**

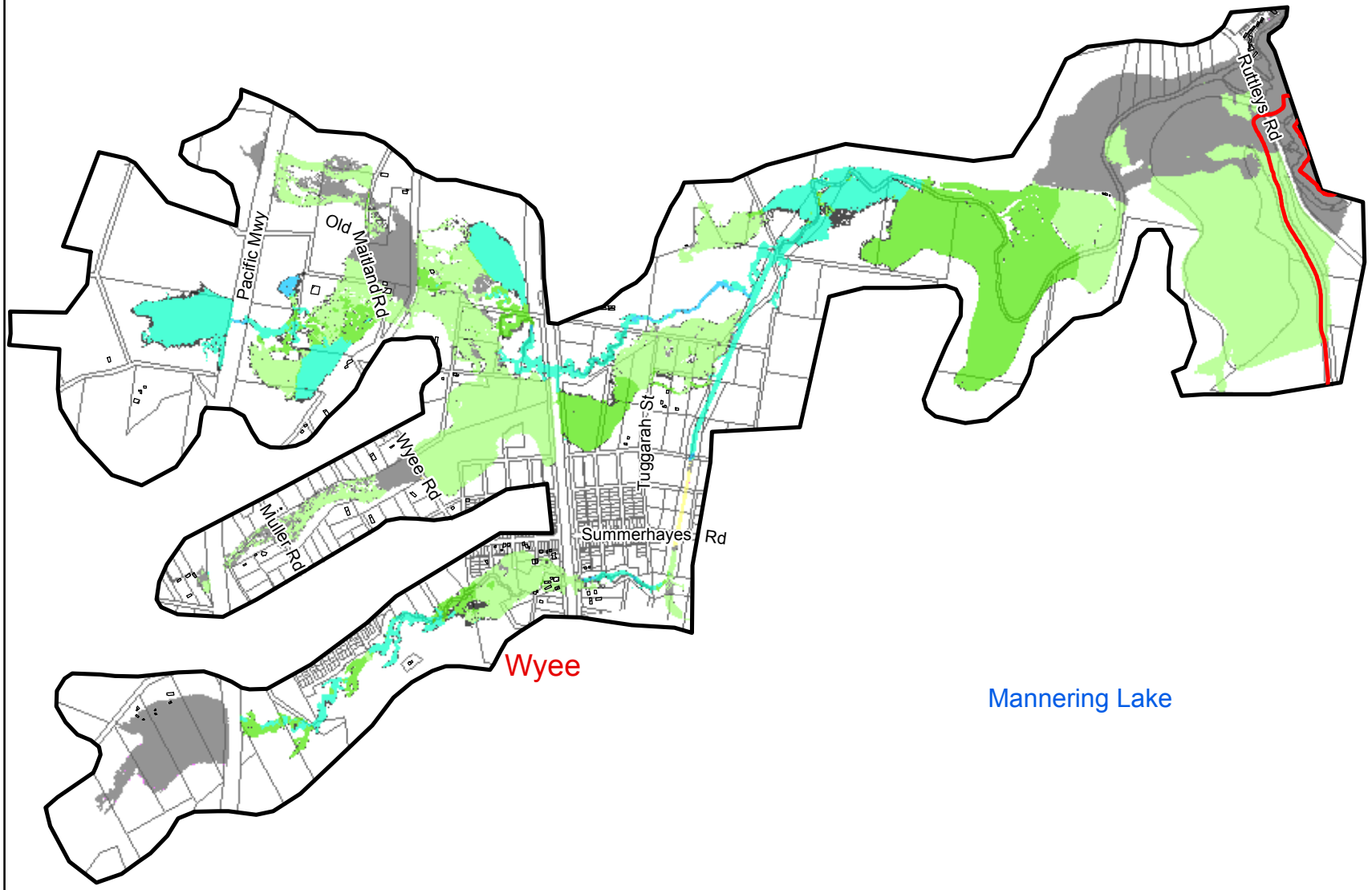
- < -0.4
- -0.4 to -0.3
- -0.3 to -0.2
- -0.2 to -0.1
- -0.1 to -0.05
- -0.05 to -0.01
- -0.01 to 0.01
- 0.01 to 0.05
- 0.05 to 0.1
- 0.1 to 0.2
- 0.2 to 0.3
- 0.3 to 0.4
- > 0.4
- Newly Flooded
- No Longer Flooded

0 1 2 km

J:\Jobs\119076\ArcGIS\ArcMap\Report\AppendixB_Calibration\61to121\FigureB117_MSWC_Impact_2007_Calibration_DX2_LossP25.mxd

FIGURE B118

**MANNERING CREEK, SWAMPY CREEK AND WYEE CREEK**
**2007 CALIBRATION EVENT**
**MANNING REDUCED BY 25%**




N

Local Government Area
Study Area
Buildings
Cadastre

**Impact (m)**

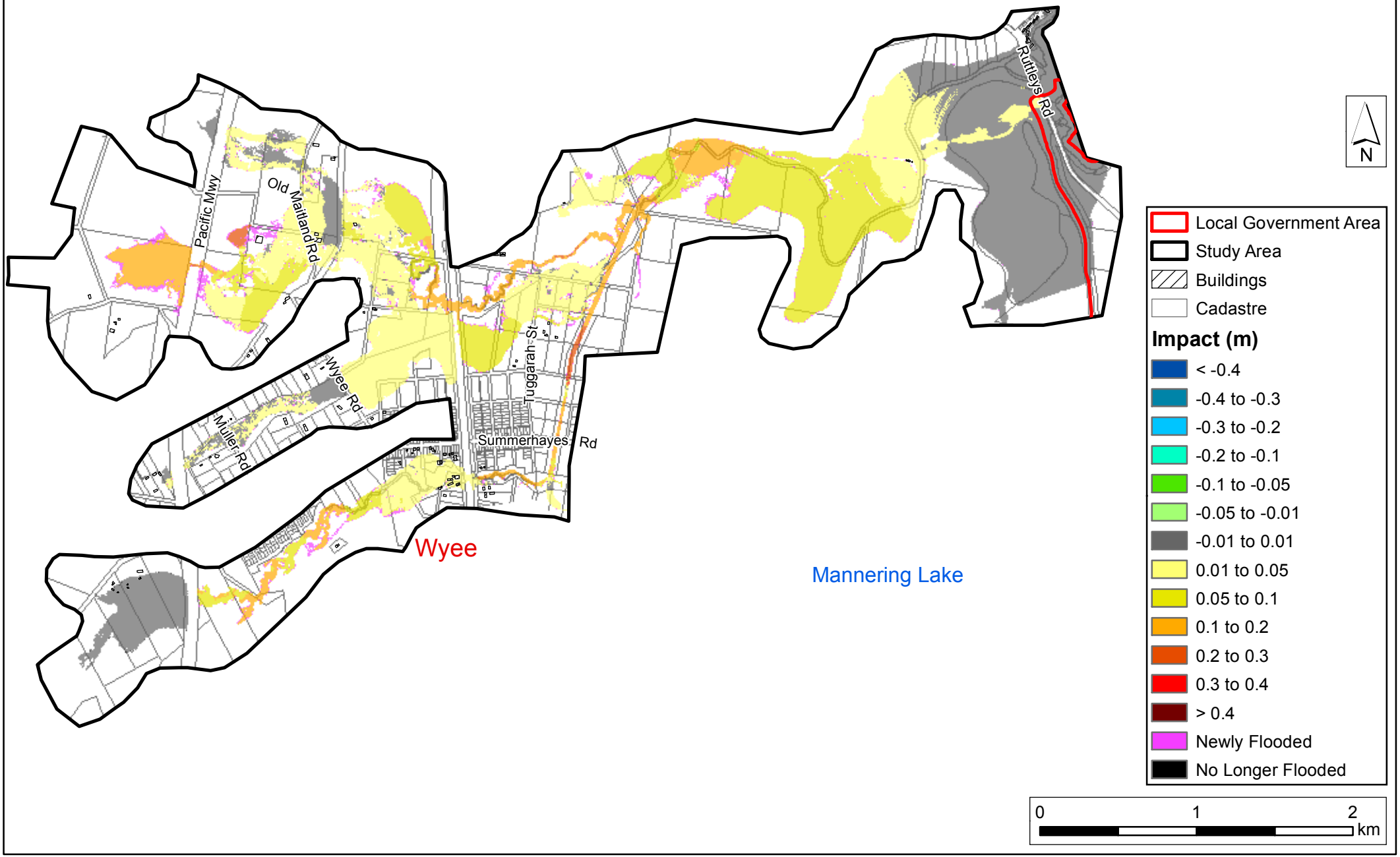
- < -0.4
- -0.4 to -0.3
- -0.3 to -0.2
- -0.2 to -0.1
- -0.1 to -0.05
- -0.05 to -0.01
- -0.01 to 0.01
- 0.01 to 0.05
- 0.05 to 0.1
- 0.1 to 0.2
- 0.2 to 0.3
- 0.3 to 0.4
- > 0.4
- Newly Flooded
- No Longer Flooded

0 1 2 km

J:\Jobs\119076\ArcGIS\ArcMap\Report\AppendixB_Calibration\61to121\FigureB118_MSWC_Impact_2007_Calibration_DX2_mann25.mxd

FIGURE B119

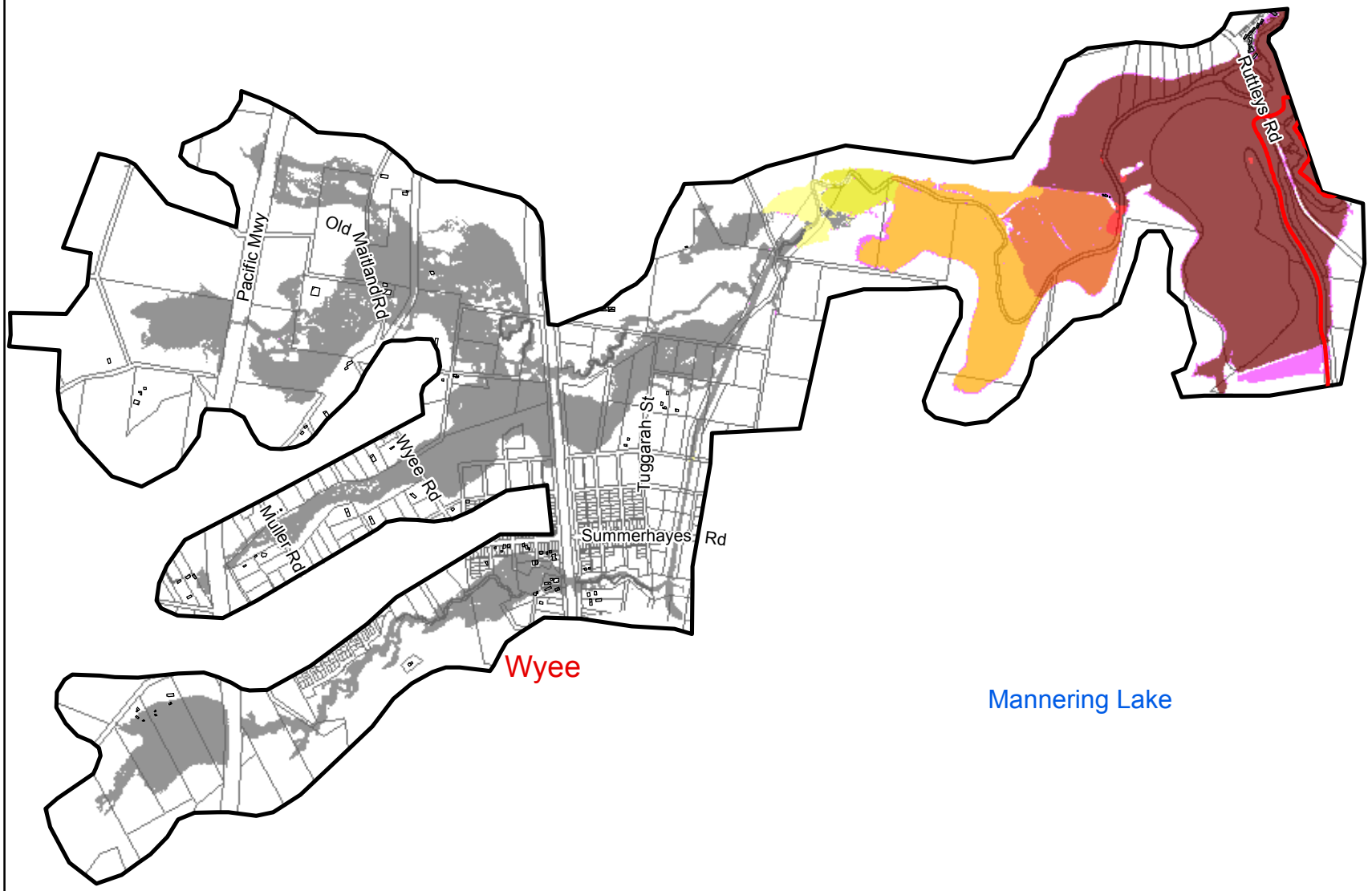
**MANNERING CREEK, SWAMPY CREEK AND WYEE CREEK**
**2007 CALIBRATION EVENT**
**MANNING INCREASED BY 25%**




J:\Jobs\119076\ArcGIS\ArcMap\Report\AppendixB_Calibration\61to121\FigureB119_MSWC_Impact_2007_Calibration_DX2_manP25.mxd

FIGURE B120

**MANNERING CREEK, SWAMPY CREEK AND WYEE CREEK**
**2007 CALIBRATION EVENT**
**LAKE LEVEL INCREASED BY 0.5M**



- Local Government Area
- Study Area
- Buildings
- Cadastre

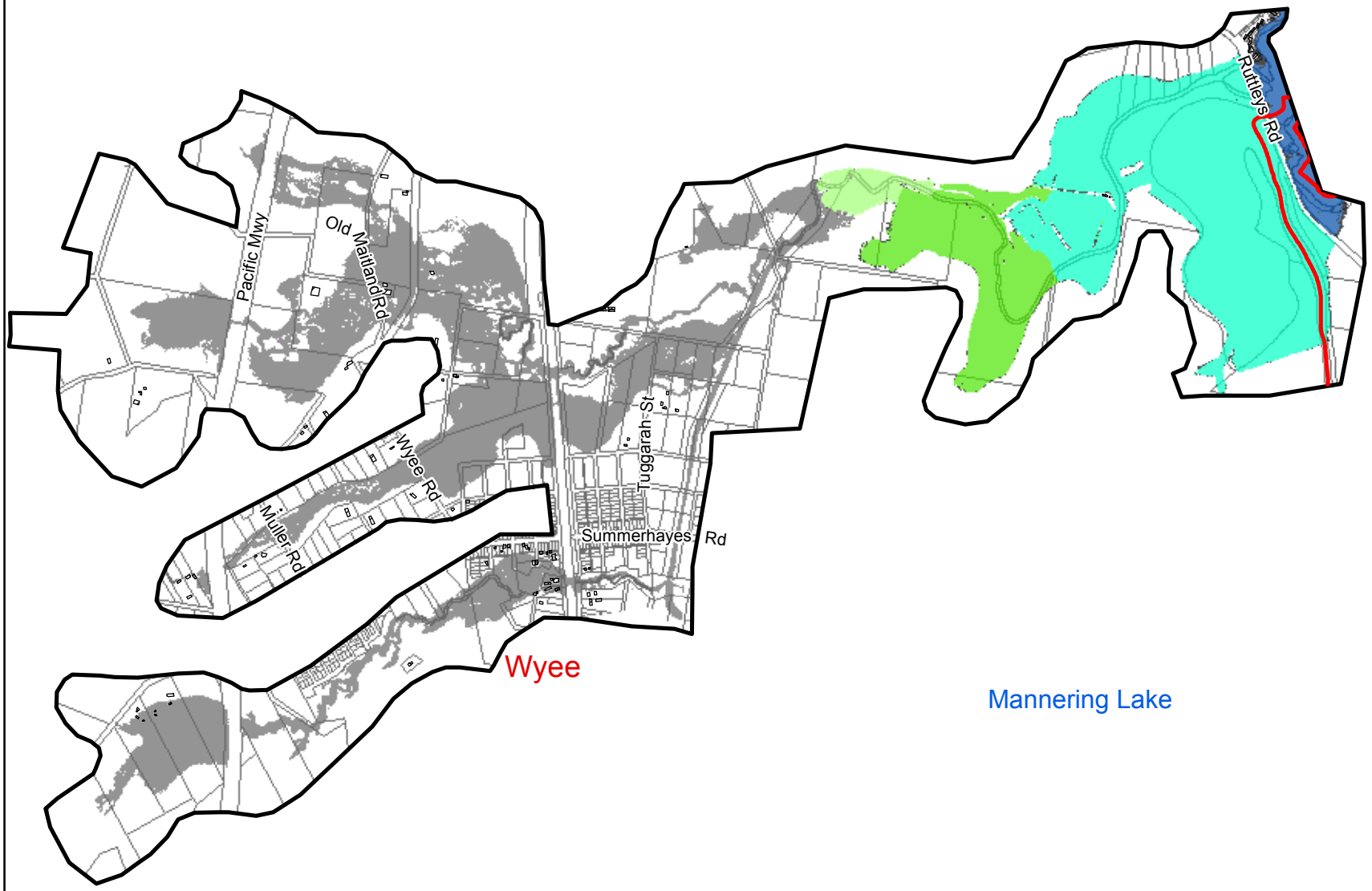
**Impact (m)**

- < -0.4
- -0.4 to -0.3
- -0.3 to -0.2
- -0.2 to -0.1
- -0.1 to -0.05
- -0.05 to -0.01
- -0.01 to 0.01
- 0.01 to 0.05
- 0.05 to 0.1
- 0.1 to 0.2
- 0.2 to 0.3
- 0.3 to 0.4
- > 0.4
- Newly Flooded
- No Longer Flooded

J:\Jobs\119076\ArcGIS\ArcMap\Report\AppendixB_Calibration\61to121\FigureB120_MSWC_Impact_2007_Calibration_DX2_TWP500MM.mxd

FIGURE B121

**MANNERING CREEK, SWAMPY CREEK AND WYEE CREEK**
**2007 CALIBRATION EVENT**
**LAKE LEVEL DECREASED BY 0.5M**



- Local Government Area
- Study Area
- Buildings
- Cadastre

**Impact (m)**

- < -0.4
- -0.4 to -0.3
- -0.3 to -0.2
- -0.2 to -0.1
- -0.1 to -0.05
- -0.05 to -0.01
- -0.01 to 0.01
- 0.01 to 0.05
- 0.05 to 0.1
- 0.1 to 0.2
- 0.2 to 0.3
- 0.3 to 0.4
- > 0.4
- Newly Flooded
- No Longer Flooded

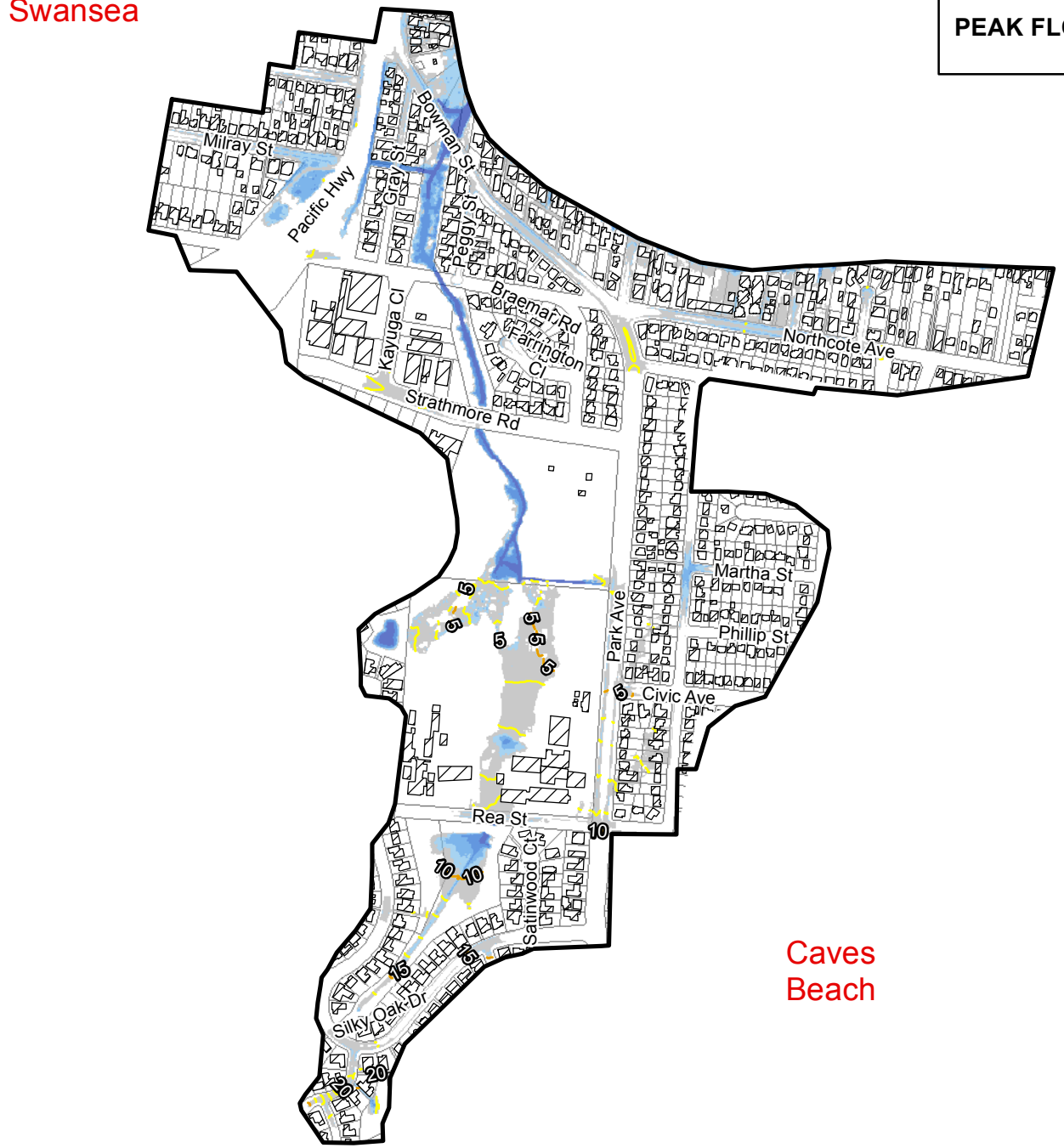
J:\Jobs\119076\ArcGIS\ArcMap\Report\AppendixB_Calibration\61to121\FigureB121_MSWC_Impact_2007_Calibration_DX2_TWm500MM.mxd

# APPENDIX C: DESIGN FLOOD MAPS – PLAINS GULLY CREEK

Appendix C

FIGURE C1

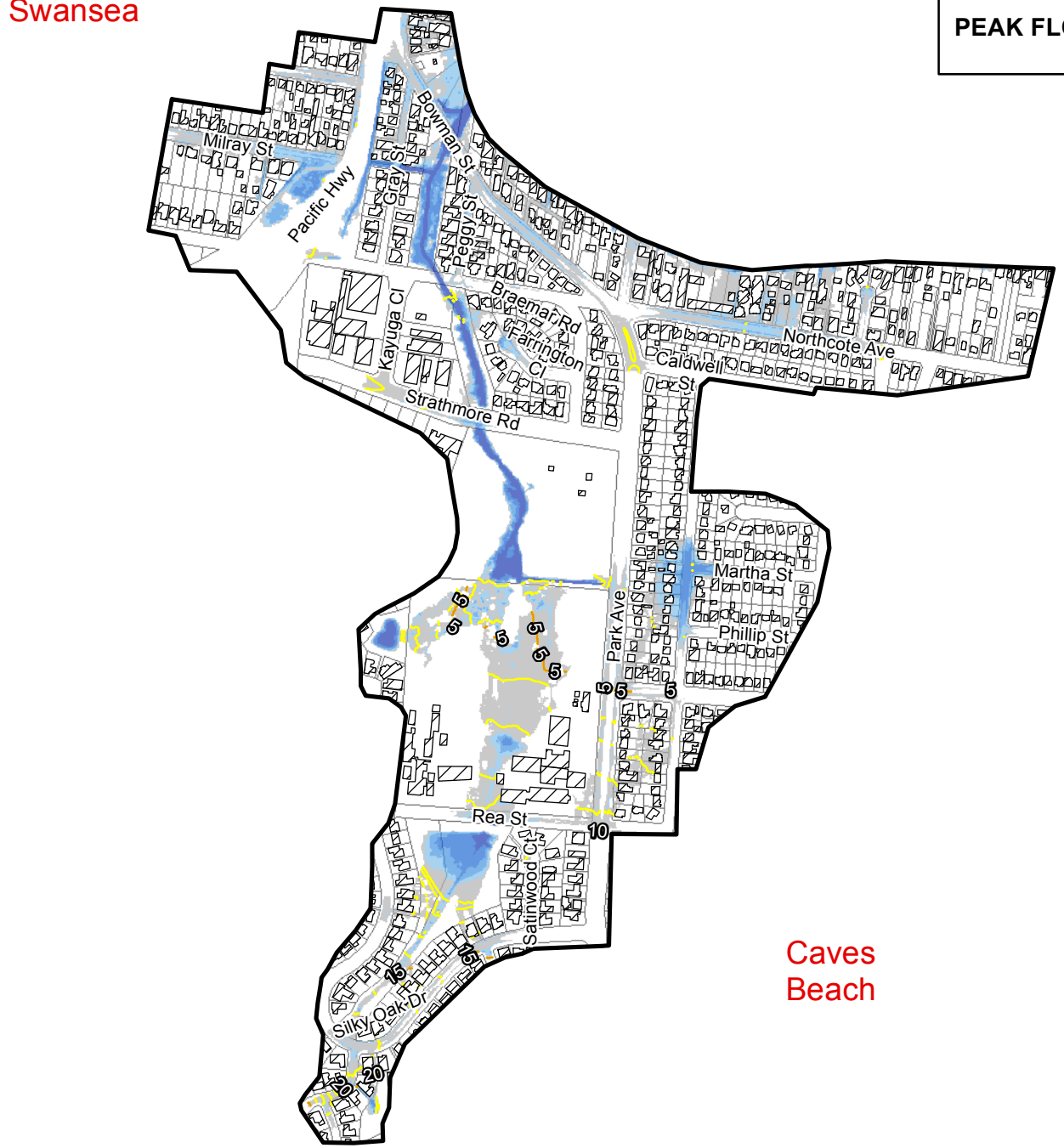
**PLAINS GULLY CREEK**
**PEAK FLOOD DEPTH AND LEVEL CONTOUR**
**50% AEP EVENT**




J:\Jobs\1190776\ArcGIS\ArcMap\Working\Template\Appendix_C\FigureC01_Plains_Gully_Creek_Peak_Flood_Depth_50%AEP.mxd

FIGURE C2

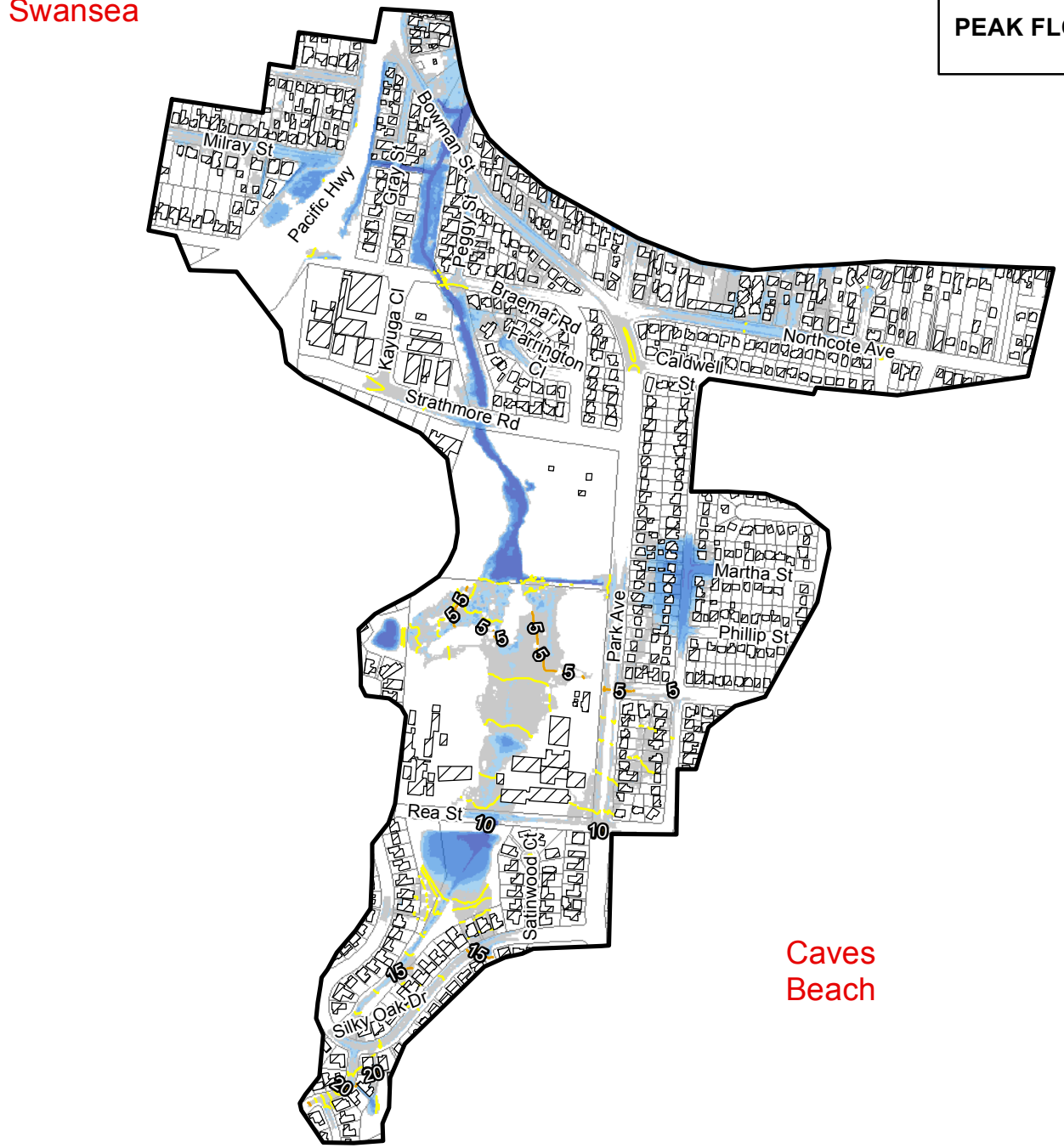
**PLAINS GULLY CREEK**
**PEAK FLOOD DEPTH AND LEVEL CONTOUR**
**20% AEP EVENT**




J:\Jobs\1190776\ArcGIS\ArcMap\Working\Template\Appendix_C\FigureC02_Plains_Gully_Creek_Peak_Flood_Depth_20%AEP.mxd

FIGURE C3

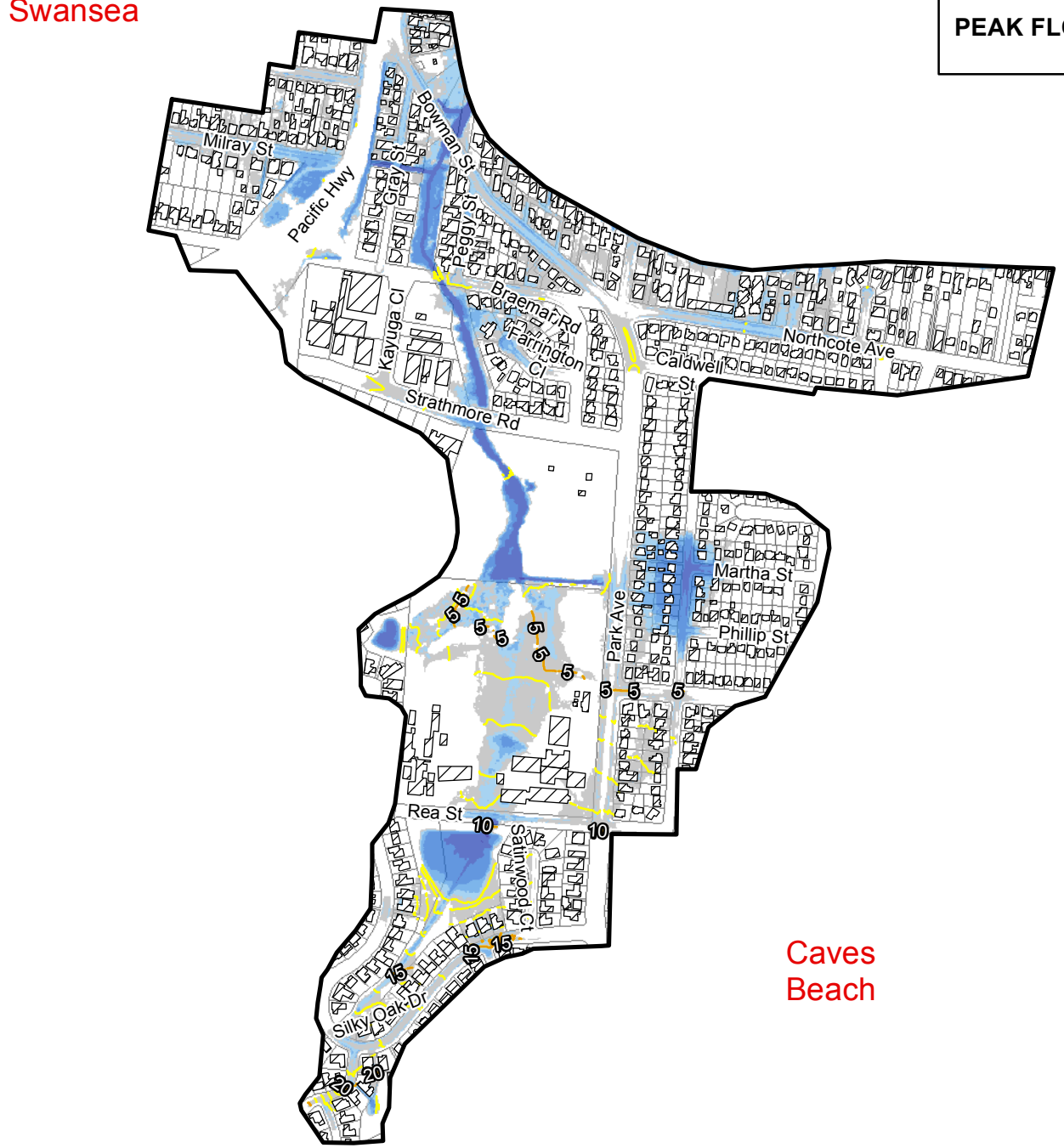
**PLAINS GULLY CREEK**
**PEAK FLOOD DEPTH AND LEVEL CONTOUR**
**10% AEP EVENT**




J:\Jobs\1190776\ArcGIS\ArcMap\Working\Template\Appendix_C\FigureC03_Plains_Gully_Creek_Peak_Flood_Depth_10%AEP.mxd

FIGURE C4

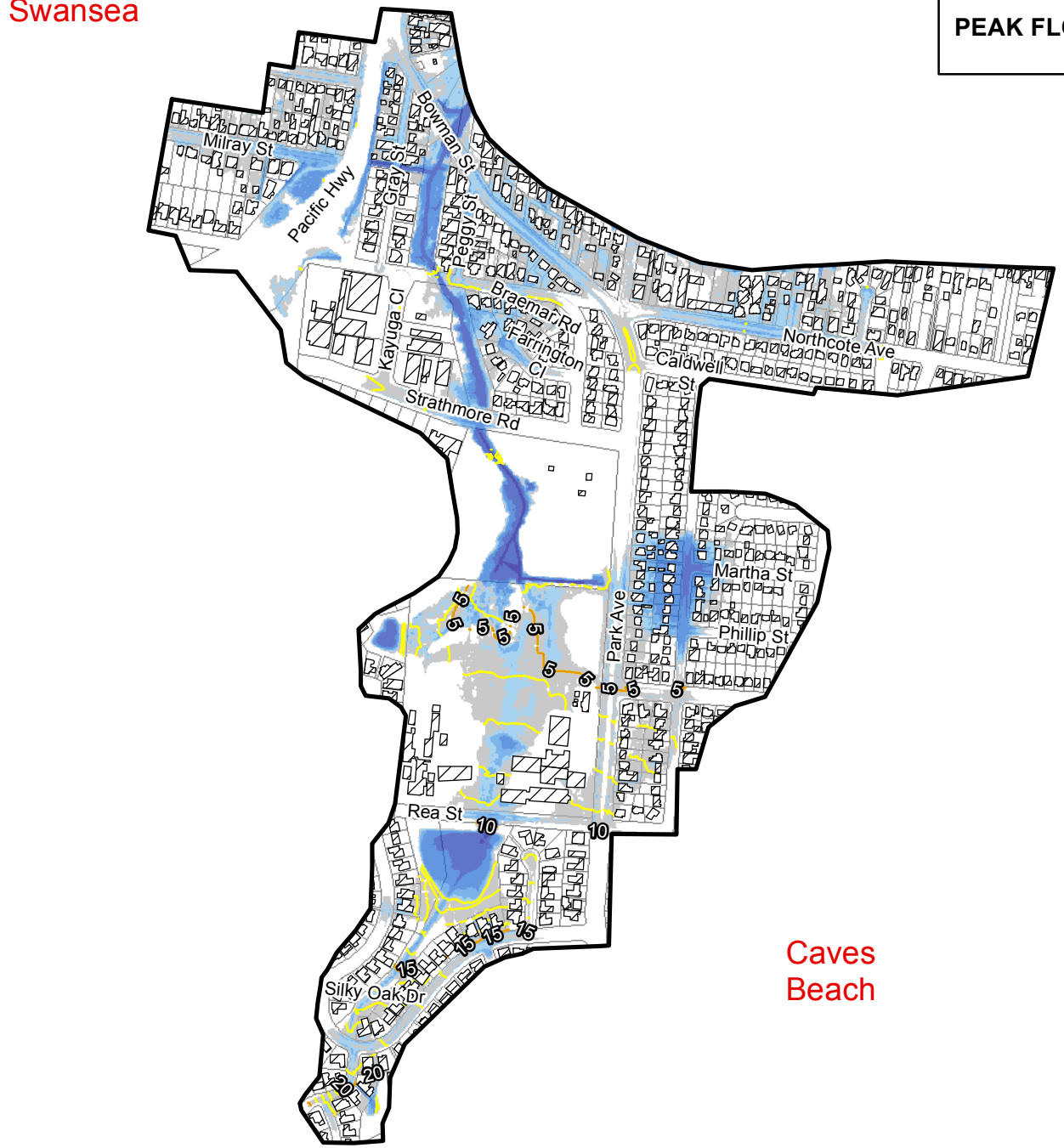
**PLAINS GULLY CREEK**
**PEAK FLOOD DEPTH AND LEVEL CONTOUR**
**5% AEP EVENT**




J:\Jobs\1190776\ArcGIS\ArcMap\Working\Template\Appendix_C\FigureC04_Plains_Gully_Creek_Peak_Flood_Depth_5%AEP.mxd

FIGURE C5

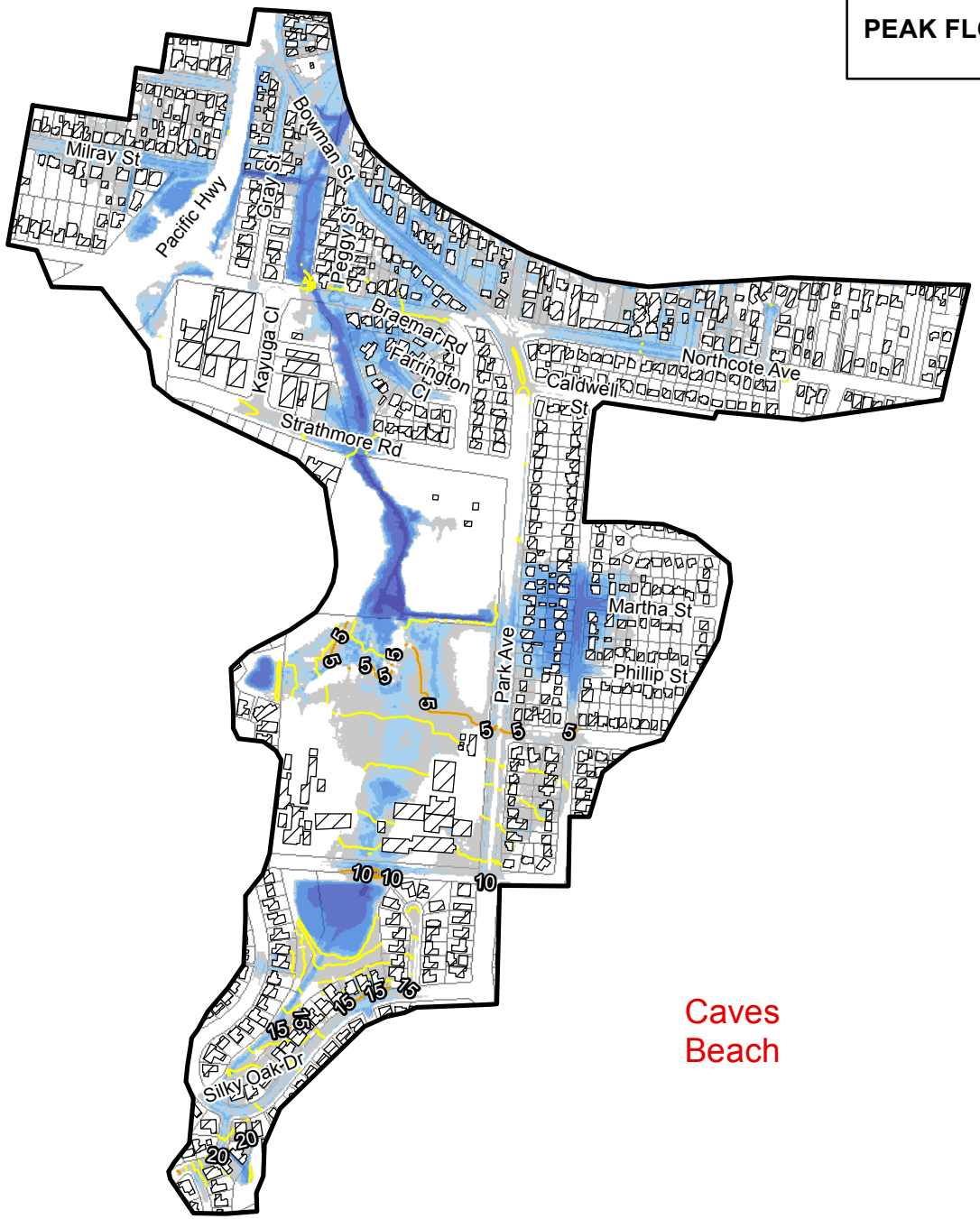
**PLAINS GULLY CREEK**
**PEAK FLOOD DEPTH AND LEVEL CONTOUR**
**2% AEP EVENT**




J:\Jobs\1190776\ArcGIS\ArcMap\Working\Template\Appendix_C\FigureC05_Plains_Gully_Creek_Peak_Flood_Depth_2%AEP.mxd

FIGURE C6

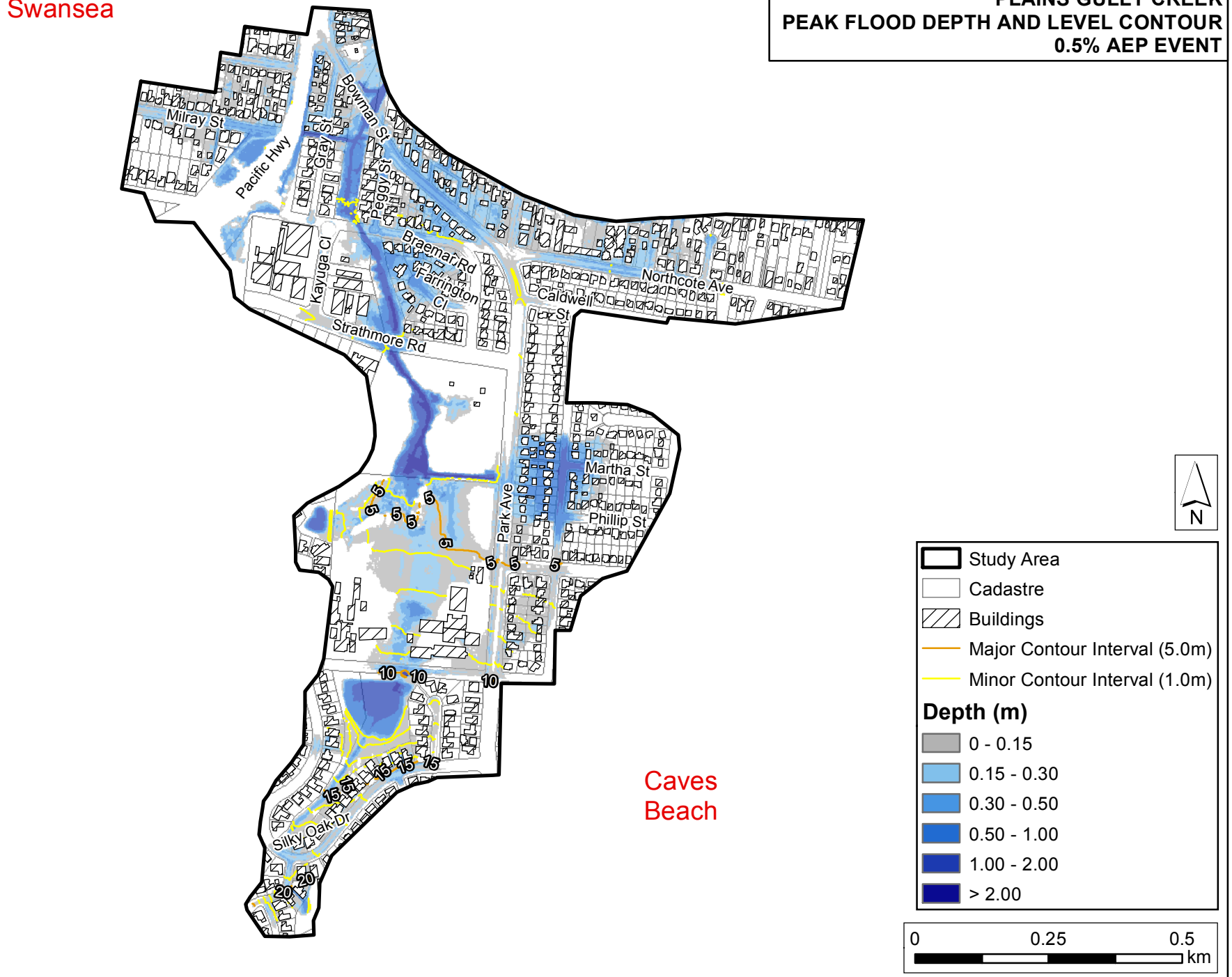
**PLAINS GULLY CREEK**
**PEAK FLOOD DEPTH AND LEVEL CONTOUR**
**1% AEP EVENT**




J:\Jobs\1190776\ArcGIS\ArcMap\Working\Template\Appendix_C\FigureC06_Plains_Gully_Creek_Peak_Flood_Depth_1%AEP.mxd

FIGURE C7

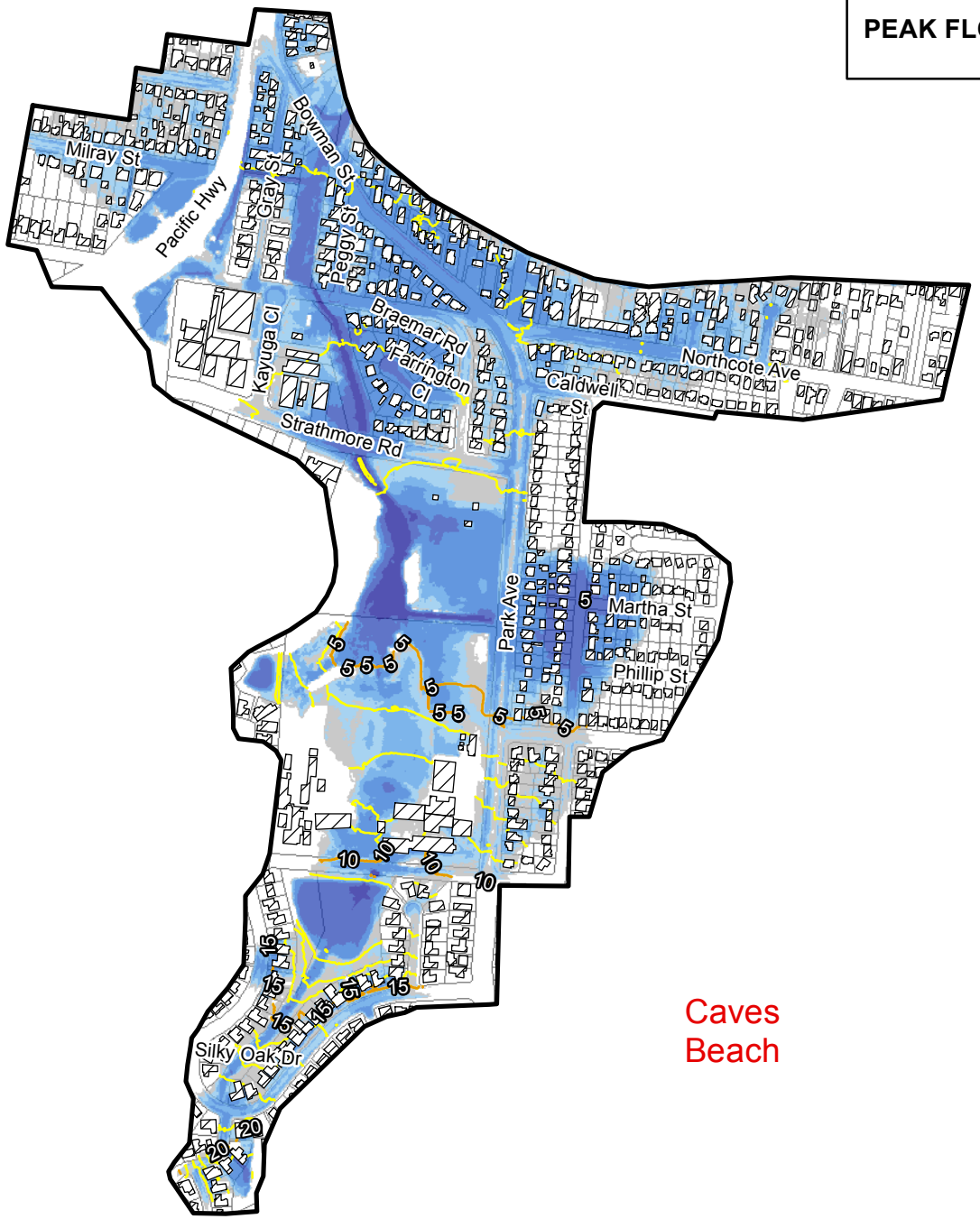
**PLAINS GULLY CREEK**
**PEAK FLOOD DEPTH AND LEVEL CONTOUR**
**0.5% AEP EVENT**




J:\Jobs\1190776\ArcGIS\ArcMap\Working\Template\Appendix_C\FigureC07_Plains_Gully_Creek_Peak_Flood_Depth_0.5%AEP.mxd

FIGURE C8

**PLAINS GULLY CREEK**
**PEAK FLOOD DEPTH AND LEVEL CONTOUR**
**PMF EVENT**




J:\Jobs\1190776\ArcGIS\ArcMap\Working\Template\Appendix_C\FigureC08_Plains_Gully_Creek_Peak_Flood_Depth_PMF.mxd

FIGURE C09
**PLAINS GULLY CREEK**
**PEAK FLOOD VELOCITIES**
**50% AEP EVENT**

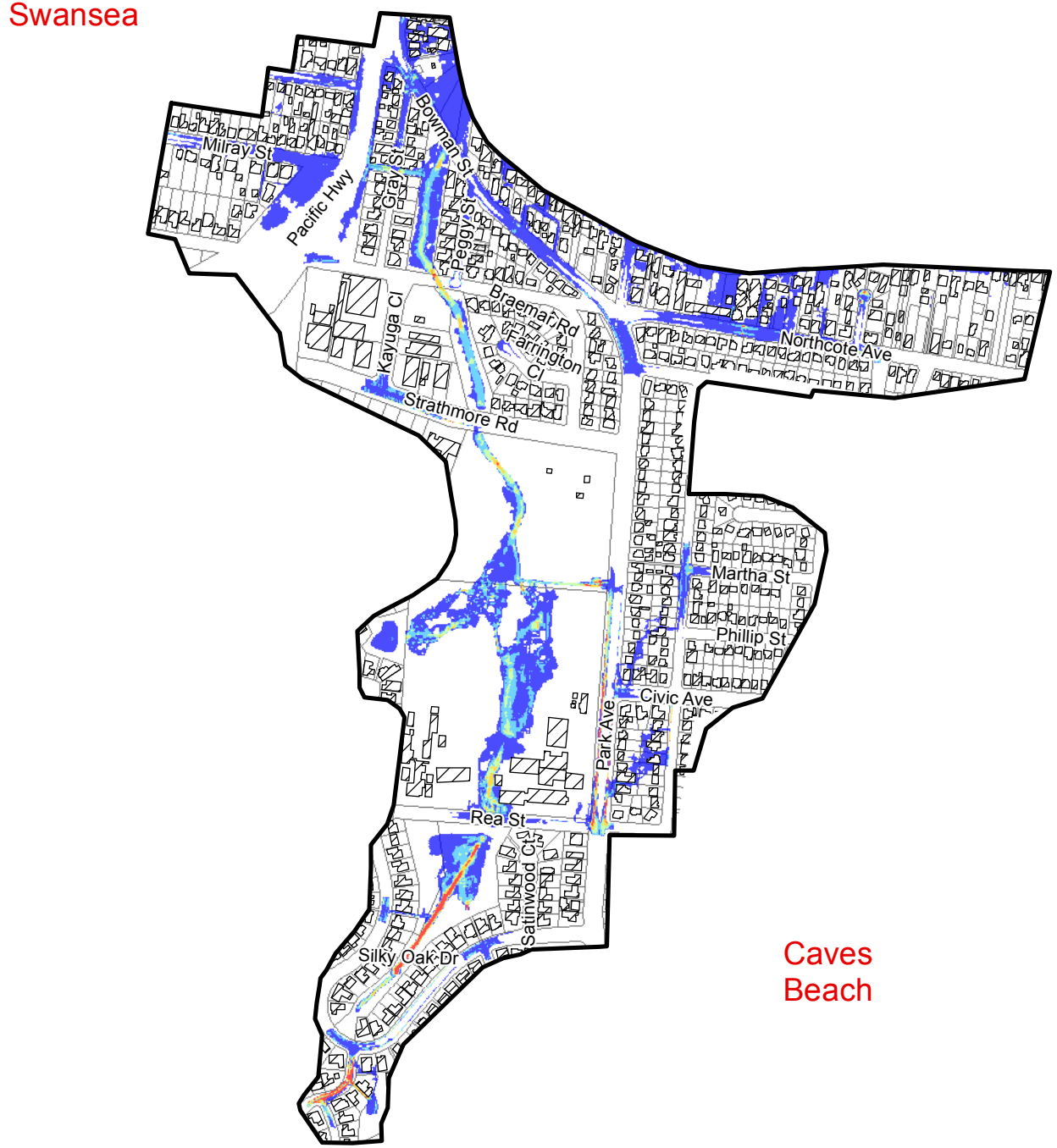



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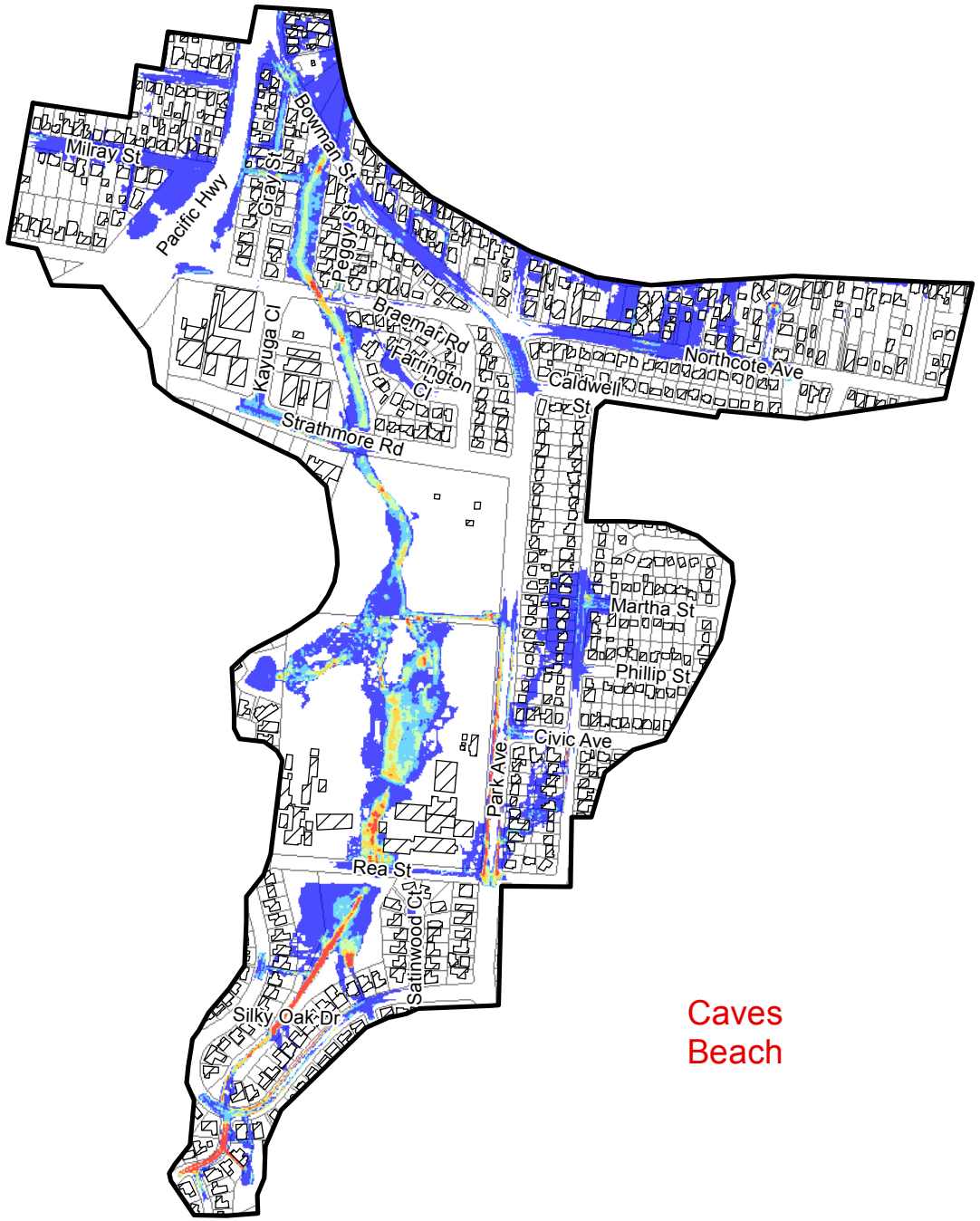
FIGURE C10
**PLAINS GULLY CREEK**
**PEAK FLOOD VELOCITIES**
**20% AEP EVENT**




J:\Jobs\1190776\ArcGIS\ArcMap\Working\Template\Appendix_C\FigureC09_Plains_Gully_Creek_Peak_Flood_Velocity_50%AEP.mxd

FIGURE C11
**PLAINS GULLY CREEK**
**PEAK FLOOD VELOCITIES**
**10% AEP EVENT**

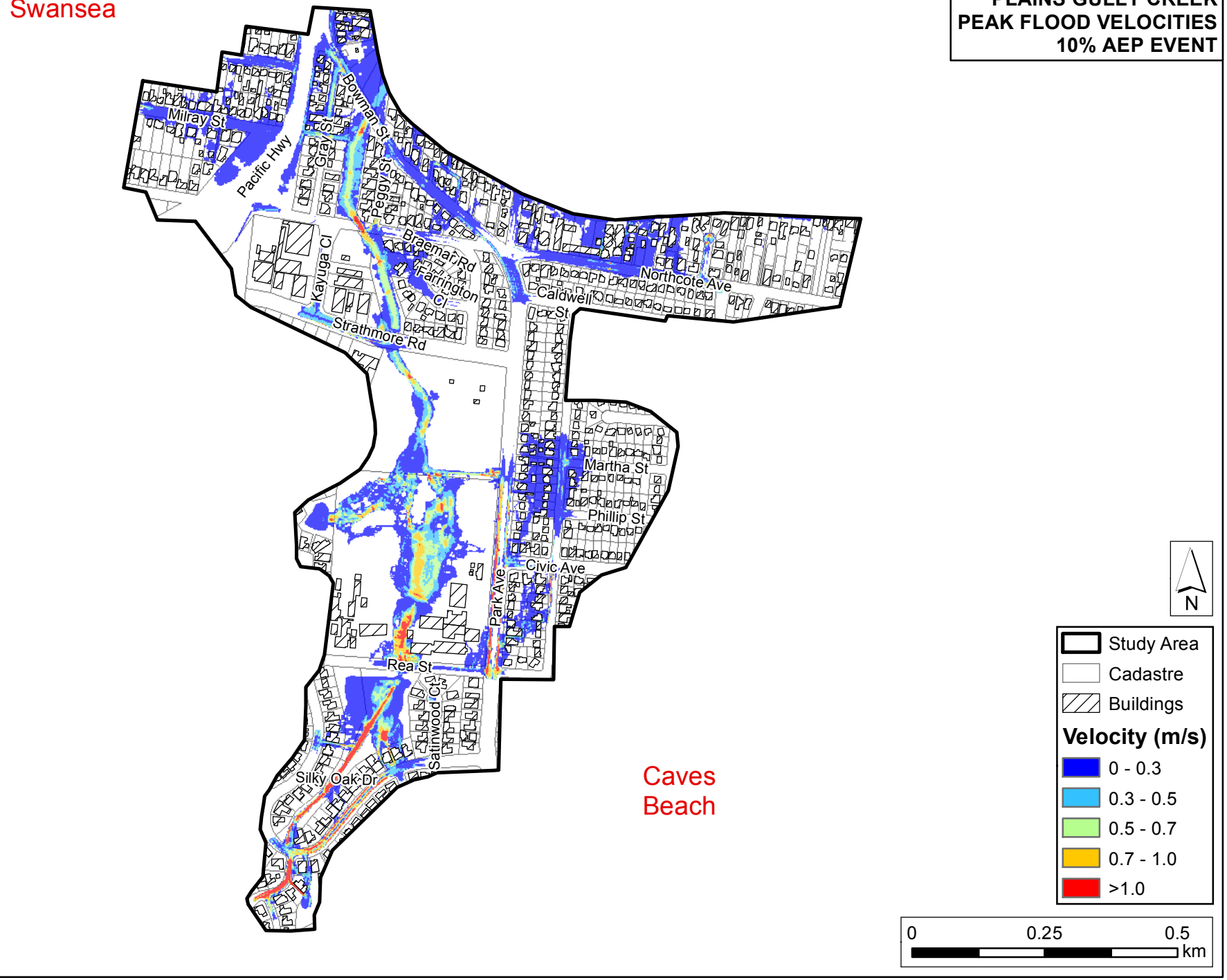



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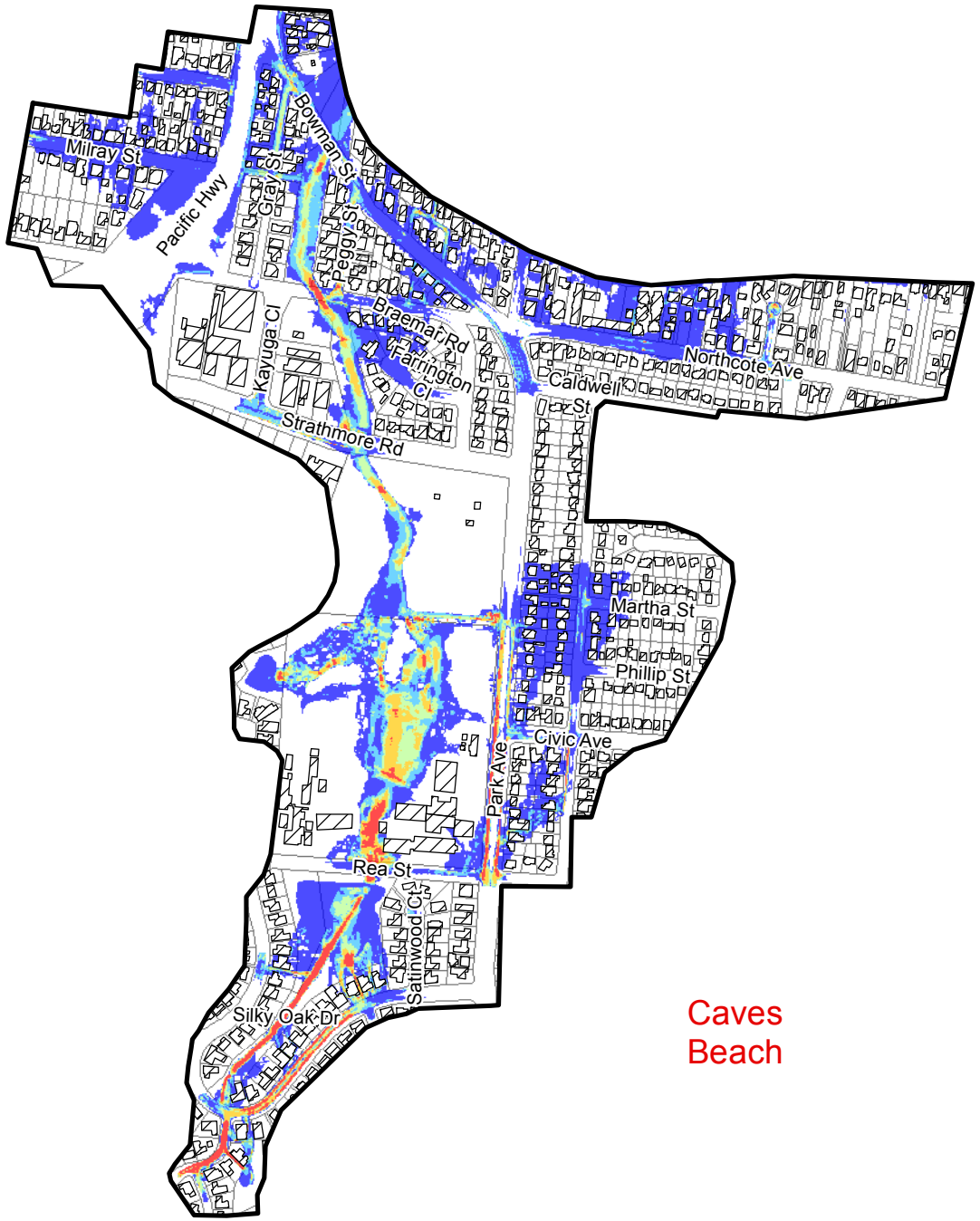
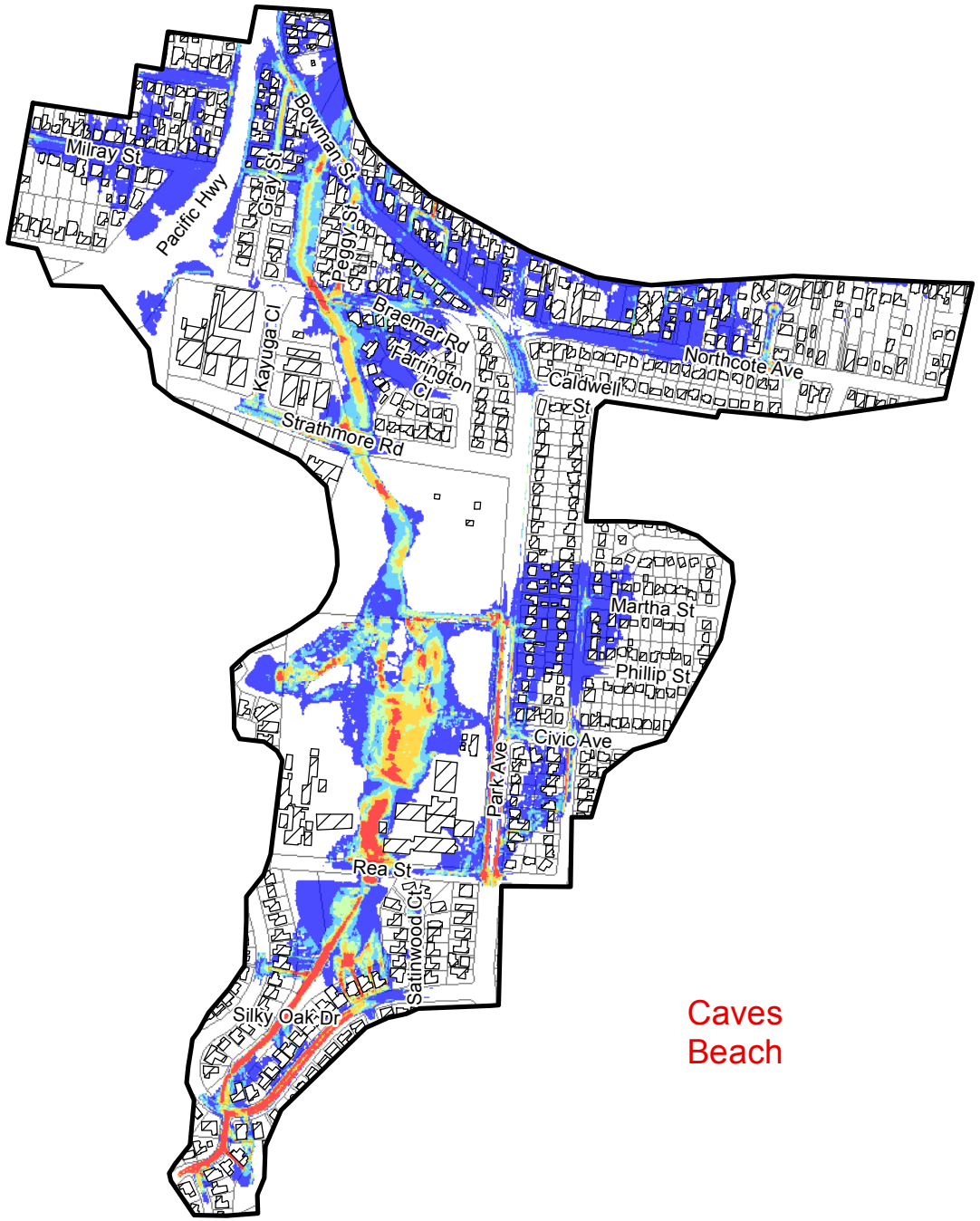
FIGURE C12
**PLAINS GULLY CREEK**
**PEAK FLOOD VELOCITIES**
**5% AEP EVENT**



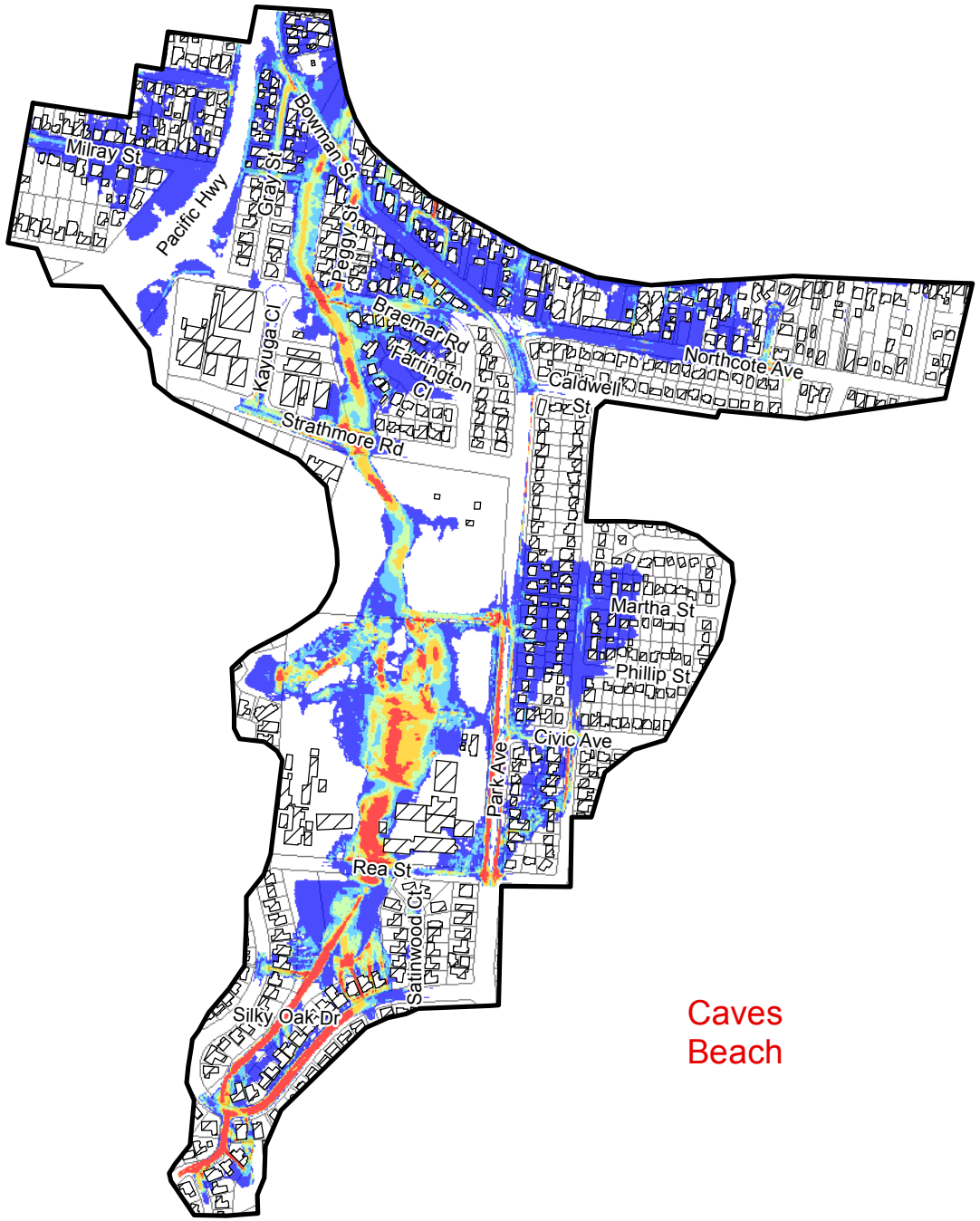

J:\Jobs\1190776\ArcGIS\ArcMap\Working\Template\Appendix_C\FigureC11_Plains_Gully_Creek_Peak_Flood_Velocity_10%AEP.mxd

FIGURE C13
**PLAINS GULLY CREEK**
**PEAK FLOOD VELOCITIES**
**2% AEP EVENT**



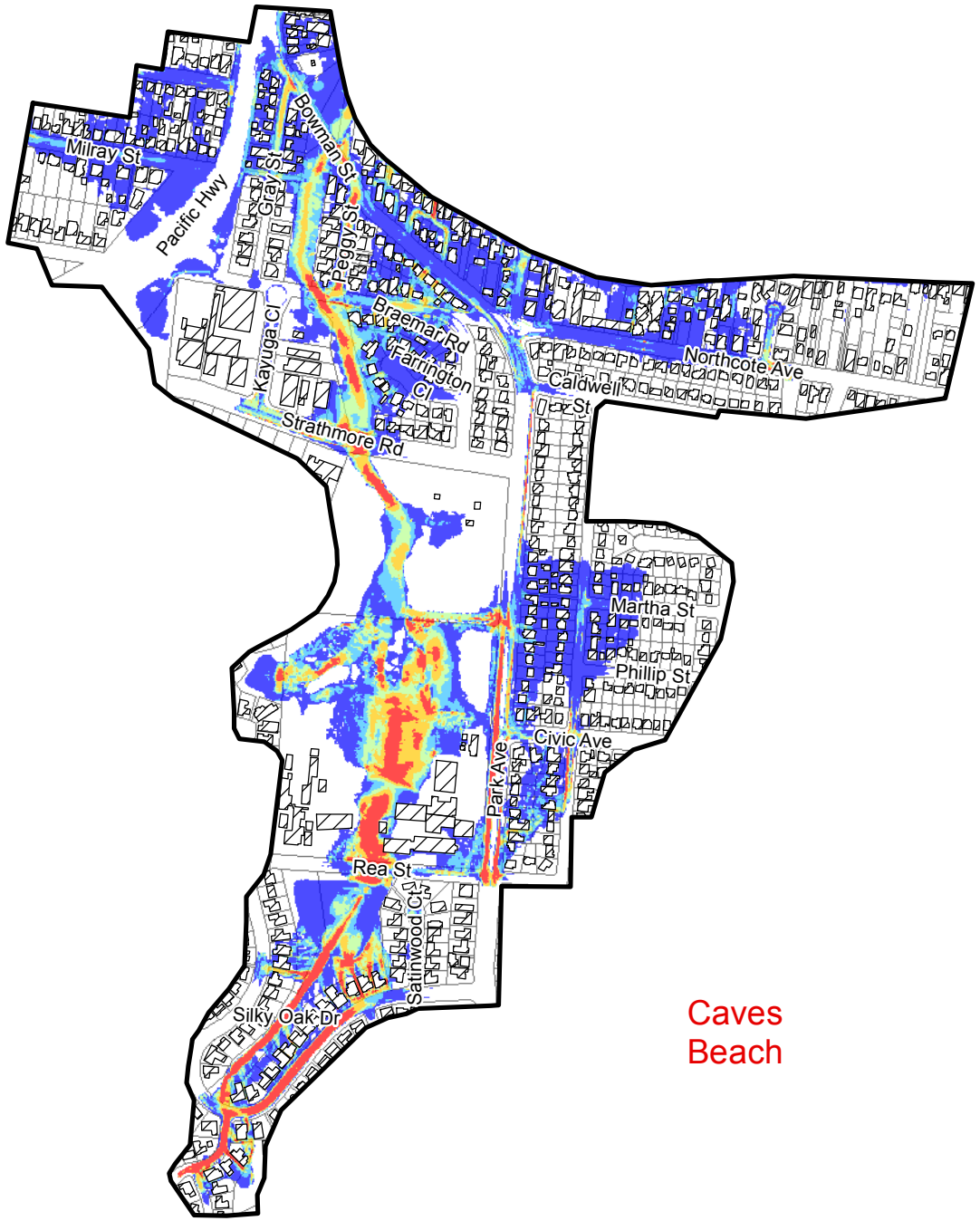

J:\Jobs\1190776\ArcGIS\ArcMap\Working\Template\Appendix_C\FigureC12_Plains_Gully_Creek_Peak_Flood_Velocity_5%AEP.mxd

FIGURE C14
**PLAINS GULLY CREEK**
**PEAK FLOOD VELOCITIES**
**1% AEP EVENT**



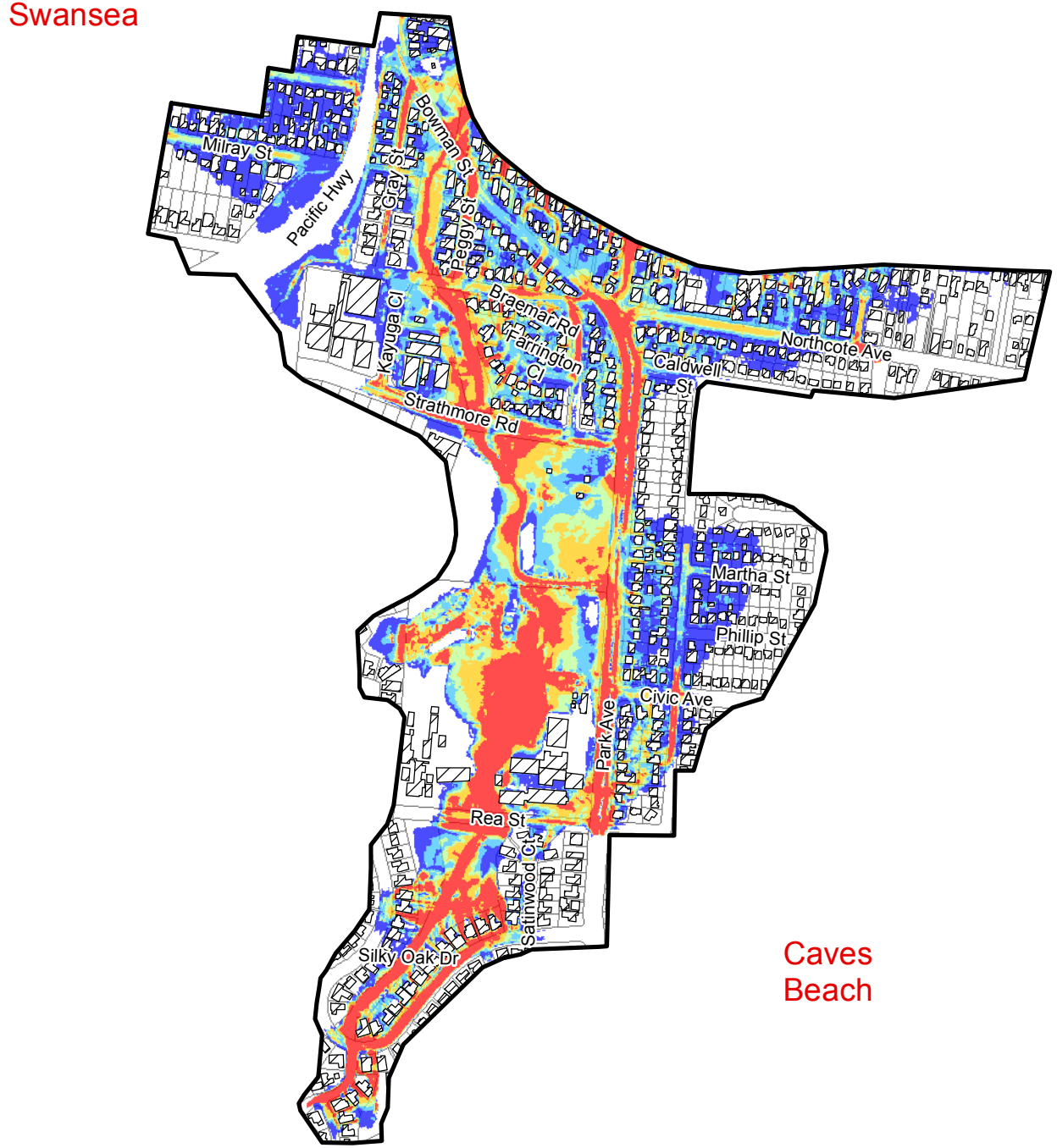

J:\Jobs\1190776\ArcGIS\ArcMap\Working\Template\Appendix_C\FigureC13_Plains_Gully_Creek_Peak_Flood_Velocity_2%AEP.mxd

FIGURE C15
**PLAINS GULLY CREEK**
**PEAK FLOOD VELOCITIES**
**0.5% AEP EVENT**




J:\Jobs\119076\ArcGIS\ArcMap\Working\Template\Appendix_C\FigureC14_Plains_Gully_Creek_Peak_Flood_Velocity_1%AEP.mxd

FIGURE C16
**PLAINS GULLY CREEK**
**PEAK FLOOD VELOCITIES**
**PMF EVENT**




J:\Jobs\1190776\ArcGIS\ArcMap\Working\Template\Appendix_C\FigureC16_Plains_Gully_Creek_Peak_Flood_Velocity_PMF.mxd

FIGURE C17
**PLAINS GULLY CREEK**
**HYDRAULIC CATEGORISATION**
**50% AEP EVENT**

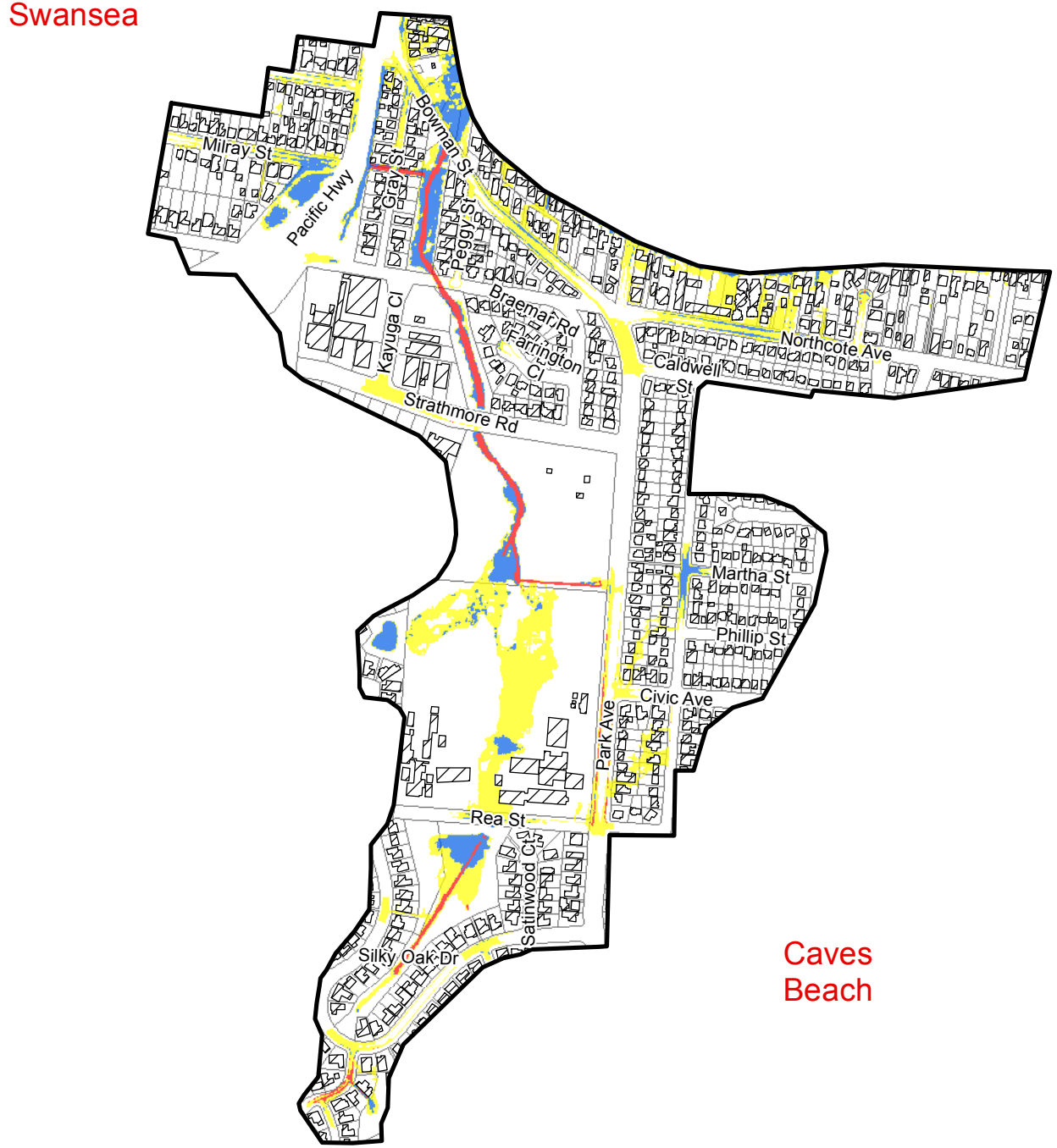



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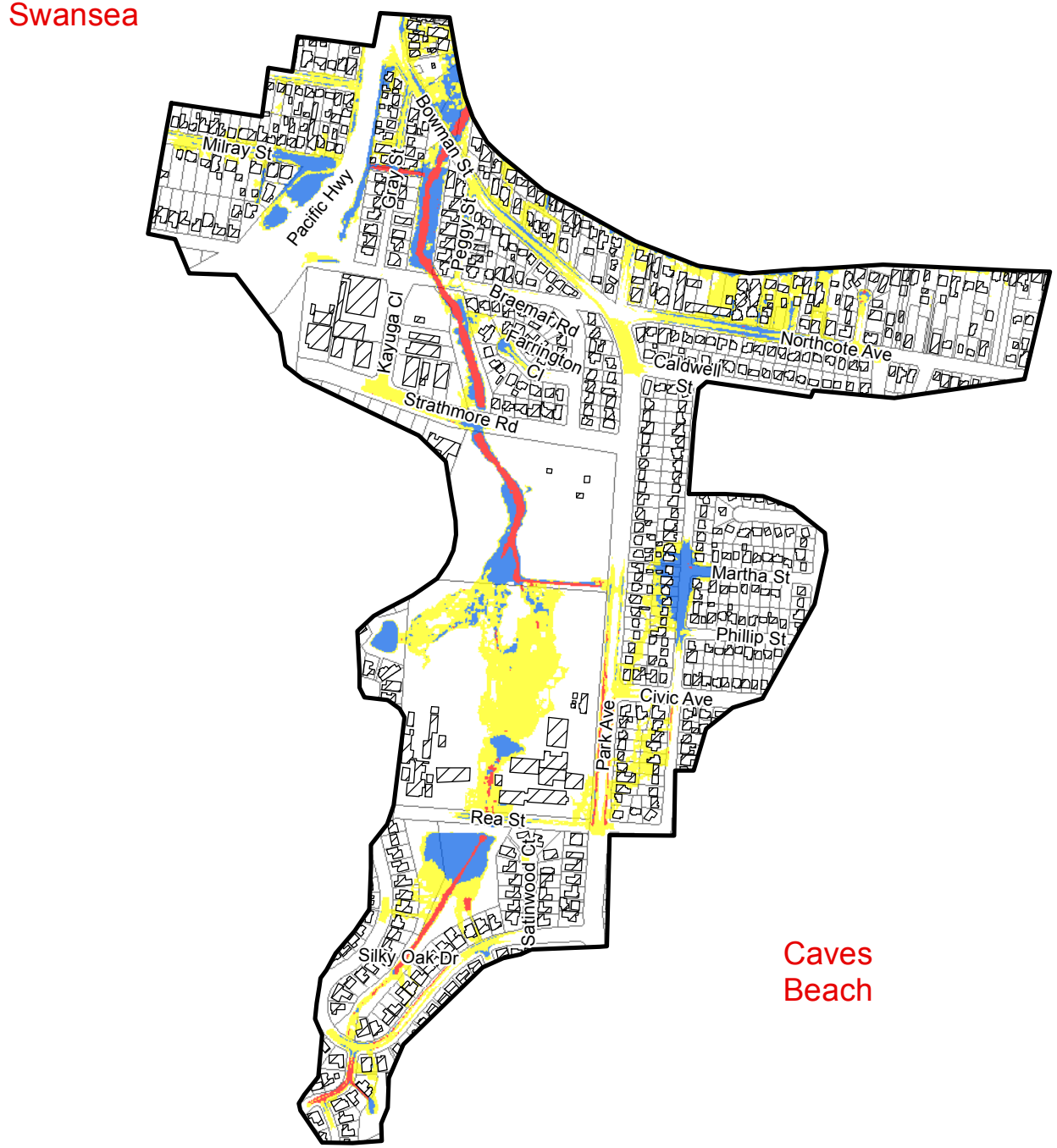
FIGURE C18

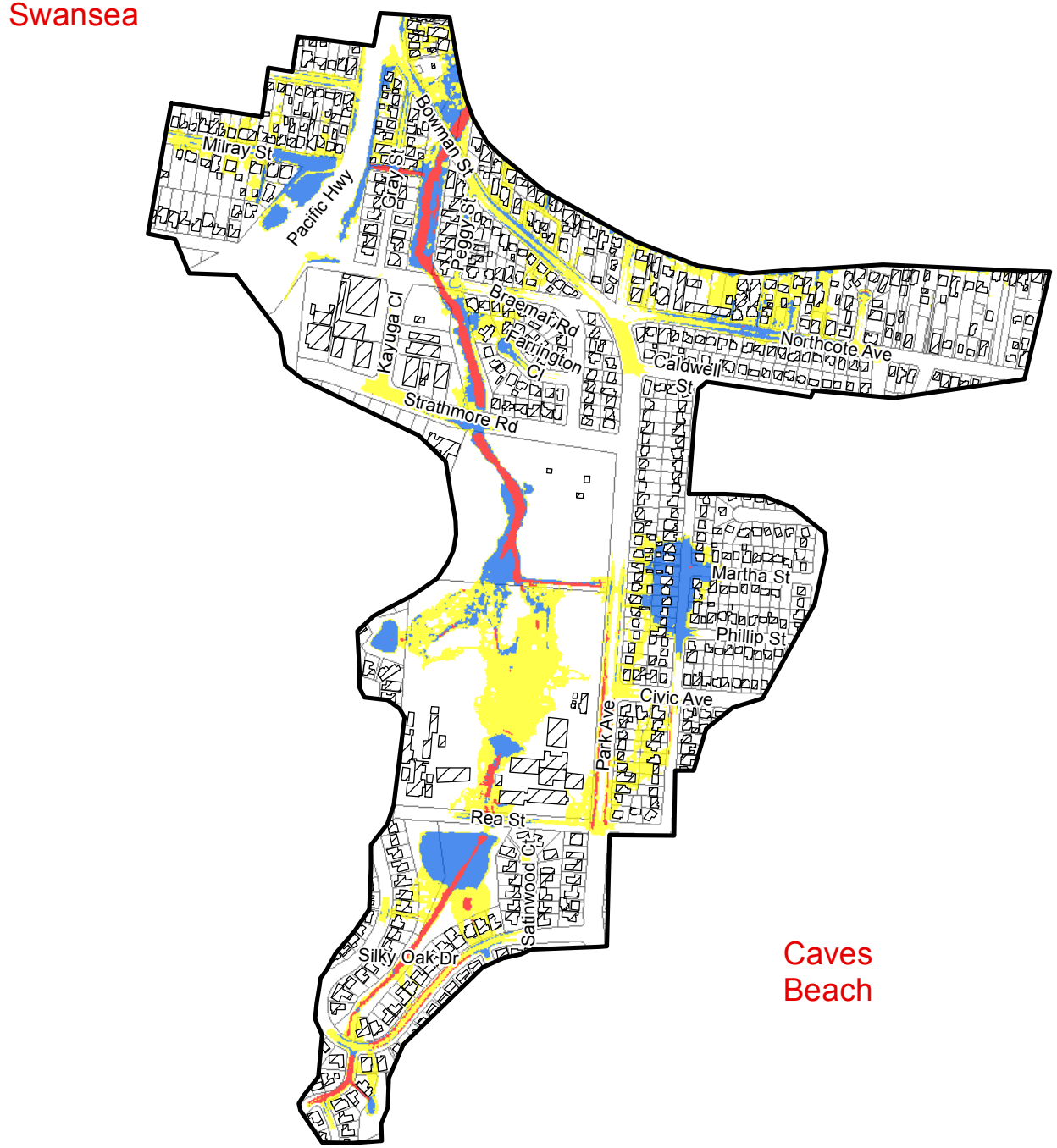
**PLAINS GULLY CREEK**
**HYDRAULIC CATEGORISATION**
**20% AEP EVENT**




J:\Jobs\1190776\ArcGIS\ArcMap\Working\Template\Appendix_C\FigureC17_Plains_Gully_Creek_Hydraulic_Categories_50%AEP.mxd

FIGURE C19

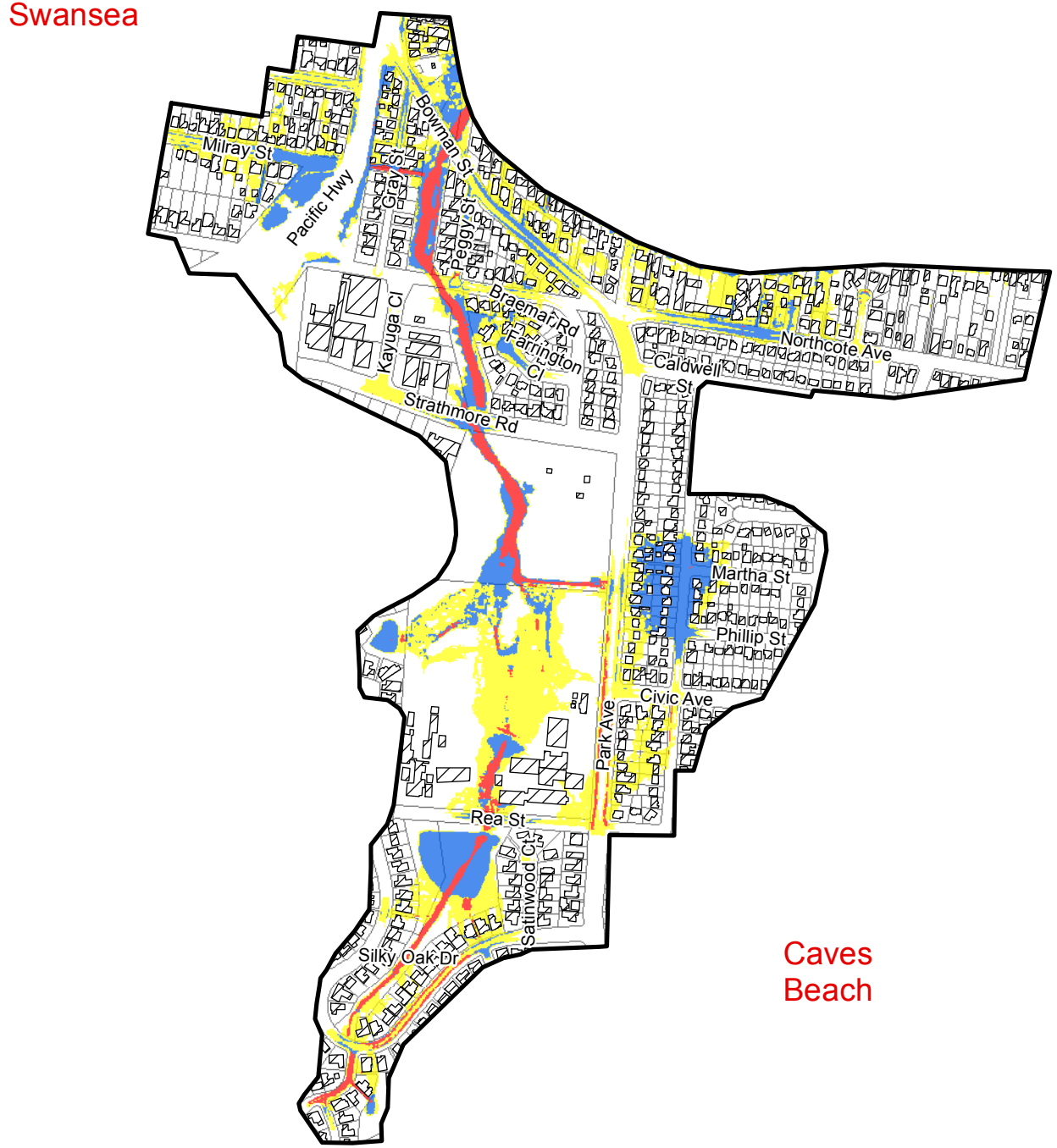
**PLAINS GULLY CREEK**
**HYDRAULIC CATEGORISATION**
**10% AEP EVENT**




J:\Jobs\1190776\ArcGIS\ArcMap\Working\Template\Appendix_C\FigureC18_Plains_Gully_Creek_Hydraulic_Categories_20%AEP.mxd

FIGURE C20

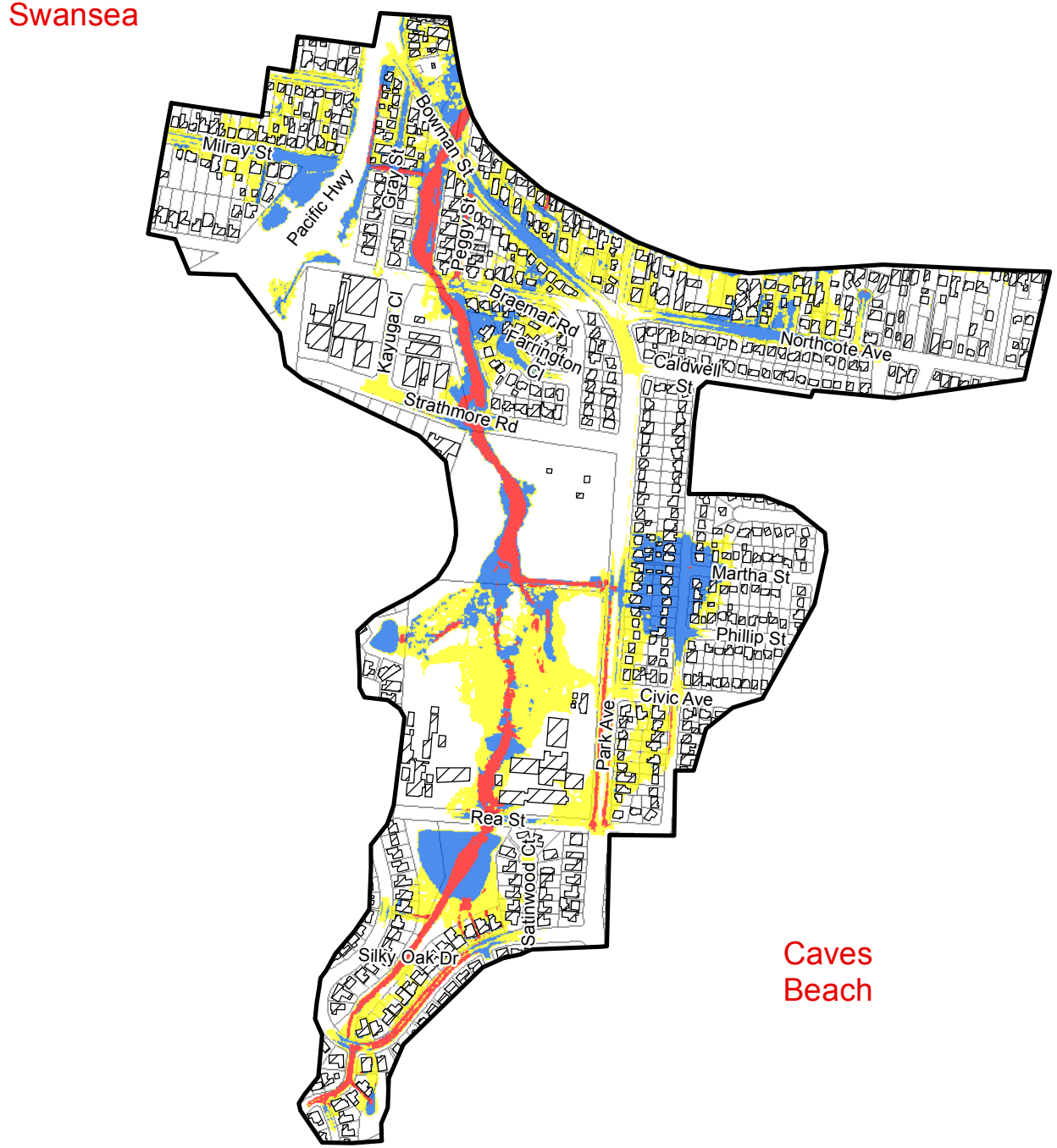
**PLAINS GULLY CREEK**
**HYDRAULIC CATEGORISATION**
**5% AEP EVENT**




J:\Jobs\119076\ArcGIS\ArcMap\Working\Template\Appendix_C\FigureC19_Plains_Gully_Creek_Hydraulic_Categories_10%AEP.mxd

FIGURE C21

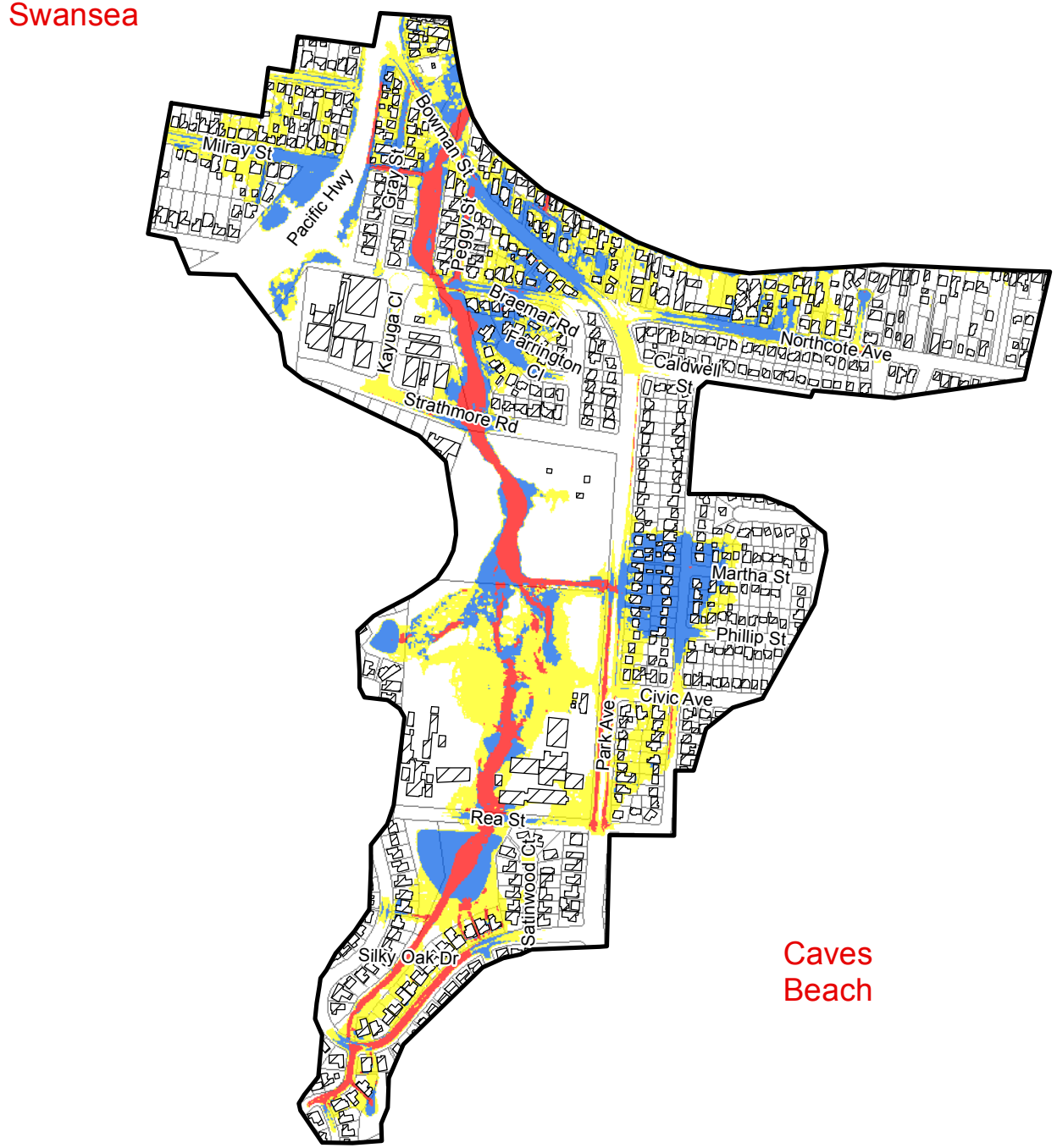
**PLAINS GULLY CREEK**
**HYDRAULIC CATEGORISATION**
**2% AEP EVENT**




J:\Jobs\1190776\ArcGIS\ArcMap\Working\Template\Appendix_C\FigureC20_Plains_Gully_Creek_Hydraulic_Categories_5%AEP.mxd

FIGURE C22

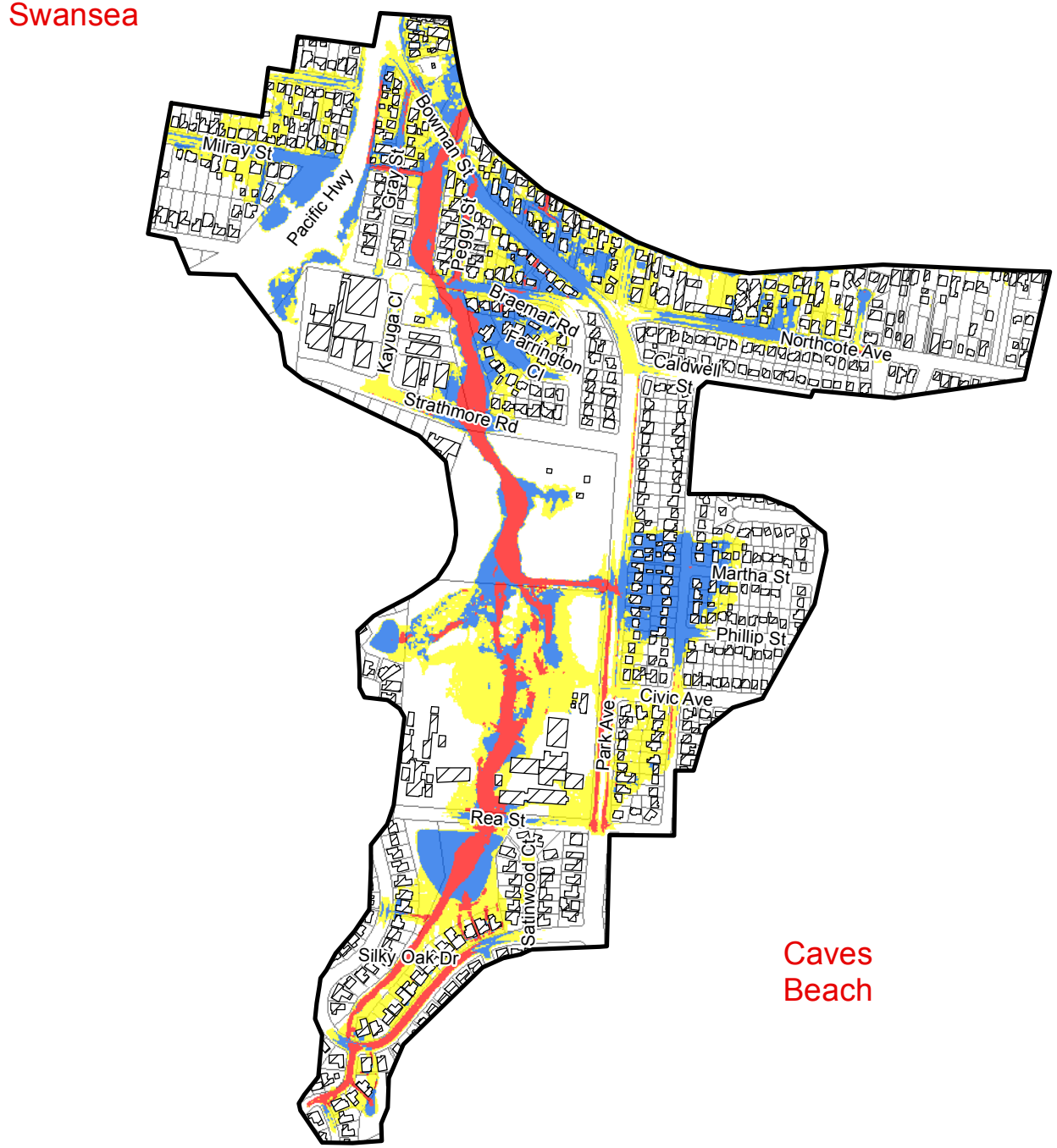
**PLAINS GULLY CREEK**
**HYDRAULIC CATEGORISATION**
**1% AEP EVENT**




J:\Jobs\119076\ArcGIS\ArcMap\Working\Template\Appendix_C\FigureC21_Plains_Gully_Creek_Hydraulic_Categories_2%AEP.mxd

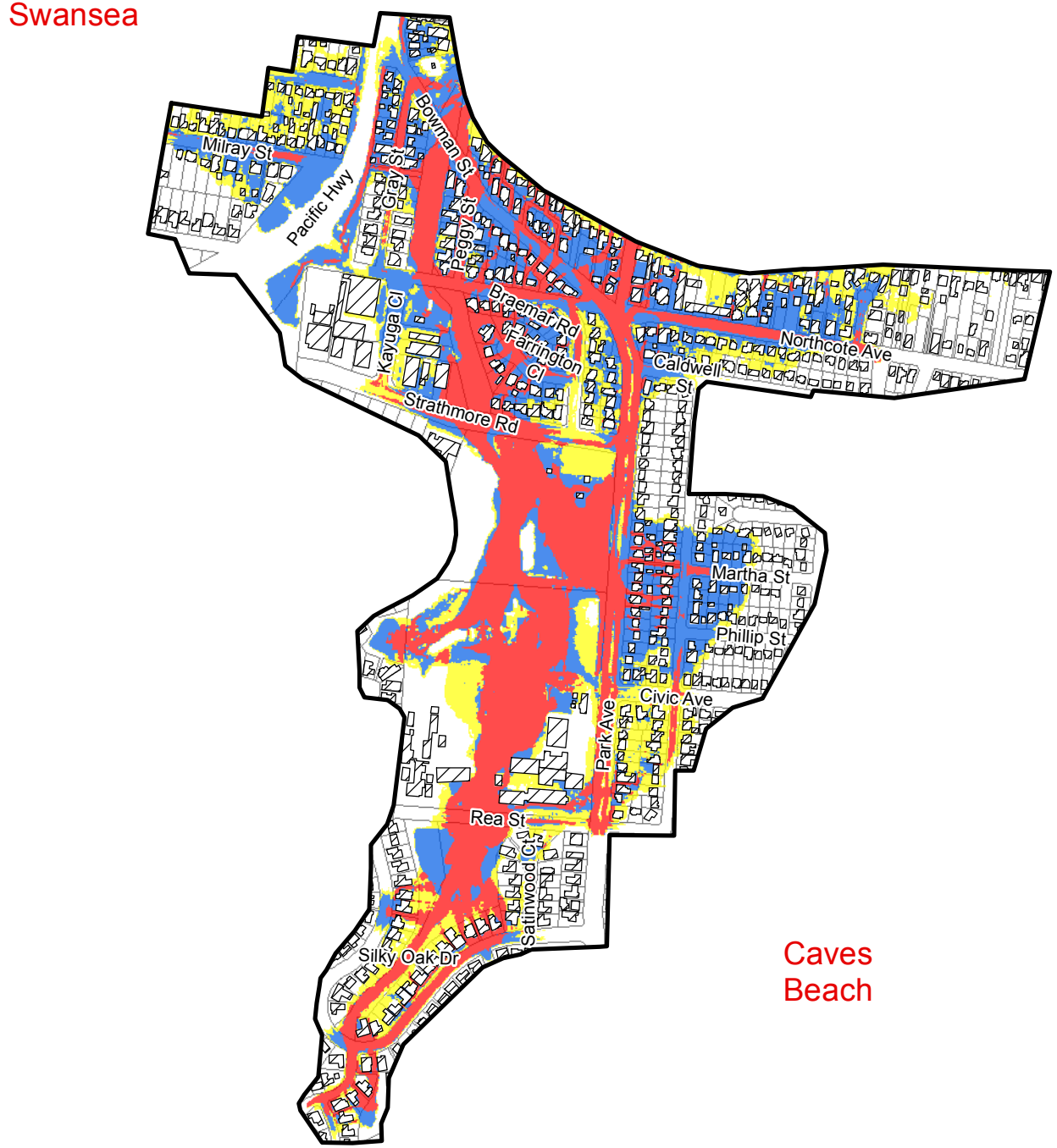
FIGURE C23

**PLAINS GULLY CREEK**
**HYDRAULIC CATEGORISATION**
**0.5% AEP EVENT**



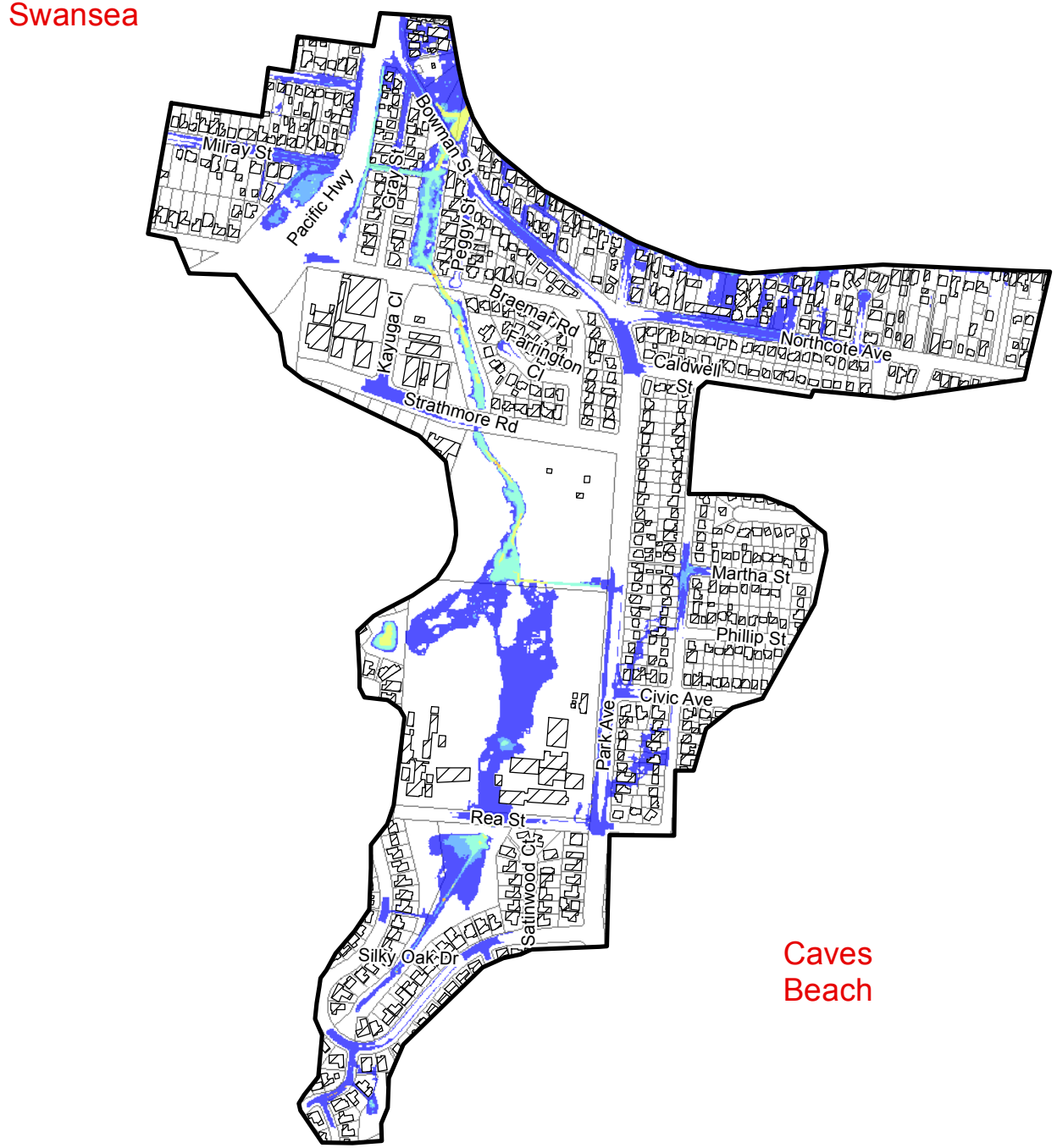

J:\Jobs\1190776\ArcGIS\ArcMap\Working\Template\Appendix_C\FigureC22_Plains_Gully_Creek_Hydraulic_Categories_1%AEP.mxd

FIGURE C24
**PLAINS GULLY CREEK**
**HYDRAULIC CATEGORISATION**
**PMF EVENT**




J:\Jobs\1190776\ArcGIS\ArcMap\Working\Template\Appendix_C\FigureC23_Plains_Gully_Creek_Hydraulic_Categories_0_5%AEP.mxd

FIGURE C25
**PLAINS GULLY CREEK HYDRAULIC HAZARD 50% AEP EVENT**




N

- Study Area
- Cadastre
- Buildings

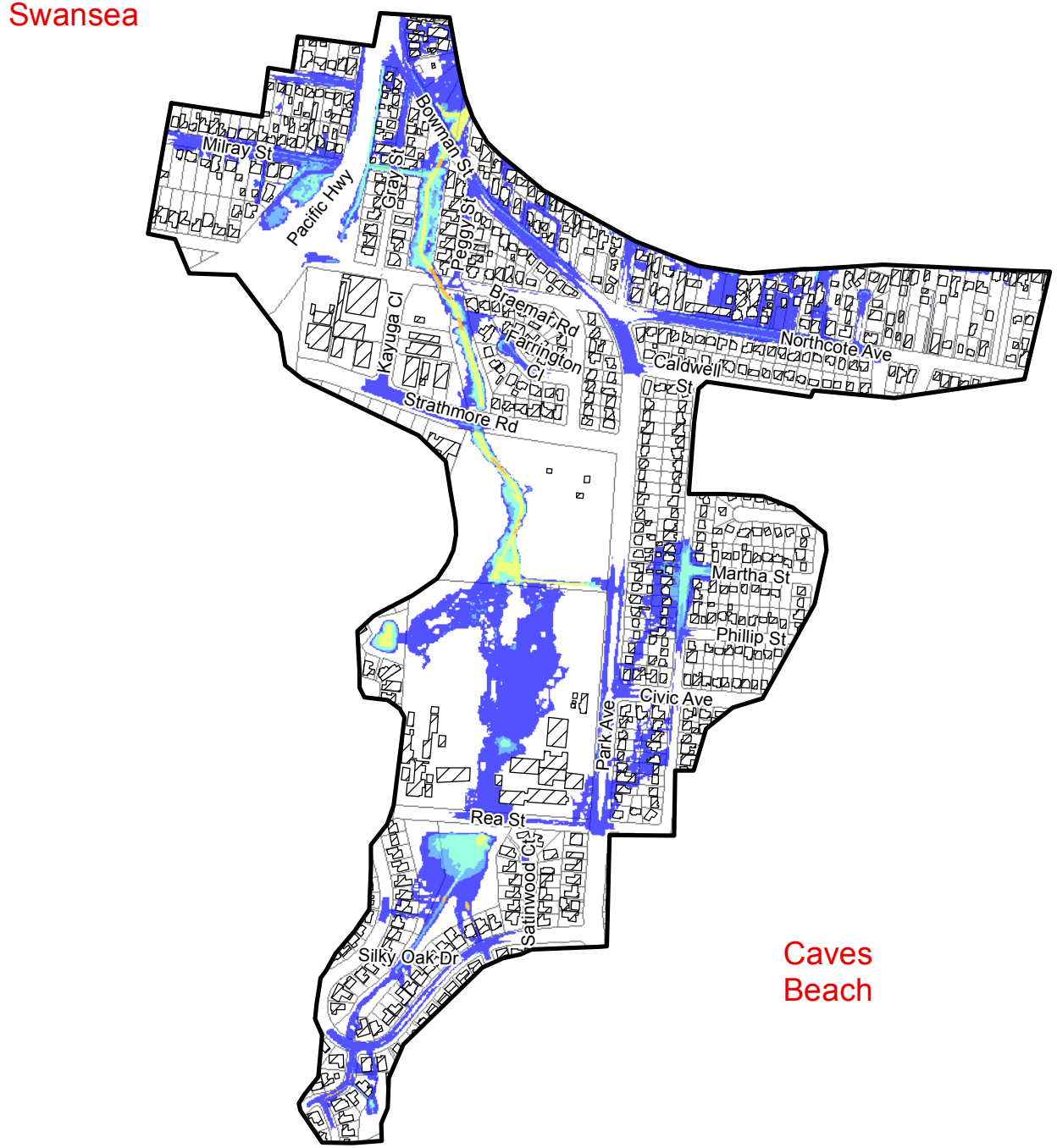
**Hazard**

- H1- Generally safe for people, vehicles and buildings
- H2- Unsafe for small vehicles
- H3- Unsafe for vehicles, children and the elderly
- H4- Unsafe for people and vehicles
- H5- Unsafe for people or vehicles. Buildings require special engineering design and construction
- H6- Unsafe for vehicles and people. All building types considered vulnerable to failure

0 0.25 0.5 km

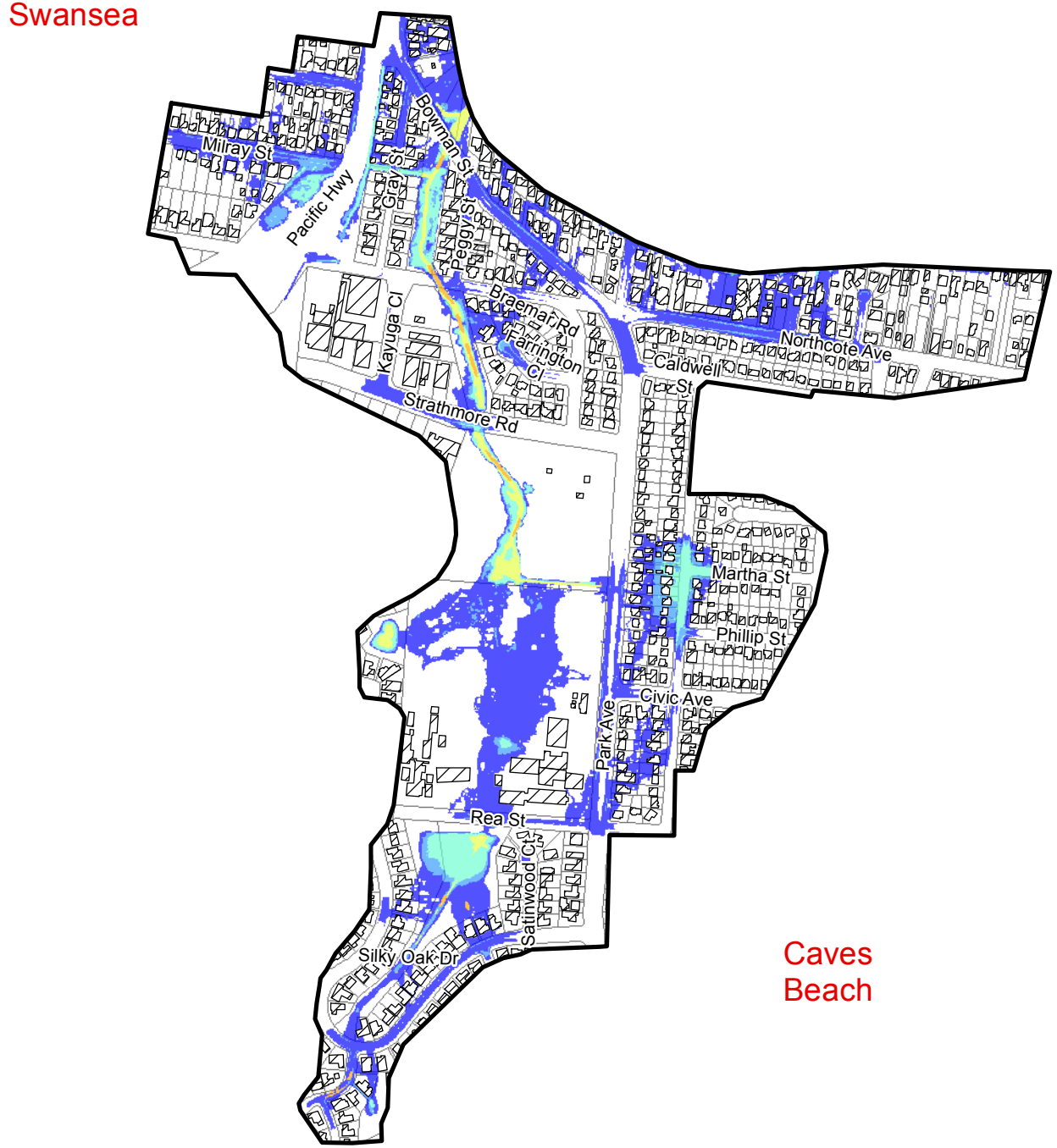
J:\Jobs\1190776\ArcGIS\ArcMap\Working\Template\Appendix_C\FigureC25_Plains_Gully_Creek_Provisional_Hazard_50%AEP.mxd

FIGURE C26
**PLAINS GULLY CREEK HYDRAULIC HAZARD 20% AEP EVENT**




J:\Jobs\119076\ArcGIS\ArcMap\Working\Template\Appendix_C\FigureC25_Plains_Gully_Creek_Provisional_Hazard_50%AEP.mxd

FIGURE C27
**PLAINS GULLY CREEK**
**HYDRAULIC HAZARD**
**10% AEP EVENT**




N

- Study Area
- Cadastre
- Buildings

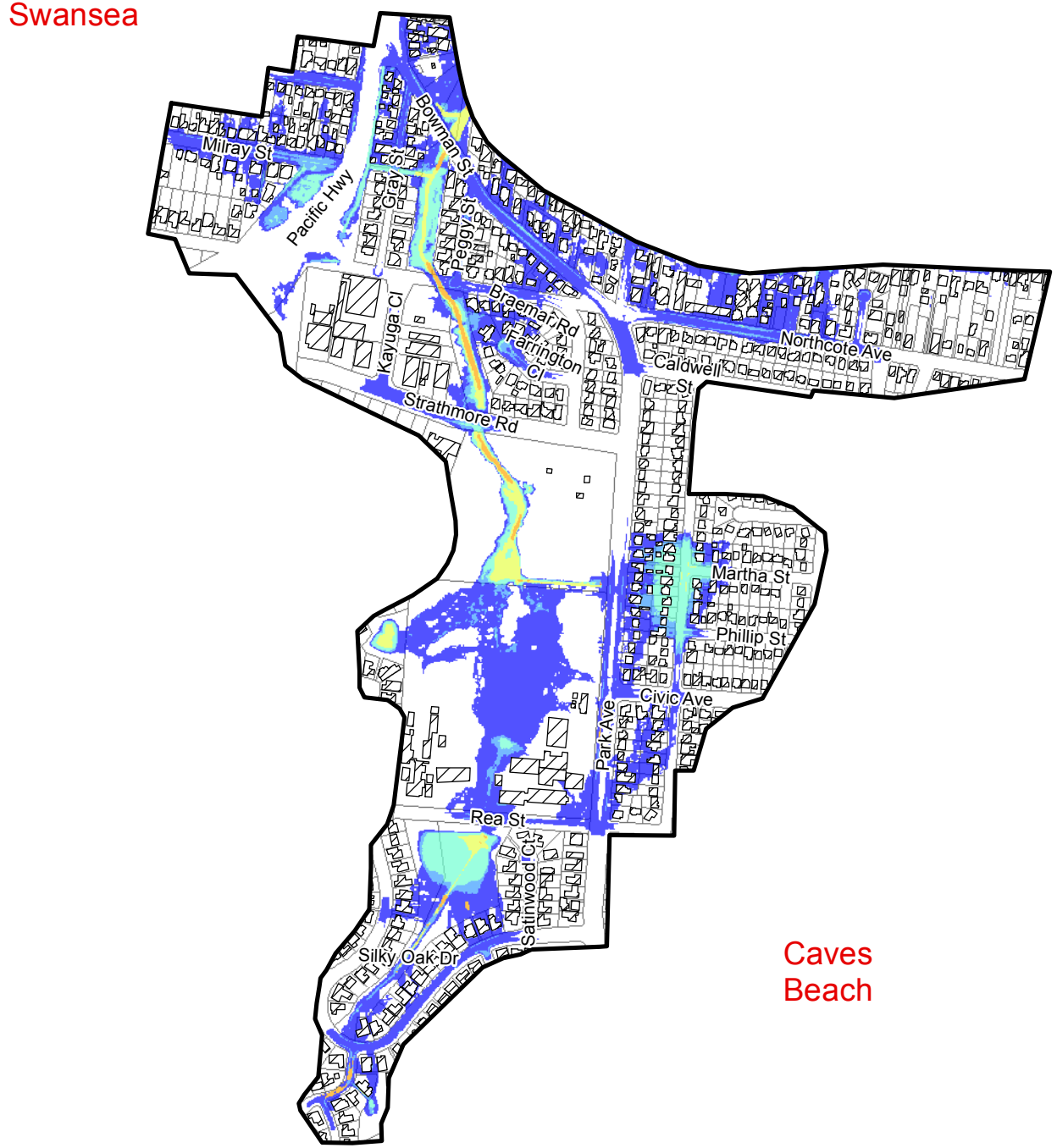
**Hazard**

- H1- Generally safe for people, vehicles and buildings
- H2- Unsafe for small vehicles
- H3- Unsafe for vehicles, children and the elderly
- H4- Unsafe for people and vehicles
- H5- Unsafe for people or vehicles. Buildings require special engineering design and construction
- H6- Unsafe for vehicles and people. All building types considered vulnerable to failure

0 0.25 0.5 km

J:\Jobs\119076\ArcGIS\ArcMap\Working\Template\Appendix_C\FigureC26_Plains_Gully_Creek_Provisional_Hazard_20%AEP.mxd

FIGURE C28
**PLAINS GULLY CREEK HYDRAULIC HAZARD 5% AEP EVENT**




N

- Study Area
- Cadastre
- Buildings

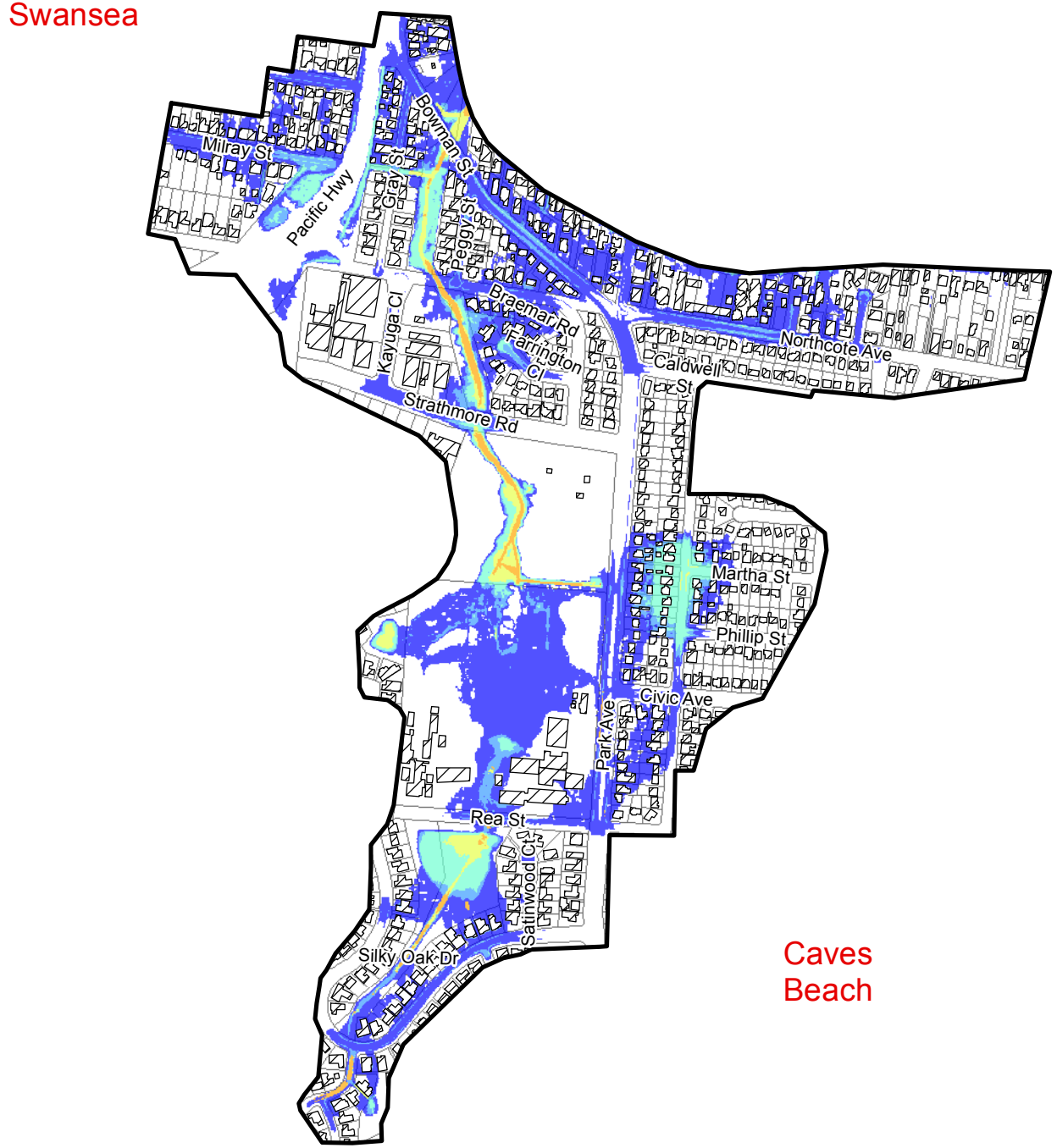
**Hazard**

- H1- Generally safe for people, vehicles and buildings
- H2- Unsafe for small vehicles
- H3- Unsafe for vehicles, children and the elderly
- H4- Unsafe for people and vehicles
- H5- Unsafe for people or vehicles. Buildings require special engineering design and construction
- H6- Unsafe for vehicles and people. All building types considered vulnerable to failure

0 0.25 0.5 km

J:\Jobs\1190776\ArcGIS\ArcMap\Working\Template\Appendix_C\FigureC27_Plains_Gully_Creek_Provisional_Hazard_10%AEP.mxd

FIGURE C29
**PLAINS GULLY CREEK**
**HYDRAULIC HAZARD**
**2% AEP EVENT**




N

- Study Area
- Cadastre
- Buildings

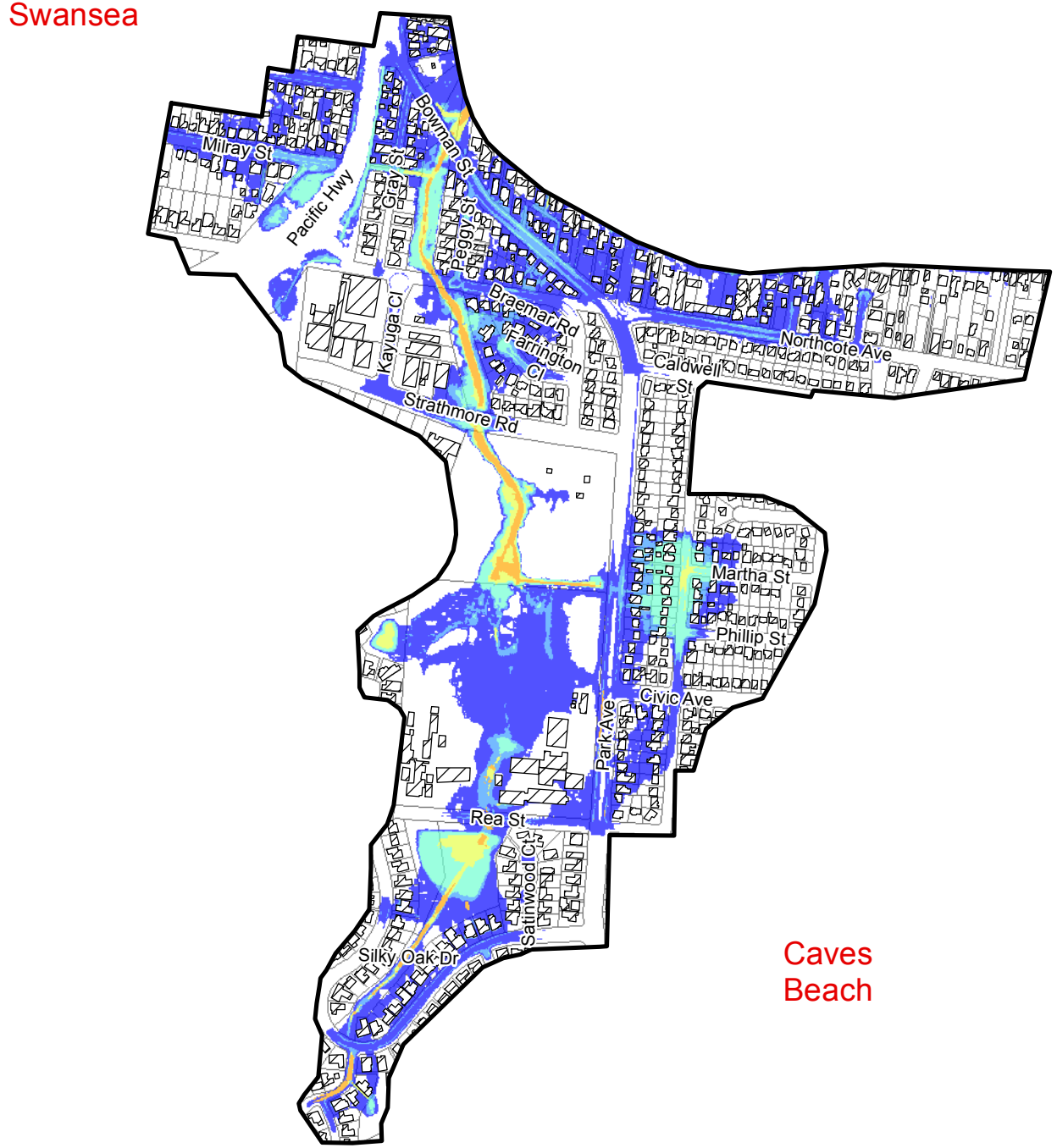
**Hazard**

- H1- Generally safe for people, vehicles and buildings
- H2- Unsafe for small vehicles
- H3- Unsafe for vehicles, children and the elderly
- H4- Unsafe for people and vehicles
- H5- Unsafe for people or vehicles. Buildings require special engineering design and construction
- H6- Unsafe for vehicles and people. All building types considered vulnerable to failure

0 0.25 0.5 km

J:\Jobs\119076\ArcGIS\ArcMap\Working\Template\Appendix_C\FigureC28_Plains_Gully_Creek_Provisional_Hazard_5%AEP.mxd

FIGURE C30
**PLAINS GULLY CREEK**
**HYDRAULIC HAZARD**
**1% AEP EVENT**




N

- Study Area
- Cadastre
- Buildings

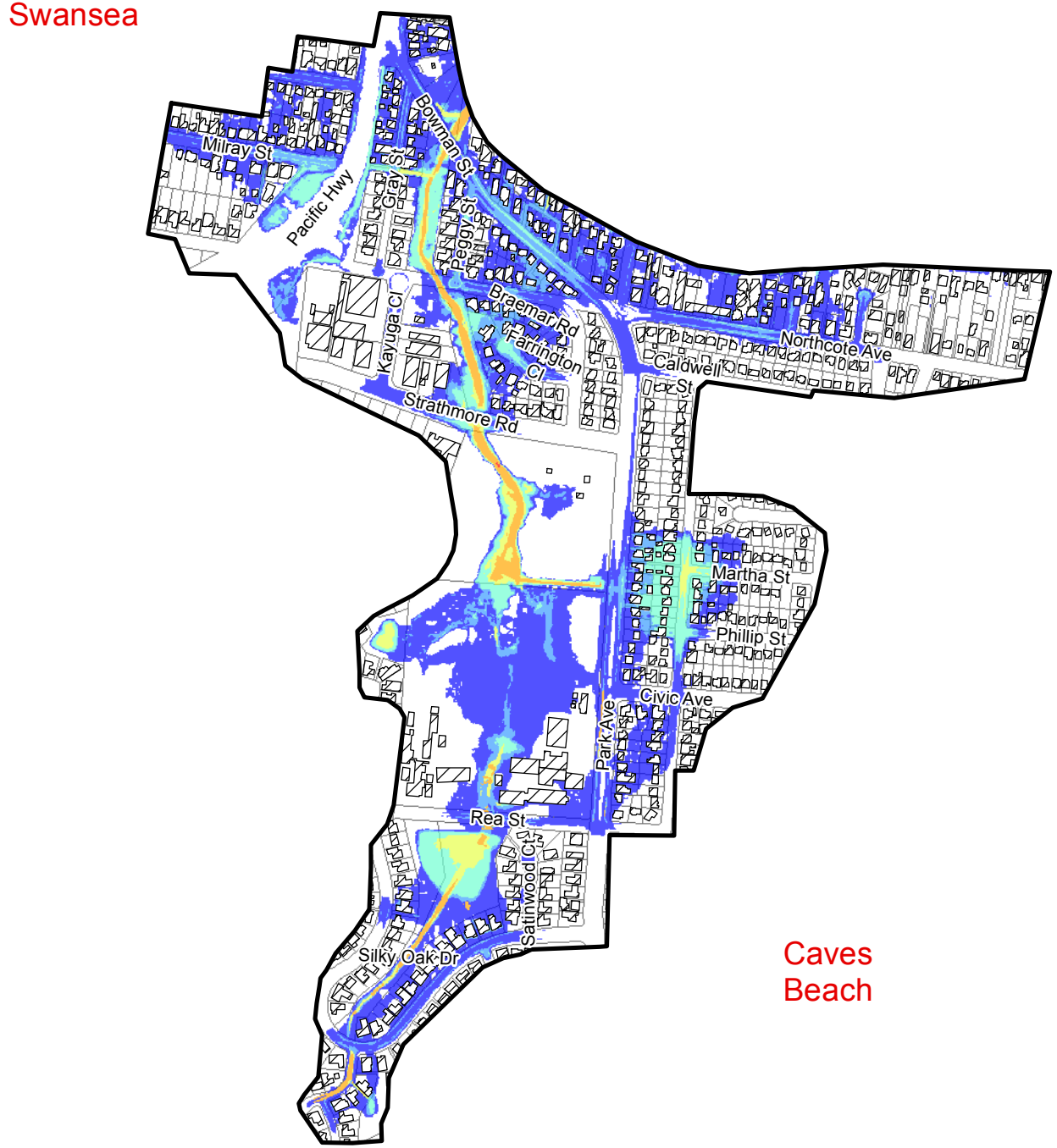
**Hazard**

- H1- Generally safe for people, vehicles and buildings
- H2- Unsafe for small vehicles
- H3- Unsafe for vehicles, children and the elderly
- H4- Unsafe for people and vehicles
- H5- Unsafe for people or vehicles. Buildings require special engineering design and construction
- H6- Unsafe for vehicles and people. All building types considered vulnerable to failure

0 0.25 0.5 km

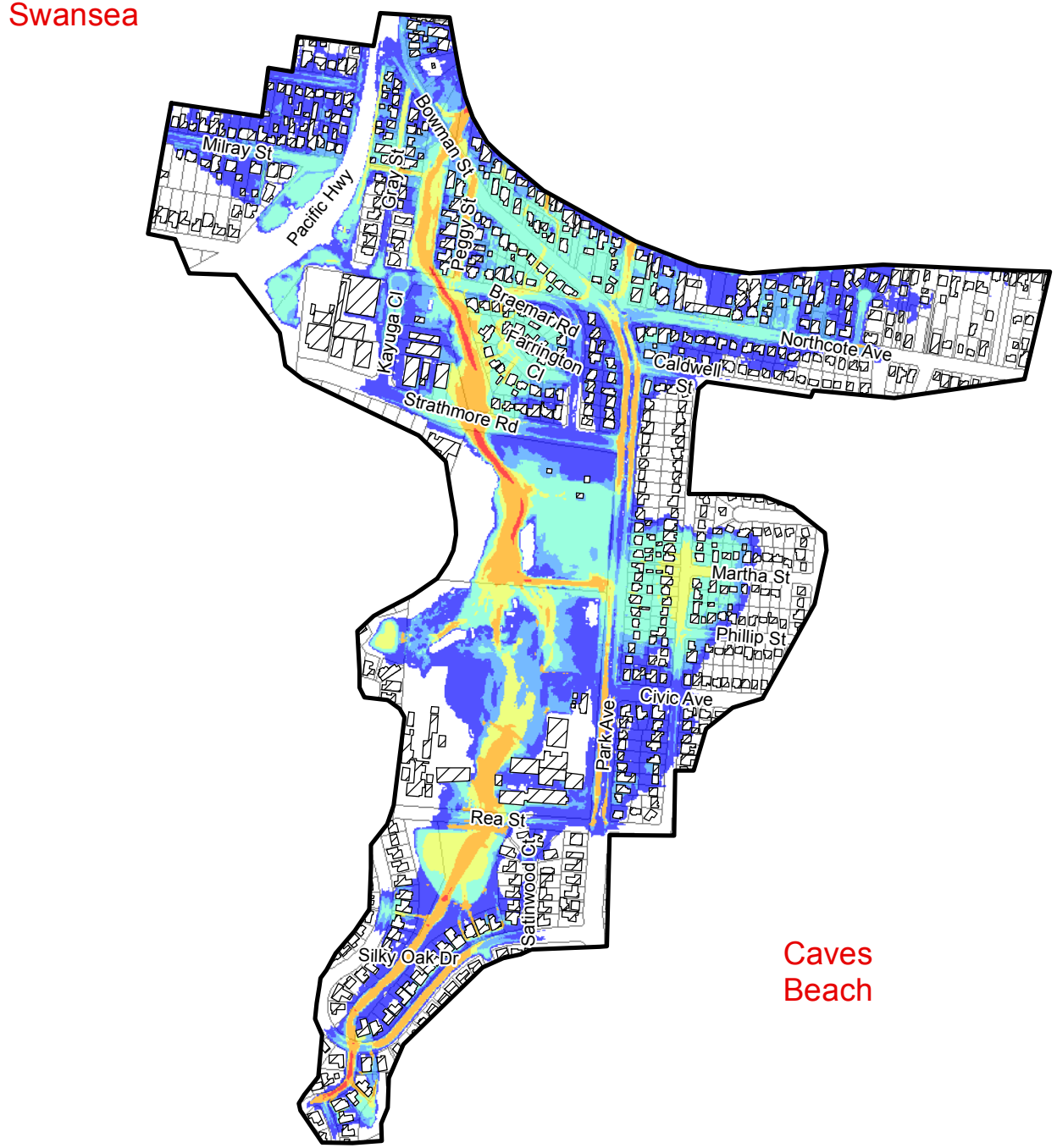
J:\Jobs\119076\ArcGIS\ArcMap\Working\Template\Appendix_C\FigureC29_Plains_Gully_Creek_Provisional_Hazard_2%AEP.mxd

FIGURE C31
**PLAINS GULLY CREEK**
**HYDRAULIC HAZARD**
**0.5% AEP EVENT**




J:\Jobs\119076\ArcGIS\ArcMap\Working\Template\Appendix_C\FigureC30_Plains_Gully_Creek_Provisional_Hazard_1%AEP.mxd

FIGURE C32
**PLAINS GULLY CREEK HYDRAULIC HAZARD PMF EVENT**




N

- Study Area
- Cadastre
- Buildings

**Hazard**

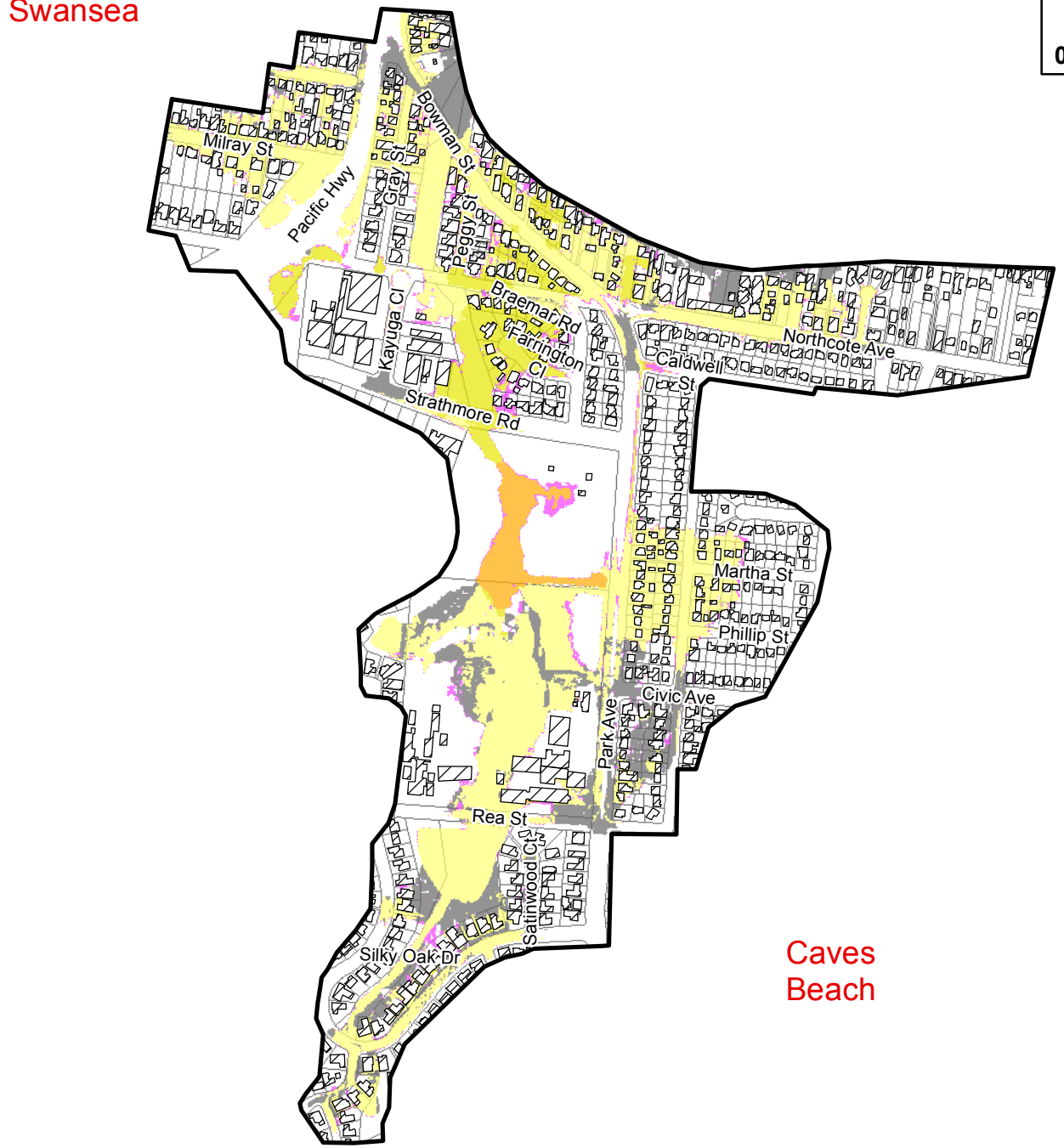
- H1- Generally safe for people, vehicles and buildings
- H2- Unsafe for small vehicles
- H3- Unsafe for vehicles, children and the elderly
- H4- Unsafe for people and vehicles
- H5- Unsafe for people or vehicles. Buildings require special engineering design and construction
- H6- Unsafe for vehicles and people. All building types considered vulnerable to failure

0 0.25 0.5 km

J:\Jobs\1190776\ArcGIS\ArcMap\Working\Template\Appendix_C\FigureC32_Plains_Gully_Creek_Provisional_Hazard_PMF.mxd

FIGURE C33

**PLAINS GULLY CREEK**
**CHANGE IN PEAK FLOOD LEVEL**
**0.5% AEP EVENT VS 1% AEP EVENT**




N

- Study Area
- Cadastre
- Buildings

**Impact (m)**

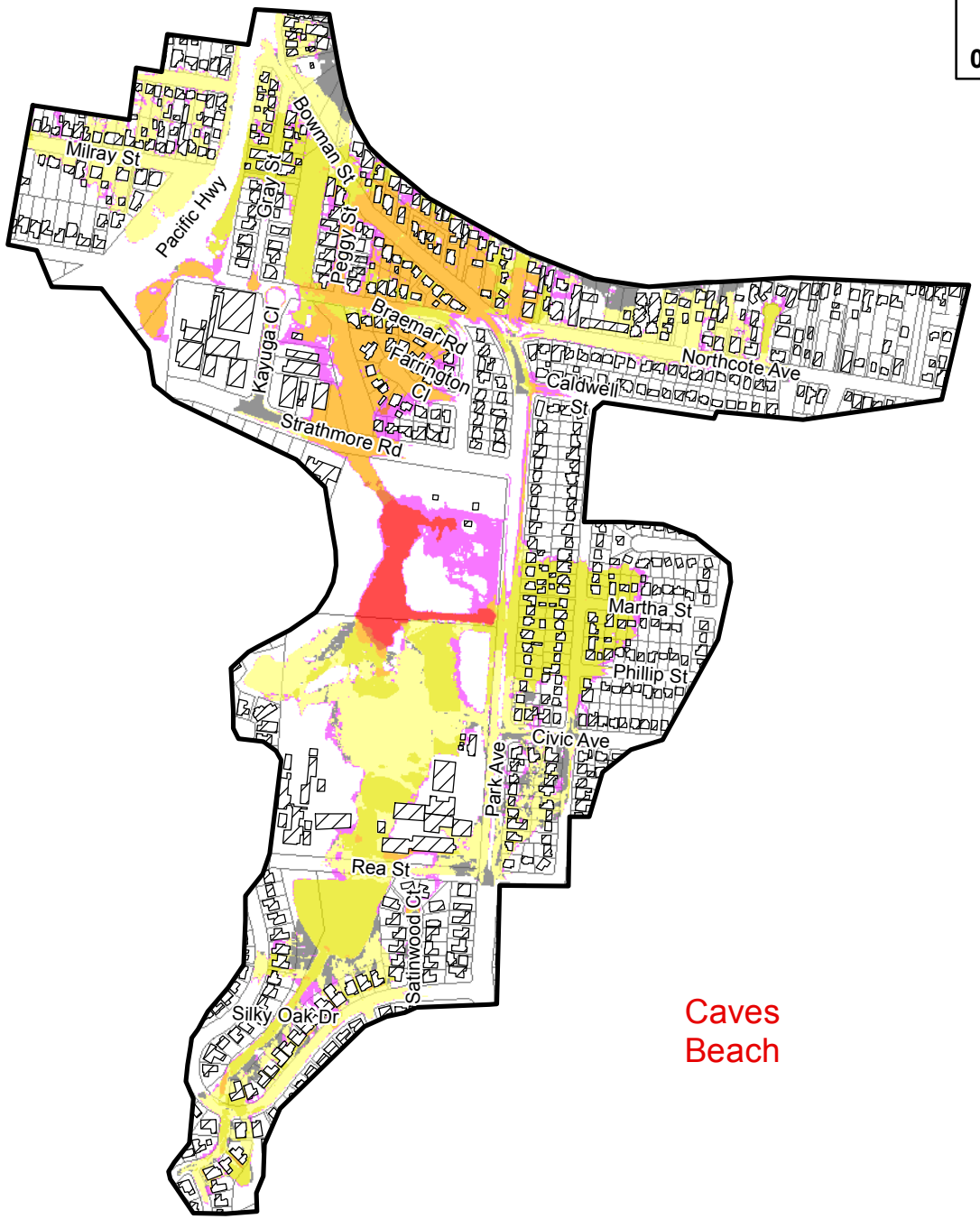
- < -0.4
- -0.4 to -0.3
- -0.3 to -0.2
- -0.2 to -0.1
- -0.1 to -0.05
- -0.05 to -0.01
- -0.01 to 0.01
- 0.01 to 0.05
- 0.05 to 0.1
- 0.1 to 0.2
- 0.2 to 0.3
- 0.3 to 0.4
- > 0.4
- Newly Flooded
- No Longer Flooded

0 0.25 0.5 km

J:\Jobs\1190776\ArcGIS\ArcMap\Working\Template\Appendix_C\FigureC33_Plains_Gully_Creek_Impact_CC_0.5%AEP_V_1%AEP.mxd

FIGURE C34

**PLAINS GULLY CREEK**
**CHANGE IN PEAK FLOOD LEVEL**
**0.2% AEP EVENT VS 1% AEP EVENT**




N

- Study Area
- Cadastre
- Buildings

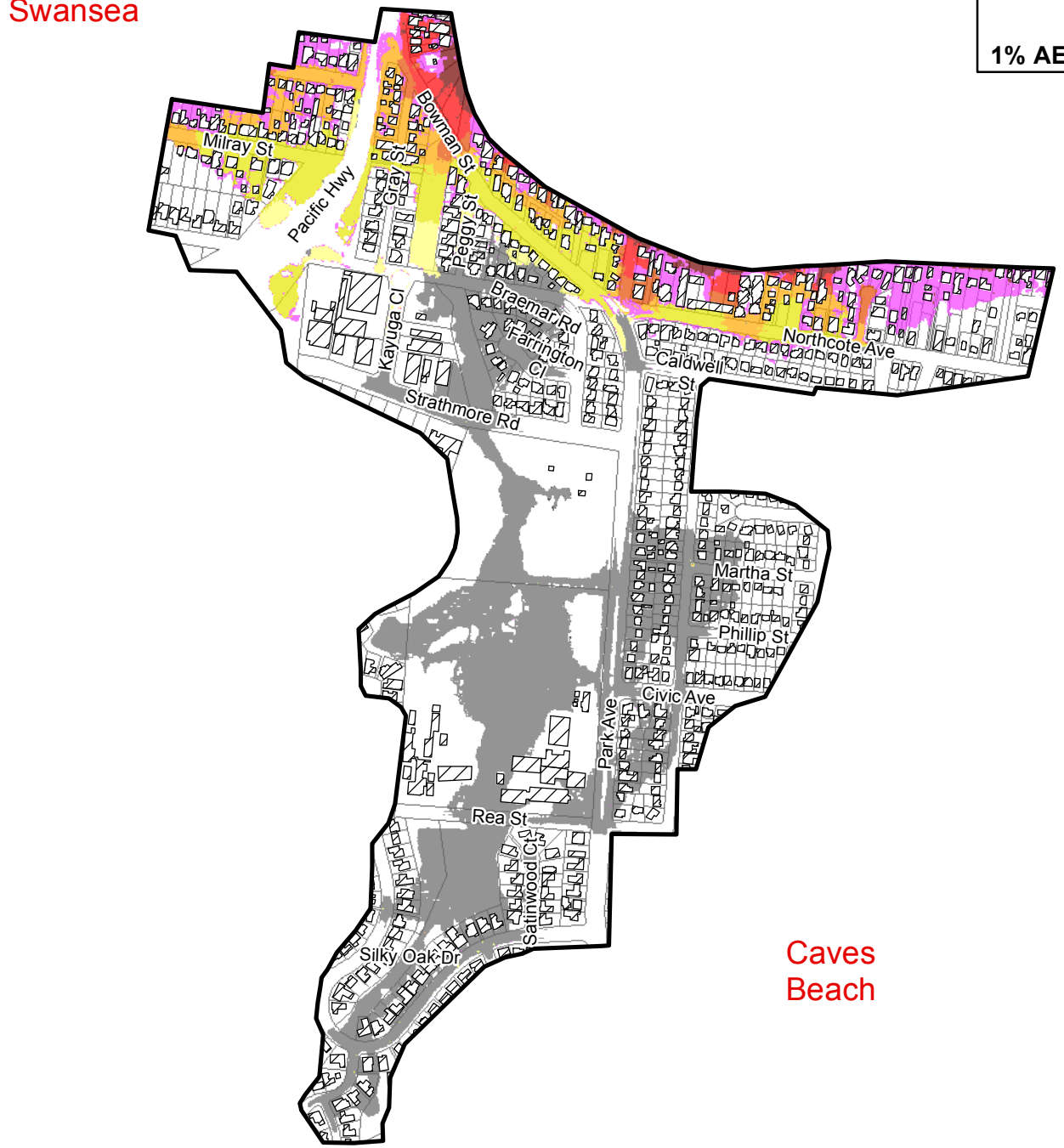
**Impact (m)**

- < -0.4
- -0.4 to -0.3
- -0.3 to -0.2
- -0.2 to -0.1
- -0.1 to -0.05
- -0.05 to -0.01
- -0.01 to 0.01
- 0.01 to 0.05
- 0.05 to 0.1
- 0.1 to 0.2
- 0.2 to 0.3
- 0.3 to 0.4
- > 0.4
- Newly Flooded
- No Longer Flooded

0 0.25 0.5 km

J:\Jobs\119076\ArcGIS\ArcMap\Working\Template\Appendix_C\FigureC34_Plains_Gully_Creek_Impact_CC_0.2%AEP_V_1%AEP.mxd

FIGURE C35
**PLAINS GULLY CREEK**
**CHANGE IN PEAK FLOOD LEVEL**
**1% AEP EVENT - SEA LEVEL RISE 400MM**



Study Area
Cadastre
Buildings

**Impact (m)**

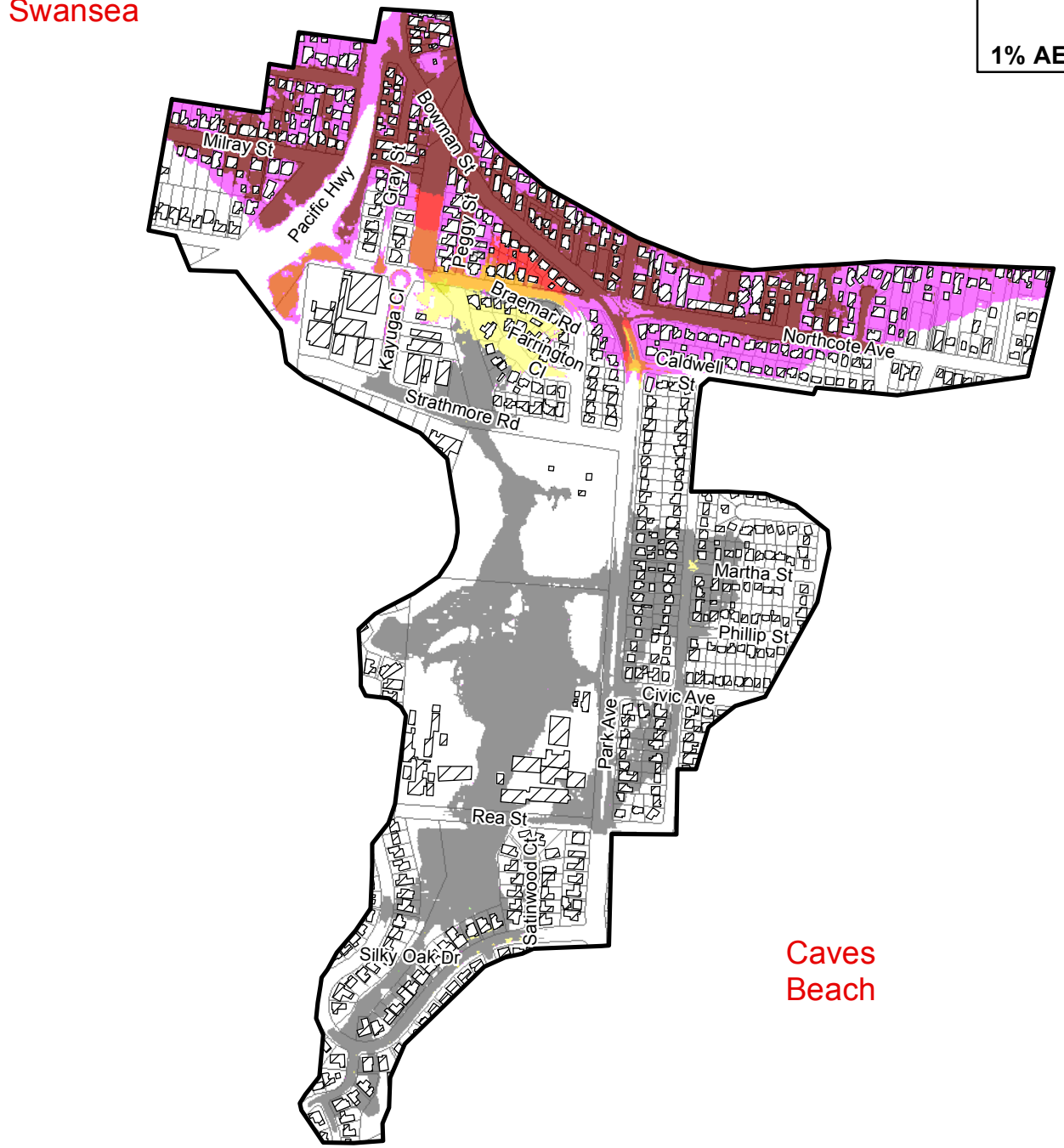
- < -0.4
- -0.4 to -0.3
- -0.3 to -0.2
- -0.2 to -0.1
- -0.1 to -0.05
- -0.05 to -0.01
- -0.01 to 0.01
- 0.01 to 0.05
- 0.05 to 0.1
- 0.1 to 0.2
- 0.2 to 0.3
- 0.3 to 0.4
- > 0.4
- Newly Flooded
- No Longer Flooded

0 0.25 0.5 km

J:\Jobs\1190776\ArcGIS\ArcMap\Working\Template\Appendix_C\FigureC34_Plains_Gully_Creek_Impact_CC_0.2%AEP_V_1%AEP.mxd

FIGURE C36

**PLAINS GULLY CREEK**
**CHANGE IN PEAK FLOOD LEVEL**
**1% AEP EVENT - SEA LEVEL RISE 900MM**




N

- Study Area
- Cadastre
- Buildings

**Impact (m)**

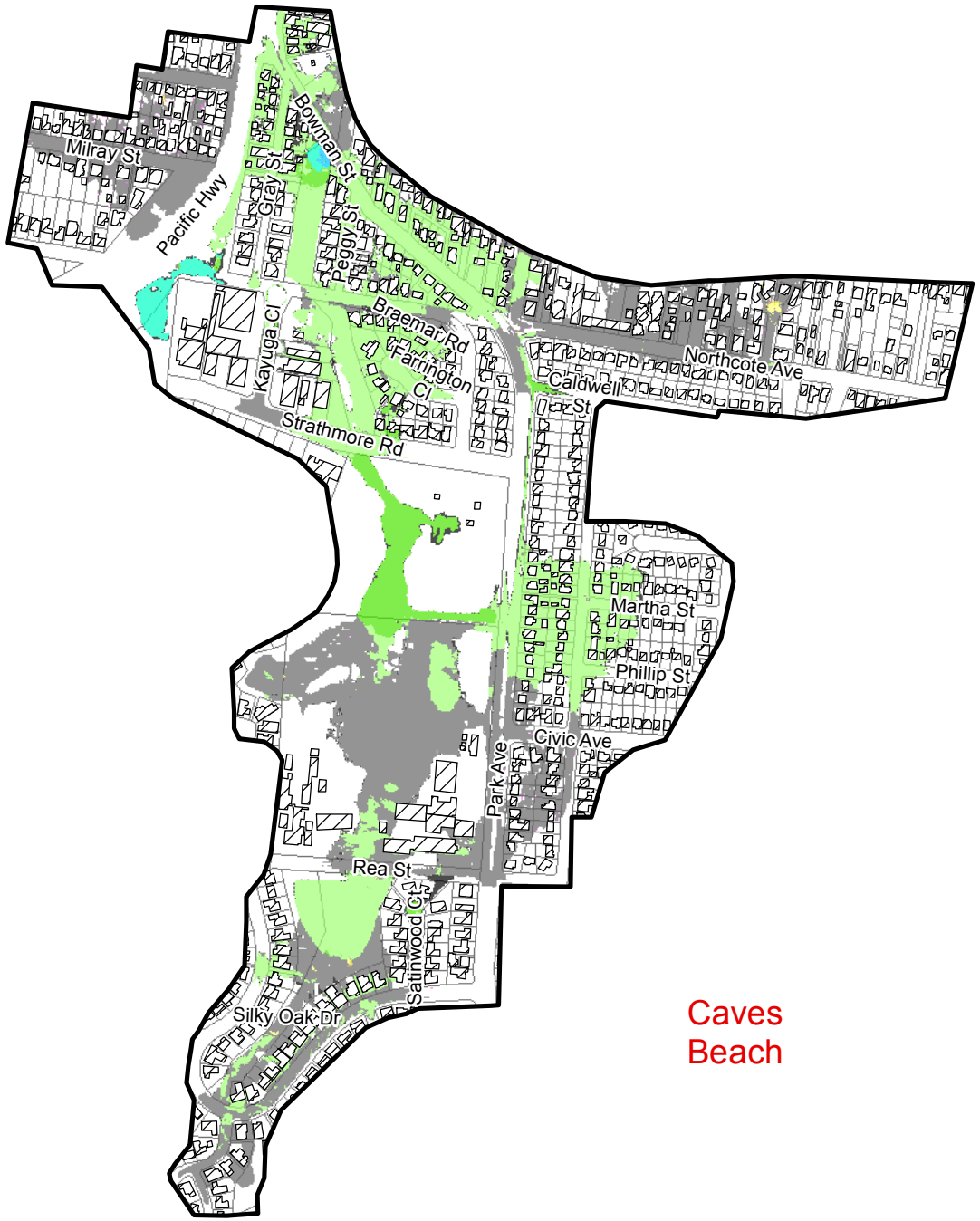
- < -0.4
- -0.4 to -0.3
- -0.3 to -0.2
- -0.2 to -0.1
- -0.1 to -0.05
- -0.05 to -0.01
- -0.01 to 0.01
- 0.01 to 0.05
- 0.05 to 0.1
- 0.1 to 0.2
- 0.2 to 0.3
- 0.3 to 0.4
- > 0.4
- Newly Flooded
- No Longer Flooded

0 0.25 0.5 km

J:\Jobs\1190776\ArcGIS\ArcMap\Working\Template\Appendix_C\FigureC35_Plains_Gully_Creek_Impact_CC_SLR04_1%AEP.mxd

FIGURE C37

**PLAINS GULLY CREEK**
**CHANGE IN PEAK FLOOD LEVEL**
**1% AEP EVENT - 25% BLOCKAGE**




N

- Study Area
- Cadastre
- Buildings

**Impact (m)**

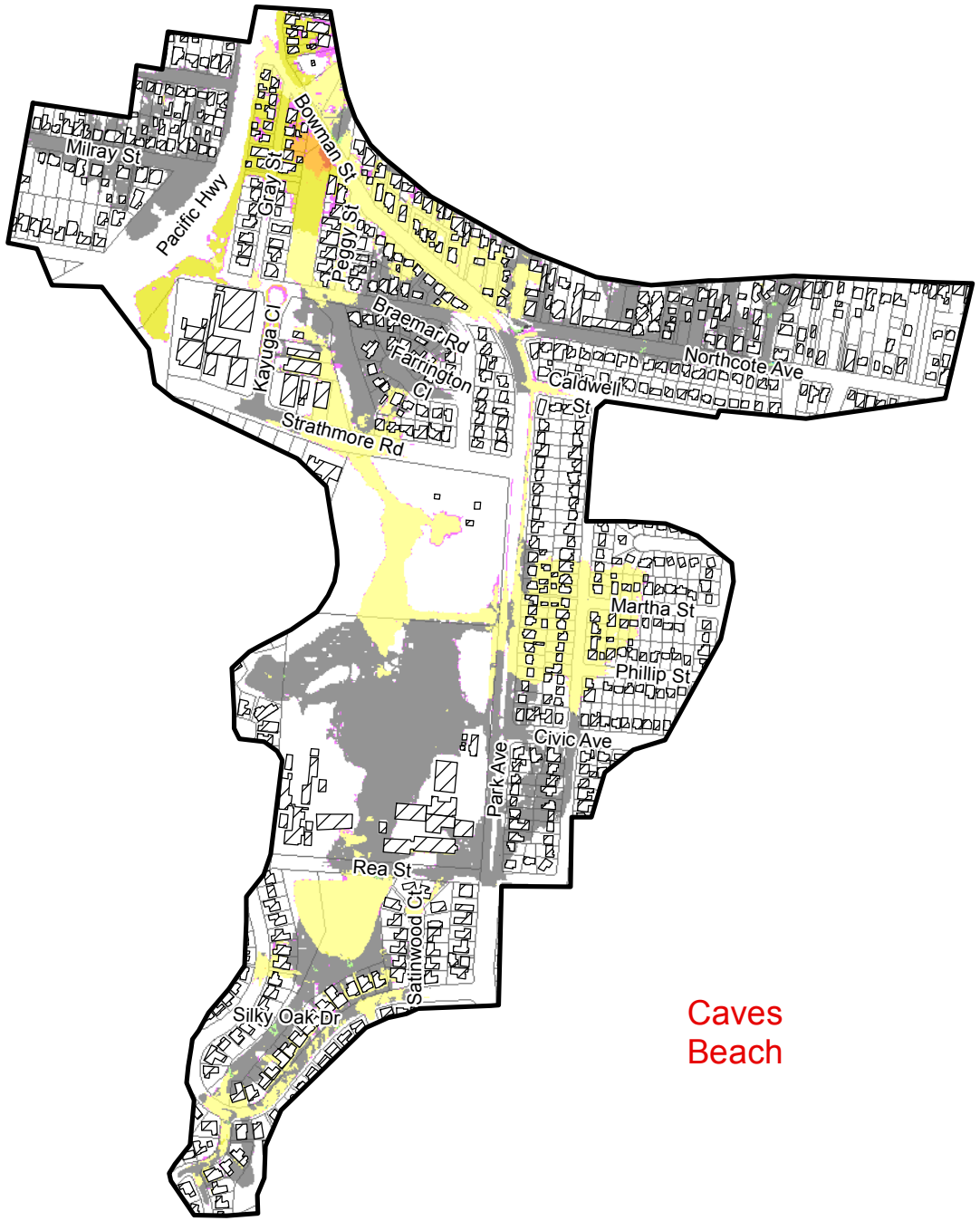
- < -0.4
- -0.4 to -0.3
- -0.3 to -0.2
- -0.2 to -0.1
- -0.1 to -0.05
- -0.05 to -0.01
- -0.01 to 0.01
- 0.01 to 0.05
- 0.05 to 0.1
- 0.1 to 0.2
- 0.2 to 0.3
- 0.3 to 0.4
- > 0.4
- Newly Flooded
- No Longer Flooded

0 0.25 0.5 km

J:\Jobs\1190776\ArcGIS\ArcMap\Working\Template\Appendix_C\FigureC36_Plains_Gully_Creek_Impact_CC_SLR09_1%AEP.mxd

FIGURE C38

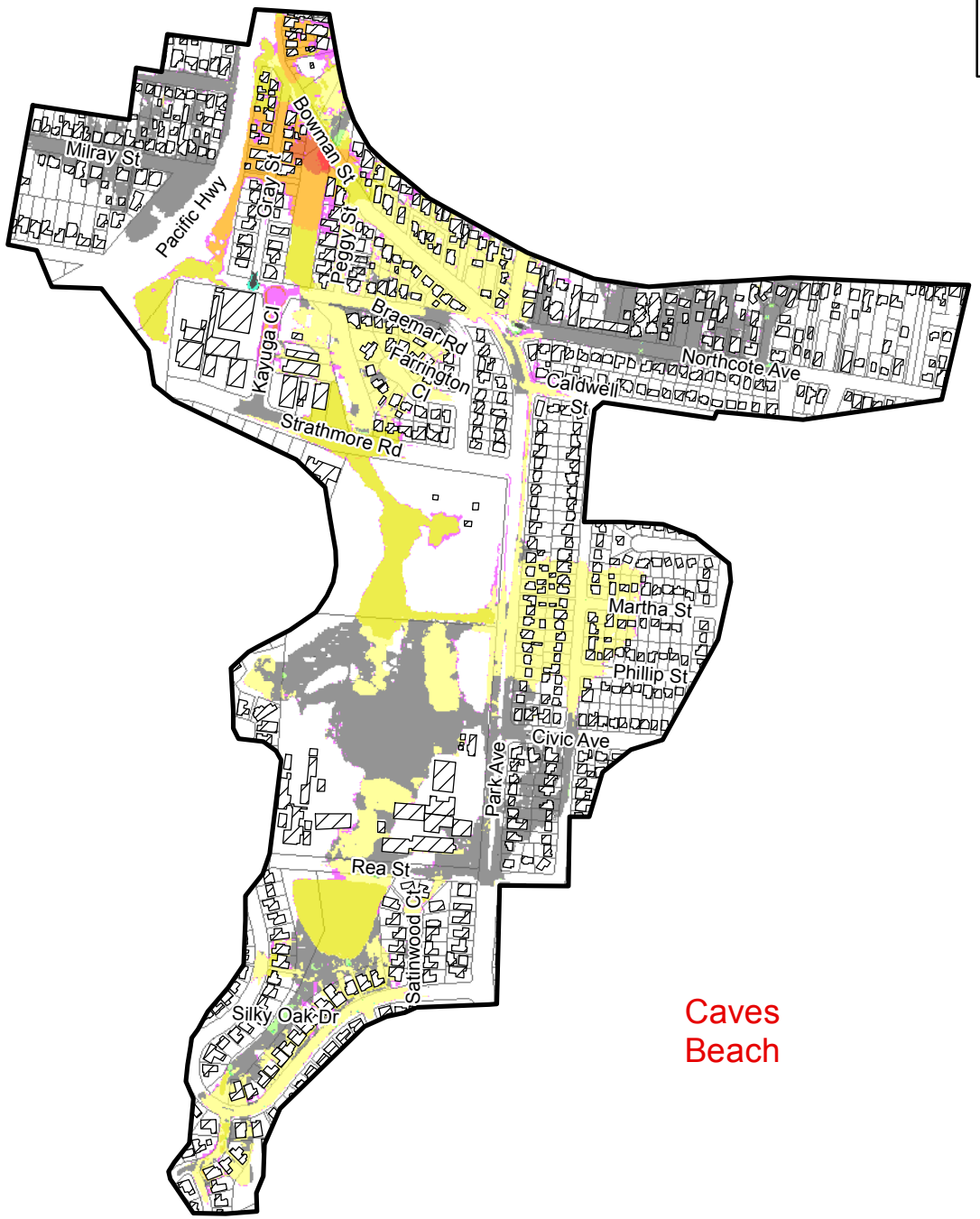
**PLAINS GULLY CREEK**
**CHANGE IN PEAK FLOOD LEVEL**
**1% AEP EVENT - 75% BLOCKAGE**




J:\Jobs\1190776\ArcGIS\ArcMap\Working\Template\Appendix_C\FigureC37_Plains_Gully_Creek_Impact_1%AEP_Blockage25pc.mxd

FIGURE C39

**PLAINS GULLY CREEK**
**CHANGE IN PEAK FLOOD LEVEL**
**1% AEP EVENT - 100% BLOCKAGE**




N

- Study Area
- Cadastre
- Buildings

**Impact (m)**

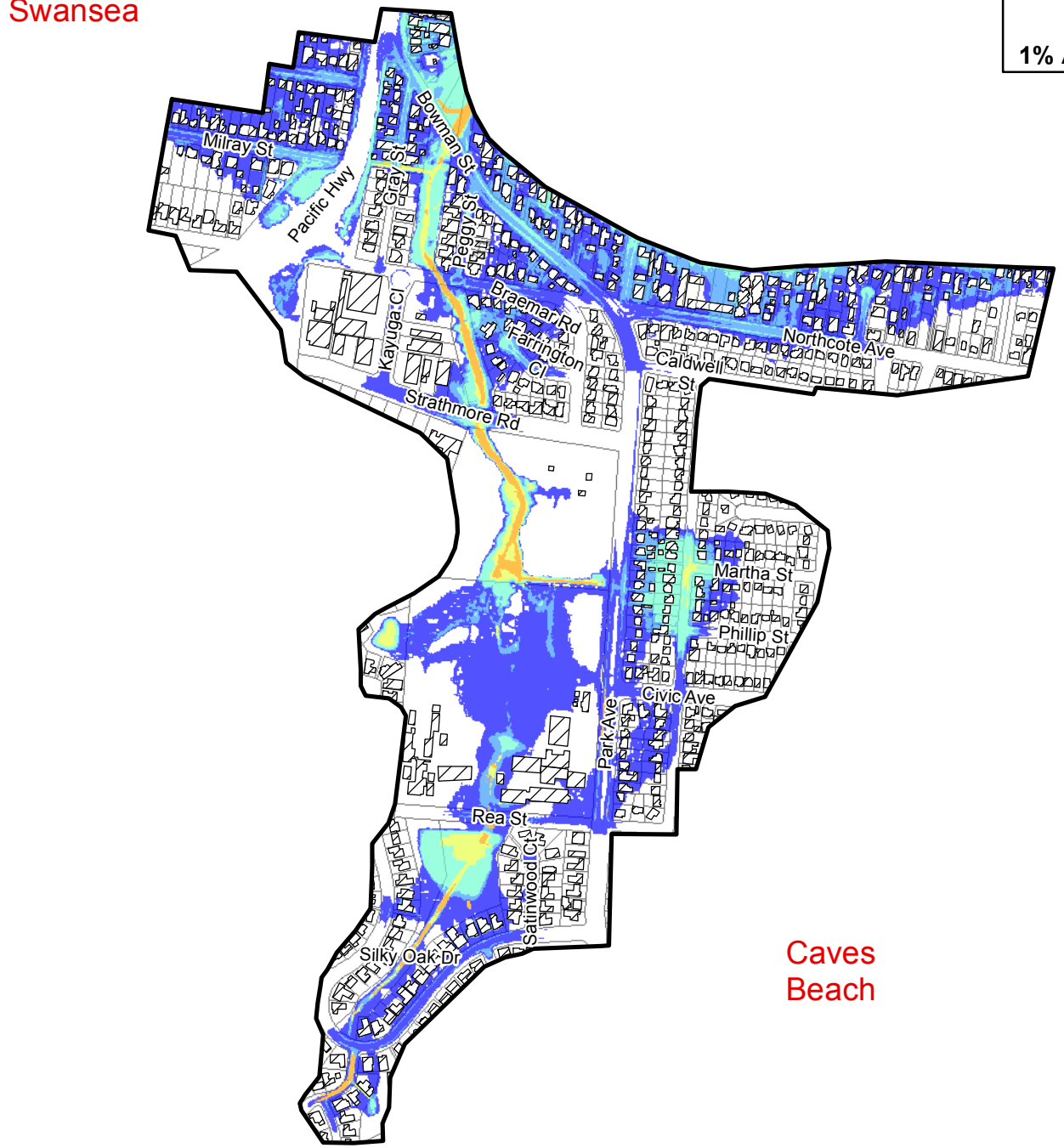
- < -0.4
- -0.4 to -0.3
- -0.3 to -0.2
- -0.2 to -0.1
- -0.1 to -0.05
- -0.05 to -0.01
- -0.01 to 0.01
- 0.01 to 0.05
- 0.05 to 0.1
- 0.1 to 0.2
- 0.2 to 0.3
- 0.3 to 0.4
- > 0.4
- Newly Flooded
- No Longer Flooded

0 0.25 0.5 km

J:\Jobs\119076\ArcGIS\ArcMap\Working\Template\Appendix_C\FigureC39_Plains_Gully_Creek_Impact_1%AEP_Blockage100pc.mxd

FIGURE C40

**PLAINS GULLY CREEK**
**HYDRAULIC HAZARD**
**1% AEP EVENT - SEA LEVEL RISE 0.4M**




N

- Study Area
- Cadastre
- Buildings

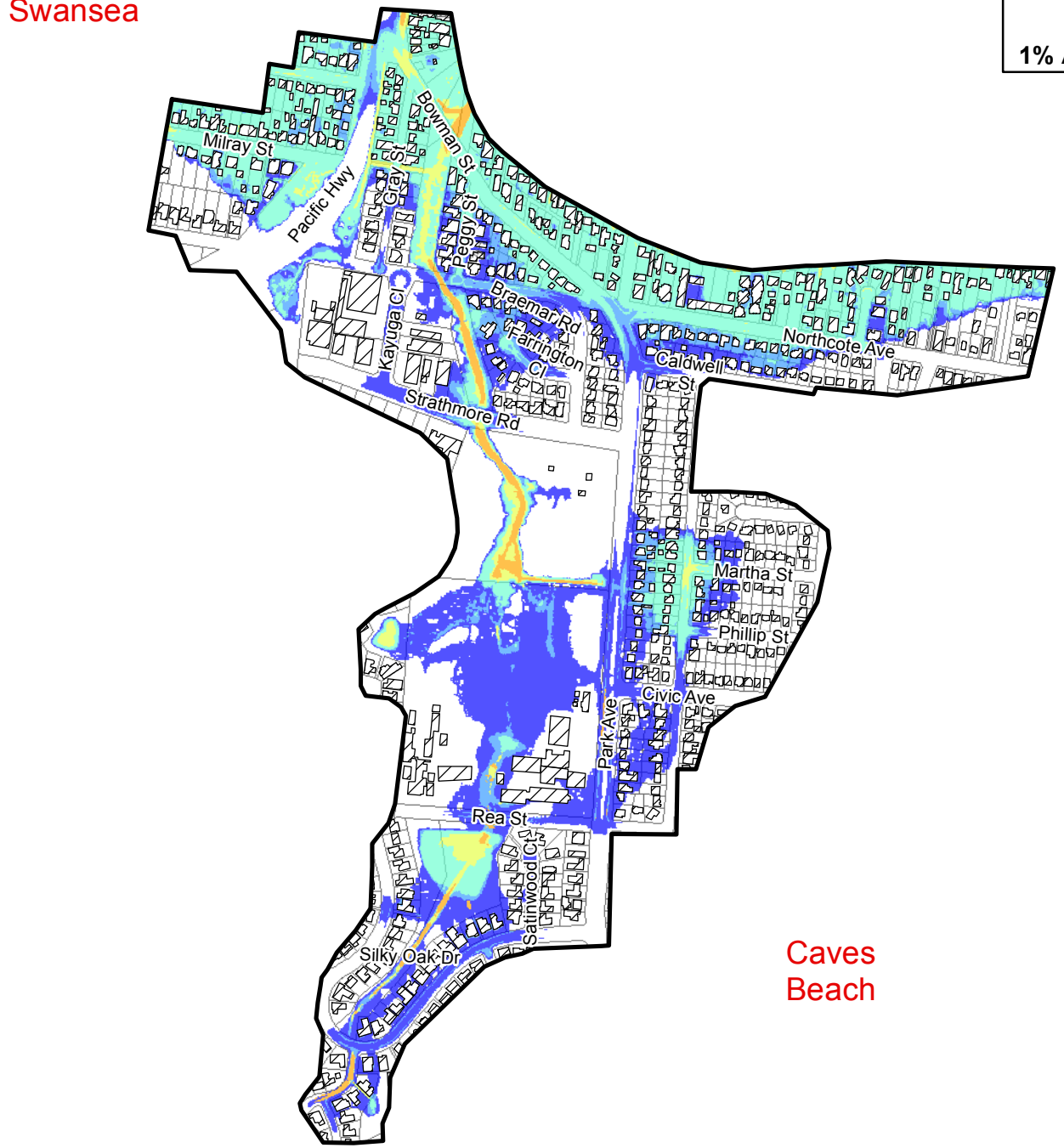
**Hazard**

- H1- Generally safe for people, vehicles and buildings
- H2- Unsafe for small vehicles
- H3- Unsafe for vehicles, children and the elderly
- H4- Unsafe for people and vehicles
- H5- Unsafe for people or vehicles. Buildings require special engineering design and construction
- H6- Unsafe for vehicles and people. All building types considered vulnerable to failure

0 0.25 0.5 km

J:\Jobs\119076\ArcGIS\ArcMap\Working\Template\Appendix_C\FigureC25_Plains_Gully_Creek_Provisional_Hazard_50%AEP.mxd

FIGURE C41
**PLAINS GULLY CREEK**
**HYDRAULIC HAZARD**
**1% AEP EVENT - SEA LEVEL RISE 0.9M**




N

- Study Area
- Cadastre
- Buildings

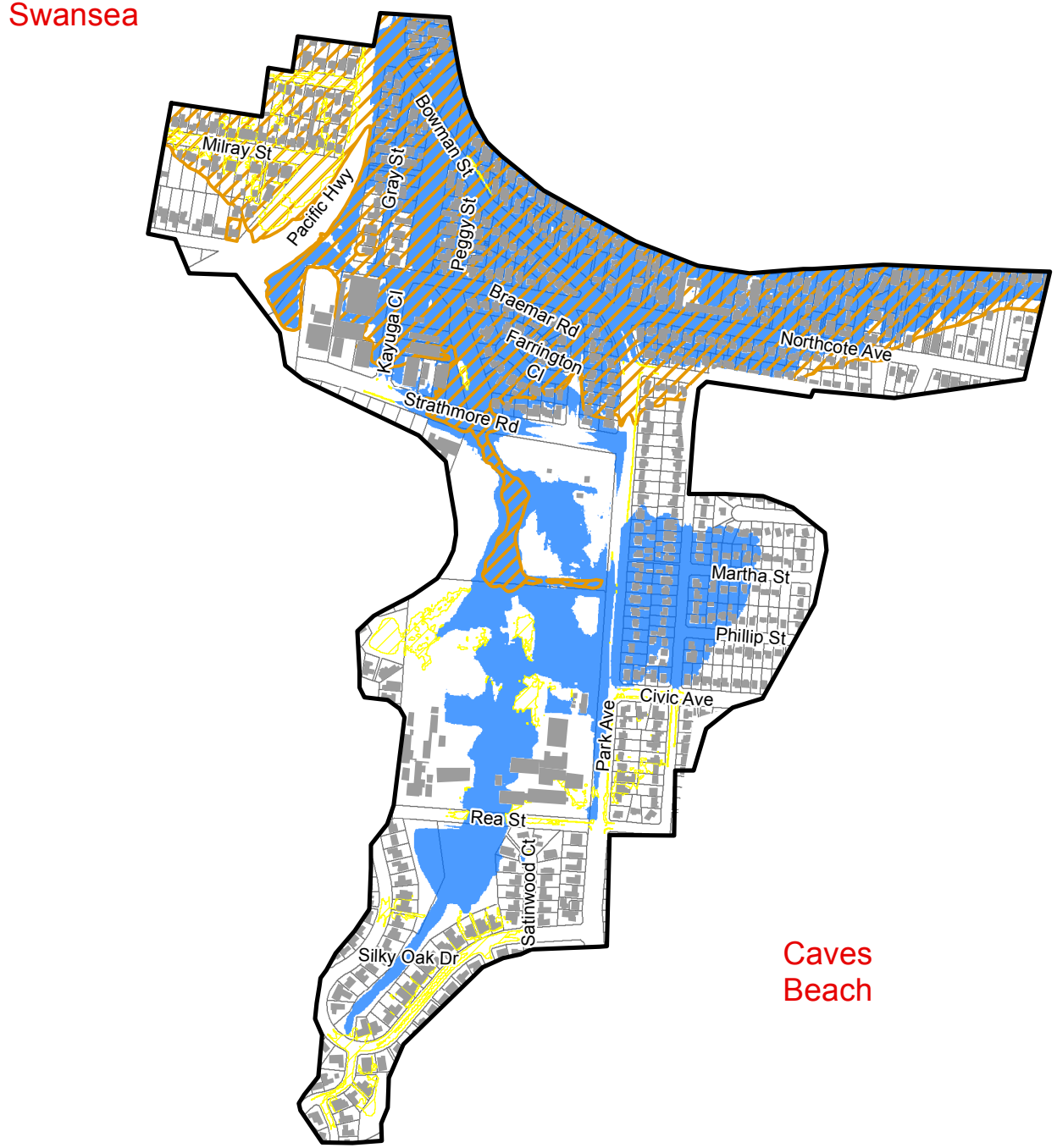
**Hazard**

- H1- Generally safe for people, vehicles and buildings
- H2- Unsafe for small vehicles
- H3- Unsafe for vehicles, children and the elderly
- H4- Unsafe for people and vehicles
- H5- Unsafe for people or vehicles. Buildings require special engineering design and construction
- H6- Unsafe for vehicles and people. All building types considered vulnerable to failure

0 0.25 0.5 km

J:\Jobs\119076\ArcGIS\ArcMap\Working\Template\Appendix_C\FigureC41_Plains_Gully_Creek_Provisional_Hazard_1%AEP_SLR09.mxd

FIGURE C42
**PLAINS GULLY CREEK FLOOD PLANNING AREA**




J:\Jobs\119076\ArcGIS\ArcMap\Report\Appendix_C\FigureC42_Plains_Gully_Creek_Flood_Planning_Area.mxd

**APPENDIX D: DESIGN FLOOD MAPS – SHEPPARDS CREEK**

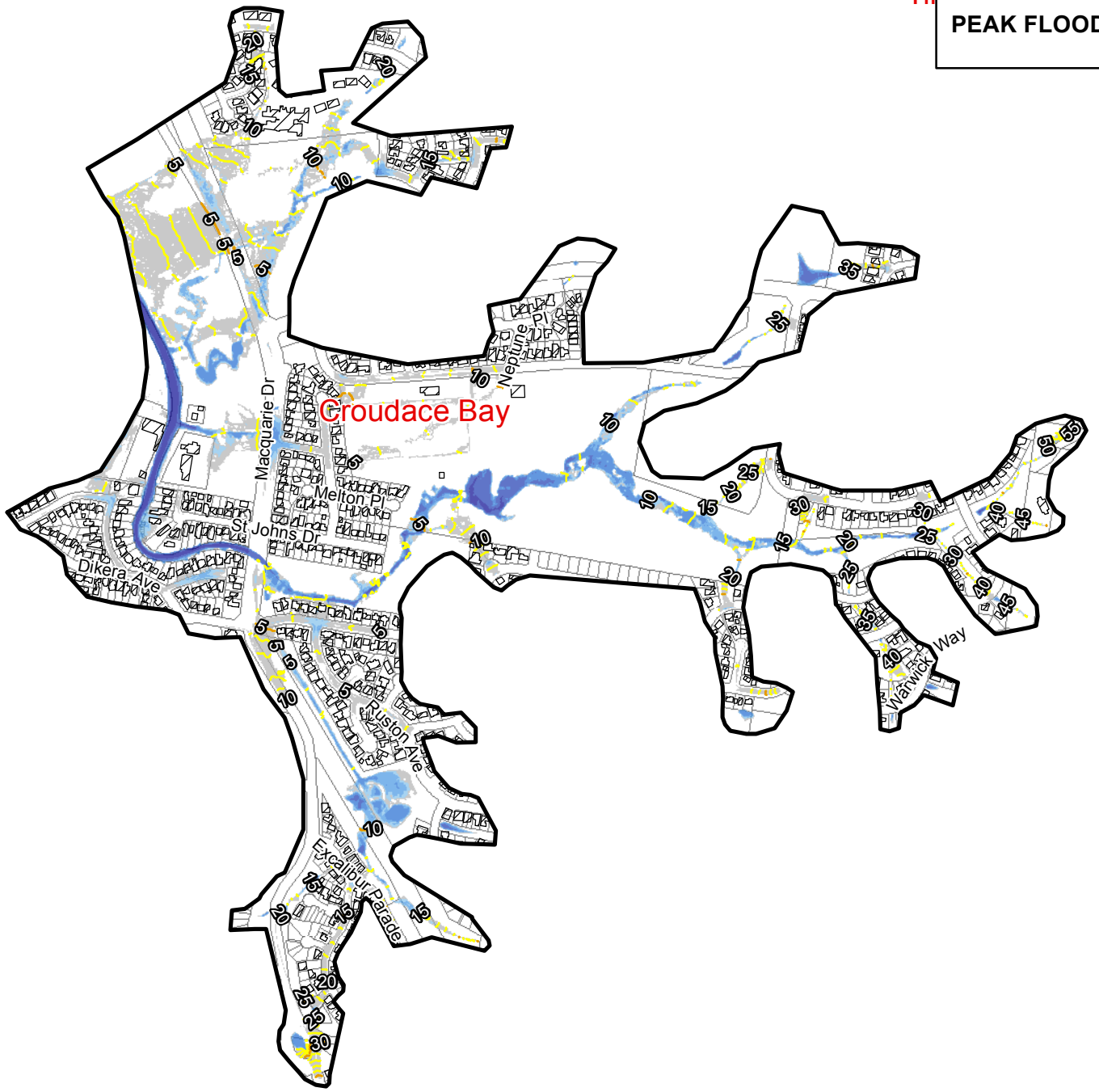
Appendix D

FIGURE D1

**SHEPPARDS CREEK**

**PEAK FLOOD DEPTH AND LEVEL CONTOUR**

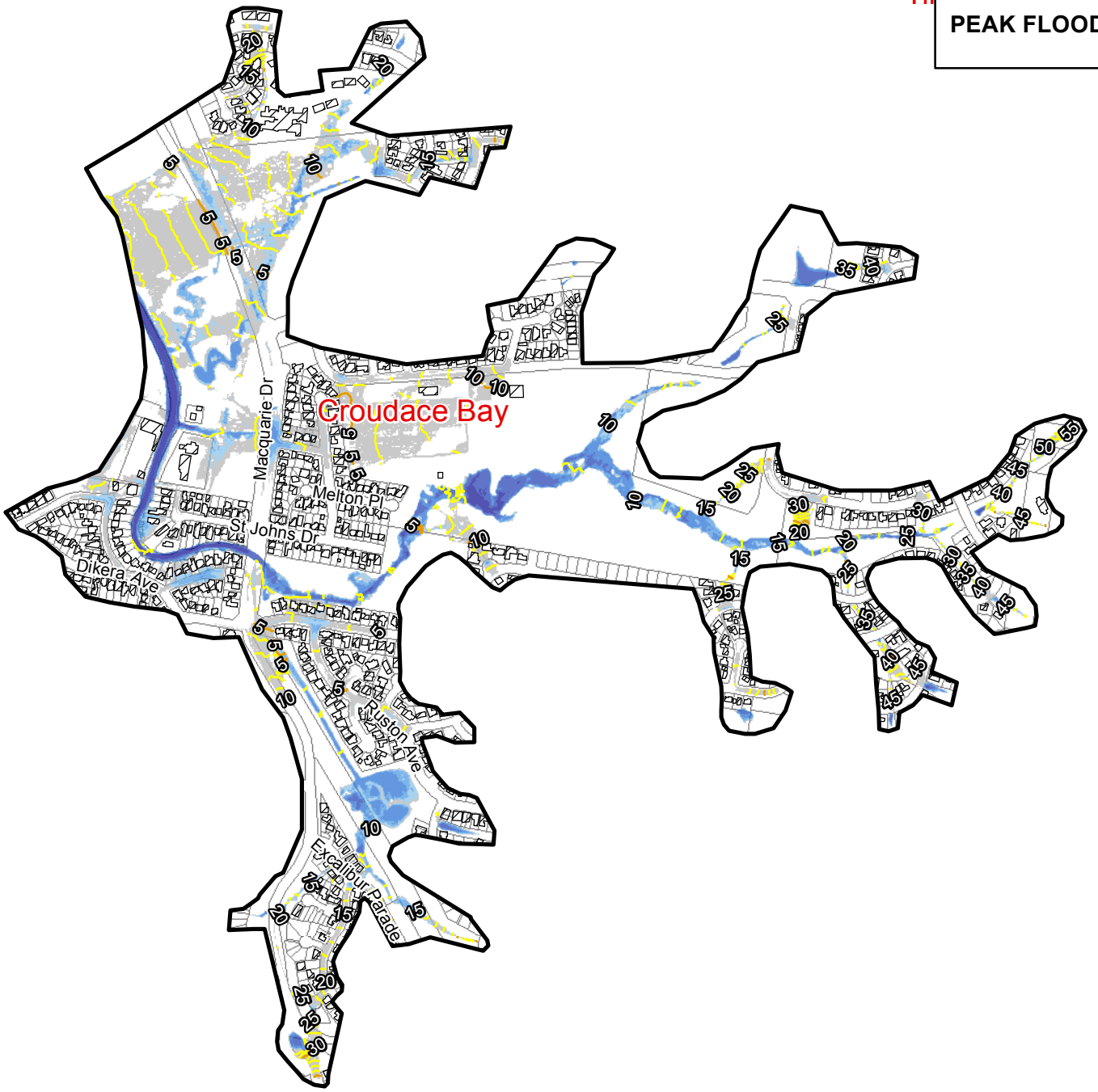
**50% AEP EVENT**




J:\Jobs\1190776\ArcGIS\ArcMap\Working\Template\Appendix_D\FigureD01_Sheppards_Creek_Peak_Flood_Depth_50%AEP.mxd

FIGURE D2

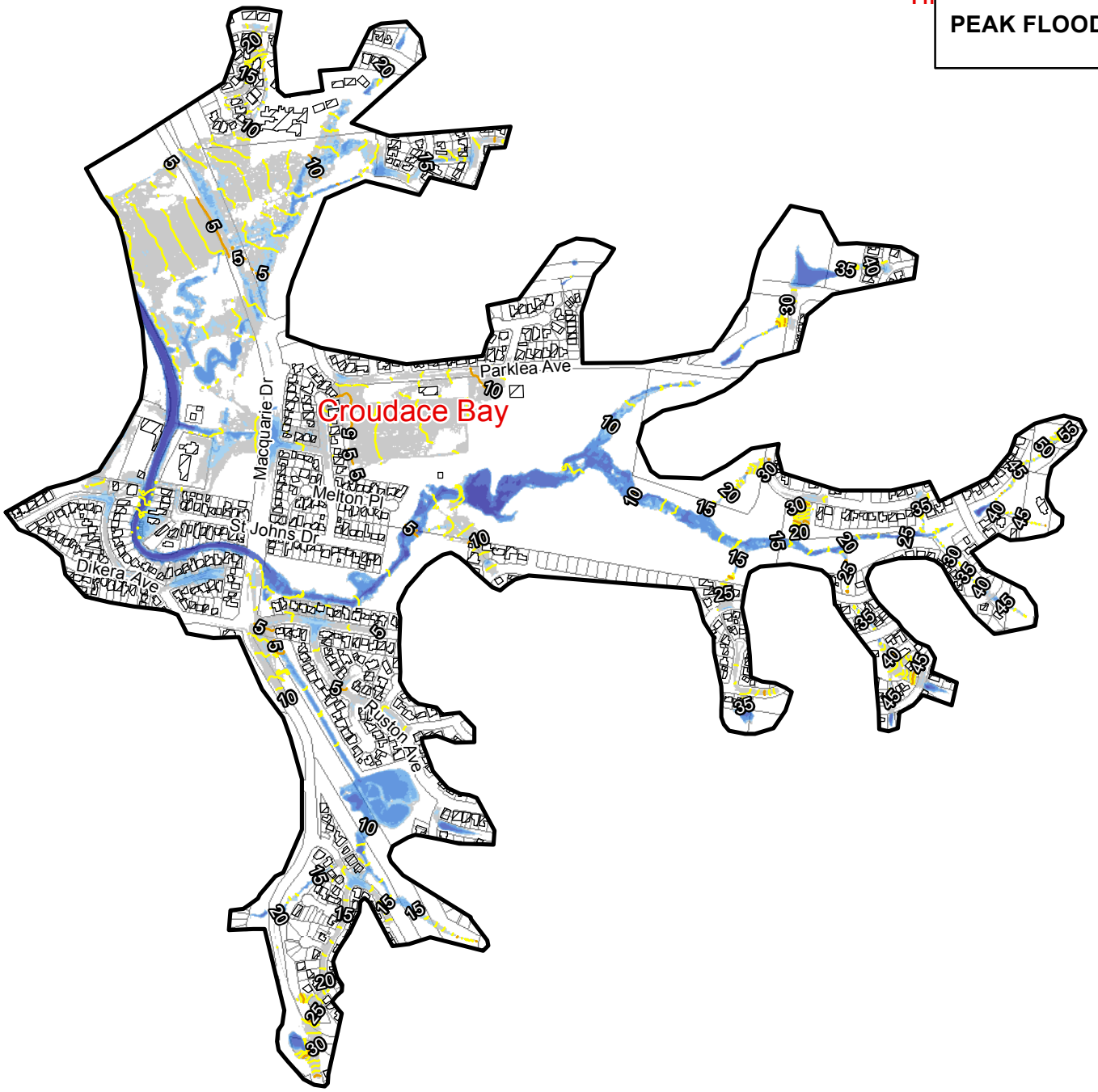
**SHEPPARDS CREEK**
**PEAK FLOOD DEPTH AND LEVEL CONTOUR**
**20% AEP EVENT**




J:\Jobs\119076\ArcGIS\ArcMap\Working\Template\Appendix_D\FigureD02_Sheppards_Creek_Peak_Flood_Depth_20%AEP.mxd

FIGURE D3

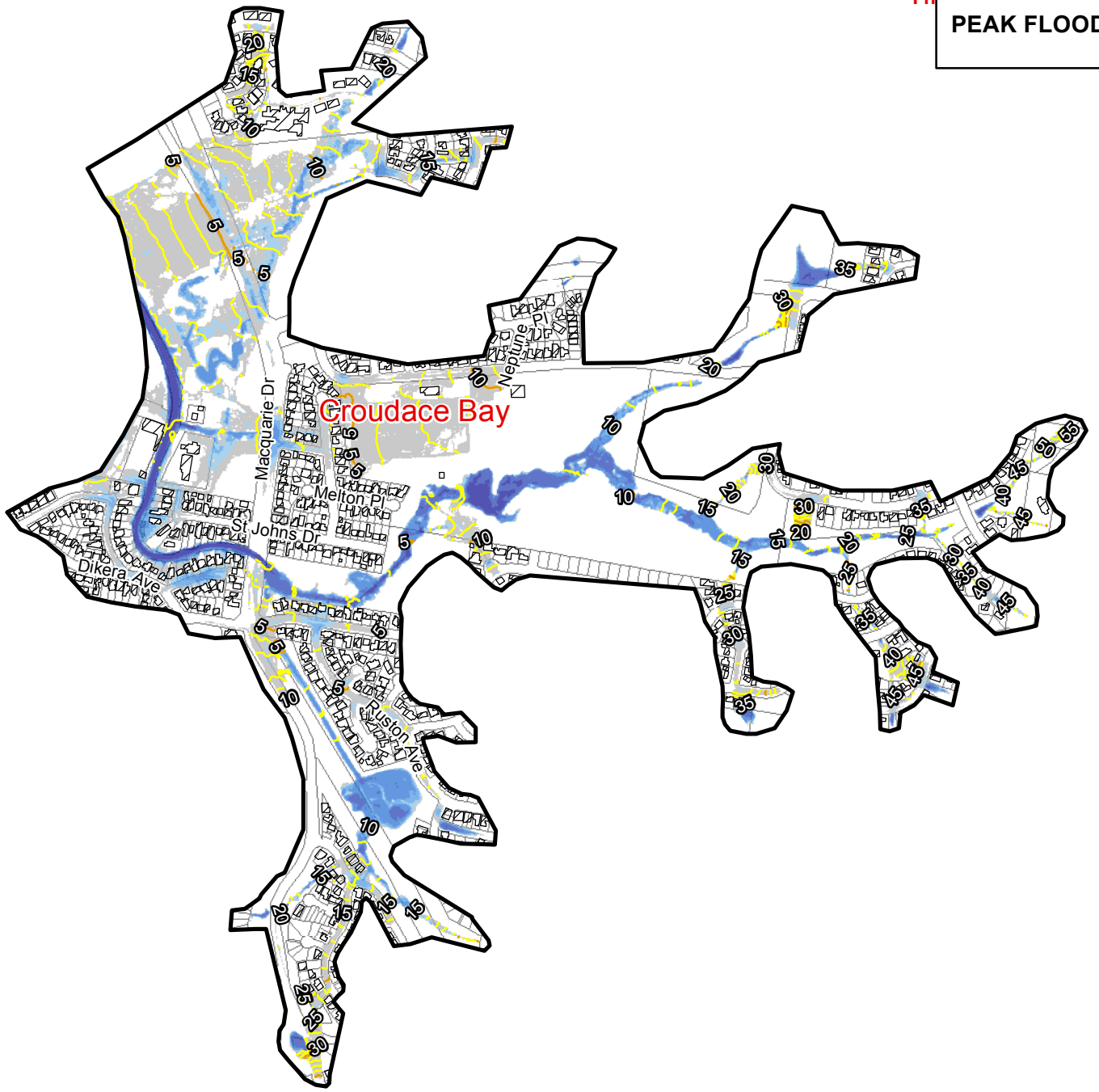
**SHEPPARDS CREEK**
**PEAK FLOOD DEPTH AND LEVEL CONTOUR**
**10% AEP EVENT**




J:\Jobs\119076\ArcGIS\ArcMap\Working\Template\Appendix_D\FigureD02_Sheppards_Creek_Peak_Flood_Depth_20%AEP.mxd

FIGURE D4

**SHEPPARDS CREEK**
**PEAK FLOOD DEPTH AND LEVEL CONTOUR**
**5% AEP EVENT**



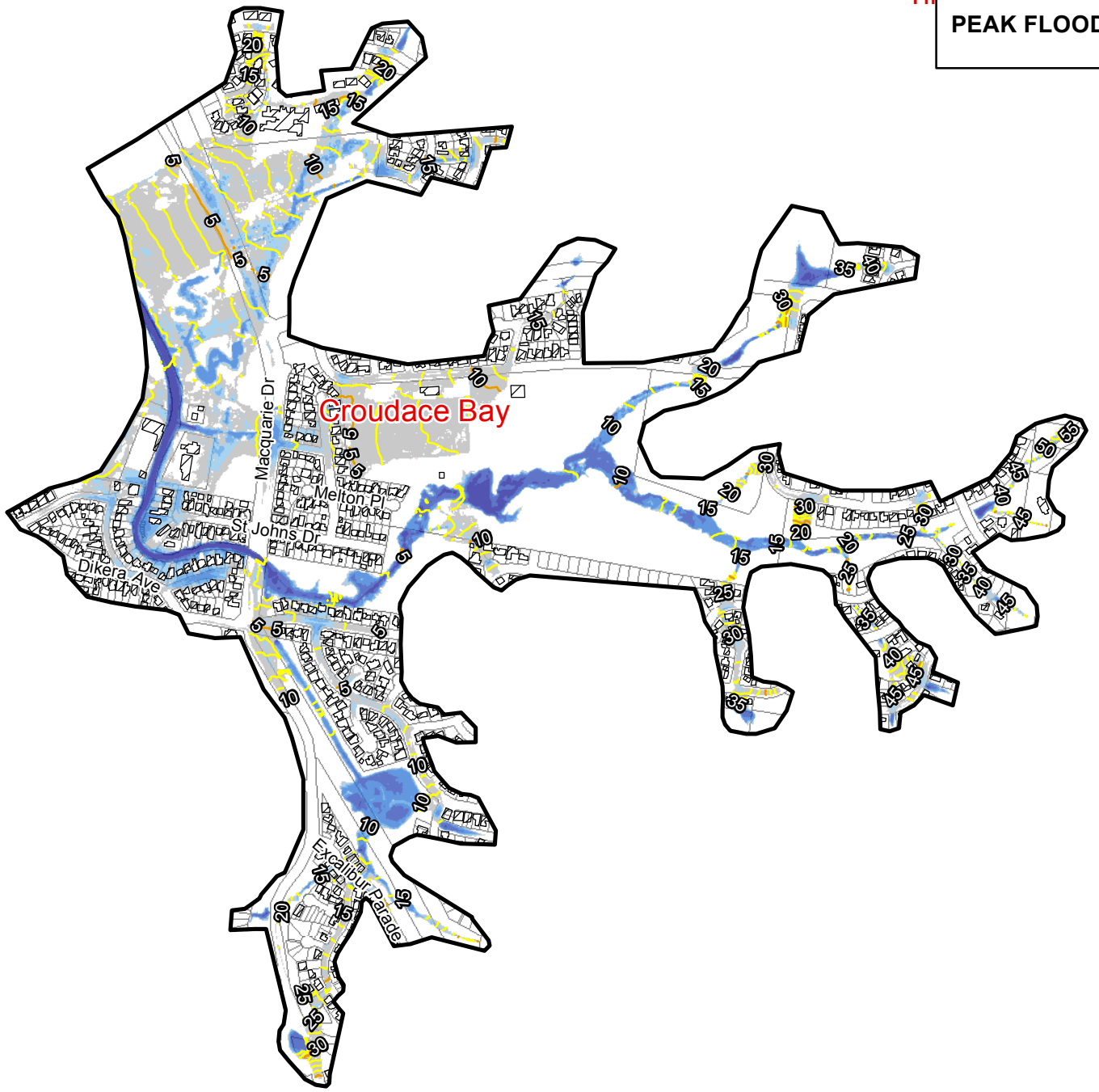

J:\Jobs\119076\ArcGIS\ArcMap\Working\Template\Appendix_D\FigureD03_Sheppards_Creek_Peak_Flood_Depth_10%AEP.mxd

FIGURE D5

**SHEPPARDS CREEK**

**PEAK FLOOD DEPTH AND LEVEL CONTOUR**

**2% AEP EVENT**



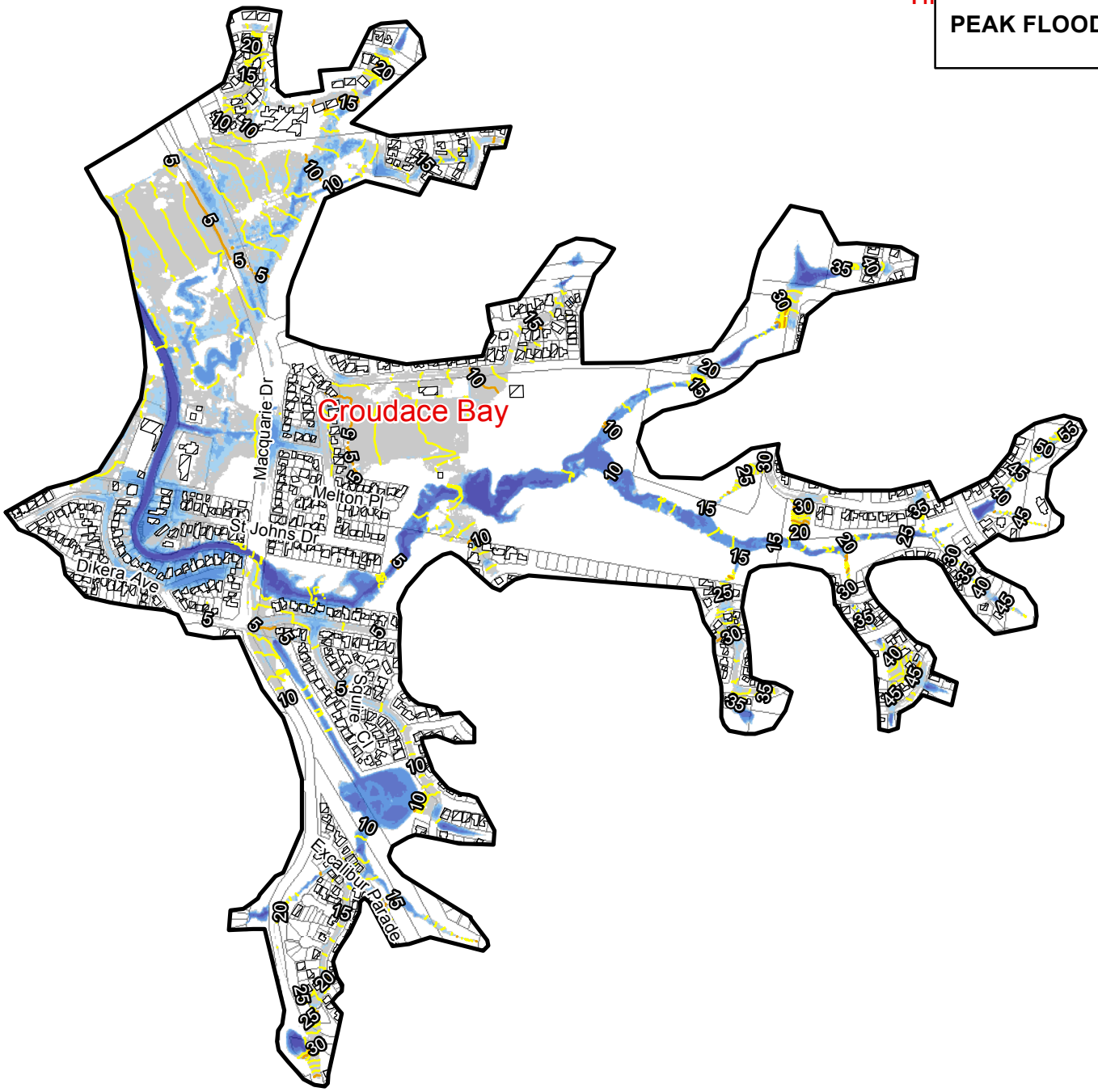

J:\Jobs\119076\ArcGIS\ArcMap\Working\Template\Appendix_D\FigureD04_Sheppards_Creek_Peak_Flood_Depth_5%AEP.mxd

FIGURE D6

**SHEPPARDS CREEK**

**PEAK FLOOD DEPTH AND LEVEL CONTOUR**

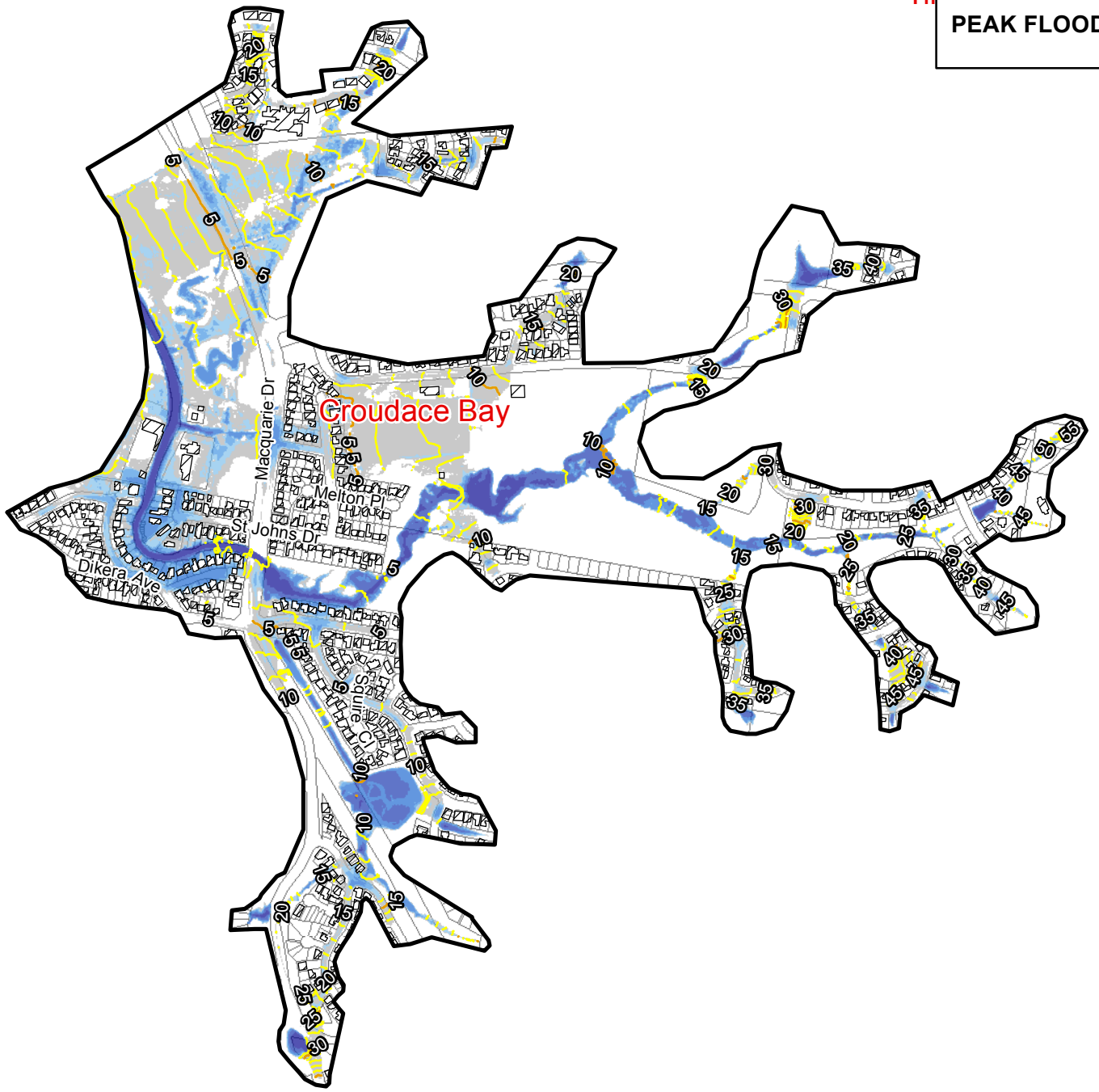
**1% AEP EVENT**




J:\Jobs\119076\ArcGIS\ArcMap\Working\Template\Appendix_D\FigureD05_Sheppards_Creek_Peak_Flood_Depth_2%AEP.mxd

FIGURE D7

**SHEPPARDS CREEK**
**PEAK FLOOD DEPTH AND LEVEL CONTOUR**
**0.5% AEP EVENT**



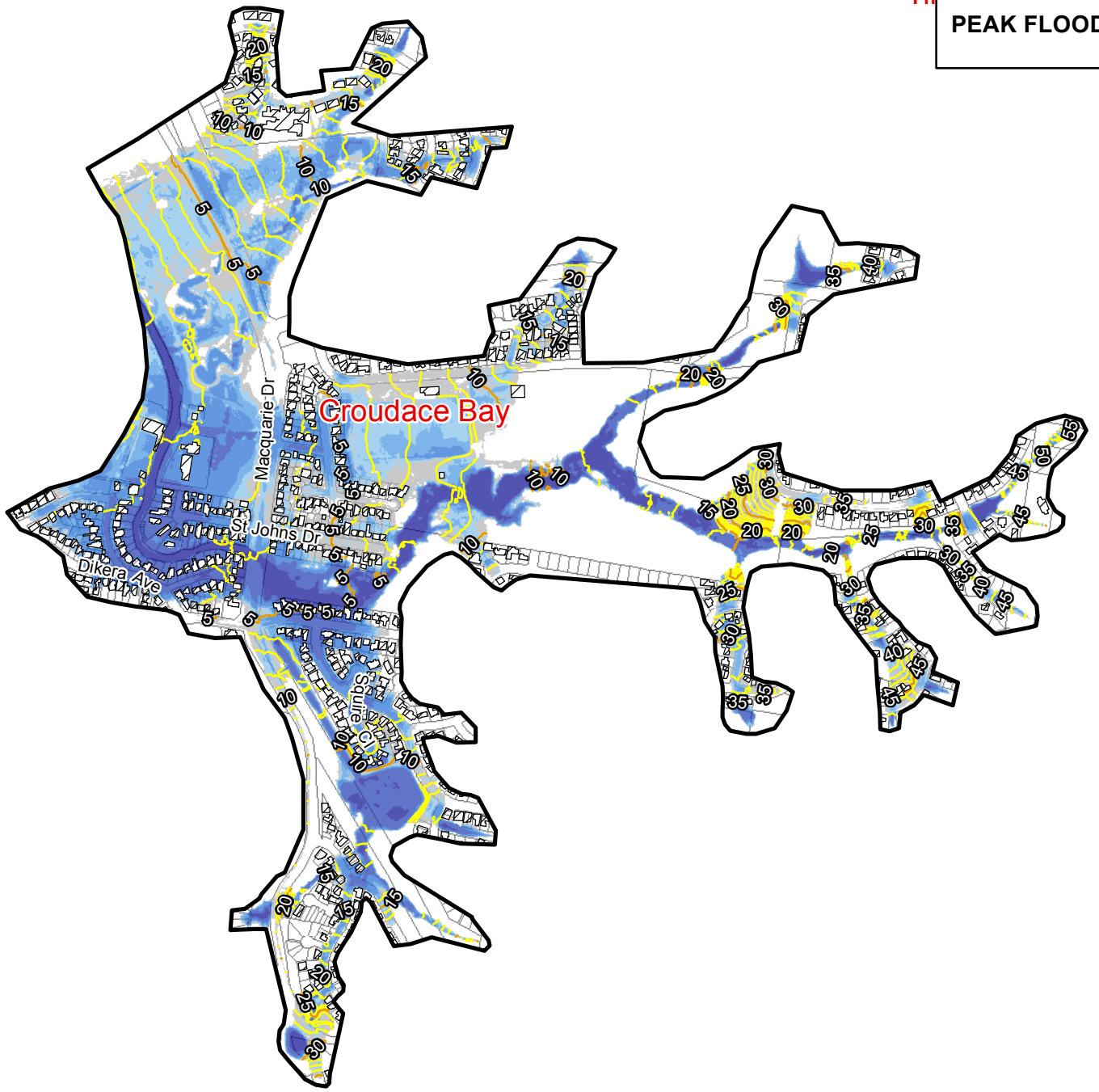

J:\Jobs\119076\ArcGIS\ArcMap\Working\Template\Appendix_D\FigureD08_Sheppards_Creek_Peak_Flood_Depth_PMF.mxd

FIGURE D8

**SHEPPARDS CREEK**

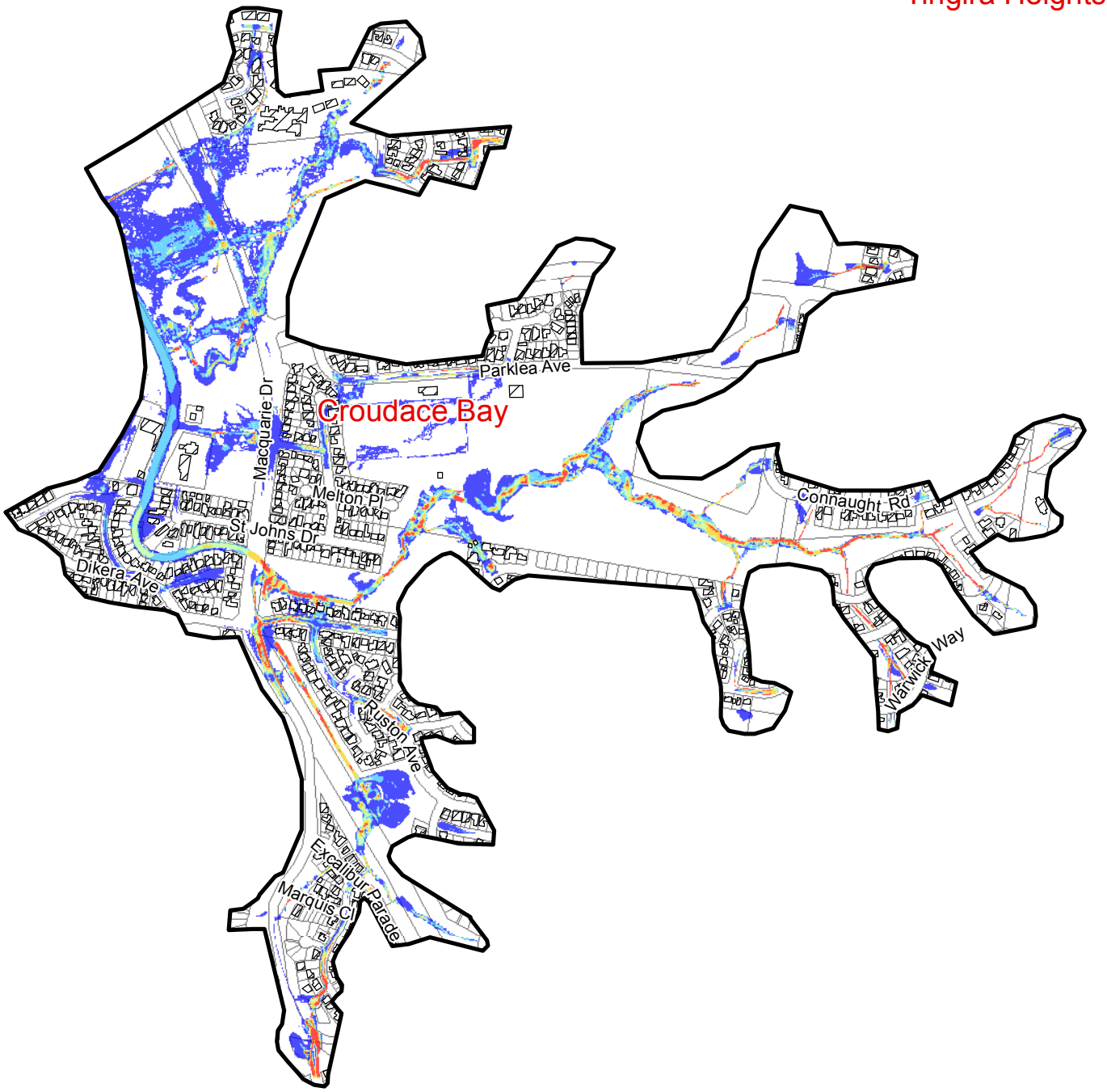
**PEAK FLOOD DEPTH AND LEVEL CONTOUR**

**PMF EVENT**



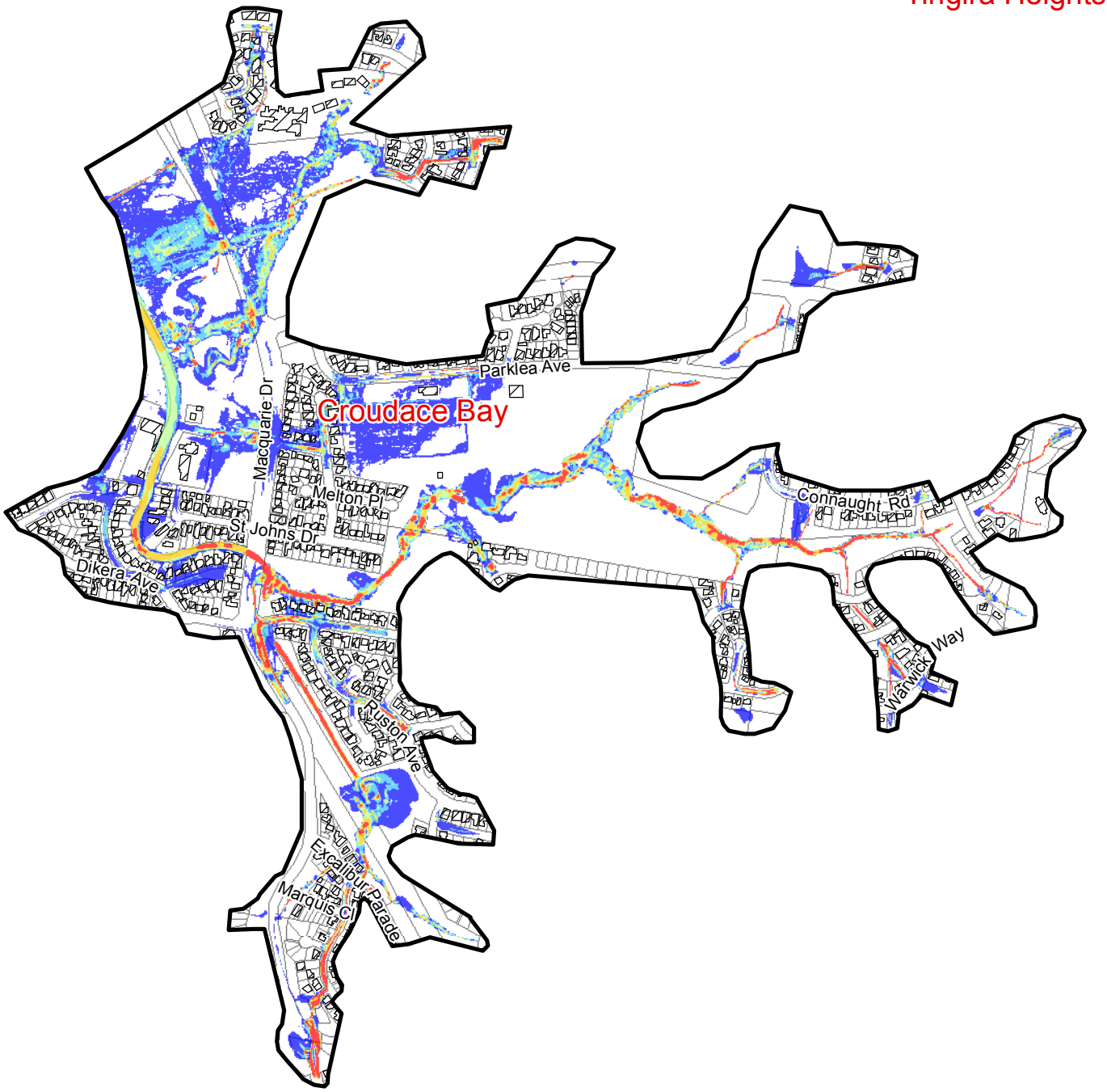

J:\Jobs\119076\ArcGIS\ArcMap\Working\Template\Appendix_D\FigureD07_Sheppards_Creek_Peak_Flood_Depth_0.5%AEP.mxd

FIGURE D9
**SHEPPARDS CREEK**
**PEAK FLOOD VELOCITIES**
**50% AEP EVENT**



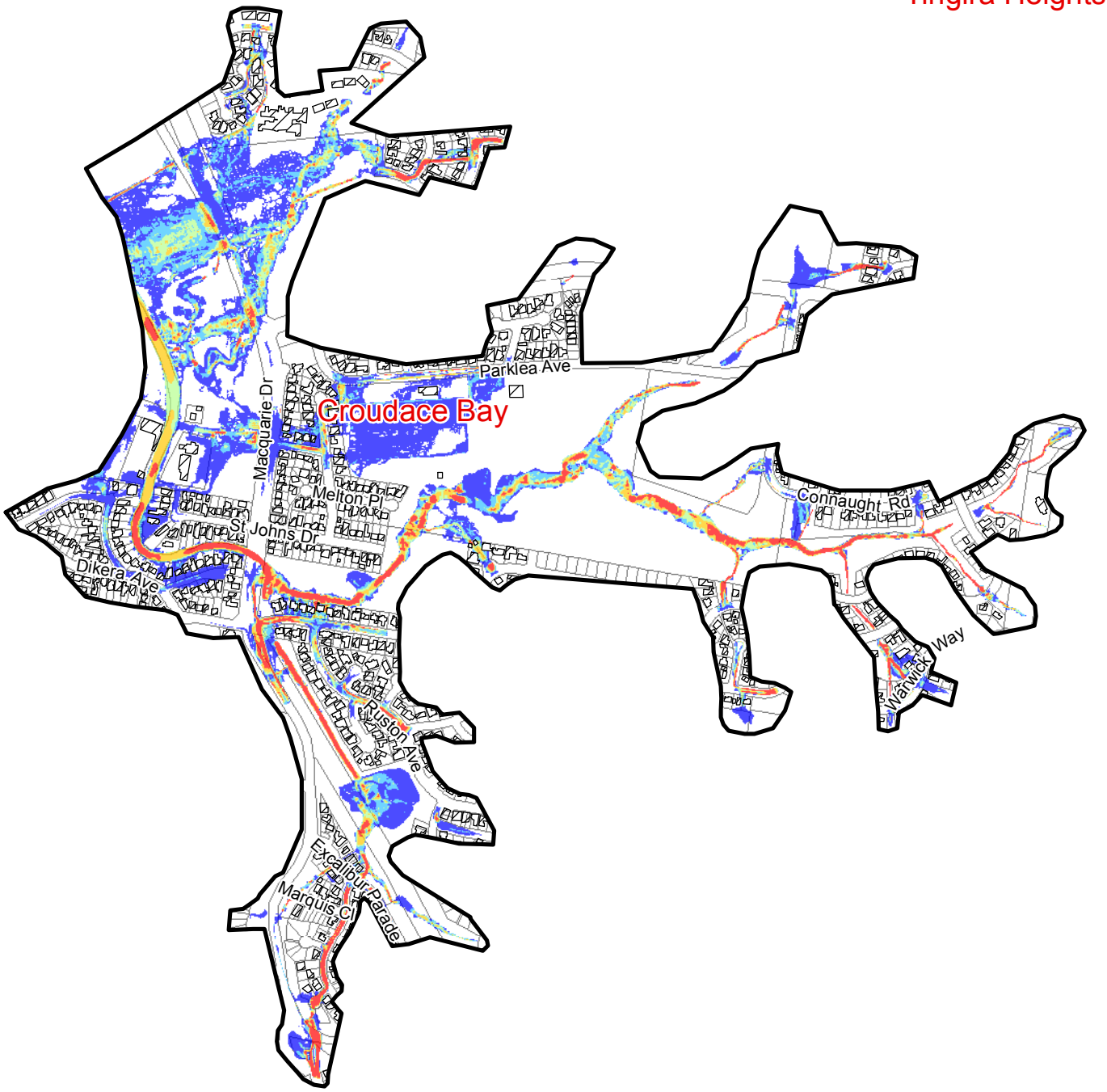

J:\Jobs\119076\ArcGIS\ArcMap\Working\Template\Appendix_D\FigureD09_Sheppards_Creek_Peak_Flood_Velocity_50%AEP.mxd

FIGURE D10
**SHEPPARDS CREEK**
**PEAK FLOOD VELOCITIES**
**20% AEP EVENT**



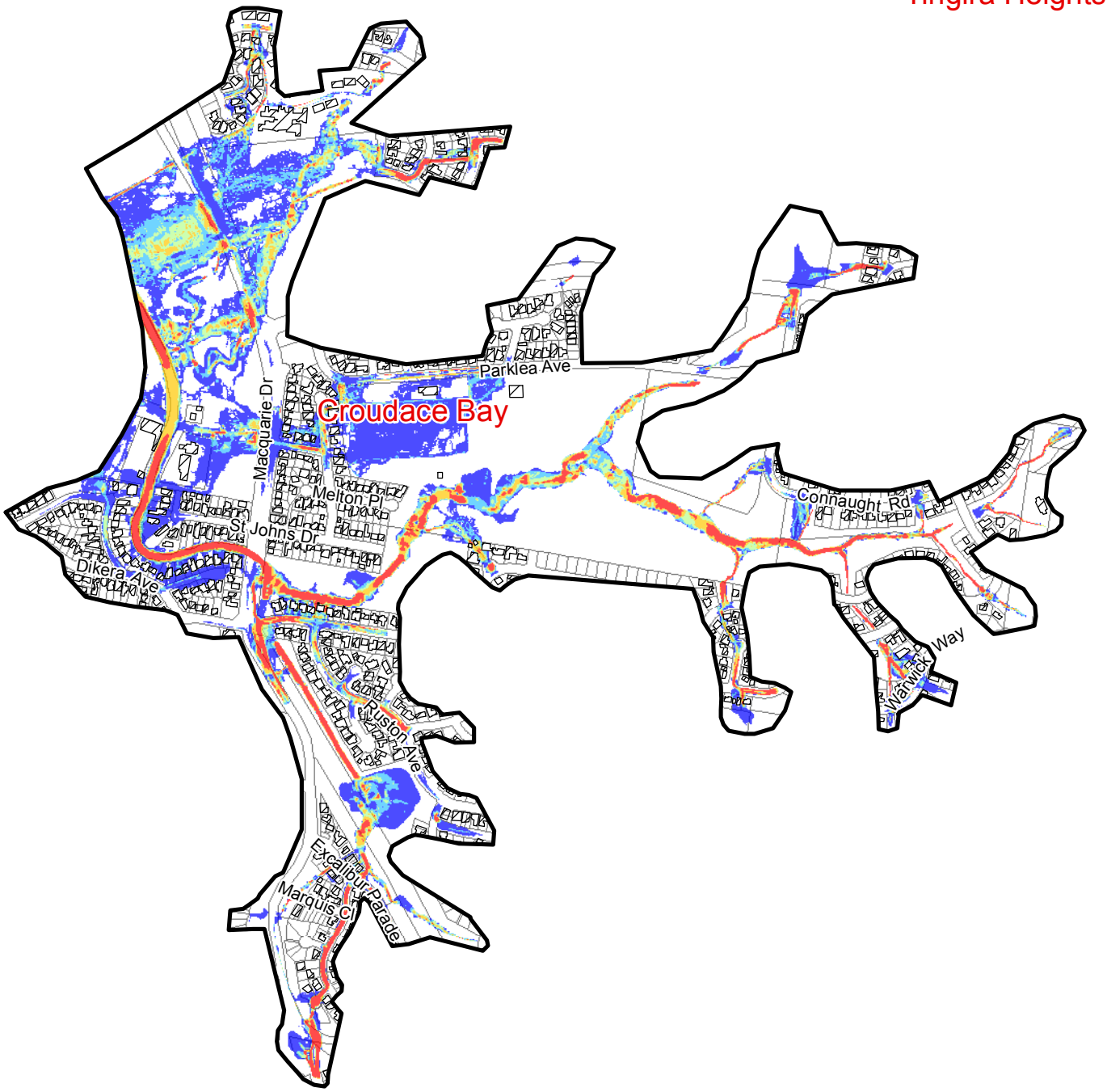

J:\Jobs\119076\ArcGIS\ArcMap\Working\Template\Appendix_D\FigureD09_Sheppards_Creek_Peak_Flood_Velocity_50%AEP.mxd

FIGURE D11
**SHEPPARDS CREEK**
**PEAK FLOOD VELOCITIES**
**10% AEP EVENT**



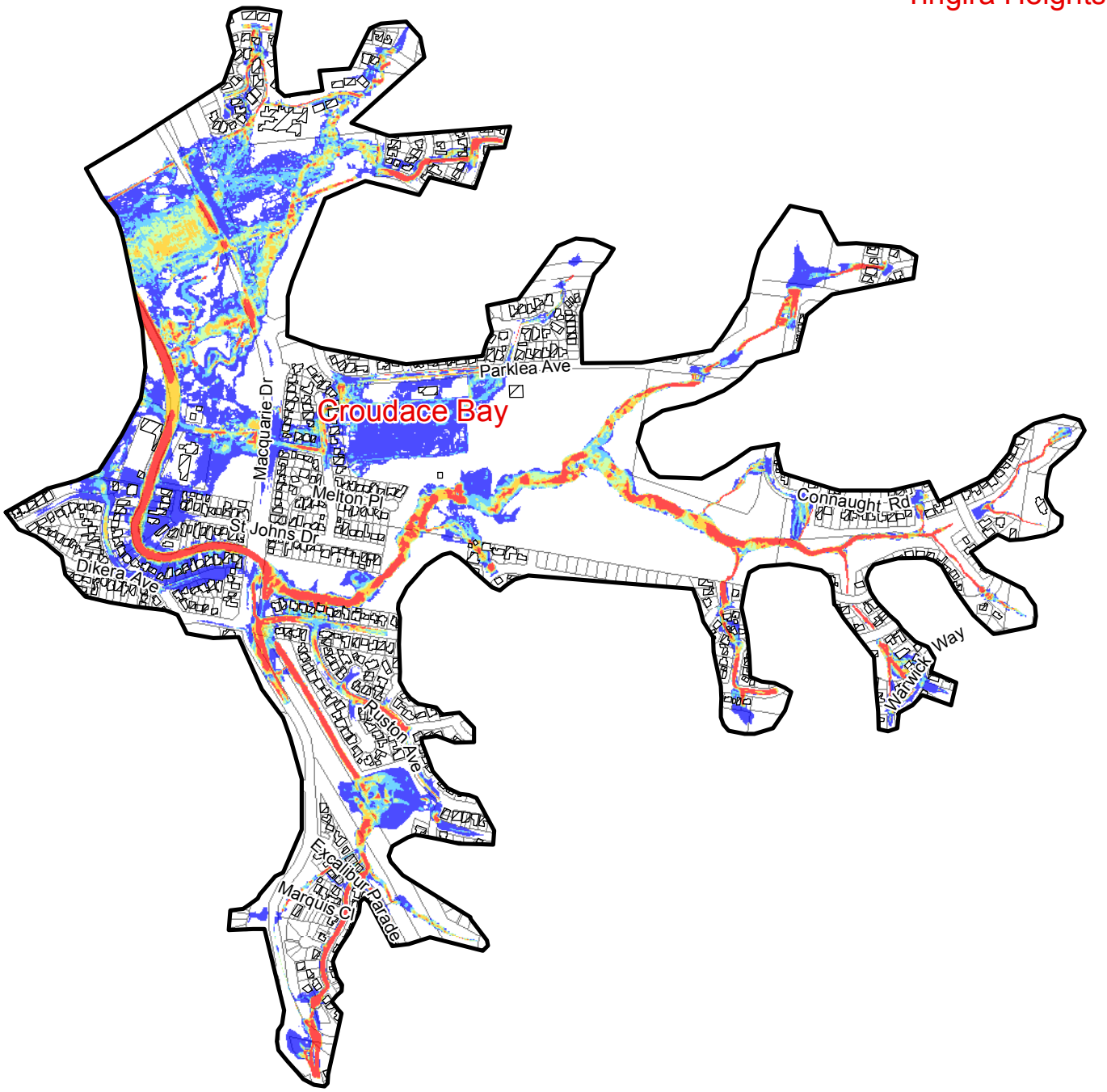

J:\Jobs\119076\ArcGIS\ArcMap\Working\Template\Appendix_D\FigureD10_Sheppards_Creek_Peak_Flood_Velocity_20%AEP.mxd

FIGURE D12
**SHEPPARDS CREEK**
**PEAK FLOOD VELOCITIES**
**5% AEP EVENT**



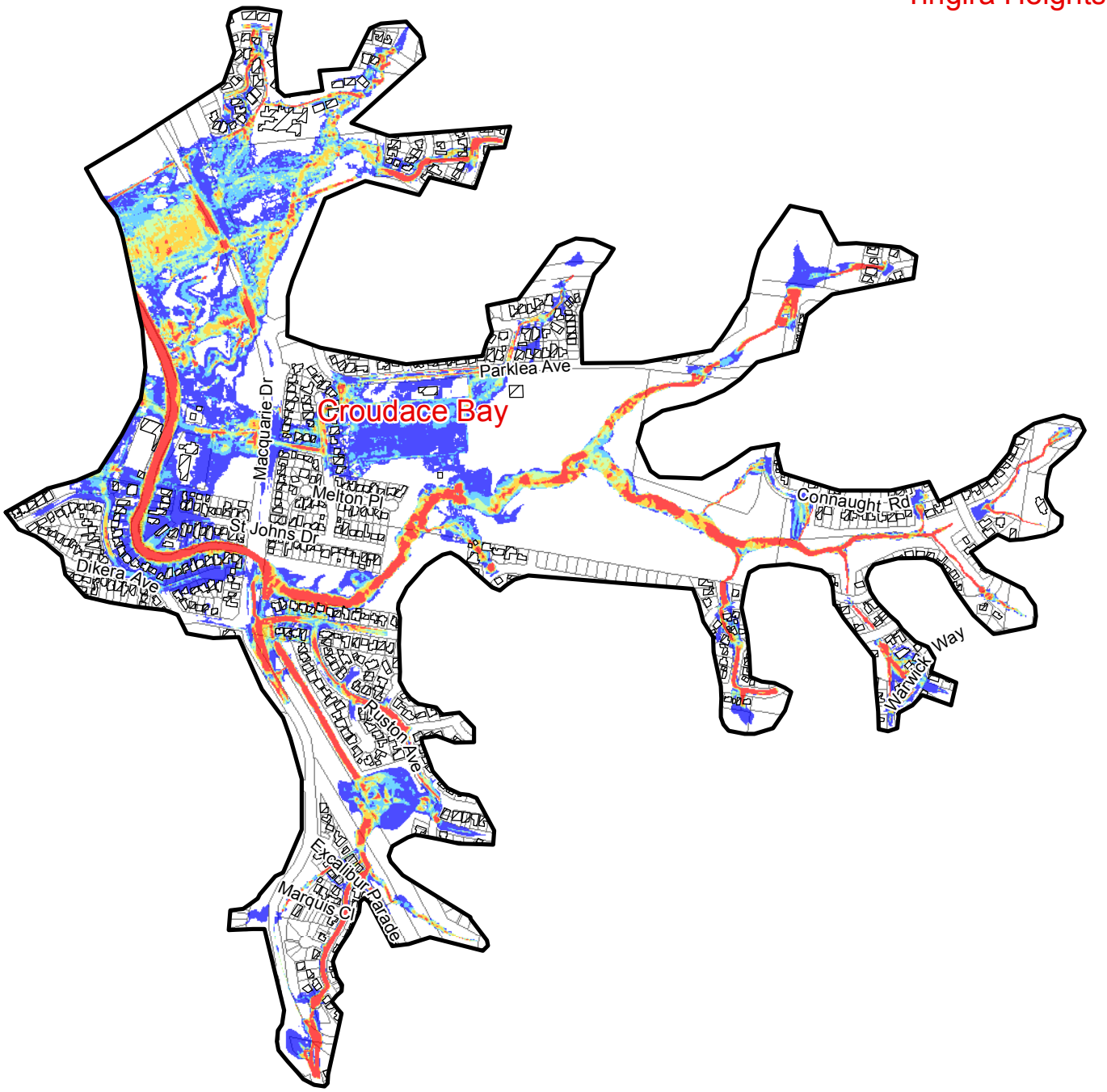

J:\Jobs\119076\ArcGIS\ArcMap\Working\Template\Appendix_D\FigureD11_Sheppards_Creek_Peak_Flood_Velocity_10%AEP.mxd

FIGURE D13
**SHEPPARDS CREEK**
**PEAK FLOOD VELOCITIES**
**2% AEP EVENT**



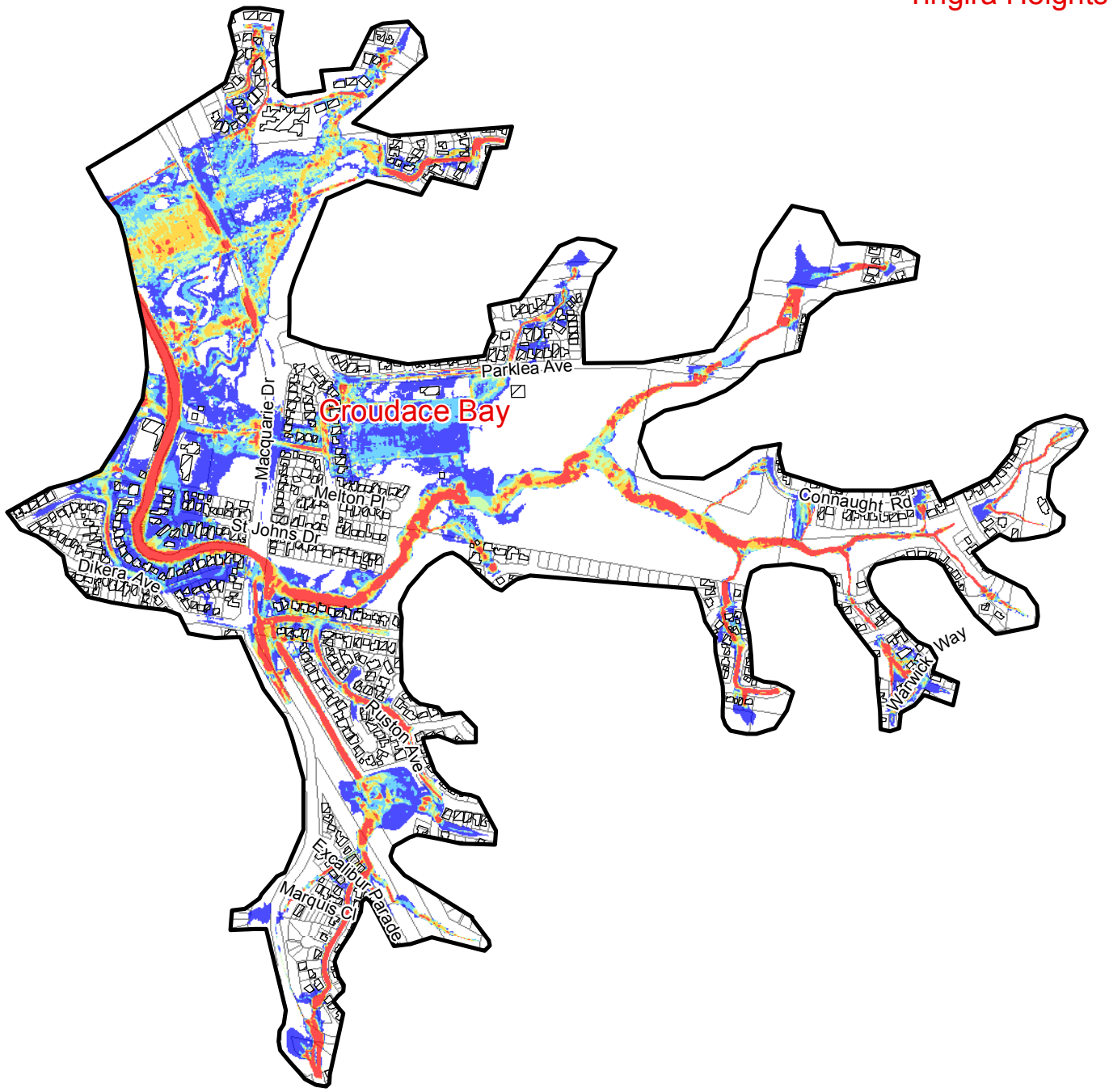

J:\Jobs\119076\ArcGIS\ArcMap\Working\Template\Appendix_D\FigureD12_Sheppards_Creek_Peak_Flood_Velocity_5%AEP.mxd

FIGURE D14
**SHEPPARDS CREEK**
**PEAK FLOOD VELOCITIES**
**1% AEP EVENT**



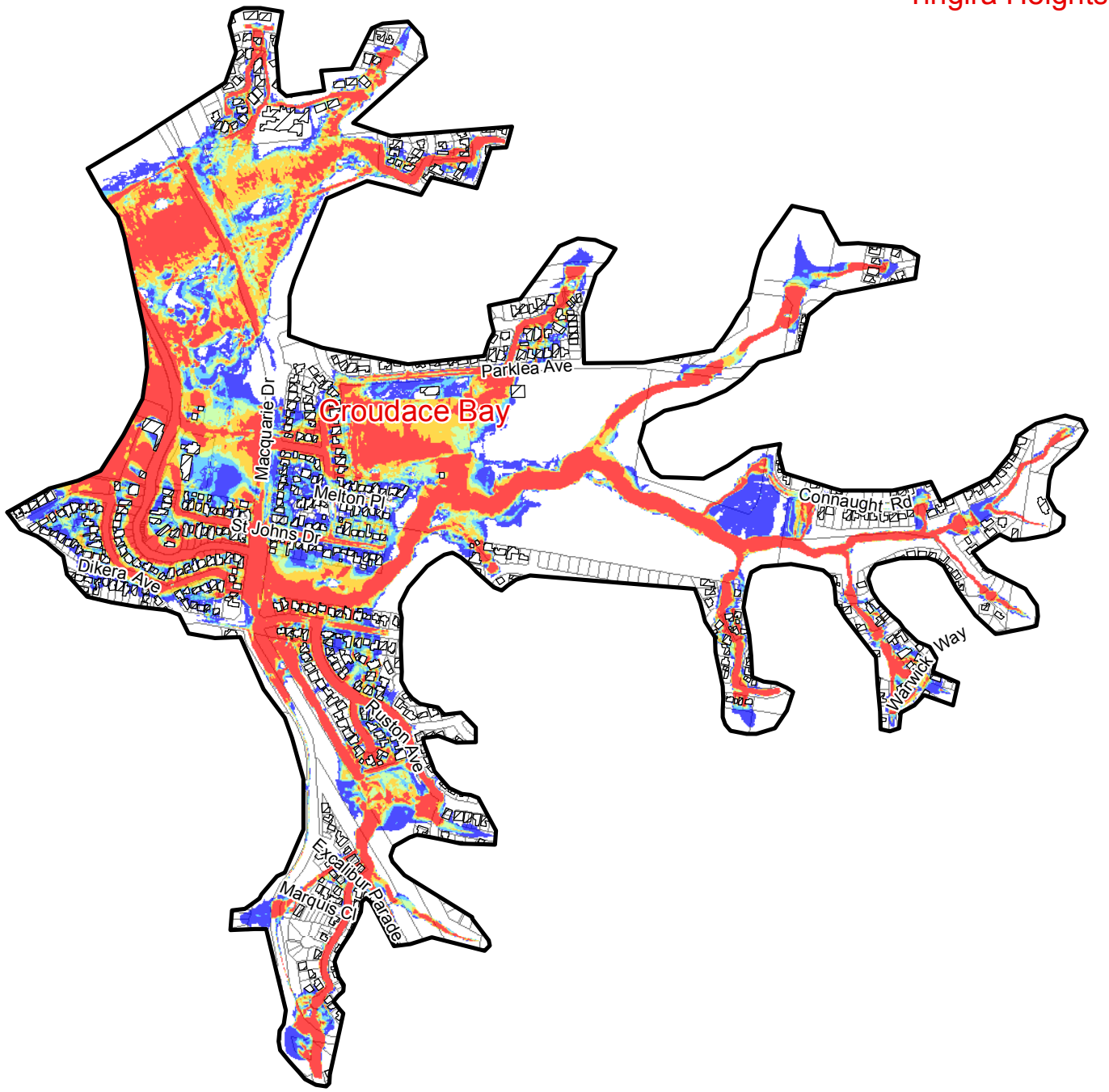

J:\Jobs\119076\ArcGIS\ArcMap\Working\Template\Appendix_D\FigureD13_Sheppards_Creek_Peak_Flood_Velocity_2%AEP.mxd

FIGURE D15
**SHEPPARDS CREEK**
**PEAK FLOOD VELOCITIES**
**0.5% AEP EVENT**



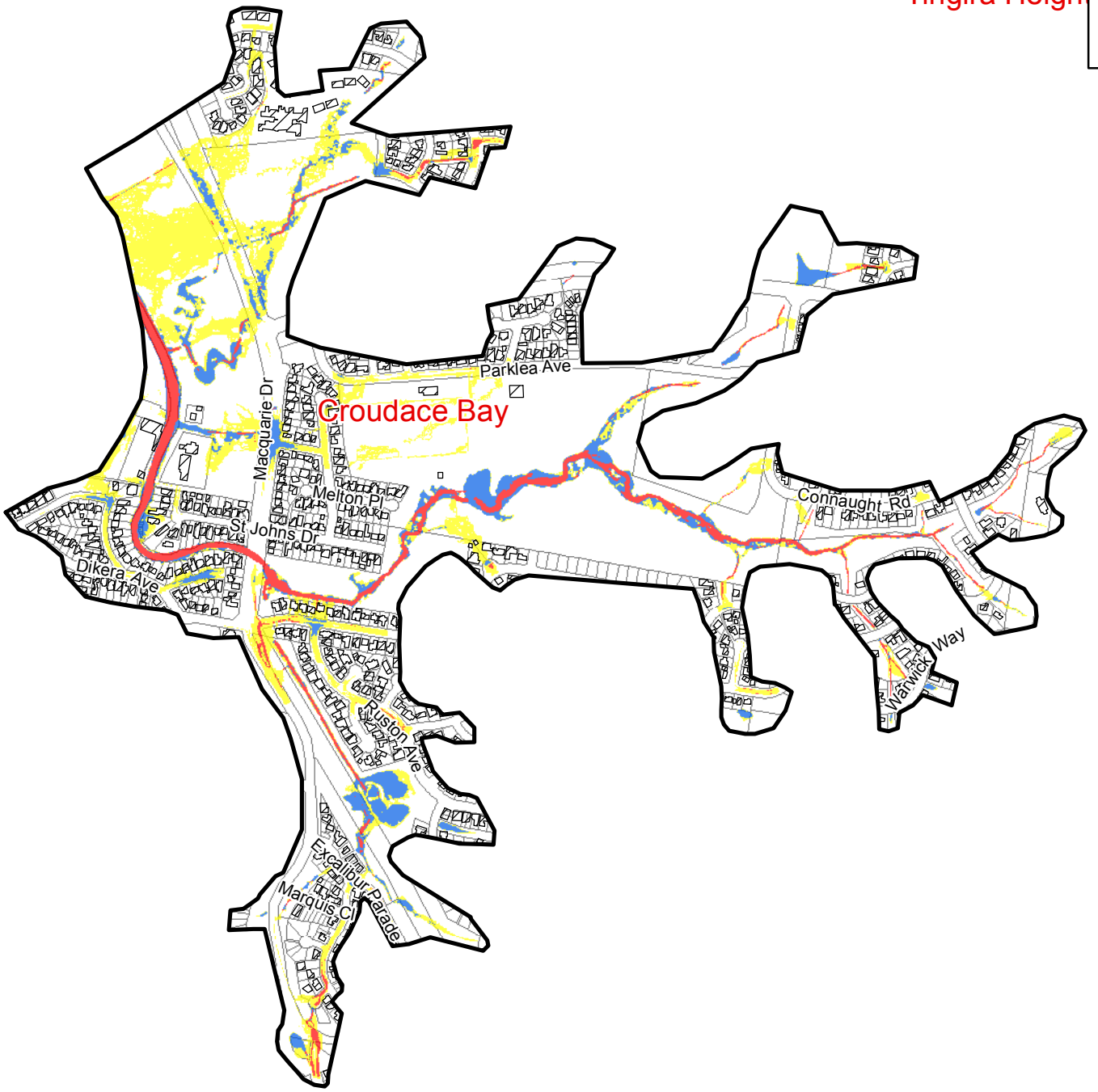

J:\Jobs\1190776\ArcGIS\ArcMap\Working\Template\Appendix_D\FigureD14_Sheppards_Creek_Peak_Flood_Velocity_1%AEP.mxd

FIGURE D16
**SHEPPARDS CREEK**
**PEAK FLOOD VELOCITIES**
**PMF EVENT**



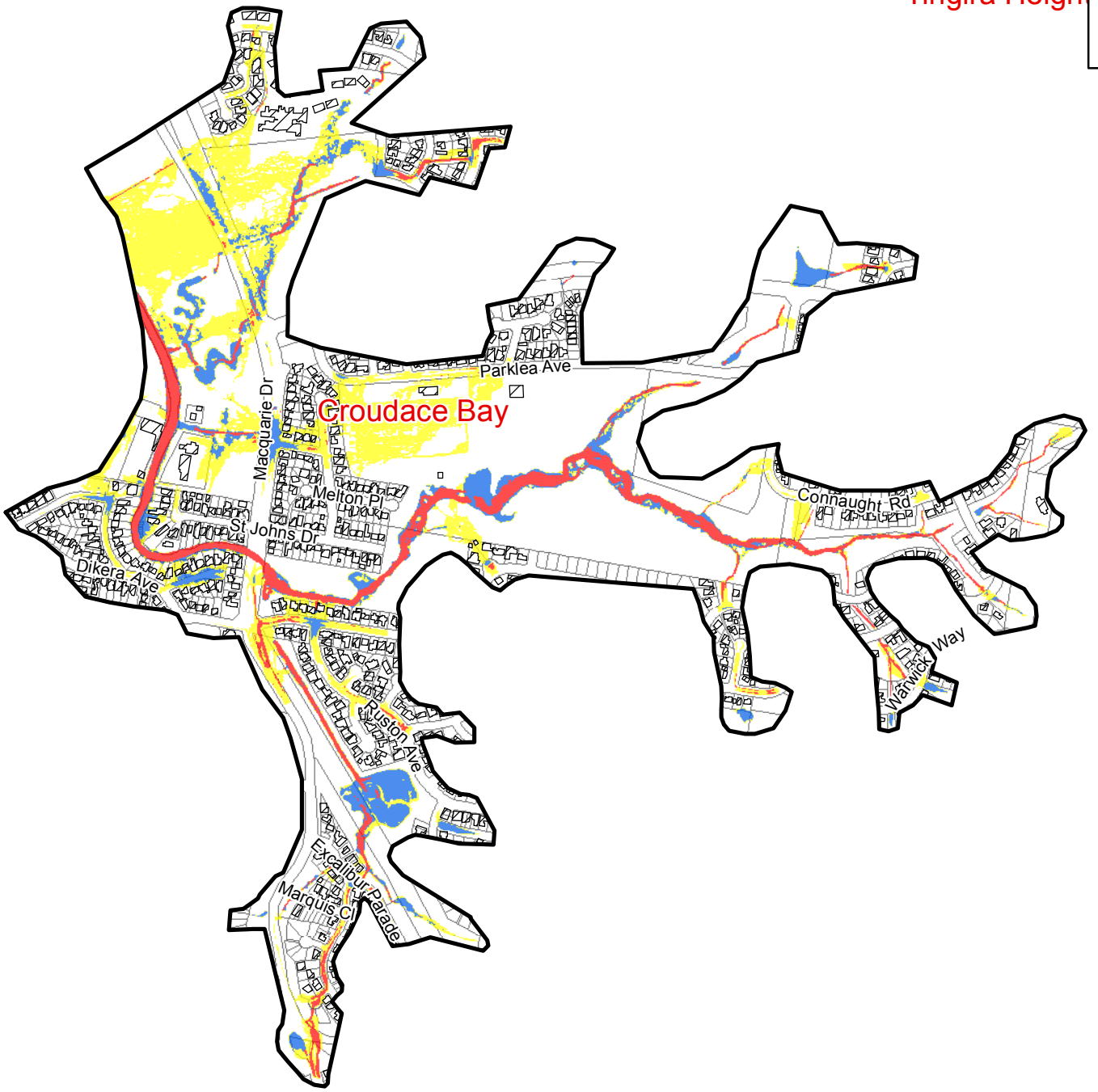

J:\Jobs\119076\ArcGIS\ArcMap\Working\Template\Appendix_D\FigureD15_Sheppards_Creek_Peak_Flood_Velocity_0.5%AEP.mxd

FIGURE D17
**SHEPPARDS CREEK**
**HYDRAULIC CATEGORISATION**
**50% AEP EVENT**



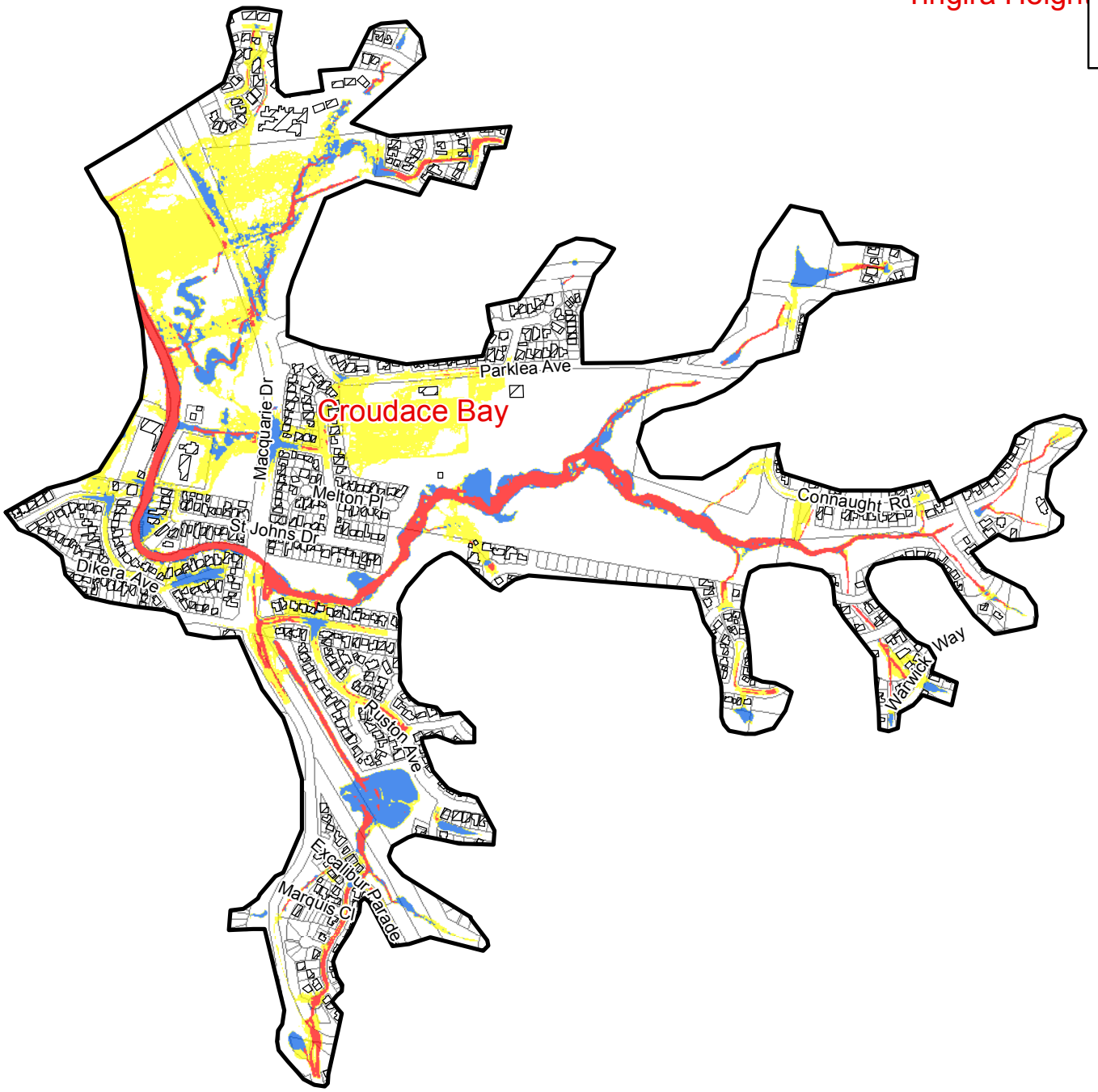

J:\Jobs\119076\ArcGIS\ArcMap\Working\Template\Appendix_D\FigureD17_Sheppards_Creek_Hydraulic_Categories_50%AEP.mxd

FIGURE D18
**SHEPPARDS CREEK**
**HYDRAULIC CATEGORISATION**
**20% AEP EVENT**



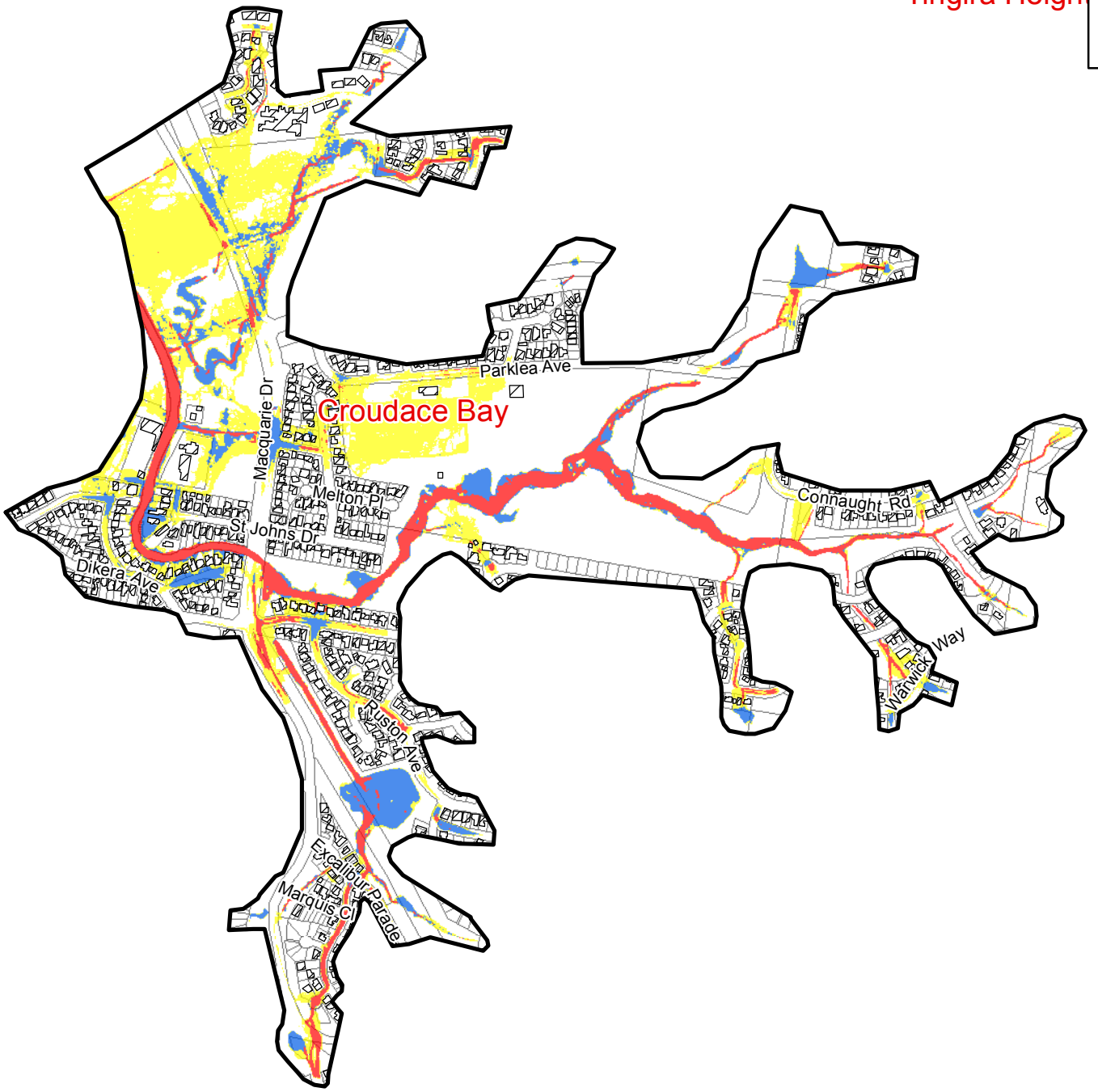

J:\Jobs\119076\ArcGIS\ArcMap\Working\Template\Appendix_D\FigureD17_Sheppards_Creek_Hydraulic_Categories_50%AEP.mxd

FIGURE D19
**SHEPPARDS CREEK**
**HYDRAULIC CATEGORISATION**
**10% AEP EVENT**



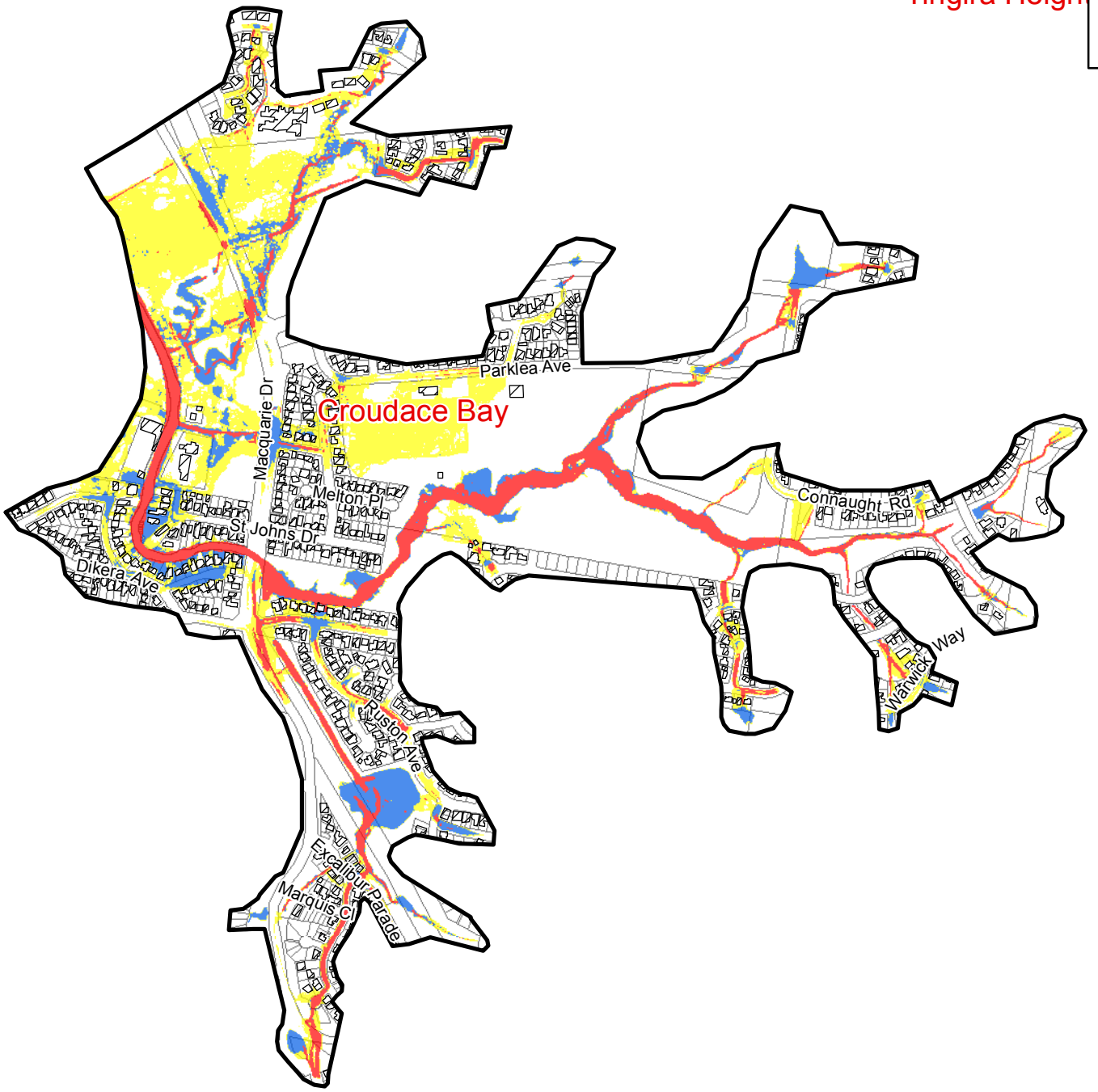

J:\Jobs\119076\ArcGIS\ArcMap\Working\Template\Appendix_D\FigureD18_Sheppards_Creek_Hydraulic_Categories_20%AEP.mxd

FIGURE D20
**SHEPPARDS CREEK**
**HYDRAULIC CATEGORISATION**
**5% AEP EVENT**



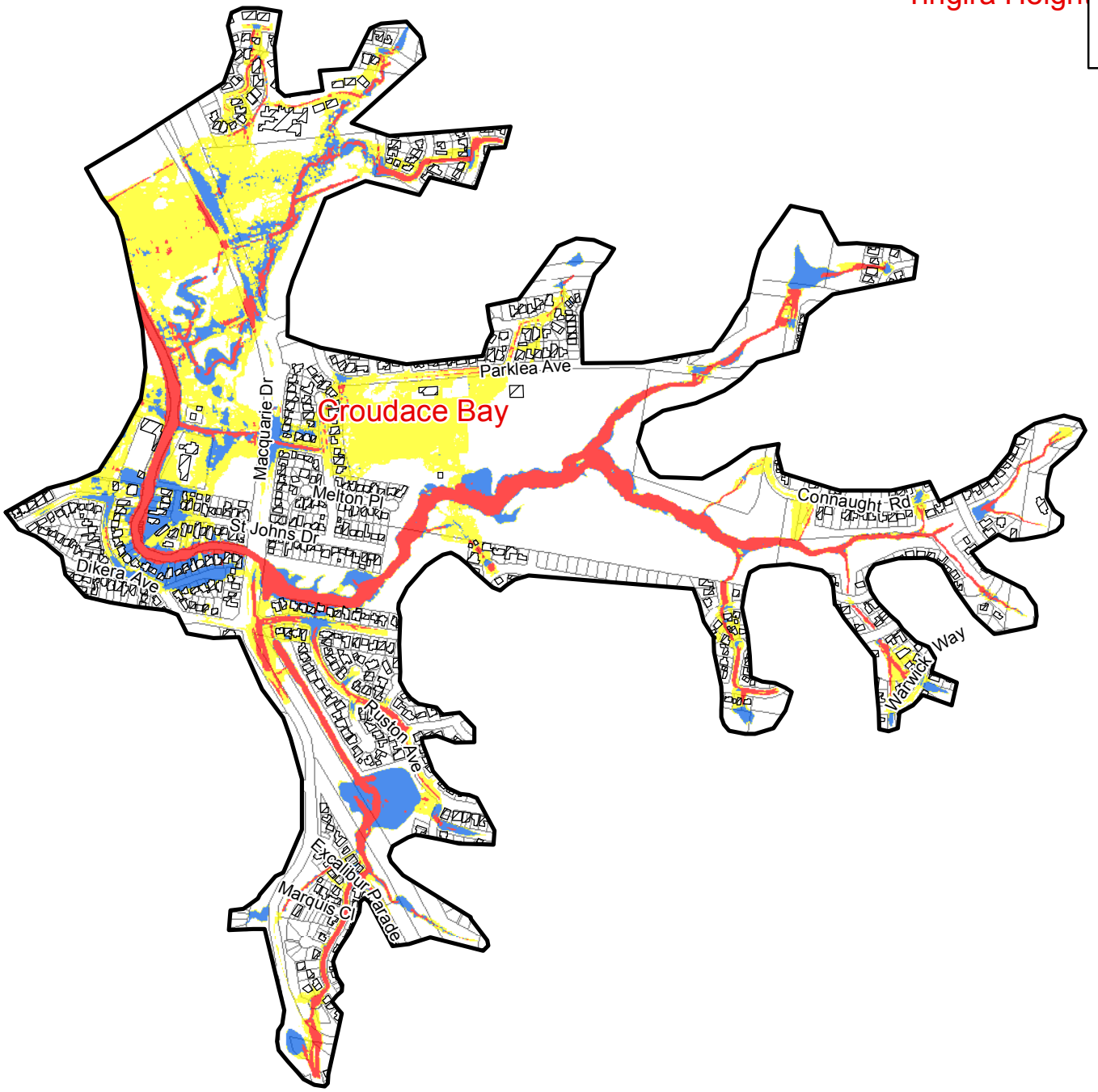

J:\Jobs\119076\ArcGIS\ArcMap\Working\Template\Appendix_D\FigureD19_Sheppards_Creek_Hydraulic_Categories_10%AEP.mxd

FIGURE D21
**SHEPPARDS CREEK**
**HYDRAULIC CATEGORISATION**
**2% AEP EVENT**



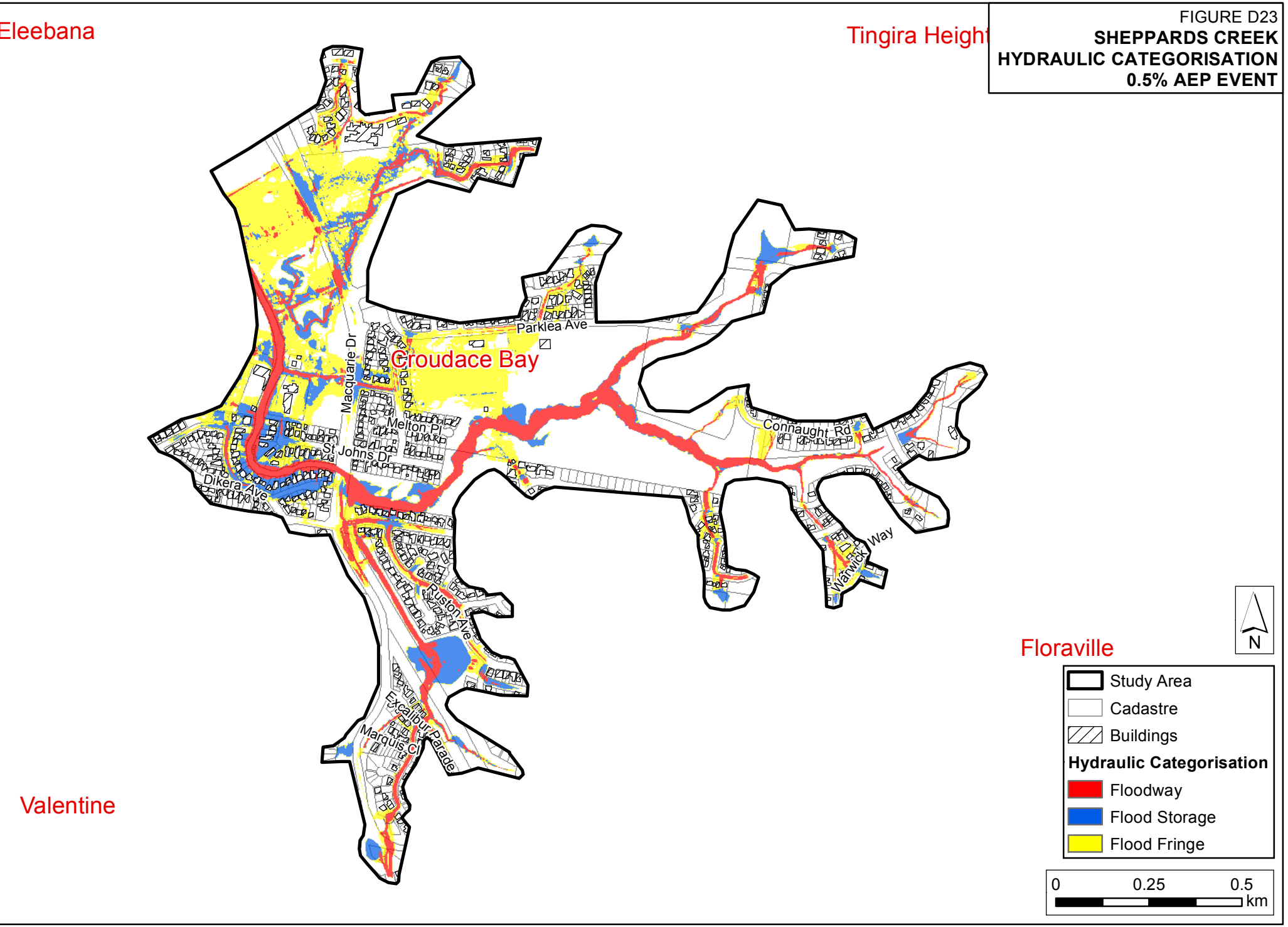

J:\Jobs\119076\ArcGIS\ArcMap\Working\Template\Appendix_D\FigureD20_Sheppards_Creek_Hydraulic_Categories_5%AEP.mxd

FIGURE D22
**SHEPPARDS CREEK**
**HYDRAULIC CATEGORISATION**
**1% AEP EVENT**



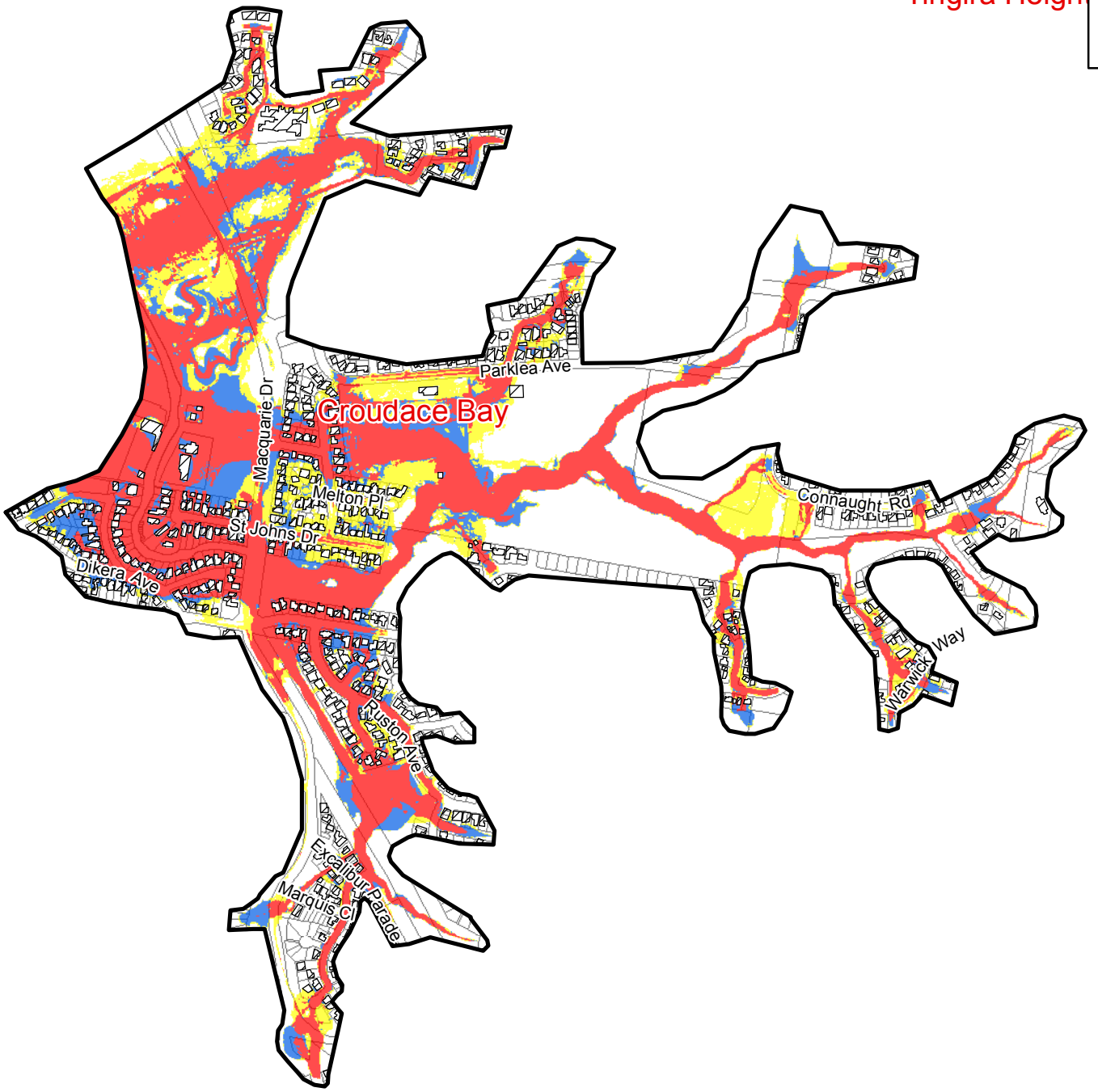

J:\Jobs\119076\ArcGIS\ArcMap\Working\Template\Appendix_D\FigureD21_Sheppards_Creek_Hydraulic_Categories_2%AEP.mxd

FIGURE D23
**SHEPPARDS CREEK**
**HYDRAULIC CATEGORISATION**
**0.5% AEP EVENT**



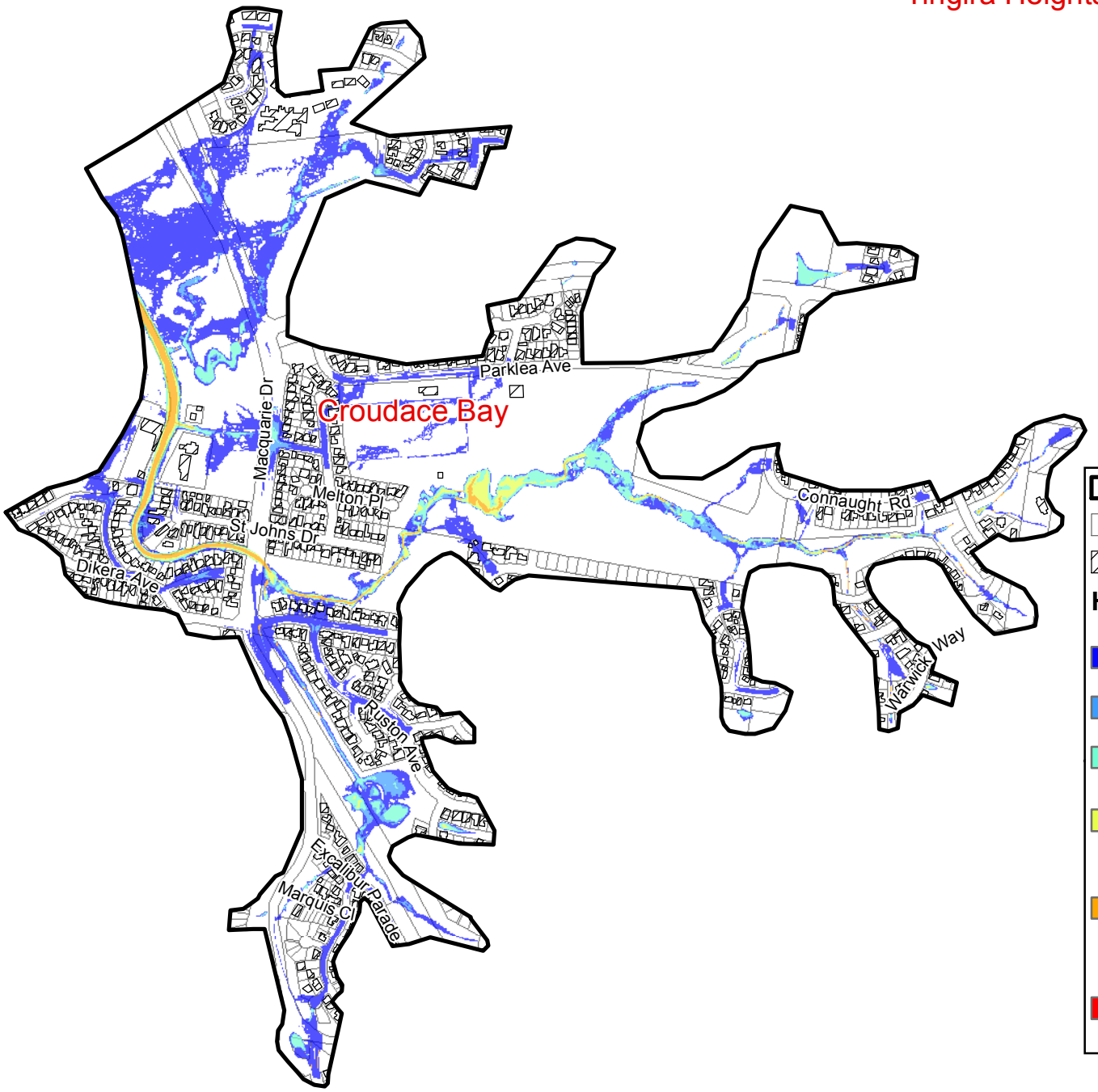

J:\Jobs\119076\ArcGIS\ArcMap\Working\Template\Appendix_D\FigureD23_Sheppards_Creek_Hydraulic_Categories_0.5%AEP.mxd

FIGURE D24
**SHEPPARDS CREEK**
**HYDRAULIC CATEGORISATION**
**PMF EVENT**



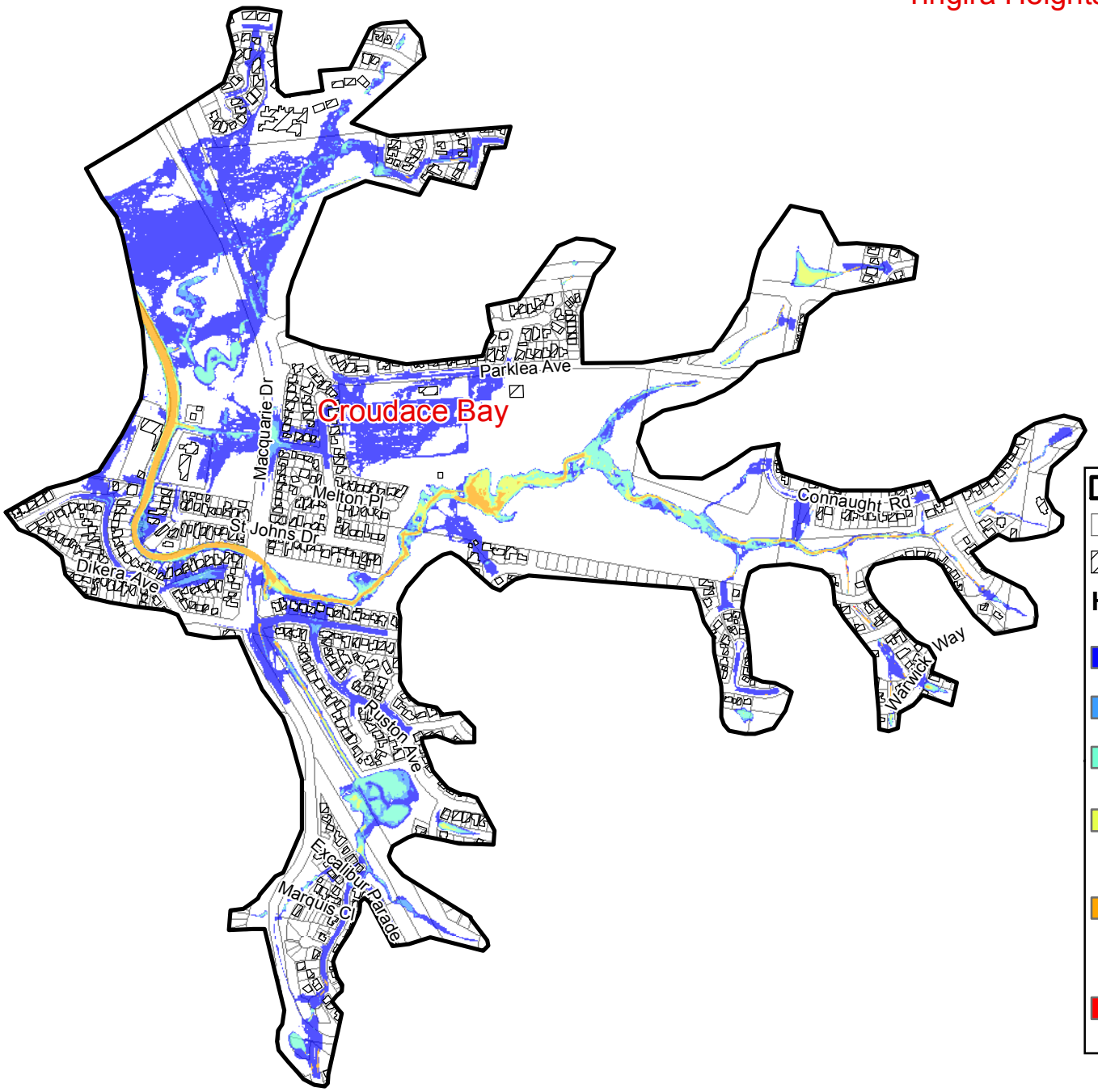

J:\Jobs\1190776\ArcGIS\ArcMap\Working\Template\Appendix_D\FigureD24_Sheppards_Creek_Hydraulic_Categories_PMF.mxd

FIGURE D25
**SHEPPARDS CREEK HYDRAULIC HAZARD 50% AEP EVENT**



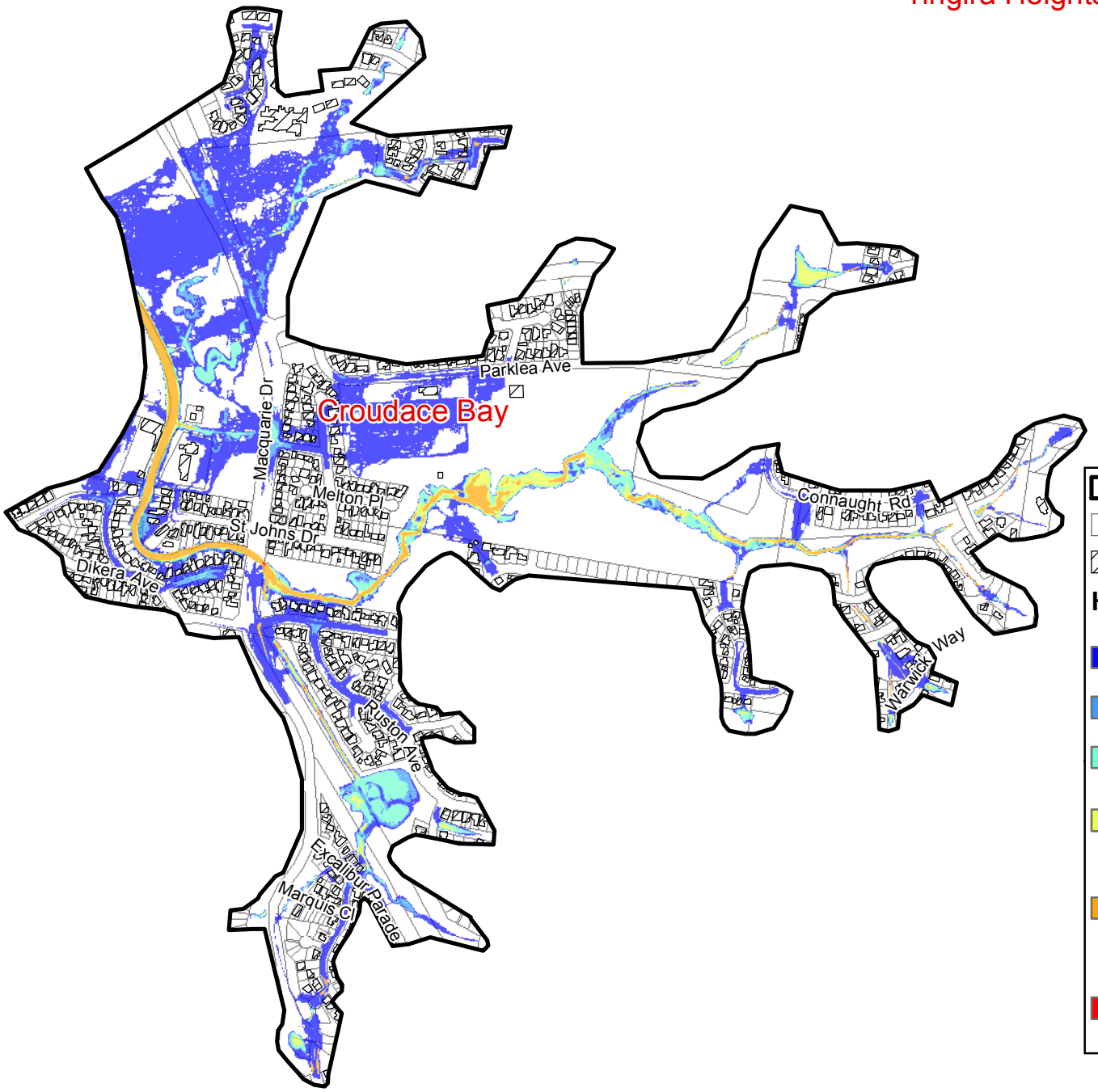

J:\Jobs\119076\ArcGIS\ArcMap\Working\Template\Appendix_D\FigureD25_Sheppards_Creek_Provisional_Hazard_50%AEP.mxd

FIGURE D26
**SHEPPARDS CREEK HYDRAULIC HAZARD 20% AEP EVENT**



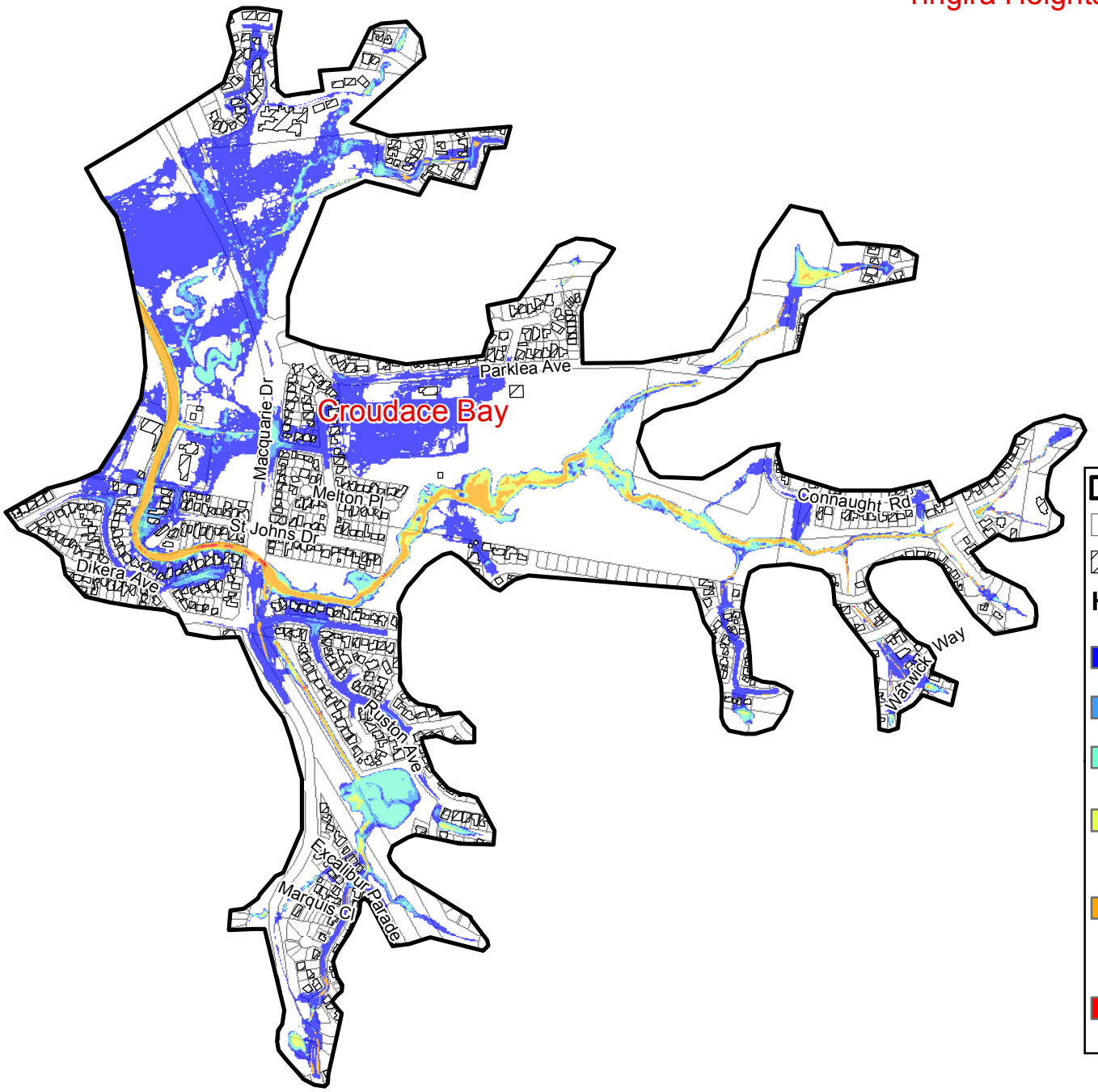

J:\Jobs\119076\ArcGIS\ArcMap\Working\Template\Appendix_D\FigureD25_Sheppards_Creek_Provisional_Hazard_50%AEP.mxd

FIGURE D27
**SHEPPARDS CREEK HYDRAULIC HAZARD 10% AEP EVENT**



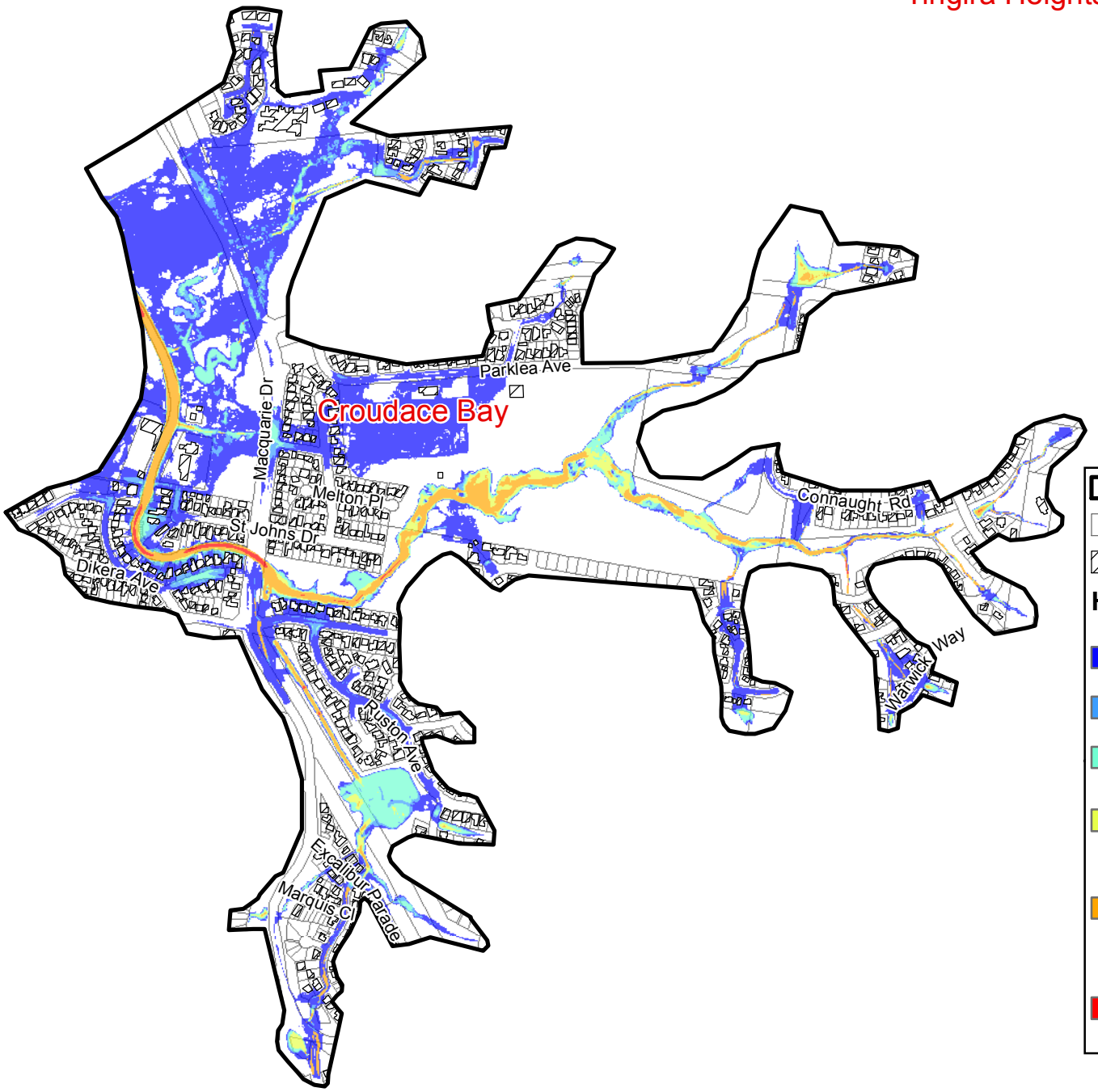

J:\Jobs\119076\ArcGIS\ArcMap\Working\Template\Appendix_C\FigureD26_Sheppards_Creek_Provisional_Hazard_20%AEP.mxd

FIGURE D28
**SHEPPARDS CREEK HYDRAULIC HAZARD 5% AEP EVENT**



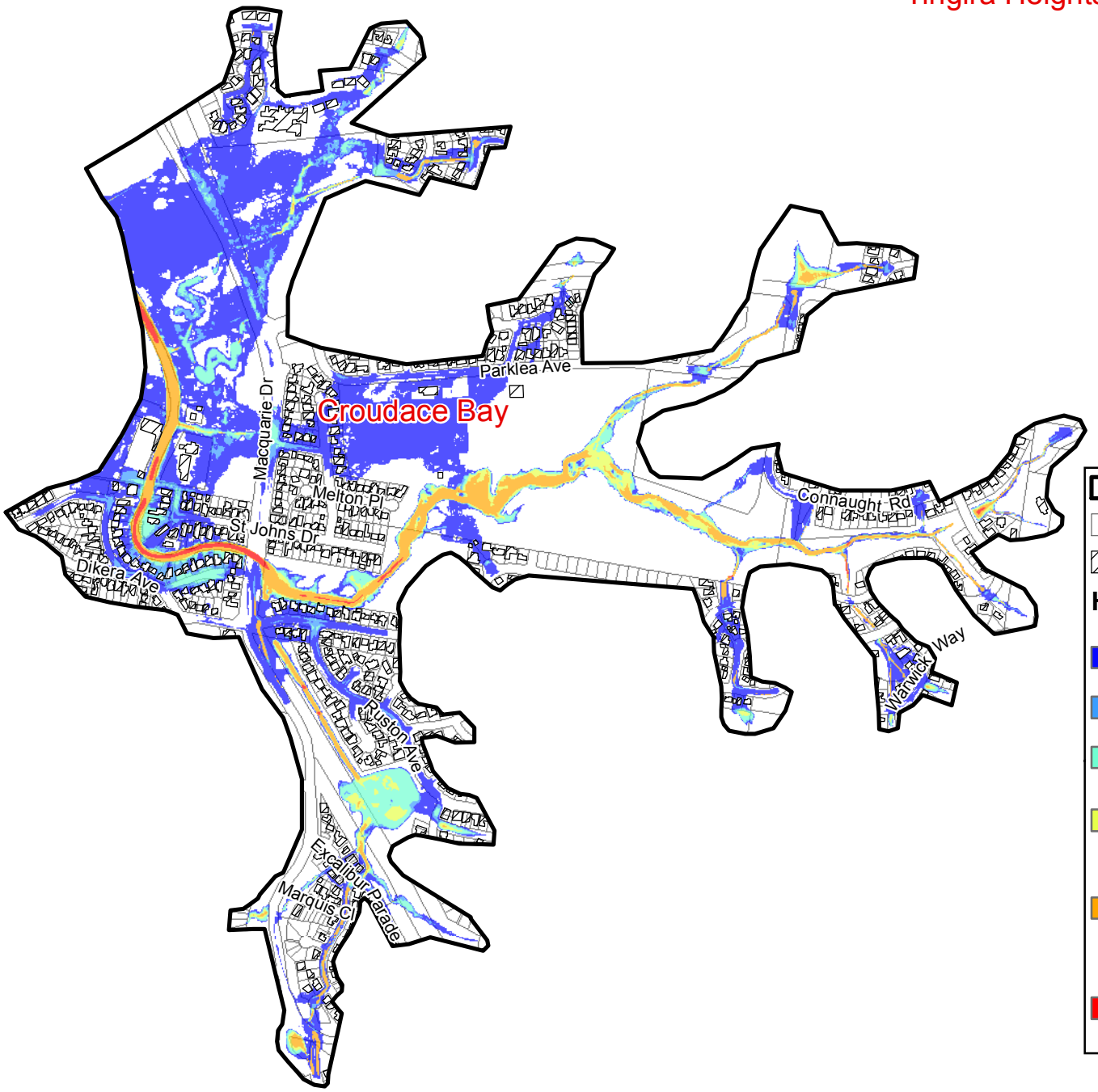

J:\Jobs\119076\ArcGIS\ArcMap\Working\Template\Appendix_C\FigureD27_Sheppards_Creek_Provisional_Hazard_10%AEP.mxd

FIGURE D29
**SHEPPARDS CREEK HYDRAULIC HAZARD 2% AEP EVENT**



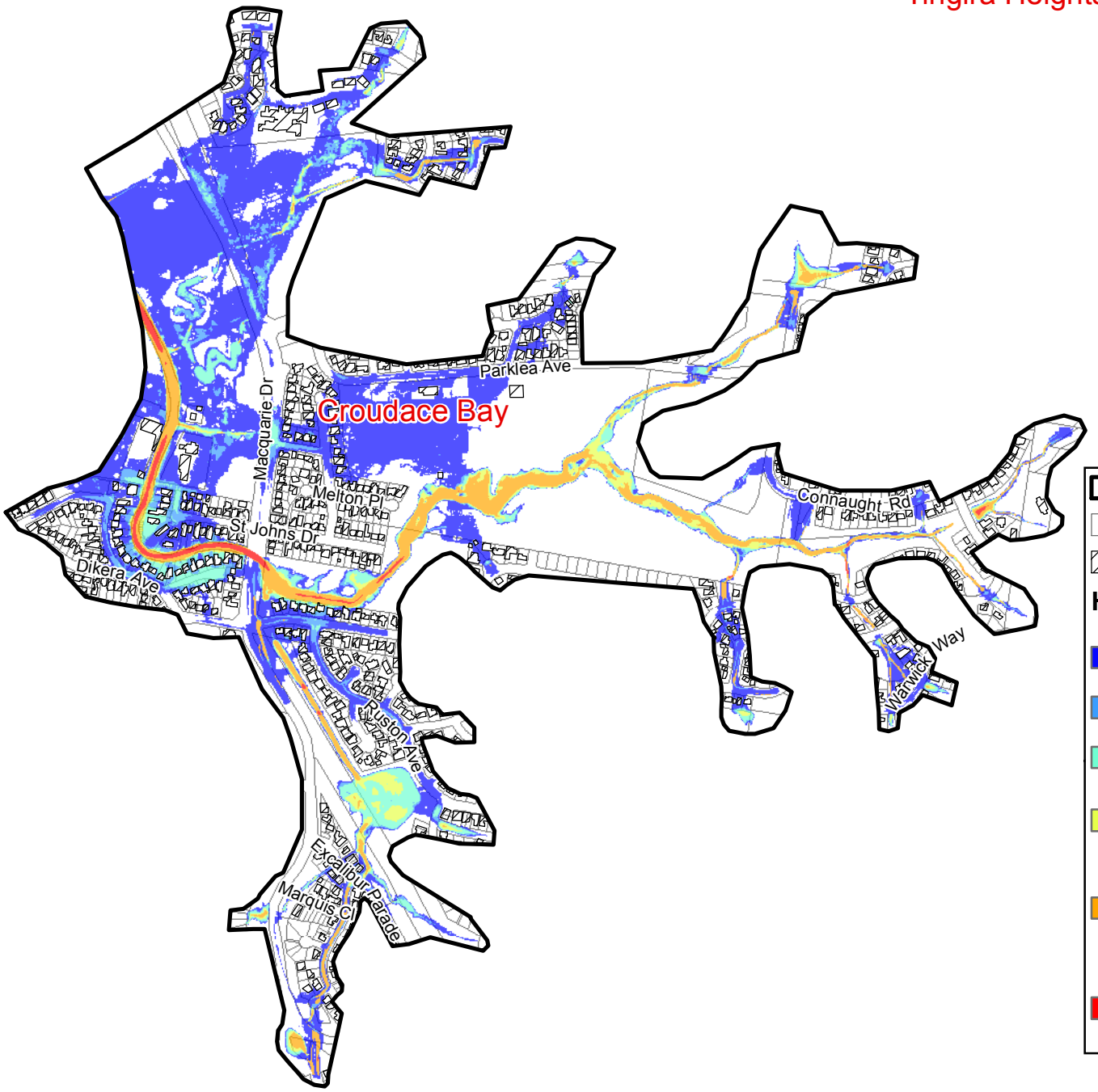

J:\Jobs\119076\ArcGIS\ArcMap\Working\Template\Appendix_C\FigureD28_Sheppards_Creek_Provisional_Hazard_5%AEP.mxd

FIGURE D30
**SHEPPARDS CREEK HYDRAULIC HAZARD 1% AEP EVENT**



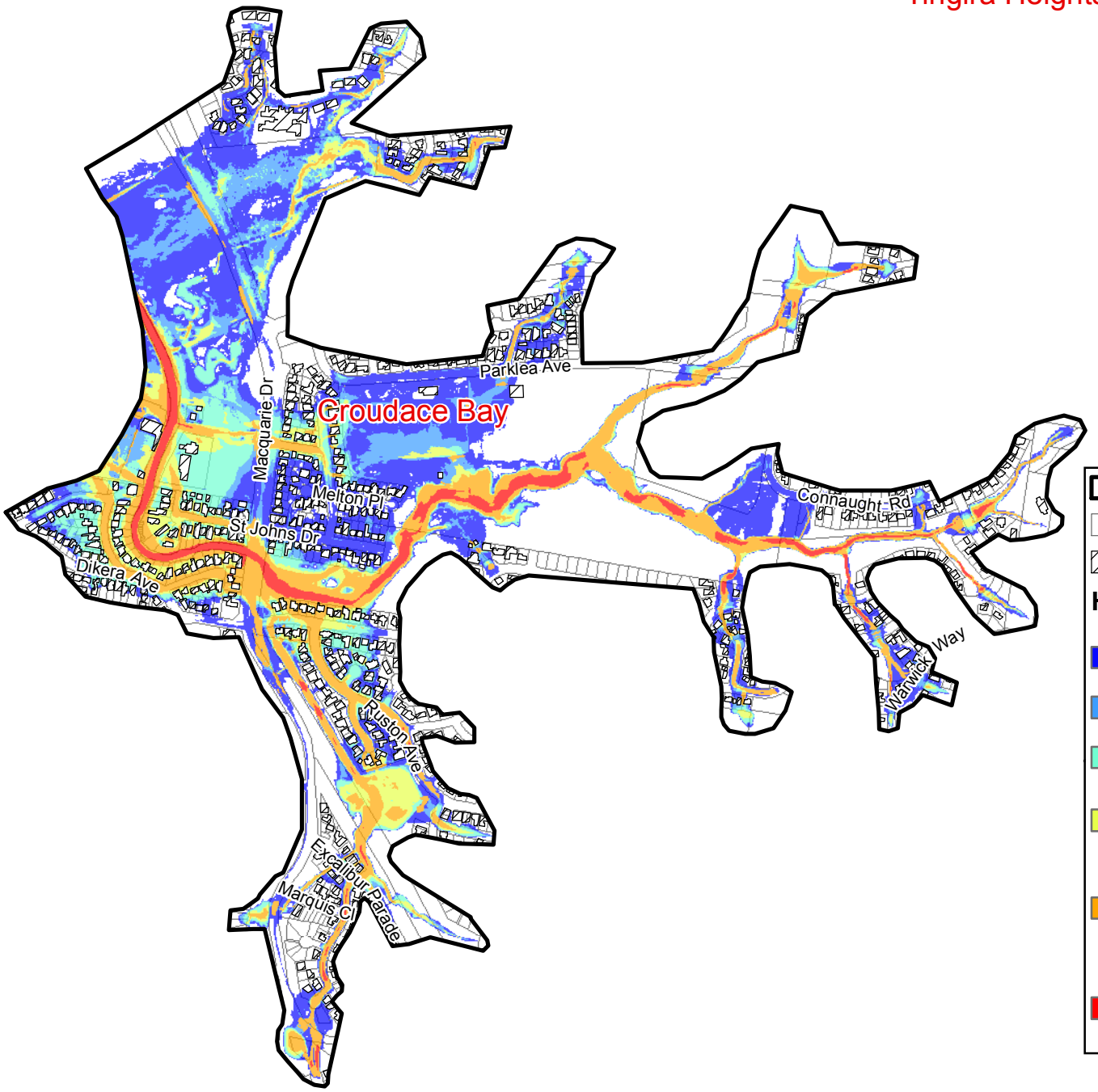

J:\Jobs\119076\ArcGIS\ArcMap\Working\Template\Appendix_C\FigureD29_Sheppards_Creek_Provisional_Hazard_2%AEP.mxd

FIGURE D31
**SHEPPARDS CREEK HYDRAULIC HAZARD 0.5% AEP EVENT**




J:\Jobs\119076\ArcGIS\ArcMap\Working\Template\Appendix_C\FigureD30_Sheppards_Creek_Provisional_Hazard_1%AEP.mxd

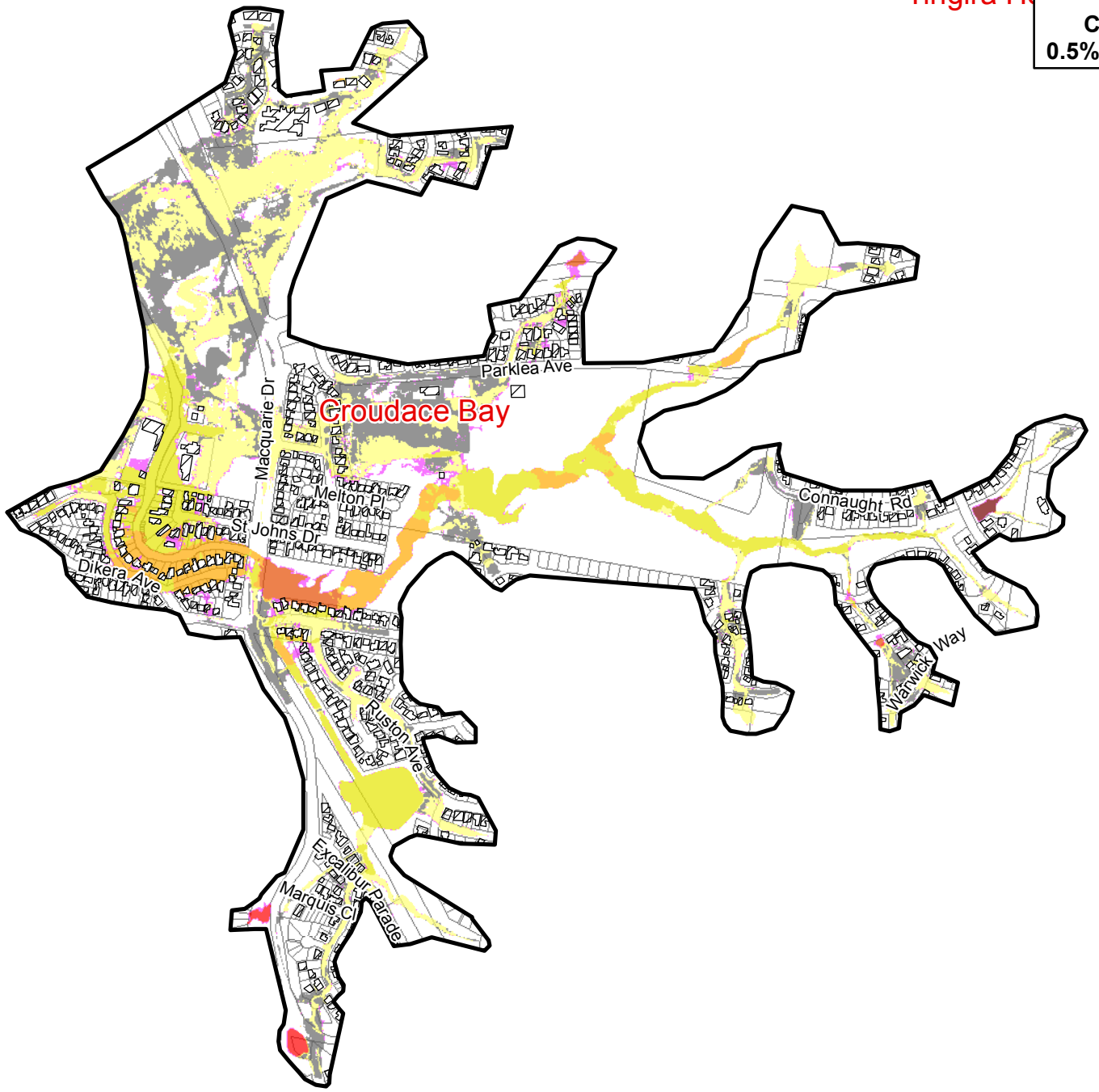
FIGURE D32
**SHEPPARDS CREEK HYDRAULIC HAZARD PMF EVENT**




J:\Jobs\119076\ArcGIS\ArcMap\Working\Template\Appendix_C\FigureD31_Sheppards_Creek_Provisional_Hazard_0.5%AEP.mxd

FIGURE D33

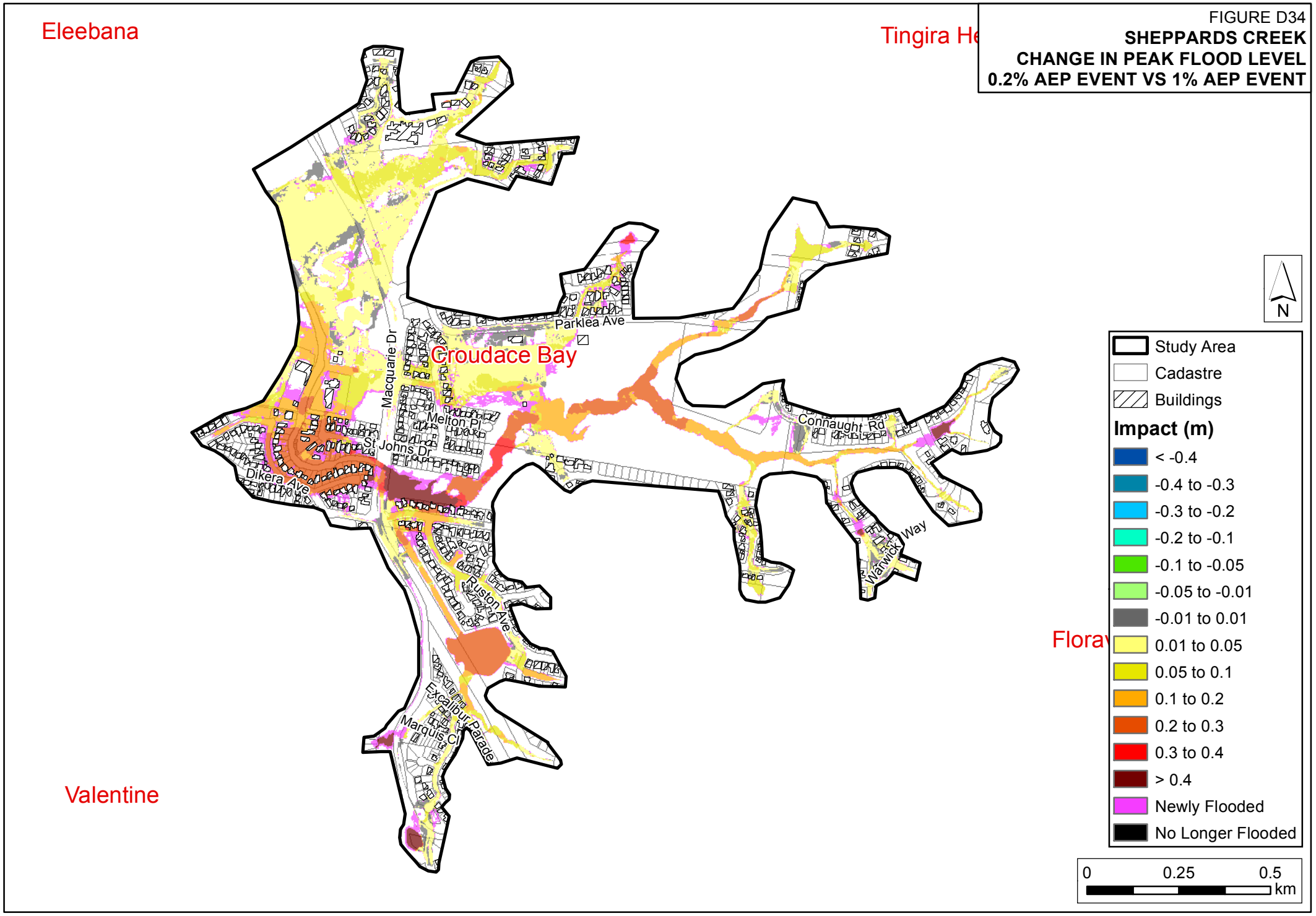
**SHEPPARDS CREEK**
**CHANGE IN PEAK FLOOD LEVEL**
**0.5% AEP EVENT VS 1% AEP EVENT**




J:\Jobs\119076\ArcGIS\ArcMap\Working\Template\Appendix_D\FigureD33_Sheppards_Creek_Impact_CC_0.5%AEP_V_1%AEP.mxd

FIGURE D34

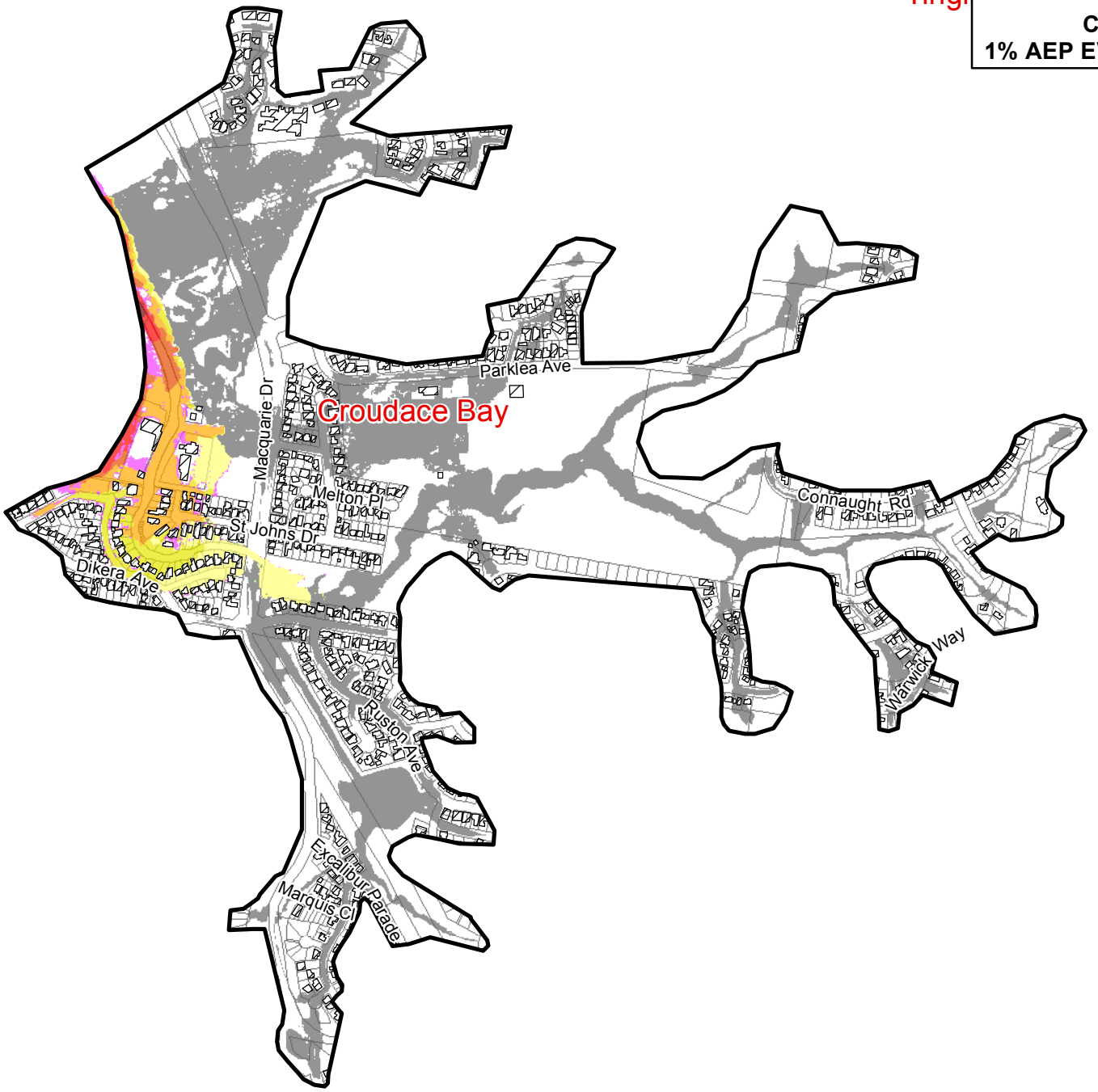
**SHEPPARDS CREEK**
**CHANGE IN PEAK FLOOD LEVEL**
**0.2% AEP EVENT VS 1% AEP EVENT**




J:\Jobs\119076\ArcGIS\ArcMap\Working\Template\Appendix_D\FigureD33_Sheppards_Creek_Impact_CC_0.5%AEP_V_1%AEP.mxd

FIGURE D35

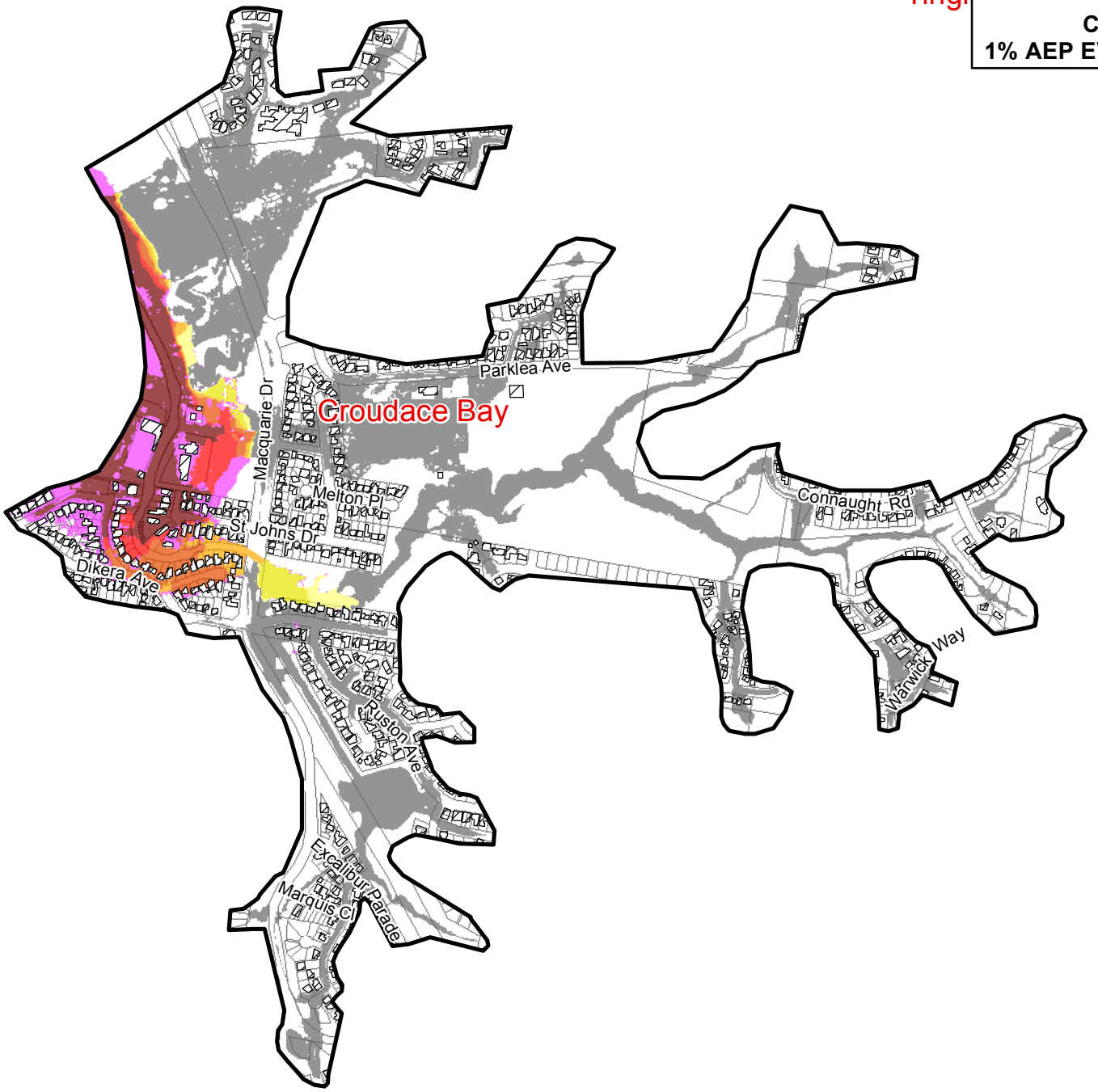
**SHEPPARDS CREEK**
**CHANGE IN PEAK FLOOD LEVEL**
**1% AEP EVENT - SEA LEVEL RISE 400MM**




J:\Jobs\119076\ArcGIS\ArcMap\Working\Template\Appendix_D\FigureD34_Sheppards_Creek_Impact_CC_0.2%AEP_V_1%AEP.mxd

FIGURE D36

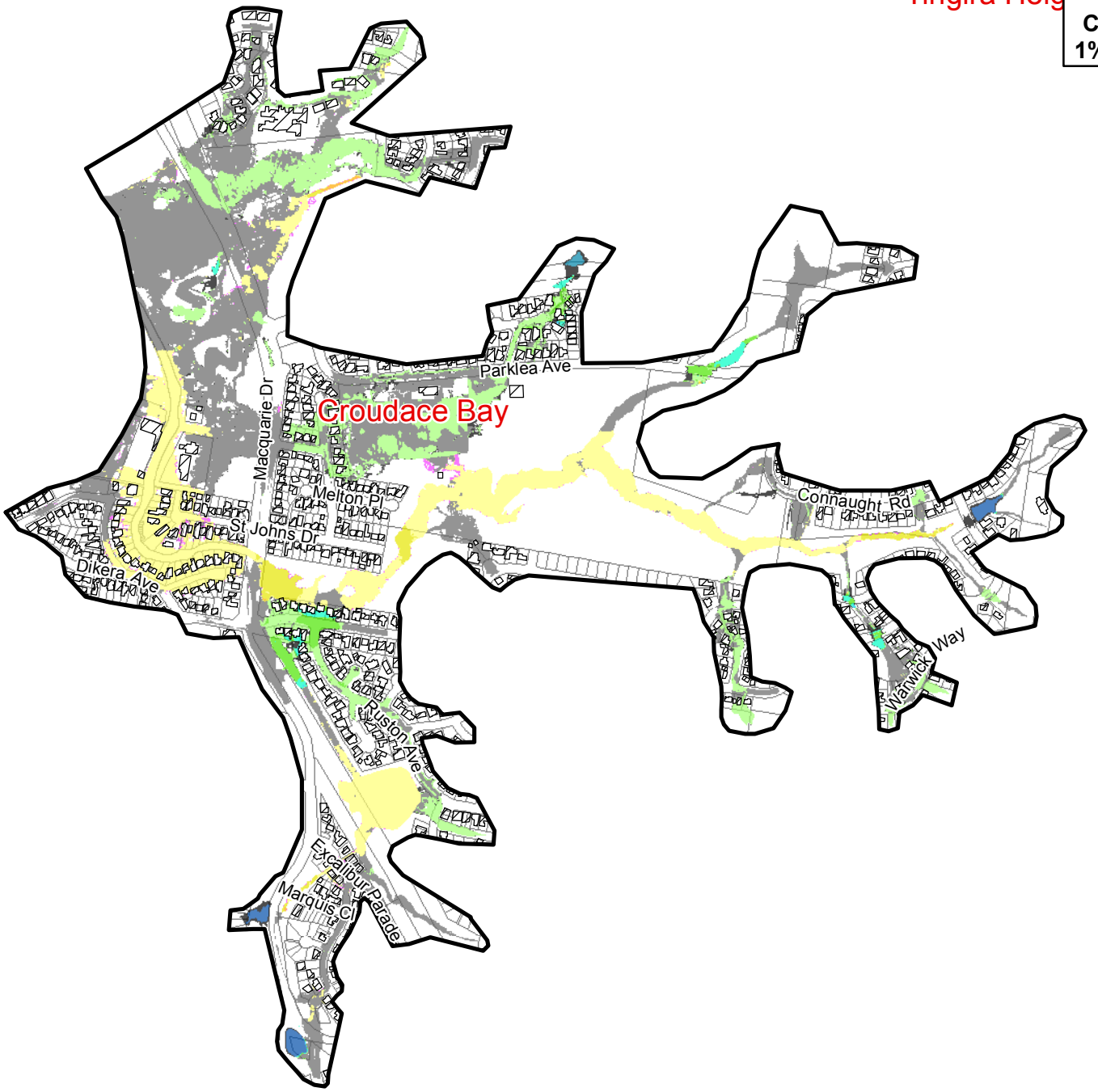
**SHEPPARDS CREEK**
**CHANGE IN PEAK FLOOD LEVEL**
**1% AEP EVENT - SEA LEVEL RISE 900MM**




J:\Jobs\119076\ArcGIS\ArcMap\Working\Template\Appendix_D\FigureD35_Sheppards_Creek_Impact_CC_SLR04_1%AEP.mxd

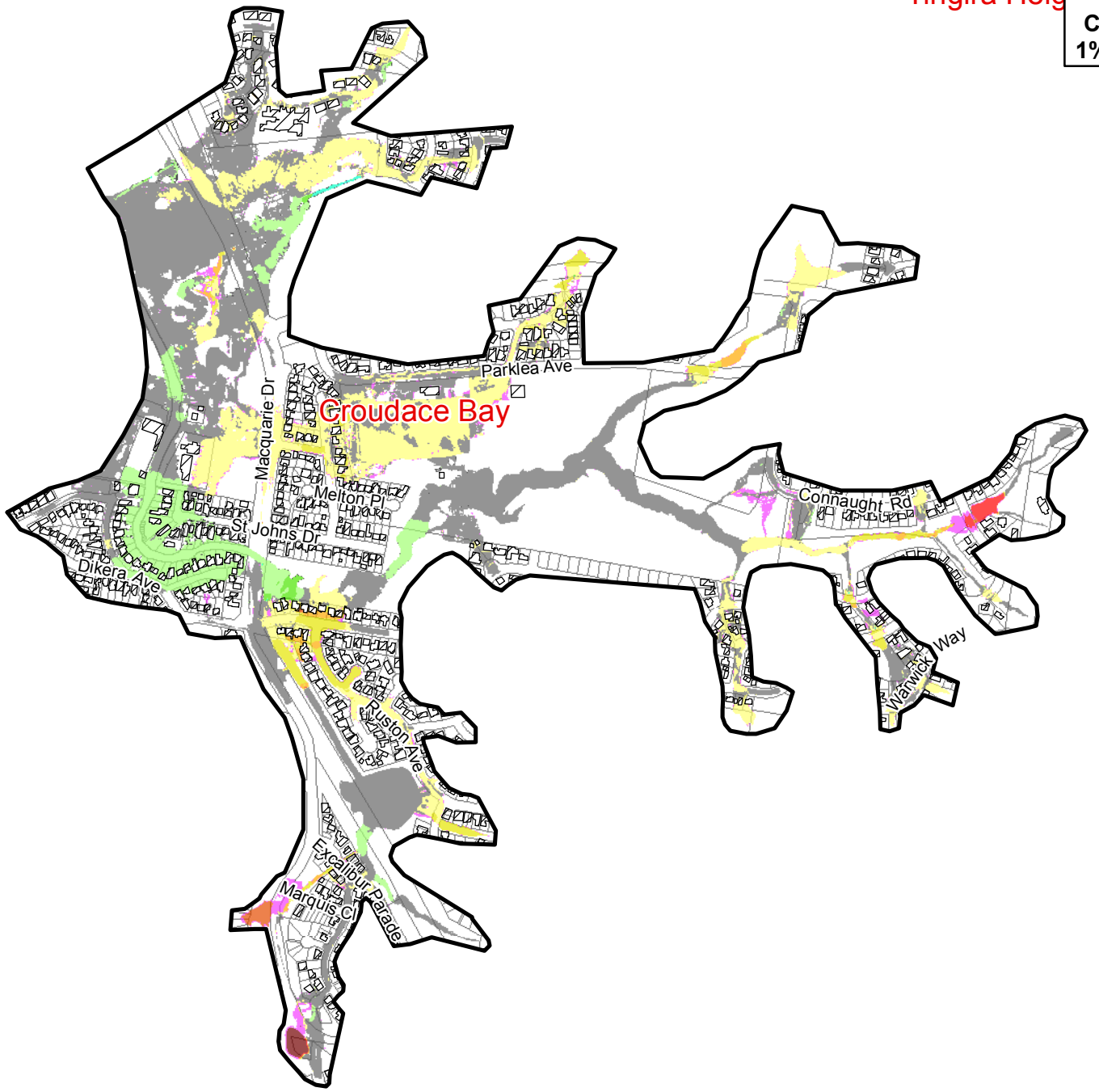
FIGURE D37

**SHEPPARDS CREEK**
**CHANGE IN PEAK FLOOD LEVEL**
**1% AEP EVENT - 25% BLOCKAGE**



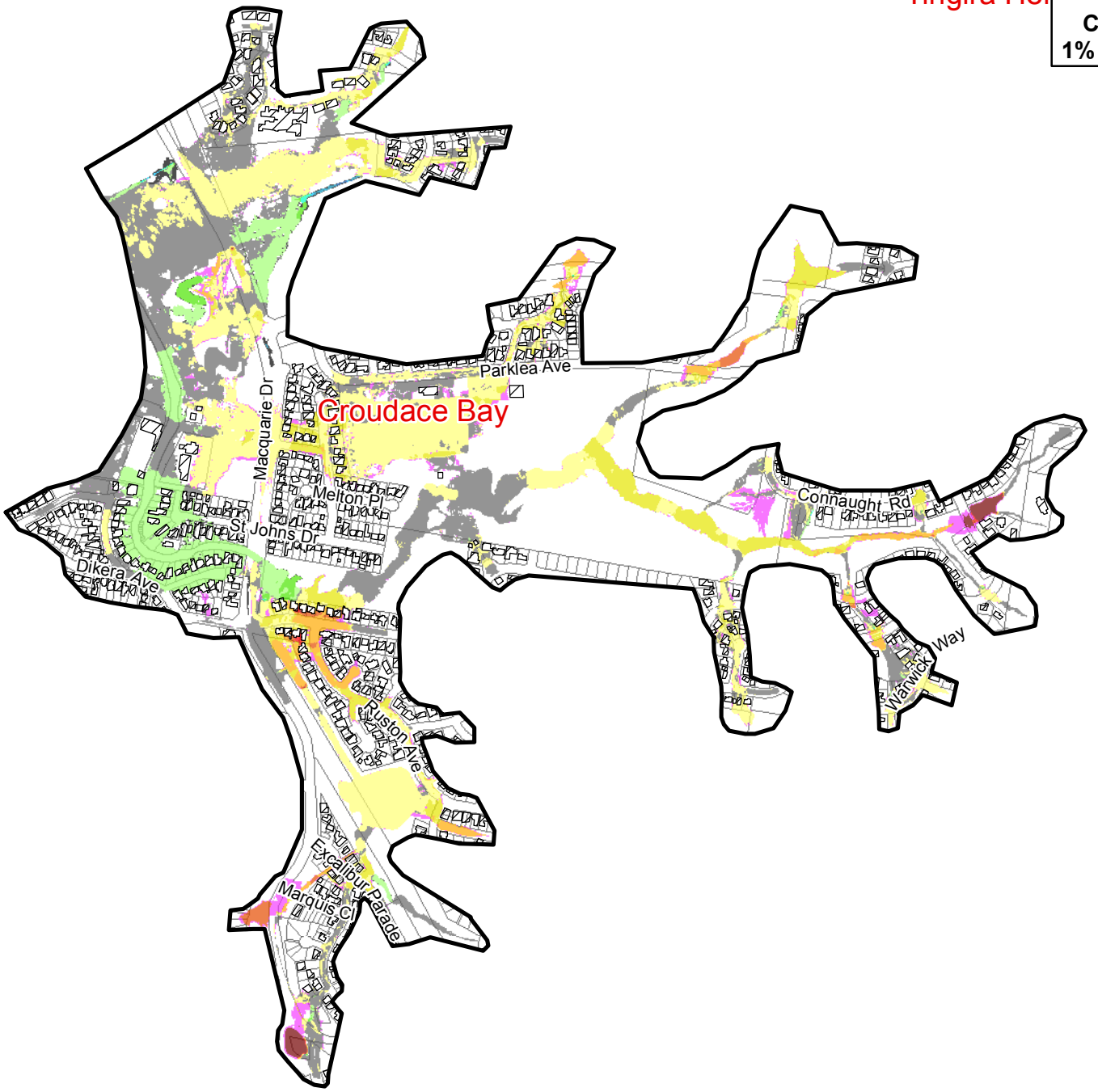

J:\Jobs\119076\ArcGIS\ArcMap\Working\Template\Appendix_D\FigureD36_Sheppards_Creek_Impact_CC_SLR09_1%AEP.mxd

FIGURE D38
**SHEPPARDS CREEK**
**CHANGE IN PEAK FLOOD LEVEL**
**1% AEP EVENT - 75% BLOCKAGE**




J:\Jobs\119076\ArcGIS\ArcMap\Working\Template\Appendix_D\FigureD38_Sheppards_Creek_Impact_1%AEP_Blockage75pc.mxd

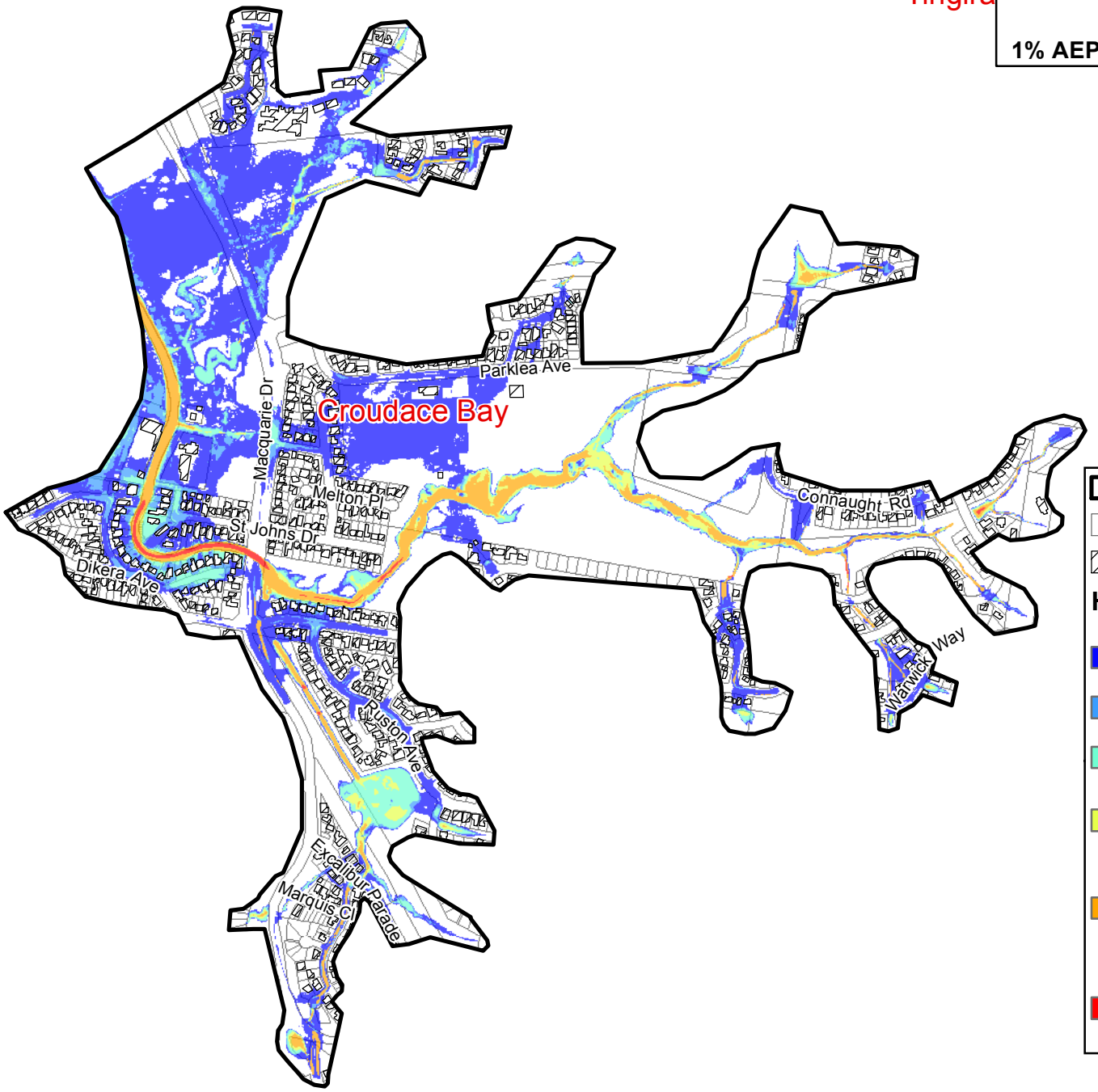
FIGURE D39
**SHEPPARDS CREEK**
**CHANGE IN PEAK FLOOD LEVEL**
**1% AEP EVENT - 100% BLOCKAGE**




J:\Jobs\119076\ArcGIS\ArcMap\Working\Template\Appendix_D\FigureD39_Sheppards_Creek_Impact_1%AEP_Blockage100pc.mxd

FIGURE D40

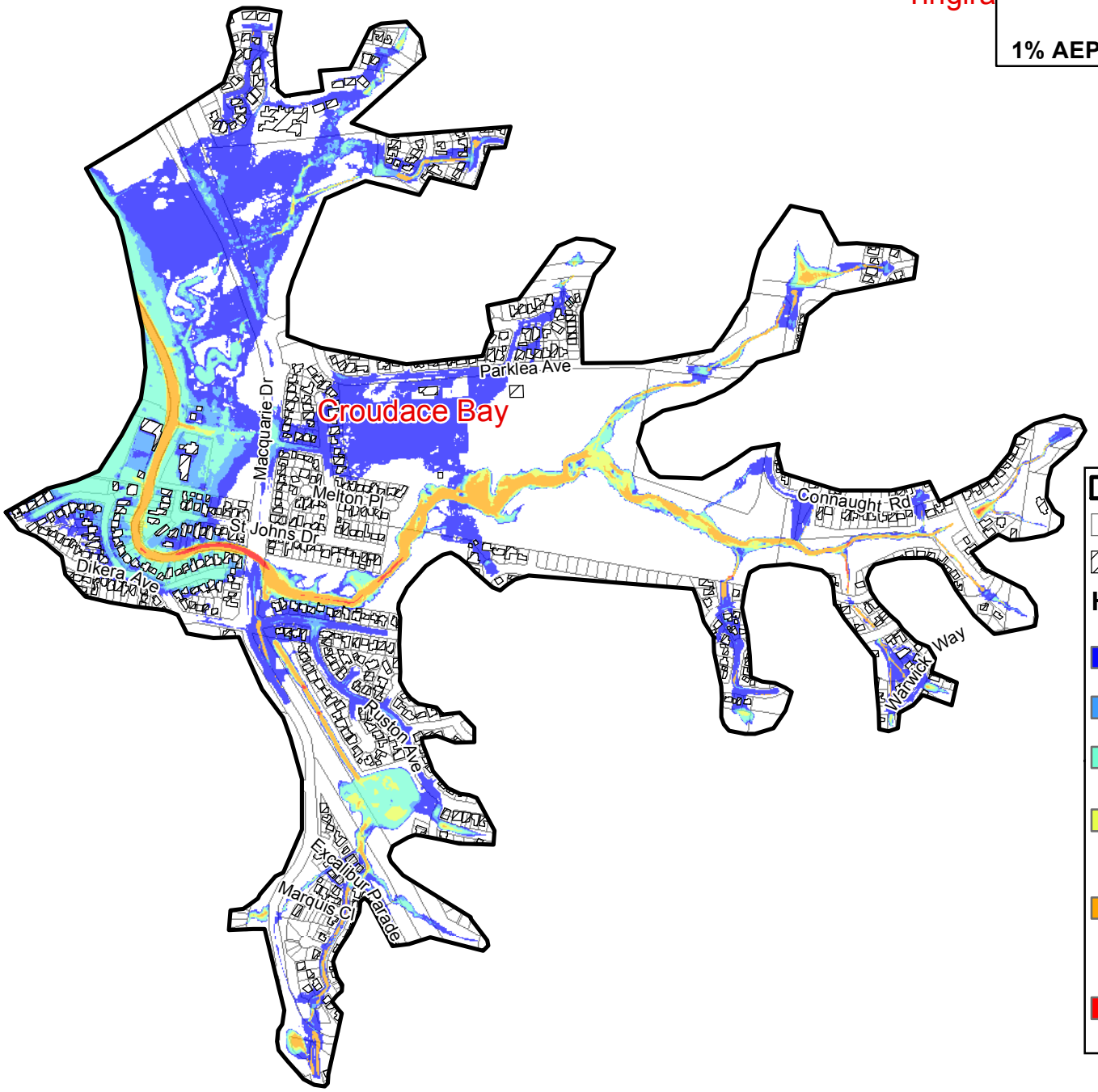
**SHEPPARDS CREEK**
**HYDRAULIC HAZARD**
**1% AEP EVENT - SEA LEVEL RISE 0.4M**




J:\Jobs\119076\ArcGIS\ArcMap\Working\Template\Appendix_D\FigureD32_Sheppards_Creek_Provisional_Hazard_PMF.mxd

FIGURE D41

**SHEPPARDS CREEK**
**HYDRAULIC HAZARD**
**1% AEP EVENT - SEA LEVEL RISE 0.9M**




J:\Jobs\119076\ArcGIS\ArcMap\Working\Template\Appendix_D\FigureD41_Sheppards_Creek_Provisional_Hazard_1%AEP_SLR09.mxd

FIGURE D42
**SHEPPARDS CREEK**
**FLOOD PLANNING AREA**

J:\Jobs\119076\ArcGIS\ArcMap\Report\Appendix_D\FigureD42_Sheppards_Creek_Flood_Planning_Area.mxd

**APPENDIX E: DESIGN FLOOD MAPS – MURABAN CREEK**

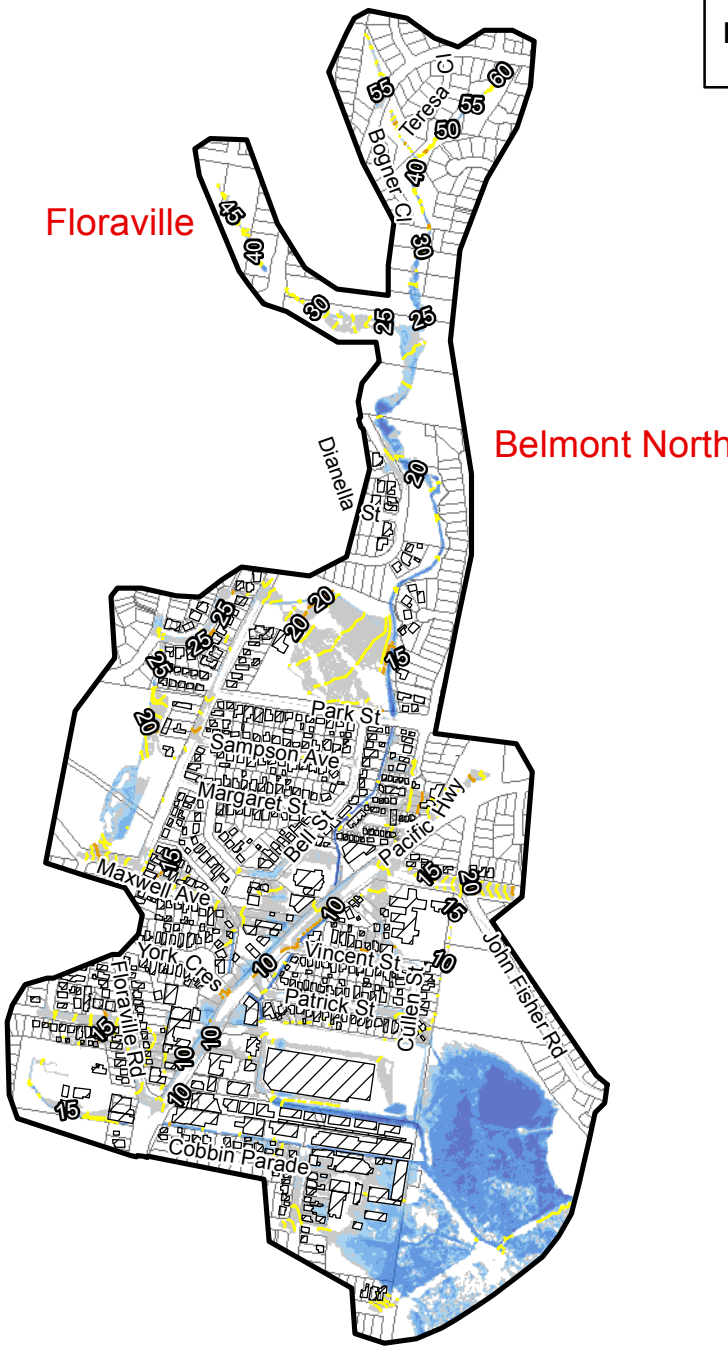
Appendix E

FIGURE E1

**MURABAN CREEK**

**PEAK FLOOD DEPTH AND LEVEL CONTOUR**

**50% AEP EVENT**




N

- Study Area
- Cadastre
- Buildings
- Major Contour Interval (5.0m)
- Minor Contour Interval (1.0m)

**Depth (m)**

- 0 - 0.15
- 0.15 - 0.30
- 0.30 - 0.50
- 0.50 - 1.00
- 1.00 - 2.00
- > 2.00

0 0.25 0.5 km

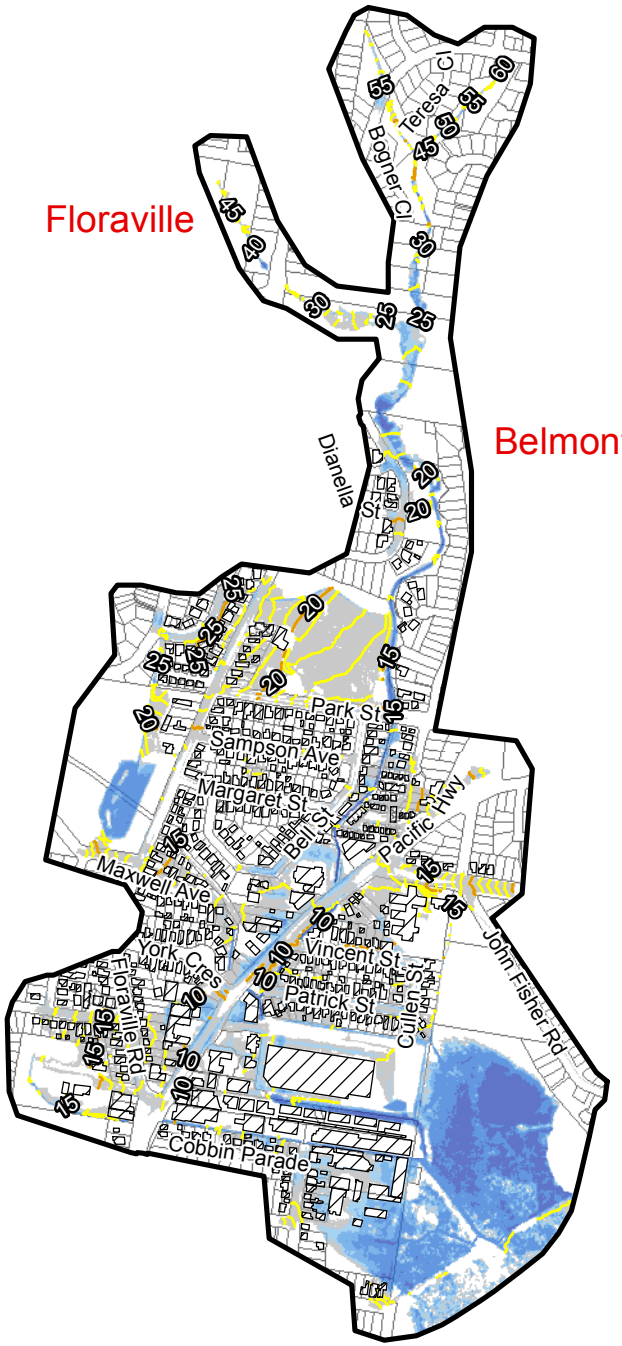
J:\Jobs\119076\ArcGIS\ArcMap\Working\Template\Appendix_E\FigureE01_Muraban_Creek_Peak_Flood_Depth_50%AEP.mxd

FIGURE E2

**MURABAN CREEK**

**PEAK FLOOD DEPTH AND LEVEL CONTOUR**

**20% AEP EVENT**




N

- Study Area
- Cadastre
- Buildings
- Major Contour Interval (5.0m)
- Minor Contour Interval (1.0m)

**Depth (m)**

- 0 - 0.15
- 0.15 - 0.30
- 0.30 - 0.50
- 0.50 - 1.00
- 1.00 - 2.00
- > 2.00

0 0.25 0.5 km

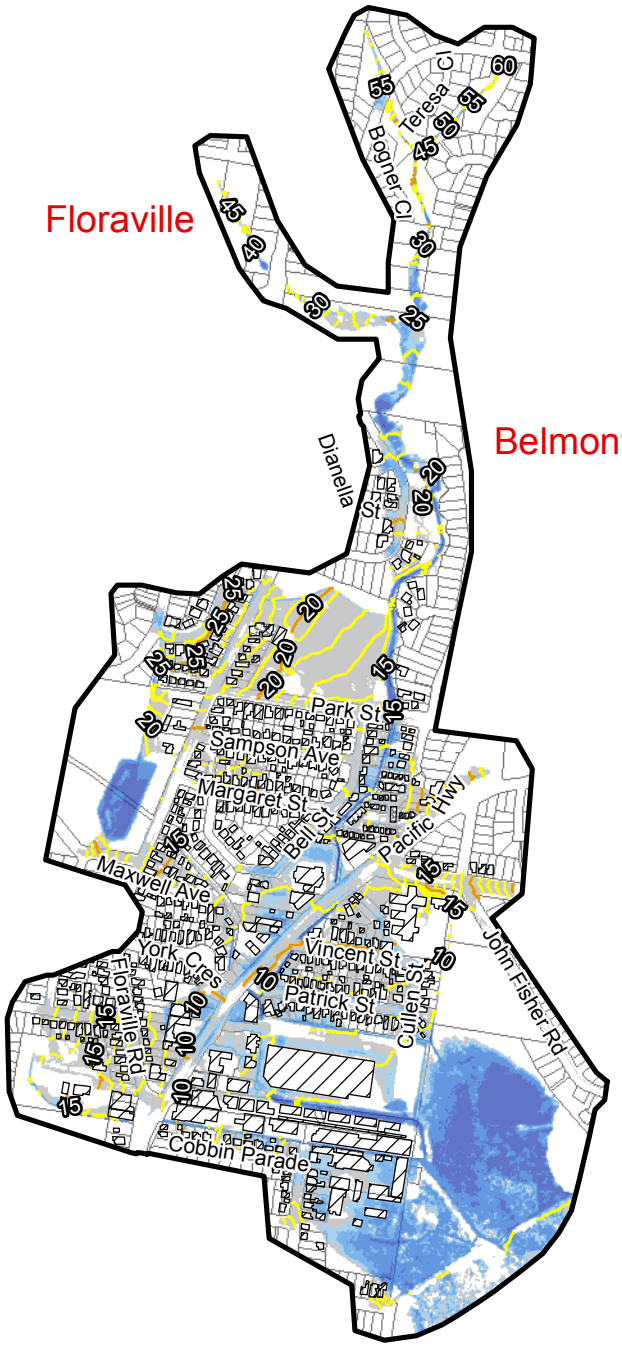
J:\Jobs\119076\ArcGIS\ArcMap\Working\Template\Appendix_E\FigureE01_Muraban_Creek_Peak_Flood_Depth_50%AEP.mxd

FIGURE E3

**MURABAN CREEK**

**PEAK FLOOD DEPTH AND LEVEL CONTOUR**

**10% AEP EVENT**




N

- Study Area
- Cadastre
- Buildings
- Major Contour Interval (5.0m)
- Minor Contour Interval (1.0m)

**Depth (m)**

- 0 - 0.15
- 0.15 - 0.30
- 0.30 - 0.50
- 0.50 - 1.00
- 1.00 - 2.00
- > 2.00

0 0.25 0.5 km

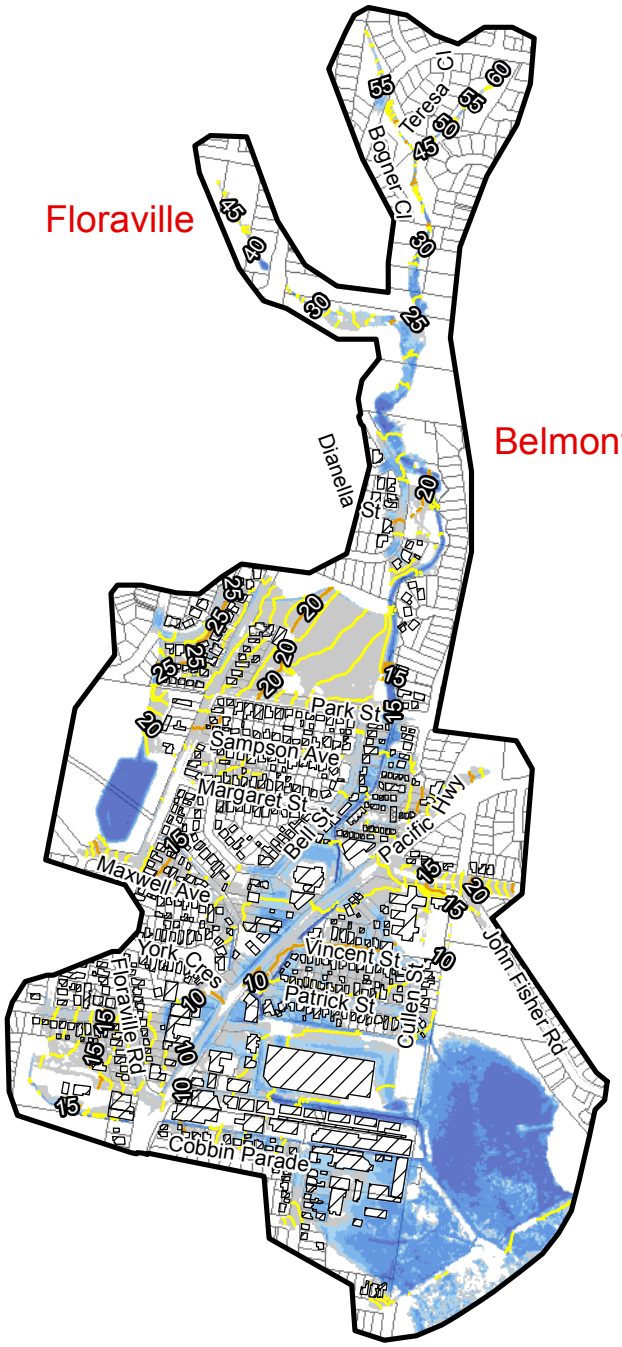
J:\Jobs\11907\6\ArcGIS\ArcMap\Working\Template\Appendix_E\FigureE02_Muraban_Creek_Peak_Flood_Depth_20%AEP.mxd

FIGURE E4

**MURABAN CREEK**

**PEAK FLOOD DEPTH AND LEVEL CONTOUR**

**5% AEP EVENT**




N

- Study Area
- Cadastre
- Buildings
- Major Contour Interval (5.0m)
- Minor Contour Interval (1.0m)

**Depth (m)**

- 0 - 0.15
- 0.15 - 0.30
- 0.30 - 0.50
- 0.50 - 1.00
- 1.00 - 2.00
- > 2.00

0 0.25 0.5 km

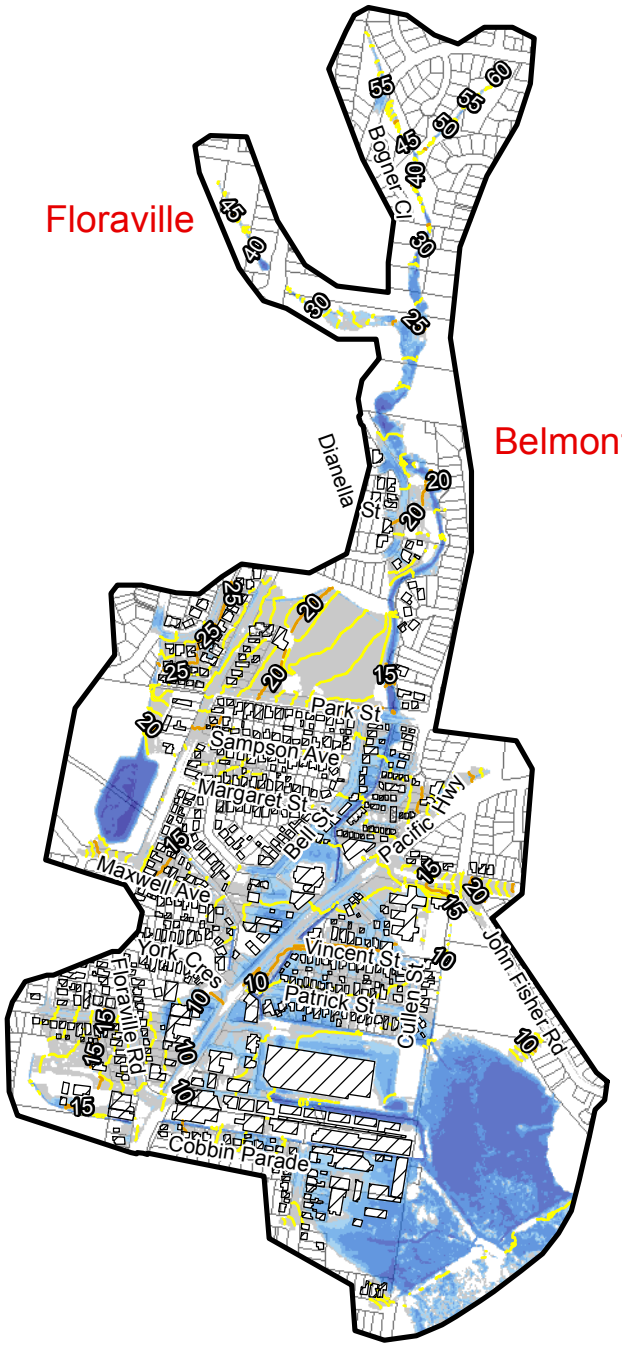
J:\Jobs\119076\ArcGIS\ArcMap\Working\Template\Appendix_E\FigureE03_Muraban_Creek_Peak_Flood_Depth_10%AEP.mxd

FIGURE E5

**MURABAN CREEK**

**PEAK FLOOD DEPTH AND LEVEL CONTOUR**

**2% AEP EVENT**




N

- Study Area
- Cadastre
- Buildings
- Major Contour Interval (5.0m)
- Minor Contour Interval (1.0m)

**Depth (m)**

- 0 - 0.15
- 0.15 - 0.30
- 0.30 - 0.50
- 0.50 - 1.00
- 1.00 - 2.00
- > 2.00

0 0.25 0.5 km

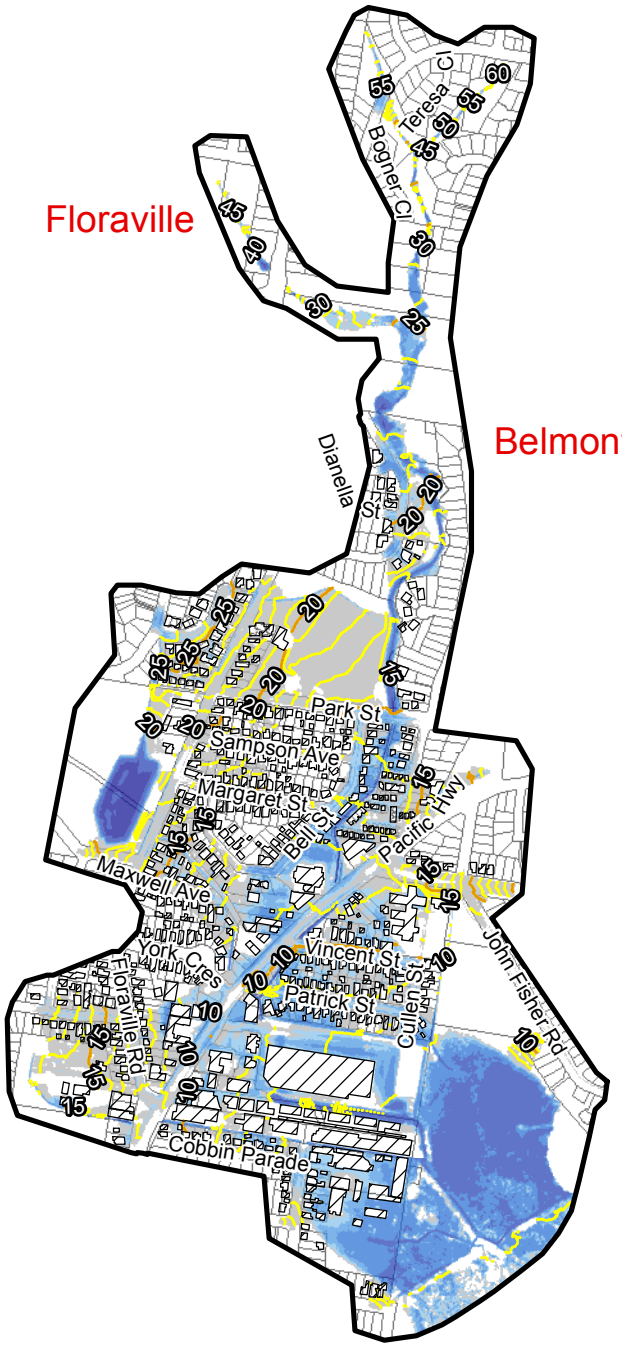
J:\Jobs\1190776\ArcGIS\ArcMap\Working\Template\Appendix_E\FigureE04_Muraban_Creek_Peak_Flood_Depth_5%AEP.mxd

FIGURE E6

**MURABAN CREEK**

**PEAK FLOOD DEPTH AND LEVEL CONTOUR**

**1% AEP EVENT**




N

- Study Area
- Cadastre
- Buildings
- Major Contour Interval (5.0m)
- Minor Contour Interval (1.0m)

**Depth (m)**

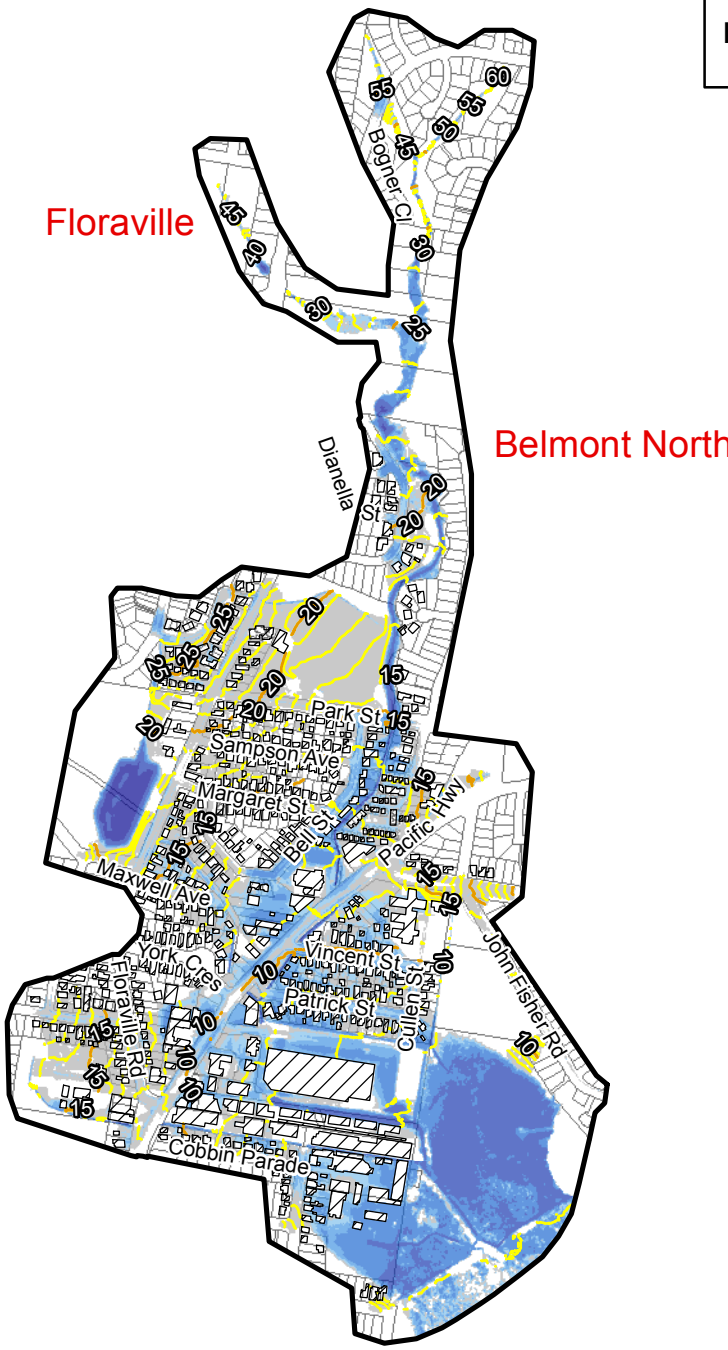
- 0 - 0.15
- 0.15 - 0.30
- 0.30 - 0.50
- 0.50 - 1.00
- 1.00 - 2.00
- > 2.00

0 0.25 0.5 km

J:\Jobs\119076\ArcGIS\ArcMap\Working\Template\Appendix_E\FigureE05_Muraban_Creek_Peak_Flood_Depth_2%AEP.mxd

FIGURE E7

**MURABAN CREEK**
**PEAK FLOOD DEPTH AND LEVEL CONTOUR**
**0.5% AEP EVENT**




N

- Study Area
- Cadastre
- Buildings
- Major Contour Interval (5.0m)
- Minor Contour Interval (1.0m)

**Depth (m)**

- 0 - 0.15
- 0.15 - 0.30
- 0.30 - 0.50
- 0.50 - 1.00
- 1.00 - 2.00
- > 2.00

0 0.25 0.5 km

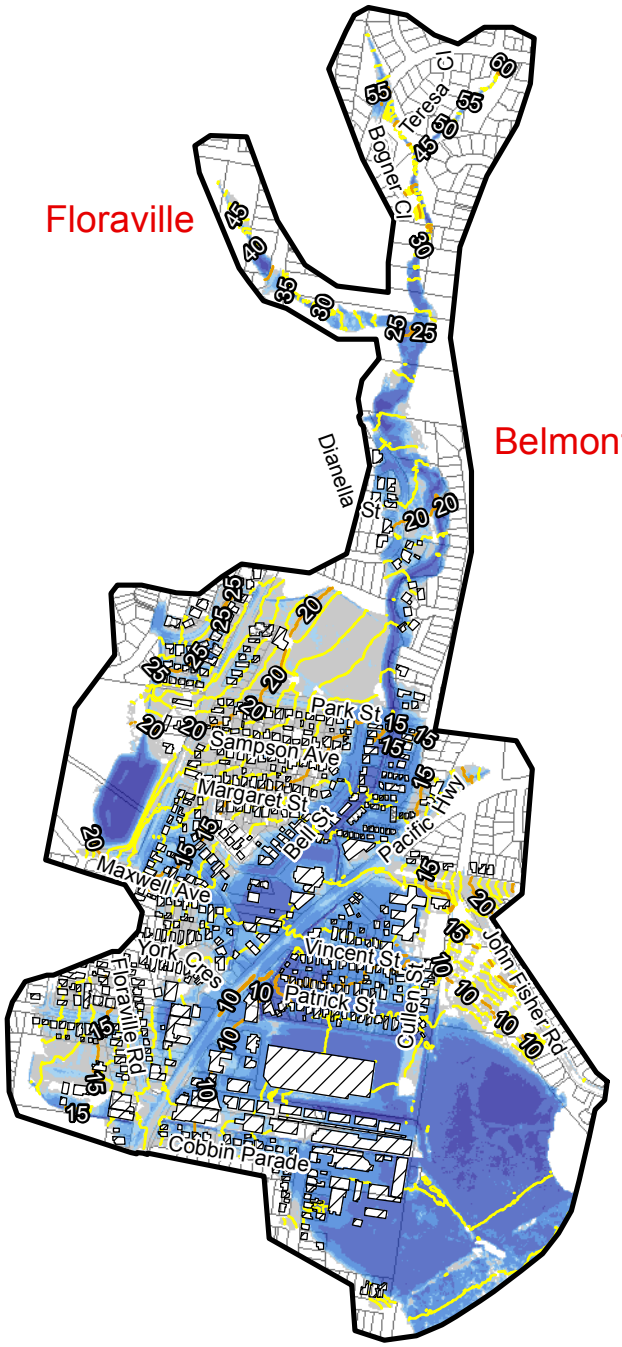
J:\Jobs\119076\ArcGIS\ArcMap\Working\Template\Appendix_E\FigureE06_Muraban_Creek_Peak_Flood_Depth_1%AEP.mxd

FIGURE E8

**MURABAN CREEK**

**PEAK FLOOD DEPTH AND LEVEL CONTOUR**

**PMF EVENT**




N

- Study Area
- Cadastre
- Buildings
- Major Contour Interval (5.0m)
- Minor Contour Interval (1.0m)

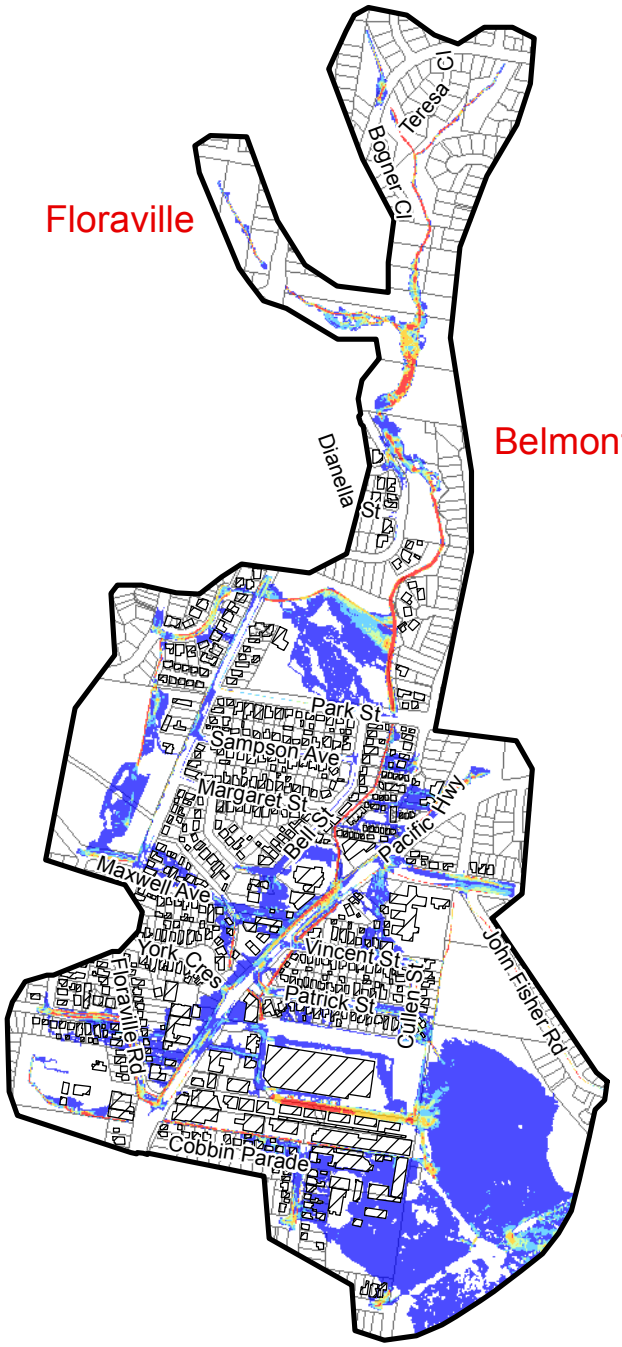
**Depth (m)**

- 0 - 0.15
- 0.15 - 0.30
- 0.30 - 0.50
- 0.50 - 1.00
- 1.00 - 2.00
- > 2.00

0 0.25 0.5 km

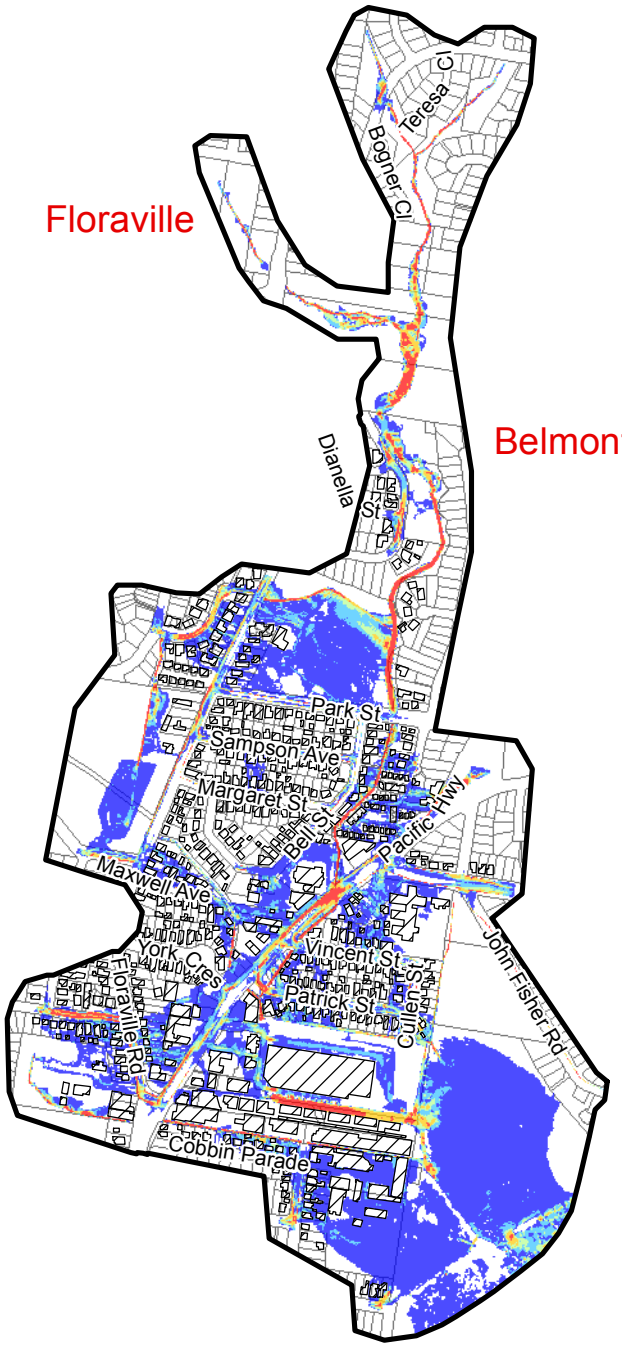
J:\Jobs\1190776\ArcGIS\ArcMap\Working\Template\Appendix_E\FigureE07_Muraban_Creek_Peak_Flood_Depth_0.5%AEP.mxd

FIGURE E9
**MURABAN CREEK**
**PEAK FLOOD VELOCITIES**
**50% AEP EVENT**



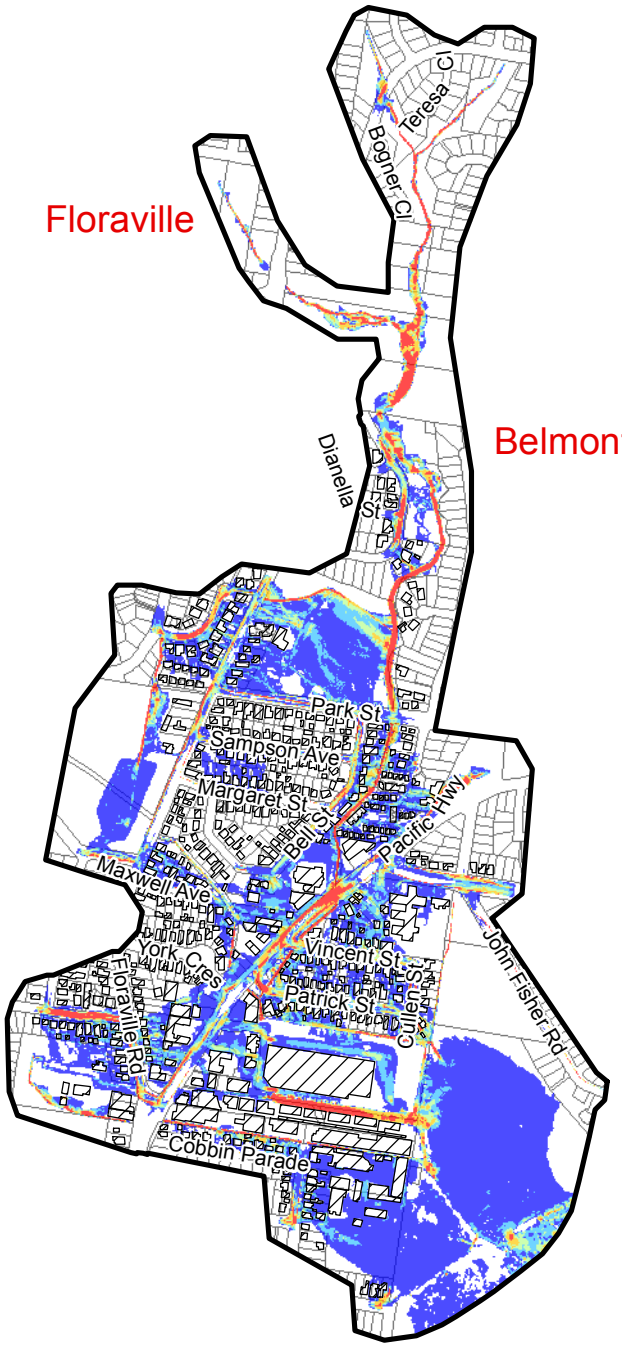

J:\Jobs\119076\ArcGIS\ArcMap\Working\Template\Appendix_E\FigureE09_Muraban_Creek_Peak_Flood_Velocity_50%AEP.mxd

FIGURE E10
**MURABAN CREEK**
**PEAK FLOOD VELOCITIES**
**20% AEP EVENT**



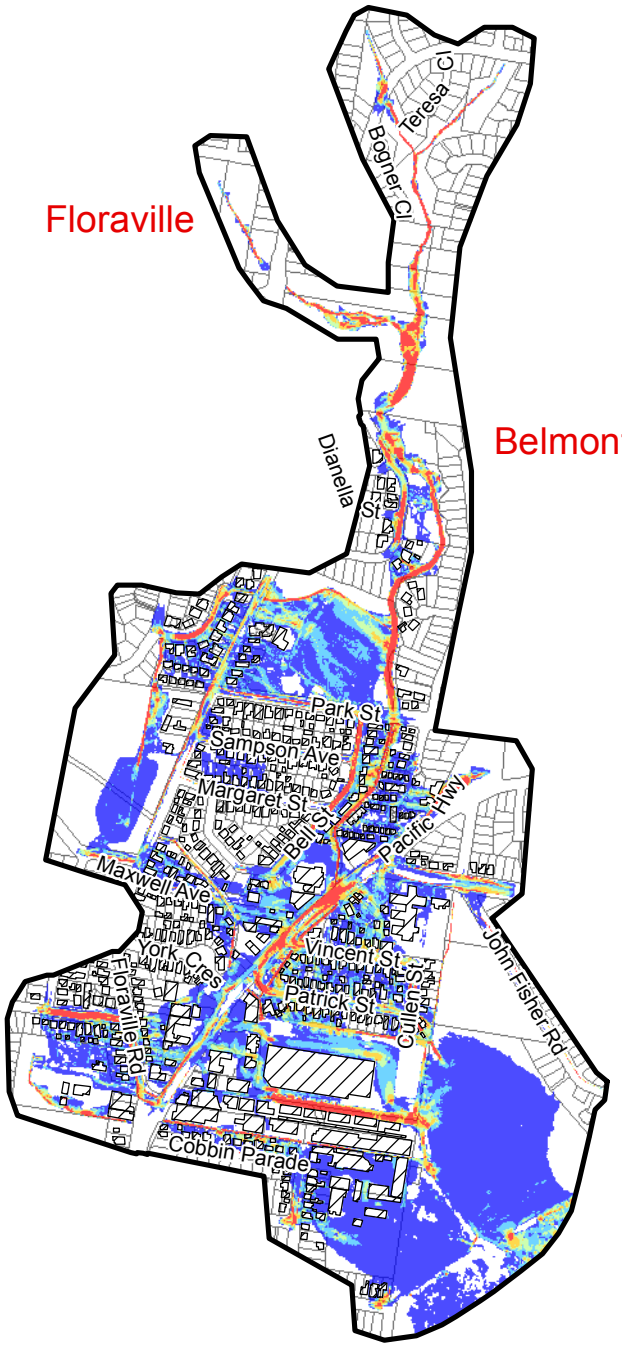

J:\Jobs\11907\6\ArcGIS\ArcMap\Working\Template\Appendix_E\FigureE09_Muraban_Creek_Peak_Flood_Velocity_50%AEP.mxd

FIGURE E11
**MURABAN CREEK**
**PEAK FLOOD VELOCITIES**
**10% AEP EVENT**



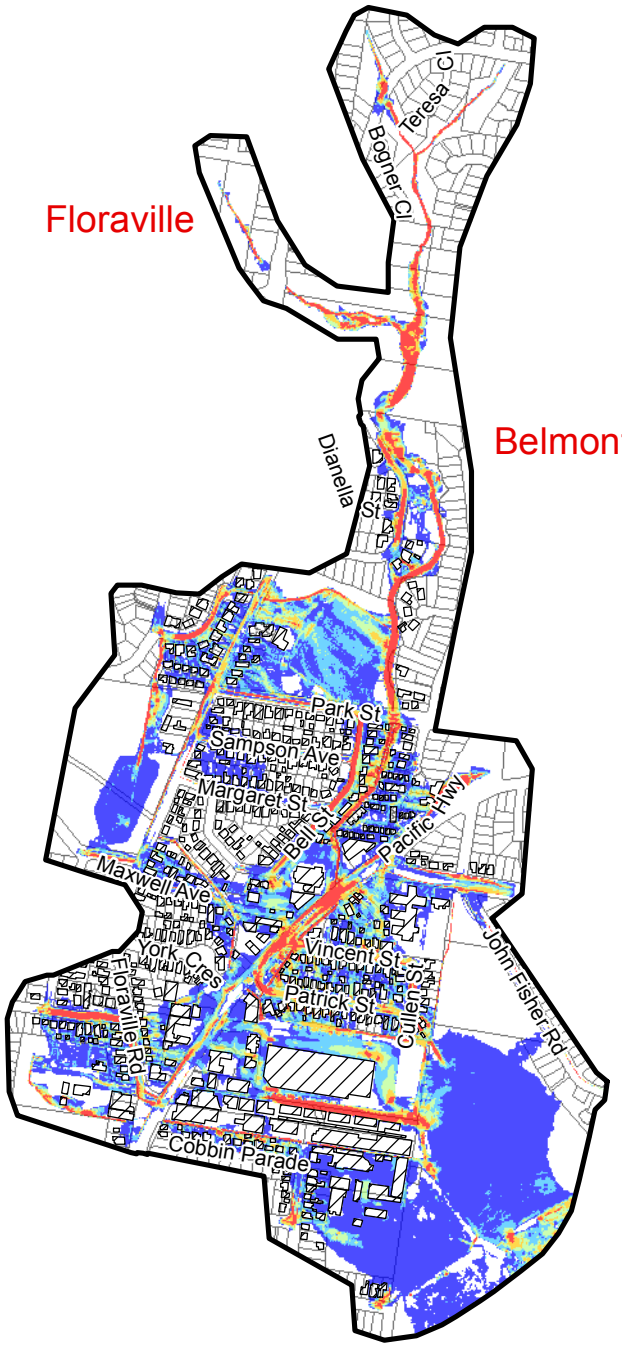

J:\Jobs\11907\6\ArcGIS\ArcMap\Working\Template\Appendix_E\FigureE10_Muraban_Creek_Peak_Flood_Velocity_20%AEP.mxd

FIGURE E12
**MURABAN CREEK**
**PEAK FLOOD VELOCITIES**
**5% AEP EVENT**



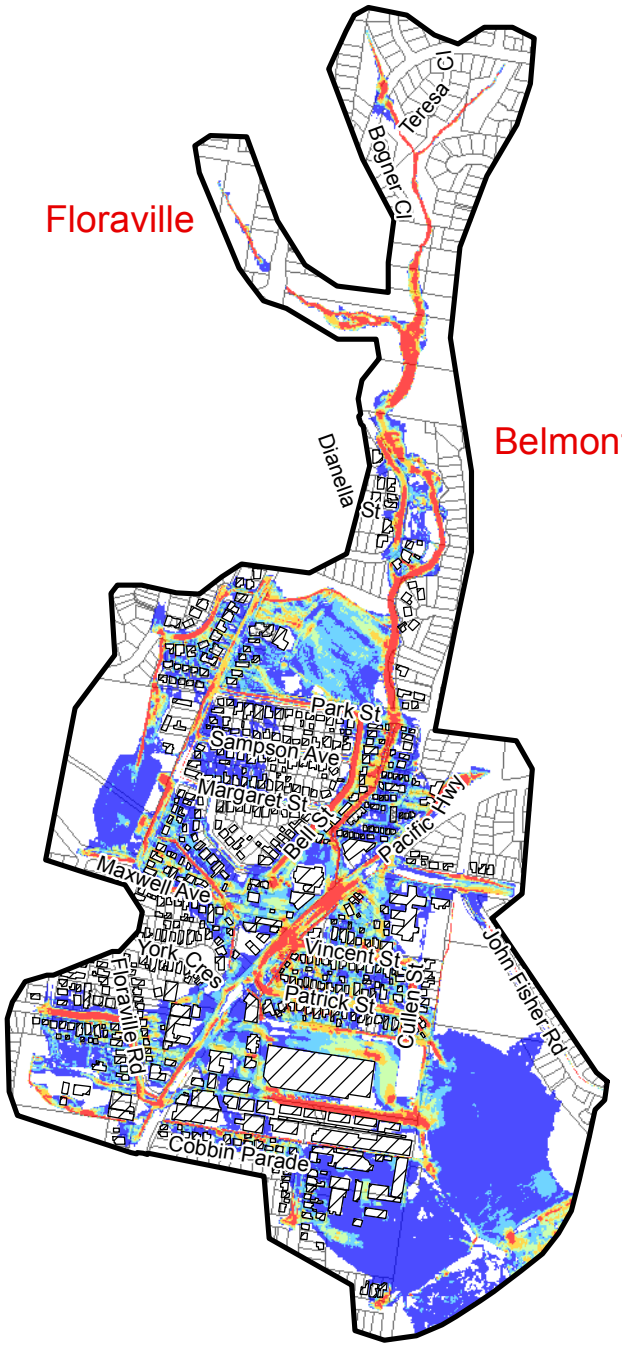

J:\Jobs\1190776\ArcGIS\ArcMap\Working\Template\Appendix_E\FigureE11_Muraban_Creek_Peak_Flood_Velocity_10%AEP.mxd

FIGURE E13
**MURABAN CREEK**
**PEAK FLOOD VELOCITIES**
**2% AEP EVENT**




J:\Jobs\11907\6\ArcGIS\ArcMap\Working\Template\Appendix_E\FigureE12_Muraban_Creek_Peak_Flood_Velocity_5%AEP.mxd

FIGURE E14
**MURABAN CREEK**
**PEAK FLOOD VELOCITIES**
**1% AEP EVENT**




N

Study Area
Cadastre
Buildings

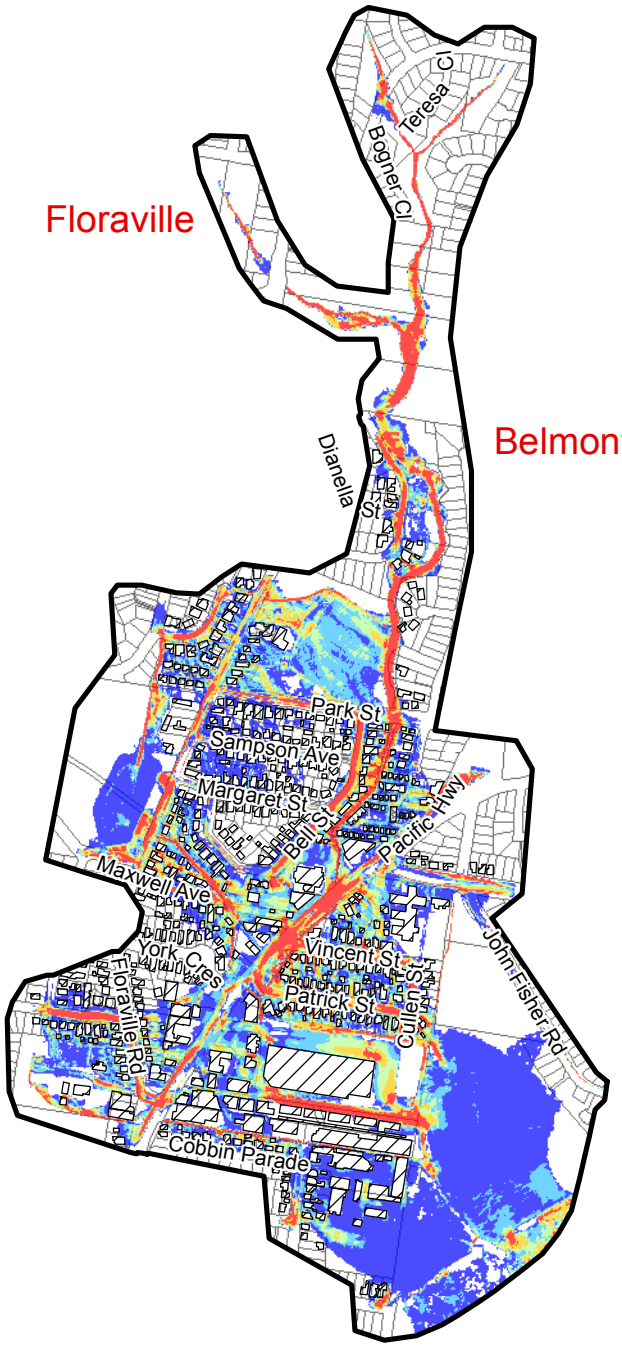
**Velocity (m/s)**

0 - 0.3
0.3 - 0.5
0.5 - 0.7
0.7 - 1.0
>1.0

0 0.25 0.5 km

J:\Jobs\11907\6\ArcGIS\ArcMap\Working\Template\Appendix_E\FigureE13_Muraban_Creek_Peak_Flood_Velocity_2%AEP.mxd

FIGURE E15
**MURABAN CREEK**
**PEAK FLOOD VELOCITIES**
**0.5% AEP EVENT**




N

Study Area
Cadastre
Buildings

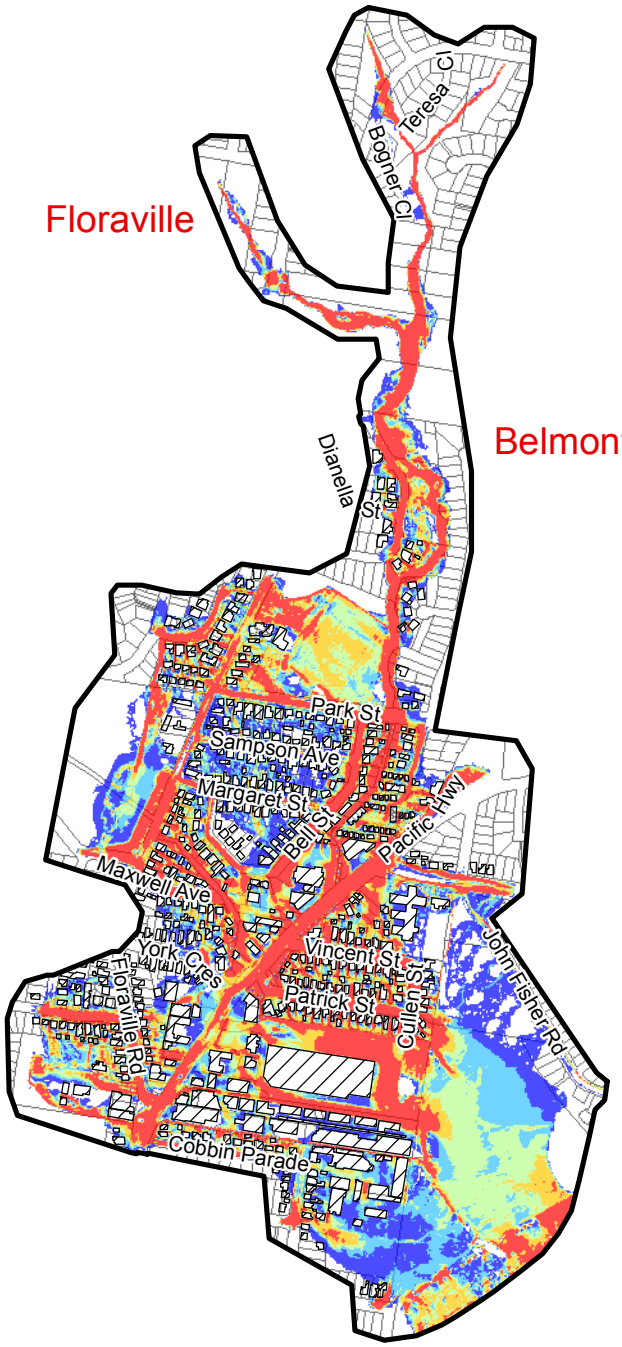
**Velocity (m/s)**

0 - 0.3
0.3 - 0.5
0.5 - 0.7
0.7 - 1.0
>1.0

0 0.25 0.5 km

J:\Jobs\119076\ArcGIS\ArcMap\Working\Template\Appendix_E\FigureE14_Muraban_Creek_Peak_Flood_Velocity_1%AEP.mxd

FIGURE E16
**MURABAN CREEK**
**PEAK FLOOD VELOCITIES**
**PMF EVENT**




N

Study Area
Cadastre
Buildings

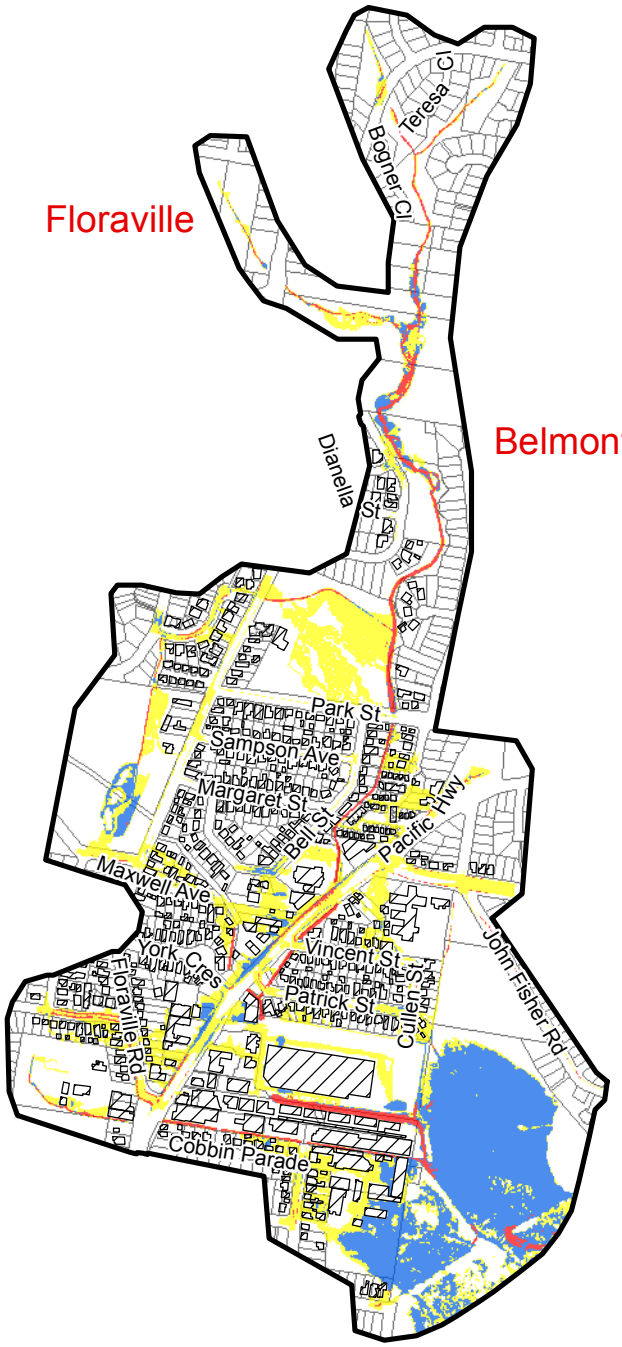
**Velocity (m/s)**

0 - 0.3
0.3 - 0.5
0.5 - 0.7
0.7 - 1.0
>1.0

0 0.25 0.5 km

J:\Jobs\1190776\ArcGIS\ArcMap\Working\Template\Appendix_E\FigureE15_Muraban_Creek_Peak_Flood_Velocity_0.5%AEP.mxd

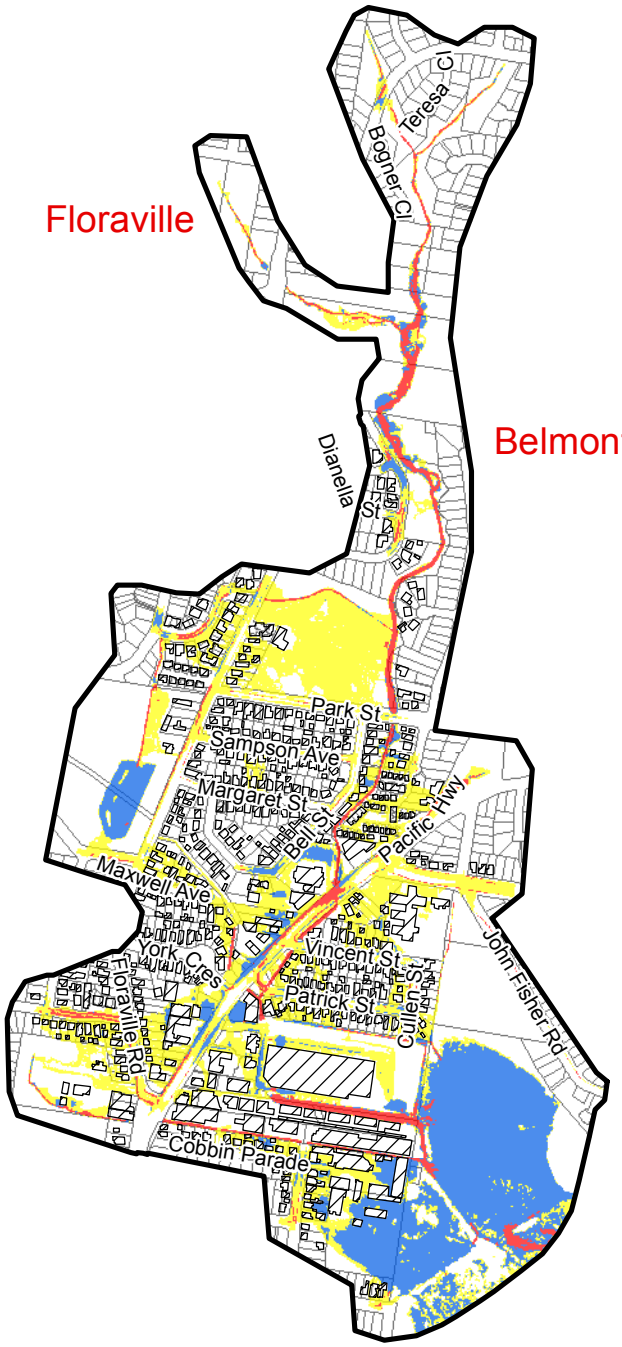
FIGURE E17
**MURABAN CREEK**
**HYDRAULIC CATEGORISATION**
**50% AEP EVENT**




J:\Jobs\119076\ArcGIS\ArcMap\Working\Template\Appendix_E\FigureE16_Muraban_Creek_Peak_Flood_Velocity_PMF.mxd

FIGURE E18

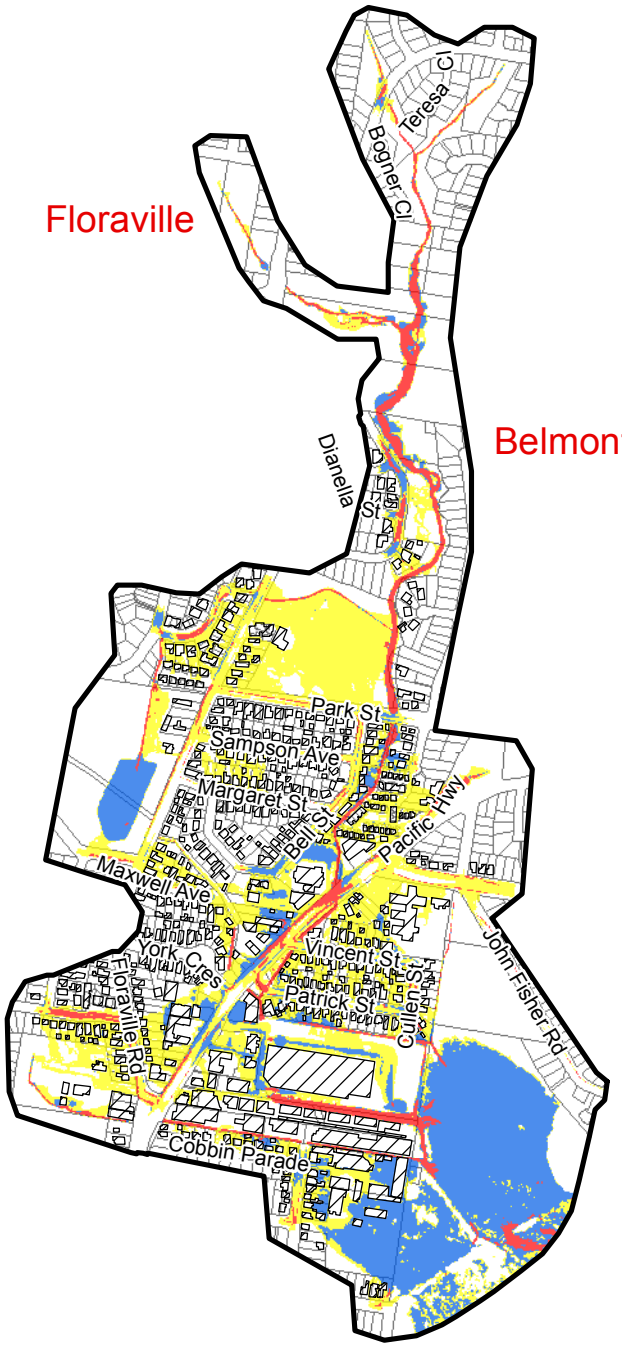
**MURABAN CREEK**
**HYDRAULIC CATEGORISATION**
**20% AEP EVENT**




J:\Jobs\1190776\ArcGIS\ArcMap\Working\Template\Appendix_E\FigureE17_Muraban_Creek_Hydraulic_Categories_50%AEP.mxd

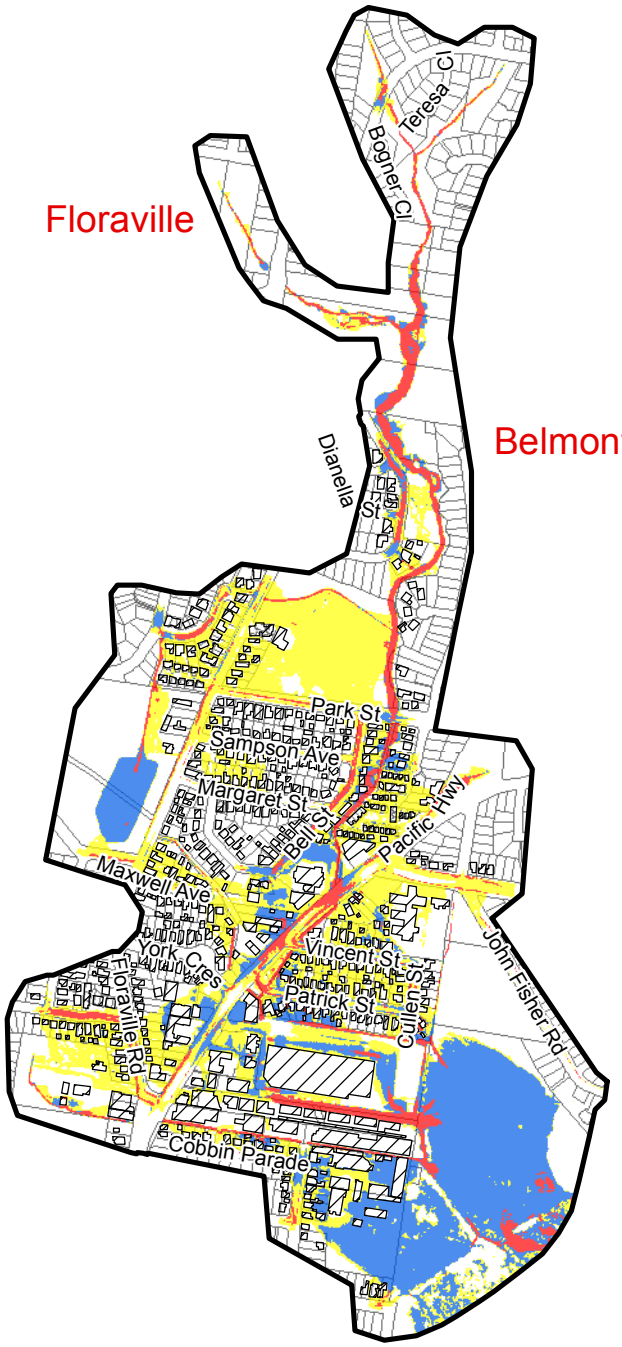
FIGURE E19

**MURABAN CREEK**
**HYDRAULIC CATEGORISATION**
**10% AEP EVENT**



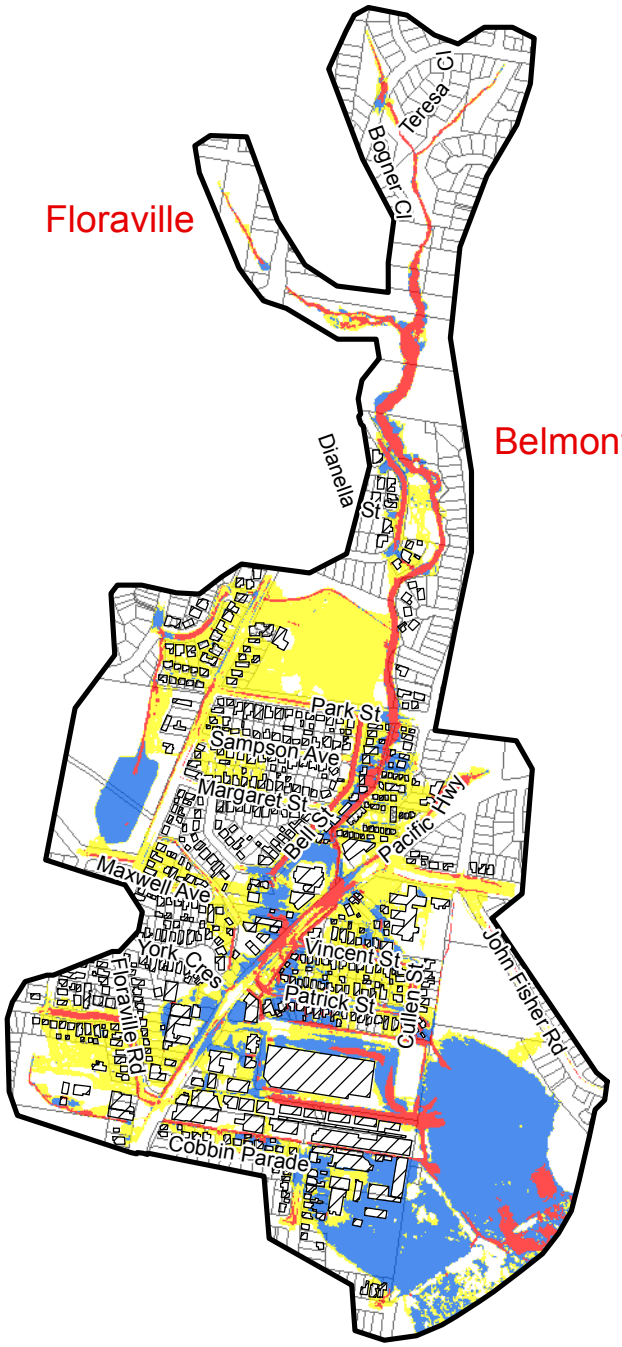

J:\Jobs\1190776\ArcGIS\ArcMap\Working\Template\Appendix_E\FigureE18_Muraban_Creek_Hydraulic_Categories_20%AEP.mxd

FIGURE E20
**MURABAN CREEK**
**HYDRAULIC CATEGORISATION**
**5% AEP EVENT**



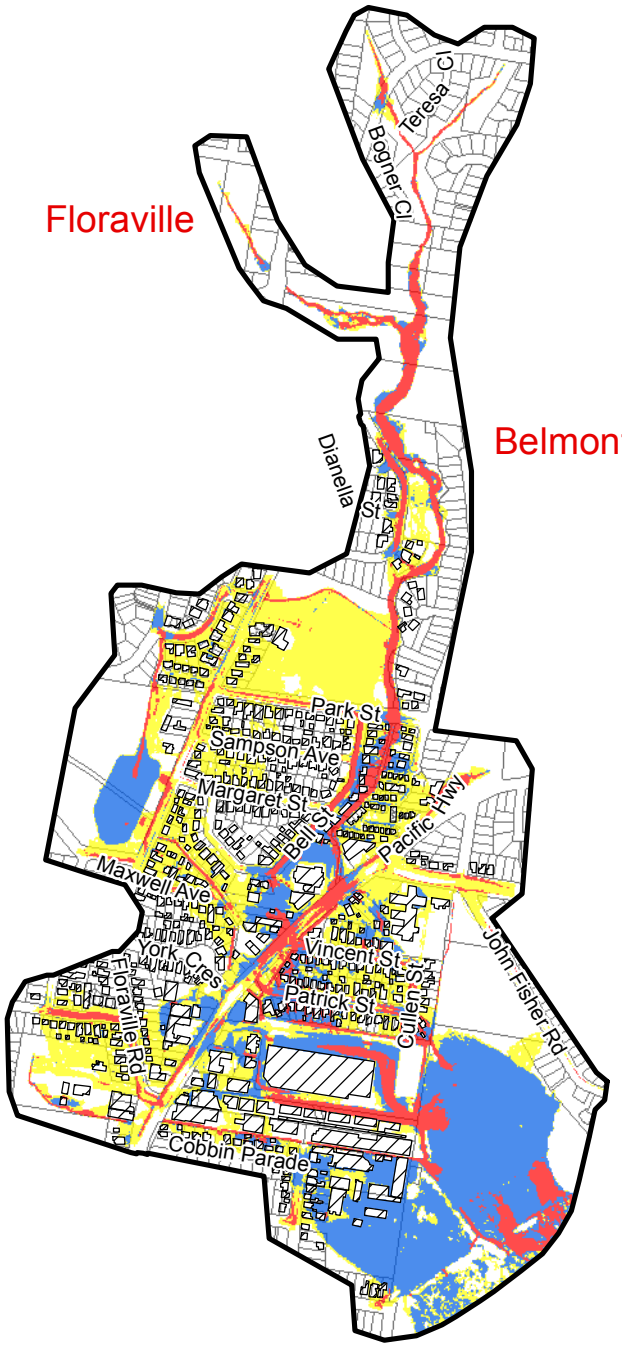

J:\Jobs\119076\ArcGIS\ArcMap\Working\Template\Appendix_E\FigureE19_Muraban_Creek_Hydraulic_Categories_10%AEP.mxd

FIGURE E21
**MURABAN CREEK**
**HYDRAULIC CATEGORISATION**
**2% AEP EVENT**



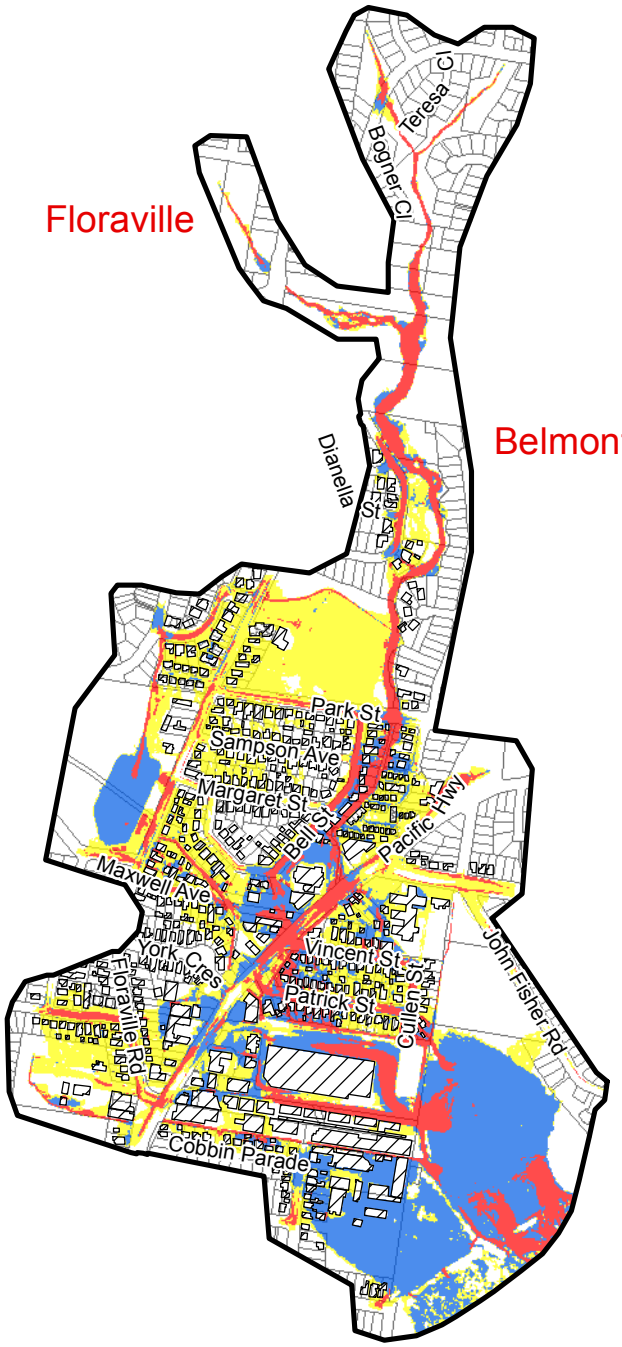

J:\Jobs\119076\ArcGIS\ArcMap\Working\Template\Appendix_E\FigureE20_Muraban_Creek_Hydraulic_Categories_5%AEP.mxd

FIGURE E22
**MURABAN CREEK**
**HYDRAULIC CATEGORISATION**
**1% AEP EVENT**




J:\Jobs\119076\ArcGIS\ArcMap\Working\Template\Appendix_E\FigureE21_Muraban_Creek_Hydraulic_Categories_2%AEP.mxd

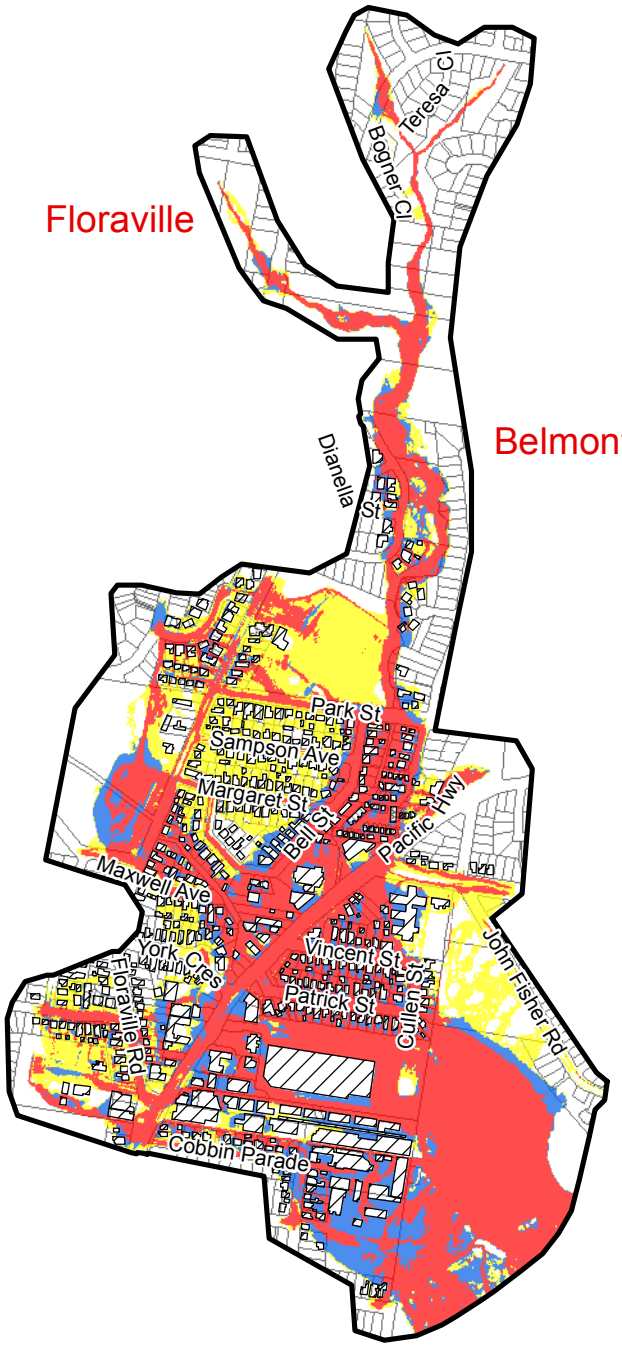
FIGURE E23
**MURABAN CREEK**
**HYDRAULIC CATEGORISATION**
**0.5% AEP EVENT**




J:\Jobs\119076\ArcGIS\ArcMap\Working\Template\Appendix_E\FigureE22_Muraban_Creek_Hydraulic_Categories_1%AEP.mxd

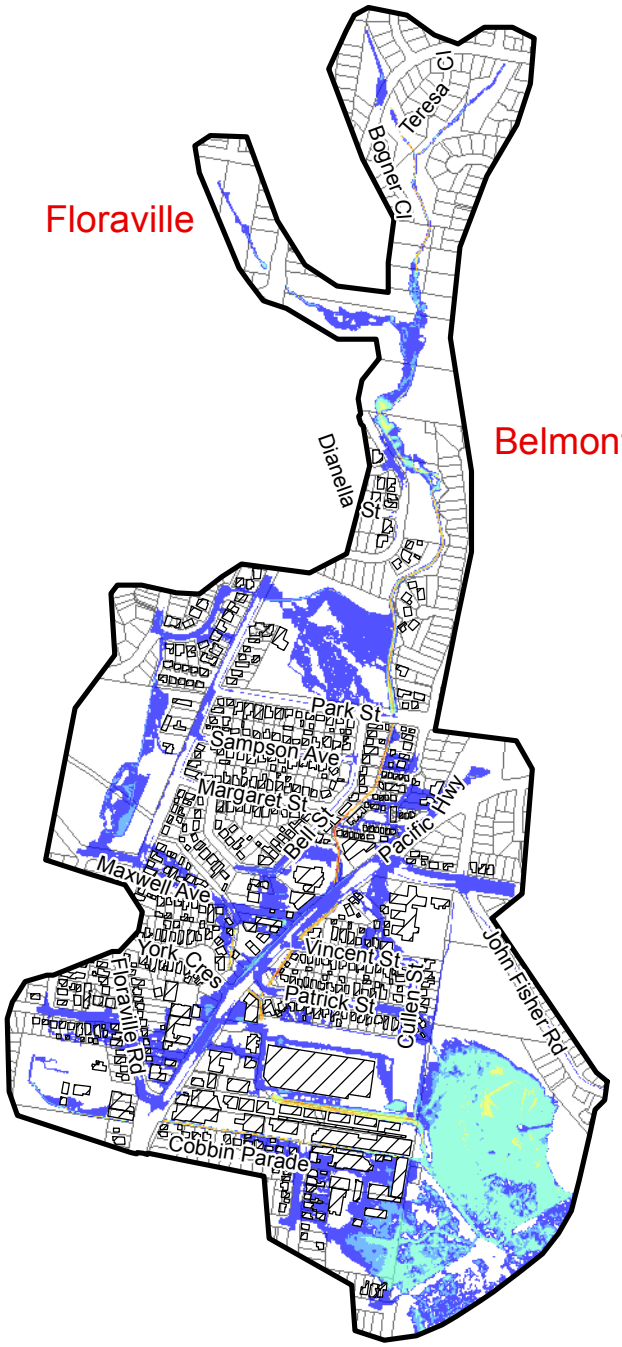
FIGURE E24

**MURABAN CREEK**
**HYDRAULIC CATEGORISATION**
**PMF EVENT**




J:\Jobs\119076\ArcGIS\ArcMap\Working\Template\Appendix_E\FigureE23_Muraban_Creek_Hydraulic_Categories_0.5%AEP.mxd

FIGURE E25
**MURABAN CREEK HYDRAULIC HAZARD 50% AEP EVENT**




N

- Study Area
- Cadastre
- Buildings

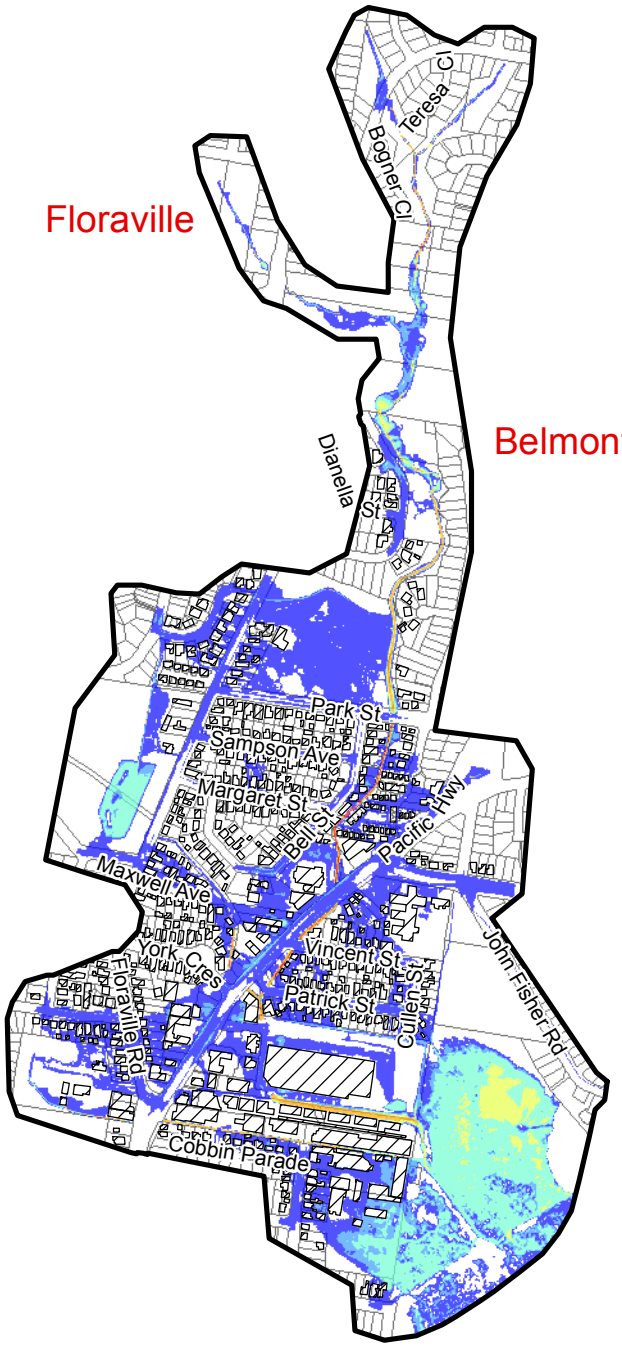
**Hazard**

- H1- Generally safe for people, vehicles and buildings
- H2- Unsafe for small vehicles
- H3- Unsafe for vehicles, children and the elderly
- H4- Unsafe for people and vehicles
- H5- Unsafe for people or vehicles. Buildings require special engineering design and construction
- H6- Unsafe for vehicles and people. All building types considered vulnerable to failure

0 0.25 0.5 km

J:\Jobs\119076\ArcGIS\ArcMap\Working\Template\Appendix_E\FigureE25_Muraban_Creek_Provisional_Hazard_50%AEP.mxd

FIGURE E26
**MURABAN CREEK HYDRAULIC HAZARD 20% AEP EVENT**




N

- Study Area
- Cadastre
- Buildings

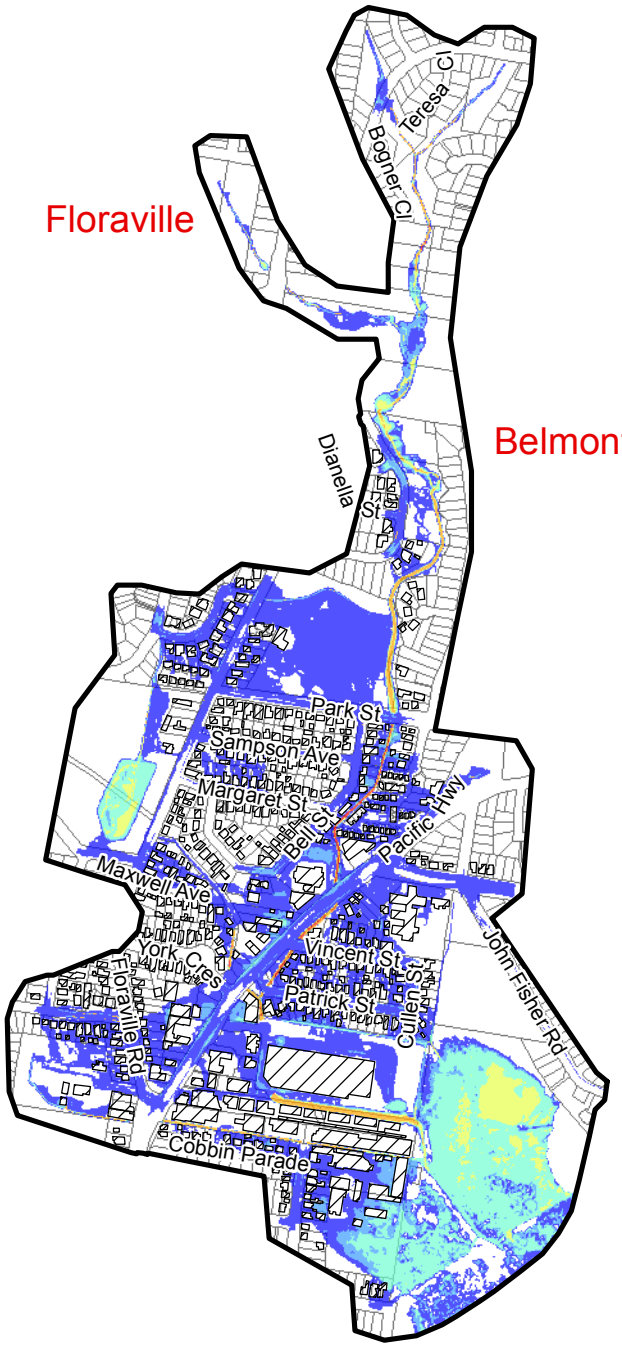
**Hazard**

- H1- Generally safe for people, vehicles and buildings
- H2- Unsafe for small vehicles
- H3- Unsafe for vehicles, children and the elderly
- H4- Unsafe for people and vehicles
- H5- Unsafe for people or vehicles. Buildings require special engineering design and construction
- H6- Unsafe for vehicles and people. All building types considered vulnerable to failure

0 0.25 0.5 km

J:\Jobs\119076\ArcGIS\ArcMap\Working\Template\Appendix_E\FigureE25_Muraban_Creek_Provisional_Hazard_50%AEP.mxd

FIGURE E27
**MURABAN CREEK HYDRAULIC HAZARD 10% AEP EVENT**




N

- Study Area
- Cadastre
- Buildings

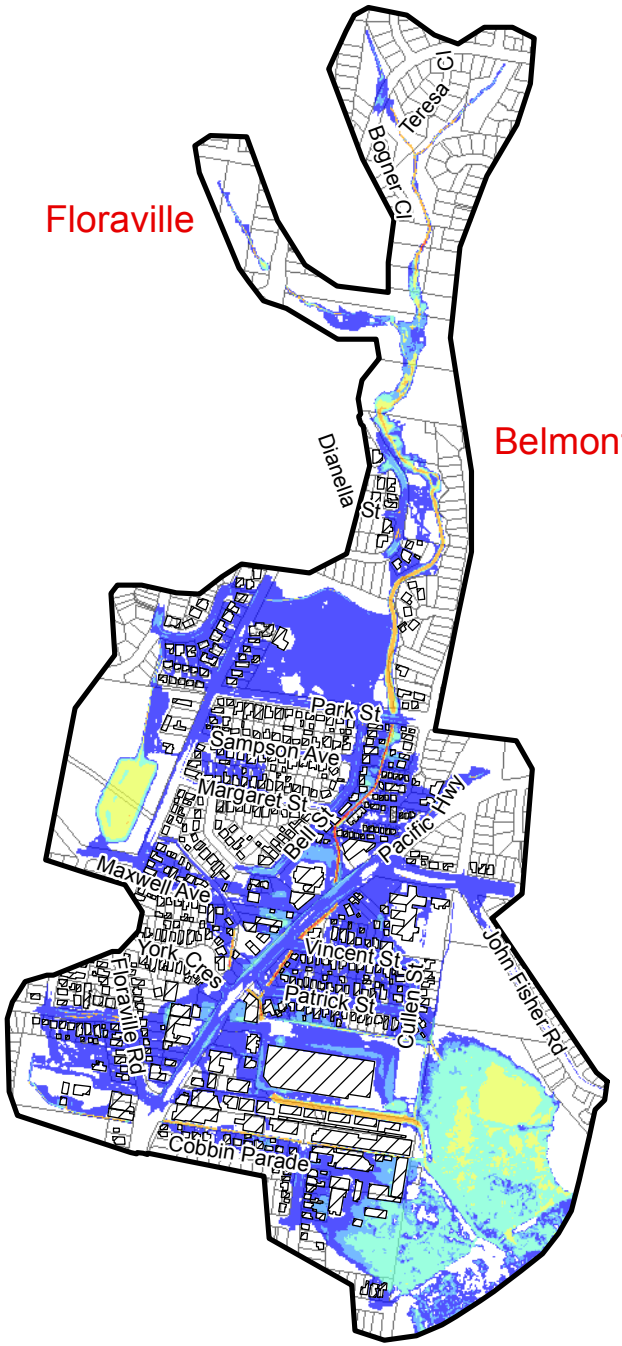
**Hazard**

- H1- Generally safe for people, vehicles and buildings
- H2- Unsafe for small vehicles
- H3- Unsafe for vehicles, children and the elderly
- H4- Unsafe for people and vehicles
- H5- Unsafe for people or vehicles. Buildings require special engineering design and construction
- H6- Unsafe for vehicles and people. All building types considered vulnerable to failure

0 0.25 0.5 km

J:\Jobs\119076\ArcGIS\ArcMap\Working\Template\Appendix_E\FigureE26_Muraban_Creek_Provisional_Hazard_20%AEP.mxd

FIGURE E28
**MURABAN CREEK HYDRAULIC HAZARD 5% AEP EVENT**




N

- Study Area
- Cadastre
- Buildings

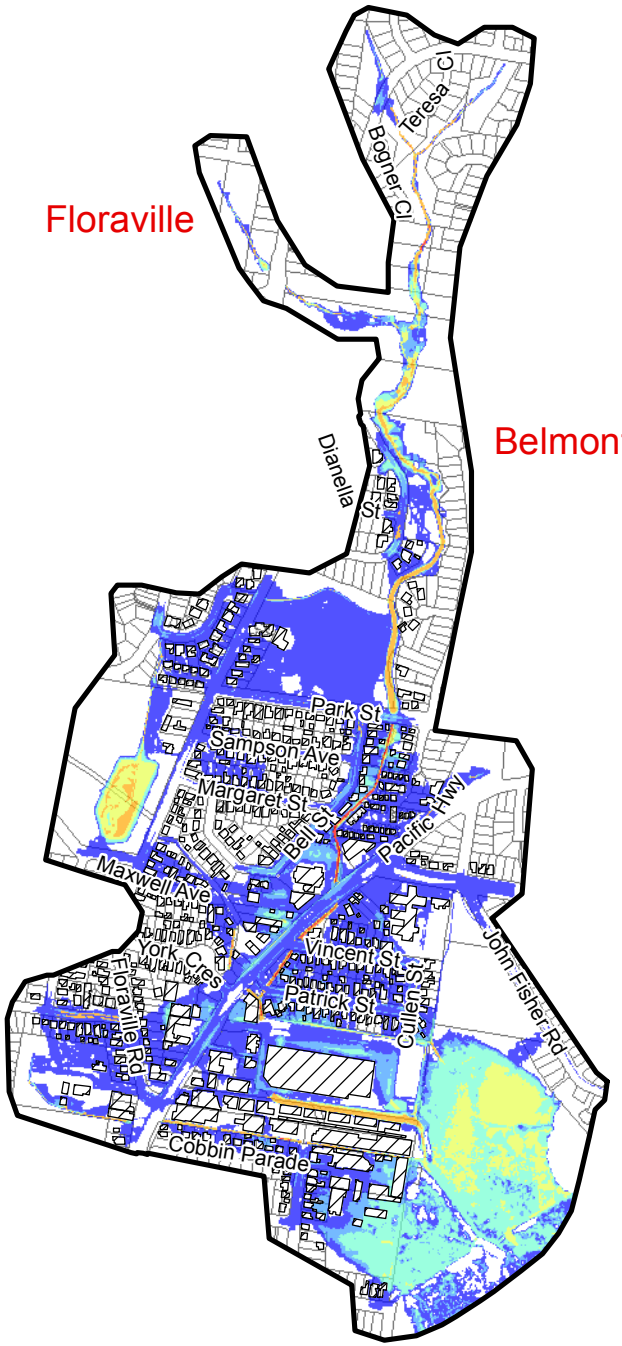
**Hazard**

- H1- Generally safe for people, vehicles and buildings
- H2- Unsafe for small vehicles
- H3- Unsafe for vehicles, children and the elderly
- H4- Unsafe for people and vehicles
- H5- Unsafe for people or vehicles. Buildings require special engineering design and construction
- H6- Unsafe for vehicles and people. All building types considered vulnerable to failure

0 0.25 0.5 km

J:\Jobs\119076\ArcGIS\ArcMap\Working\Template\Appendix_E\FigureE27_Muraban_Creek_Provisional_Hazard_10%AEP.mxd

FIGURE E29
**MURABAN CREEK HYDRAULIC HAZARD 2% AEP EVENT**




N

- Study Area
- Cadastre
- Buildings

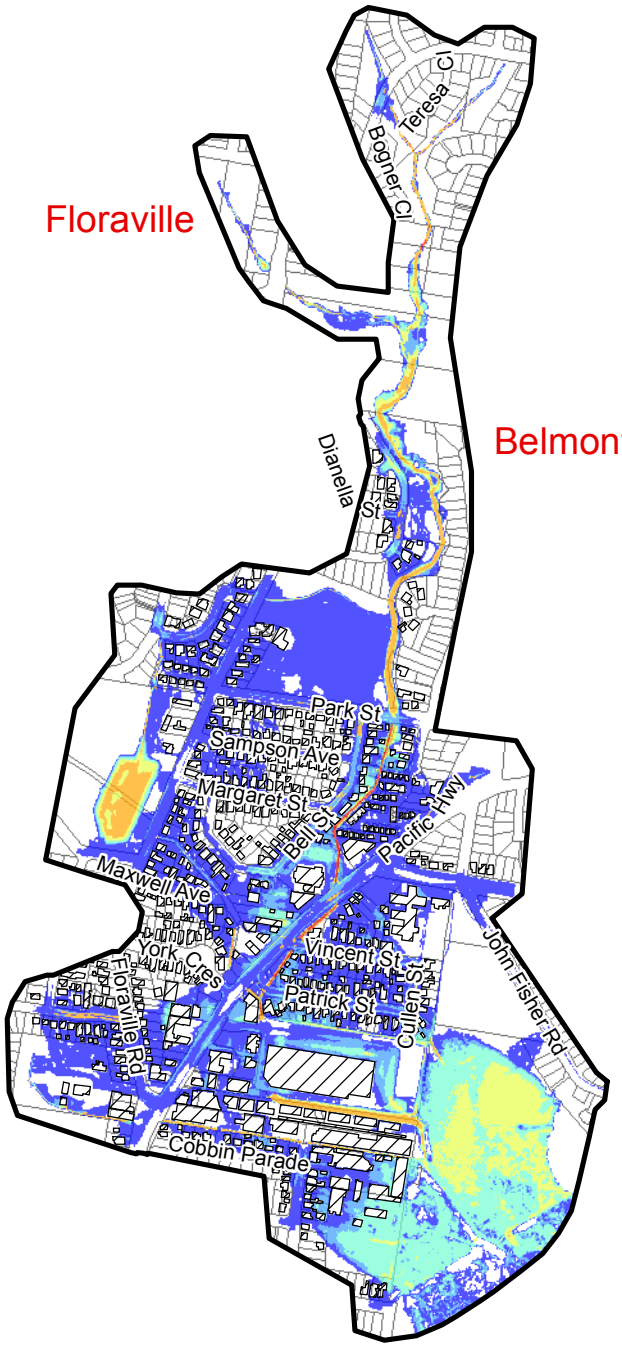
**Hazard**

- H1- Generally safe for people, vehicles and buildings
- H2- Unsafe for small vehicles
- H3- Unsafe for vehicles, children and the elderly
- H4- Unsafe for people and vehicles
- H5- Unsafe for people or vehicles. Buildings require special engineering design and construction
- H6- Unsafe for vehicles and people. All building types considered vulnerable to failure

0 0.25 0.5 km

J:\Jobs\119076\ArcGIS\ArcMap\Working\Template\Appendix_E\FigureE28_Muraban_Creek_Provisional_Hazard_5%AEP.mxd

FIGURE E30
**MURABAN CREEK HYDRAULIC HAZARD 1% AEP EVENT**




N

- Study Area
- Cadastre
- Buildings

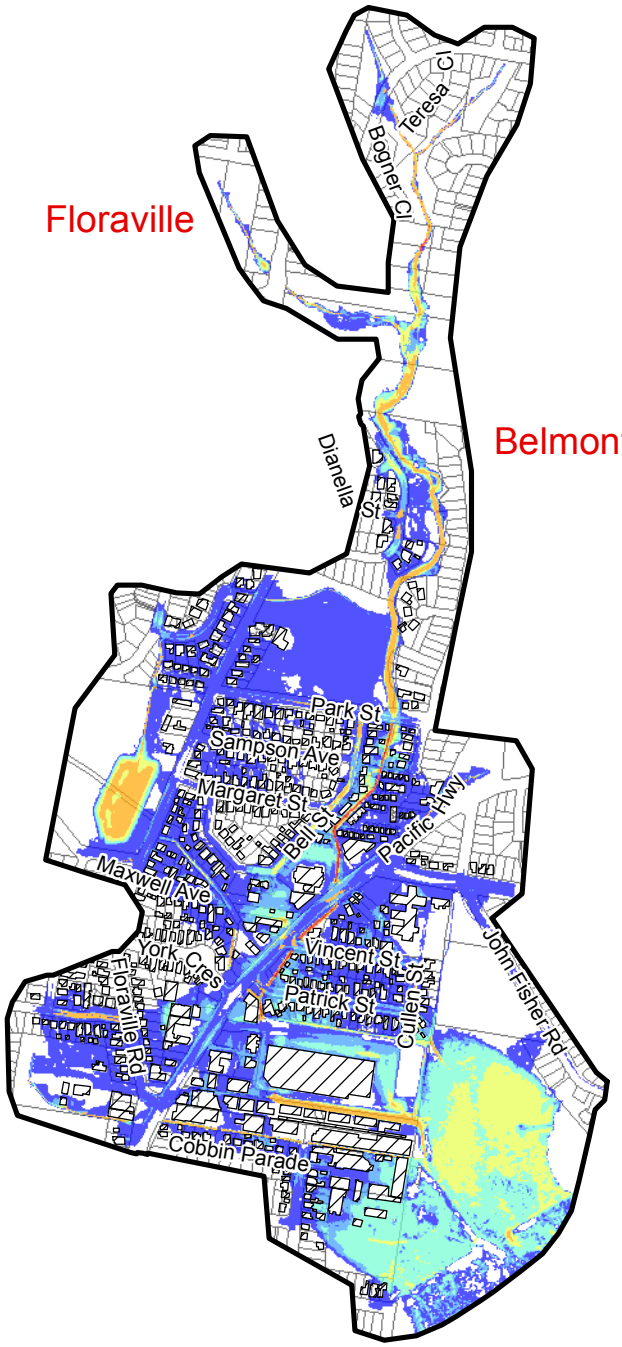
**Hazard**

- H1- Generally safe for people, vehicles and buildings
- H2- Unsafe for small vehicles
- H3- Unsafe for vehicles, children and the elderly
- H4- Unsafe for people and vehicles
- H5- Unsafe for people or vehicles. Buildings require special engineering design and construction
- H6- Unsafe for vehicles and people. All building types considered vulnerable to failure

0 0.25 0.5 km

J:\Jobs\119076\ArcGIS\ArcMap\Working\Template\Appendix_E\FigureE29_Muraban_Creek_Provisional_Hazard_2%AEP.mxd

FIGURE E31
**MURABAN CREEK HYDRAULIC HAZARD 0.5% AEP EVENT**




N

- Study Area
- Cadastre
- Buildings

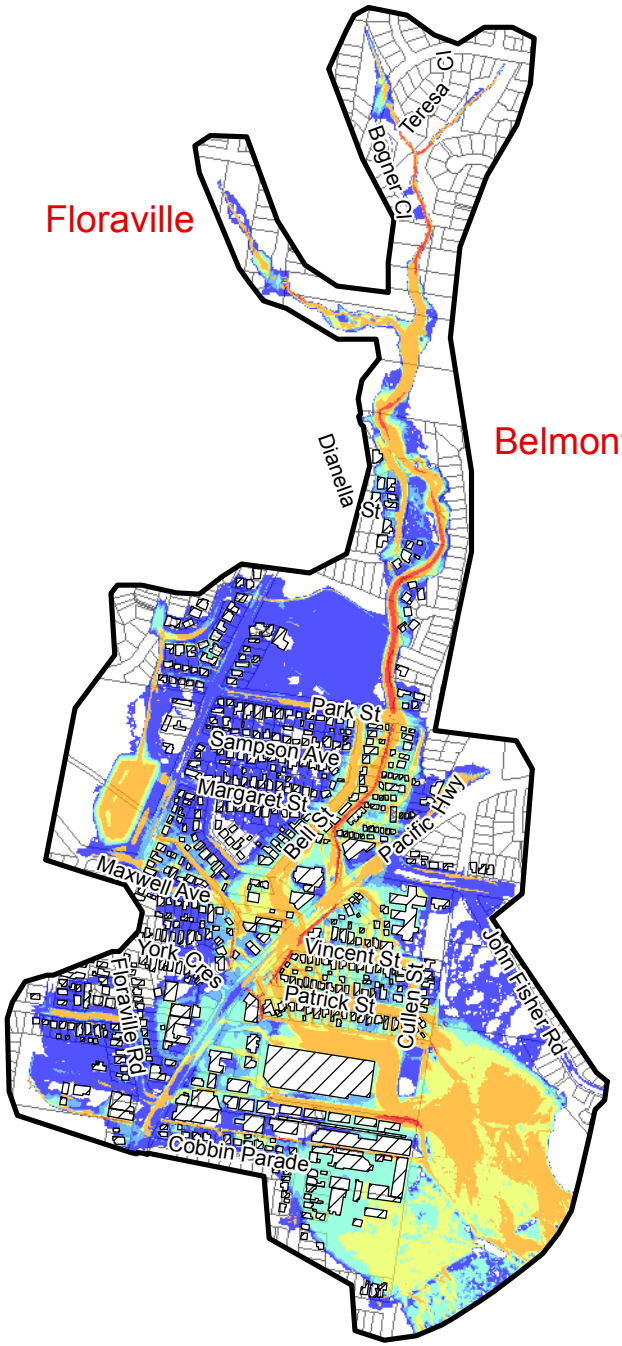
**Hazard**

- H1- Generally safe for people, vehicles and buildings
- H2- Unsafe for small vehicles
- H3- Unsafe for vehicles, children and the elderly
- H4- Unsafe for people and vehicles
- H5- Unsafe for people or vehicles. Buildings require special engineering design and construction
- H6- Unsafe for vehicles and people. All building types considered vulnerable to failure

0 0.25 0.5 km

J:\Jobs\119076\ArcGIS\ArcMap\Working\Template\Appendix_E\FigureE30_Muraban_Creek_Provisional_Hazard_1%AEP.mxd

FIGURE E32
**MURABAN CREEK HYDRAULIC HAZARD PMF EVENT**




N

- Study Area
- Cadastre
- Buildings

**Hazard**

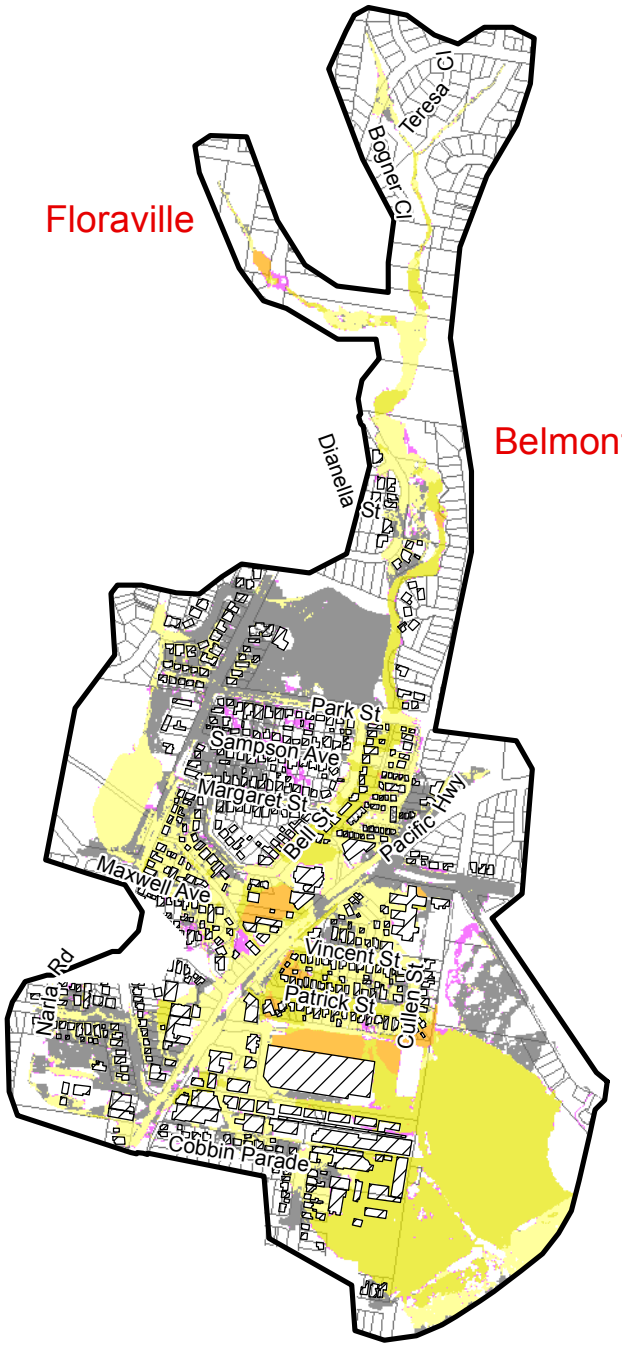
- H1- Generally safe for people, vehicles and buildings
- H2- Unsafe for small vehicles
- H3- Unsafe for vehicles, children and the elderly
- H4- Unsafe for people and vehicles
- H5- Unsafe for people or vehicles. Buildings require special engineering design and construction
- H6- Unsafe for vehicles and people. All building types considered vulnerable to failure

0 0.25 0.5 km

J:\Jobs\119076\ArcGIS\ArcMap\Working\Template\Appendix_E\FigureE32_Muraban_Creek_Provisional_Hazard_PMF.mxd

FIGURE E33

**MURABAN CREEK**
**CHANGE IN PEAK FLOOD LEVEL**
**0.5% AEP EVENT VS 1% AEP EVENT**




N

- Study Area
- Cadastre
- Buildings

**Impact (m)**

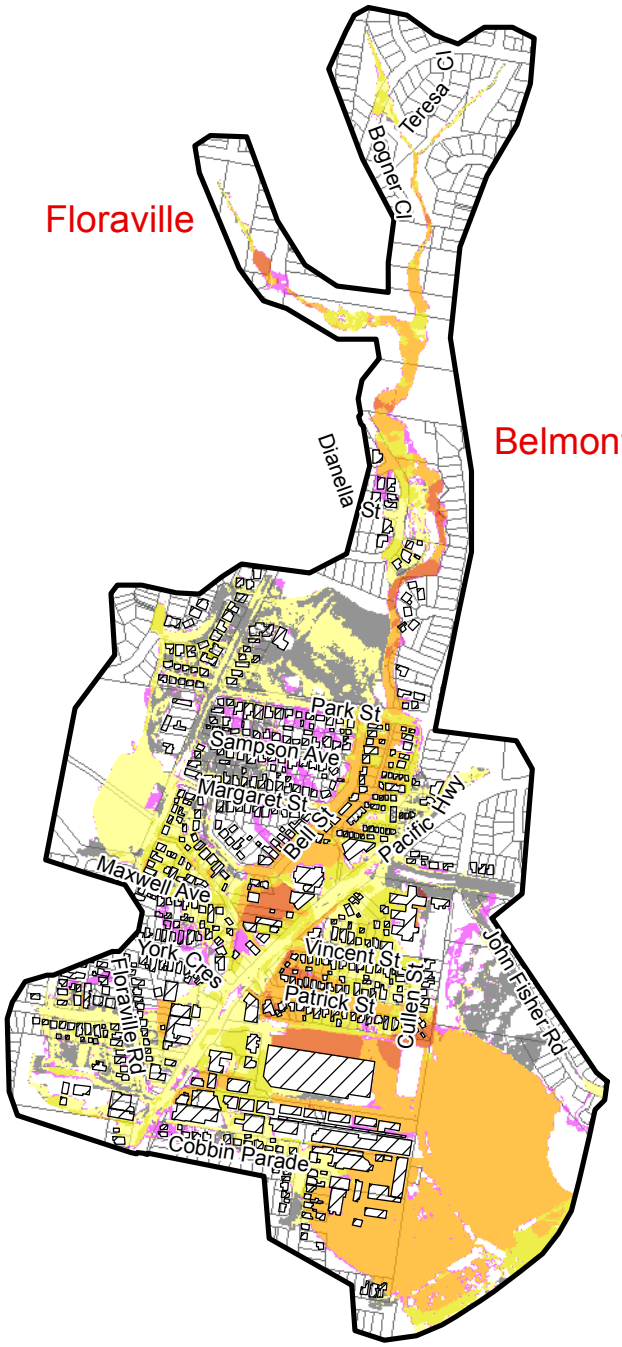
- < -0.4
- -0.4 to -0.3
- -0.3 to -0.2
- -0.2 to -0.1
- -0.1 to -0.05
- -0.05 to -0.01
- -0.01 to 0.01
- 0.01 to 0.05
- 0.05 to 0.1
- 0.1 to 0.2
- 0.2 to 0.3
- 0.3 to 0.4
- > 0.4
- Newly Flooded
- No Longer Flooded

0 0.25 0.5 km

J:\Jobs\119076\ArcGIS\ArcMap\Working\Template\Appendix_E\FigureE33_Muraban_Creek_Impact_CC_0_5%AEP_V_1%AEP.mxd

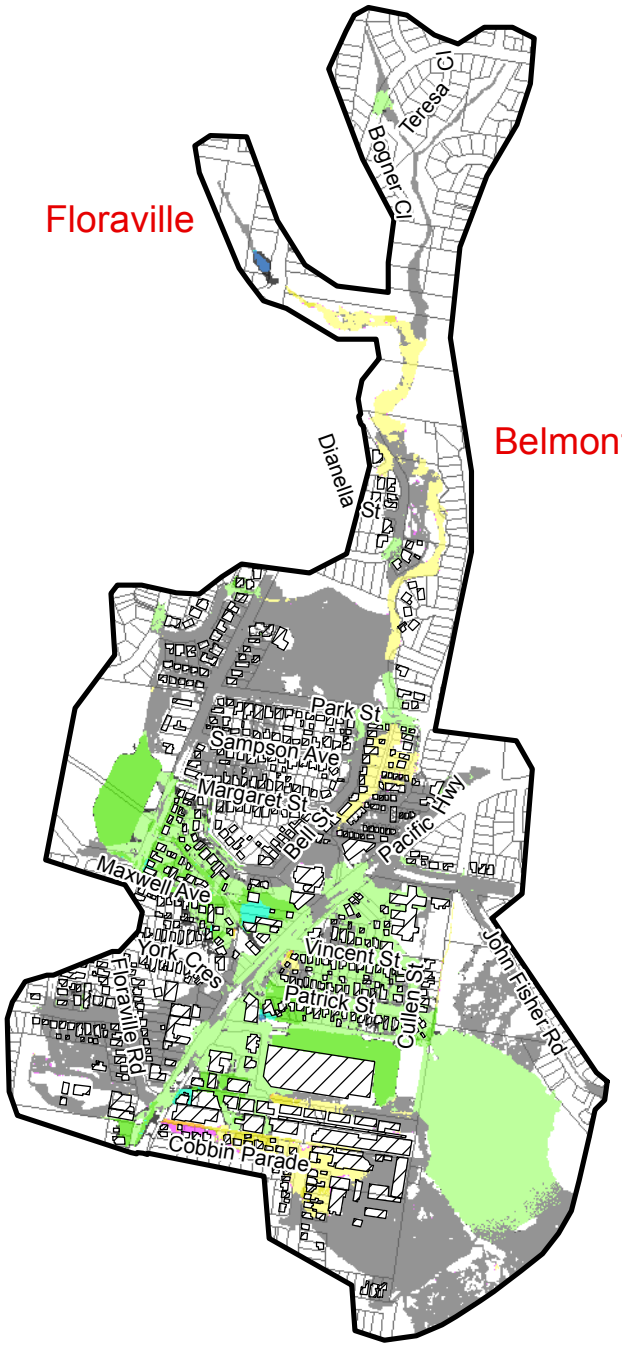
FIGURE E34

**MURABAN CREEK**
**CHANGE IN PEAK FLOOD LEVEL**
**0.2% AEP EVENT VS 1% AEP EVENT**




J:\Jobs\119076\ArcGIS\ArcMap\Working\Template\Appendix_E\FigureE33_Muraban_Creek_Impact_CC_0_5%AEP_V_1%AEP.mxd

FIGURE E35
**MURABAN CREEK**
**CHANGE IN PEAK FLOOD LEVEL**
**1% AEP EVENT - 25% BLOCKAGE**




N

- Study Area
- Cadastre
- Buildings

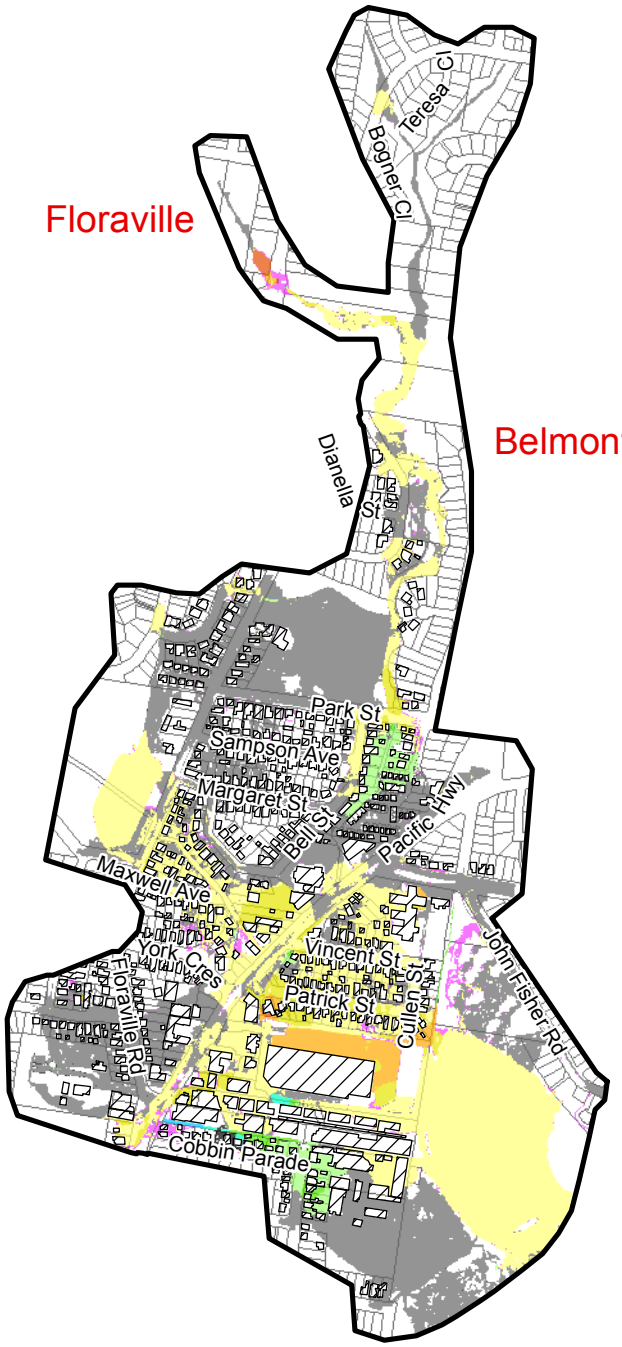
**Impact (m)**

- < -0.4
- -0.4 to -0.3
- -0.3 to -0.2
- -0.2 to -0.1
- -0.1 to -0.05
- -0.05 to -0.01
- -0.01 to 0.01
- 0.01 to 0.05
- 0.05 to 0.1
- 0.1 to 0.2
- 0.2 to 0.3
- 0.3 to 0.4
- > 0.4
- Newly Flooded
- No Longer Flooded

0 0.25 0.5 km

J:\Jobs\11907\6\ArcGIS\ArcMap\Working\Template\Appendix_E\FigureE34_Muraban_Creek_Impact_CC_0_2%AEP_V_1%AEP.mxd

FIGURE E36
**MURABAN CREEK**
**CHANGE IN PEAK FLOOD LEVEL**
**1% AEP EVENT - 75% BLOCKAGE**




N

- Study Area
- Cadastre
- Buildings

**Impact (m)**

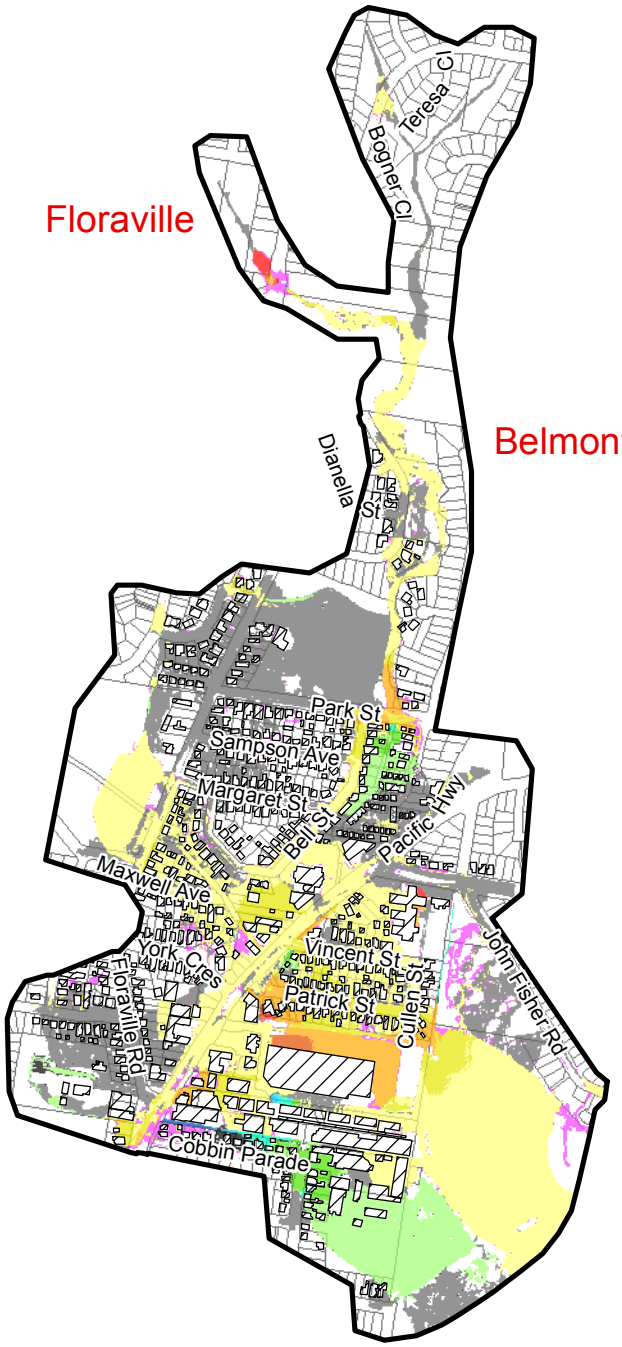
- < -0.4
- -0.4 to -0.3
- -0.3 to -0.2
- -0.2 to -0.1
- -0.1 to -0.05
- -0.05 to -0.01
- -0.01 to 0.01
- 0.01 to 0.05
- 0.05 to 0.1
- 0.1 to 0.2
- 0.2 to 0.3
- 0.3 to 0.4
- > 0.4
- Newly Flooded
- No Longer Flooded

0 0.25 0.5 km

J:\Jobs\119076\ArcGIS\ArcMap\Working\Template\Appendix_E\FigureE35_Muraban_Creek_Impact_1%AEP_Blockage25pc.mxd

FIGURE E37

**MURABAN CREEK**
**CHANGE IN PEAK FLOOD LEVEL**
**1% AEP EVENT - 100% BLOCKAGE**




N

- Study Area
- Cadastre
- Buildings

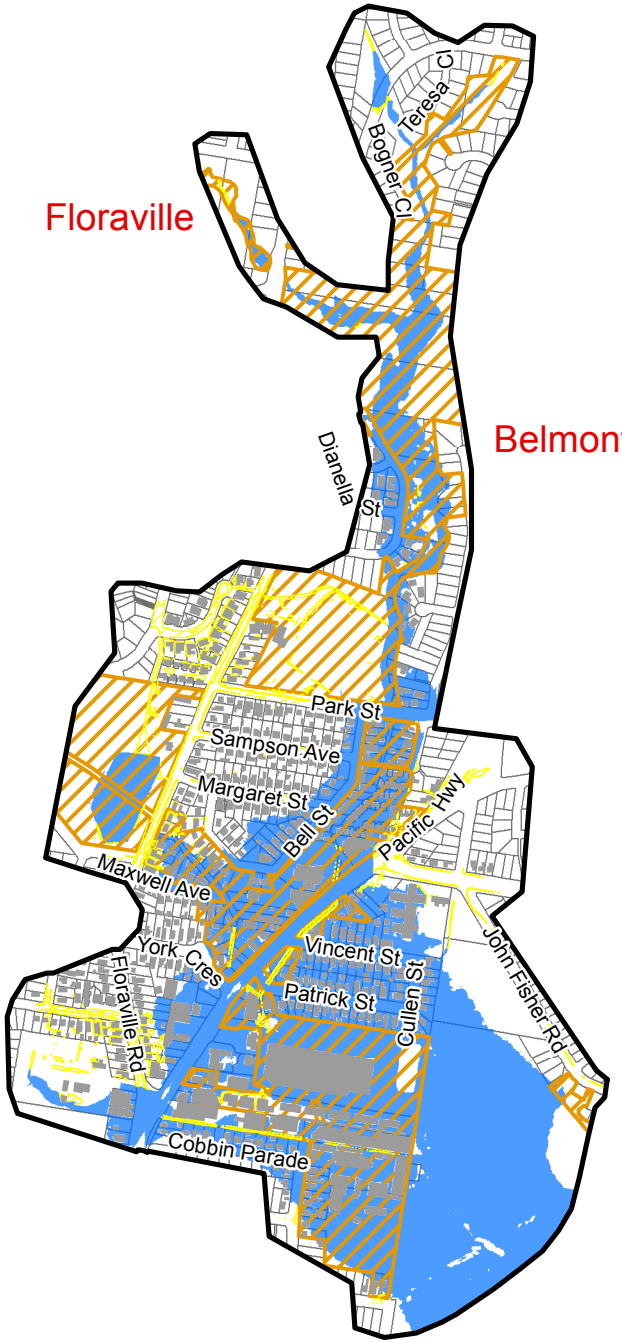
**Impact (m)**

- < -0.4
- -0.4 to -0.3
- -0.3 to -0.2
- -0.2 to -0.1
- -0.1 to -0.05
- -0.05 to -0.01
- -0.01 to 0.01
- 0.01 to 0.05
- 0.05 to 0.1
- 0.1 to 0.2
- 0.2 to 0.3
- 0.3 to 0.4
- > 0.4
- Newly Flooded
- No Longer Flooded

0 0.25 0.5 km

J:\Jobs\119076\ArcGIS\ArcMap\Working\Template\Appendix_E\FigureE37_Muraban_Creek_Impact_1%AEP_Blockage100pc.mxd

FIGURE E38
**MURABAN CREEK**
**FLOOD PLANNING AREA**




N

- Study Area
- Cadastre
- Buildings
- Lake Macquarie Waterway FPA
- Overland Flow FPA
- Mainstream FPA (includes 0.5m freeboard)

0 0.25 0.5 km

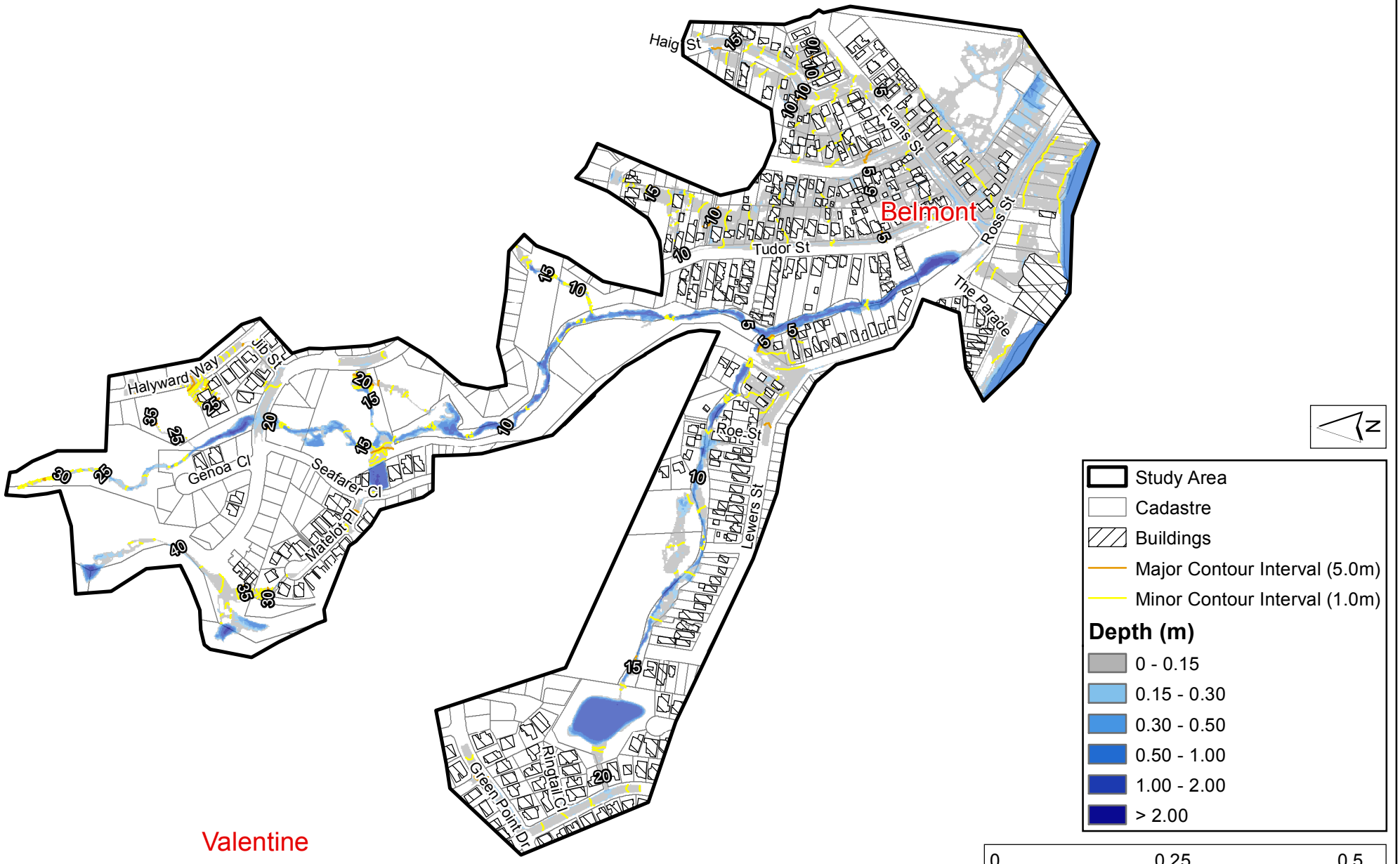
J:\Jobs\119076\ArcGIS\ArcMap\Report\Appendix_E\FigureE38_Muraban_Creek_Flood_Planning_Area.mxd

**APPENDIX F: DESIGN FLOOD MAPS – MILLS GULLY CREEK**

Appendix F

FIGURE F1

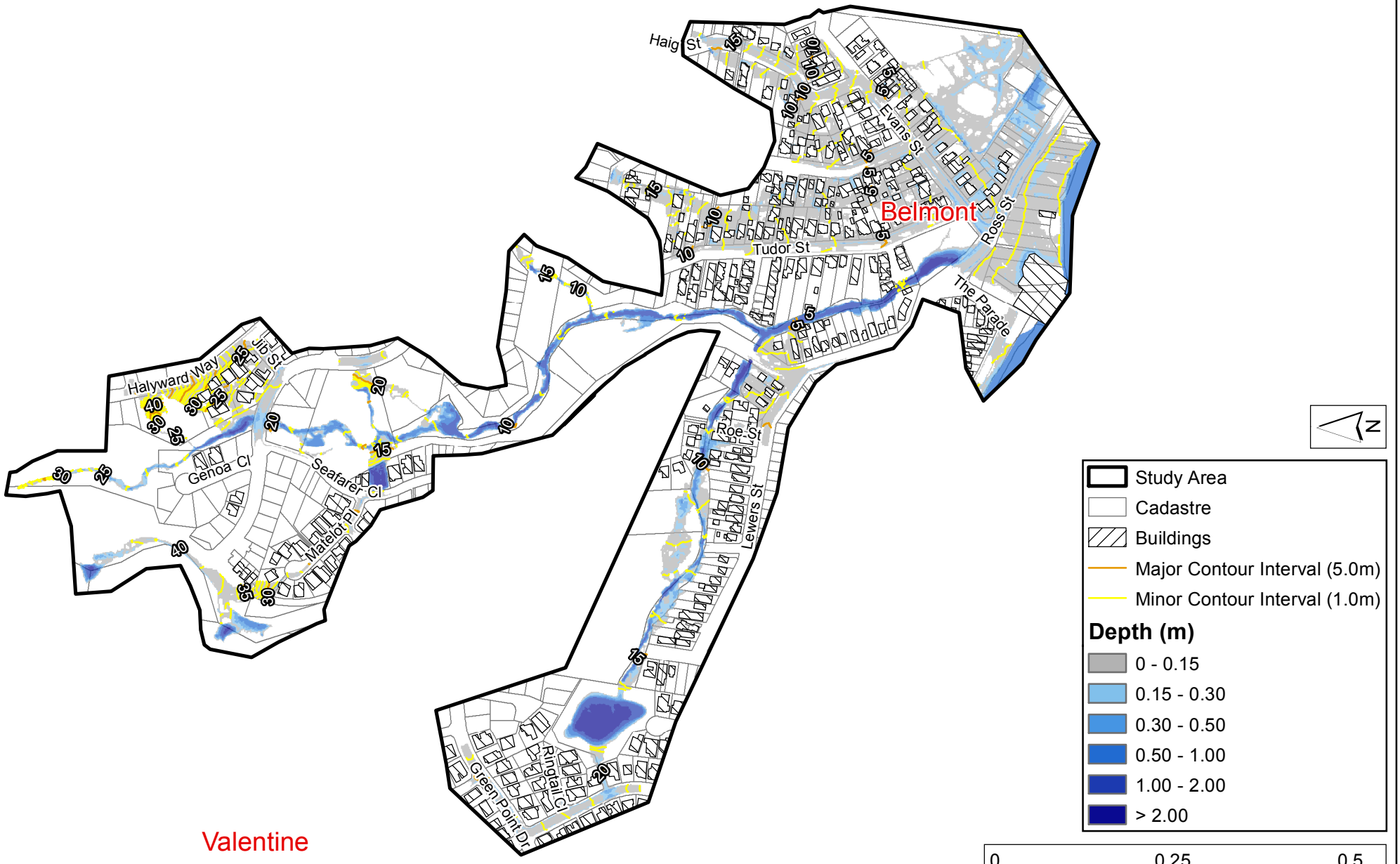
**MILLS GULLY CREEK**
**PEAK FLOOD DEPTH AND LEVEL CONTOUR**
**50% AEP EVENT**




J:\Jobs\11907\6\ArcGIS\ArcMap\Working\Template\Appendix_F\FigureF01_Mills_Creek_Peak_Flood_Depth_50%AEP.mxd

FIGURE F2

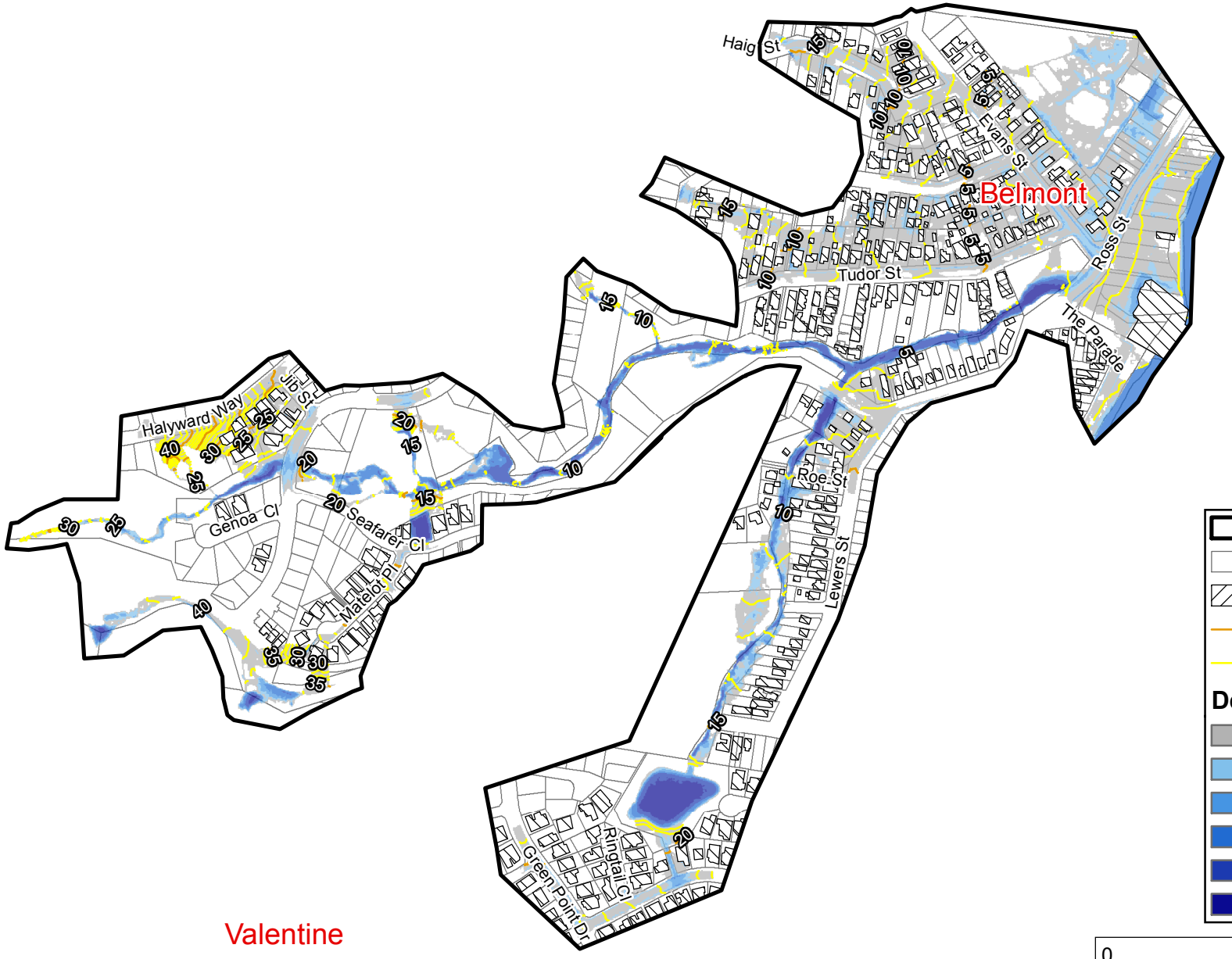
**MILLS GULLY CREEK**
**PEAK FLOOD DEPTH AND LEVEL CONTOUR**
**20% AEP EVENT**




J:\Jobs\11190776\ArcGIS\ArcMap\Working\Template\Appendix_F\FigureF02_Mills_Creek_Peak_Flood_Depth_20%AEP.mxd

FIGURE F3

**MILLS GULLY CREEK**
**PEAK FLOOD DEPTH AND LEVEL CONTOUR**
**10% AEP EVENT**




Study Area
Cadastre
Buildings
Major Contour Interval (5.0m)
Minor Contour Interval (1.0m)

**Depth (m)**

0 - 0.15
0.15 - 0.30
0.30 - 0.50
0.50 - 1.00
1.00 - 2.00
> 2.00

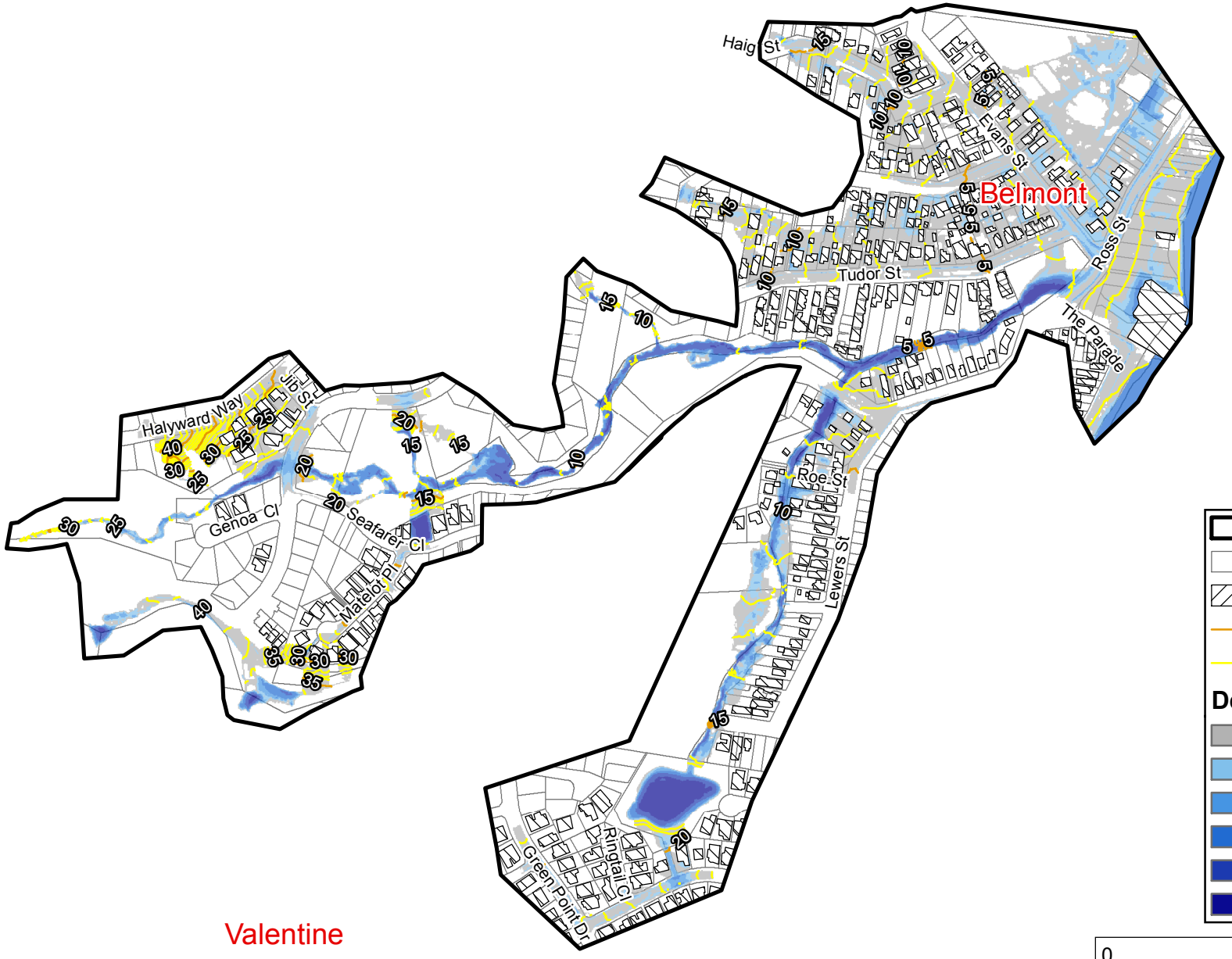
N

0 0.25 0.5 km

J:\Jobs\1190776\ArcGIS\ArcMap\Working\Template\Appendix_F\FigureF03_Mills_Creek_Peak_Flood_Depth_10%AEP.mxd

FIGURE F4

**MILLS GULLY CREEK**
**PEAK FLOOD DEPTH AND LEVEL CONTOUR**
**5% AEP EVENT**




Study Area
Cadastre
Buildings
Major Contour Interval (5.0m)
Minor Contour Interval (1.0m)

**Depth (m)**

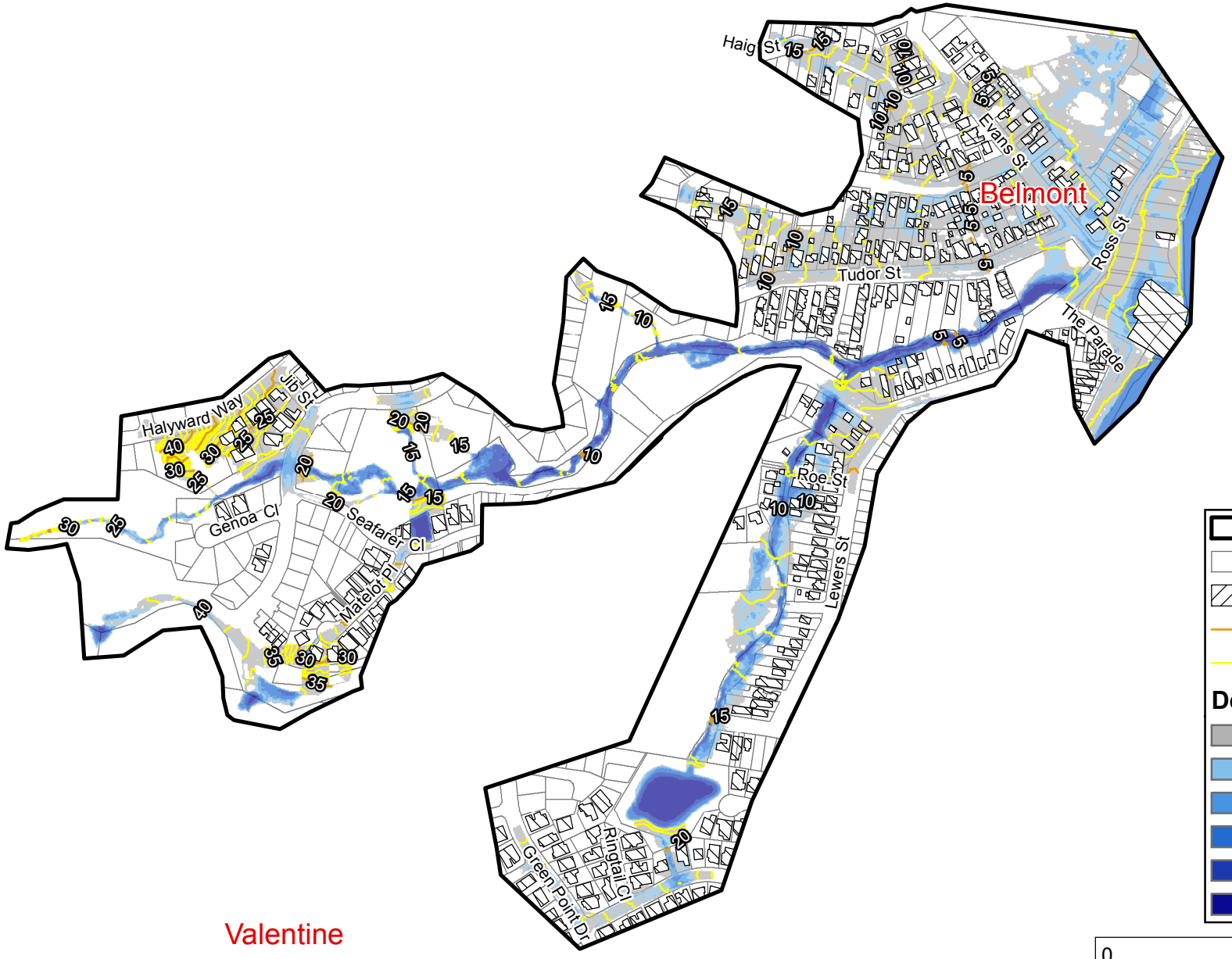
0 - 0.15
0.15 - 0.30
0.30 - 0.50
0.50 - 1.00
1.00 - 2.00
> 2.00

0 0.25 0.5 km

J:\Jobs\1190776\ArcGIS\ArcMap\Working\Template\Appendix_F\FigureF04_Mills_Creek_Peak_Flood_Depth_5%AEP.mxd

FIGURE F5

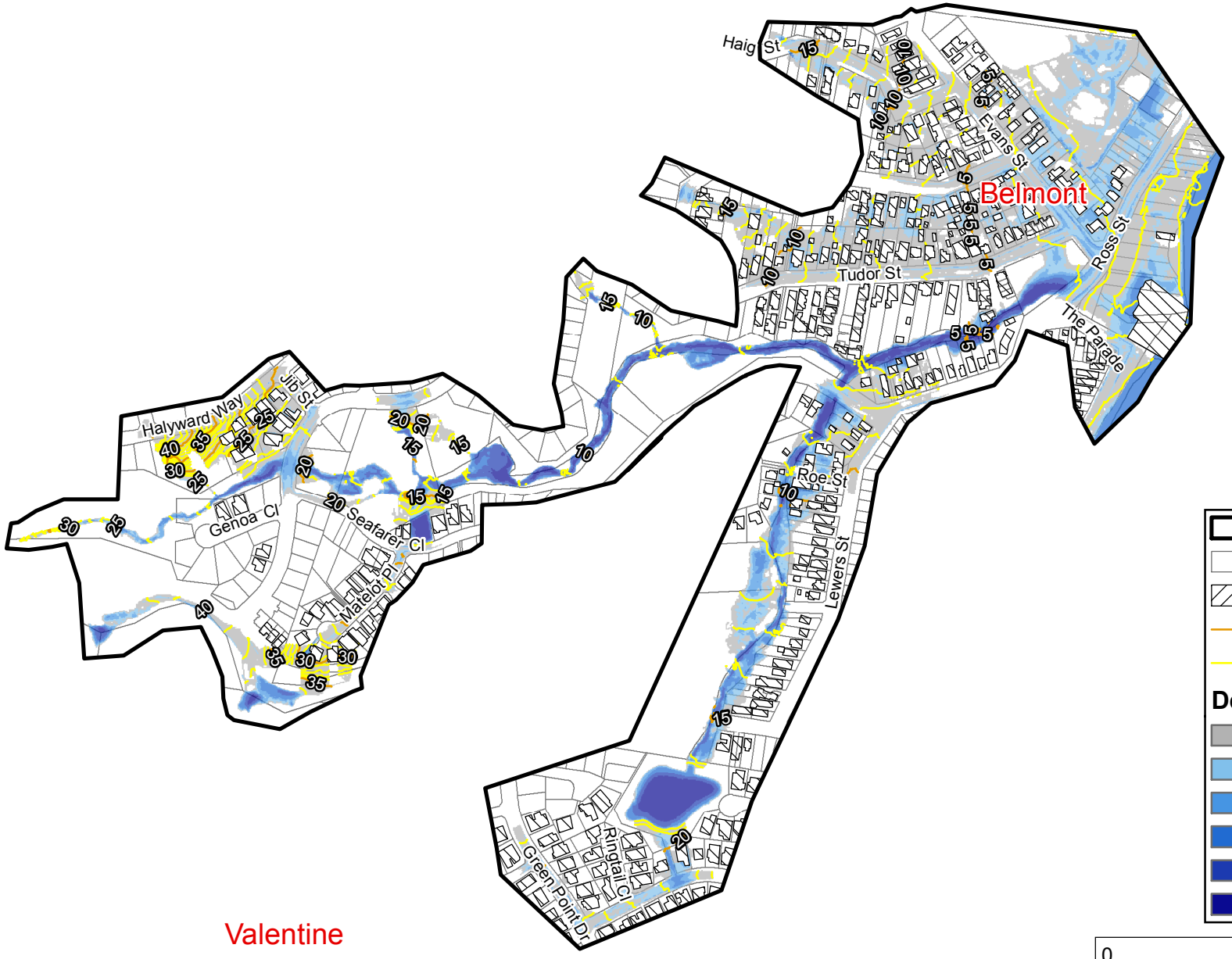
# MILLS GULLY CREEK
# PEAK FLOOD DEPTH AND LEVEL CONTOUR
# 2% AEP EVENT




J:\Jobs\1190776\ArcGIS\ArcMap\Working\Template\Appendix_F\FigureF05_Mills_Creek_Peak_Flood_Depth_2%AEP.mxd

FIGURE F6

**MILLS GULLY CREEK**
**PEAK FLOOD DEPTH AND LEVEL CONTOUR**
**1% AEP EVENT**




N

- Study Area
- Cadastre
- Buildings
- Major Contour Interval (5.0m)
- Minor Contour Interval (1.0m)

**Depth (m)**

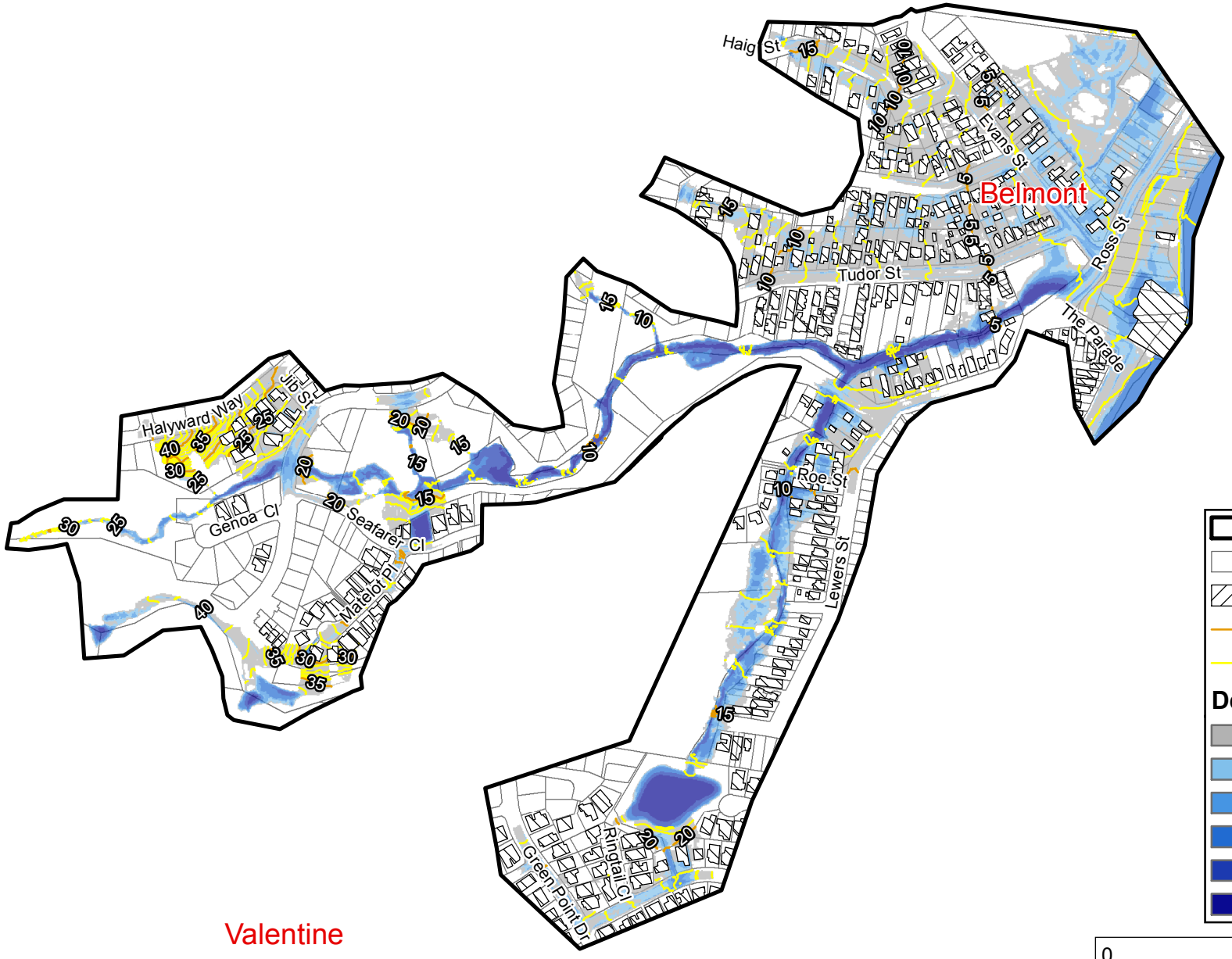
- 0 - 0.15
- 0.15 - 0.30
- 0.30 - 0.50
- 0.50 - 1.00
- 1.00 - 2.00
- > 2.00

0 0.25 0.5 km

J:\Jobs\1190776\ArcGIS\ArcMap\Working\Template\Appendix_F\FigureF06_Mills_Creek_Peak_Flood_Depth_1%AEP.mxd

FIGURE F7

**MILLS GULLY CREEK**
**PEAK FLOOD DEPTH AND LEVEL CONTOUR**
**0.5% AEP EVENT**



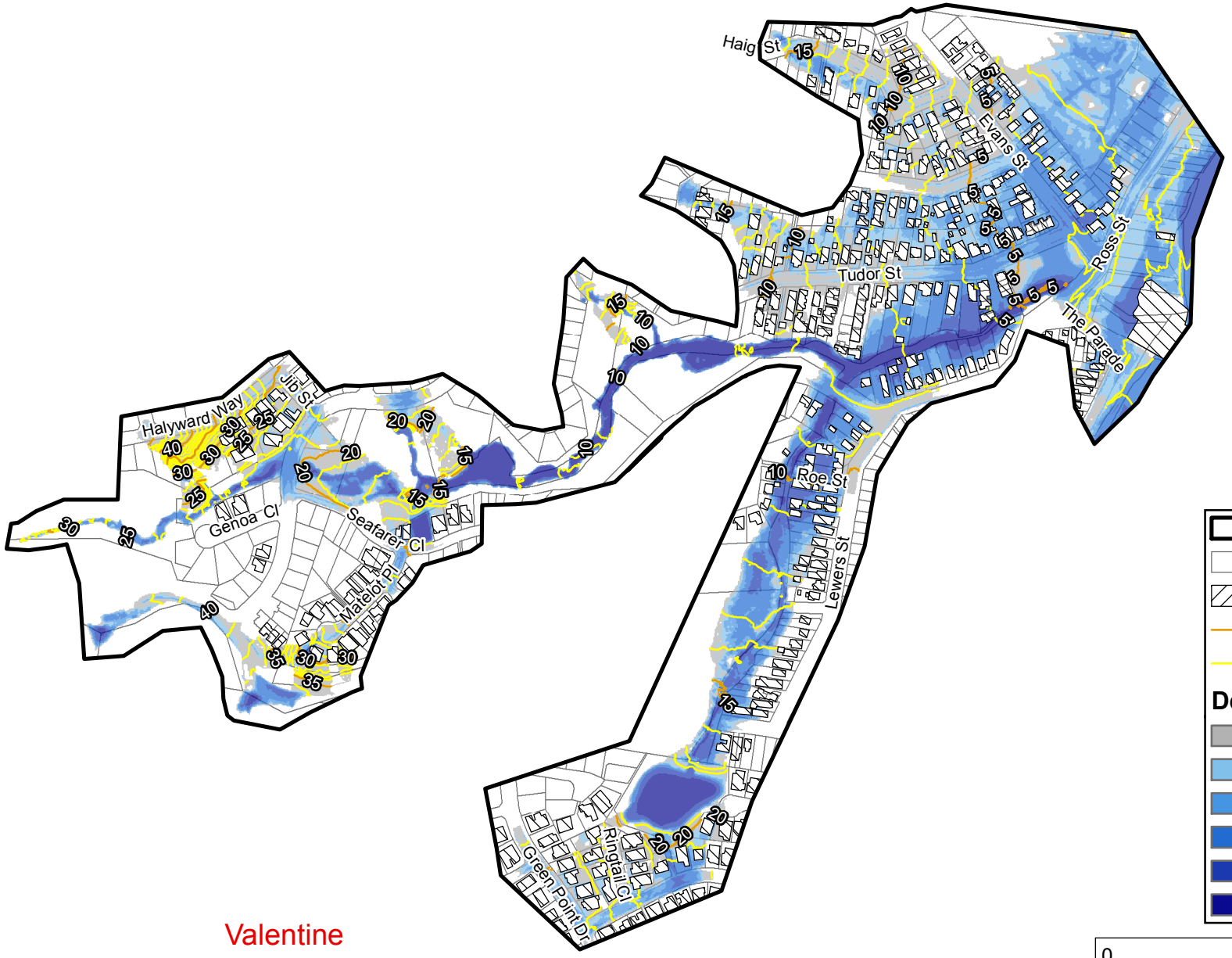

J:\Jobs\11907\6\ArcGIS\ArcMap\Working\Template\Appendix_F\FigureF07_Mills_Creek_Peak_Flood_Depth_0.5%AEP.mxd

FIGURE F8

**MILLS GULLY CREEK**

**PEAK FLOOD DEPTH AND LEVEL CONTOUR**

**PMF EVENT**




Study Area
Cadastre
Buildings
Major Contour Interval (5.0m)
Minor Contour Interval (1.0m)

**Depth (m)**

0 - 0.15
0.15 - 0.30
0.30 - 0.50
0.50 - 1.00
1.00 - 2.00
> 2.00

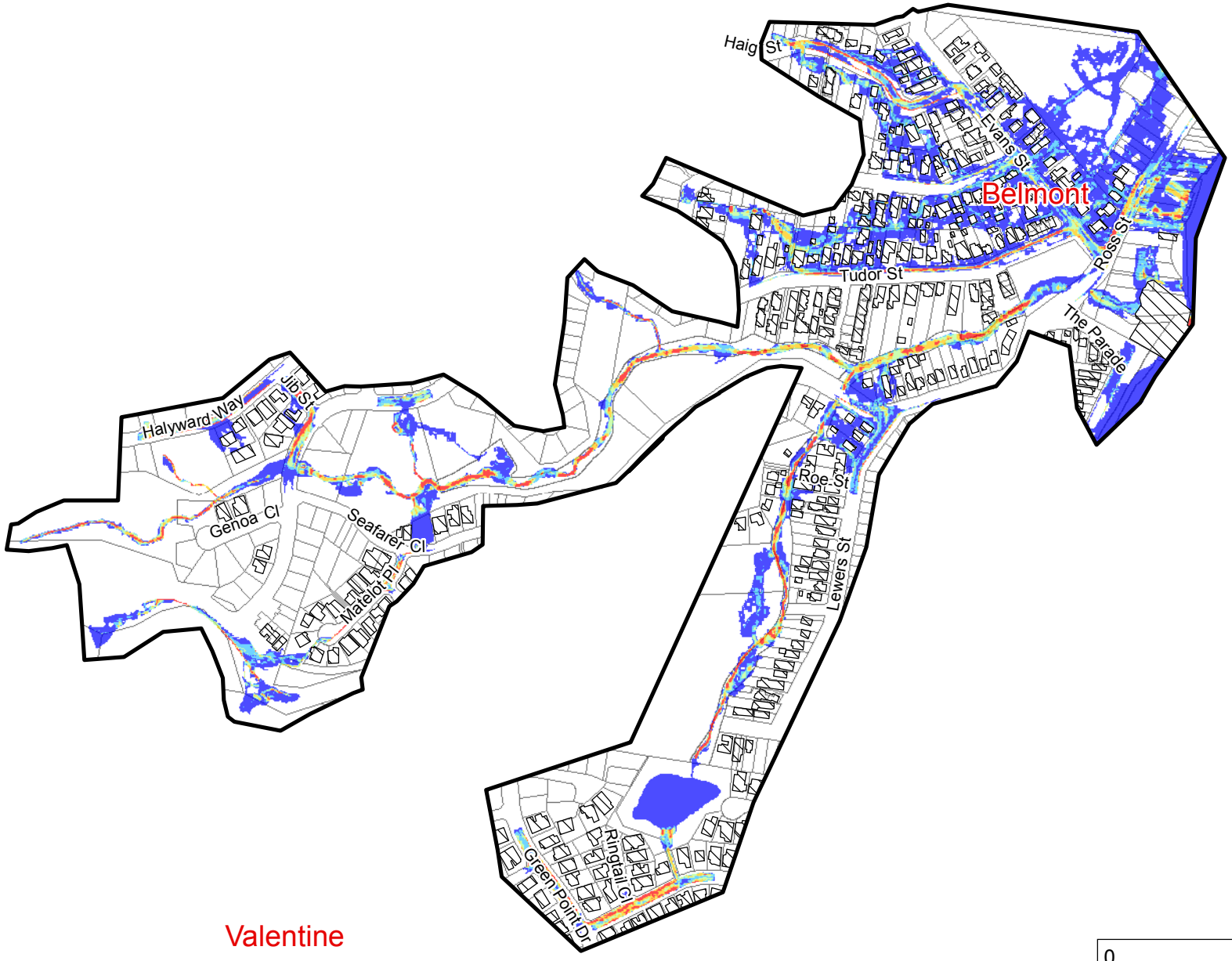
N

0 0.25 0.5 km

J:\Jobs\1190776\ArcGIS\ArcMap\Working\Template\Appendix_F\FigureF08_Mills_Creek_Peak_Flood_Depth_PMF.mxd

FIGURE F9

**MILLS GULLY CREEK**
**PEAK FLOOD VELOCITIES**
**50% AEP EVENT**




N

Study Area
Cadastre
Buildings

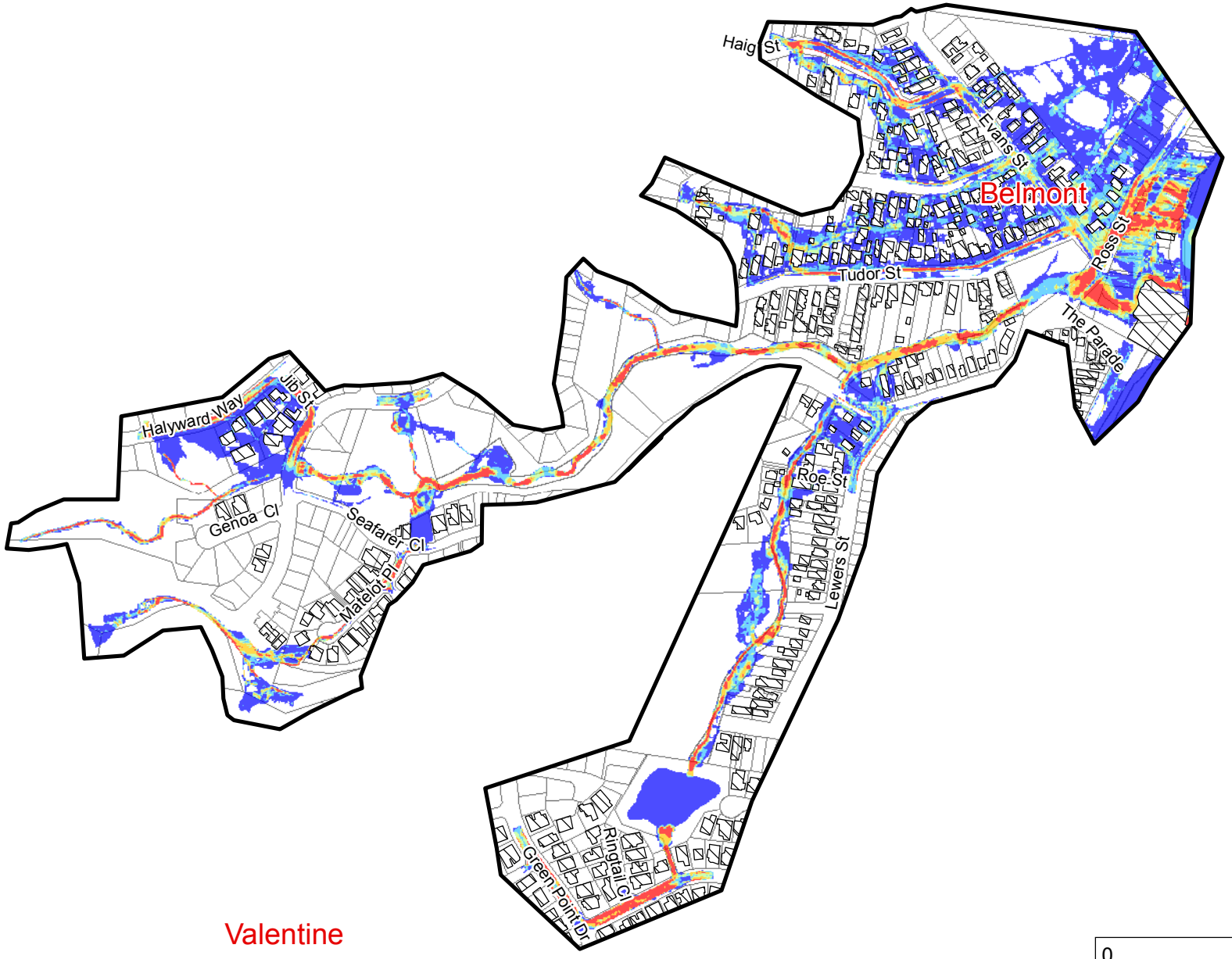
**Velocity (m/s)**

0 - 0.3
0.3 - 0.5
0.5 - 0.7
0.7 - 1.0
>1.0

0 0.25 0.5 km

J:\Jobs\119076\ArcGIS\ArcMap\Working\Template\Appendix_F\FigureF08_Mills_Creek_Peak_Flood_Depth_PMF.mxd

FIGURE F10
**MILLS GULLY CREEK**
**PEAK FLOOD VELOCITIES**
**20% AEP EVENT**




N

Study Area
Cadastre
Buildings

**Velocity (m/s)**

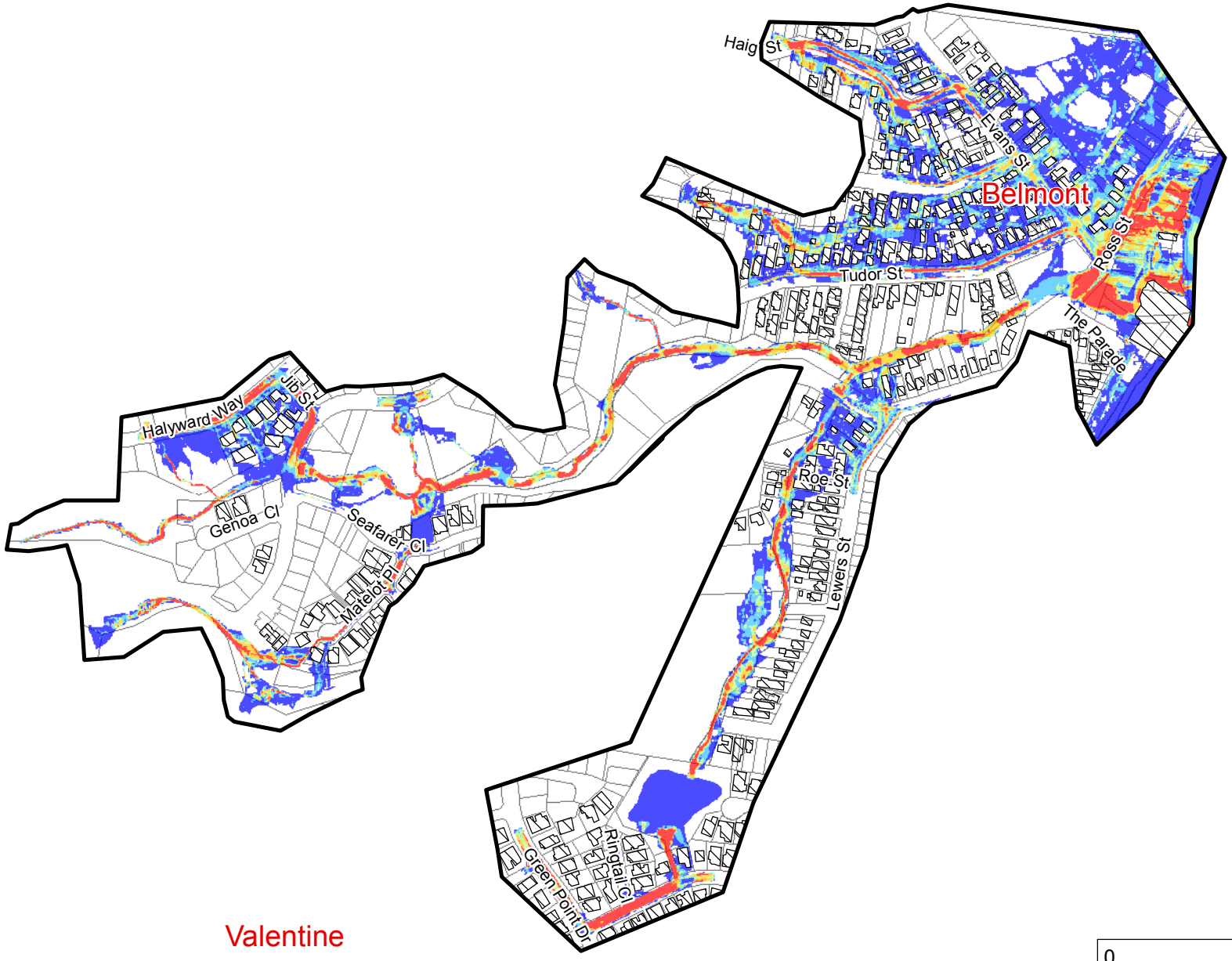
0 - 0.3
0.3 - 0.5
0.5 - 0.7
0.7 - 1.0
>1.0

0 0.25 0.5 km

J:\Jobs\119076\ArcGIS\ArcMap\Working\Template\Appendix_F\FigureF09_Mills_Creek_Peak_Flood_Velocity_50%AEP.mxd

FIGURE F11

**MILLS GULLY CREEK**
**PEAK FLOOD VELOCITIES**
**10% AEP EVENT**




N

Study Area
Cadastre
Buildings

**Velocity (m/s)**

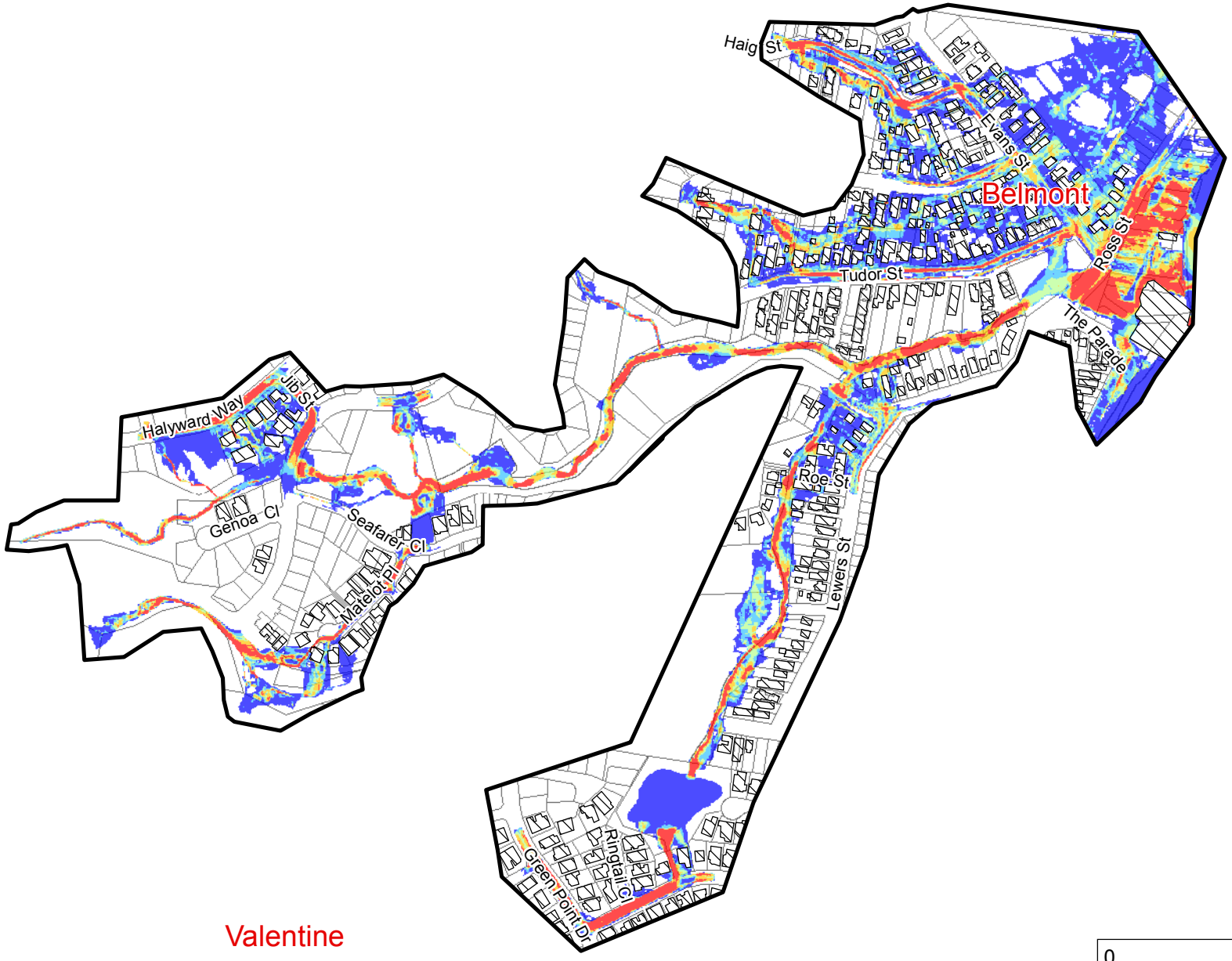
0 - 0.3
0.3 - 0.5
0.5 - 0.7
0.7 - 1.0
>1.0

0 0.25 0.5 km

J:\Jobs\119076\ArcGIS\ArcMap\Working\Template\Appendix_F\FigureF10_Mills_Creek_Peak_Flood_Velocity_20%AEP.mxd

FIGURE F12

**MILLS GULLY CREEK**
**PEAK FLOOD VELOCITIES**
**5% AEP EVENT**




N

Study Area
Cadastre
Buildings

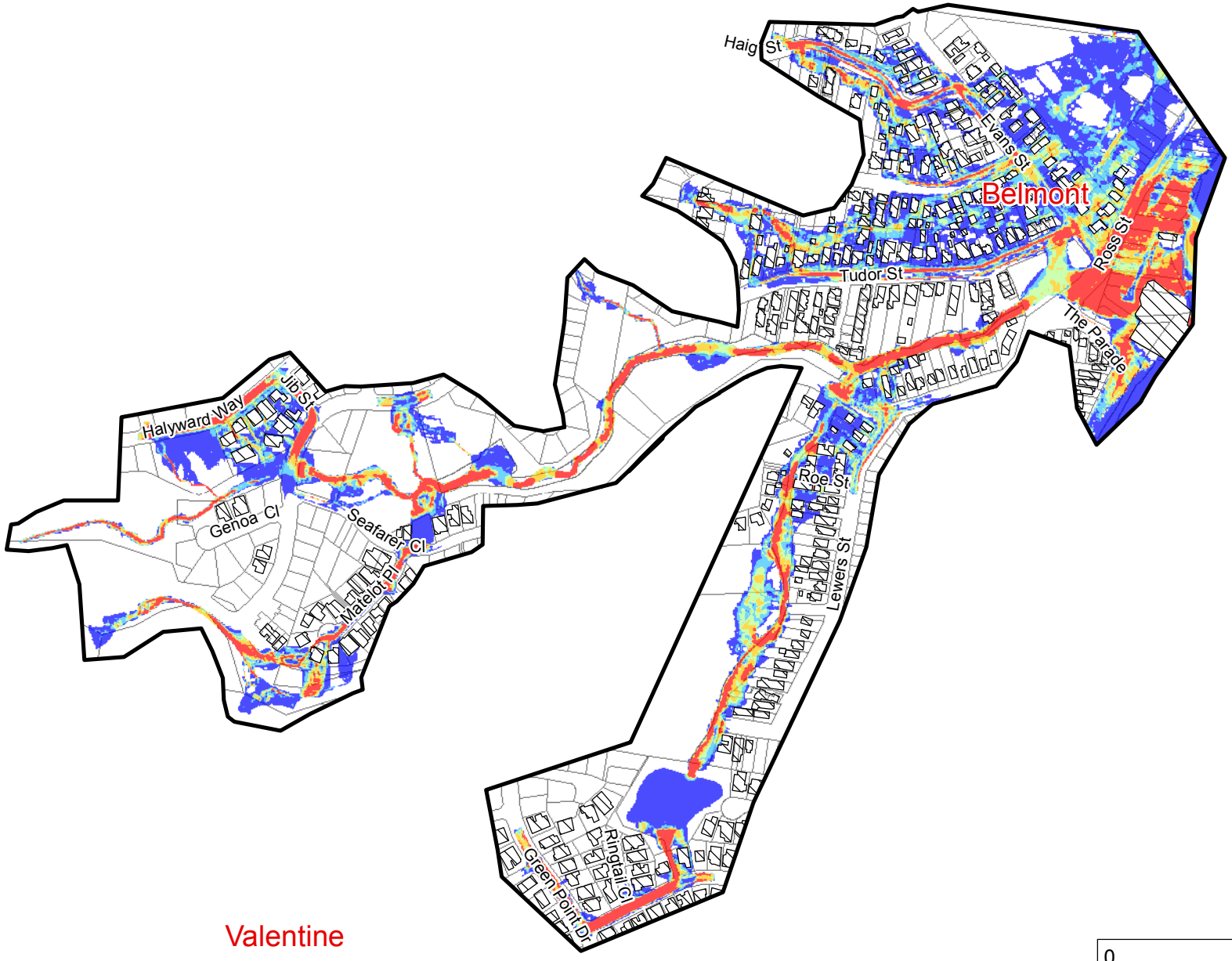
**Velocity (m/s)**

0 - 0.3
0.3 - 0.5
0.5 - 0.7
0.7 - 1.0
>1.0

0 0.25 0.5 km

J:\Jobs\1190761\ArcGIS\ArcMap\Working\Template\Appendix_F\FigureF11_Mills_Creek_Peak_Flood_Velocity_10%AEP.mxd

FIGURE F13
**MILLS GULLY CREEK**
**PEAK FLOOD VELOCITIES**
**2% AEP EVENT**




N

Study Area
Cadastre
Buildings

**Velocity (m/s)**

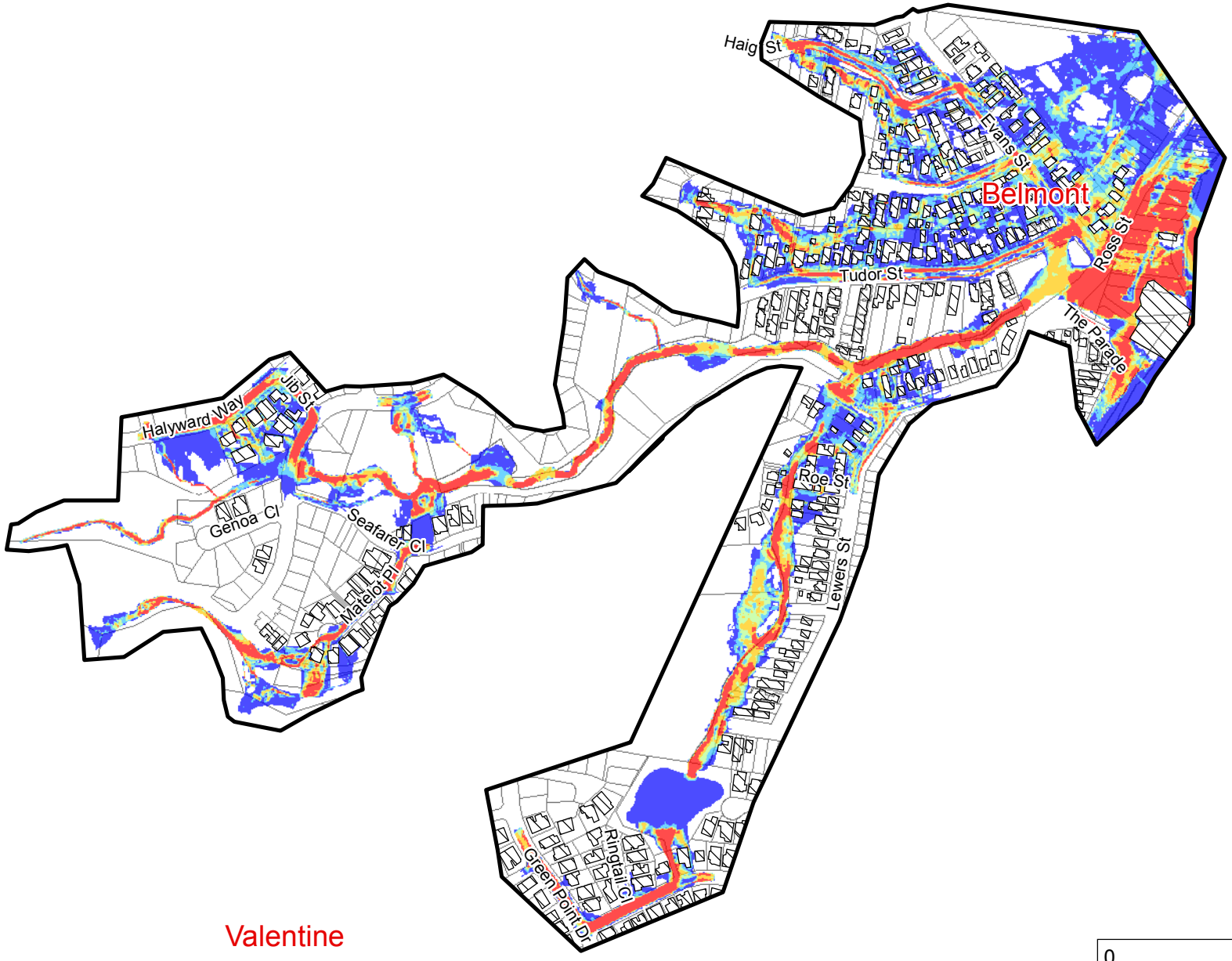
0 - 0.3
0.3 - 0.5
0.5 - 0.7
0.7 - 1.0
>1.0

0 0.25 0.5 km

J:\Jobs\119076\ArcGIS\ArcMap\Working\Template\Appendix_F\FigureF12_Mills_Creek_Peak_Flood_Velocity_5%AEP.mxd

FIGURE F14

**MILLS GULLY CREEK**
**PEAK FLOOD VELOCITIES**
**1% AEP EVENT**




N

Study Area
Cadastre
Buildings

**Velocity (m/s)**

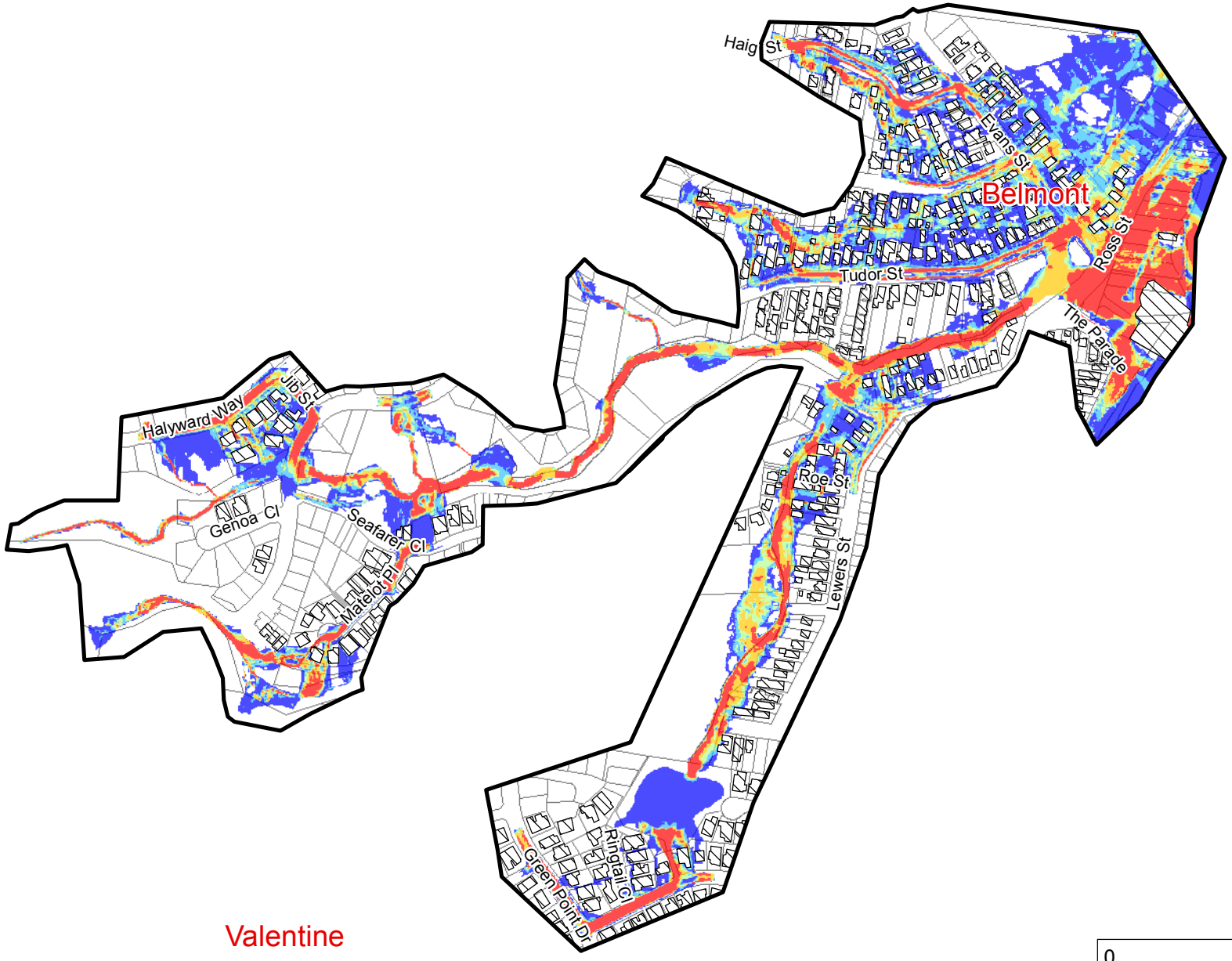
0 - 0.3
0.3 - 0.5
0.5 - 0.7
0.7 - 1.0
>1.0

0 0.25 0.5 km

J:\Jobs\119076\ArcGIS\ArcMap\Working\Template\Appendix_F\FigureF13_Mills_Creek_Peak_Flood_Velocity_2%AEP.mxd

FIGURE F15

**MILLS GULLY CREEK**
**PEAK FLOOD VELOCITIES**
**0.5% AEP EVENT**




N

Study Area
Cadastre
Buildings

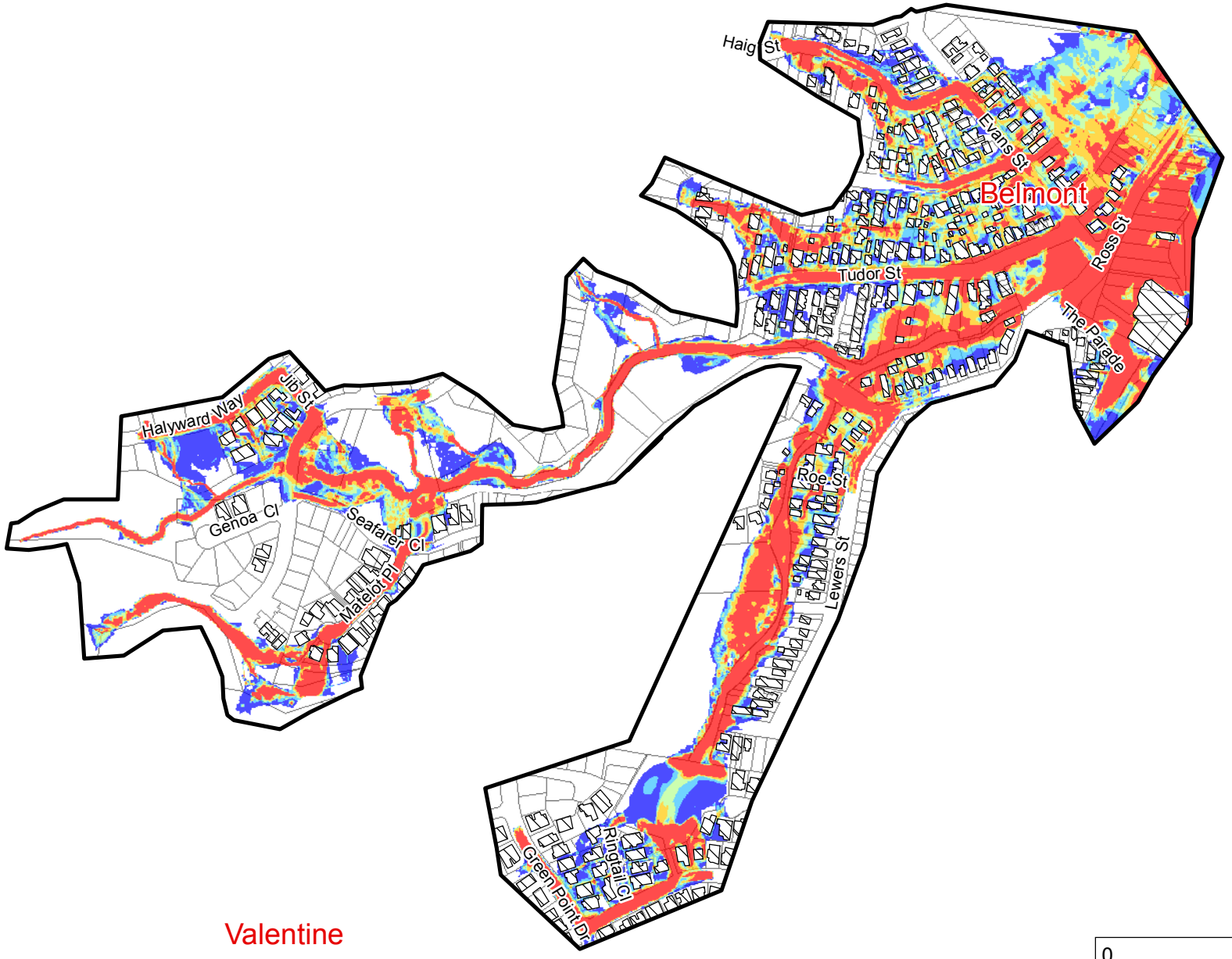
**Velocity (m/s)**

0 - 0.3
0.3 - 0.5
0.5 - 0.7
0.7 - 1.0
>1.0

0 0.25 0.5 km

J:\Jobs\119076\ArcGIS\ArcMap\Working\Template\Appendix_F\FigureF14_Mills_Creek_Peak_Flood_Velocity_1%AEP.mxd

FIGURE F16
**MILLS GULLY CREEK**
**PEAK FLOOD VELOCITIES**
**PMF EVENT**




N

Study Area
Cadastre
Buildings

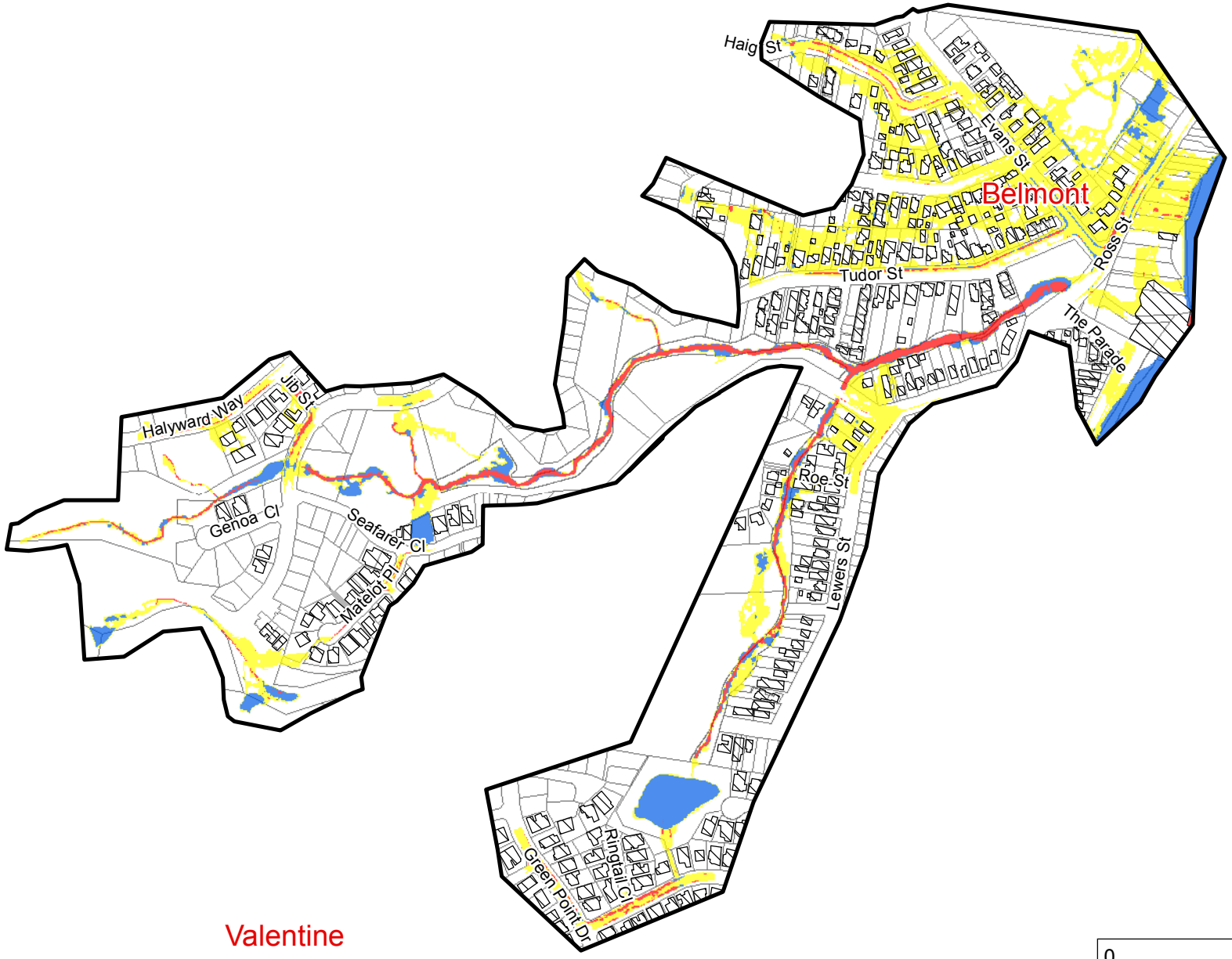
**Velocity (m/s)**

0 - 0.3
0.3 - 0.5
0.5 - 0.7
0.7 - 1.0
>1.0

0 0.25 0.5 km

J:\Jobs\119076\ArcGIS\ArcMap\Working\Template\Appendix_F\FigureF15_Mills_Creek_Peak_Flood_Velocity_0.5%AEP.mxd

FIGURE F17
**MILLS GULLY CREEK**
**HYDRAULIC CATEGORISATION**
**50% AEP EVENT**

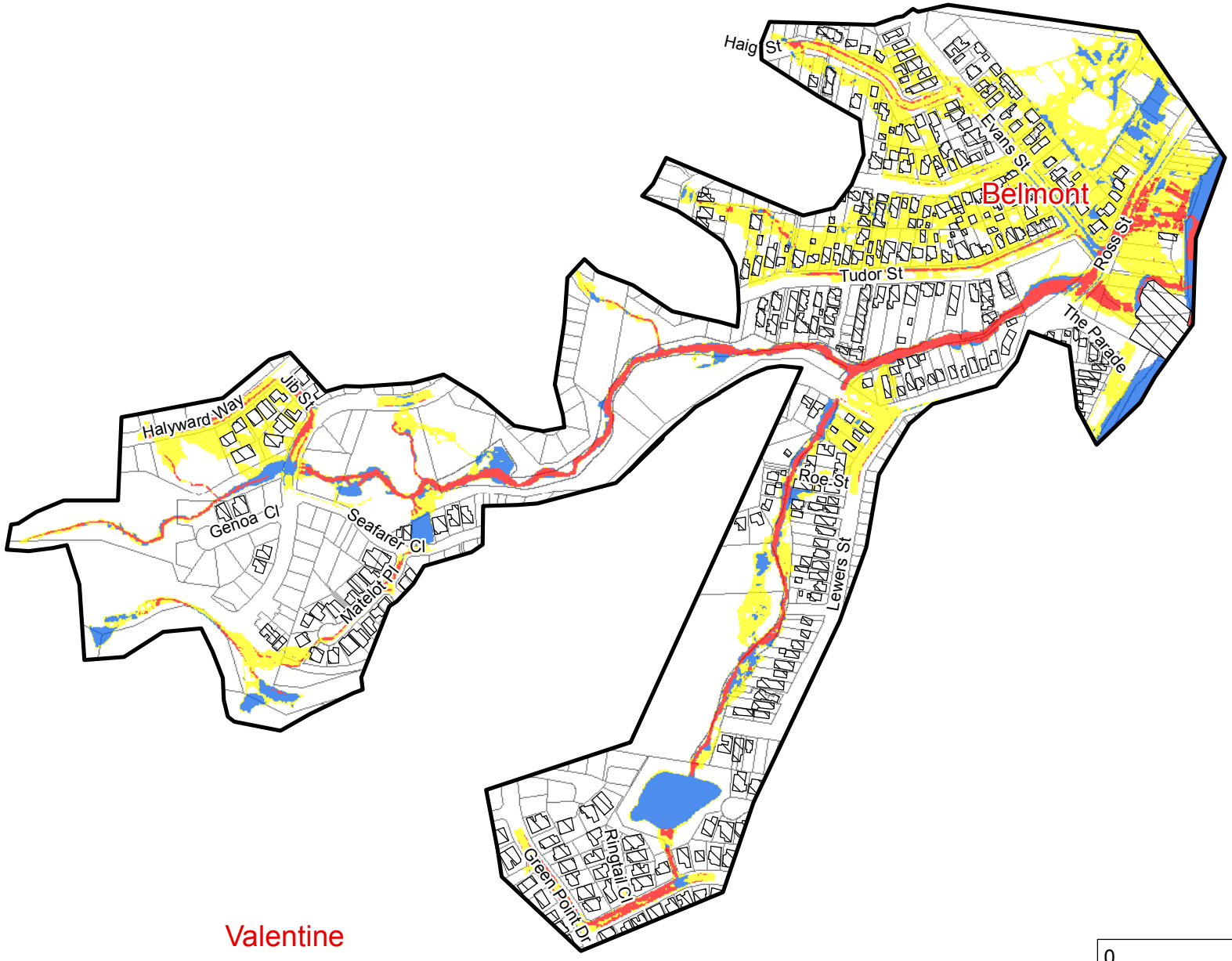



Study Area
Cadastre
Buildings
**Hydraulic Categorisation**
Floodway
Flood Storage
Flood Fringe

0 0.25 0.5 km

J:\Jobs\119076\ArcGIS\ArcMap\Working\Template\Appendix_F\FigureF17_Mills_Creek_Hydraulic_Categories_50%AEP.mxd

FIGURE F18
**MILLS GULLY CREEK**
**HYDRAULIC CATEGORISATION**
**20% AEP EVENT**

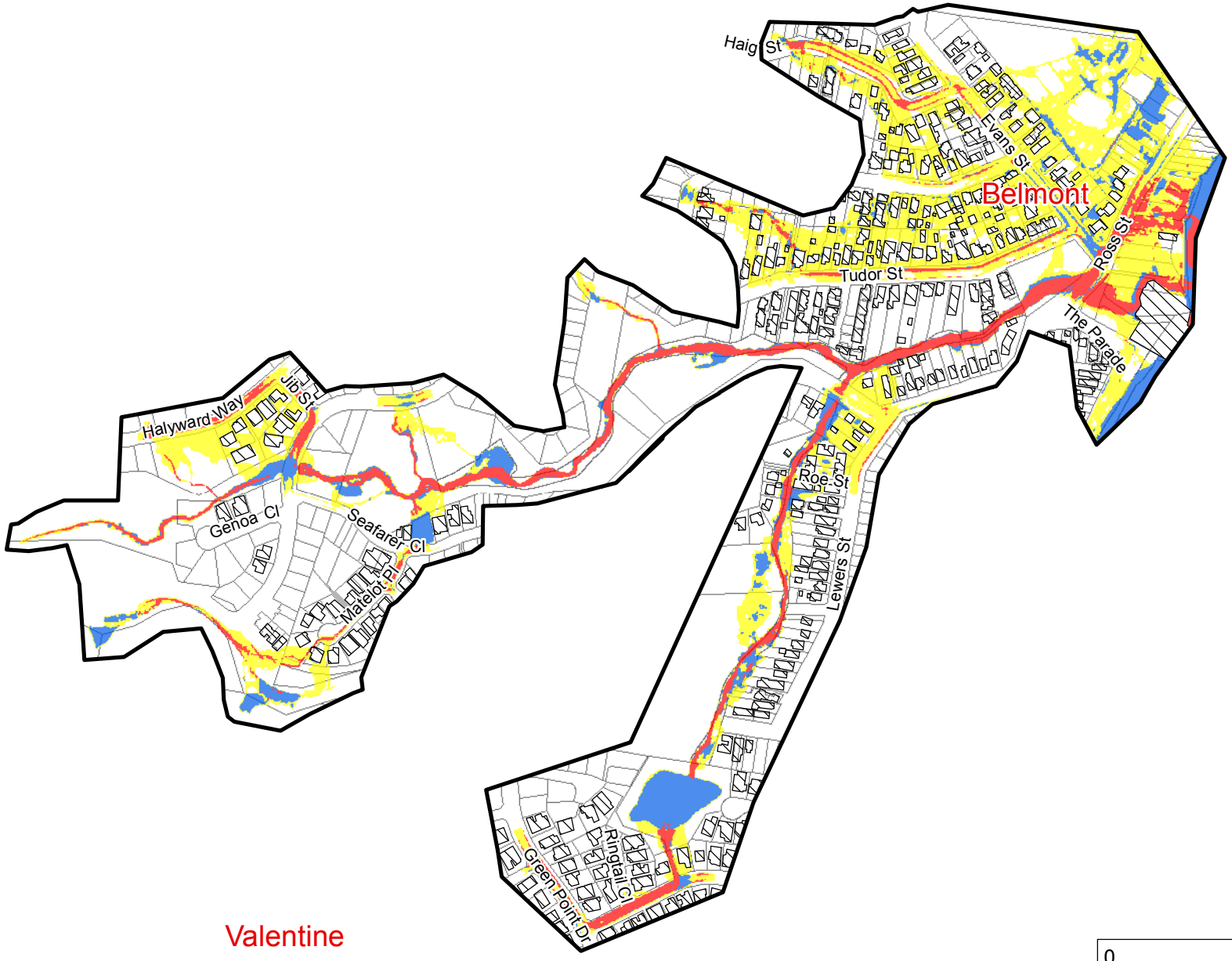



Study Area
Cadastre
Buildings
**Hydraulic Categorisation**
Floodway
Flood Storage
Flood Fringe

0 0.25 0.5 km

J:\Jobs\119076\ArcGIS\ArcMap\Working\Template\Appendix_F\FigureF17_Mills_Creek_Hydraulic_Categories_50%AEP.mxd

FIGURE F19
**MILLS GULLY CREEK**
**HYDRAULIC CATEGORISATION**
**10% AEP EVENT**



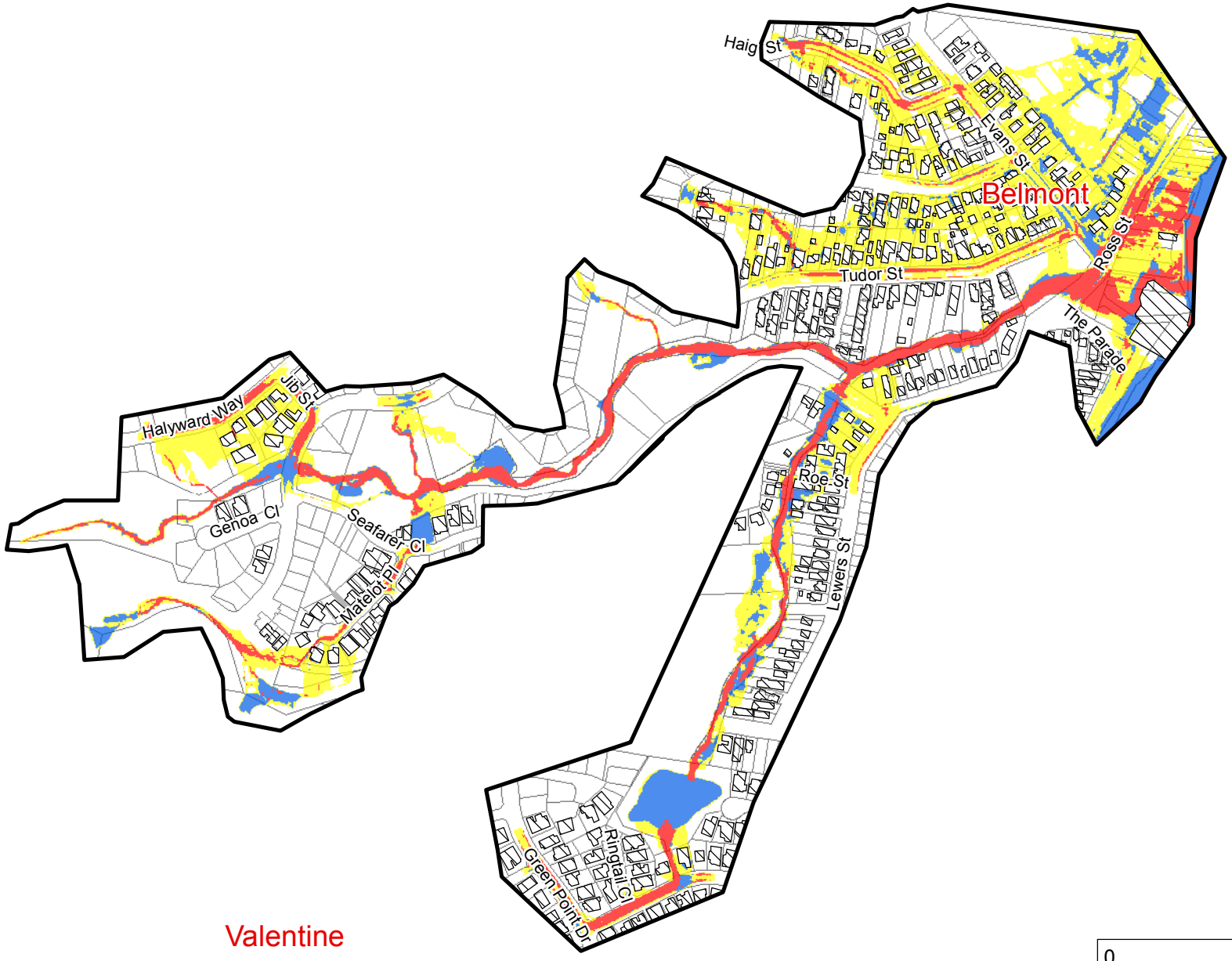

N

Study Area
Cadastre
Buildings
**Hydraulic Categorisation**
Floodway
Flood Storage
Flood Fringe

0 0.25 0.5 km

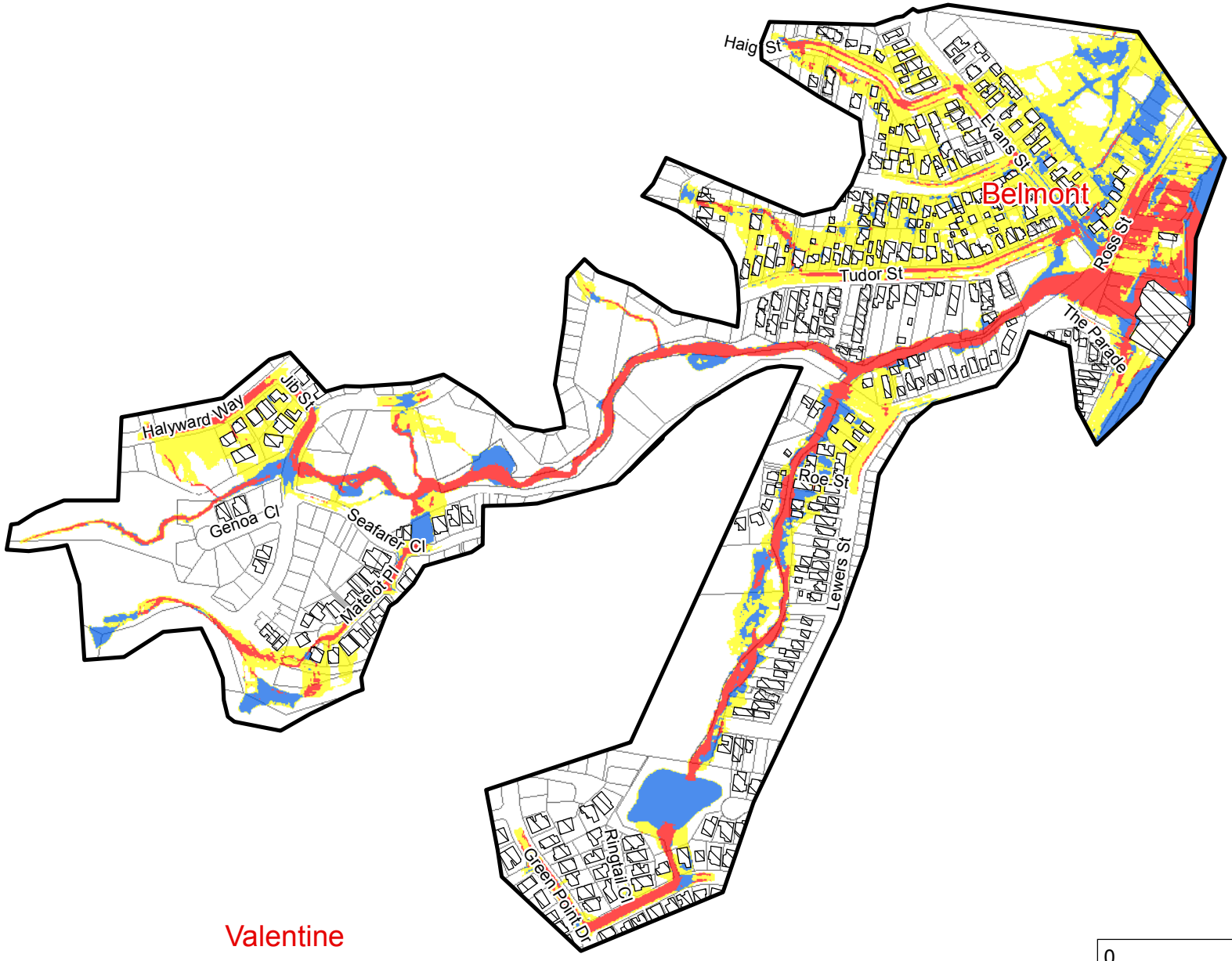
J:\Jobs\119076\ArcGIS\ArcMap\Working\Template\Appendix_F\FigureF18_Mills_Creek_Hydraulic_Categories_20%AEP.mxd

FIGURE F20
**MILLS GULLY CREEK**
**HYDRAULIC CATEGORISATION**
**5% AEP EVENT**




J:\Jobs\119076\ArcGIS\ArcMap\Working\Template\Appendix_F\FigureF19_Mills_Creek_Hydraulic_Categories_10%AEP.mxd

FIGURE F21
**MILLS GULLY CREEK**
**HYDRAULIC CATEGORISATION**
**2% AEP EVENT**



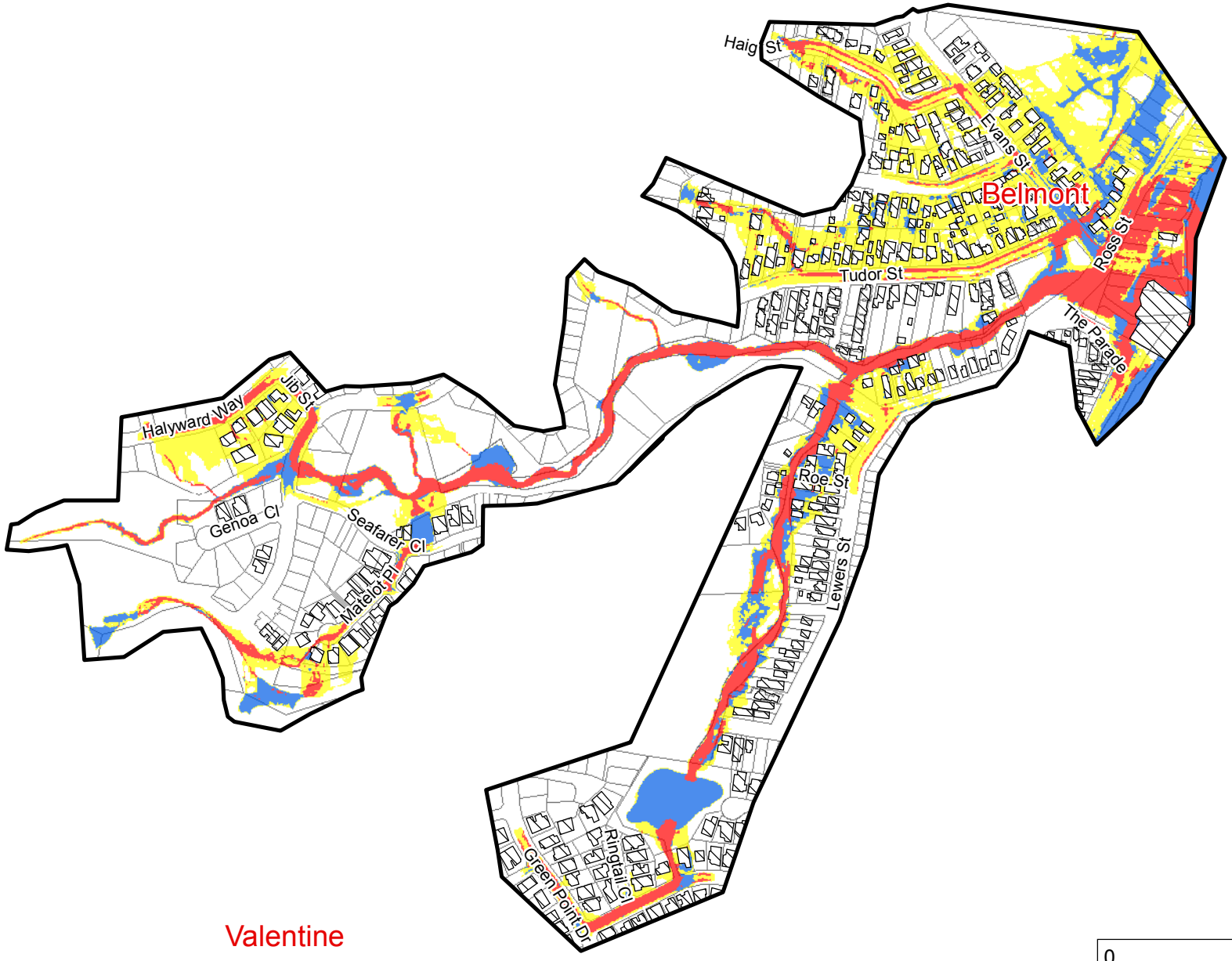

N

Study Area
Cadastre
Buildings
**Hydraulic Categorisation**
Floodway
Flood Storage
Flood Fringe

0 0.25 0.5 km

J:\Jobs\119076\ArcGIS\ArcMap\Working\Template\Appendix_F\FigureF20_Mills_Creek_Hydraulic_Categories_5%AEP.mxd

FIGURE F22
**MILLS GULLY CREEK**
**HYDRAULIC CATEGORISATION**
**1% AEP EVENT**



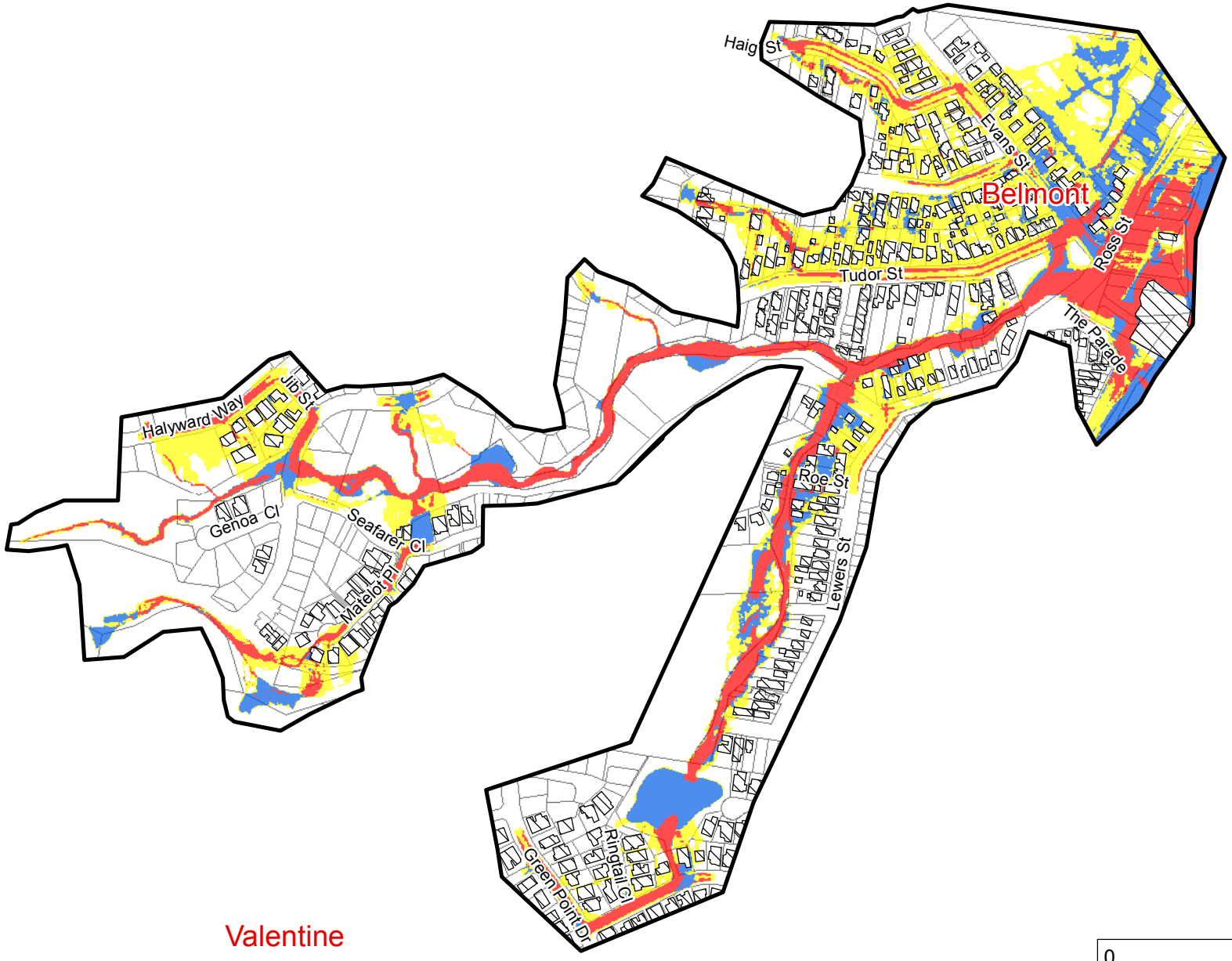

N

Study Area
Cadastre
Buildings
**Hydraulic Categorisation**
Floodway
Flood Storage
Flood Fringe

0 0.25 0.5 km

J:\Jobs\119076\ArcGIS\ArcMap\Working\Template\Appendix_F\FigureF21_Mills_Creek_Hydraulic_Categories_2%AEP.mxd

FIGURE F23
**MILLS GULLY CREEK**
**HYDRAULIC CATEGORISATION**
**0.5% AEP EVENT**



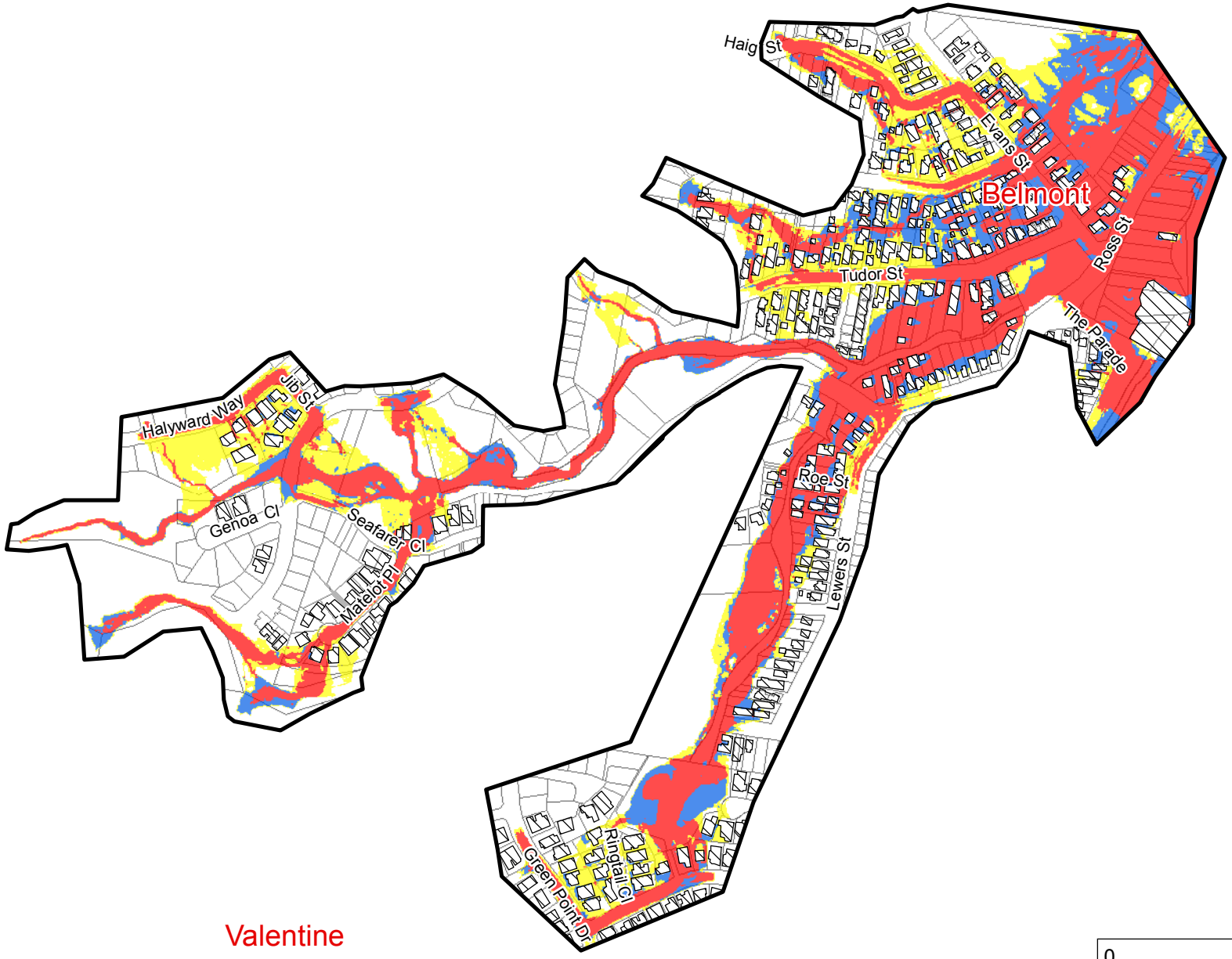

N

Study Area
Cadastre
Buildings
**Hydraulic Categorisation**
Floodway
Flood Storage
Flood Fringe

0 0.25 0.5 km

J:\Jobs\119076\ArcGIS\ArcMap\Working\Template\Appendix_F\FigureF22_Mills_Creek_Hydraulic_Categories_1%AEP.mxd

FIGURE F24
**MILLS GULLY CREEK**
**HYDRAULIC CATEGORISATION**
**PMF EVENT**




N

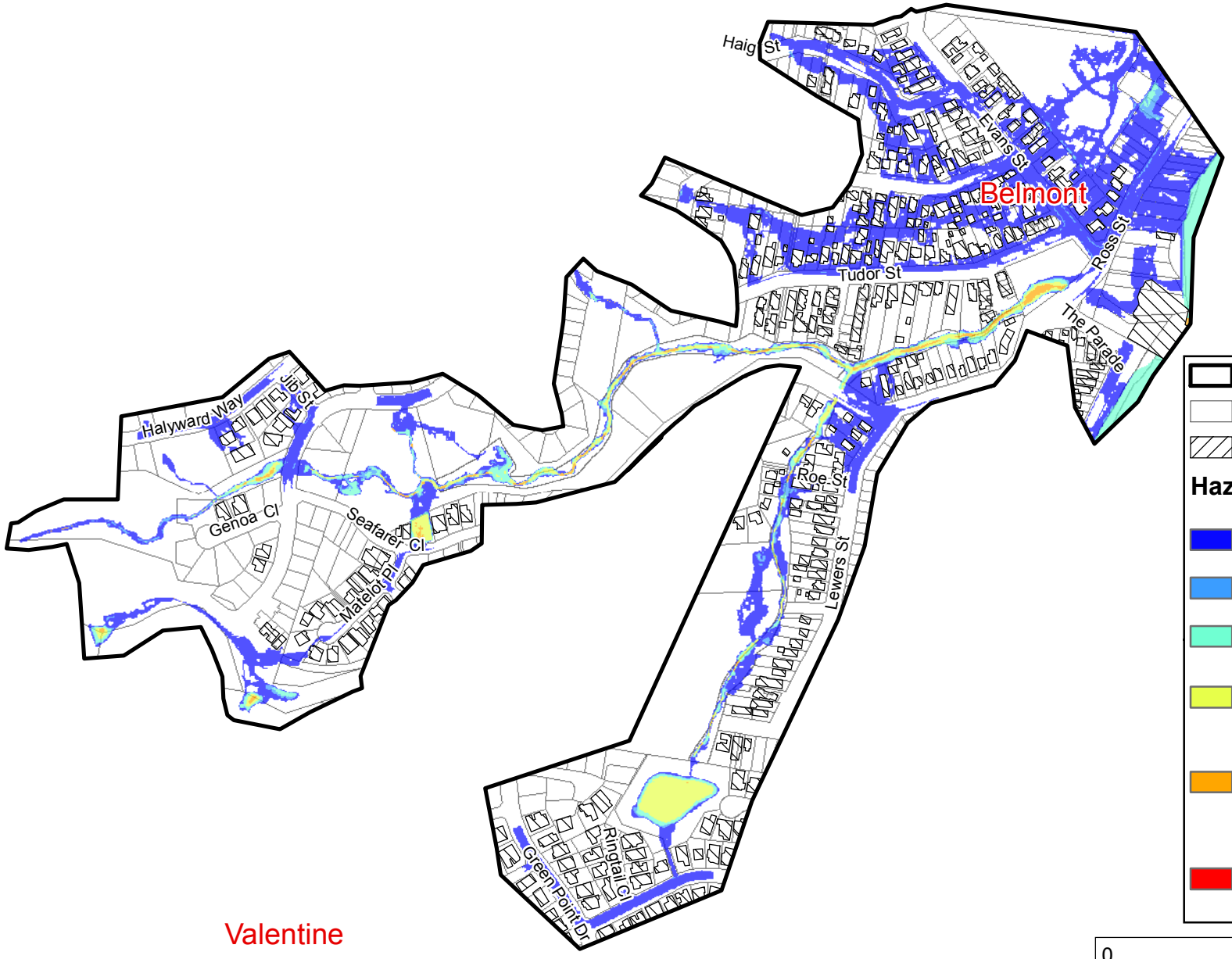
Study Area
Cadastre
Buildings
**Hydraulic Categorisation**
Floodway
Flood Storage
Flood Fringe

0 0.25 0.5 km

J:\Jobs\119076\ArcGIS\ArcMap\Working\Template\Appendix_F\FigureF23_Mills_Creek_Hydraulic_Categories_0.5%AEP.mxd

FIGURE F25

# MILLS GULLY CREEK HYDRAULIC HAZARD 50% AEP EVENT




N

- Study Area
- Cadastre
- Buildings

**Hazard**

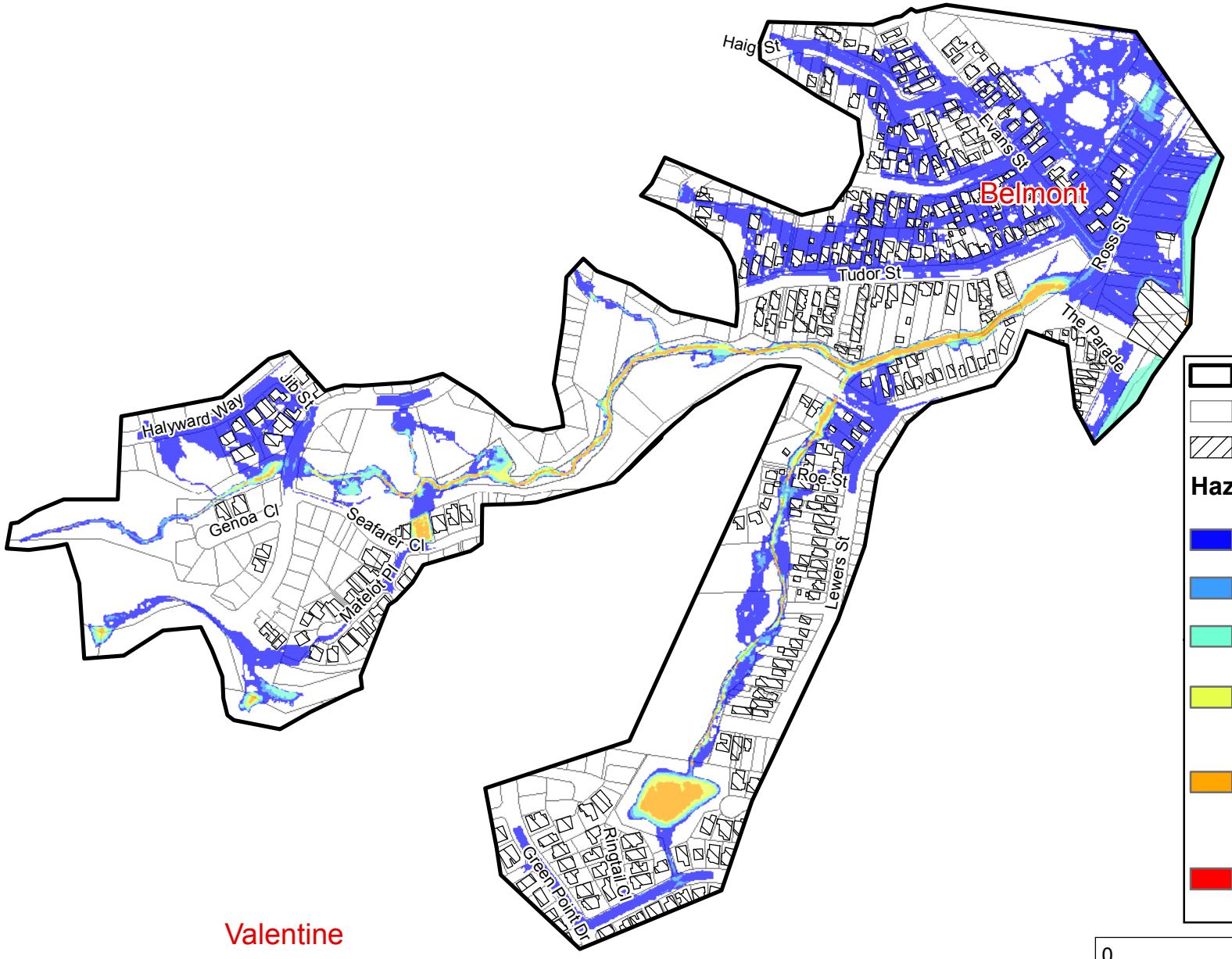
- H1- Generally safe for people, vehicles and buildings
- H2- Unsafe for small vehicles
- H3- Unsafe for vehicles, children and the elderly
- H4- Unsafe for people and vehicles
- H5- Unsafe for people or vehicles. Buildings require special engineering design and construction
- H6- Unsafe for vehicles and people. All building types considered vulnerable to failure

0 0.25 0.5 km

J:\Jobs\119076\ArcGIS\ArcMap\Working\Template\Appendix_F\FigureF25_Mills_Creek_Provisional_Hazard_50%AEP.mxd

FIGURE F26

# MILLS GULLY CREEK HYDRAULIC HAZARD 20% AEP EVENT




N

- Study Area
- Cadastre
- Buildings

**Hazard**

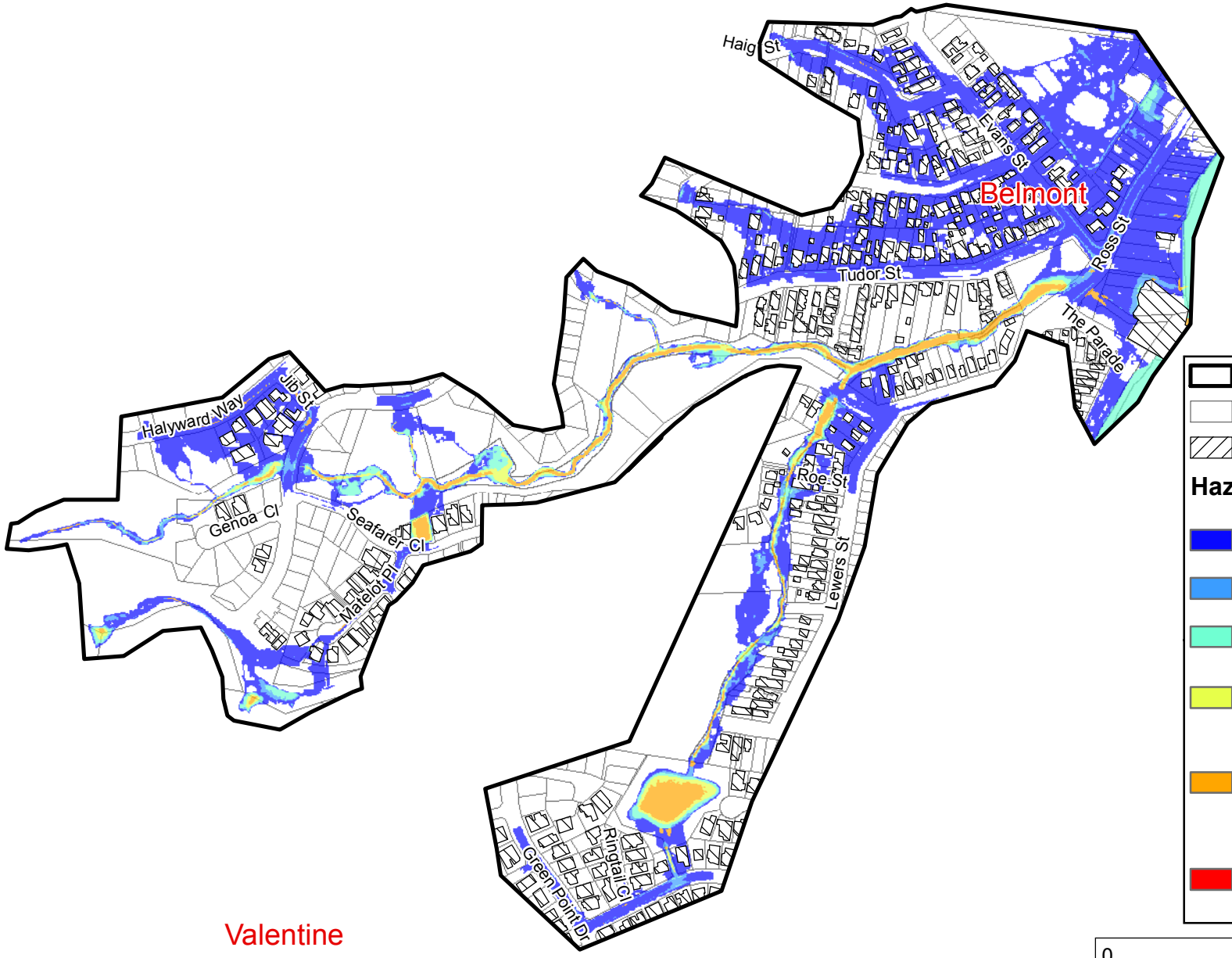
- H1- Generally safe for people, vehicles and buildings
- H2- Unsafe for small vehicles
- H3- Unsafe for vehicles, children and the elderly
- H4- Unsafe for people and vehicles
- H5- Unsafe for people or vehicles. Buildings require special engineering design and construction
- H6- Unsafe for vehicles and people. All building types considered vulnerable to failure

0 0.25 0.5 km

J:\Jobs\119076\ArcGIS\ArcMap\Working\Template\Appendix_F\FigureF25_Mills_Creek_Provisional_Hazard_50%AEP.mxd

FIGURE F27

# MILLS GULLY CREEK HYDRAULIC HAZARD 10% AEP EVENT




N

- Study Area
- Cadastre
- Buildings

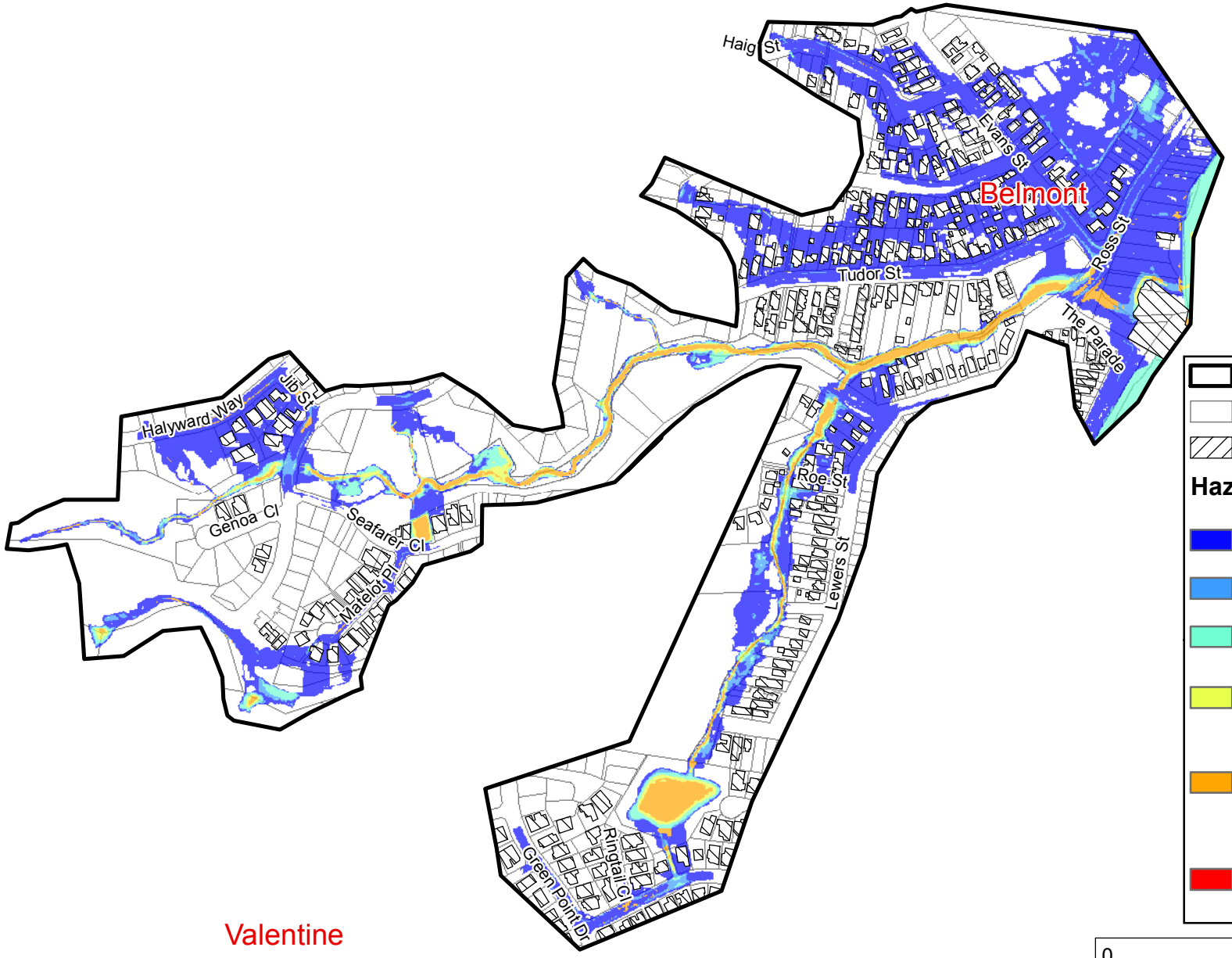
**Hazard**

- H1- Generally safe for people, vehicles and buildings
- H2- Unsafe for small vehicles
- H3- Unsafe for vehicles, children and the elderly
- H4- Unsafe for people and vehicles
- H5- Unsafe for people or vehicles. Buildings require special engineering design and construction
- H6- Unsafe for vehicles and people. All building types considered vulnerable to failure

0 0.25 0.5 km

J:\Jobs\119076\ArcGIS\ArcMap\Working\Template\Appendix_F\FigureF26_Mills_Creek_Provisional_Hazard_20%AEP.mxd

FIGURE F28
**MILLS GULLY CREEK**
**HYDRAULIC HAZARD**
**5% AEP EVENT**




N

Study Area
Cadastre
Buildings

**Hazard**

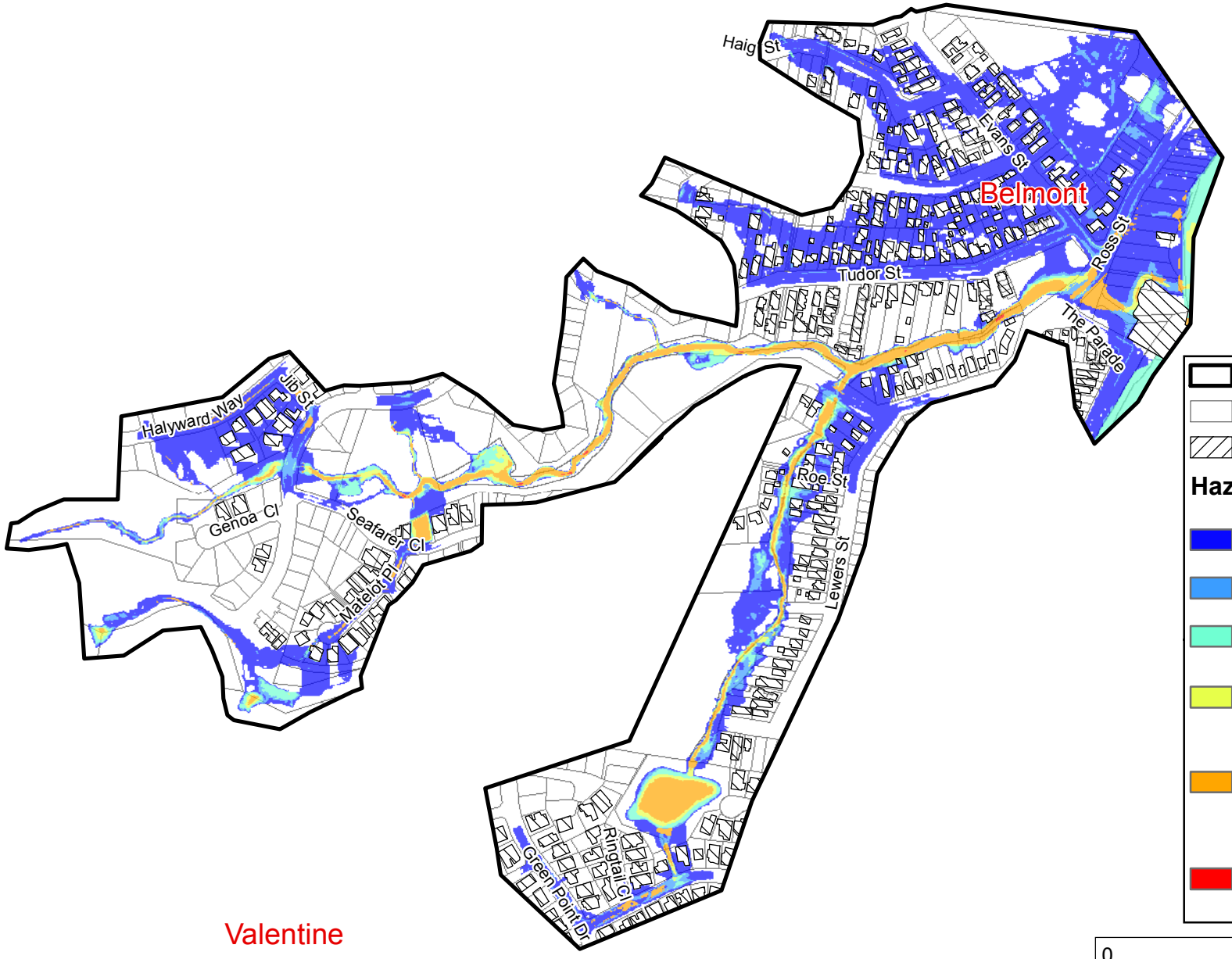
- H1- Generally safe for people, vehicles and buildings
- H2- Unsafe for small vehicles
- H3- Unsafe for vehicles, children and the elderly
- H4- Unsafe for people and vehicles
- H5- Unsafe for people or vehicles. Buildings require special engineering design and construction
- H6- Unsafe for vehicles and people. All building types considered vulnerable to failure

0 0.25 0.5 km

J:\Jobs\119076\ArcGIS\ArcMap\Working\Template\Appendix_F\FigureF27_Mills_Creek_Provisional_Hazard_10%AEP.mxd

FIGURE F29

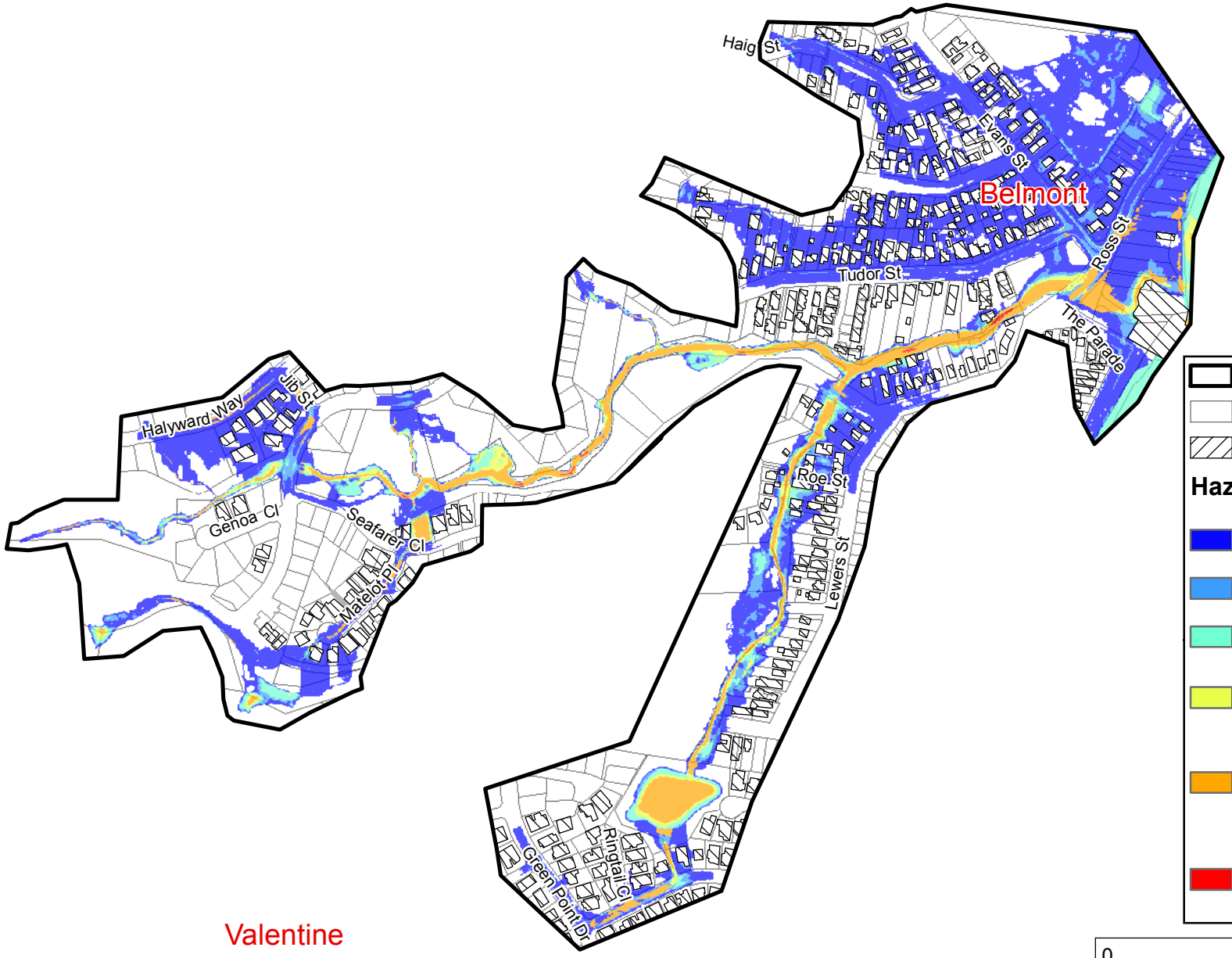
# MILLS GULLY CREEK HYDRAULIC HAZARD 2% AEP EVENT




J:\Jobs\119076\ArcGIS\ArcMap\Working\Template\Appendix_F\FigureF28_Mills_Creek_Provisional_Hazard_5%AEP.mxd

FIGURE F30

# MILLS GULLY CREEK HYDRAULIC HAZARD 1% AEP EVENT




N

- Study Area
- Cadastre
- Buildings

**Hazard**

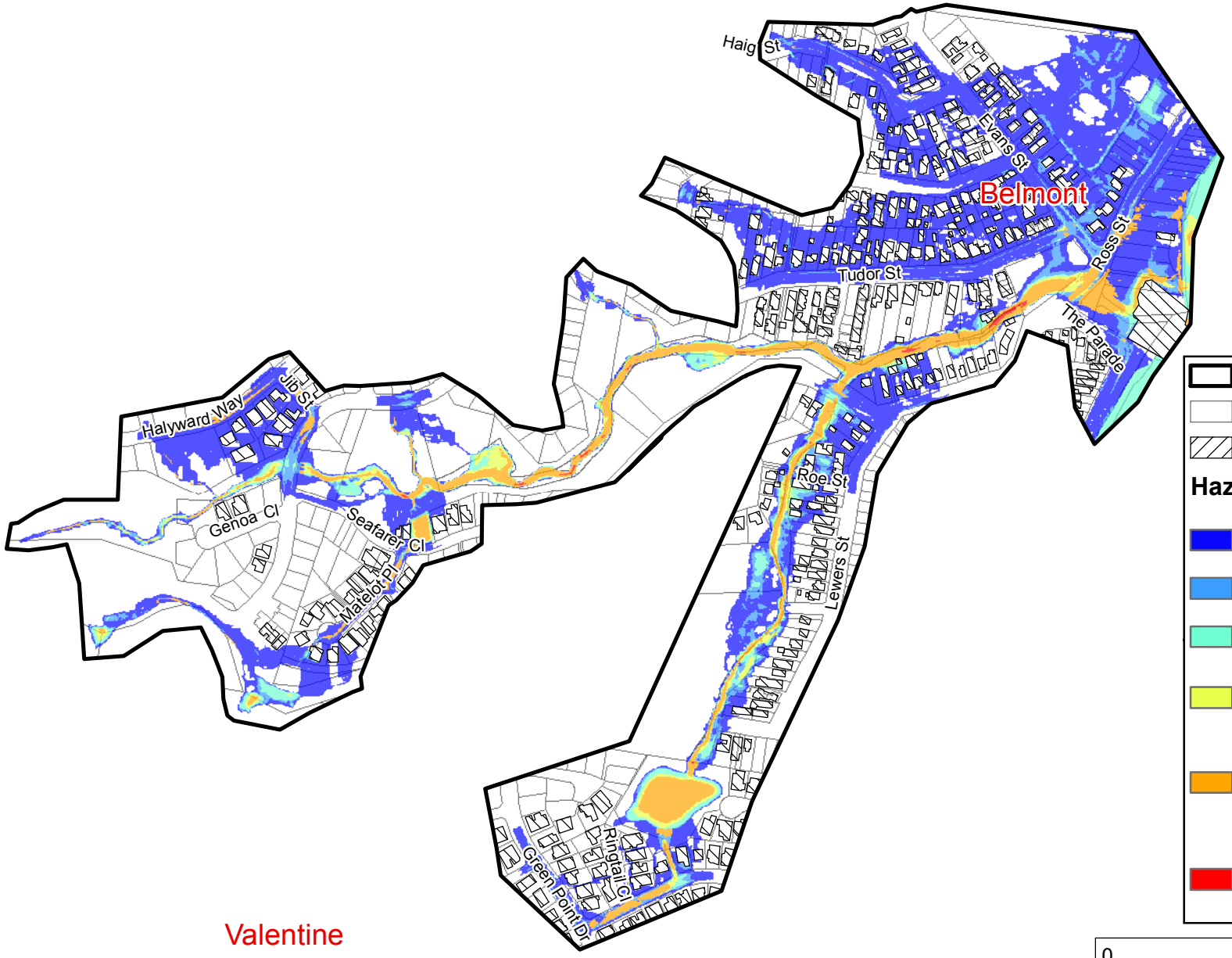
- H1- Generally safe for people, vehicles and buildings
- H2- Unsafe for small vehicles
- H3- Unsafe for vehicles, children and the elderly
- H4- Unsafe for people and vehicles
- H5- Unsafe for people or vehicles. Buildings require special engineering design and construction
- H6- Unsafe for vehicles and people. All building types considered vulnerable to failure

0 0.25 0.5 km

J:\Jobs\119076\ArcGIS\ArcMap\Working\Template\Appendix_F\FigureF29_Mills_Creek_Provisional_Hazard_2%AEP.mxd

FIGURE F31

# MILLS GULLY CREEK HYDRAULIC HAZARD 0.5% AEP EVENT




N

- Study Area
- Cadastre
- Buildings

**Hazard**

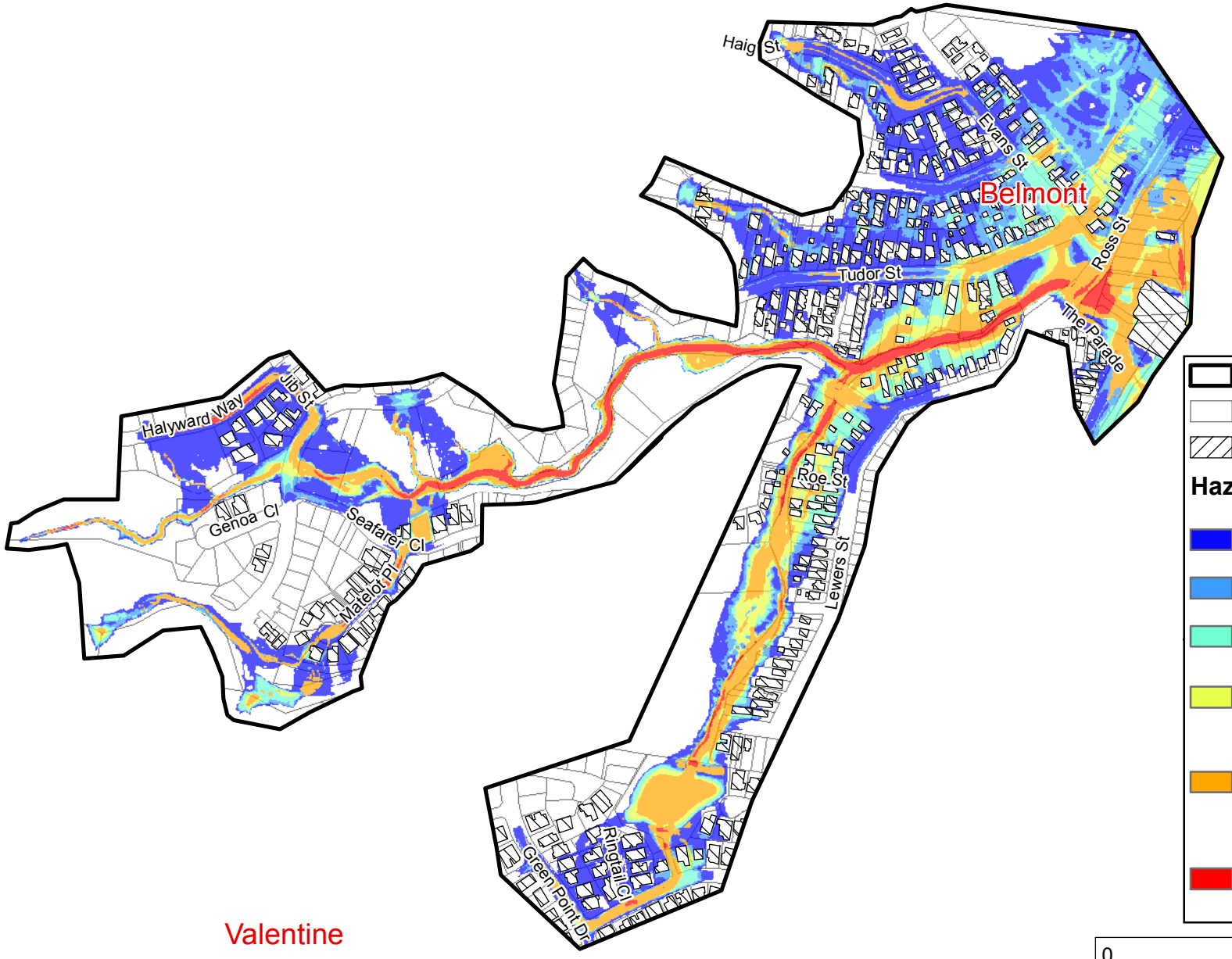
- H1- Generally safe for people, vehicles and buildings
- H2- Unsafe for small vehicles
- H3- Unsafe for vehicles, children and the elderly
- H4- Unsafe for people and vehicles
- H5- Unsafe for people or vehicles. Buildings require special engineering design and construction
- H6- Unsafe for vehicles and people. All building types considered vulnerable to failure

0 0.25 0.5 km

J:\Jobs\1190776\ArcGIS\ArcMap\Working\Template\Appendix_F\FigureF30_Mills_Creek_Provisional_Hazard_1%AEP.mxd

FIGURE F32

# MILLS GULLY CREEK HYDRAULIC HAZARD PMF EVENT




N

- Study Area
- Cadastre
- Buildings

**Hazard**

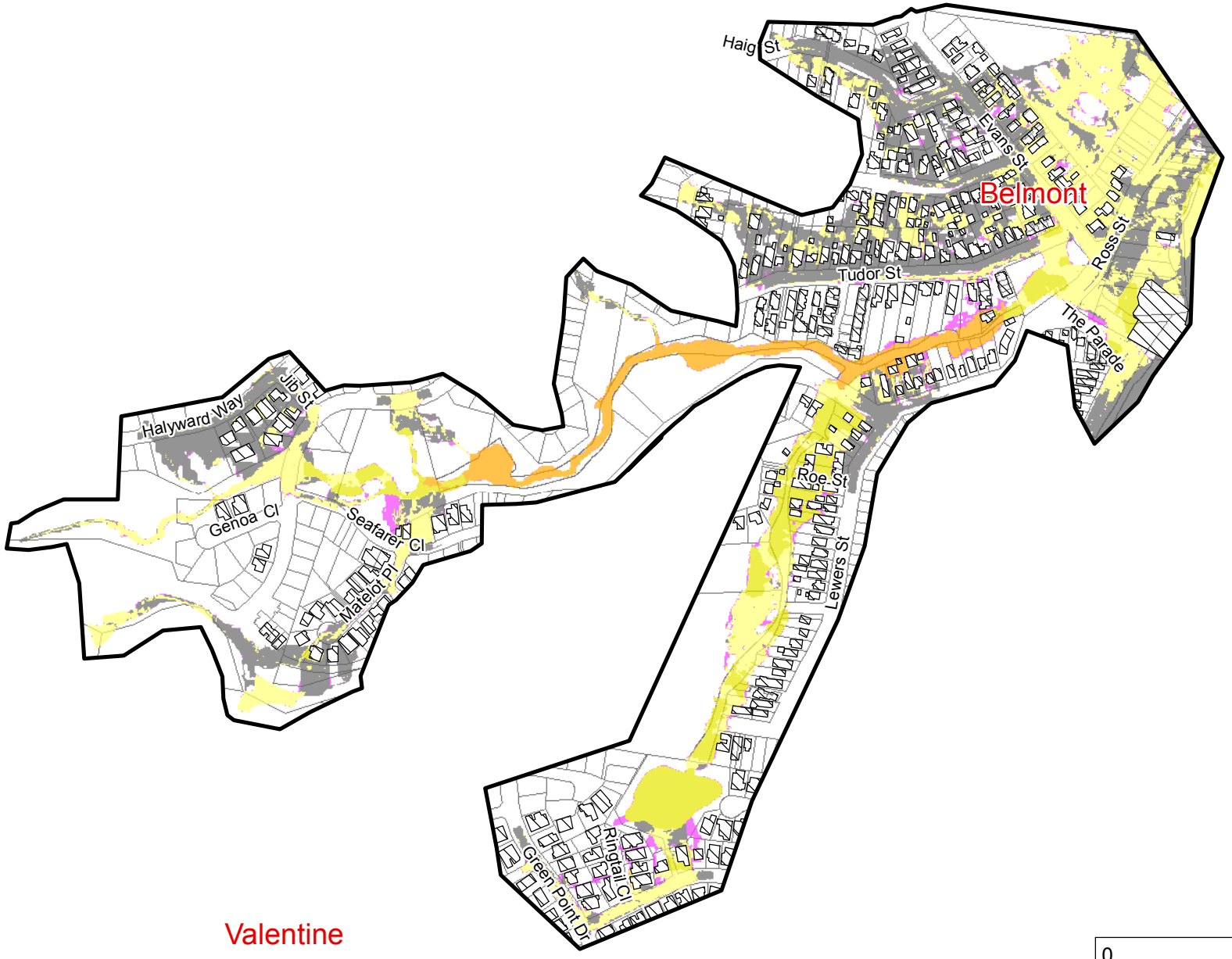
- H1- Generally safe for people, vehicles and buildings
- H2- Unsafe for small vehicles
- H3- Unsafe for vehicles, children and the elderly
- H4- Unsafe for people and vehicles
- H5- Unsafe for people or vehicles. Buildings require special engineering design and construction
- H6- Unsafe for vehicles and people. All building types considered vulnerable to failure

0 0.25 0.5 km

J:\Jobs\119076\ArcGIS\ArcMap\Working\Template\Appendix_F\FigureF31_Mills_Creek_Provisional_Hazard_0.5%AEP.mxd

FIGURE F33

**MILLS GULLY CREEK**
**CHANGE IN PEAK FLOOD LEVEL**
**0.5% AEP EVENT VS 1% AEP EVENT**




N

Study Area
Cadastre
Buildings

**Impact (m)**

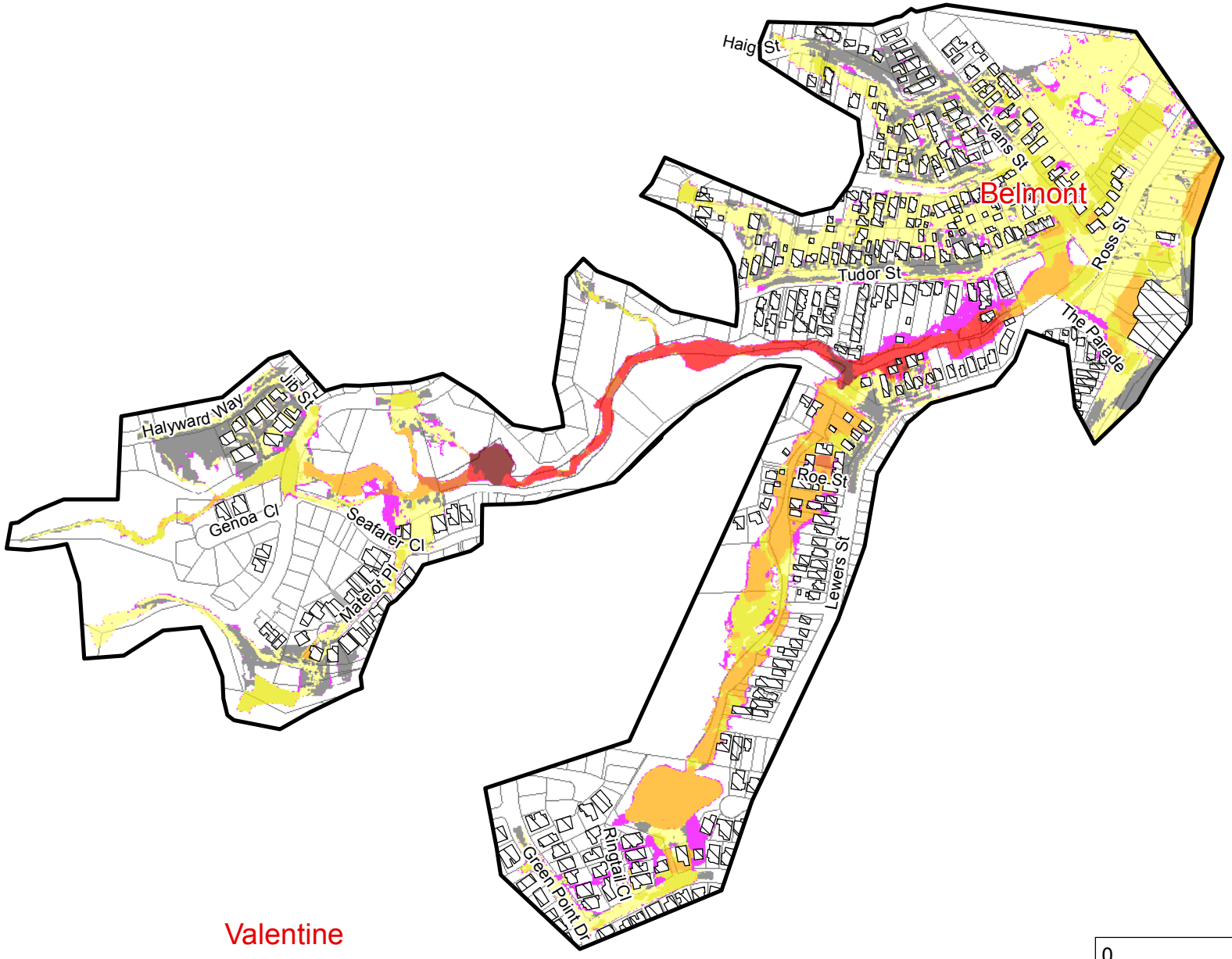
< -0.4
-0.4 to -0.3
-0.3 to -0.2
-0.2 to -0.1
-0.1 to -0.05
-0.05 to -0.01
-0.01 to 0.01
0.01 to 0.05
0.05 to 0.1
0.1 to 0.2
0.2 to 0.3
0.3 to 0.4
> 0.4
Newly Flooded
No Longer Flooded

0 0.25 0.5 km

J:\Jobs\119076\ArcGIS\ArcMap\Working\Template\Appendix_F\FigureF33_Mills_Creek_Impact_CC_0.5%AEP_V_1%AEP.mxd

FIGURE F34

**MILLS GULLY CREEK**
**CHANGE IN PEAK FLOOD LEVEL**
**0.2% AEP EVENT VS 1% AEP EVENT**




N

Study Area
Cadastre
Buildings

**Impact (m)**

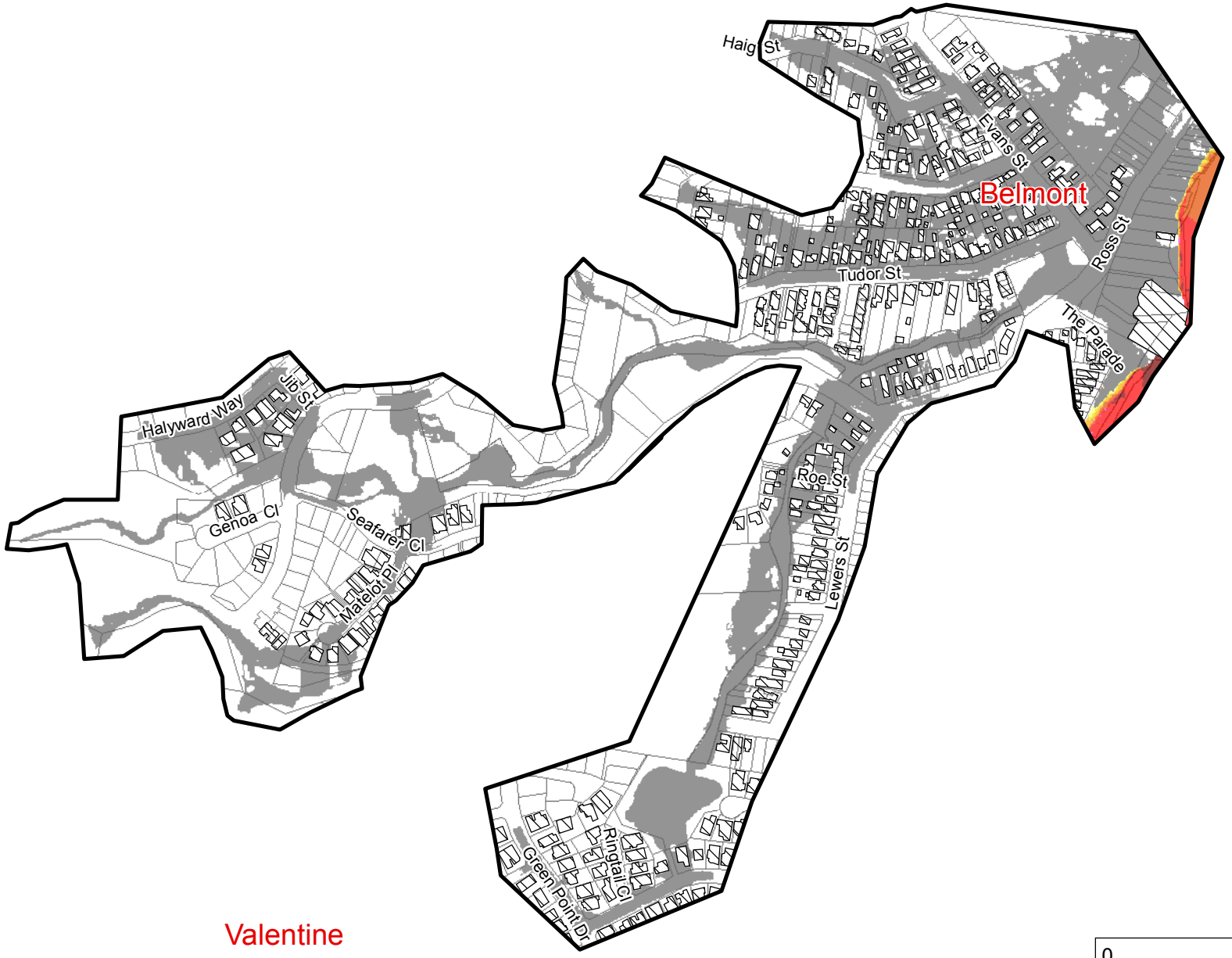
< -0.4
-0.4 to -0.3
-0.3 to -0.2
-0.2 to -0.1
-0.1 to -0.05
-0.05 to -0.01
-0.01 to 0.01
0.01 to 0.05
0.05 to 0.1
0.1 to 0.2
0.2 to 0.3
0.3 to 0.4
> 0.4
Newly Flooded
No Longer Flooded

0 0.25 0.5 km

J:\Jobs\119076\ArcGIS\ArcMap\Working\Template\Appendix_F\FigureF33_Mills_Creek_Impact_CC_0.5%AEP_V_1%AEP.mxd

FIGURE F35

**MILLS GULLY CREEK**
**CHANGE IN PEAK FLOOD LEVEL**
**1% AEP EVENT - SEA LEVEL RISE 400MM**




N

Study Area
Cadastre
Buildings

**Impact (m)**

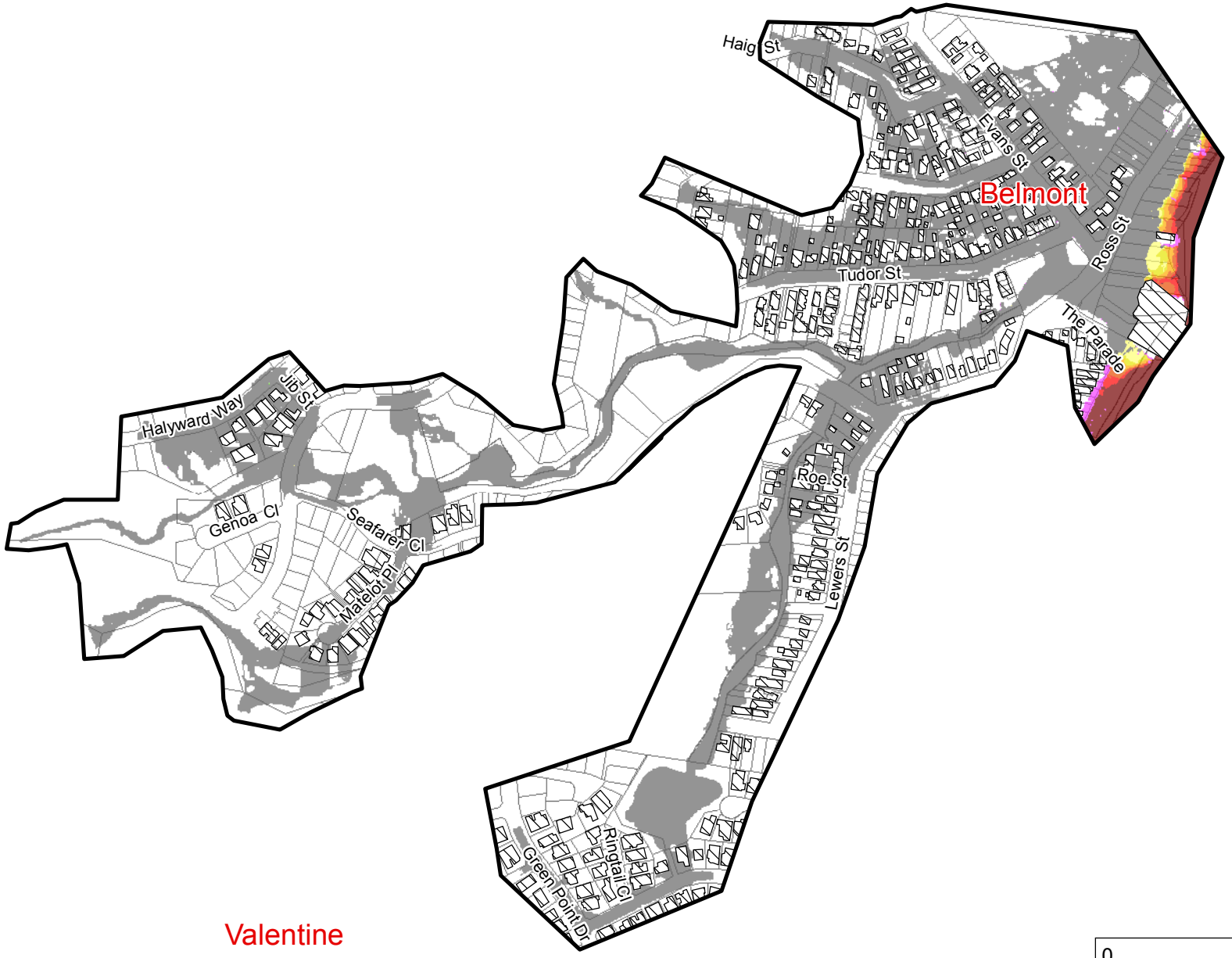
- < -0.4
- -0.4 to -0.3
- -0.3 to -0.2
- -0.2 to -0.1
- -0.1 to -0.05
- -0.05 to -0.01
- -0.01 to 0.01
- 0.01 to 0.05
- 0.05 to 0.1
- 0.1 to 0.2
- 0.2 to 0.3
- 0.3 to 0.4
- > 0.4
- Newly Flooded
- No Longer Flooded

0 0.25 0.5 km

J:\Jobs\119076\ArcGIS\ArcMap\Working\Template\Appendix_F\FigureF34_Mills_Creek_Impact_CC_0.2%AEP_V_1%AEP.mxd

FIGURE F36

**MILLS GULLY CREEK**
**CHANGE IN PEAK FLOOD LEVEL**
**1% AEP EVENT - SEA LEVEL RISE 900MM**




N

Study Area
Cadastre
Buildings

**Impact (m)**

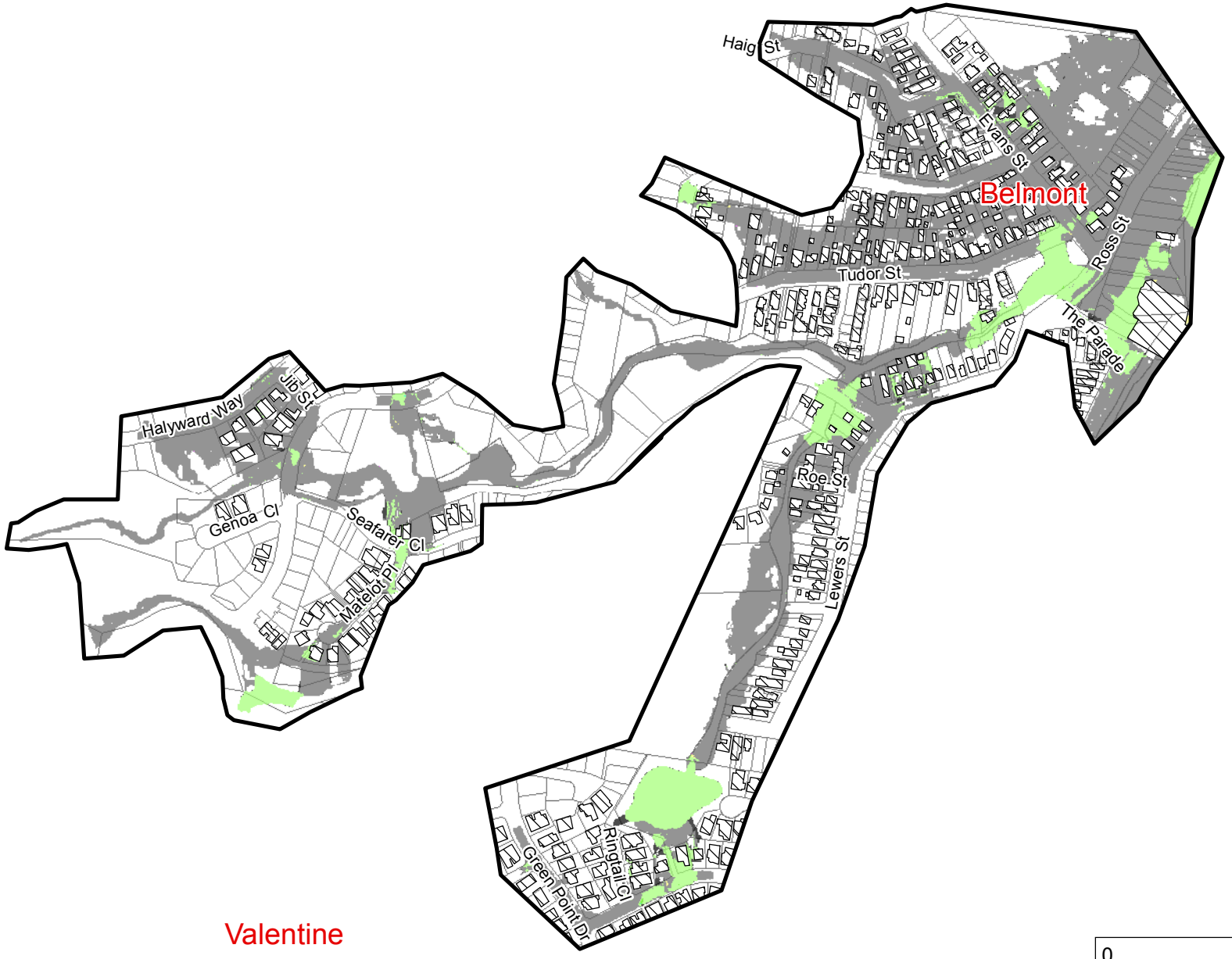
< -0.4
-0.4 to -0.3
-0.3 to -0.2
-0.2 to -0.1
-0.1 to -0.05
-0.05 to -0.01
-0.01 to 0.01
0.01 to 0.05
0.05 to 0.1
0.1 to 0.2
0.2 to 0.3
0.3 to 0.4
> 0.4
Newly Flooded
No Longer Flooded

0 0.25 0.5 km

J:\Jobs\119076\ArcGIS\ArcMap\Working\Template\Appendix_F\FigureF35_Mills_Creek_Impact_CC_SLR04_1%AEP.mxd

FIGURE F37

**MILLS GULLY CREEK**
**CHANGE IN PEAK FLOOD LEVEL**
**1% AEP EVENT - 25% BLOCKAGE**




N

- Study Area
- Cadastre
- Buildings

**Impact (m)**

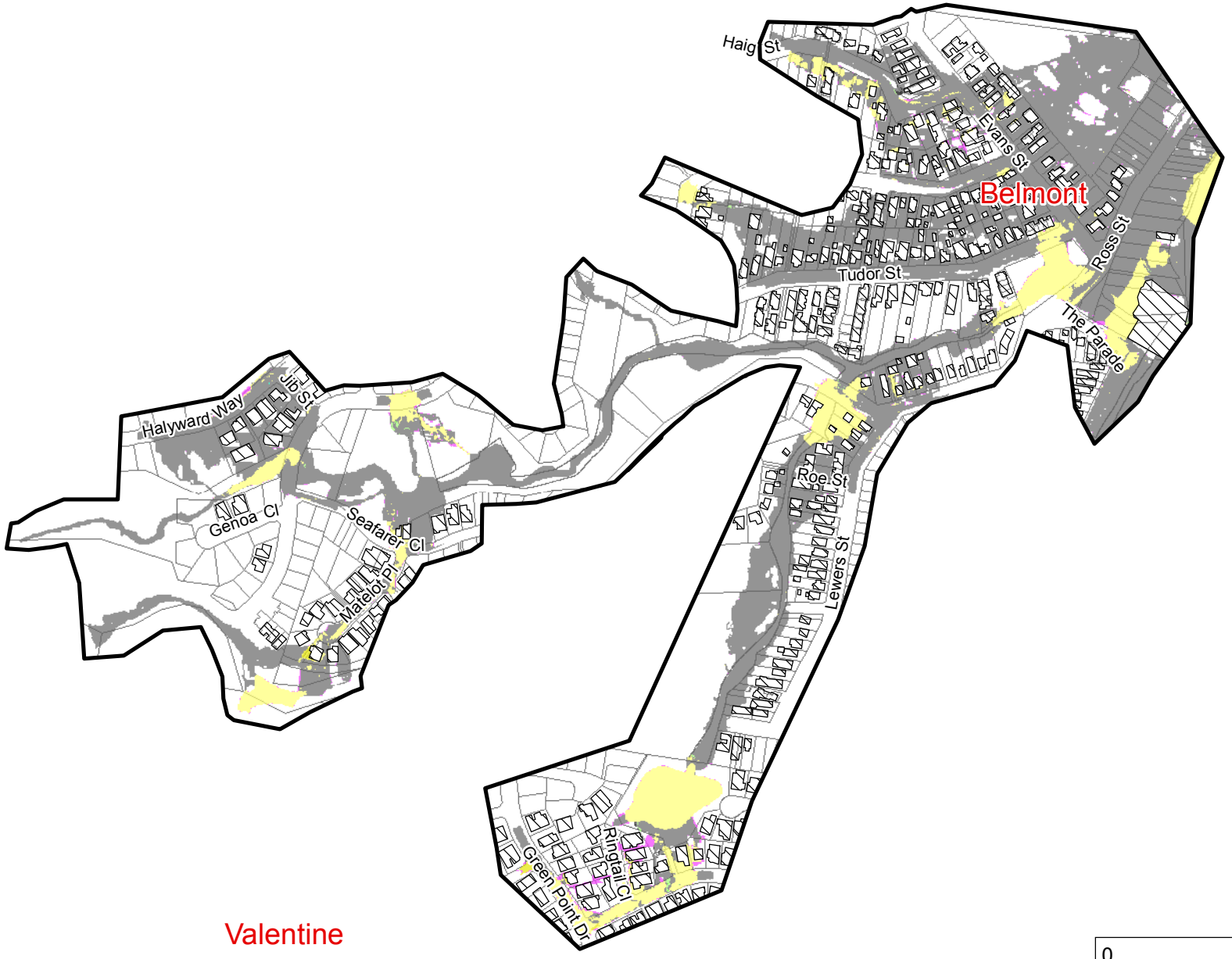
- < -0.4
- -0.4 to -0.3
- -0.3 to -0.2
- -0.2 to -0.1
- -0.1 to -0.05
- -0.05 to -0.01
- -0.01 to 0.01
- 0.01 to 0.05
- 0.05 to 0.1
- 0.1 to 0.2
- 0.2 to 0.3
- 0.3 to 0.4
- > 0.4
- Newly Flooded
- No Longer Flooded

0 0.25 0.5 km

J:\Jobs\119076\ArcGIS\ArcMap\Working\Template\Appendix_F\FigureF36_Mills_Creek_Impact_CC_SLR09_1%AEP.mxd

FIGURE F38

# MILLS GULLY CREEK
# CHANGE IN PEAK FLOOD LEVEL
# 1% AEP EVENT - 75% BLOCKAGE




N

- Study Area
- Cadastre
- Buildings

**Impact (m)**

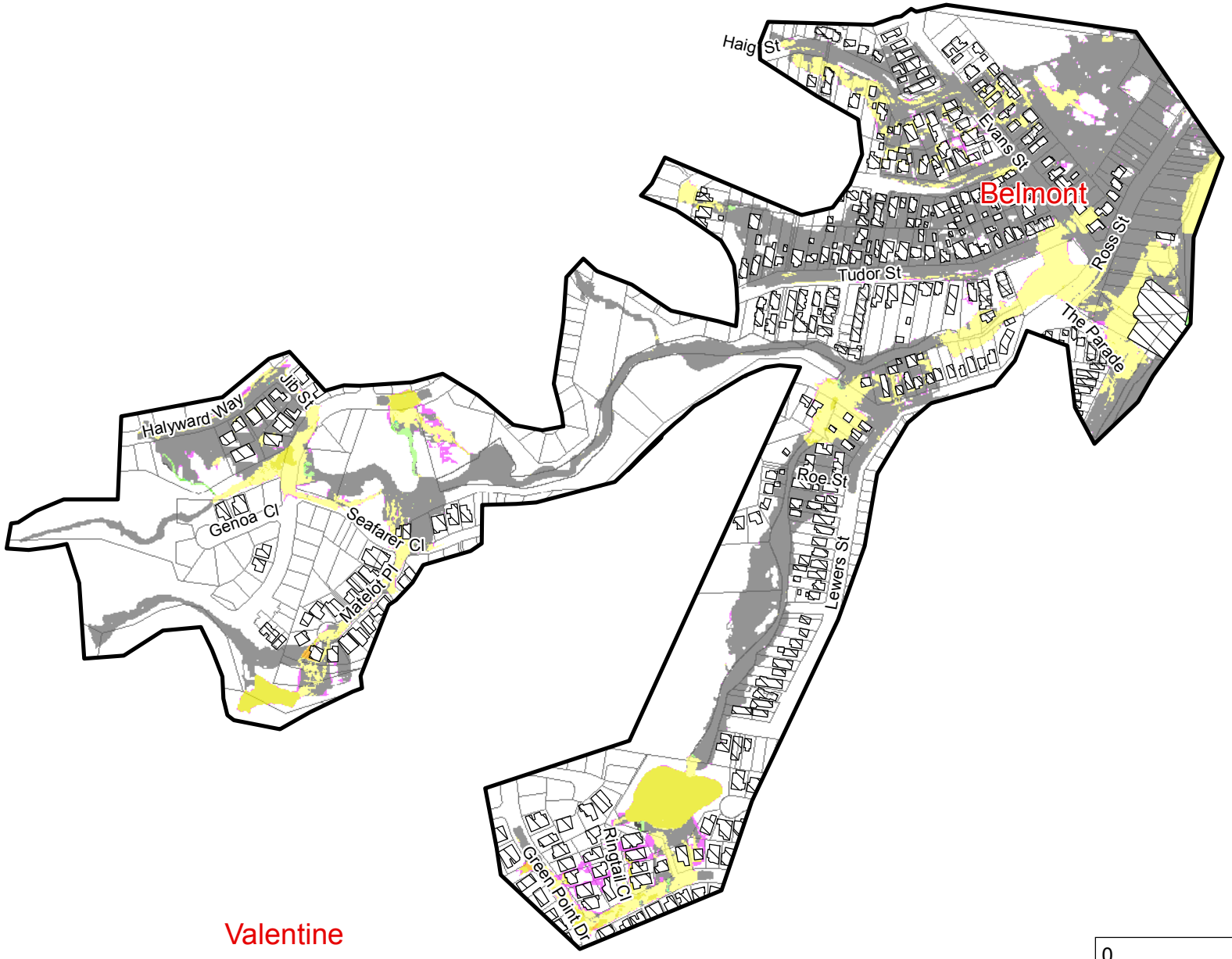
- < -0.4
- -0.4 to -0.3
- -0.3 to -0.2
- -0.2 to -0.1
- -0.1 to -0.05
- -0.05 to -0.01
- -0.01 to 0.01
- 0.01 to 0.05
- 0.05 to 0.1
- 0.1 to 0.2
- 0.2 to 0.3
- 0.3 to 0.4
- > 0.4
- Newly Flooded
- No Longer Flooded

0 0.25 0.5 km

J:\Jobs\119076\ArcGIS\ArcMap\Working\Template\Appendix_F\FigureF37_Mills_Creek_Impact_1%AEP_Blockage25pc.mxd

FIGURE F39

# MILLS GULLY CREEK
# CHANGE IN PEAK FLOOD LEVEL
# 1% AEP EVENT - 100% BLOCKAGE




N

Study Area
Cadastre
Buildings

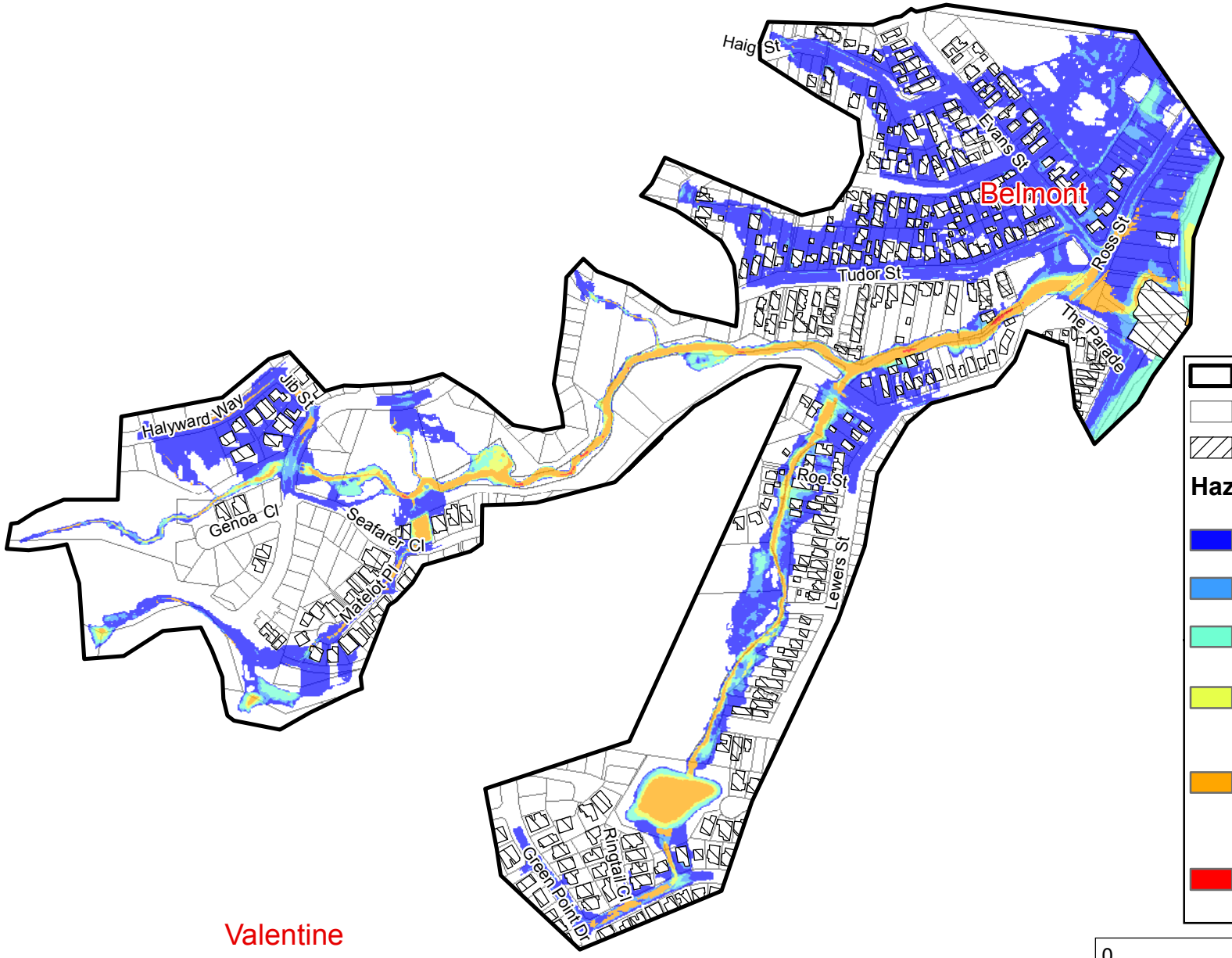
**Impact (m)**

- < -0.4
- -0.4 to -0.3
- -0.3 to -0.2
- -0.2 to -0.1
- -0.1 to -0.05
- -0.05 to -0.01
- -0.01 to 0.01
- 0.01 to 0.05
- 0.05 to 0.1
- 0.1 to 0.2
- 0.2 to 0.3
- 0.3 to 0.4
- > 0.4
- Newly Flooded
- No Longer Flooded

0 0.25 0.5 km

J:\Jobs\119076\ArcGIS\ArcMap\Working\Template\Appendix_F\FigureF38_Mills_Creek_Impact_1%AEP_Blockage75pc.mxd

FIGURE F40
**MILLS GULLY CREEK**
**HYDRAULIC HAZARD**
**1% AEP EVENT - SEA LEVEL RISE 0.4M**




N

Study Area
Cadastre
Buildings

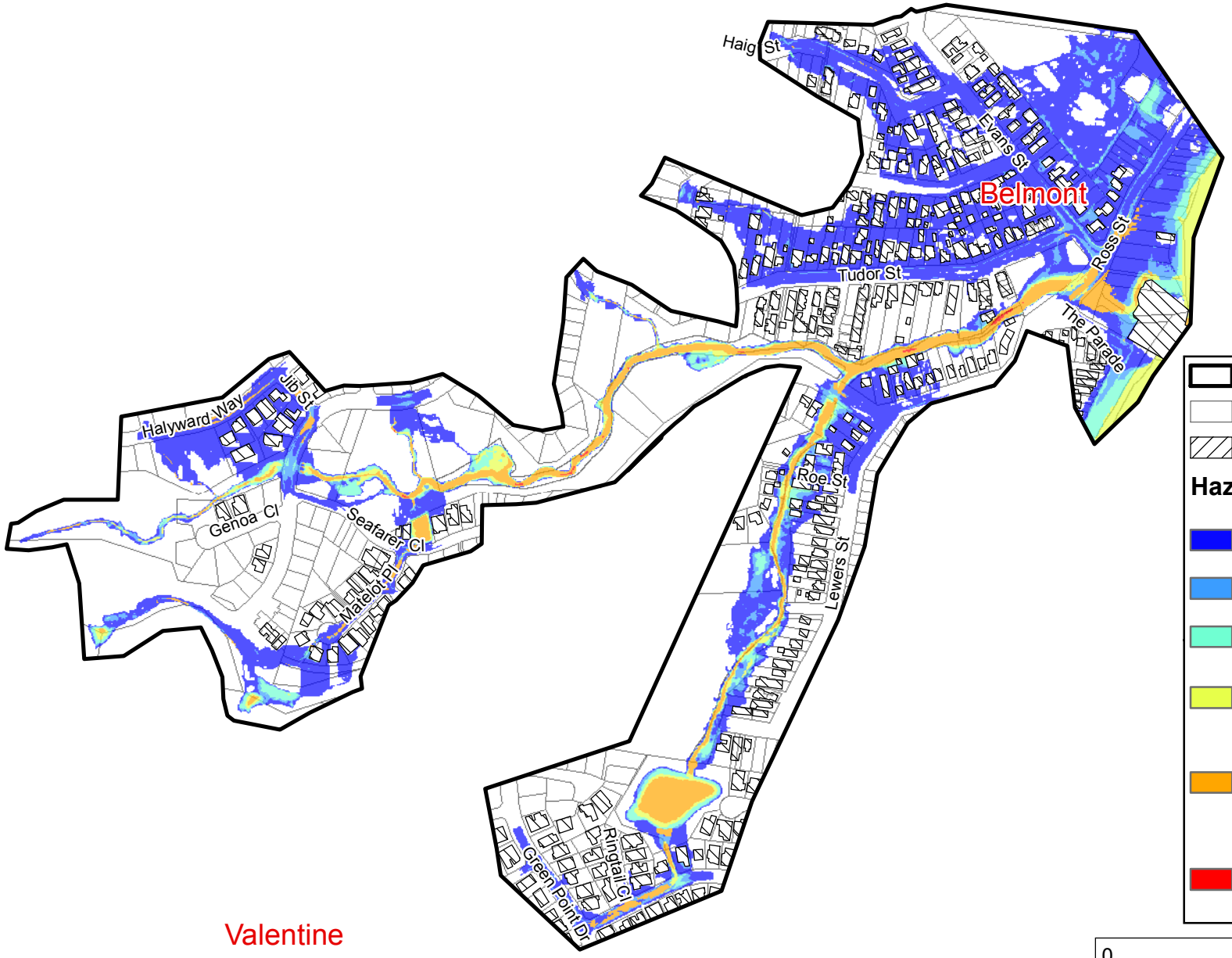
**Hazard**

- H1- Generally safe for people, vehicles and buildings
- H2- Unsafe for small vehicles
- H3- Unsafe for vehicles, children and the elderly
- H4- Unsafe for people and vehicles
- H5- Unsafe for people or vehicles. Buildings require special engineering design and construction
- H6- Unsafe for vehicles and people. All building types considered vulnerable to failure

0 0.25 0.5 km

J:\Jobs\119076\ArcGIS\ArcMap\Working\Template\Appendix_F\FigureF25_Mills_Creek_Provisional_Hazard_50%AEP.mxd

FIGURE F41
**MILLS GULLY CREEK**
**HYDRAULIC HAZARD**
**1% AEP EVENT - SEA LEVEL RISE 0.9M**




N

Study Area
Cadastre
Buildings

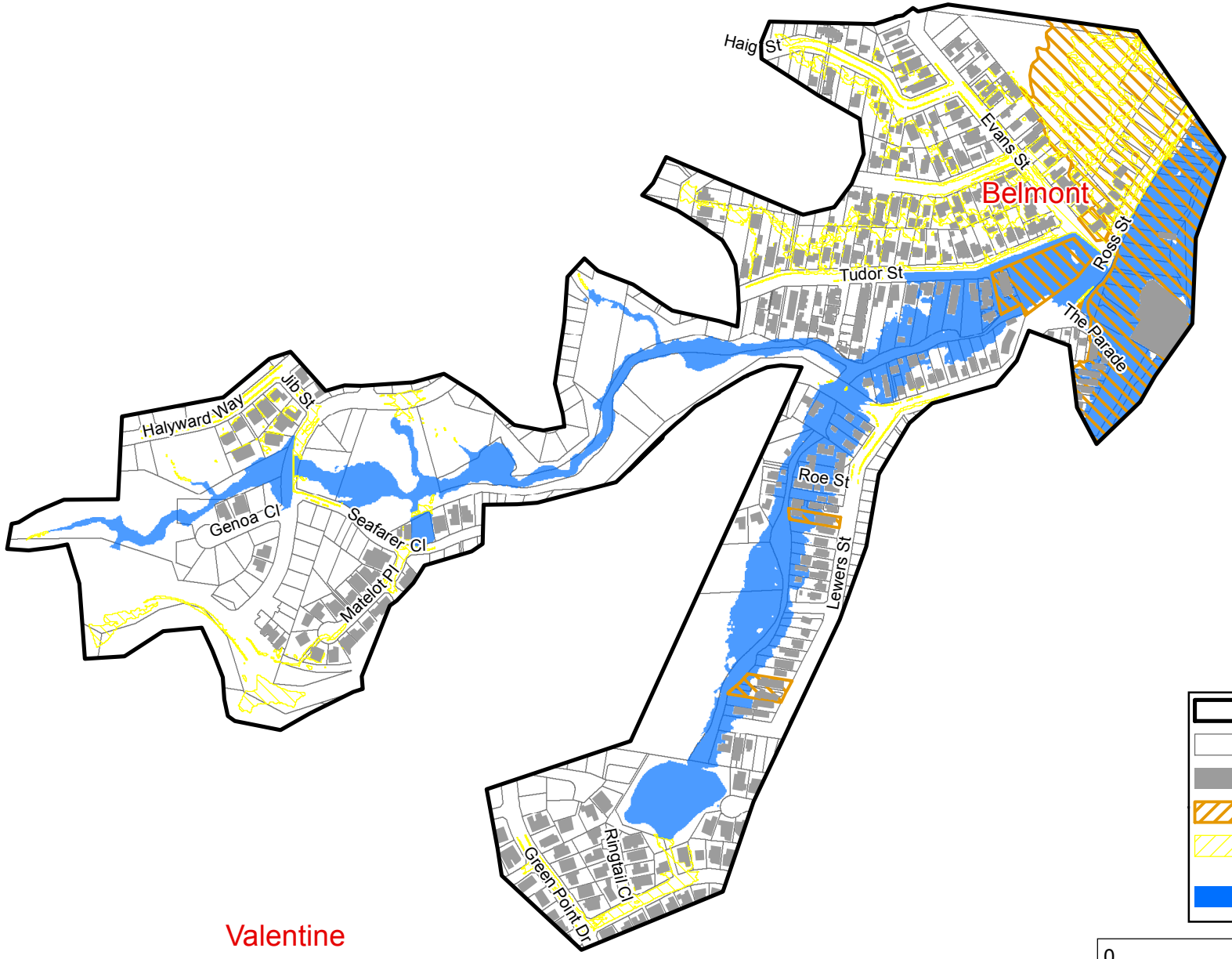
**Hazard**

- H1- Generally safe for people, vehicles and buildings
- H2- Unsafe for small vehicles
- H3- Unsafe for vehicles, children and the elderly
- H4- Unsafe for people and vehicles
- H5- Unsafe for people or vehicles. Buildings require special engineering design and construction
- H6- Unsafe for vehicles and people. All building types considered vulnerable to failure

0 0.25 0.5 km

J:\Jobs\119076\ArcGIS\ArcMap\Working\Template\Appendix_F\FigureF40_Mills_Creek_Provisional_Hazard_1%AEP_SLR04.mxd

FIGURE F42
**MILLS GULLY CREEK**
**FLOOD PLANNING AREA**

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**APPENDIX G: DESIGN FLOOD MAPS – PUNTEI CREEK**

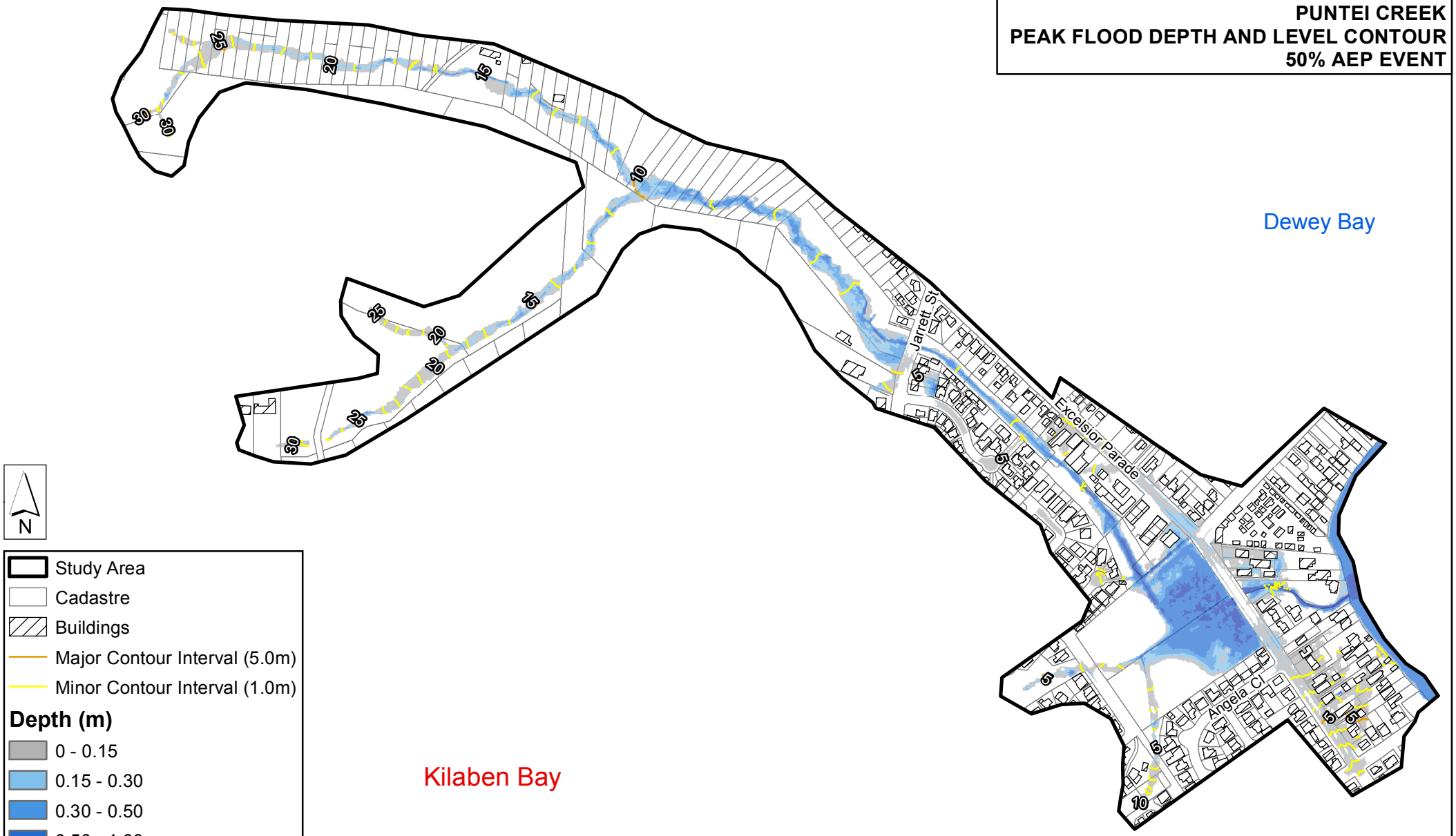
Appendix G

FIGURE G1

**PUNTEI CREEK**

**PEAK FLOOD DEPTH AND LEVEL CONTOUR**

**50% AEP EVENT**



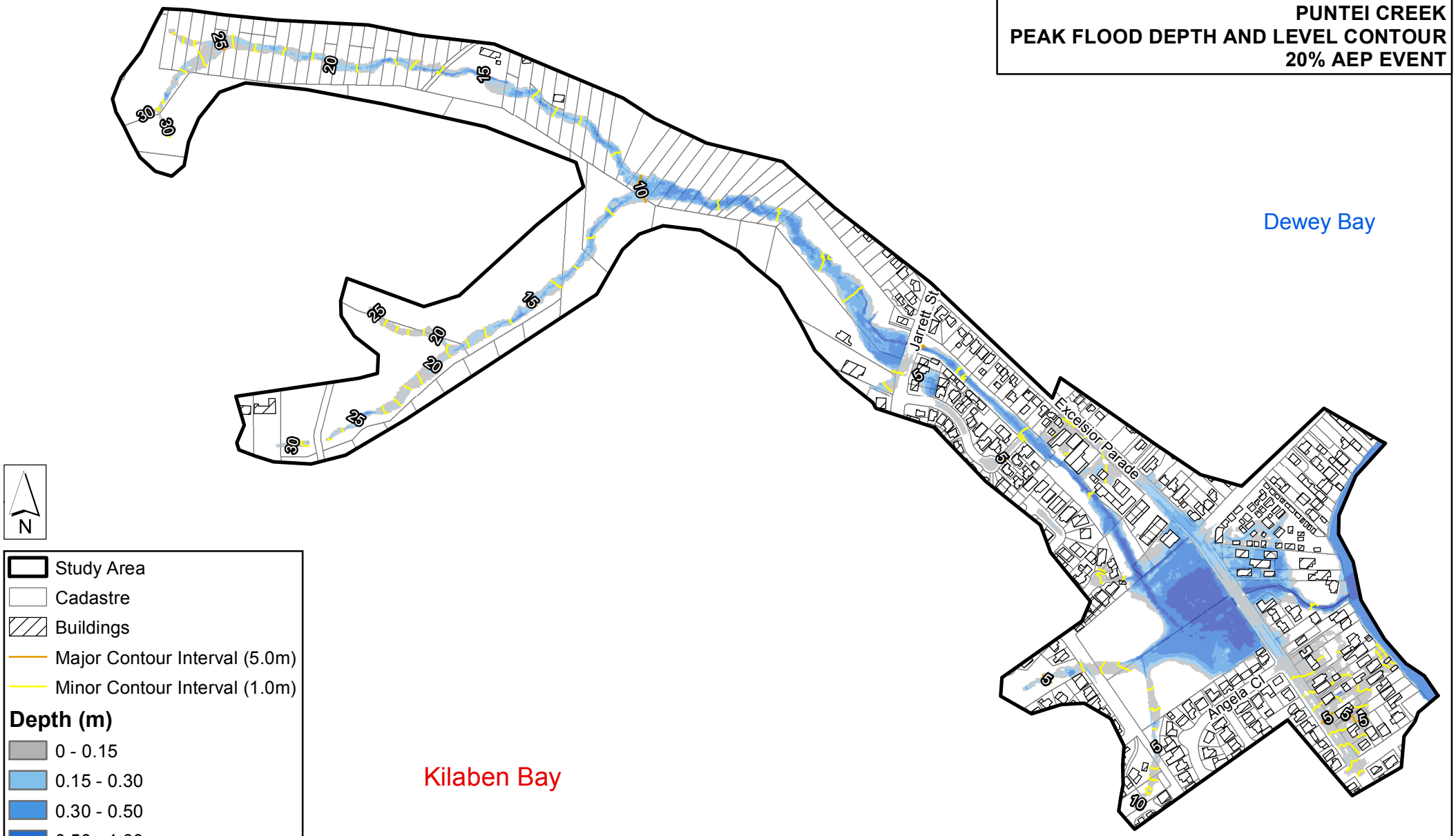

J:\Jobs\1190776\ArcGIS\ArcMap\Working\Template\Appendix_G\FigureG01_Puntei_Creek_Peak_Flood_Depth_50%AEP.mxd

FIGURE G2

**PUNTEI CREEK**

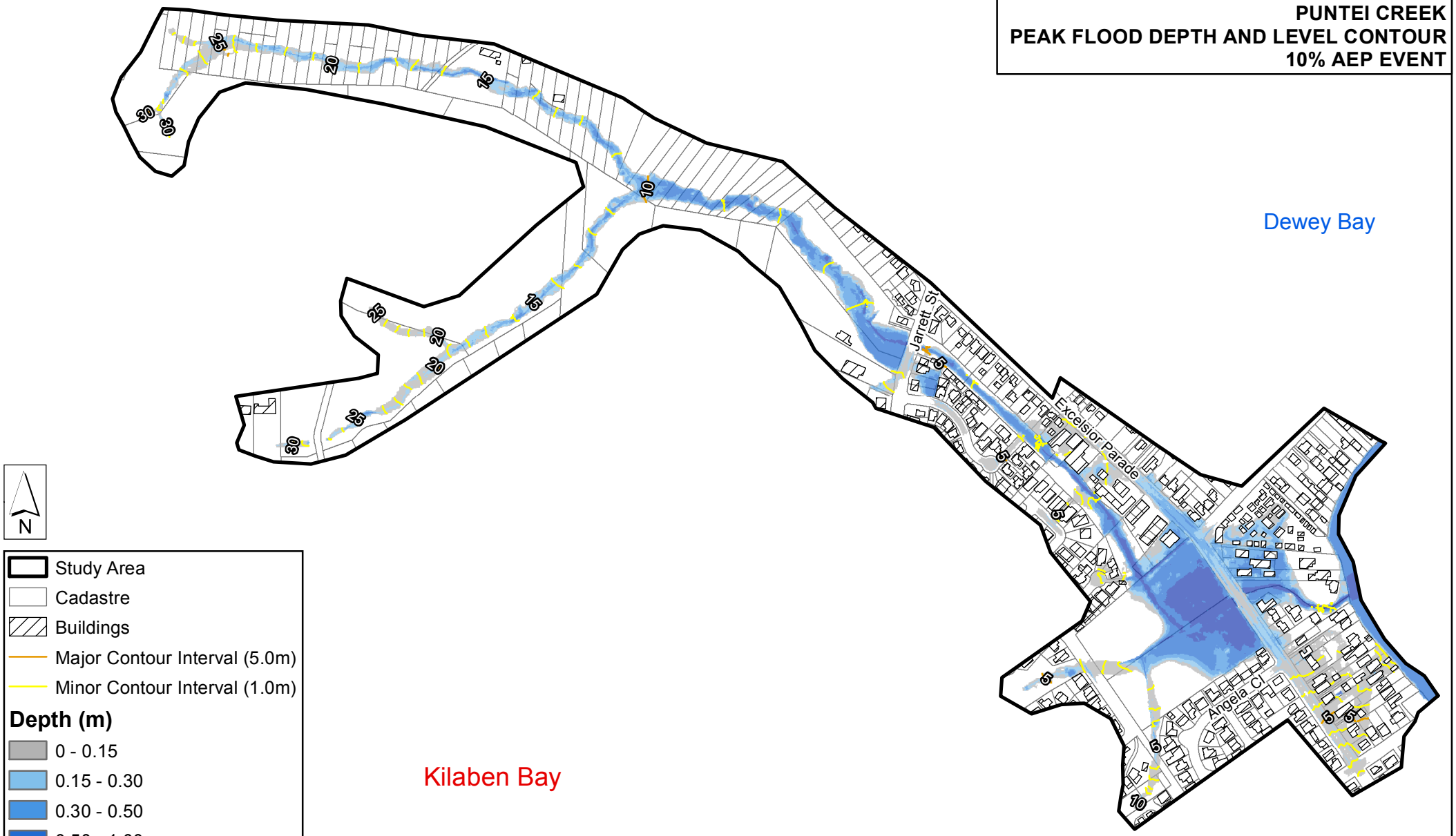
**PEAK FLOOD DEPTH AND LEVEL CONTOUR**

**20% AEP EVENT**




J:\Jobs\1190776\ArcGIS\ArcMap\Working\Template\Appendix_G\FigureG02_Puntei_Creek_Peak_Flood_Depth_20%AEP.mxd

FIGURE G3
**PUNTEI CREEK**
**PEAK FLOOD DEPTH AND LEVEL CONTOUR**
**10% AEP EVENT**



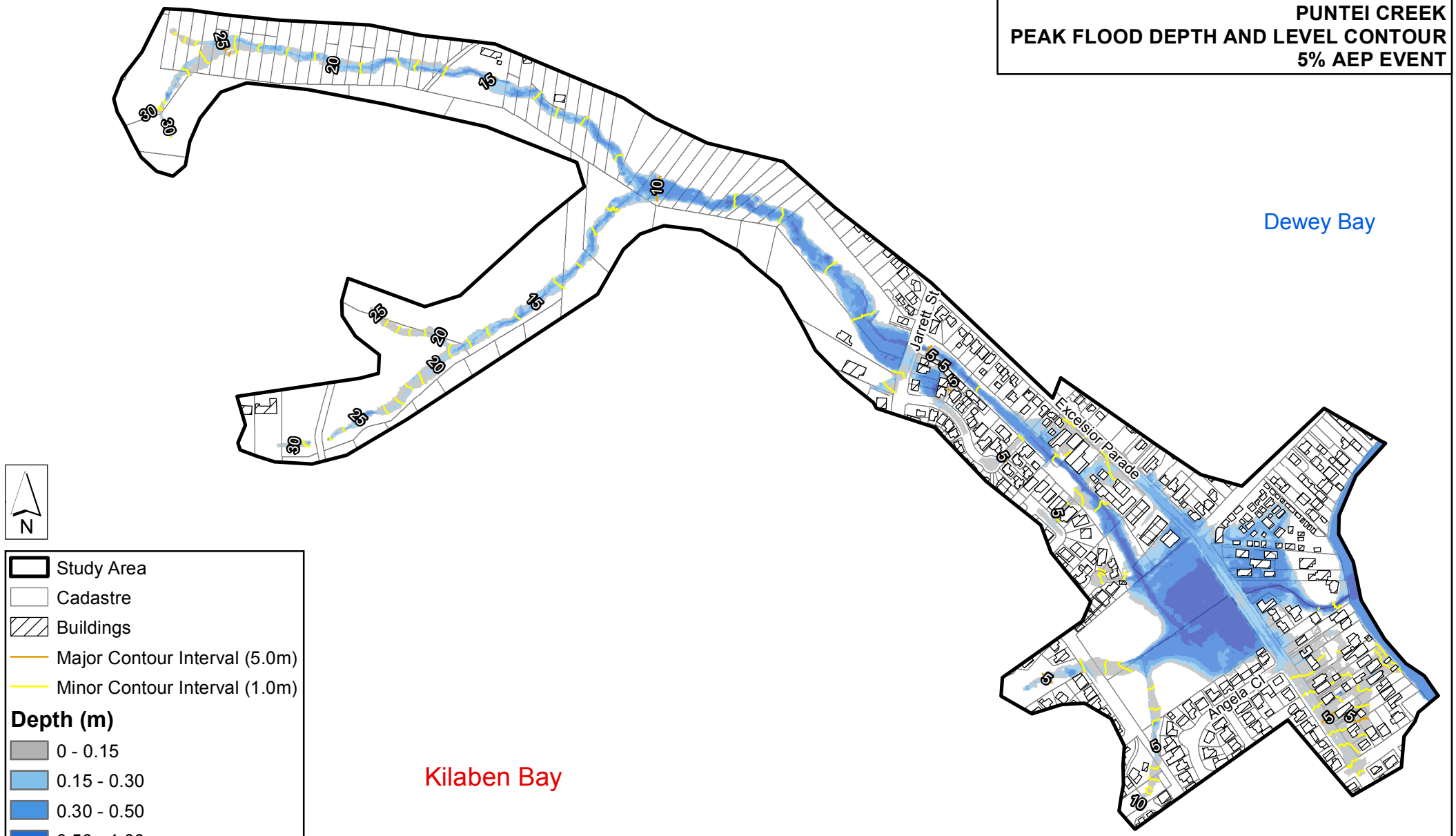

J:\Jobs\1190776\ArcGIS\ArcMap\Working\Template\Appendix_G\FigureG03_Puntei_Creek_Peak_Flood_Depth_10%AEP.mxd

FIGURE G4

**PUNTEI CREEK**

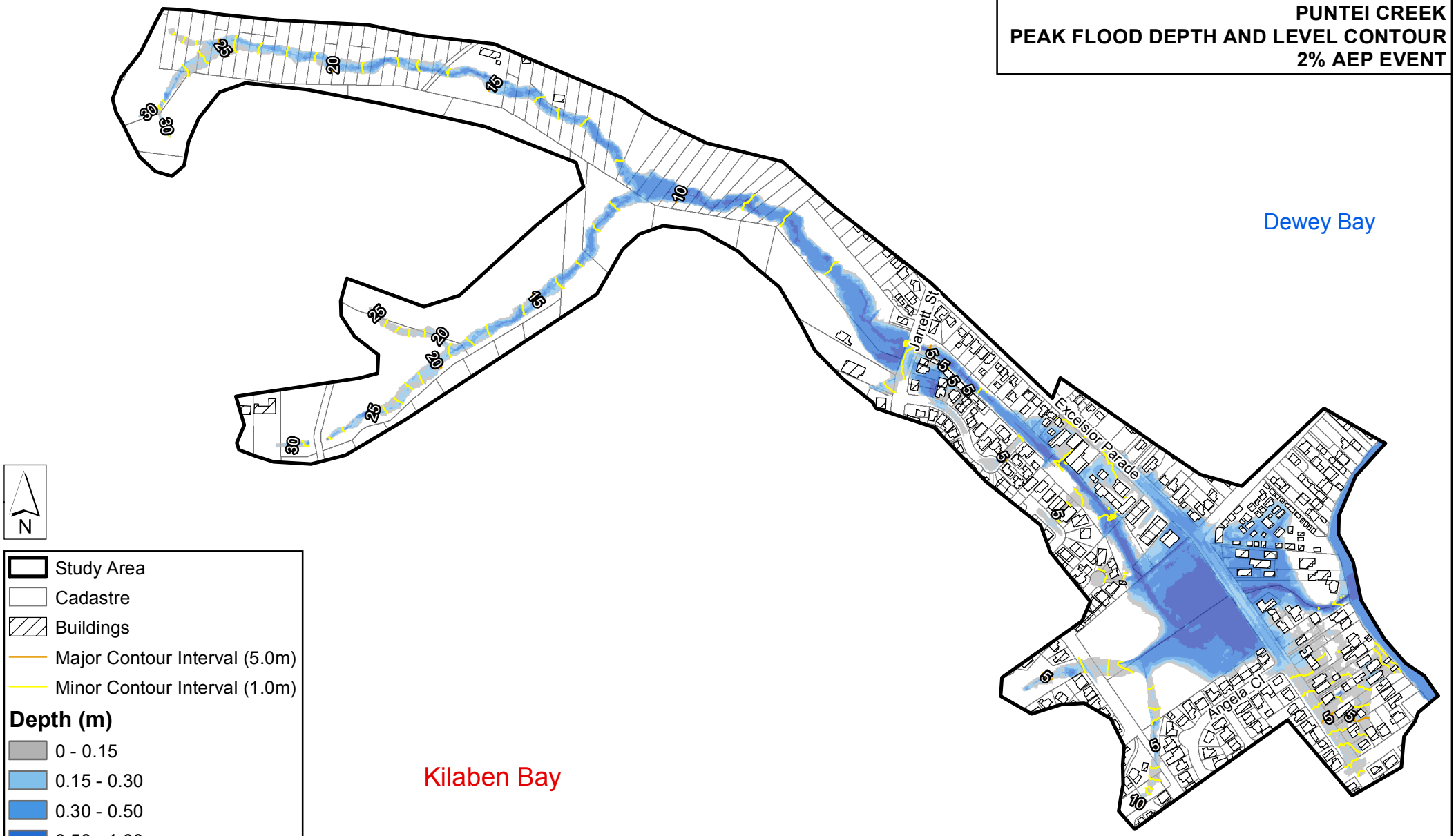
**PEAK FLOOD DEPTH AND LEVEL CONTOUR**

**5% AEP EVENT**




J:\Jobs\1190776\ArcGIS\ArcMap\Working\Template\Appendix_G\FigureG04_Puntei_Creek_Peak_Flood_Depth_5%AEP.mxd

FIGURE G5
**PUNTEI CREEK**
**PEAK FLOOD DEPTH AND LEVEL CONTOUR**
**2% AEP EVENT**



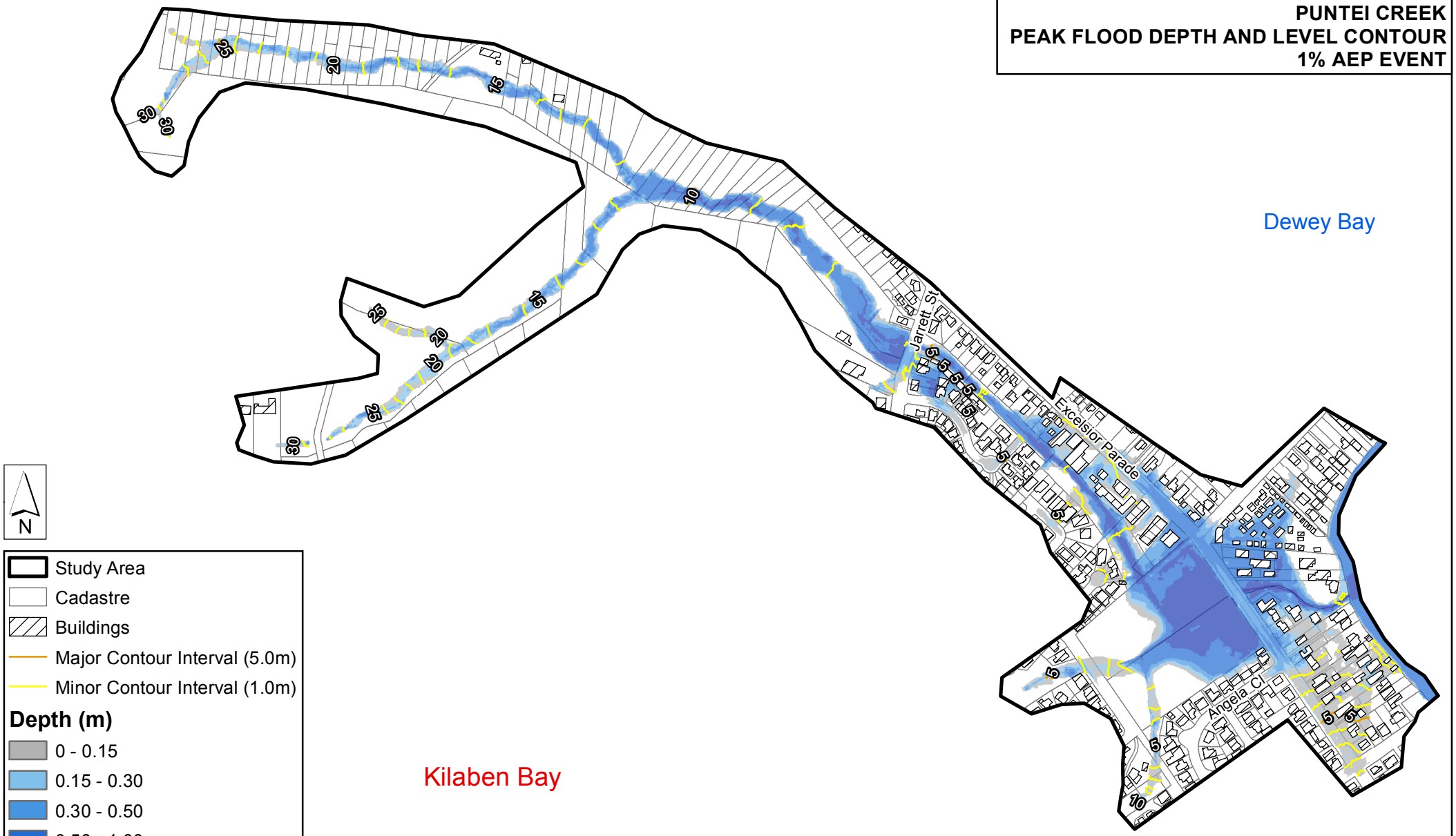

J:\Jobs\1190776\ArcGIS\ArcMap\Working\Template\Appendix_G\FigureG05_Puntei_Creek_Peak_Flood_Depth_2%AEP.mxd

FIGURE G6

**PUNTEI CREEK**

**PEAK FLOOD DEPTH AND LEVEL CONTOUR**

**1% AEP EVENT**



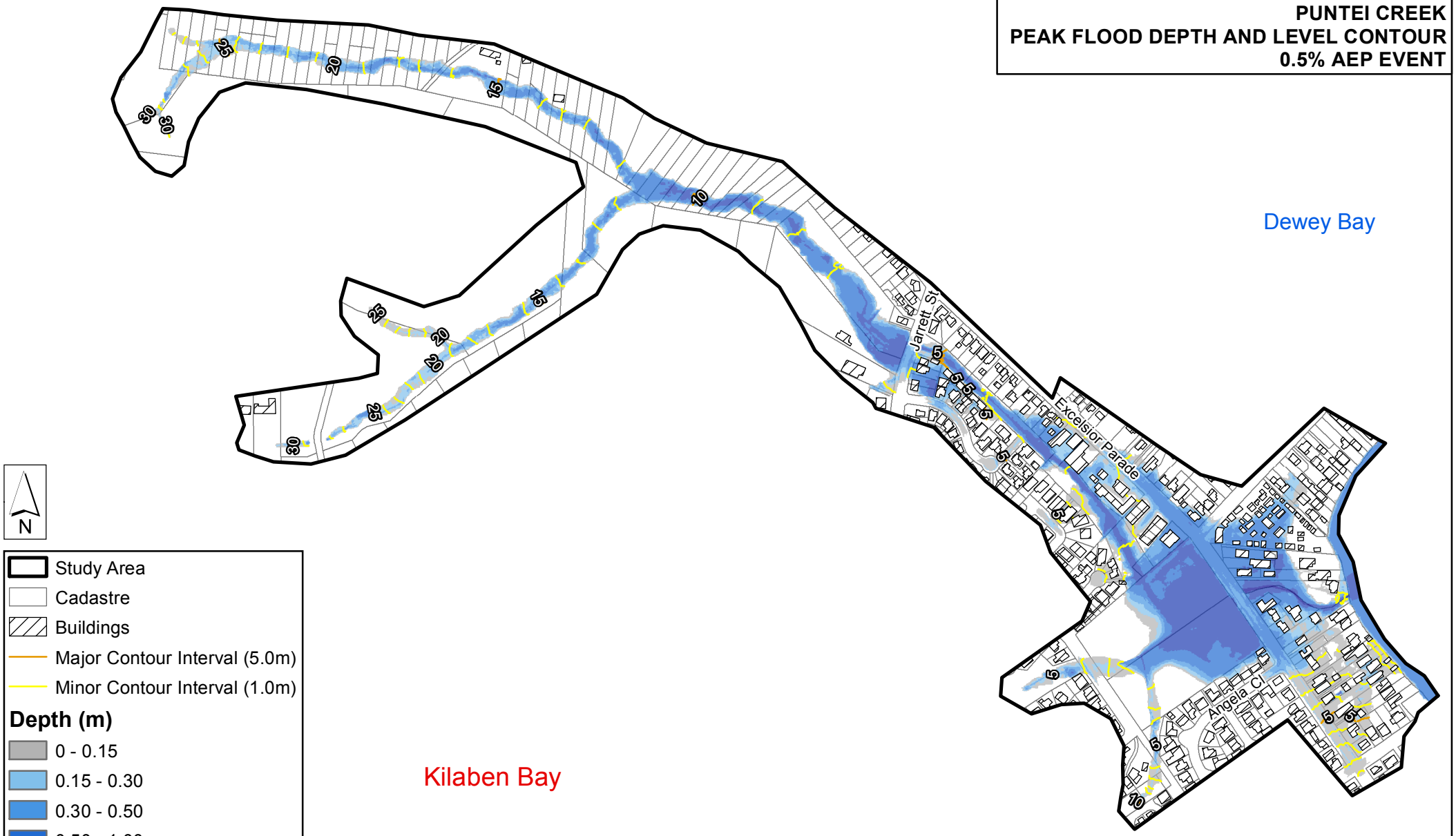

J:\Jobs\1190776\ArcGIS\ArcMap\Working\Template\Appendix_G\FigureG06_Puntei_Creek_Peak_Flood_Depth_1%AEP.mxd

FIGURE G7

**PUNTEI CREEK**

**PEAK FLOOD DEPTH AND LEVEL CONTOUR**

**0.5% AEP EVENT**



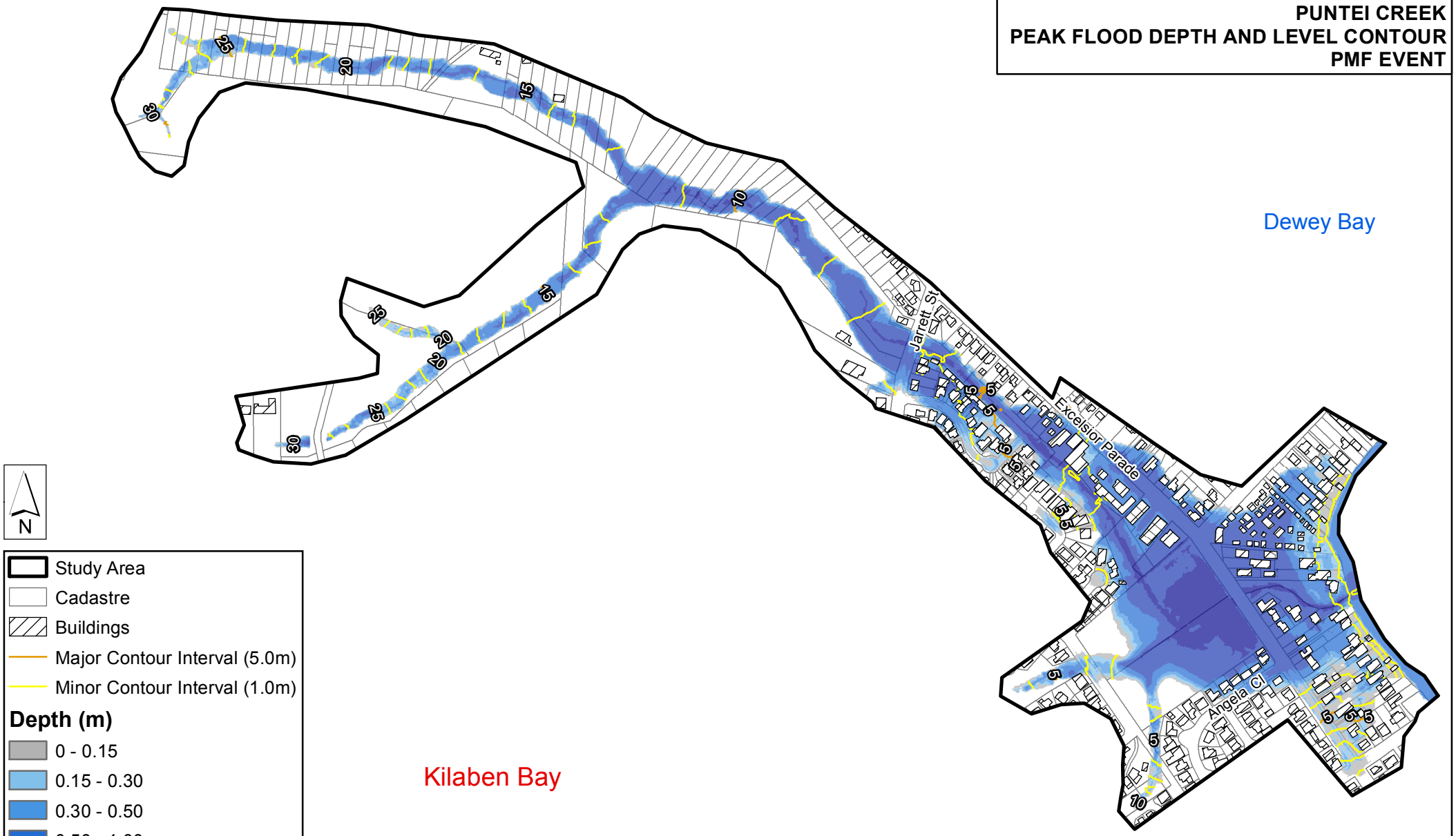

J:\Jobs\1190776\ArcGIS\ArcMap\Working\Template\Appendix_G\FigureG07_Puntei_Creek_Peak_Flood_Depth_0.5%AEP.mxd

FIGURE G8

**PUNTEI CREEK**

**PEAK FLOOD DEPTH AND LEVEL CONTOUR**

**PMF EVENT**




J:\Jobs\1190776\ArcGIS\ArcMap\Working\Template\Appendix_G\FigureG08_Puntei_Creek_Peak_Flood_Depth_PMF.mxd

FIGURE G9
**PUNTEI CREEK**
**PEAK FLOOD VELOCITY**
**50% AEP EVENT**

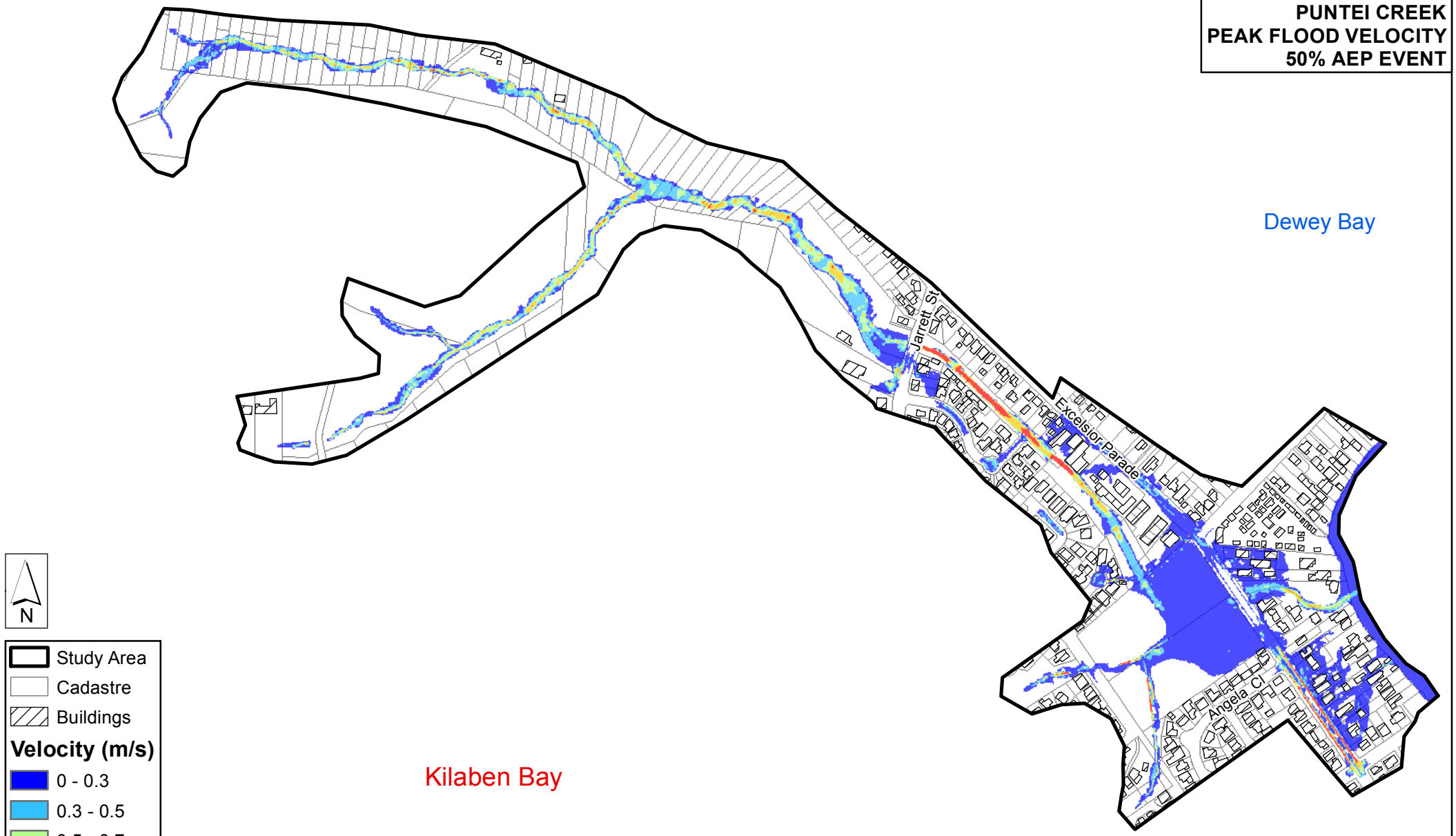



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FIGURE G10
**PUNTEI CREEK**
**PEAK FLOOD VELOCITY**
**20% AEP EVENT**

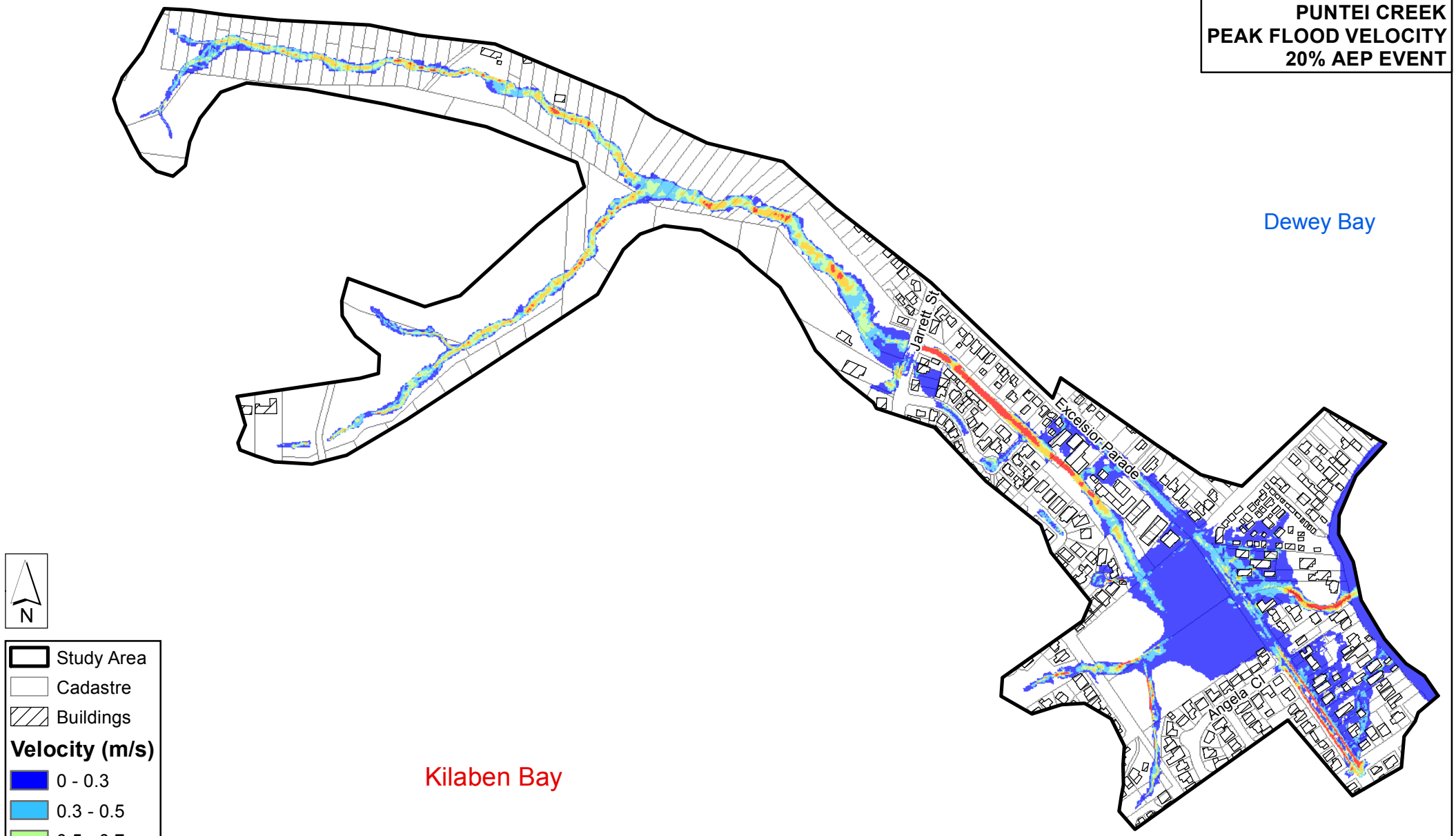


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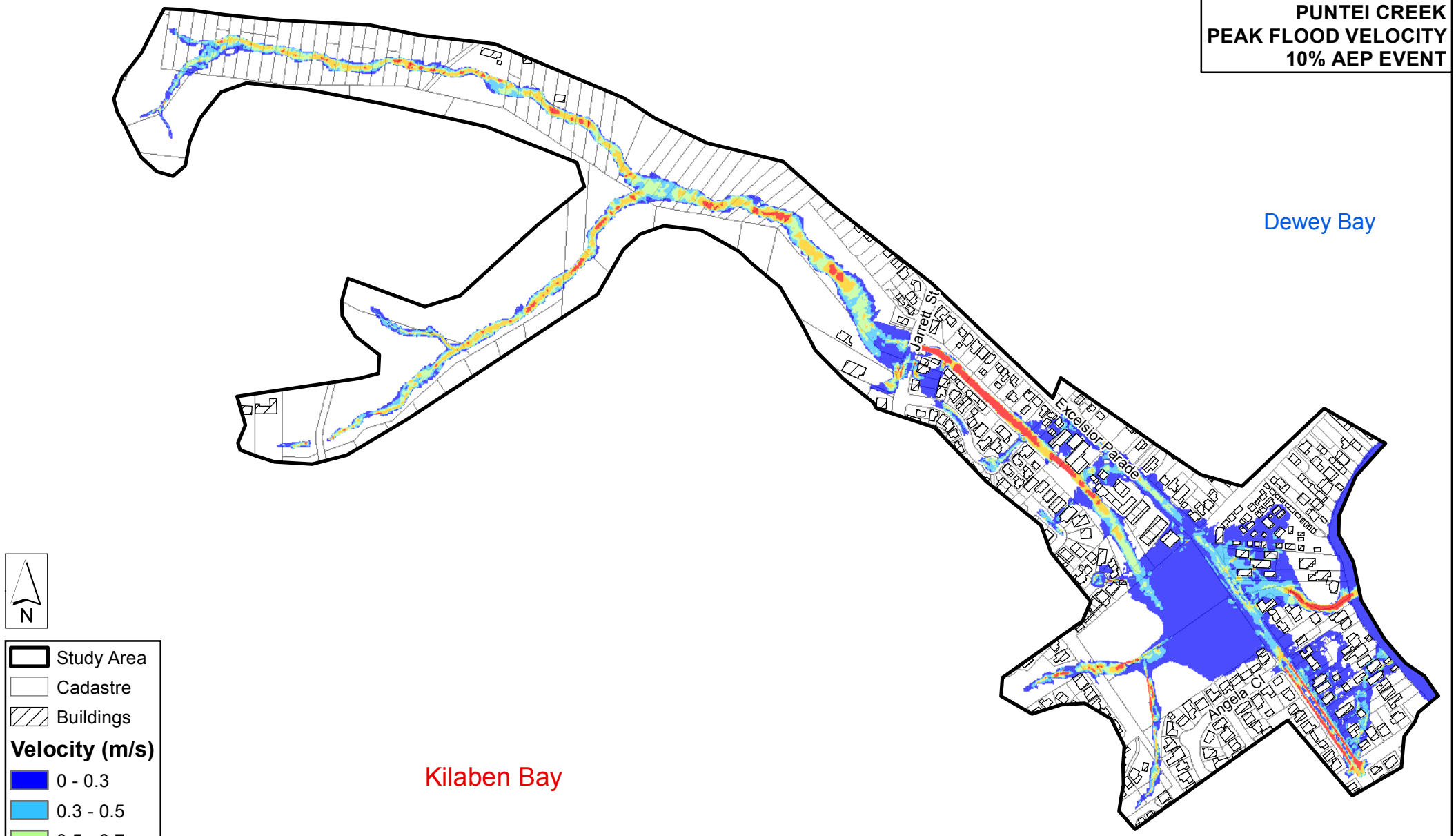
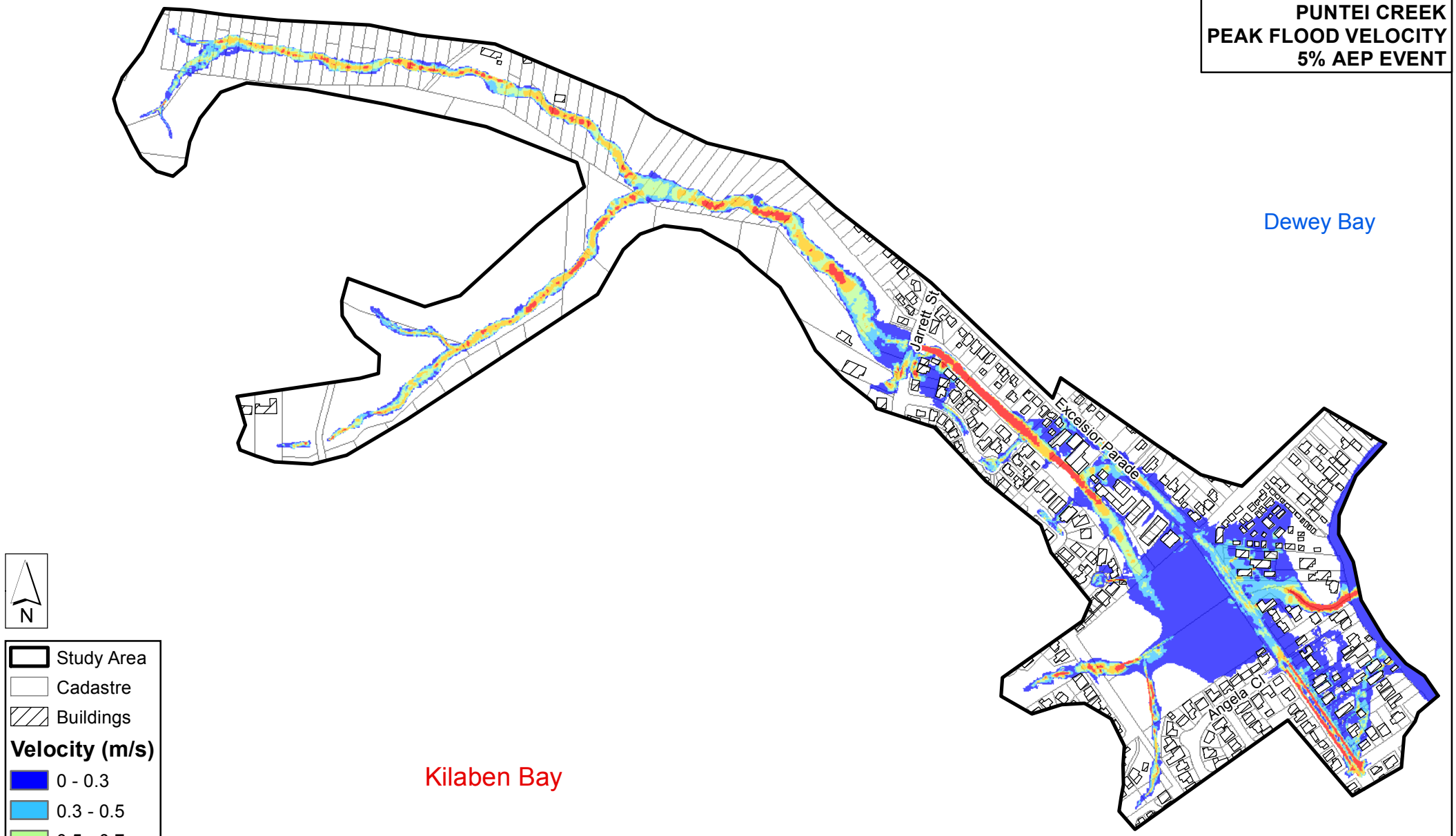
FIGURE G11
**PUNTEI CREEK**
**PEAK FLOOD VELOCITY**
**10% AEP EVENT**



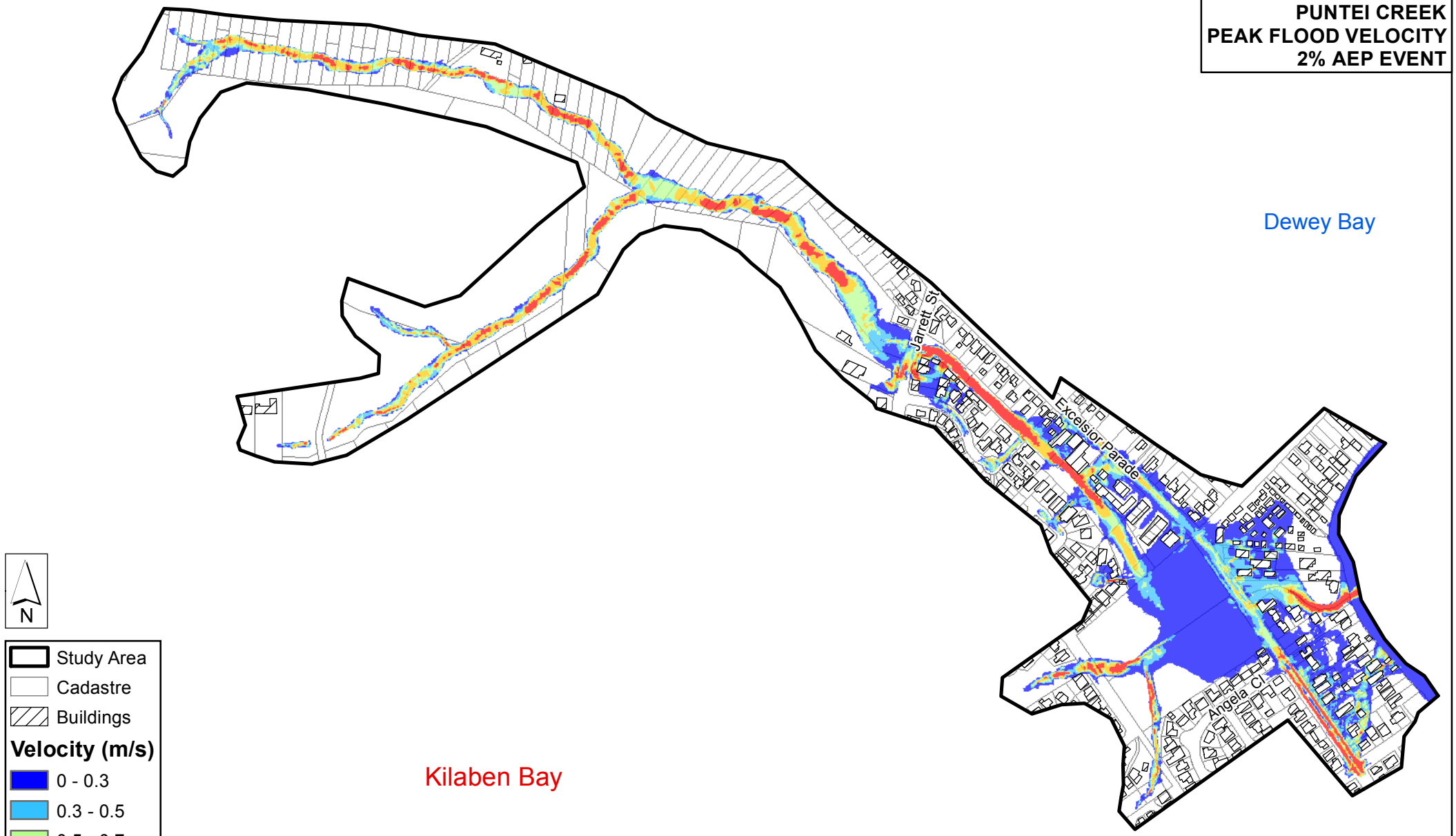

J:\Jobs\119076\ArcGIS\ArcMap\Working\Template\Appendix_F\FigureG10_Puntei_Creek_Peak_Flood_Velocity_20%AEP.mxd

FIGURE G12
**PUNTEI CREEK**
**PEAK FLOOD VELOCITY**
**5% AEP EVENT**




J:\Jobs\119076\ArcGIS\ArcMap\Working\Template\Appendix_F\FigureG11_Puntei_Creek_Peak_Flood_Velocity_10%AEP.mxd

FIGURE G13
**PUNTEI CREEK**
**PEAK FLOOD VELOCITY**
**2% AEP EVENT**




J:\Jobs\119076\ArcGIS\ArcMap\Working\Template\Appendix_F\FigureG12_Puntei_Creek_Peak_Flood_Velocity_5%AEP.mxd

FIGURE G14
**PUNTEI CREEK**
**PEAK FLOOD VELOCITY**
**1% AEP EVENT**

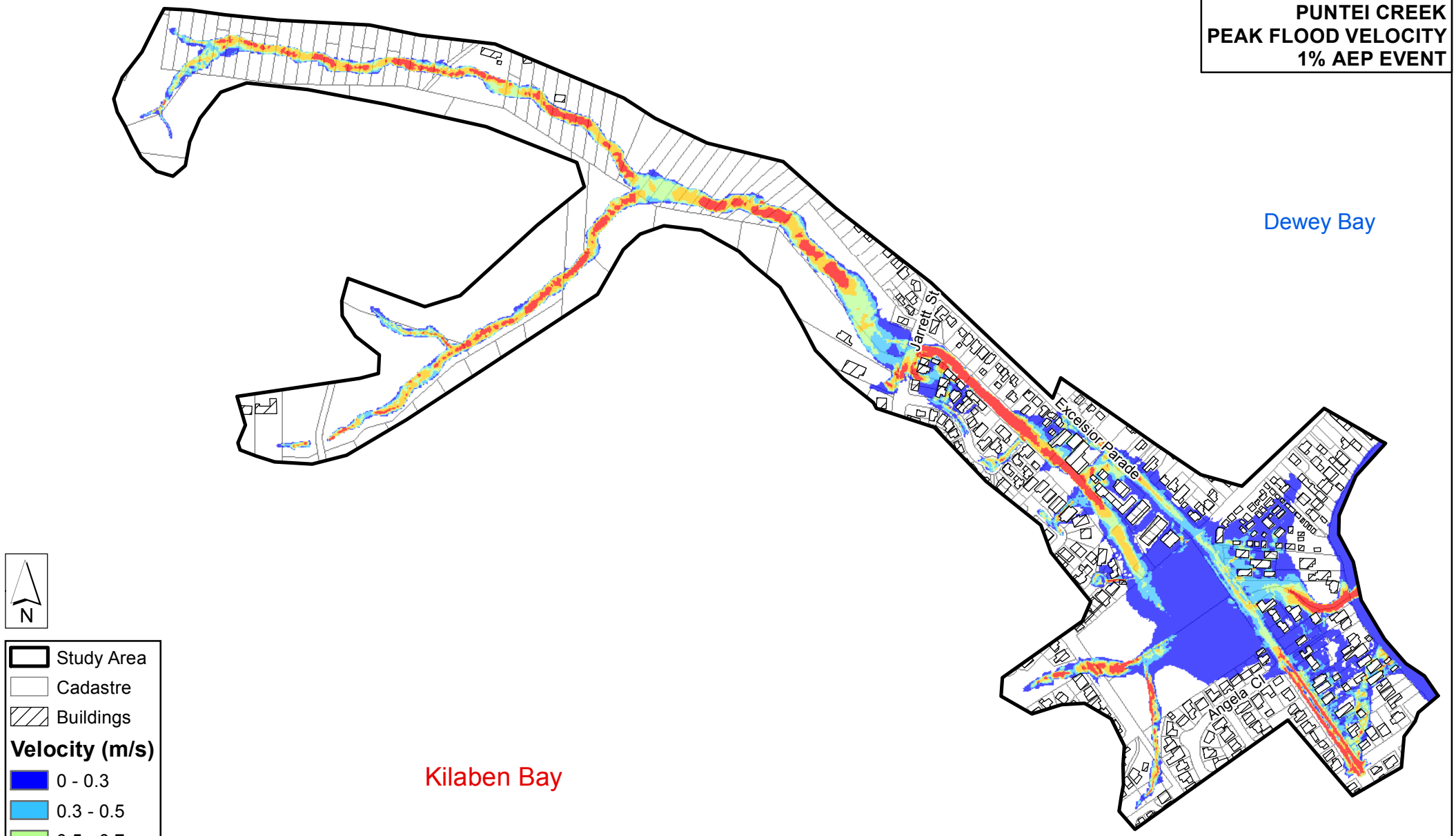



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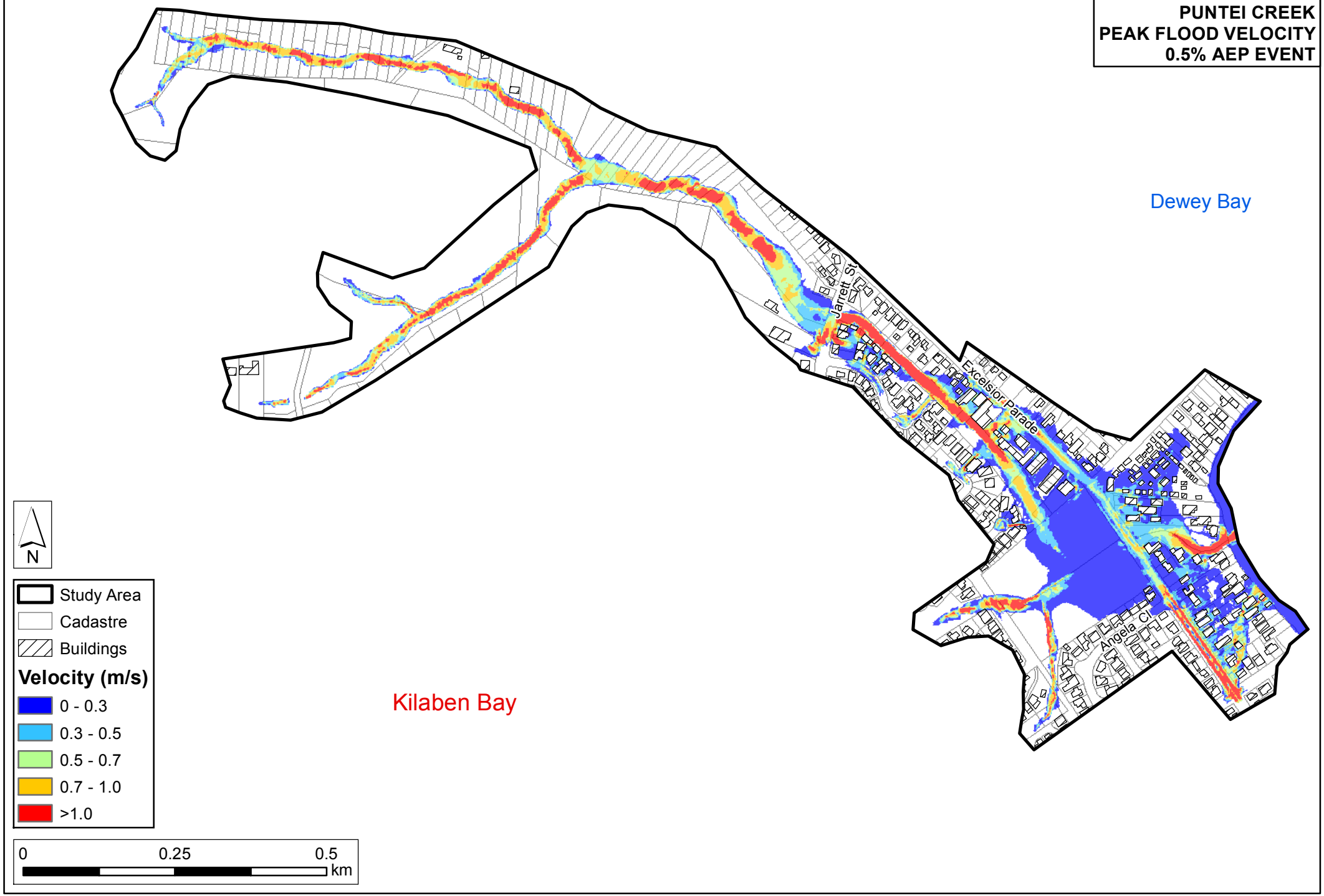
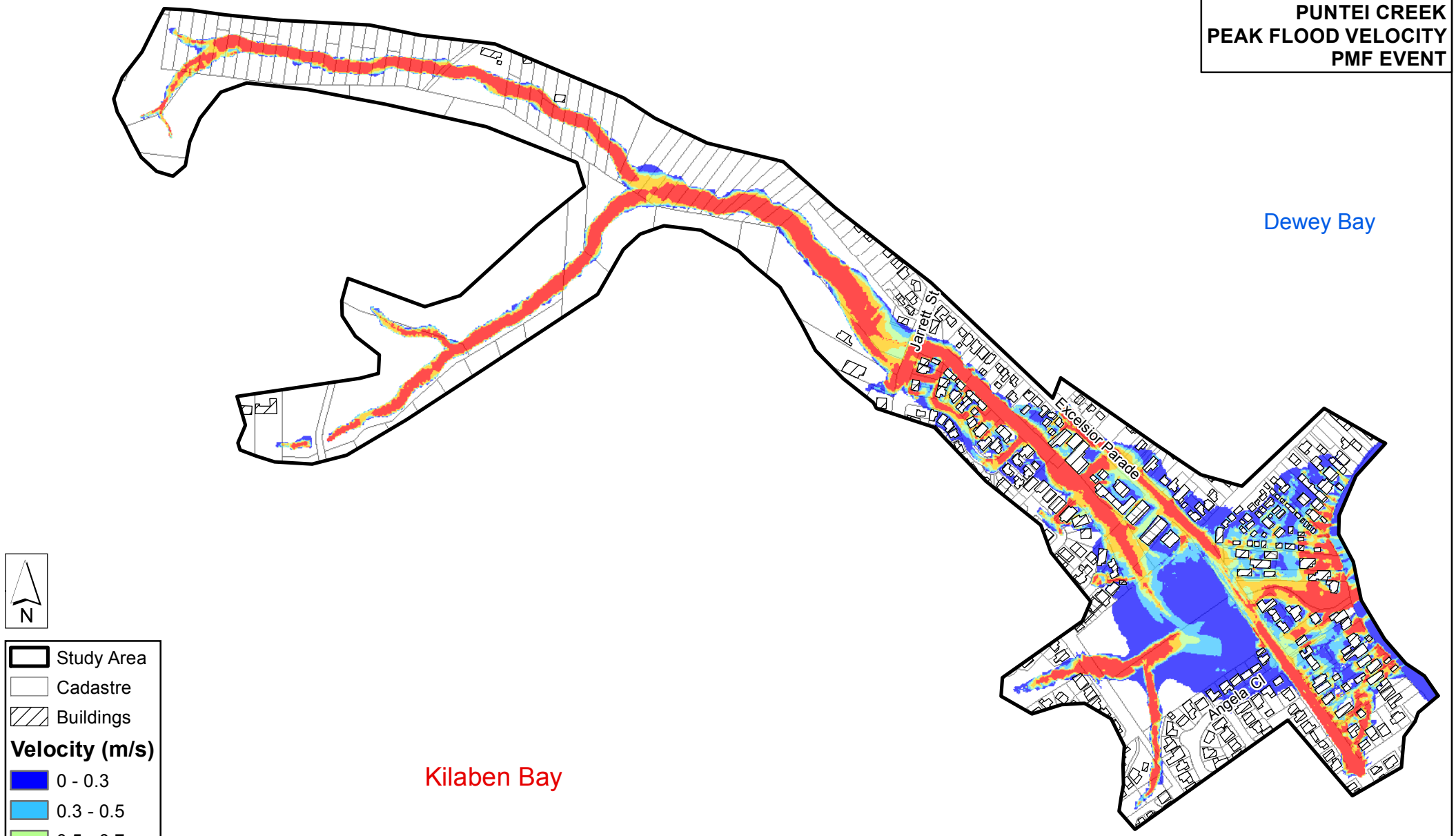
FIGURE G15
**PUNTEI CREEK**
**PEAK FLOOD VELOCITY**
**0.5% AEP EVENT**



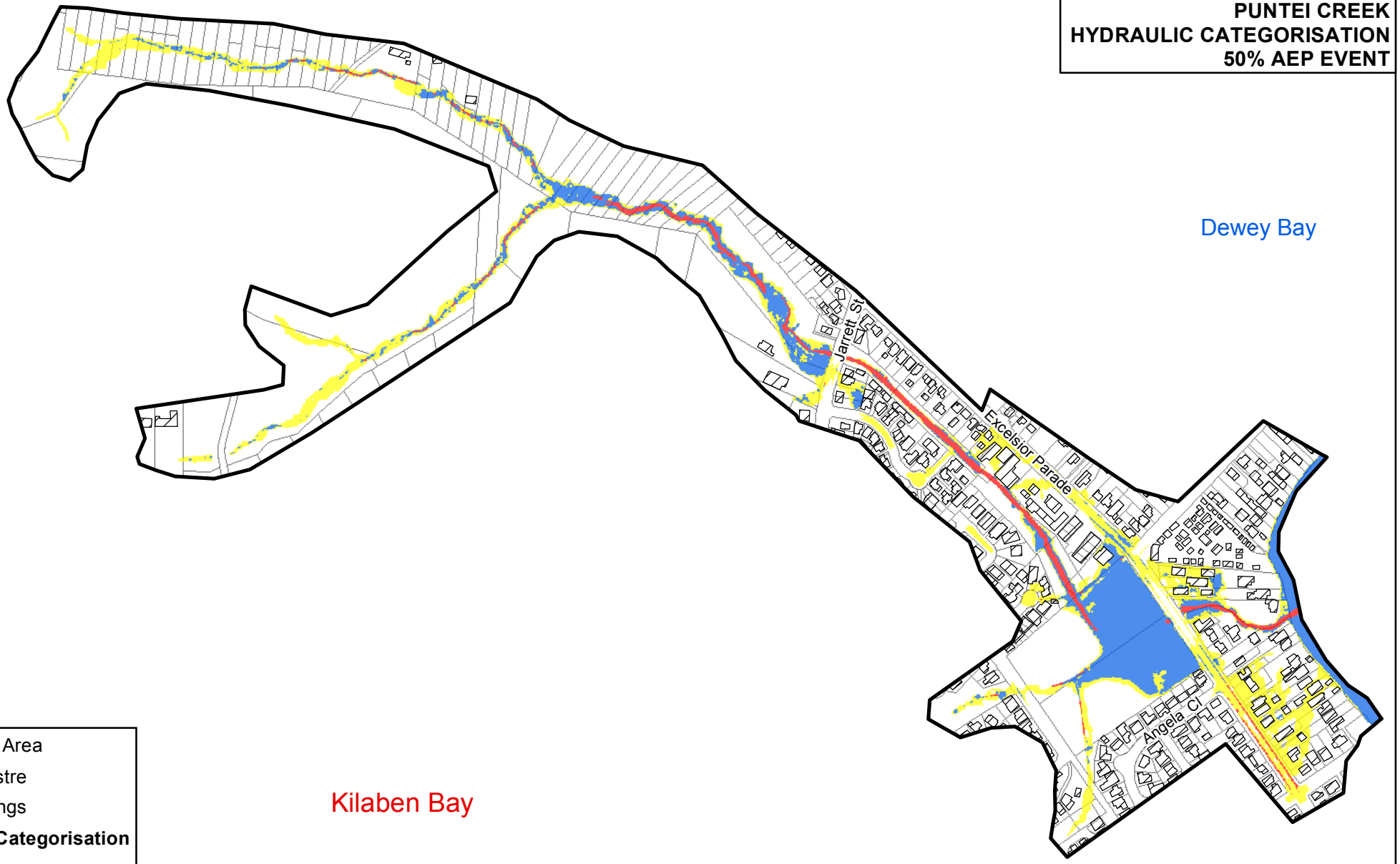

J:\Jobs\119076\ArcGIS\ArcMap\Working\Template\Appendix_F\FigureG14_Puntei_Creek_Peak_Flood_Velocity_1%AEP.mxd

FIGURE G16
**PUNTEI CREEK**
**PEAK FLOOD VELOCITY**
**PMF EVENT**



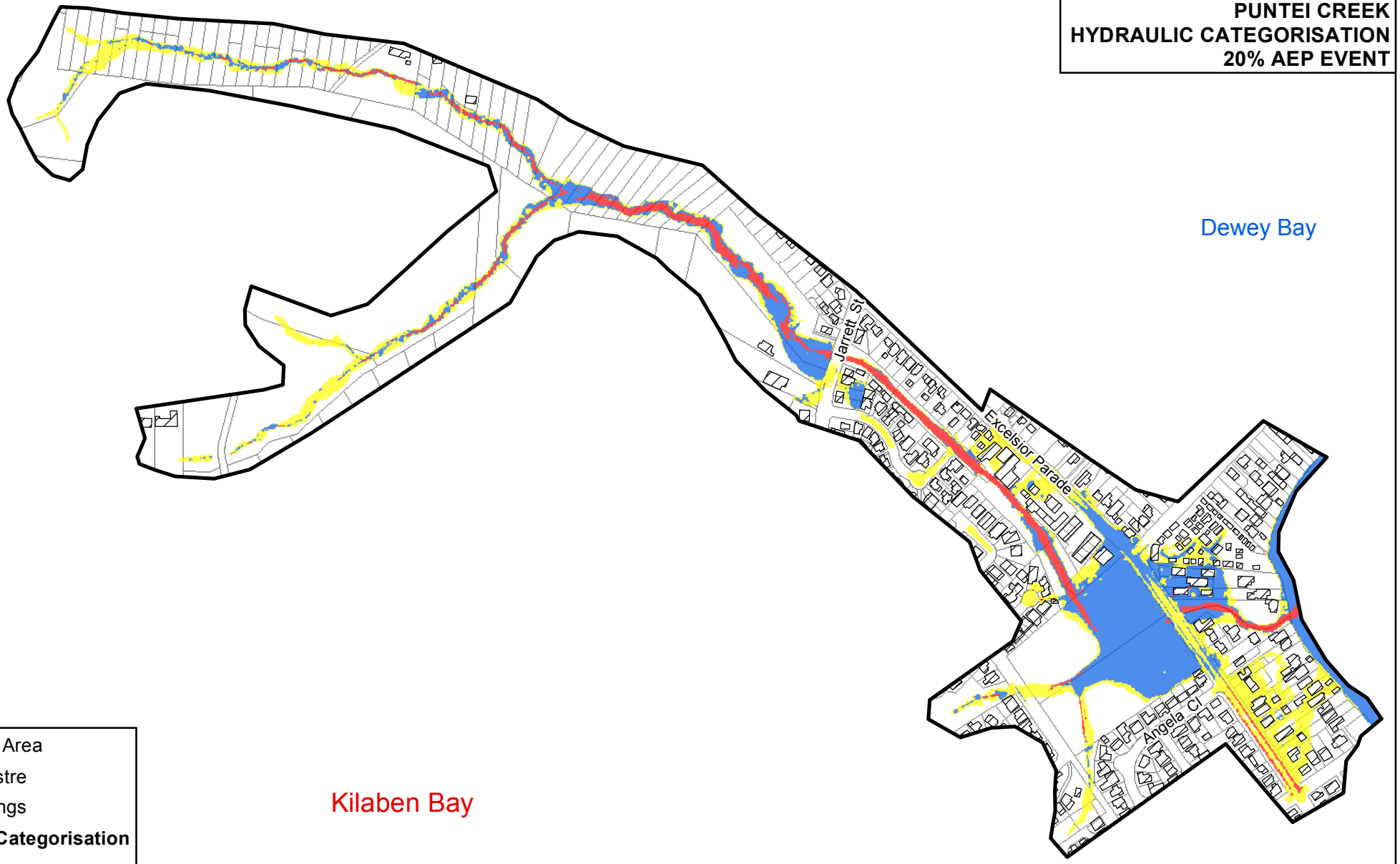

J:\Jobs\1190776\ArcGIS\ArcMap\Working\Template\Appendix_F\FigureG15_Puntei_Creek_Peak_Flood_Velocity_0.5%AEP.mxd

FIGURE G17
**PUNTEI CREEK**
**HYDRAULIC CATEGORISATION**
**50% AEP EVENT**



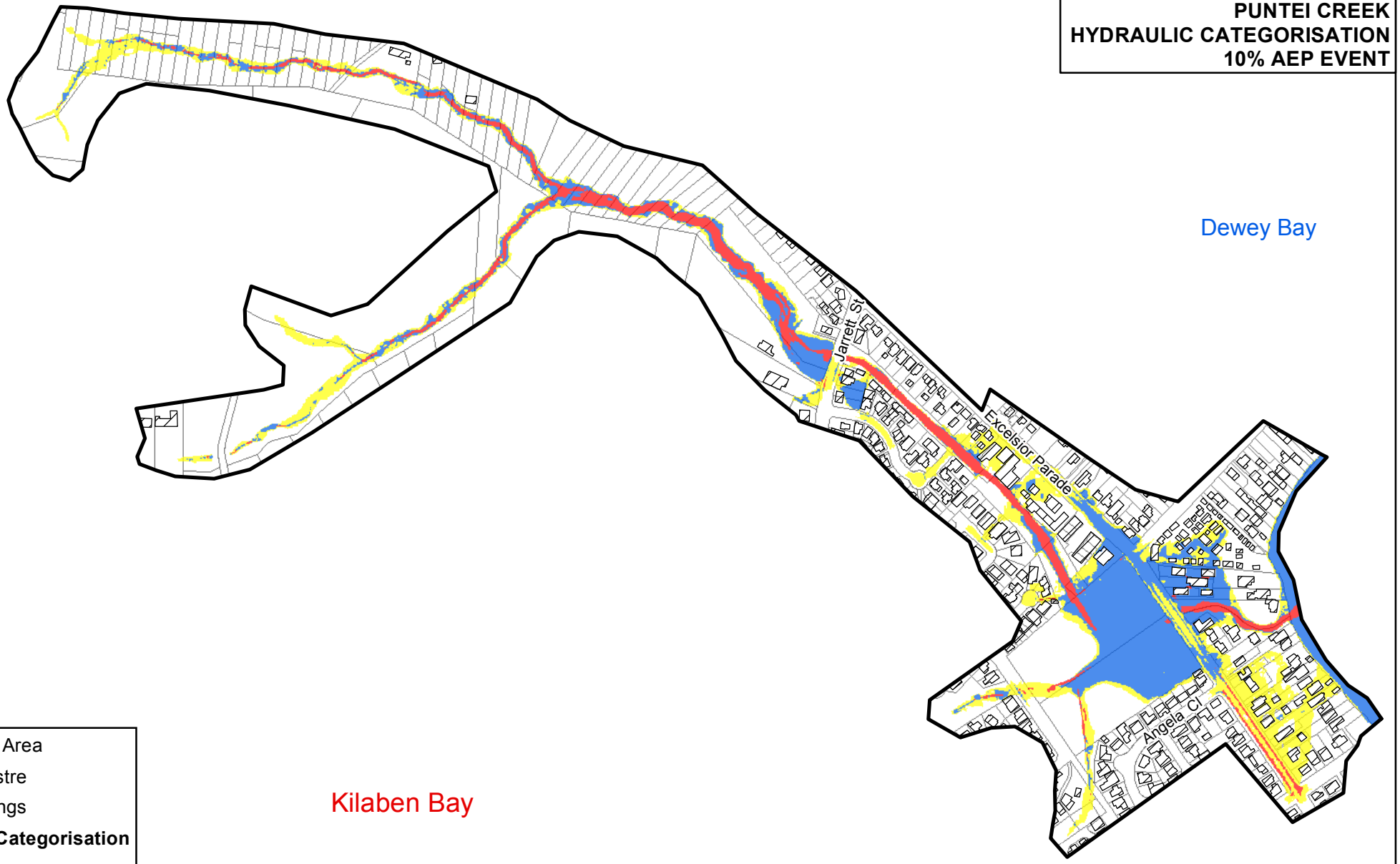

J:\Jobs\119076\ArcGIS\ArcMap\Working\Template\Appendix_F\FigureG16_Puntei_Creek_Peak_Flood_Velocity_PMF.mxd

FIGURE G18
**PUNTEI CREEK**
**HYDRAULIC CATEGORISATION**
**20% AEP EVENT**



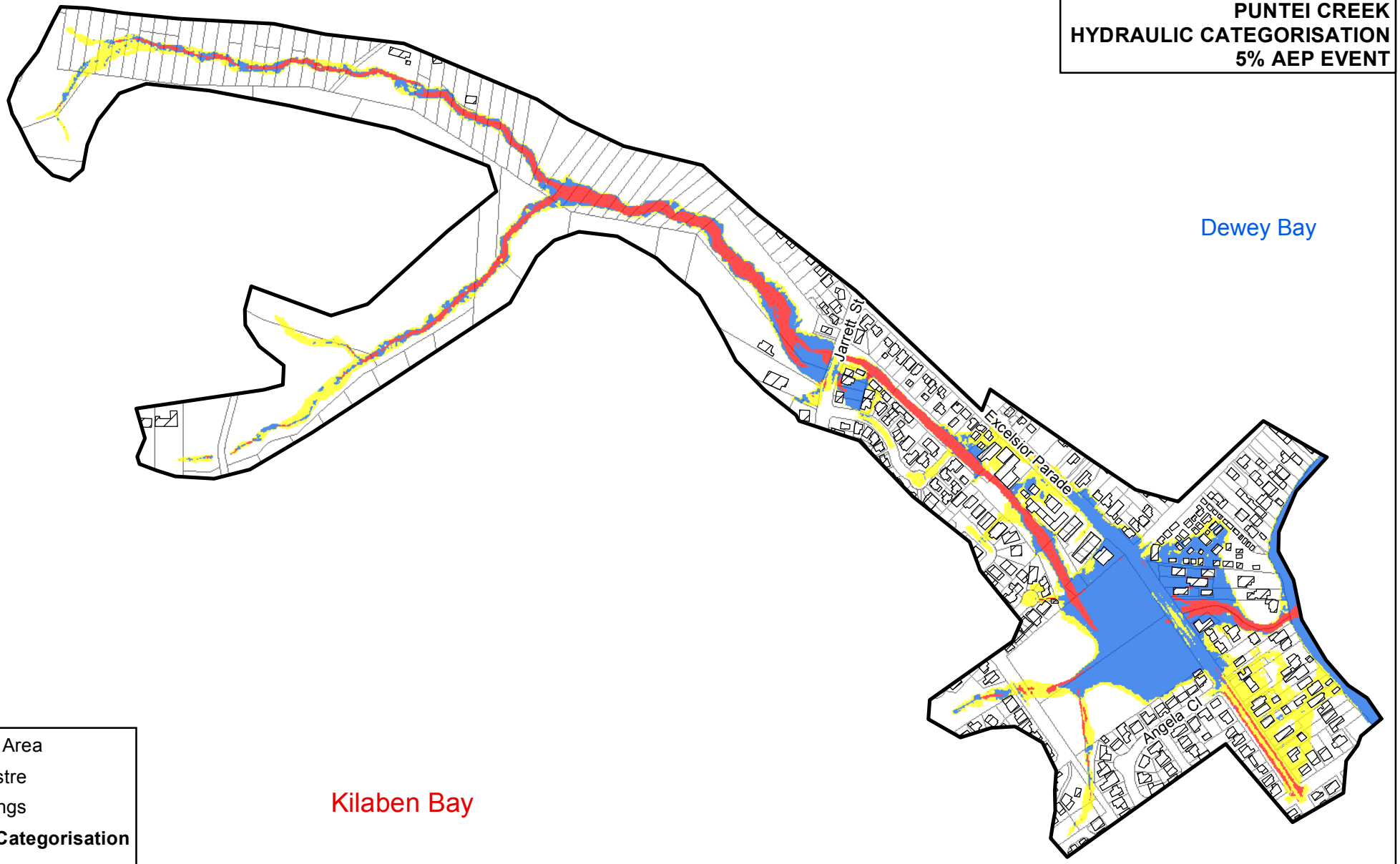

J:\Jobs\1190776\ArcGIS\ArcMap\Working\Template\Appendix_F\FigureG17_Puntei_Creek_Hydraulic_Categories_50%AEP.mxd

FIGURE G19
**PUNTEI CREEK**
**HYDRAULIC CATEGORISATION**
**10% AEP EVENT**



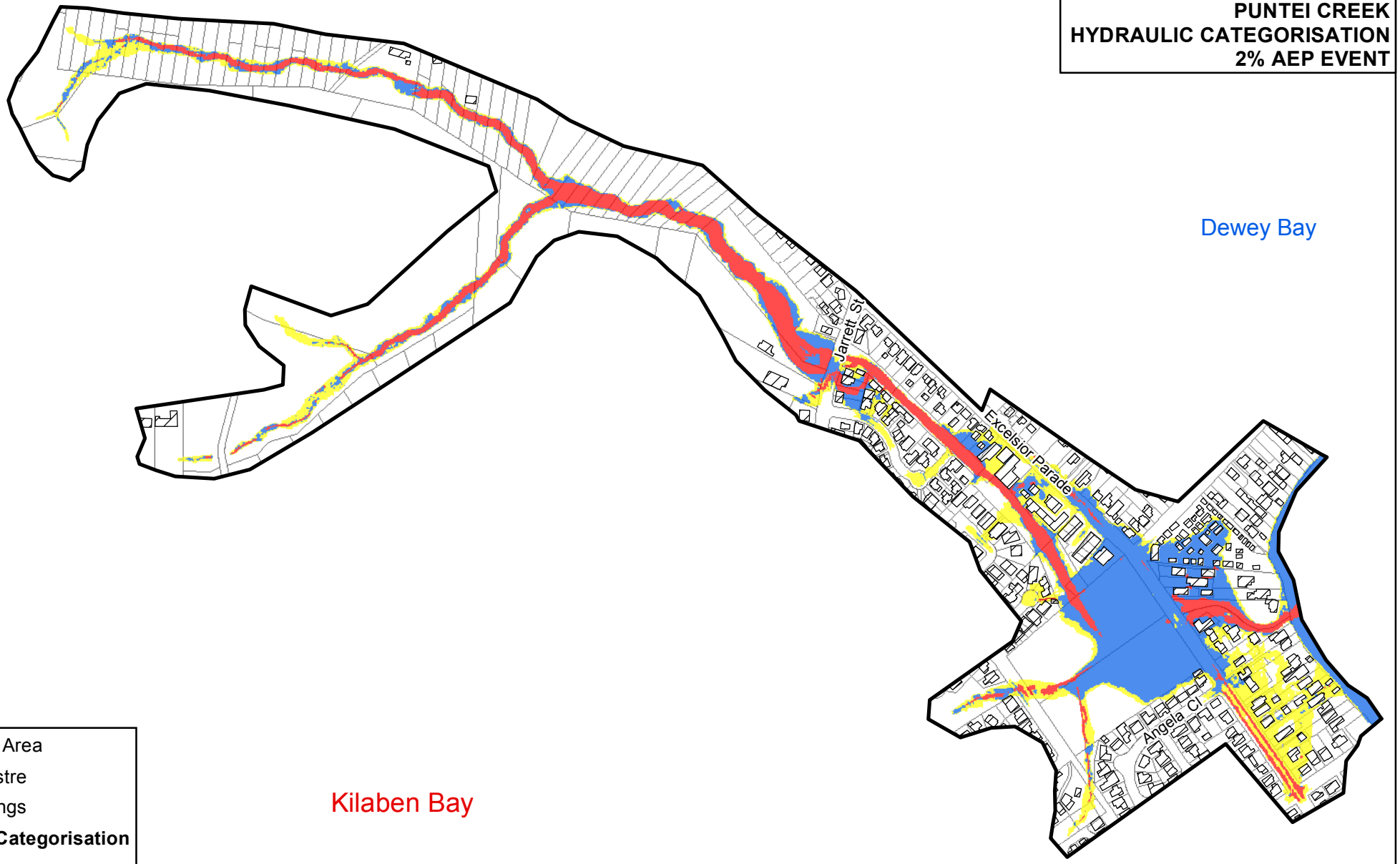

J:\Jobs\119076\ArcGIS\ArcMap\Working\Template\Appendix_F\FigureG18_Puntei_Creek_Hydraulic_Categories_20%AEP.mxd

FIGURE G20
**PUNTEI CREEK**
**HYDRAULIC CATEGORISATION**
**5% AEP EVENT**



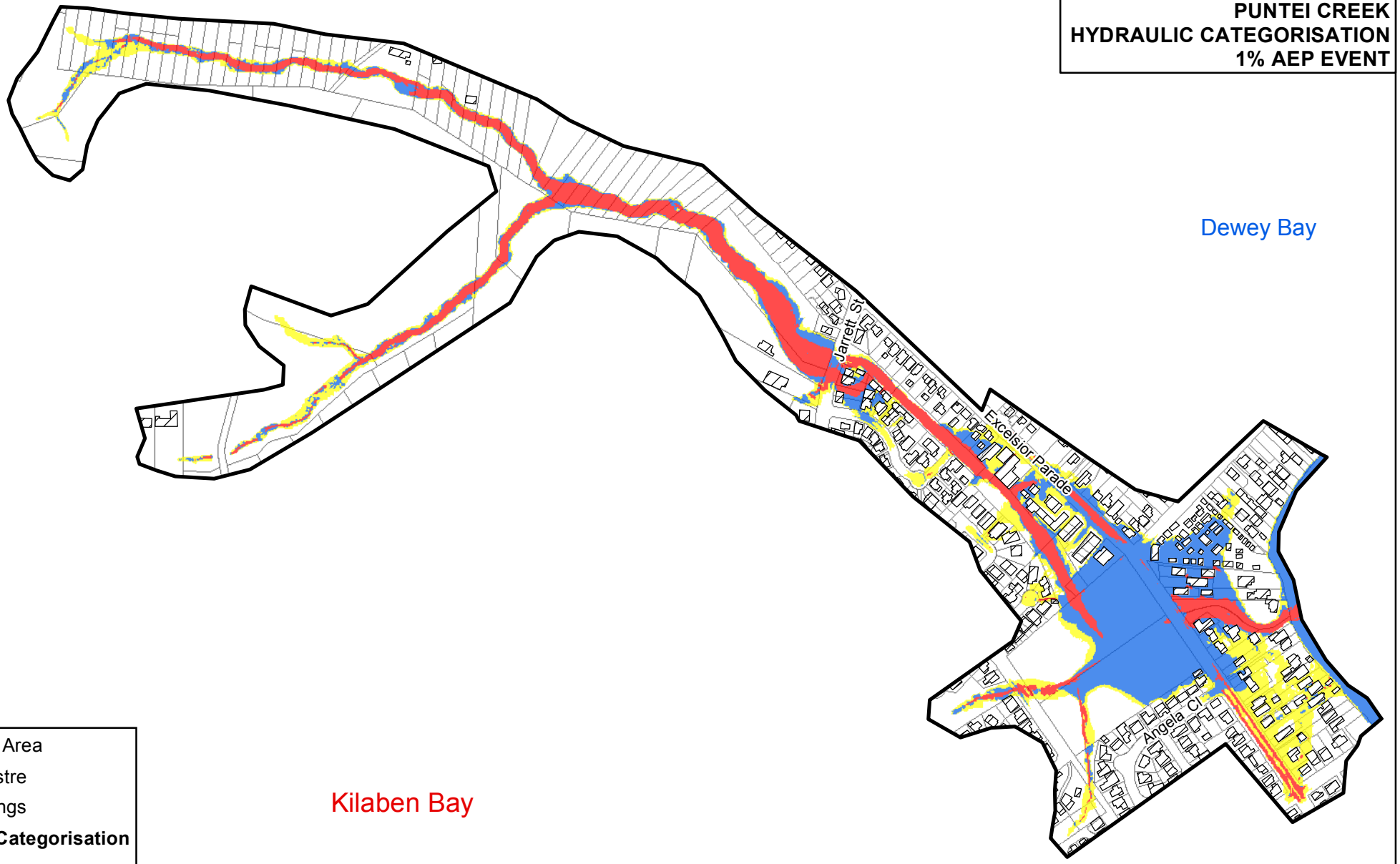

J:\Jobs\119076\ArcGIS\ArcMap\Working\Template\Appendix_F\FigureG19_Puntei_Creek_Hydraulic_Categories_10%AEP.mxd

FIGURE G21
**PUNTEI CREEK**
**HYDRAULIC CATEGORISATION**
**2% AEP EVENT**



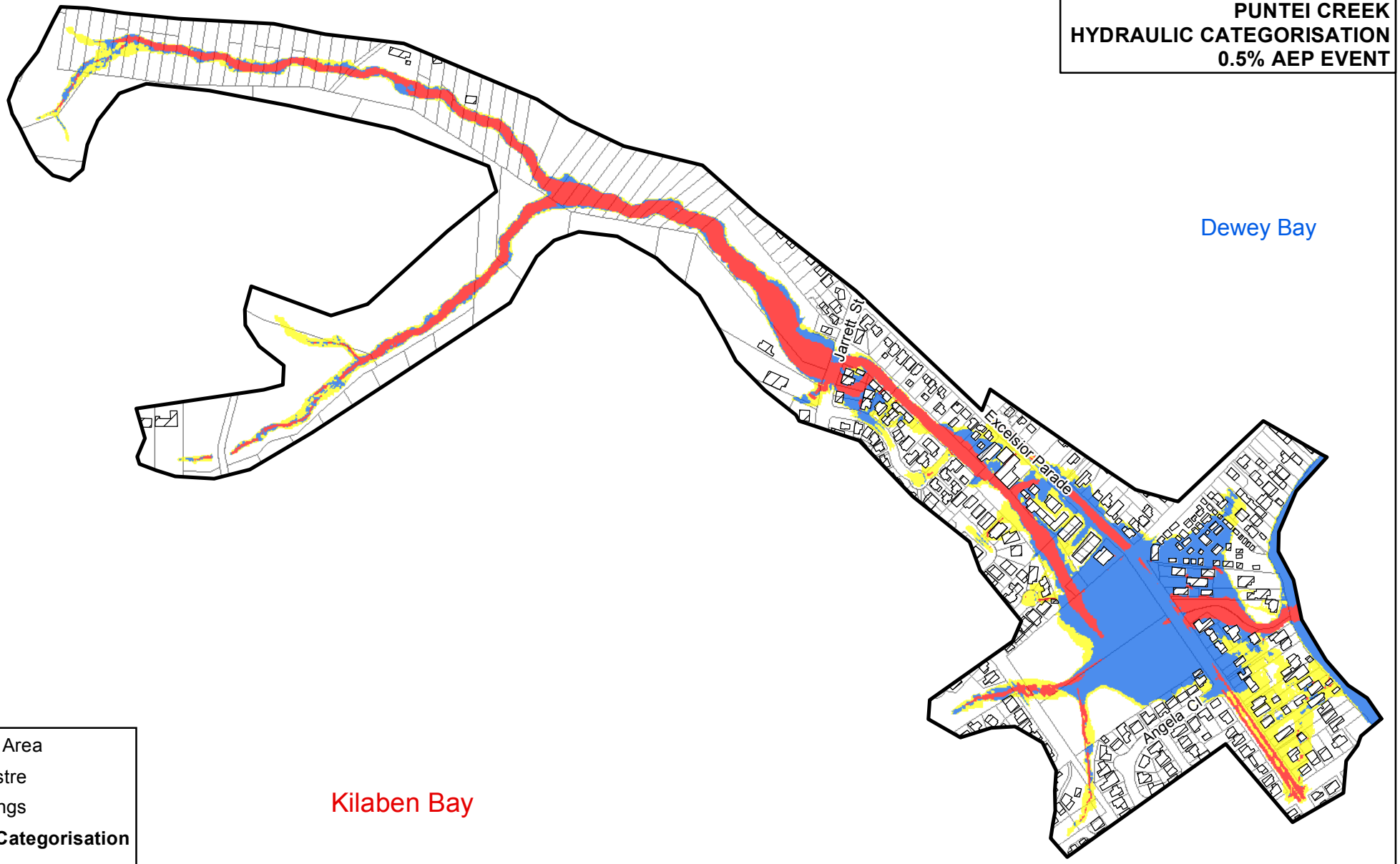

J:\Jobs\119076\ArcGIS\ArcMap\Working\Template\Appendix_F\FigureG20_Puntei_Creek_Hydraulic_Categories_5%AEP.mxd

FIGURE G22
**PUNTEI CREEK**
**HYDRAULIC CATEGORISATION**
**1% AEP EVENT**



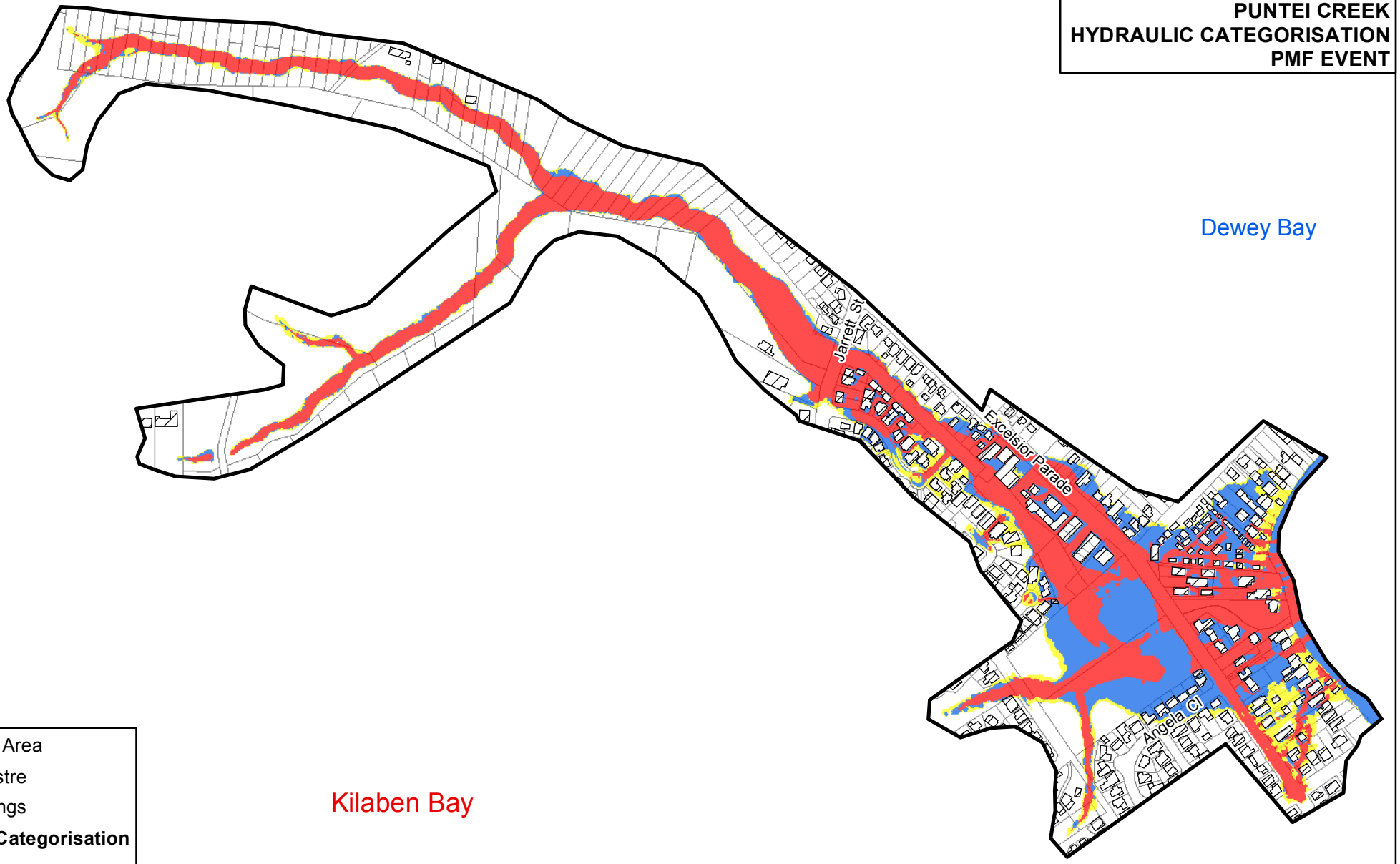

J:\Jobs\119076\ArcGIS\ArcMap\Working\Template\Appendix_F\FigureG21_Puntei_Creek_Hydraulic_Categories_2%AEP.mxd

FIGURE G23
**PUNTEI CREEK**
**HYDRAULIC CATEGORISATION**
**0.5% AEP EVENT**



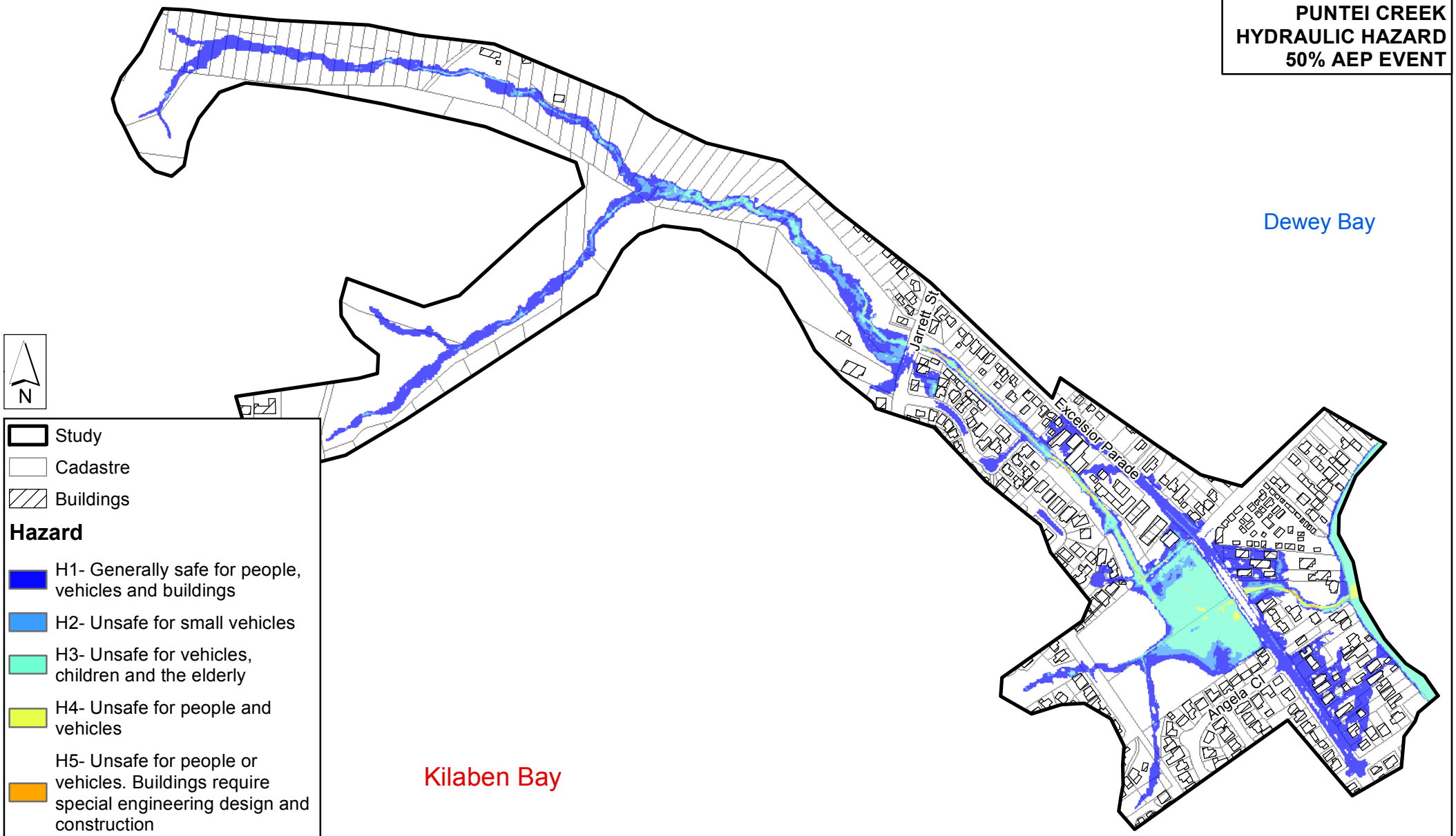

J:\Jobs\1190776\ArcGIS\ArcMap\Working\Template\Appendix_F\FigureG22_Puntei_Creek_Hydraulic_Categories_1%AEP.mxd

FIGURE G24
**PUNTEI CREEK**
**HYDRAULIC CATEGORISATION**
**PMF EVENT**




J:\Jobs\119076\ArcGIS\ArcMap\Working\Template\Appendix_F\FigureG23_Puntei_Creek_Hydraulic_Categories_0.5%AEP.mxd

FIGURE G25
**PUNTEI CREEK**
**HYDRAULIC HAZARD**
**50% AEP EVENT**




J:\Jobs\119076\ArcGIS\ArcMap\Working\Template\Appendix_G\FigureG25_Puntei_Creek_Provisional_Hazard_50%AEP.mxd

FIGURE G26
**PUNTEI CREEK**
**HYDRAULIC HAZARD**
**20% AEP EVENT**

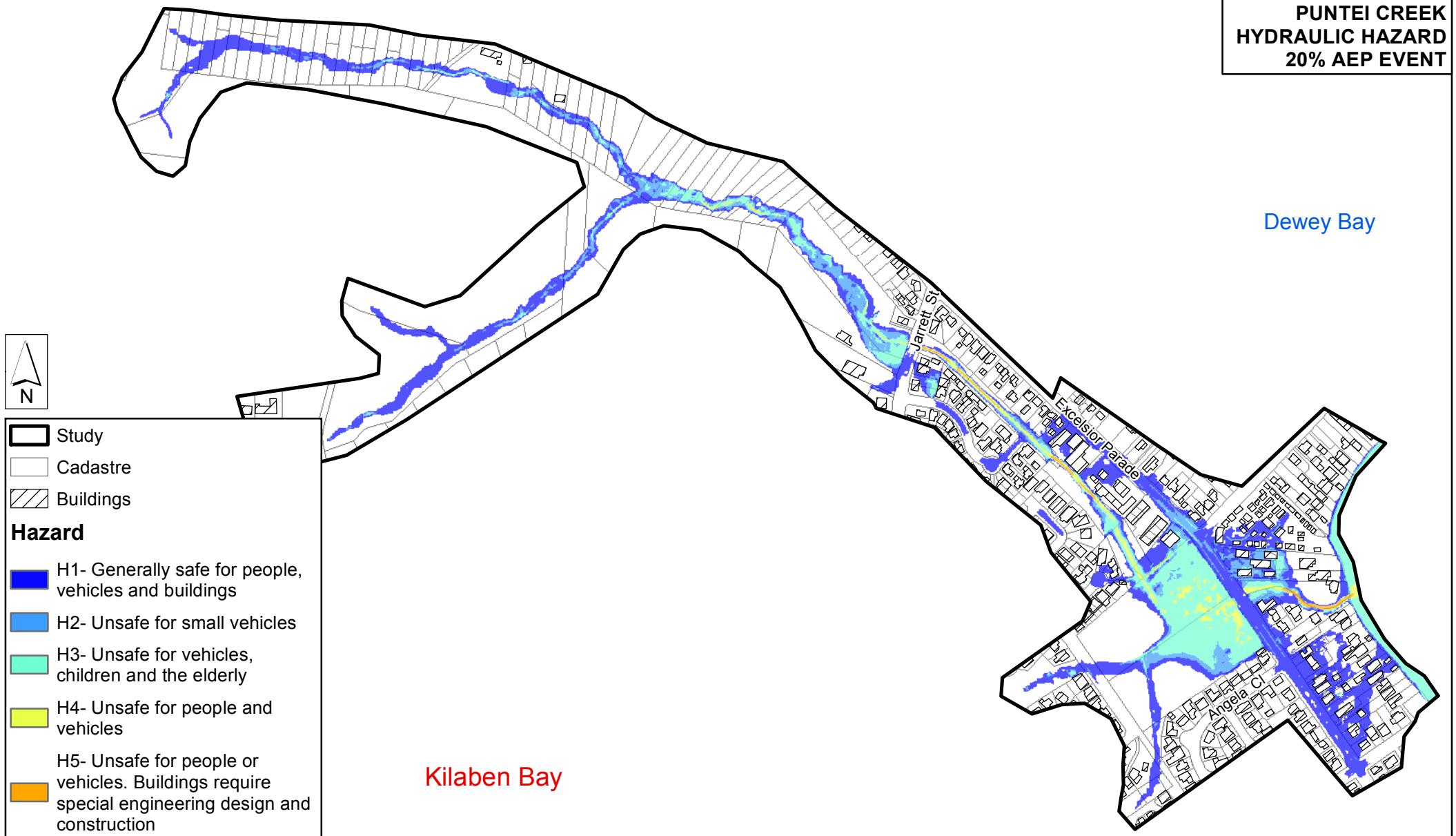



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FIGURE G27
**PUNTEI CREEK**
**HYDRAULIC HAZARD**
**10% AEP EVENT**

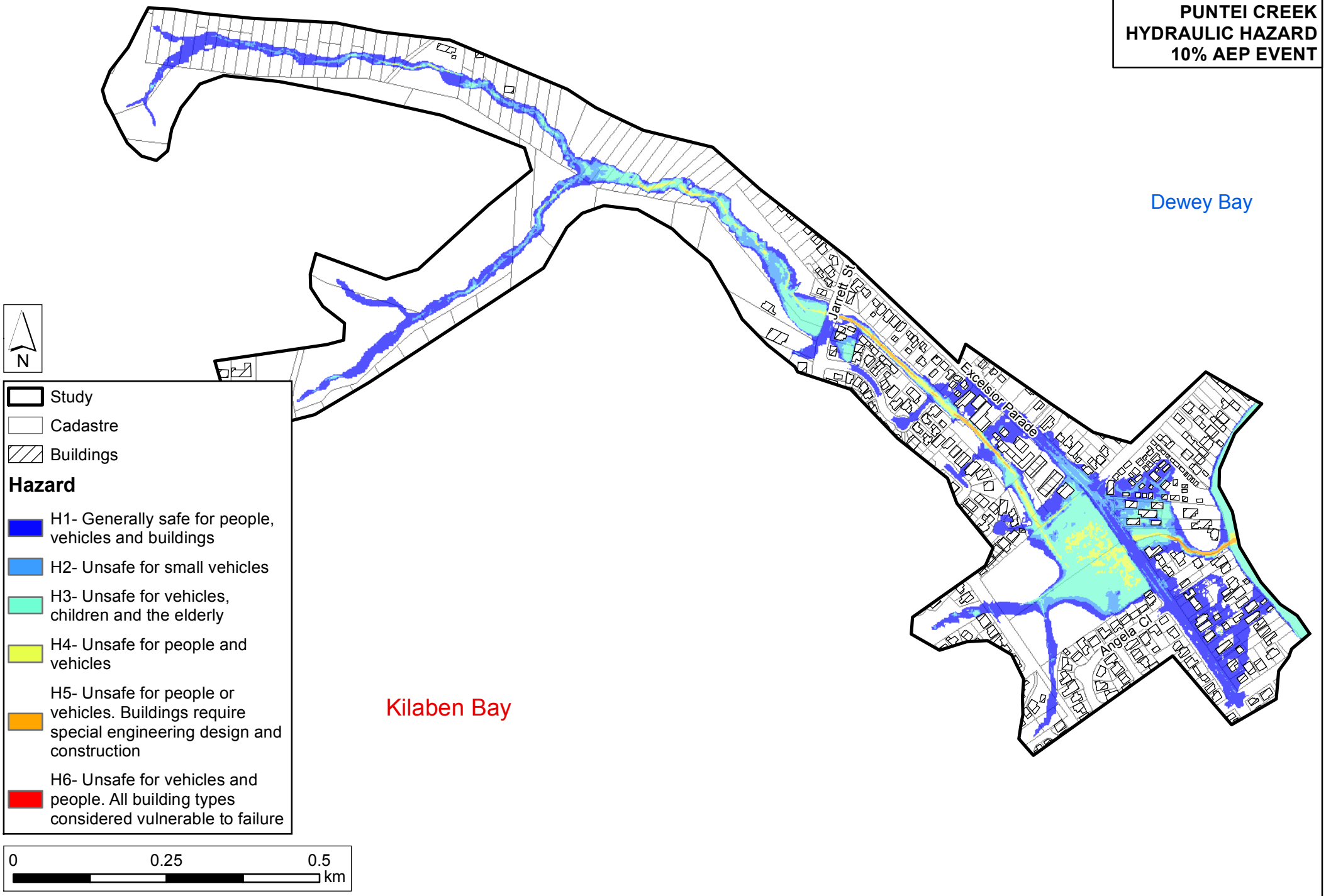


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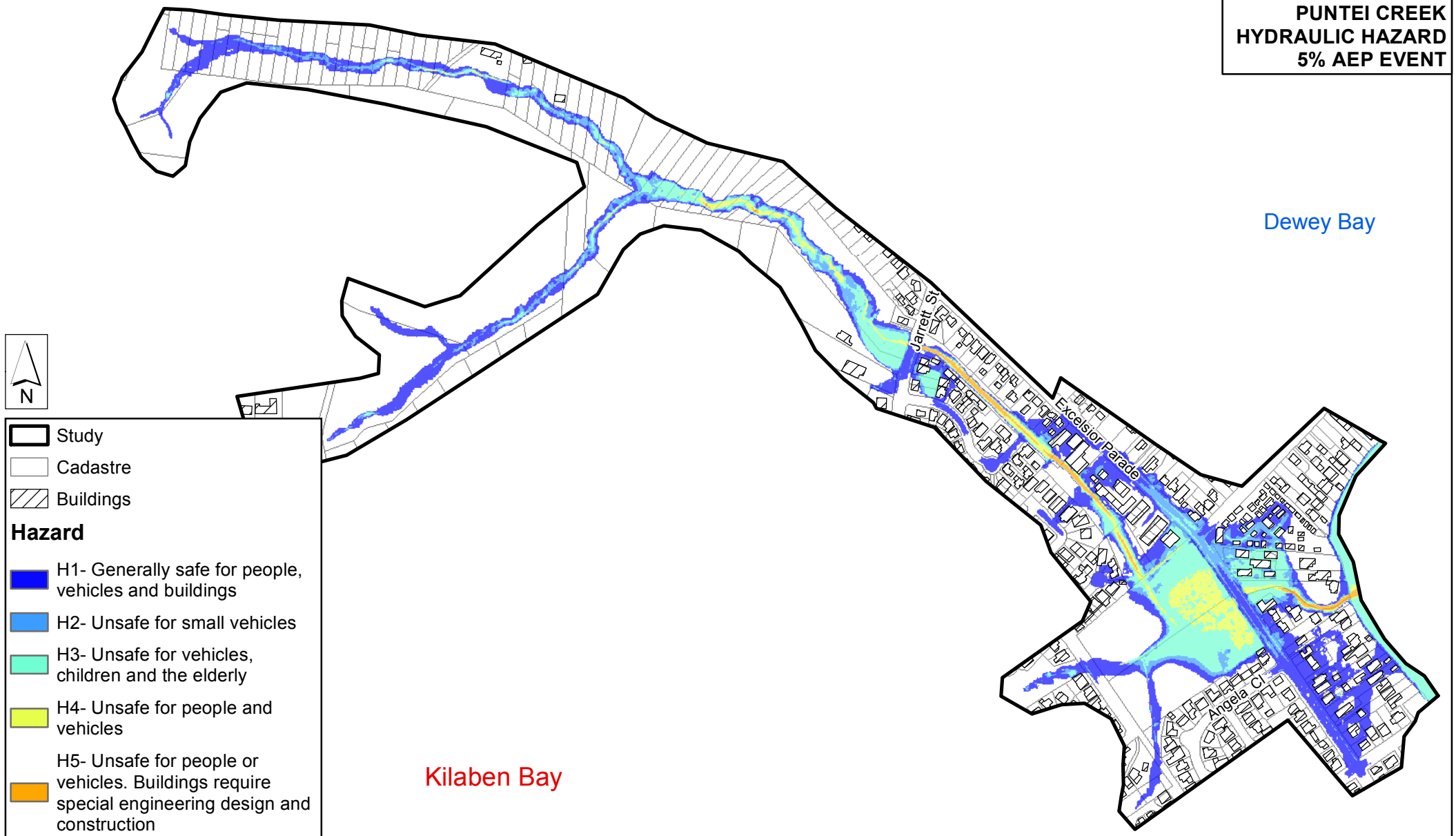
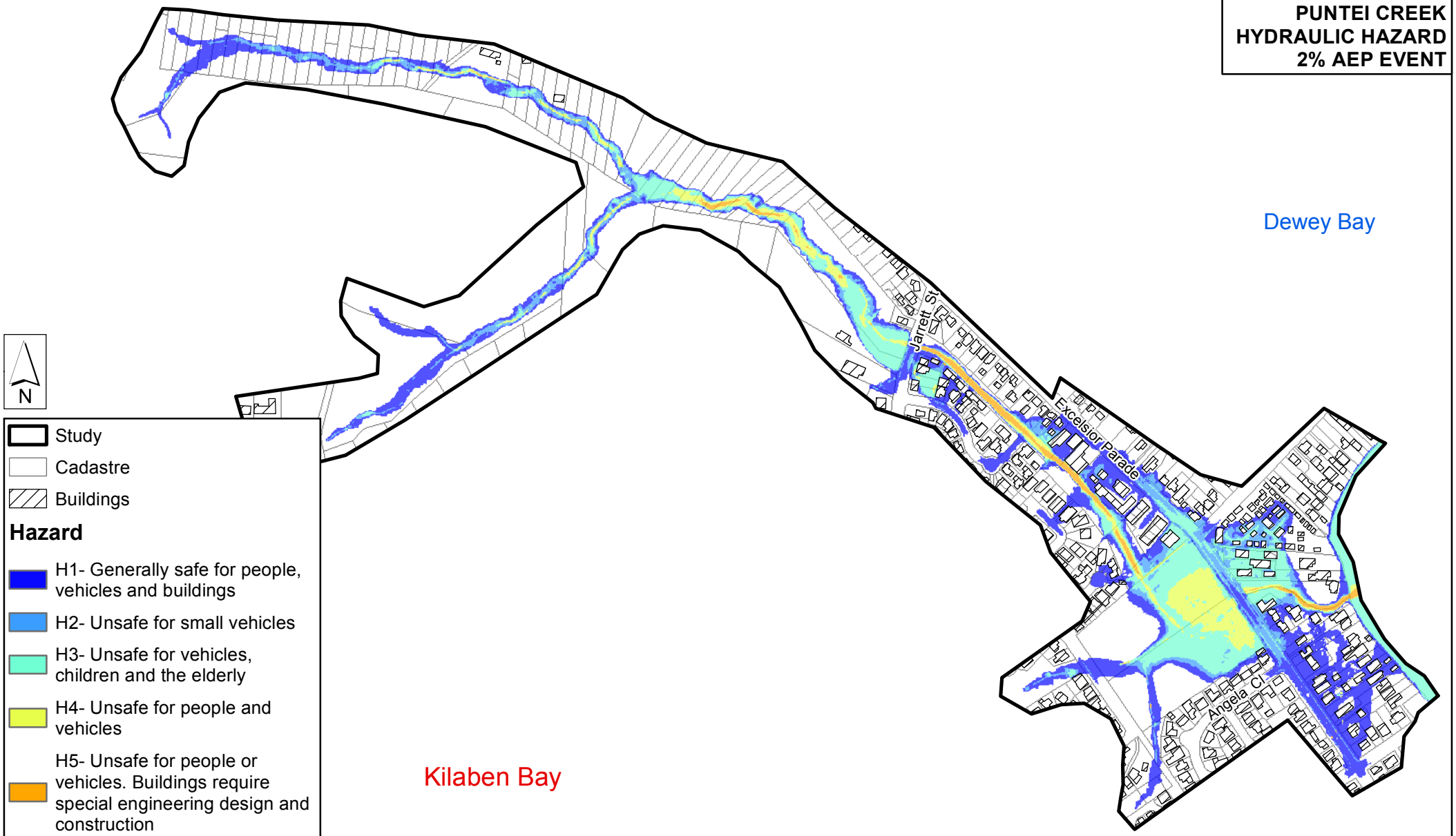
FIGURE G28
**PUNTEI CREEK**
**HYDRAULIC HAZARD**
**5% AEP EVENT**



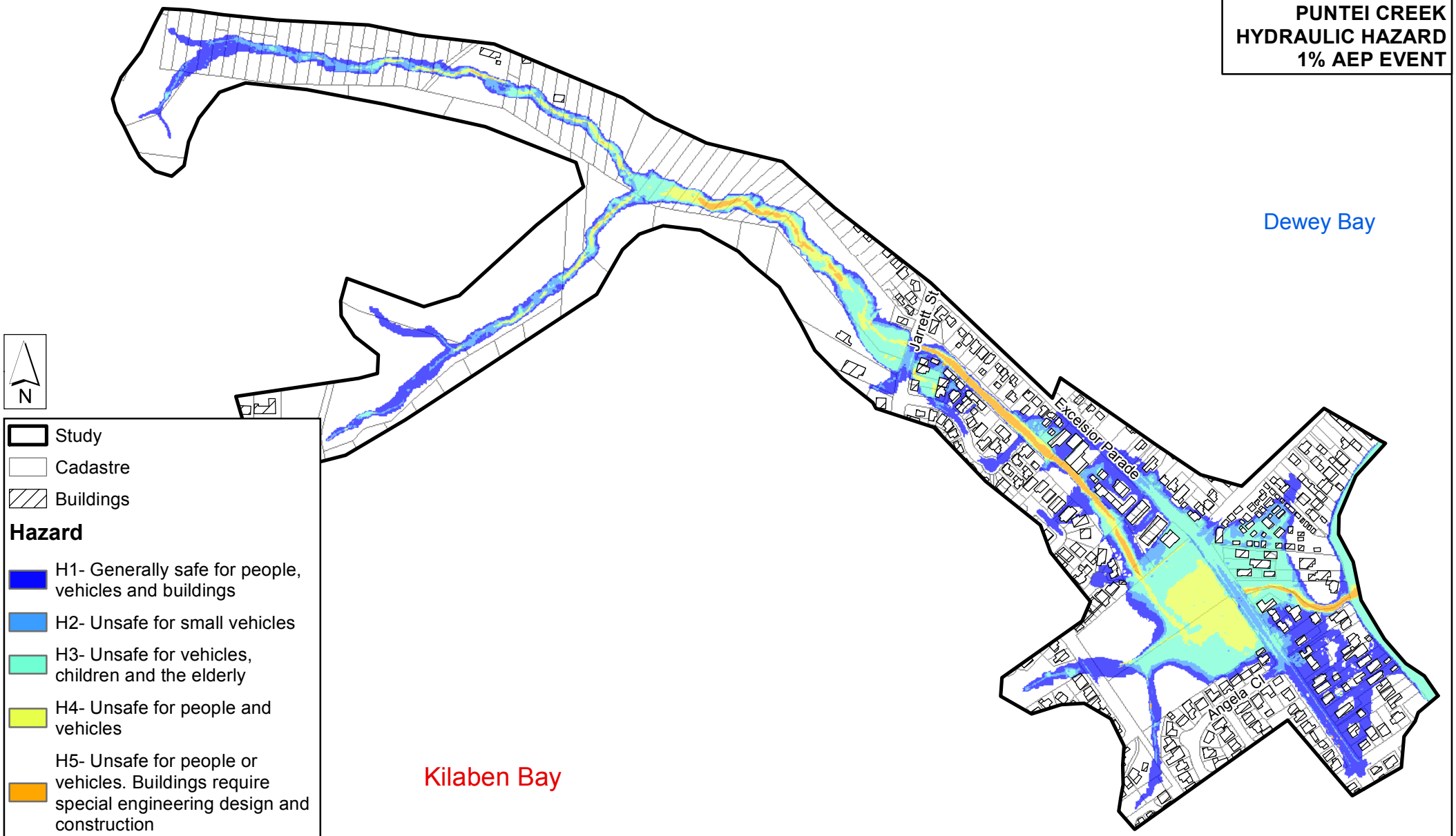

J:\Jobs\119076\ArcGIS\ArcMap\Working\Template\Appendix_F\FigureG27_Puntei_Creek_Provisional_Hazard_10%AEP.mxd

FIGURE G29
**PUNTEI CREEK**
**HYDRAULIC HAZARD**
**2% AEP EVENT**



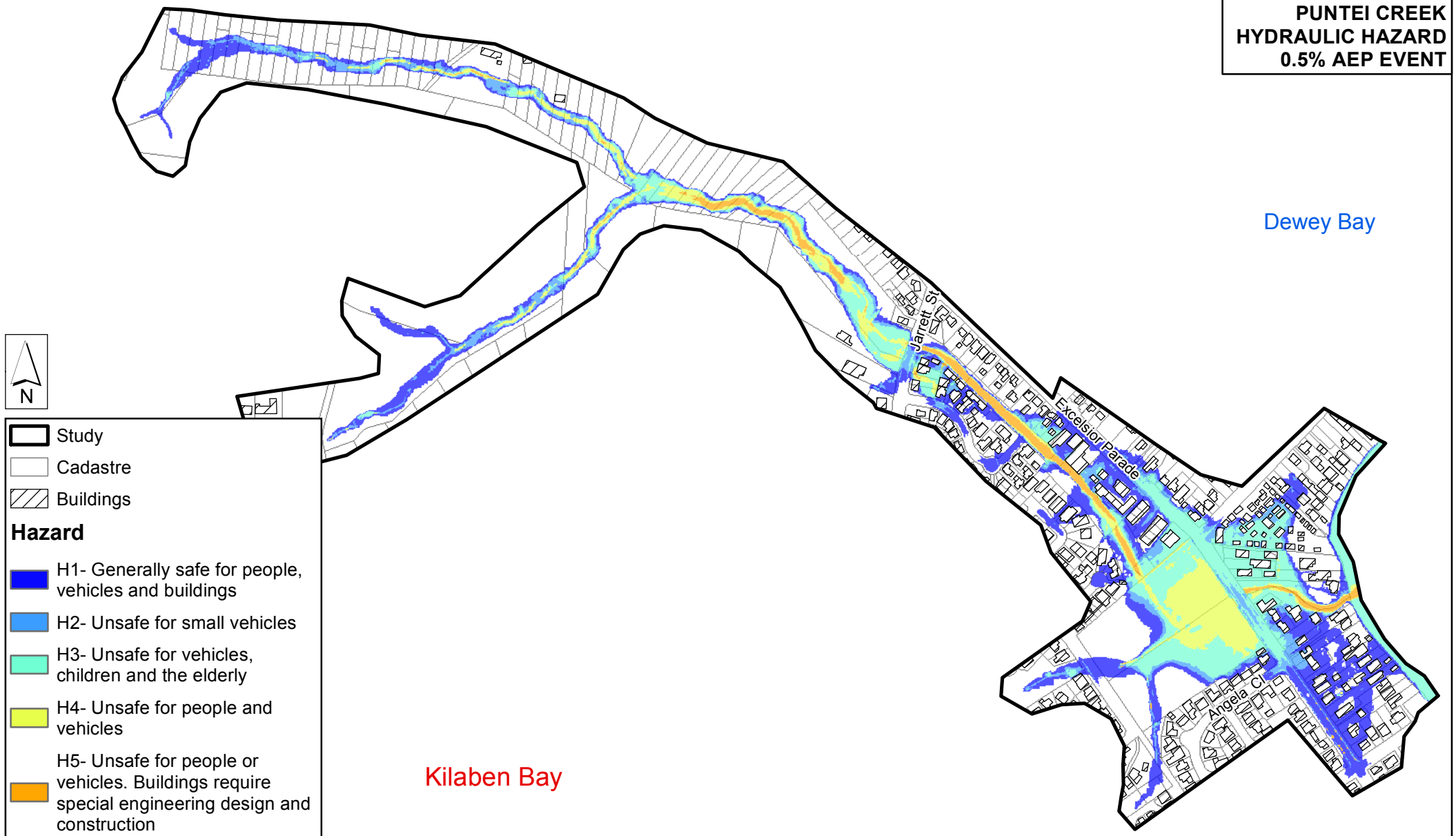

J:\Jobs\119076\ArcGIS\ArcMap\Working\Template\Appendix_F\FigureG29_Puntei_Creek_Provisional_Hazard_2%AEP.mxd

FIGURE G30
**PUNTEI CREEK**
**HYDRAULIC HAZARD**
**1% AEP EVENT**



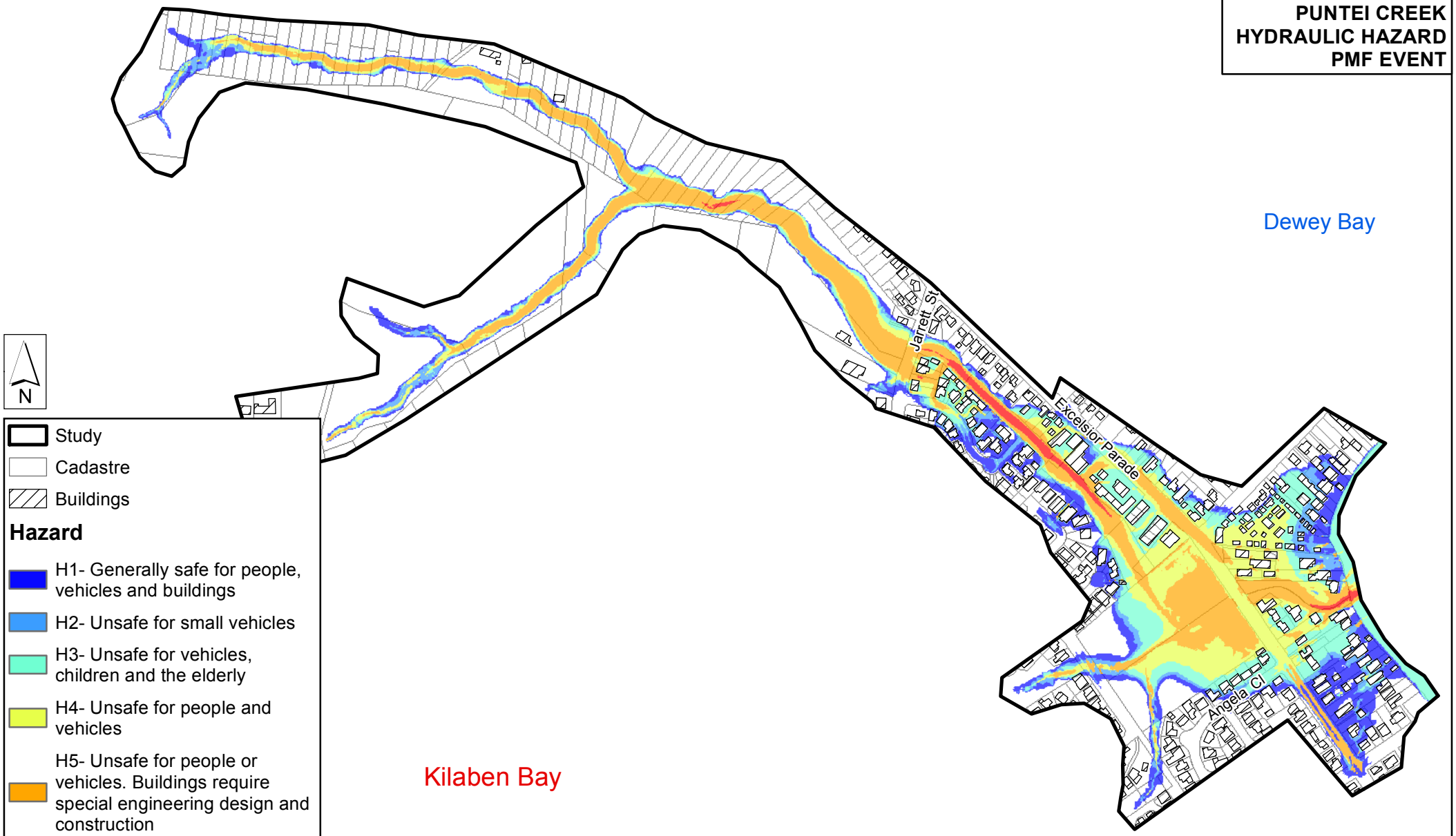

J:\Jobs\119076\ArcGIS\ArcMap\Working\Template\Appendix_F\FigureG29_Puntei_Creek_Provisional_Hazard_2%AEP.mxd

FIGURE G31
**PUNTEI CREEK**
**HYDRAULIC HAZARD**
**0.5% AEP EVENT**




J:\Jobs\119076\ArcGIS\ArcMap\Working\Template\Appendix_F\FigureG30_Puntei_Creek_Provisional_Hazard_1%AEP.mxd

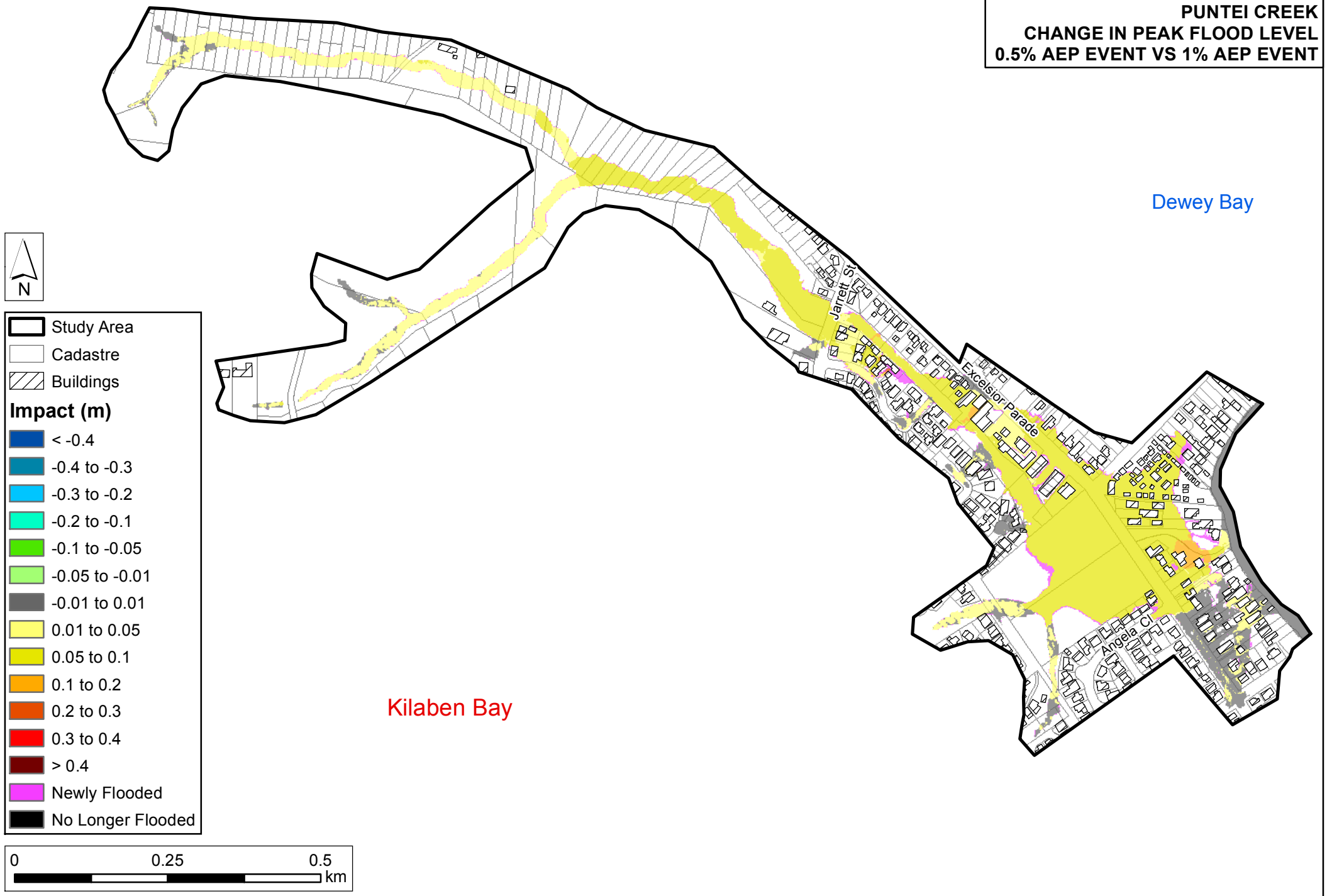
FIGURE G32
**PUNTEI CREEK**
**HYDRAULIC HAZARD**
**PMF EVENT**




J:\Jobs\1190776\ArcGIS\ArcMap\Working\Template\Appendix_F\FigureG31_Puntei_Creek_Provisional_Hazard_0.5%AEP.mxd

FIGURE G33

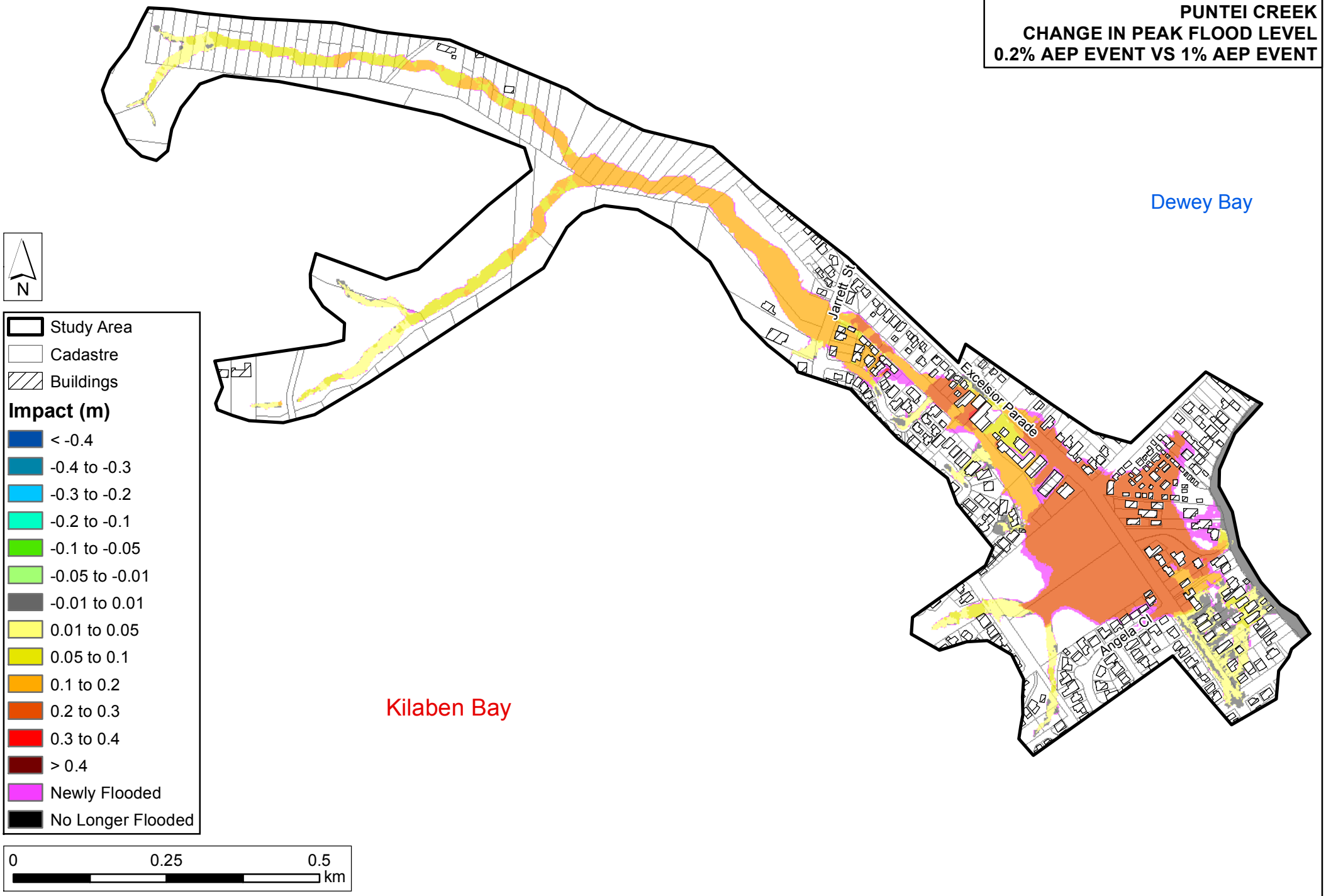
**PUNTEI CREEK**
**CHANGE IN PEAK FLOOD LEVEL**
**0.5% AEP EVENT VS 1% AEP EVENT**




J:\Jobs\119076\ArcGIS\ArcMap\Working\Template\Appendix_G\FigureG33_Puntei_Creek_Impact_CC_0.5%AEP_V_1%AEP.mxd

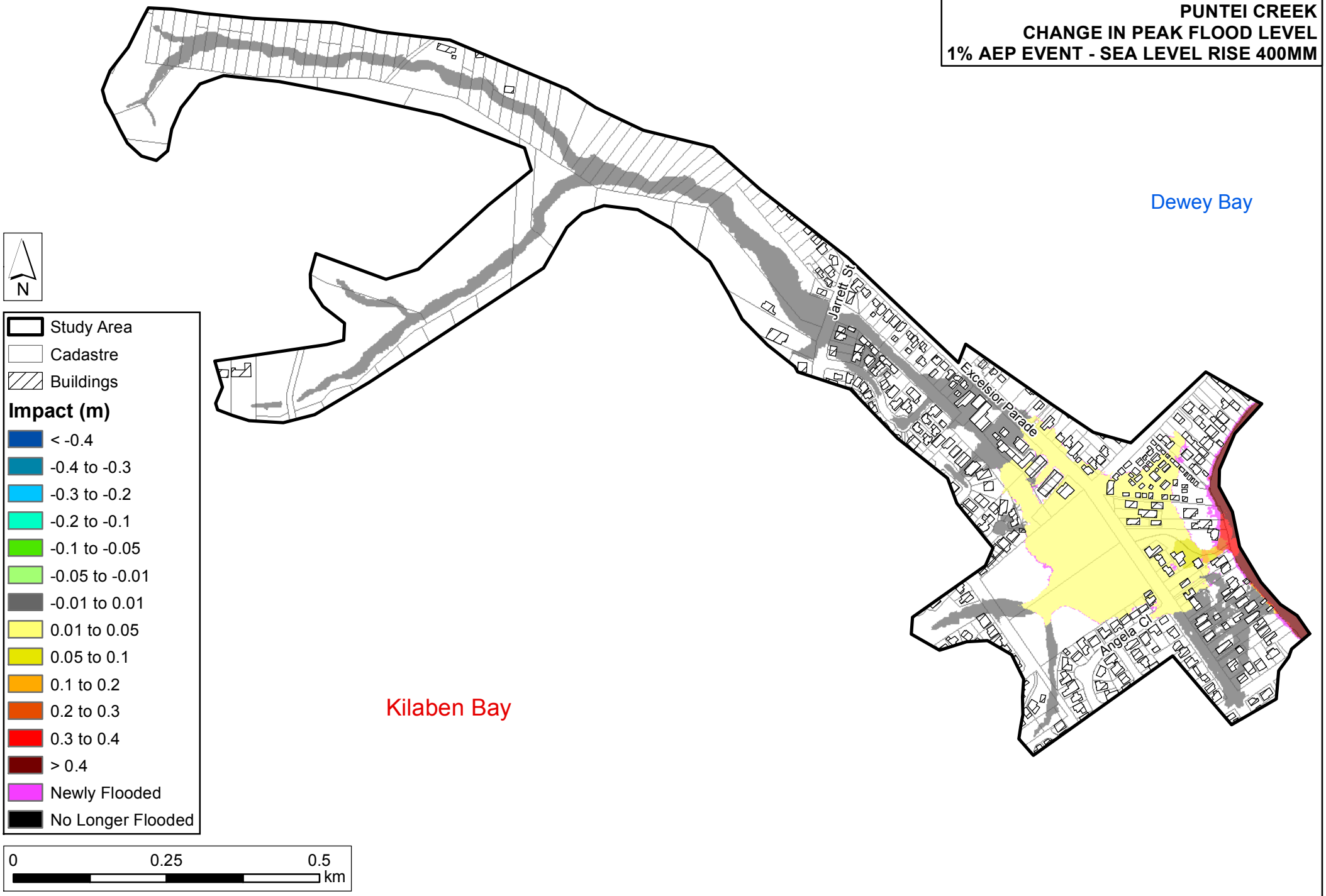
FIGURE G34

**PUNTEI CREEK**
**CHANGE IN PEAK FLOOD LEVEL**
**0.2% AEP EVENT VS 1% AEP EVENT**



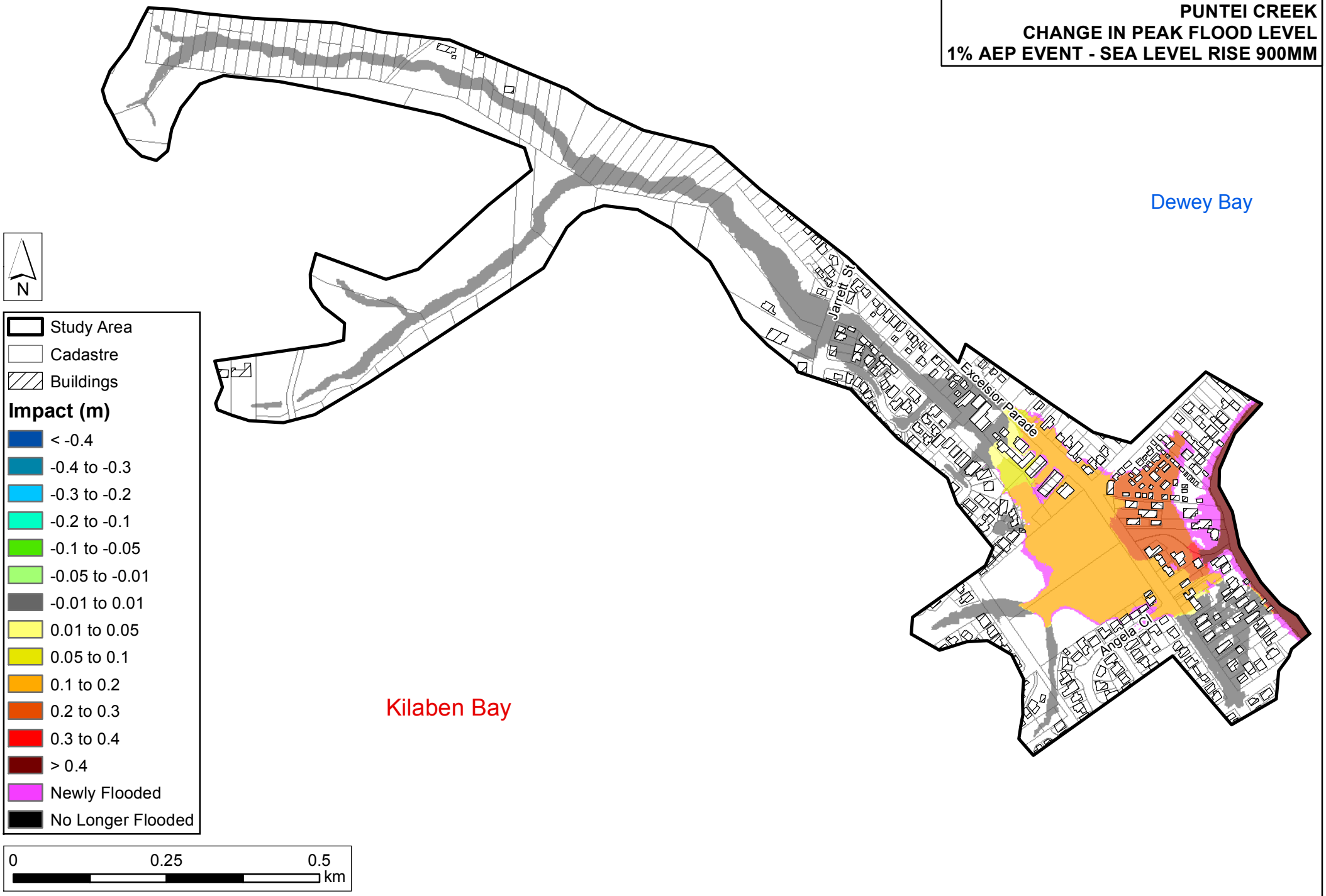

J:\Jobs\119076\ArcGIS\ArcMap\Working\Template\Appendix_G\FigureG33_Puntei_Creek_Impact_CC_0.5%AEP_V_1%AEP.mxd

FIGURE G35
**PUNTEI CREEK**
**CHANGE IN PEAK FLOOD LEVEL**
**1% AEP EVENT - SEA LEVEL RISE 400MM**



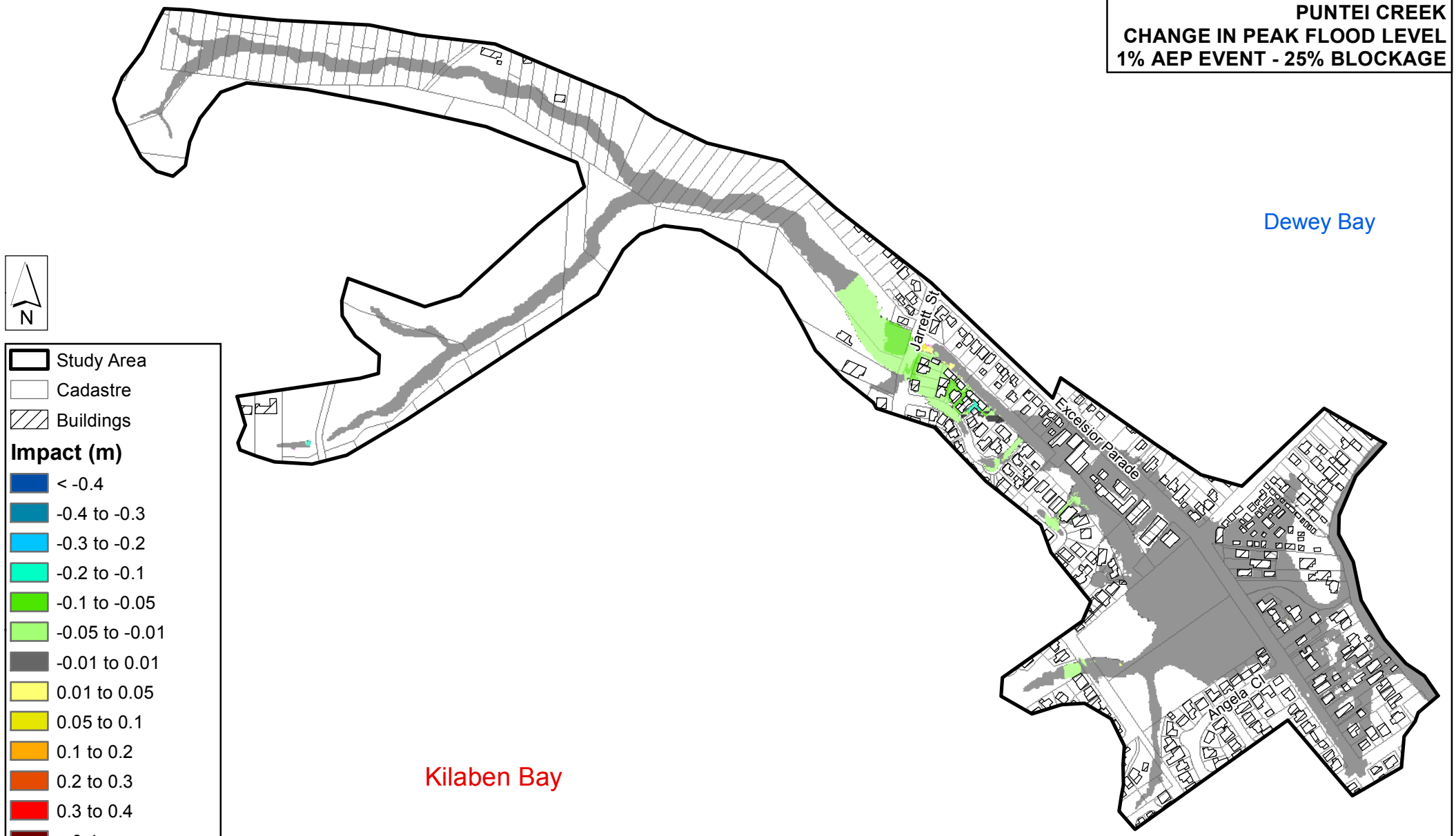

J:\Jobs\119076\ArcGIS\ArcMap\Working\Template\Appendix_G\FigureG34_Puntei_Creek_Impact_CC_0.2%AEP_V_1%AEP.mxd

FIGURE G36
**PUNTEI CREEK**
**CHANGE IN PEAK FLOOD LEVEL**
**1% AEP EVENT - SEA LEVEL RISE 900MM**




J:\Jobs\119076\ArcGIS\ArcMap\Working\Template\Appendix_G\FigureG35_Puntei_Creek_Impact_CC_SLR04_1%AEP.mxd

FIGURE G37
**PUNTEI CREEK**
**CHANGE IN PEAK FLOOD LEVEL**
**1% AEP EVENT - 25% BLOCKAGE**




J:\Jobs\119076\ArcGIS\ArcMap\Working\Template\Appendix_G\FigureG37_Puntei_Creek_Impact_1%AEP_Blockage25pc.mxd

FIGURE G38
**PUNTEI CREEK**
**CHANGE IN PEAK FLOOD LEVEL**
**1% AEP EVENT - 75% BLOCKAGE**

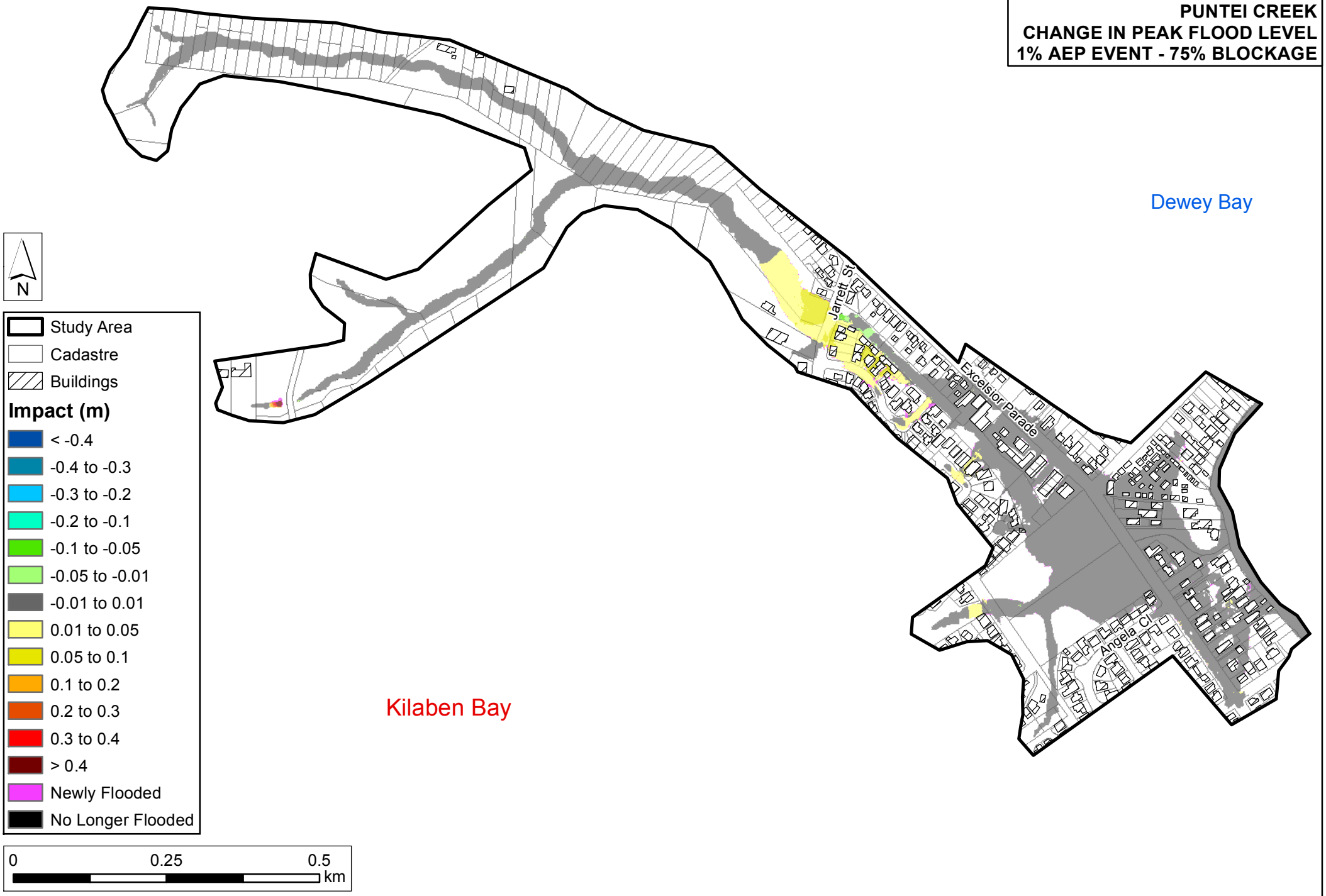



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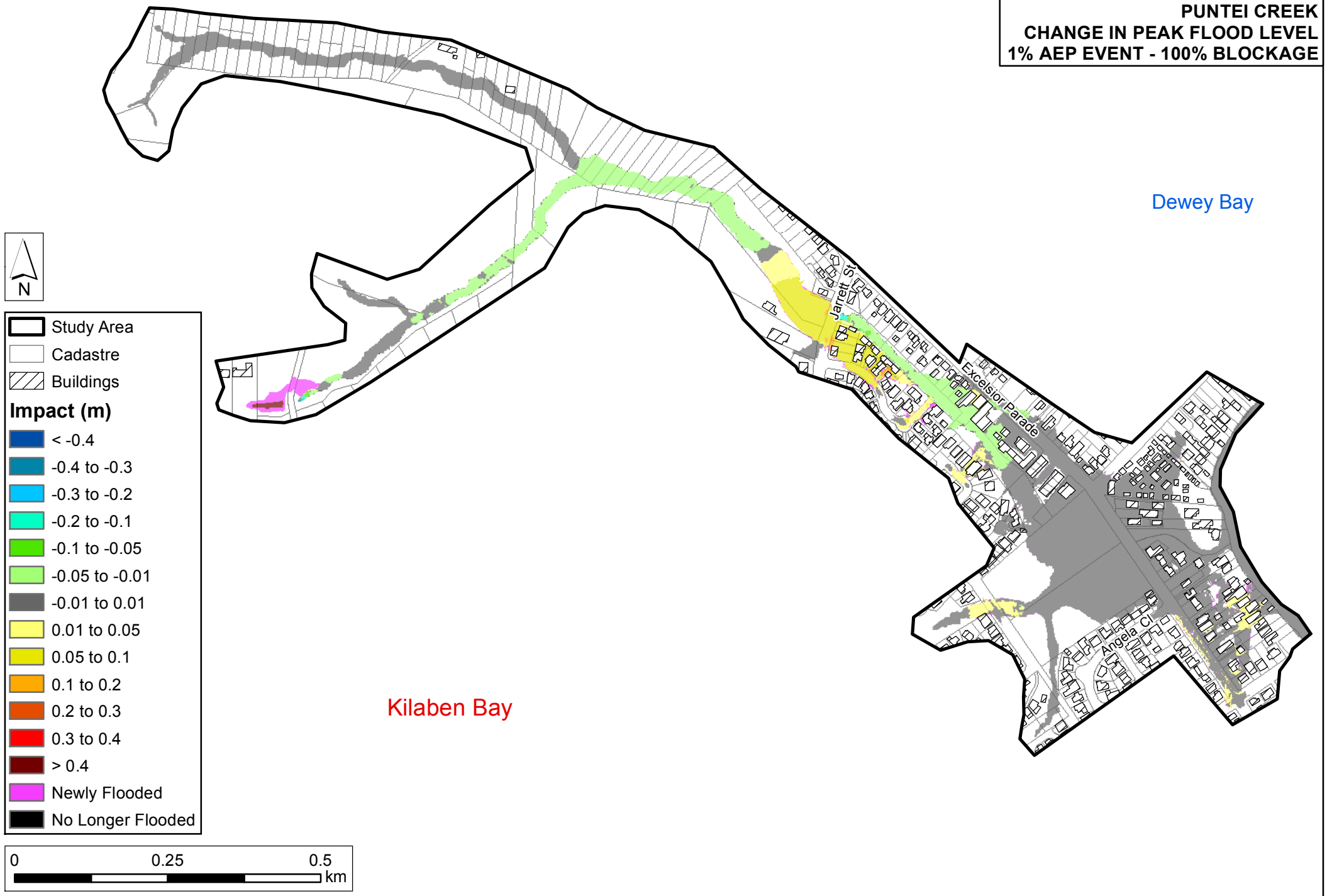
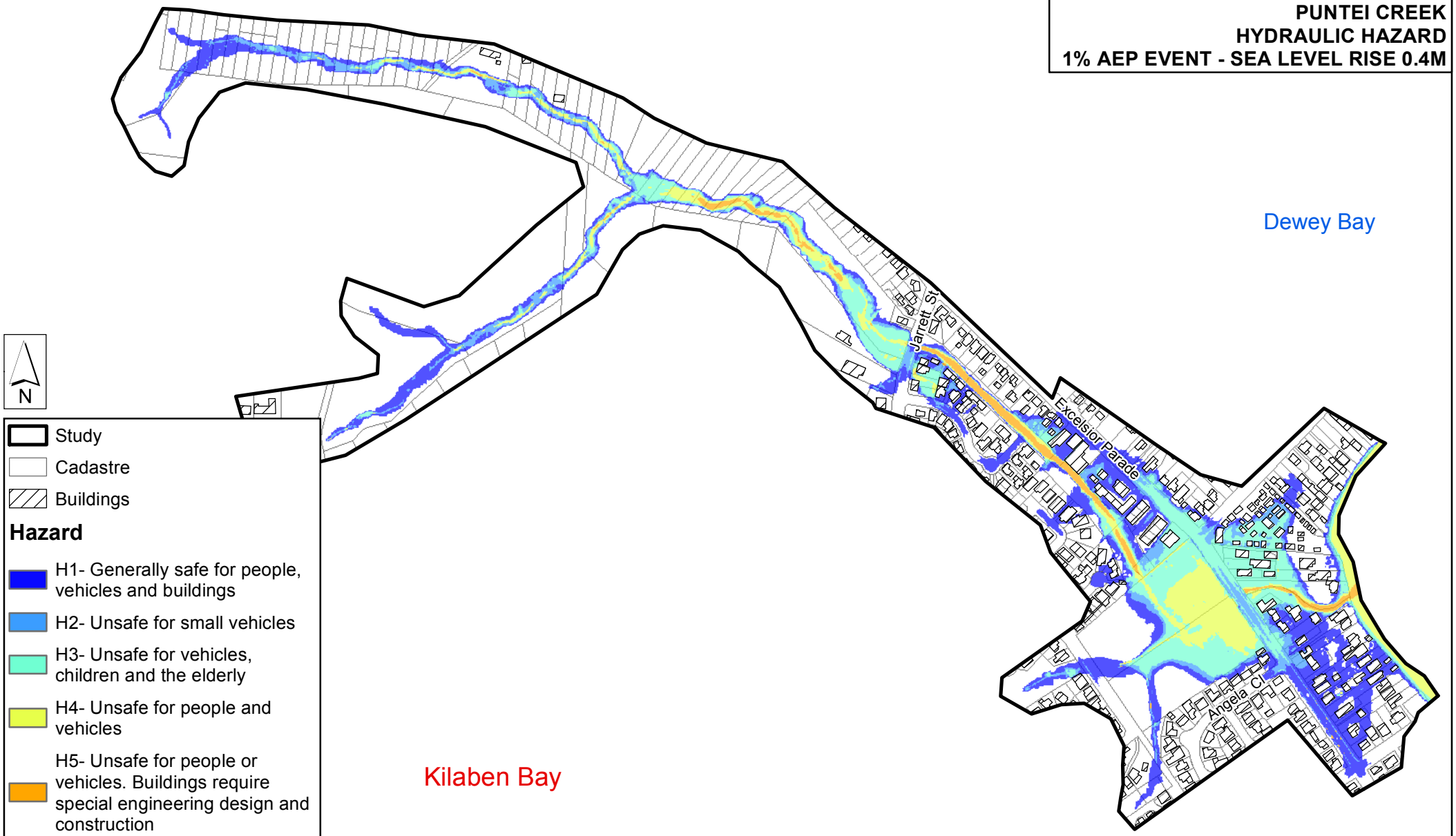
FIGURE G39
**PUNTEI CREEK**
**CHANGE IN PEAK FLOOD LEVEL**
**1% AEP EVENT - 100% BLOCKAGE**



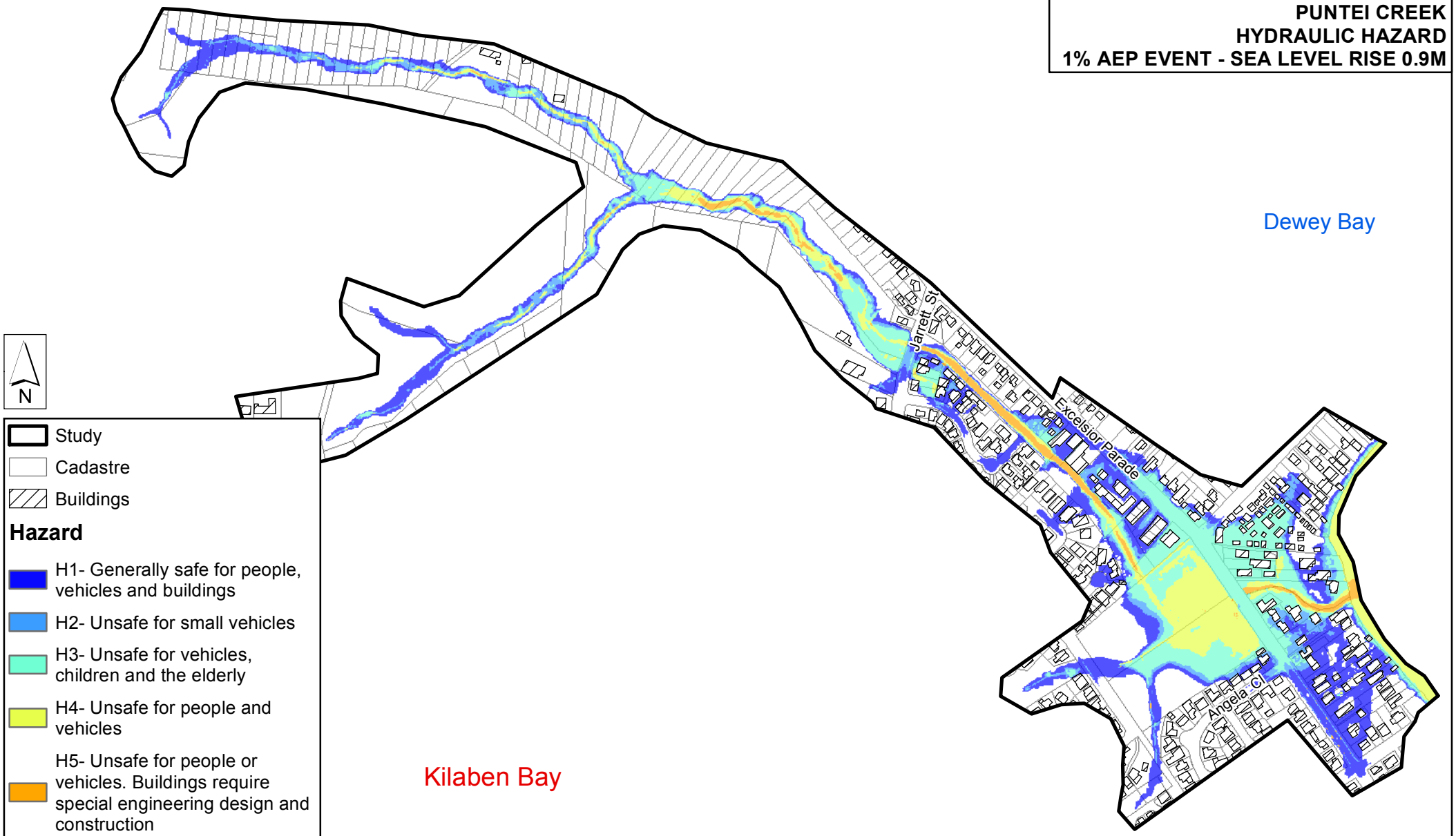

J:\Jobs\119076\ArcGIS\ArcMap\Working\Template\Appendix_G\FigureG38_Puntei_Creek_Impact_1%AEP_Blockage75pc.mxd

FIGURE G40
**PUNTEI CREEK**
**HYDRAULIC HAZARD**
**1% AEP EVENT - SEA LEVEL RISE 0.4M**



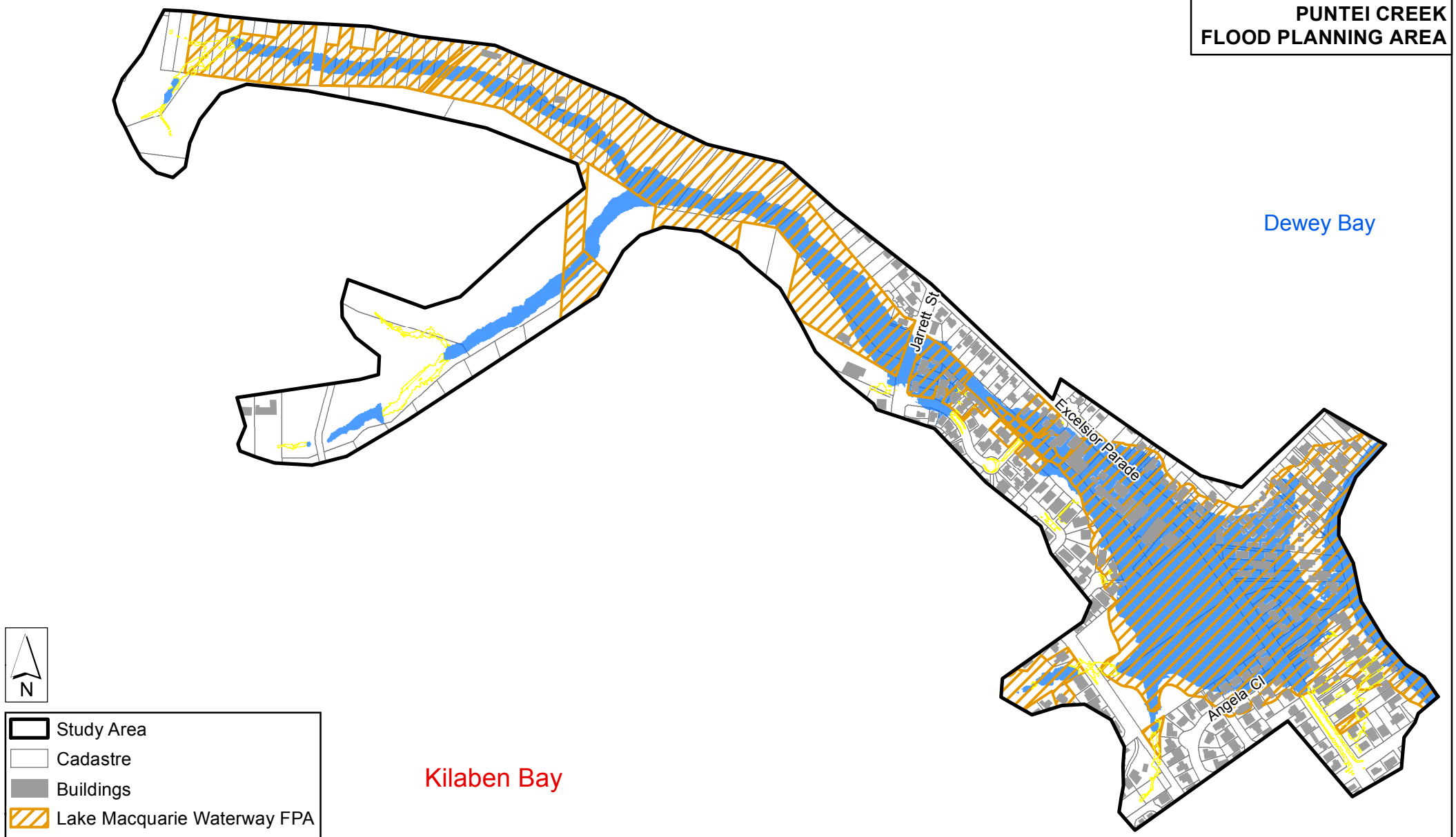

J:\Jobs\119076\ArcGIS\ArcMap\Working\Template\Appendix_G\FigureG25_Puntei_Creek_Provisional_Hazard_50%AEP.mxd

FIGURE G41
**PUNTEI CREEK**
**HYDRAULIC HAZARD**
**1% AEP EVENT - SEA LEVEL RISE 0.9M**




J:\Jobs\119076\ArcGIS\ArcMap\Working\Template\Appendix_G\FigureG40_Puntei_Creek_Provisional_Hazard_1%AEP_SLR04.mxd

FIGURE G42
**PUNTEI CREEK**
**FLOOD PLANNING AREA**



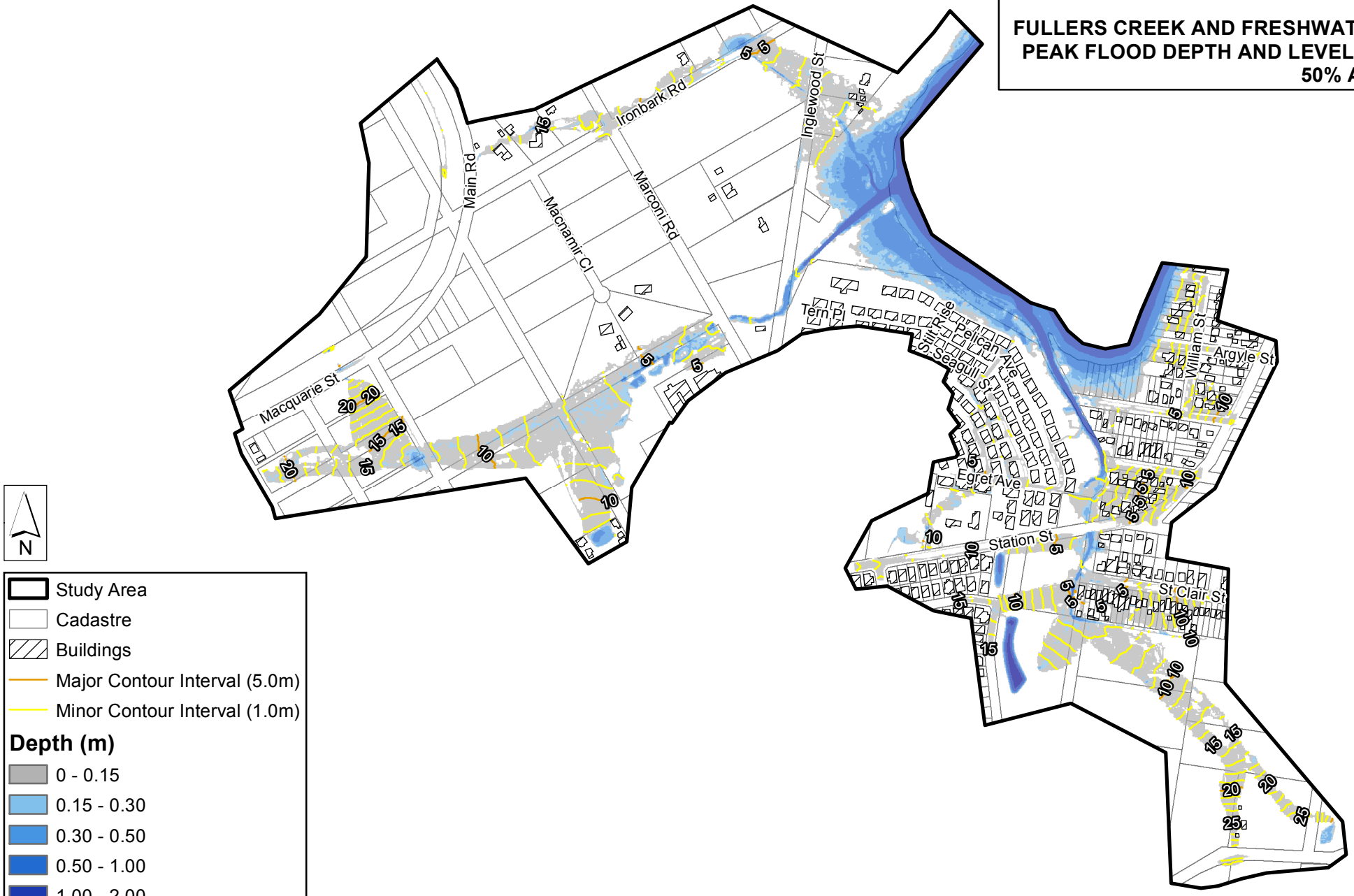

J:\Jobs\119076\ArcGIS\ArcMap\Report\Appendix_G\FigureG42_Puntei_Creek_Flood_Planning_Area.mxd

**APPENDIX H: DESIGN FLOOD MAPS – FULLERS CREEK AND FRESHWATER CREEK**

Appendix H

FIGURE H1

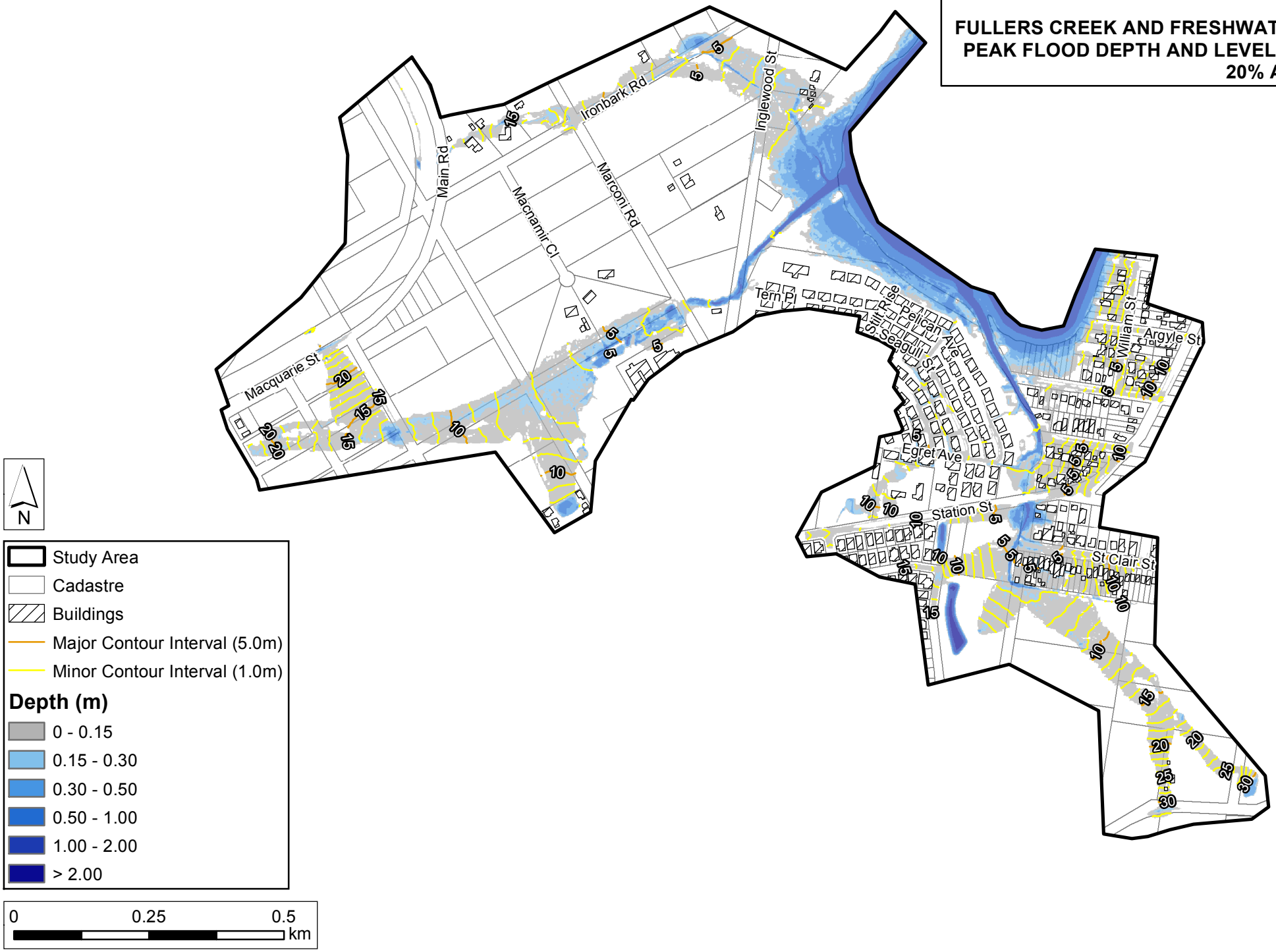
**FULLERS CREEK AND FRESHWATER CREEK**
**PEAK FLOOD DEPTH AND LEVEL CONTOUR**
**50% AEP EVENT**




J:\Jobs\1190776\ArcGIS\ArcMap\Working\Template\Appendix_H\FigureH01_FFC_Peak_Flood_Depth_50%AEP.mxd

FIGURE H2

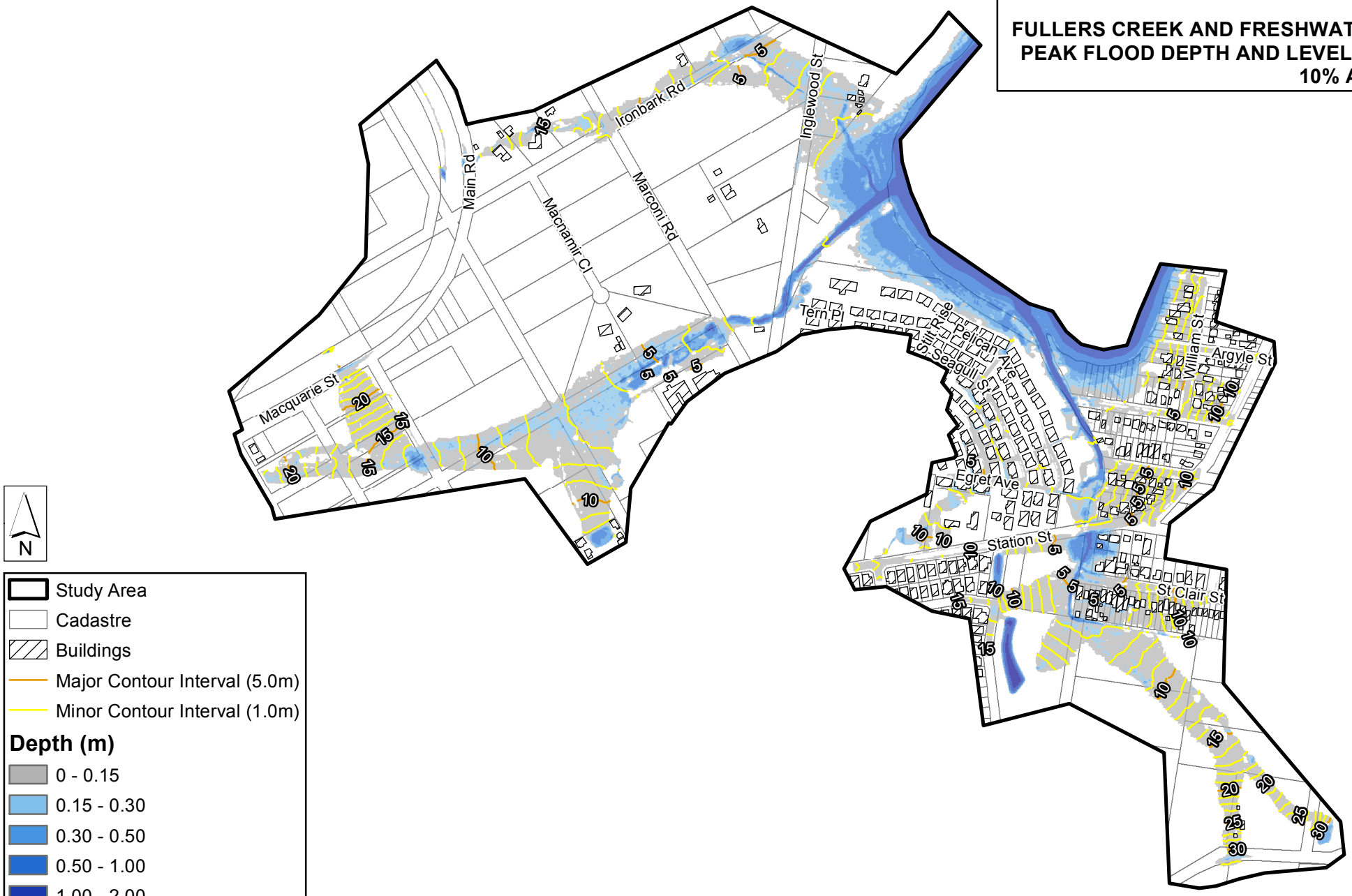
# FULLERS CREEK AND FRESHWATER CREEK PEAK FLOOD DEPTH AND LEVEL CONTOUR 20% AEP EVENT




J:\Jobs\1190776\ArcGIS\ArcMap\Working\Template\Appendix_H\FigureH02_FFC_Peak_Flood_Depth_20%AEP.mxd

FIGURE H3

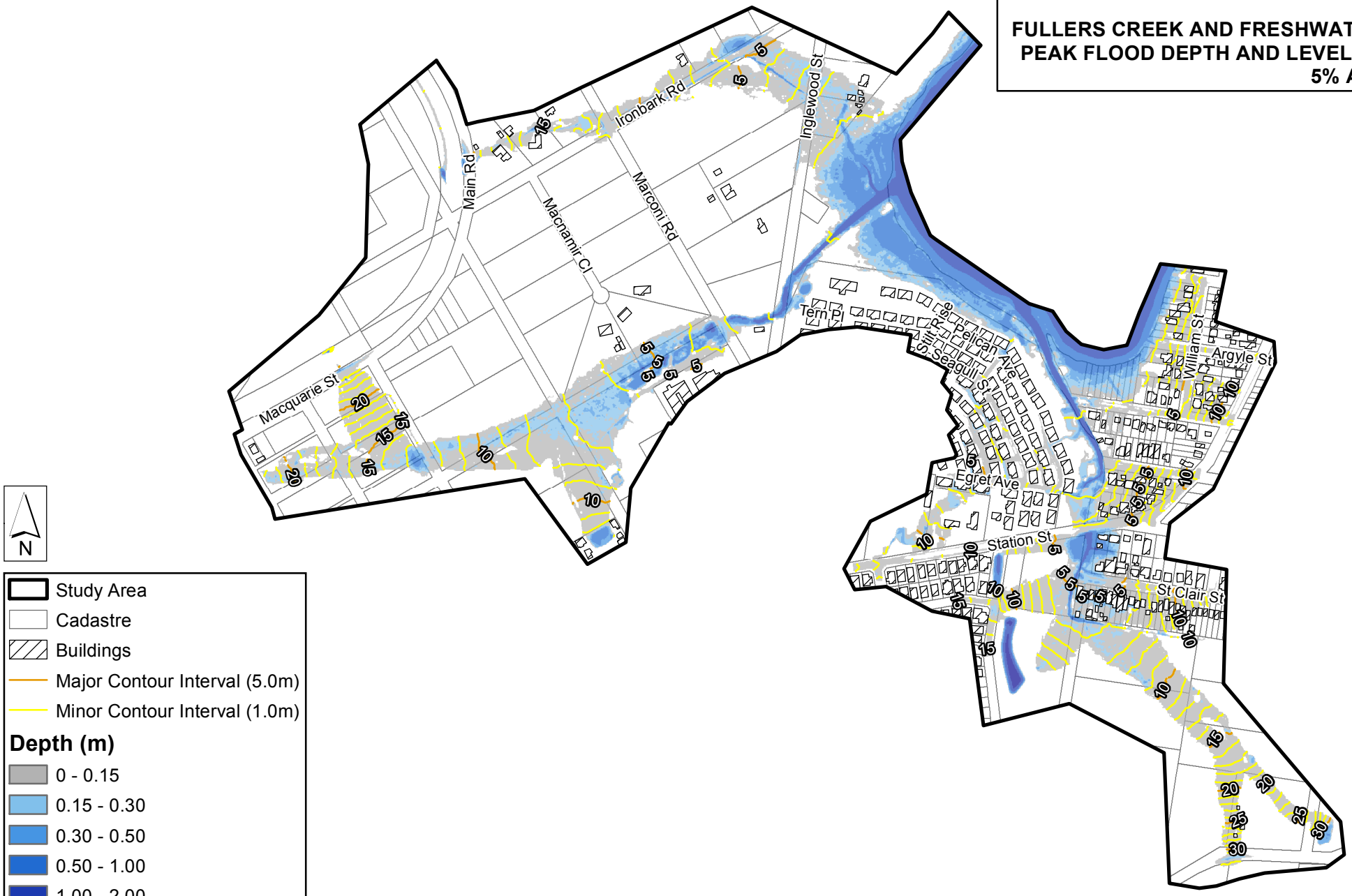
# FULLERS CREEK AND FRESHWATER CREEK PEAK FLOOD DEPTH AND LEVEL CONTOUR 10% AEP EVENT




J:\Jobs\1190776\ArcGIS\ArcMap\Working\Template\Appendix_H\FigureH03_FFC_Peak_Flood_Depth_10%AEP.mxd

FIGURE H4

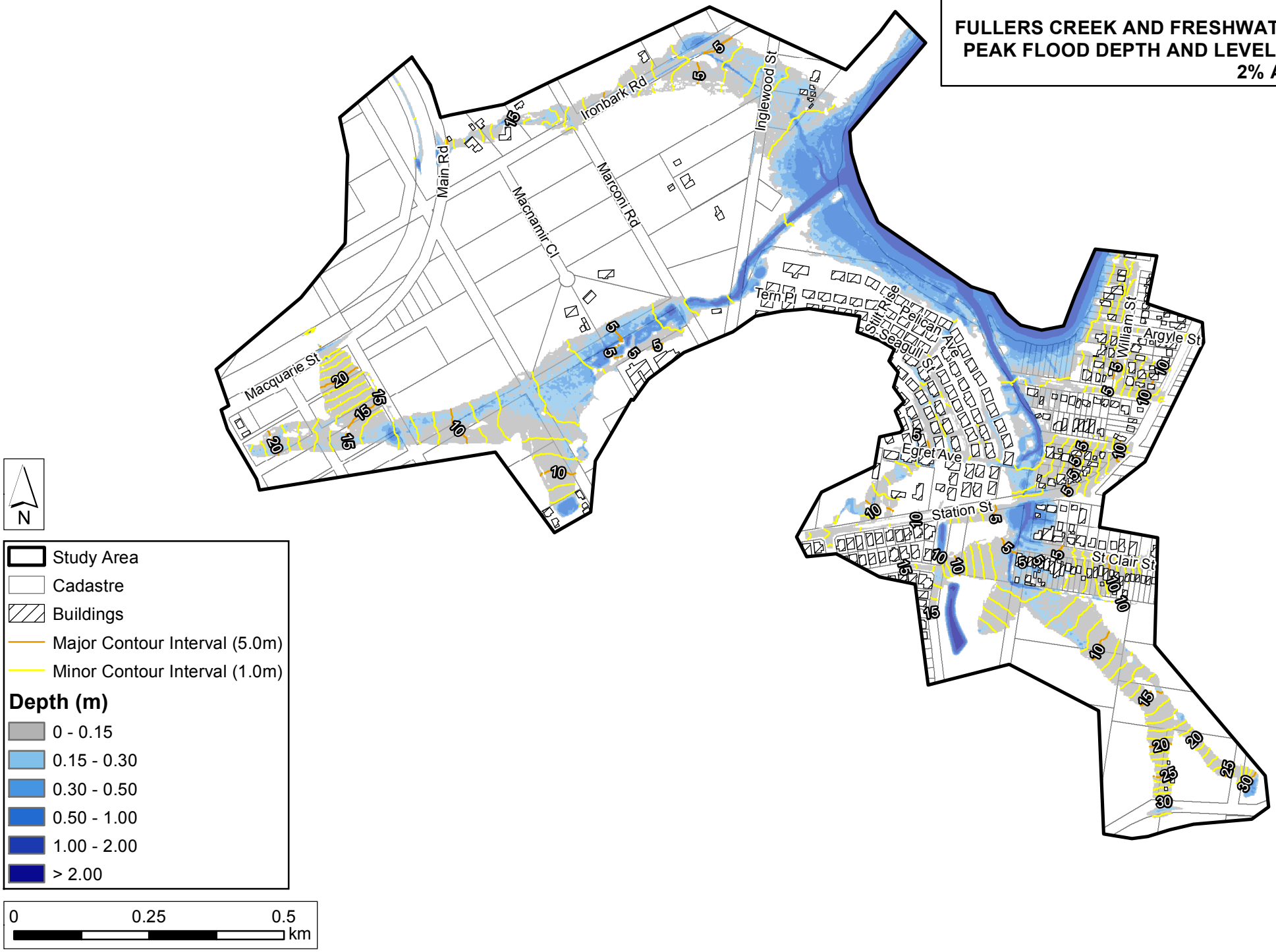
# FULLERS CREEK AND FRESHWATER CREEK PEAK FLOOD DEPTH AND LEVEL CONTOUR 5% AEP EVENT




J:\Jobs\1190776\ArcGIS\ArcMap\Working\Template\Appendix_H\FigureH04_FFC_Peak_Flood_Depth_5%AEP.mxd

FIGURE H5

# FULLERS CREEK AND FRESHWATER CREEK PEAK FLOOD DEPTH AND LEVEL CONTOUR 2% AEP EVENT




J:\Jobs\1190776\ArcGIS\ArcMap\Working\Template\Appendix_H\FigureH05_FFC_Peak_Flood_Depth_2%AEP.mxd

FIGURE H6

# FULLERS CREEK AND FRESHWATER CREEK PEAK FLOOD DEPTH AND LEVEL CONTOUR 1% AEP EVENT

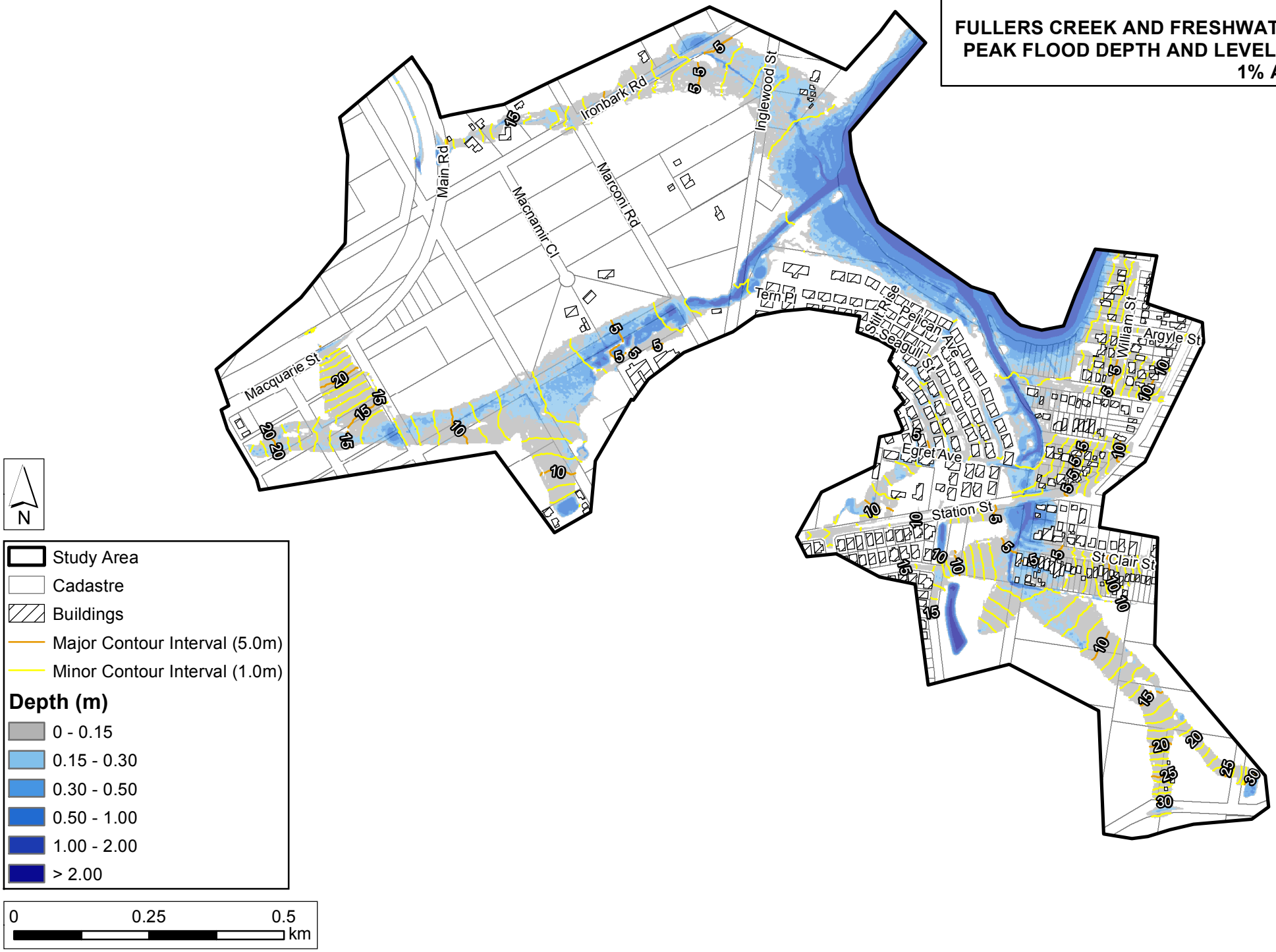



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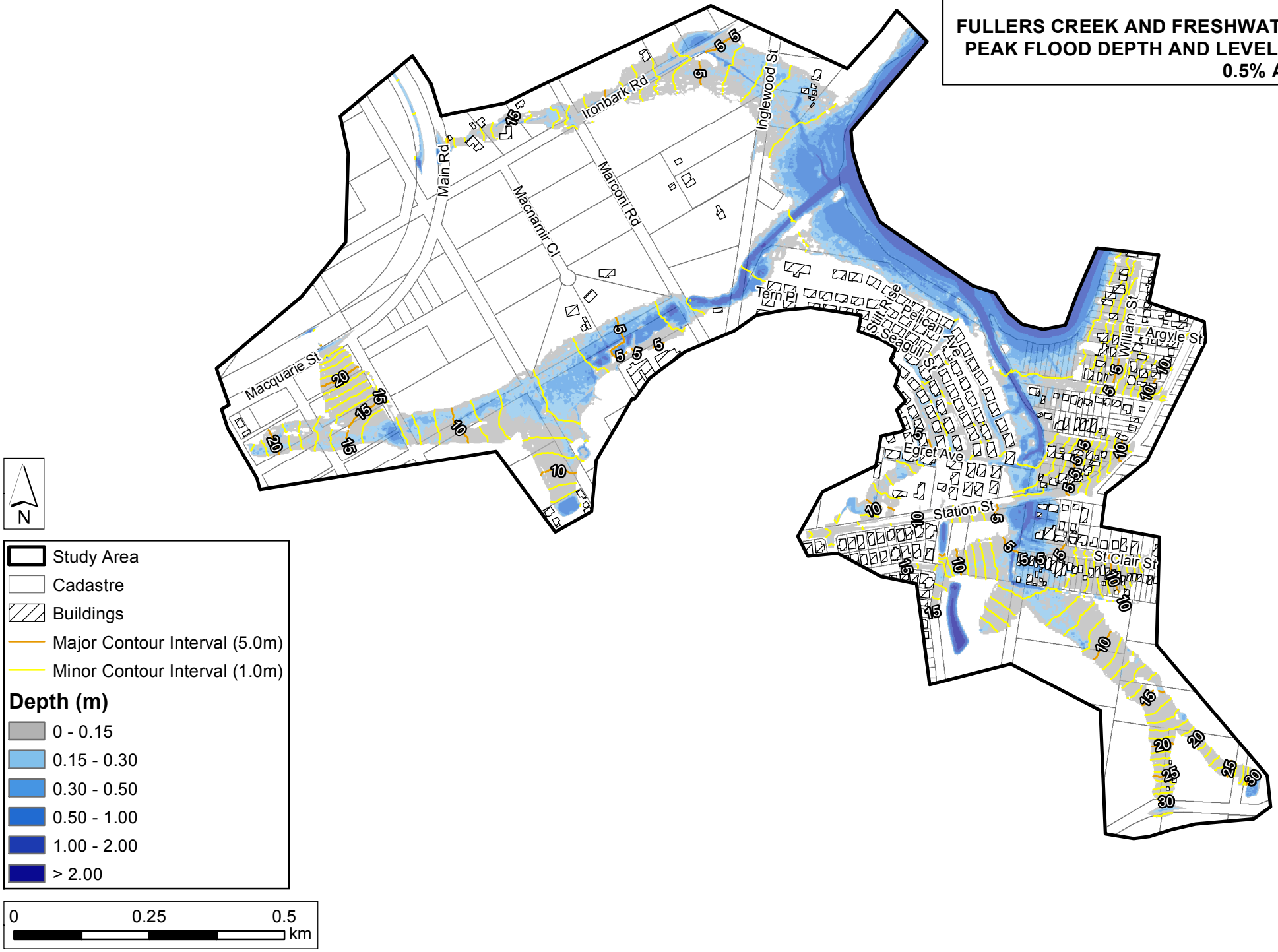
FIGURE H7

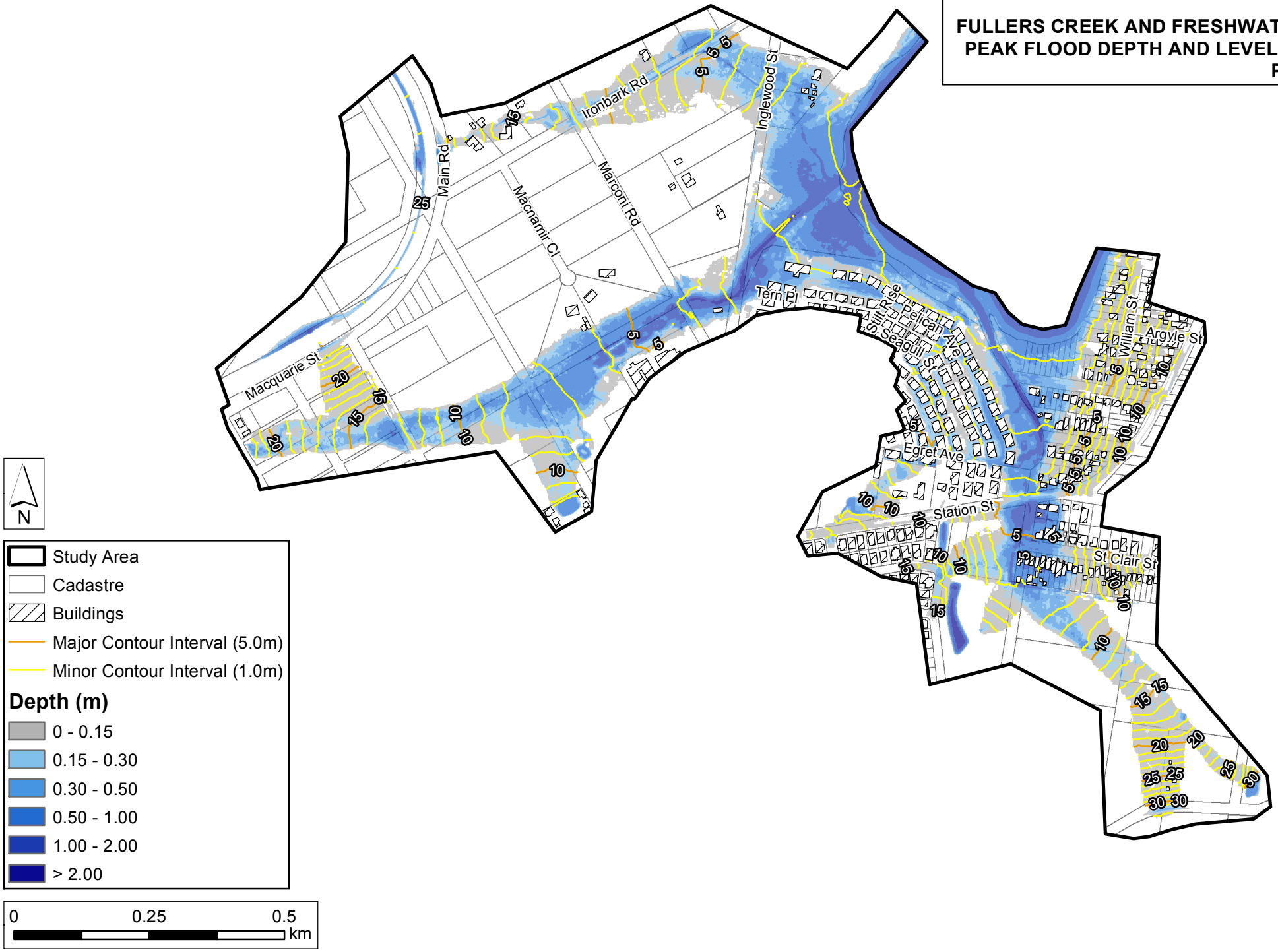
**FULLERS CREEK AND FRESHWATER CREEK**
**PEAK FLOOD DEPTH AND LEVEL CONTOUR**
**0.5% AEP EVENT**




J:\Jobs\1190776\ArcGIS\ArcMap\Working\Template\Appendix_H\FigureH07_FFC_Peak_Flood_Depth_0.5%AEP.mxd

FIGURE H8

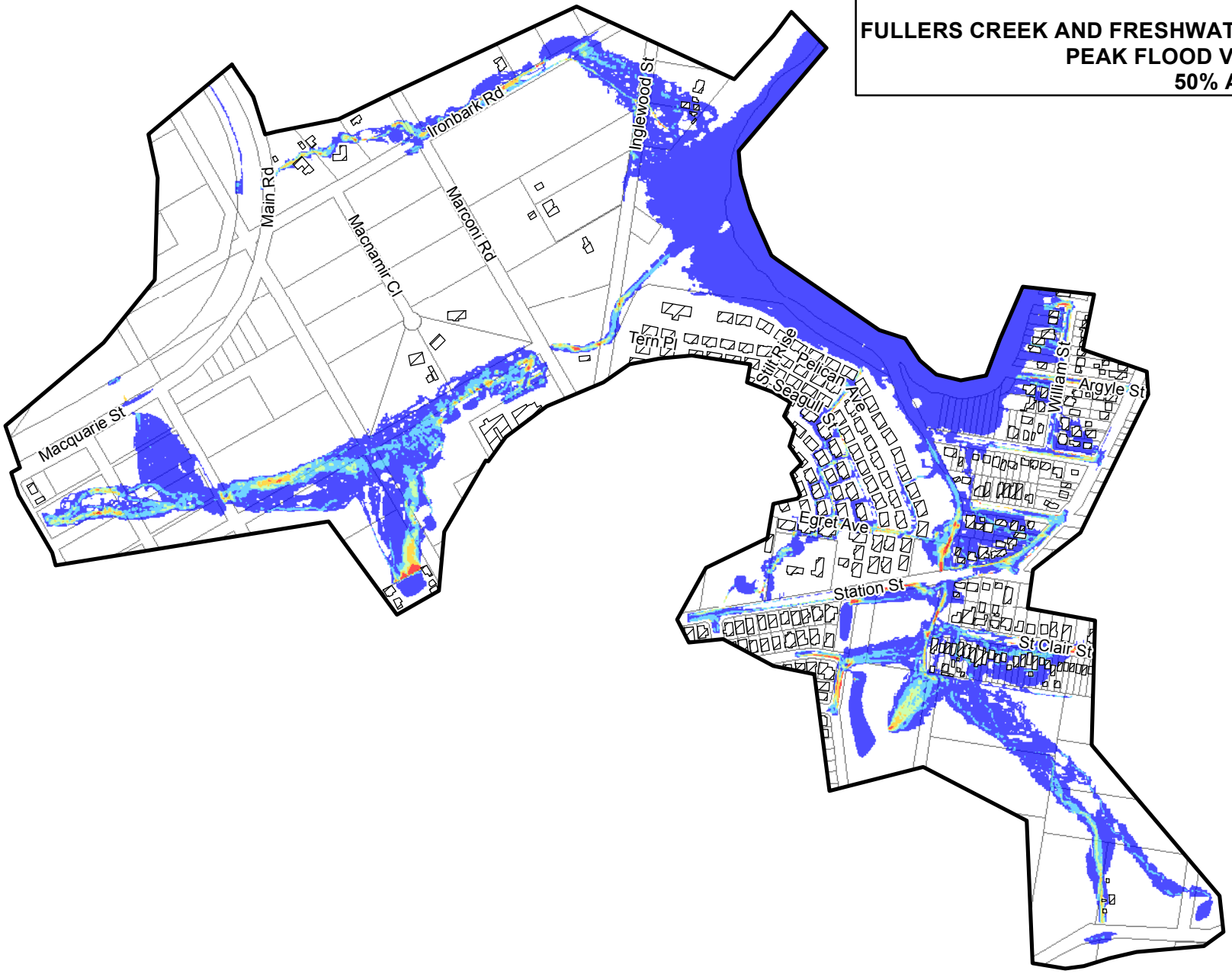
# FULLERS CREEK AND FRESHWATER CREEK PEAK FLOOD DEPTH AND LEVEL CONTOUR PMF EVENT




J:\Jobs\1190776\ArcGIS\ArcMap\Working\Template\Appendix_H\FigureH08_FFC_Peak_Flood_Depth_PMF.mxd

FIGURE H9

**FULLERS CREEK AND FRESHWATER CREEK**
**PEAK FLOOD VELOCITIES**
**50% AEP EVENT**




N

Study Area
Cadastre
Buildings

**Velocity (m/s)**

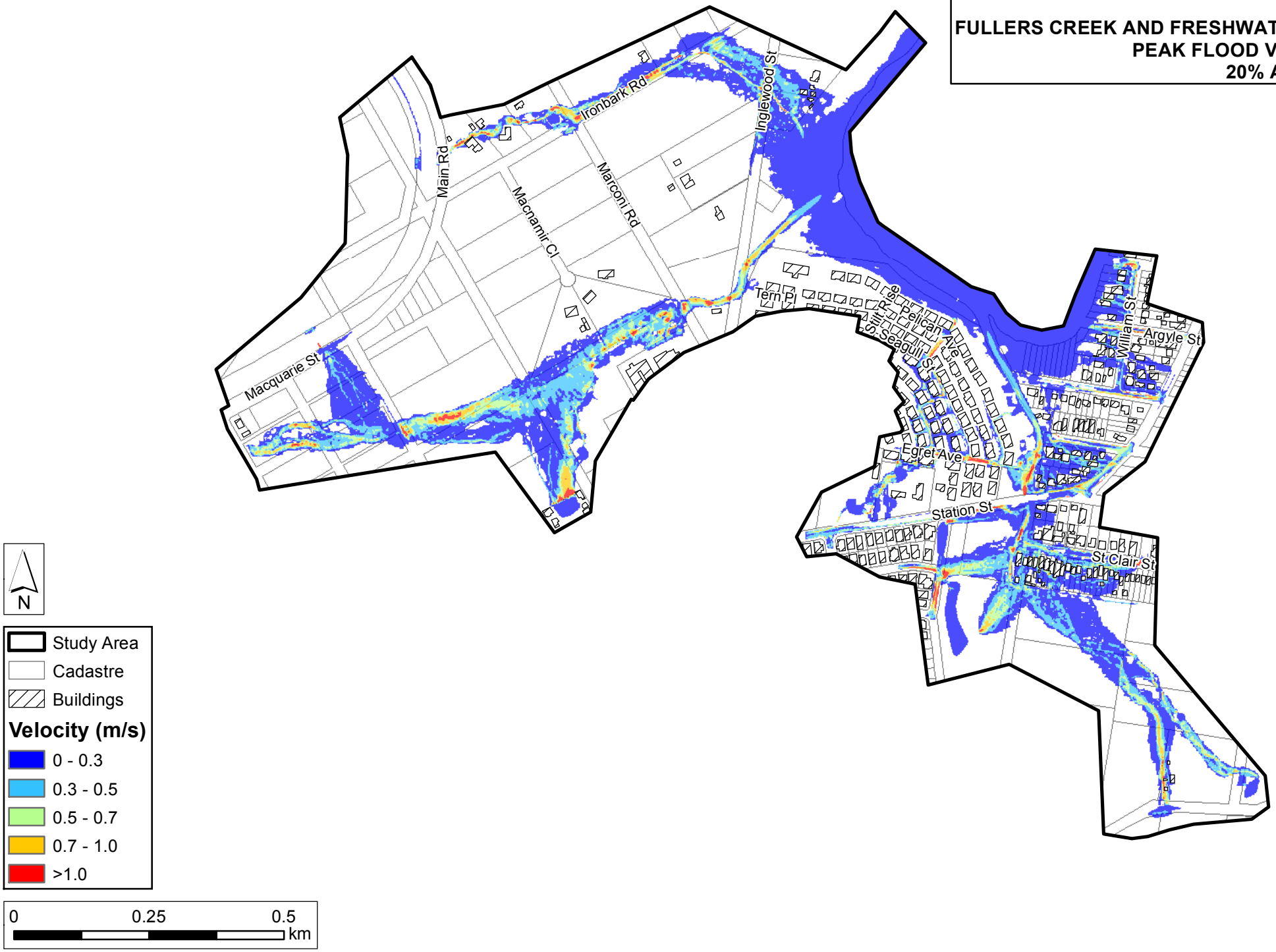
0 - 0.3
0.3 - 0.5
0.5 - 0.7
0.7 - 1.0
>1.0

0 0.25 0.5 km

J:\Jobs\1190776\ArcGIS\ArcMap\Working\Template\Appendix_G\FigureH08_FFC_Peak_Flood_Depth_PMF.mxd

FIGURE H10

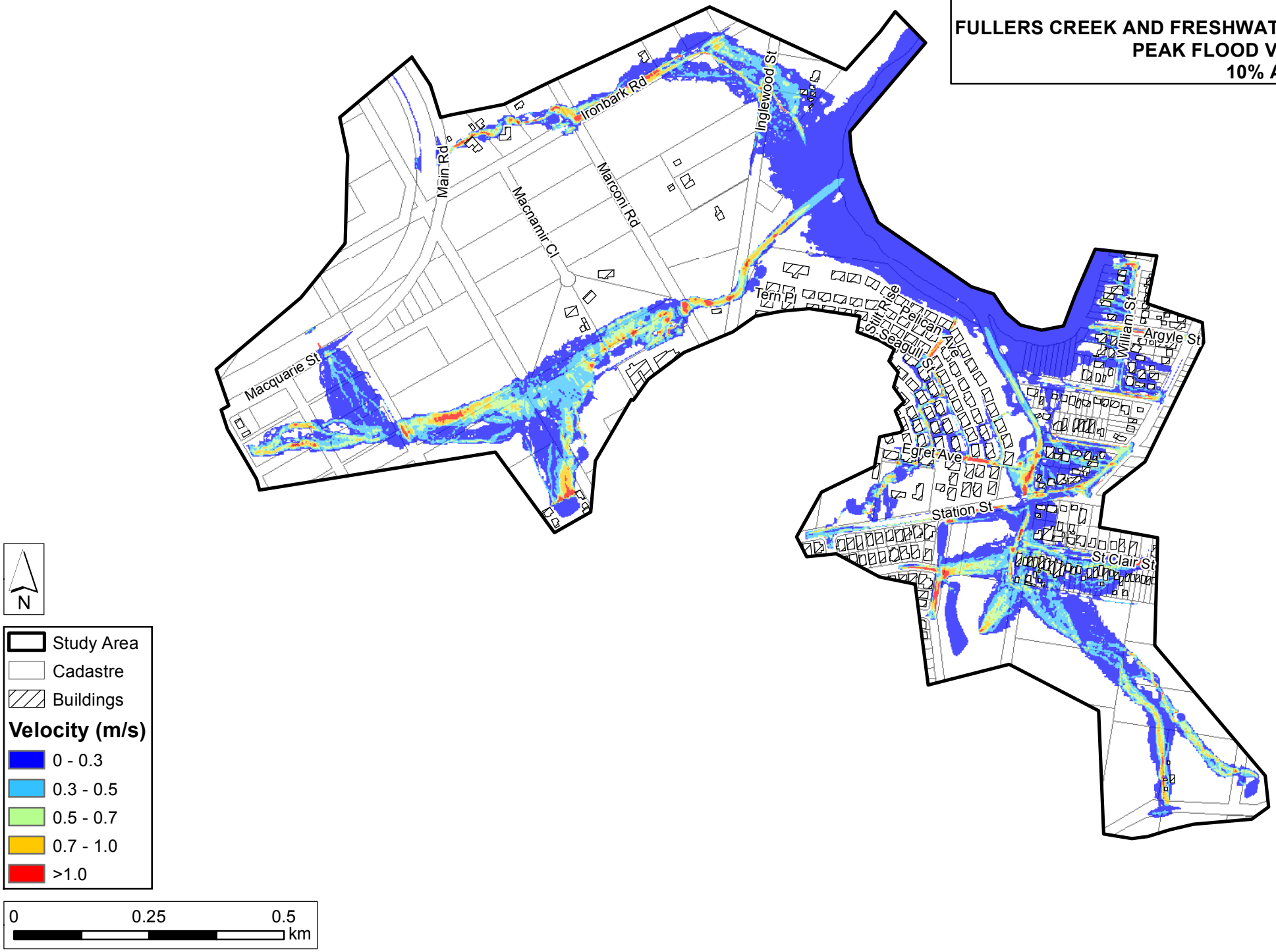
**FULLERS CREEK AND FRESHWATER CREEK**
**PEAK FLOOD VELOCITIES**
**20% AEP EVENT**




J:\Jobs\1190776\ArcGIS\ArcMap\Working\Template\Appendix_G\FigureH09_FFC_Peak_Flood_Velocity_50%AEP.mxd

FIGURE H11

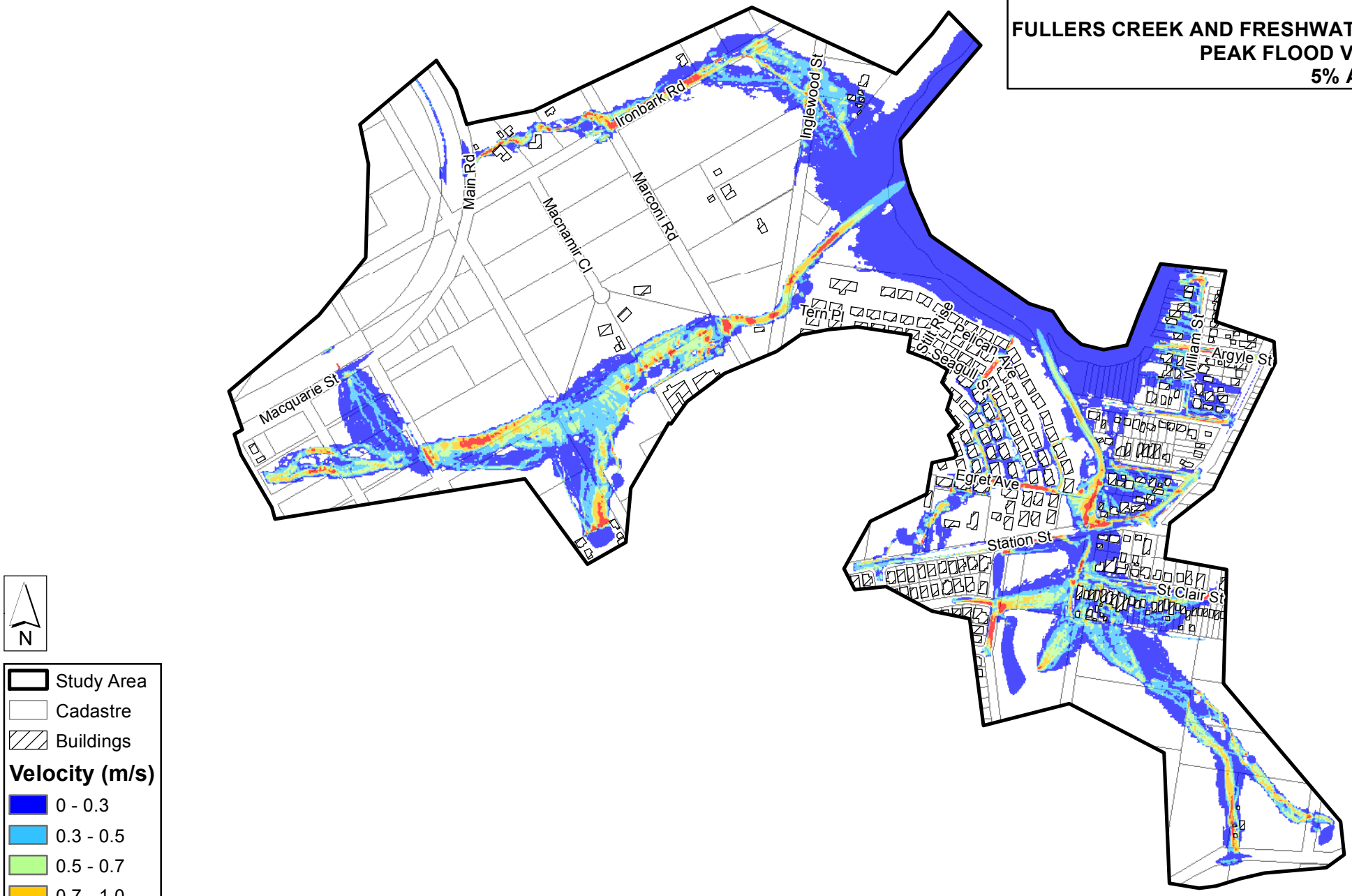
**FULLERS CREEK AND FRESHWATER CREEK**
**PEAK FLOOD VELOCITIES**
**10% AEP EVENT**




J:\Jobs\1190776\ArcGIS\ArcMap\Working\Template\Appendix_G\FigureH10_FFC_Peak_Flood_Velocity_20%AEP.mxd

FIGURE H12

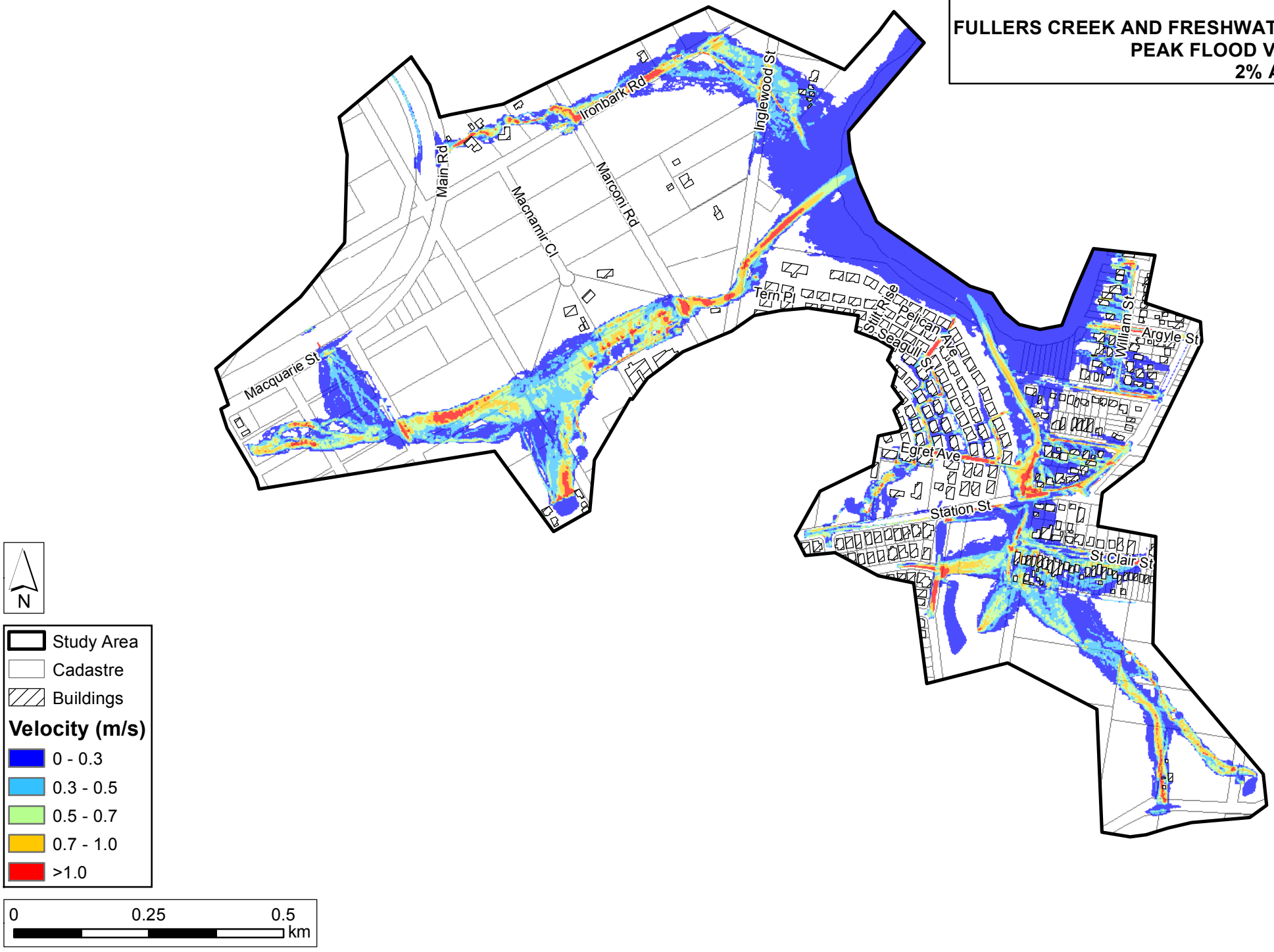
**FULLERS CREEK AND FRESHWATER CREEK**
**PEAK FLOOD VELOCITIES**
**5% AEP EVENT**




J:\Jobs\1190776\ArcGIS\ArcMap\Working\Template\Appendix_G\FigureH11_FFC_Peak_Flood_Velocity_10%AEP.mxd

FIGURE H13

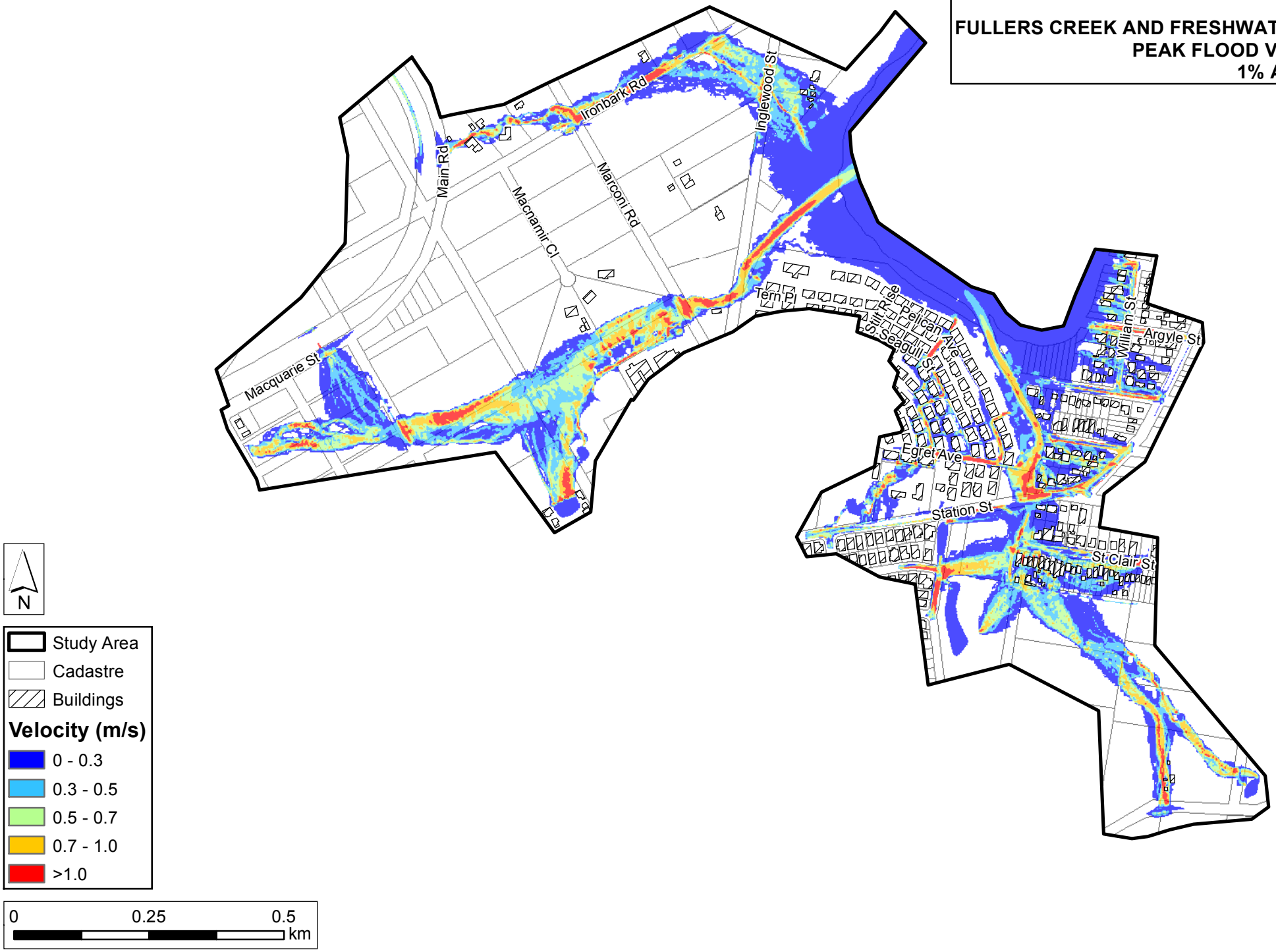
**FULLERS CREEK AND FRESHWATER CREEK**
**PEAK FLOOD VELOCITIES**
**2% AEP EVENT**




J:\Jobs\1190776\ArcGIS\ArcMap\Working\Template\Appendix_G\FigureH12_FFC_Peak_Flood_Velocity_5%AEP.mxd

FIGURE H14

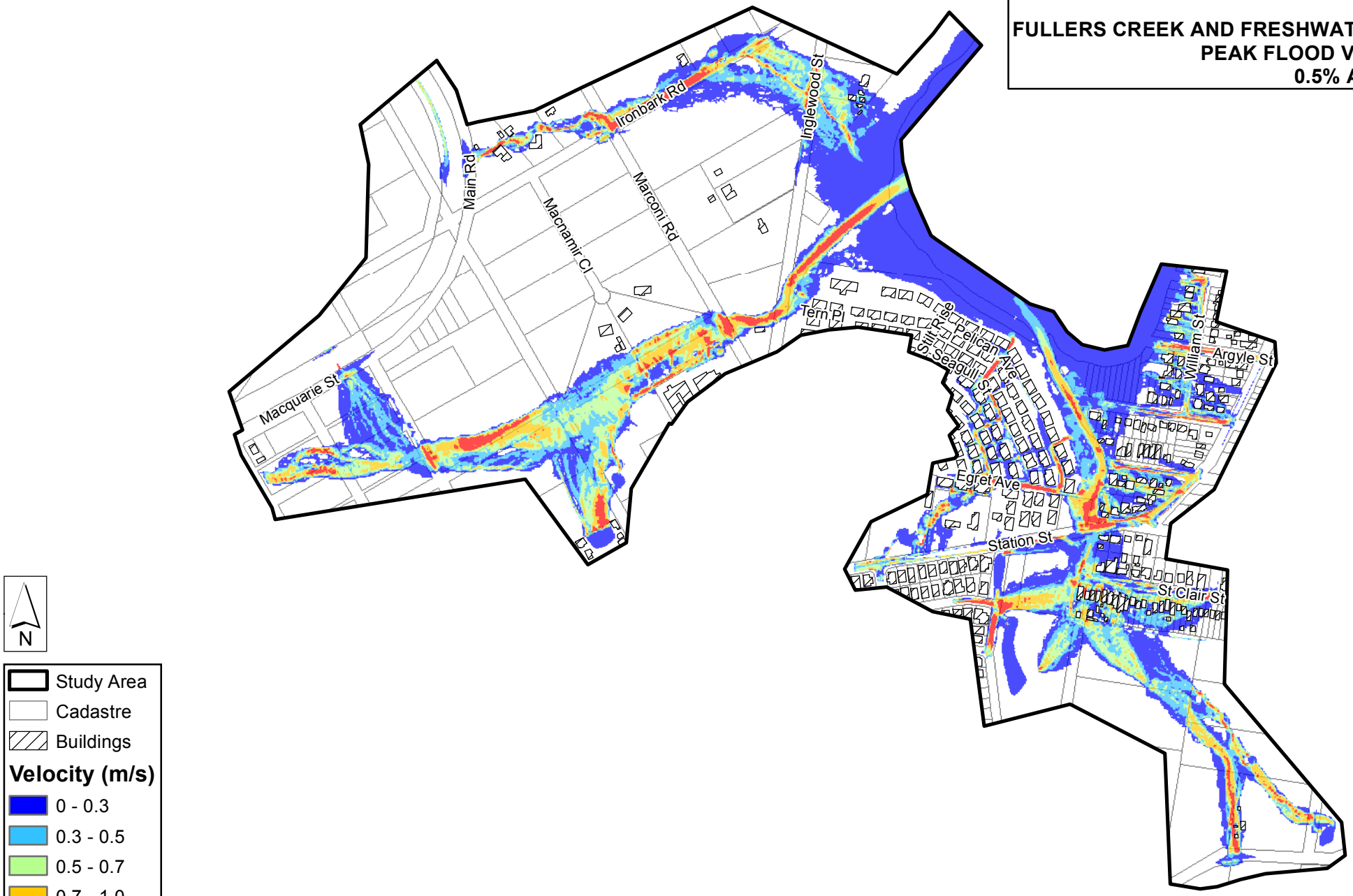
**FULLERS CREEK AND FRESHWATER CREEK**
**PEAK FLOOD VELOCITIES**
**1% AEP EVENT**




J:\Jobs\1190776\ArcGIS\ArcMap\Working\Template\Appendix_G\FigureH13_FFC_Peak_Flood_Velocity_2%AEP.mxd

FIGURE H15

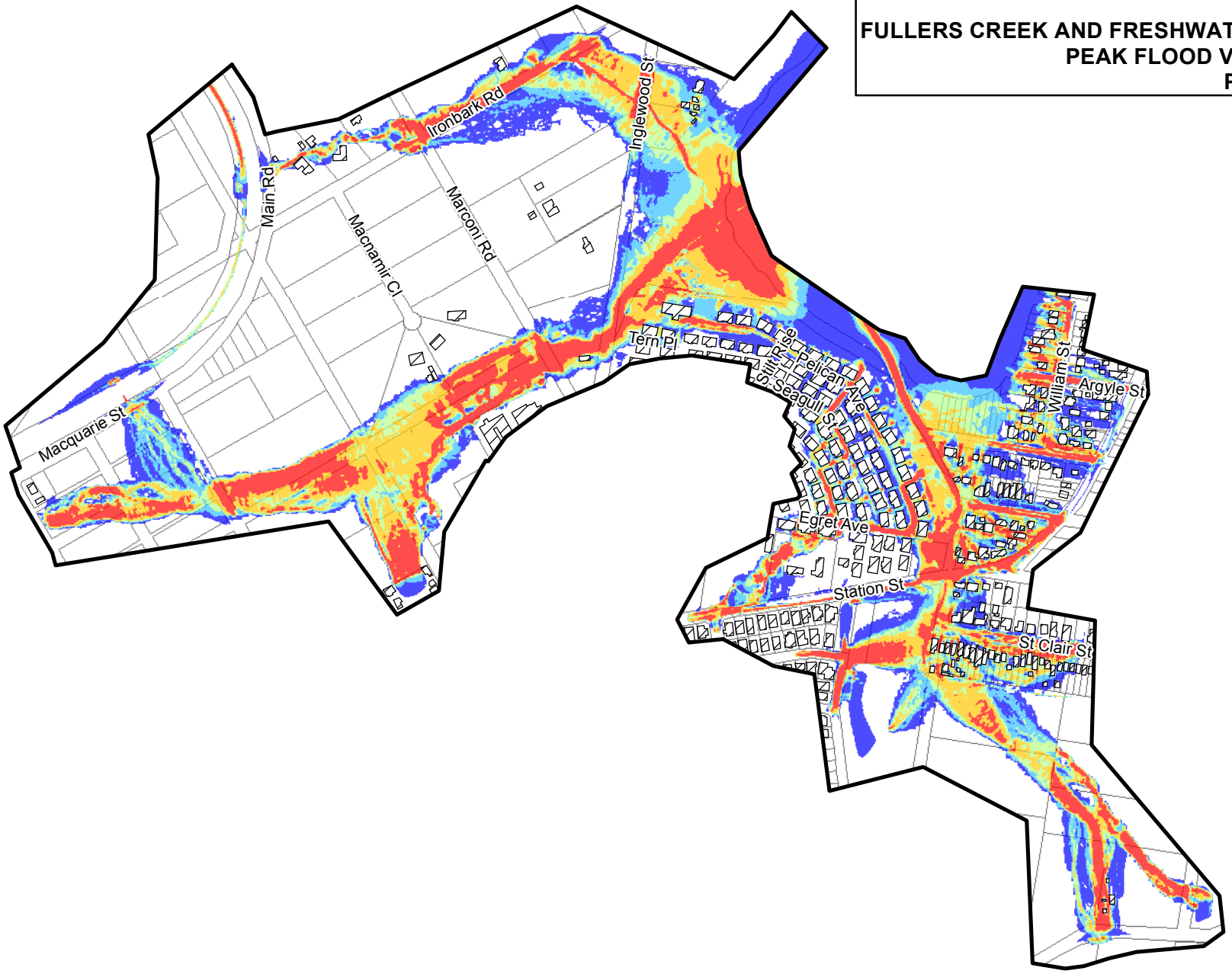
**FULLERS CREEK AND FRESHWATER CREEK**
**PEAK FLOOD VELOCITIES**
**0.5% AEP EVENT**




J:\Jobs\1190776\ArcGIS\ArcMap\Working\Template\Appendix_GIFigureH14_FFC_Peak_Flood_Velocity_1%AEP.mxd

FIGURE H16

**FULLERS CREEK AND FRESHWATER CREEK**
**PEAK FLOOD VELOCITIES**
**PMF EVENT**




N

- Study Area
- Cadastre
- Buildings

**Velocity (m/s)**

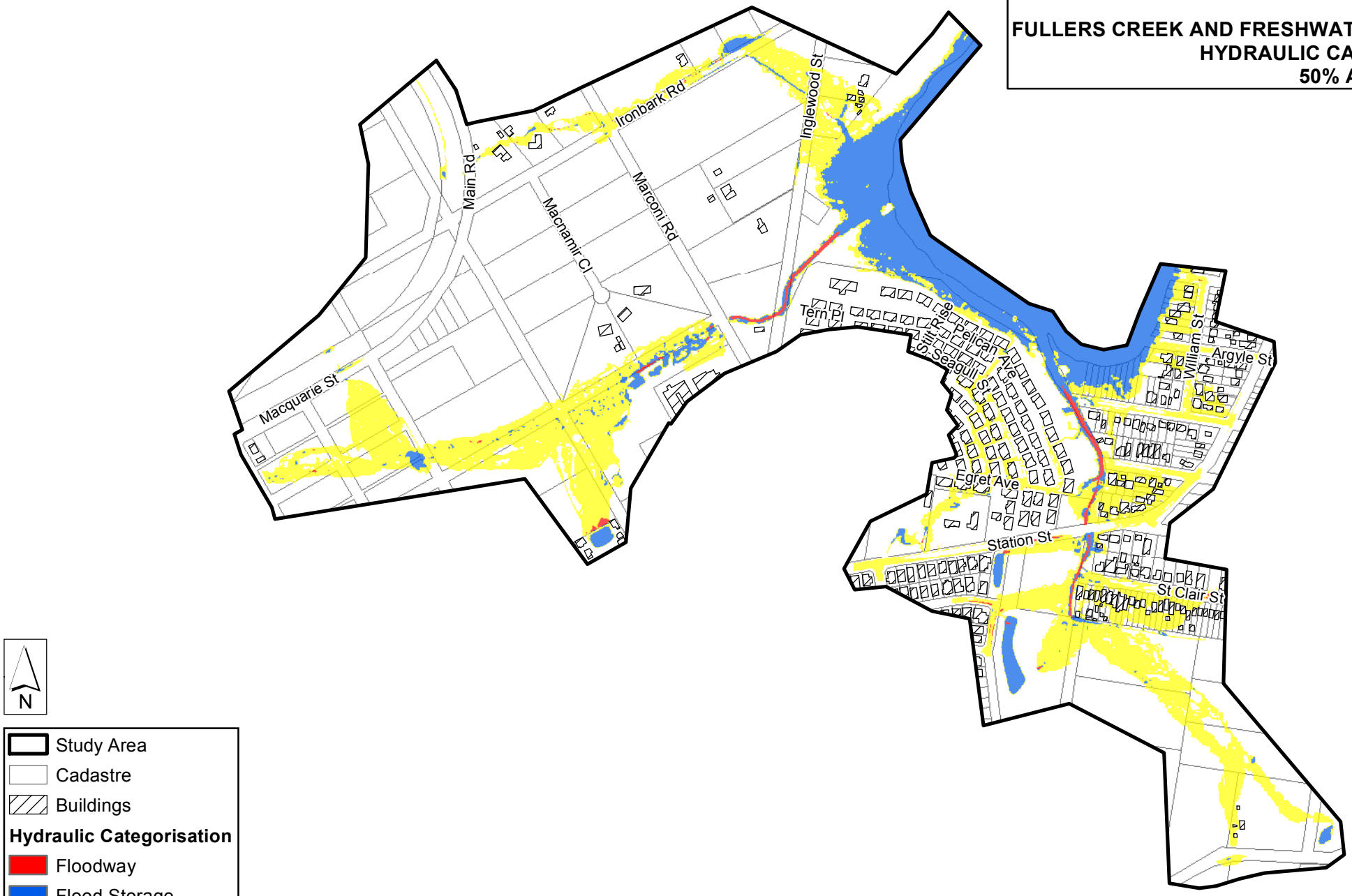
- 0 - 0.3
- 0.3 - 0.5
- 0.5 - 0.7
- 0.7 - 1.0
- >1.0

0 0.25 0.5 km

J:\Jobs\1190776\ArcGIS\ArcMap\Working\Template\Appendix_G\FigureH15_FFC_Peak_Flood_Velocity_0.5%AEP.mxd

FIGURE H17

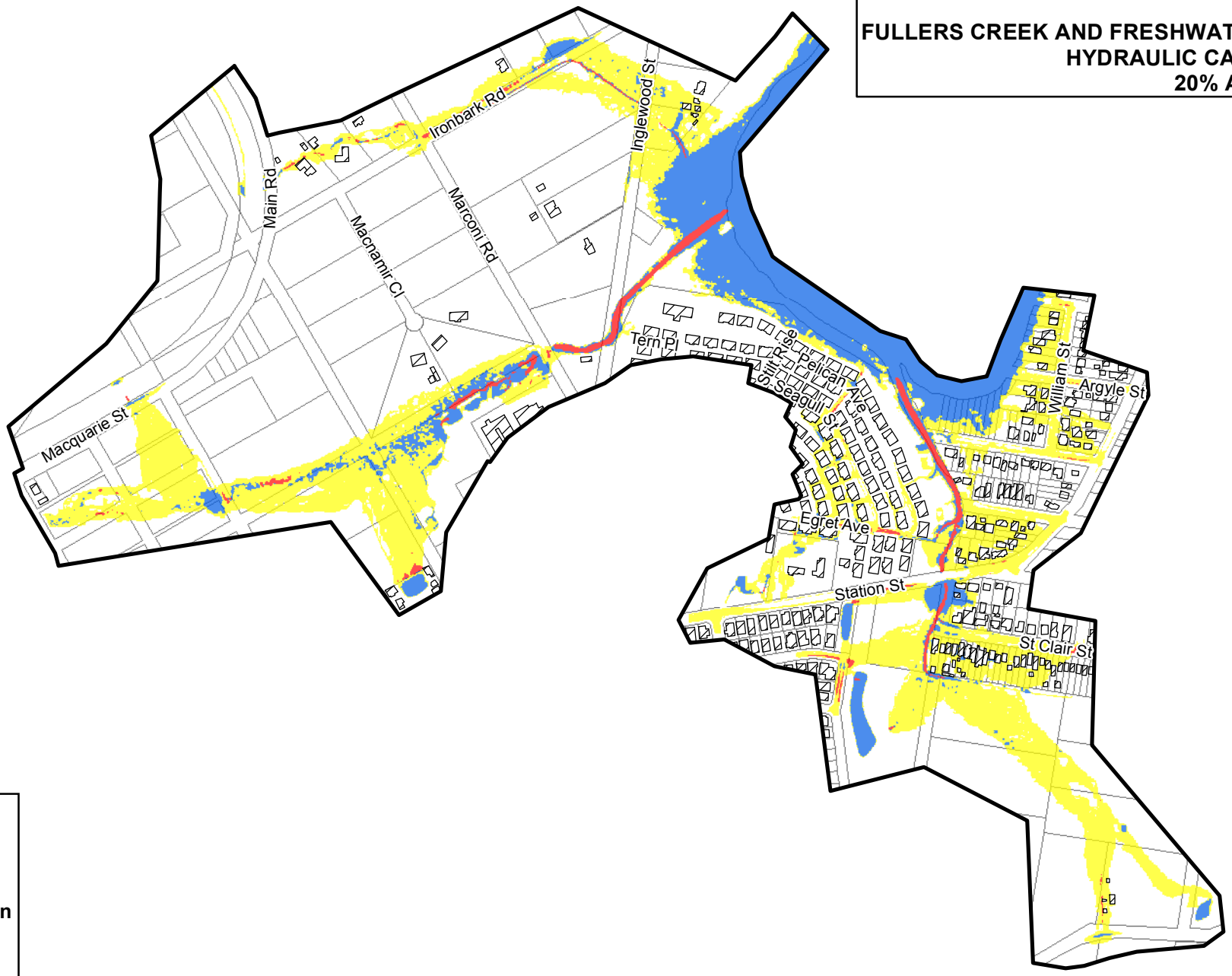
**FULLERS CREEK AND FRESHWATER CREEK**
**HYDRAULIC CATEGORIES**
**50% AEP EVENT**




J:\Jobs\1190776\ArcGIS\ArcMap\Working\Template\Appendix_G\FigureH16_FFC_Peak_Flood_Velocity_PMF.mxd

FIGURE H18

# FULLERS CREEK AND FRESHWATER CREEK HYDRAULIC CATEGORIES 20% AEP EVENT




N

- Study Area
- Cadastre
- Buildings

**Hydraulic Categorisation**

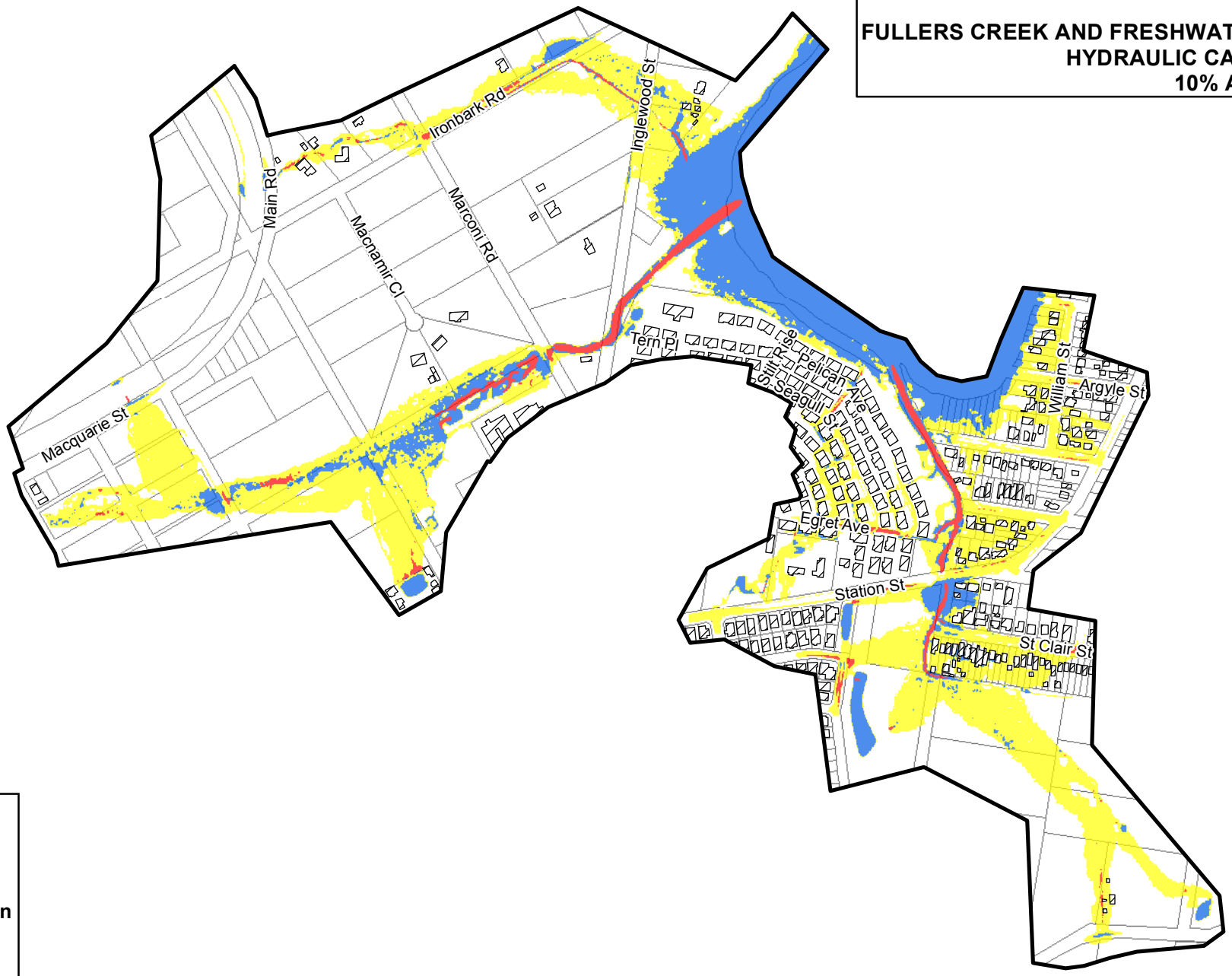
- Floodway
- Flood Storage
- Flood Fringe

0 0.25 0.5 km

J:\Jobs\119076\ArcGIS\ArcMap\Working\Template\Appendix_G\FigureH17_FFC_Hydraulic_Categories_50%AEP.mxd

FIGURE H19

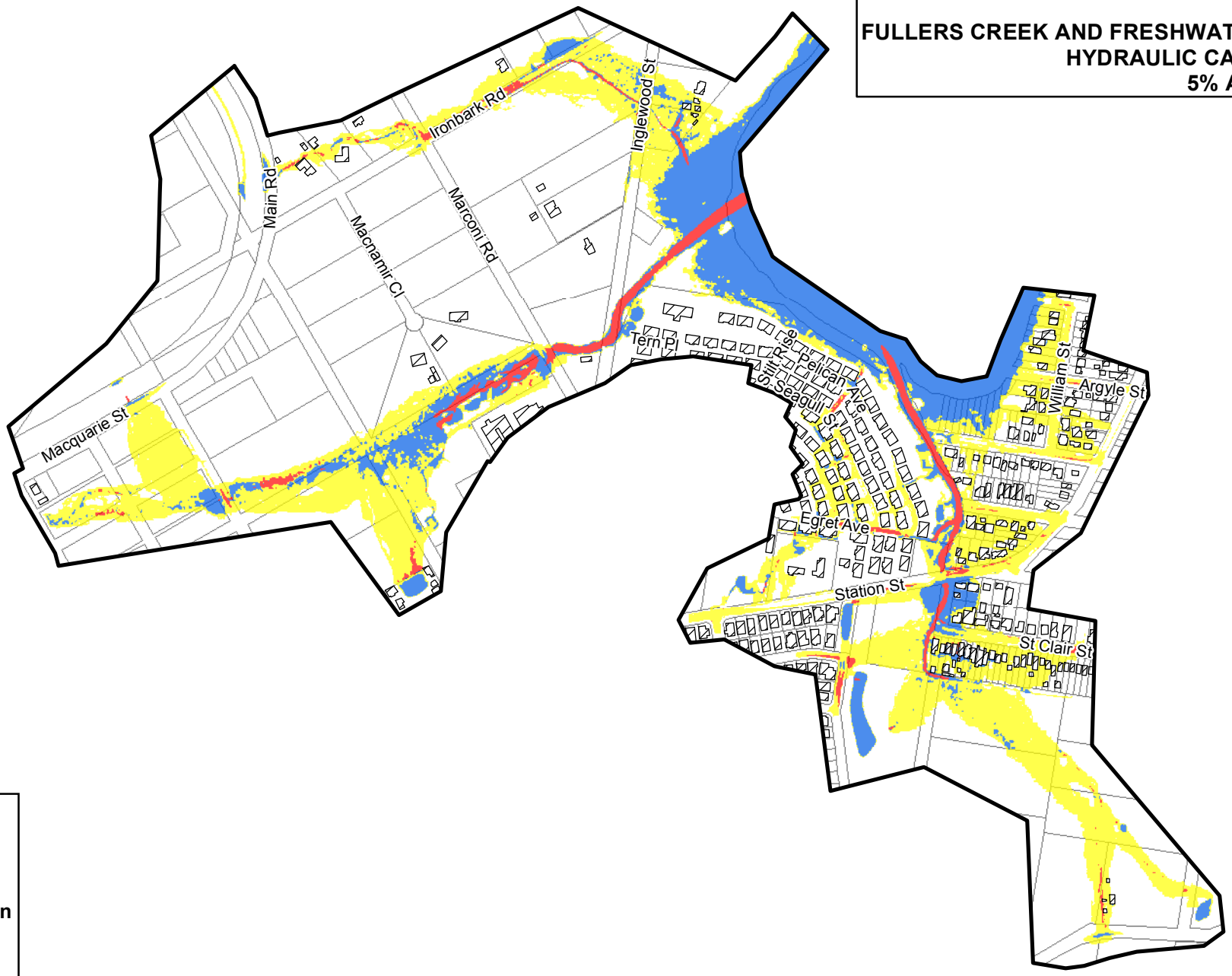
# FULLERS CREEK AND FRESHWATER CREEK HYDRAULIC CATEGORIES 10% AEP EVENT




J:\Jobs\119076\ArcGIS\ArcMap\Working\Template\Appendix_G\FigureH18_FFC_Hydraulic_Categories_20%AEP.mxd

FIGURE H20

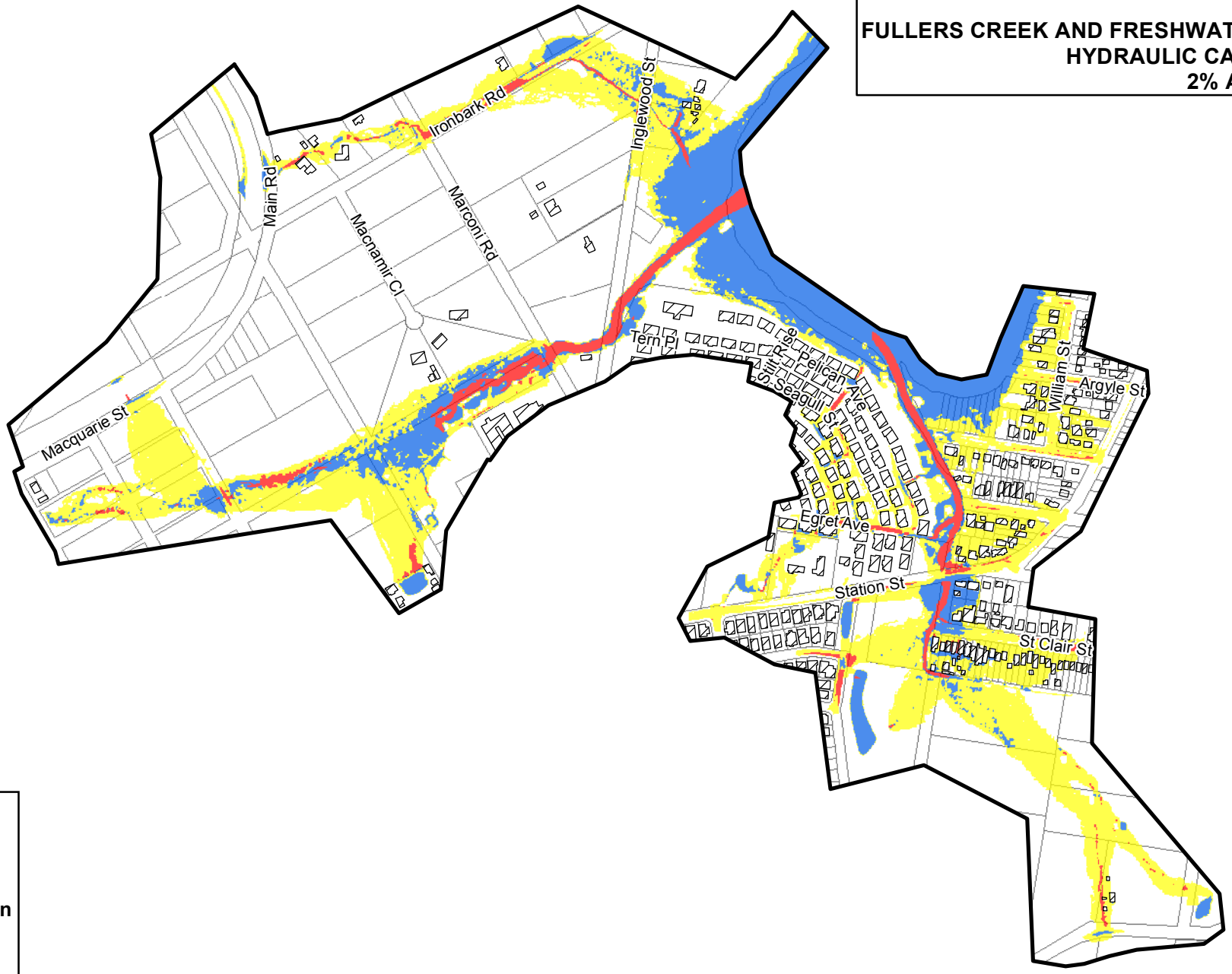
# FULLERS CREEK AND FRESHWATER CREEK HYDRAULIC CATEGORIES 5% AEP EVENT




J:\Jobs\119076\ArcGIS\ArcMap\Working\Template\Appendix_G\FigureH19_FFC_Hydraulic_Categories_10%AEP.mxd

FIGURE H21

**FULLERS CREEK AND FRESHWATER CREEK**
**HYDRAULIC CATEGORIES**
**2% AEP EVENT**




N

- Study Area
- Cadastre
- Buildings

**Hydraulic Categorisation**

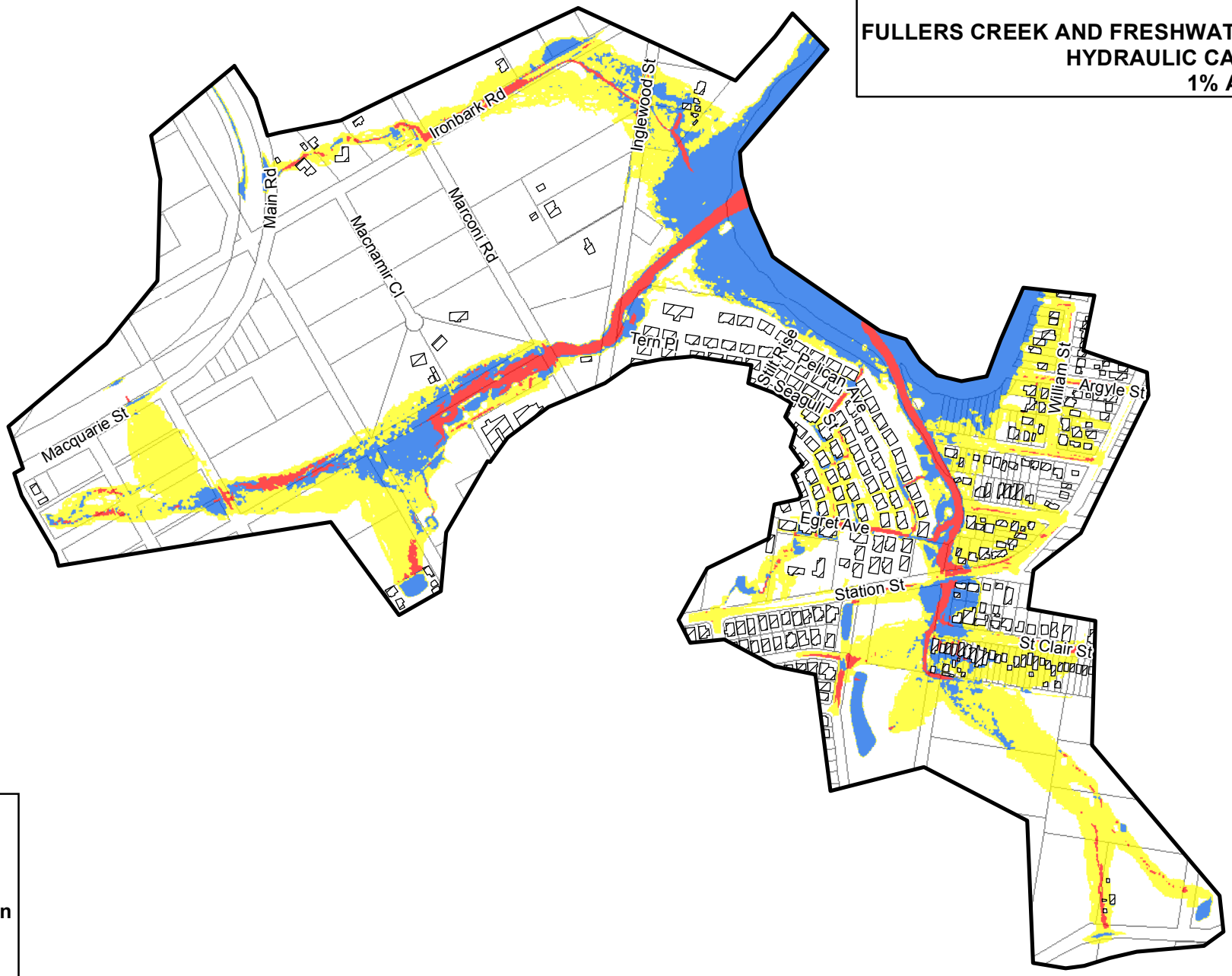
- Floodway
- Flood Storage
- Flood Fringe

0 0.25 0.5 km

J:\Jobs\119076\ArcGIS\ArcMap\Working\Template\Appendix_G\FigureH20_FFC_Hydraulic_Categories_5%AEP.mxd

FIGURE H22

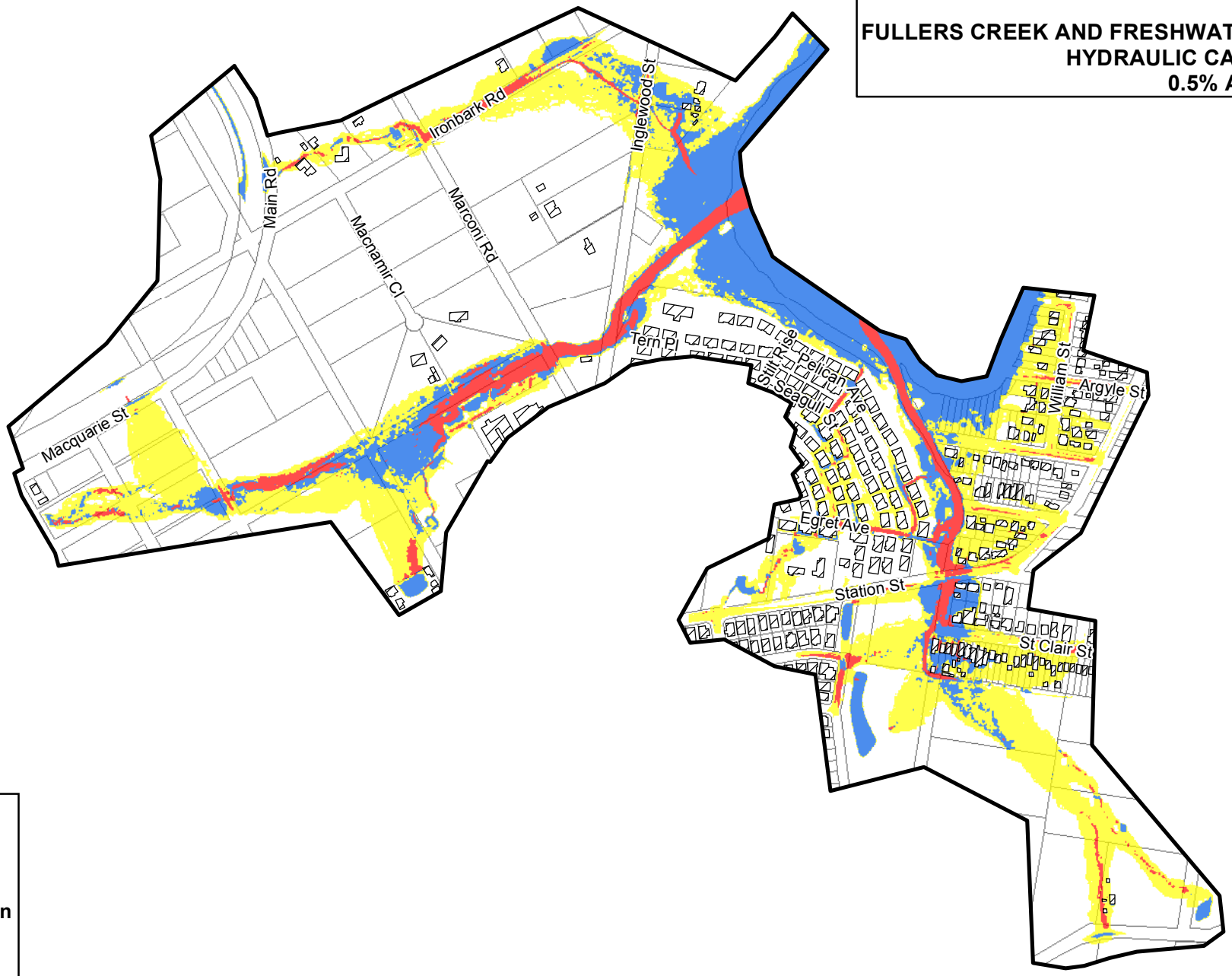
# FULLERS CREEK AND FRESHWATER CREEK HYDRAULIC CATEGORIES 1% AEP EVENT




J:\Jobs\119076\ArcGIS\ArcMap\Working\Template\Appendix_G\FigureH21_FFC_Hydraulic_Categories_2%AEP.mxd

FIGURE H23

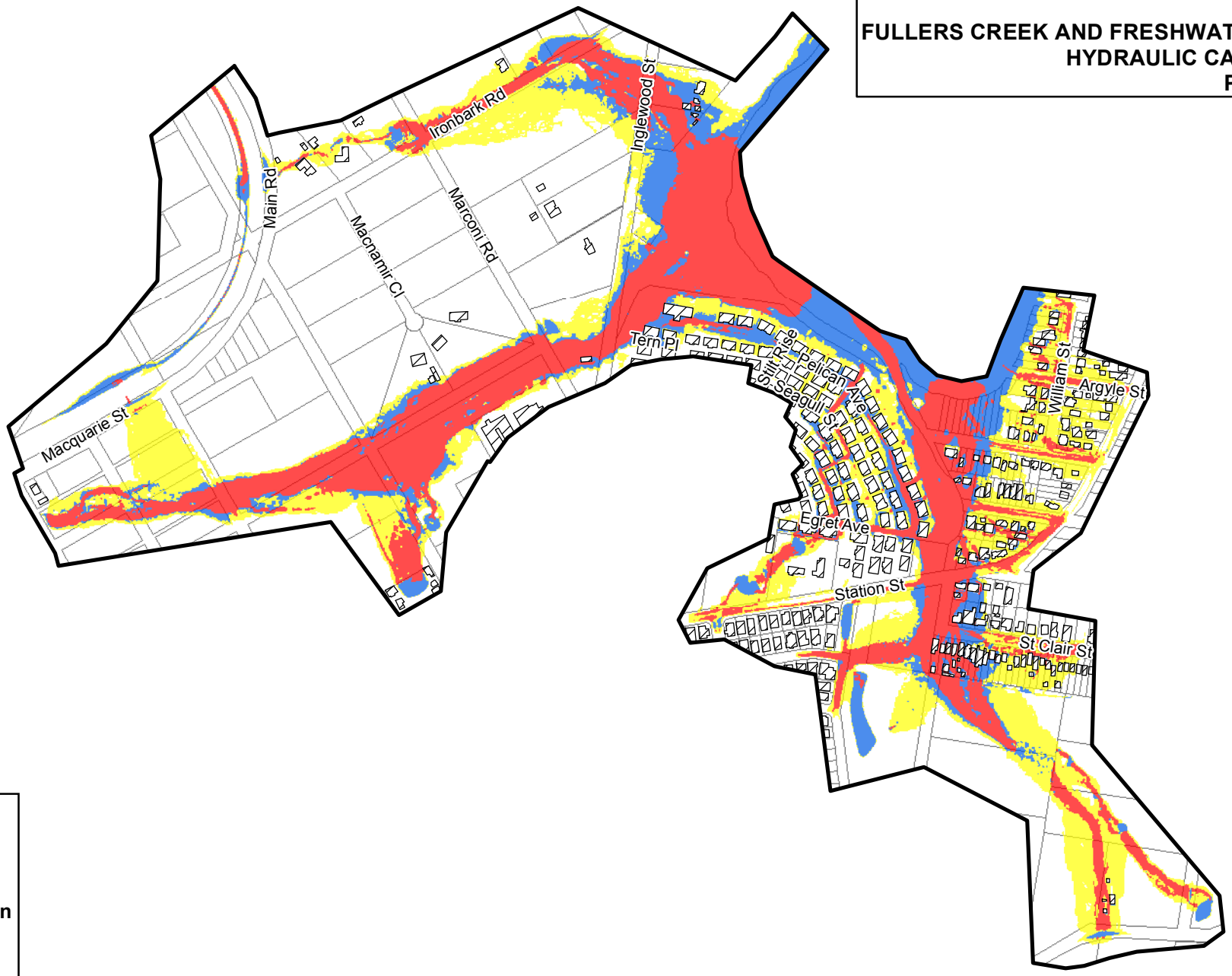
# FULLERS CREEK AND FRESHWATER CREEK HYDRAULIC CATEGORIES 0.5% AEP EVENT




J:\Jobs\119076\ArcGIS\ArcMap\Working\Template\Appendix_GI\FigureH22_FFC_Hydraulic_Categories_1%AEP.mxd

FIGURE H24

# FULLERS CREEK AND FRESHWATER CREEK HYDRAULIC CATEGORIES PMF EVENT




N

- Study Area
- Cadastre
- Buildings

**Hydraulic Categorisation**

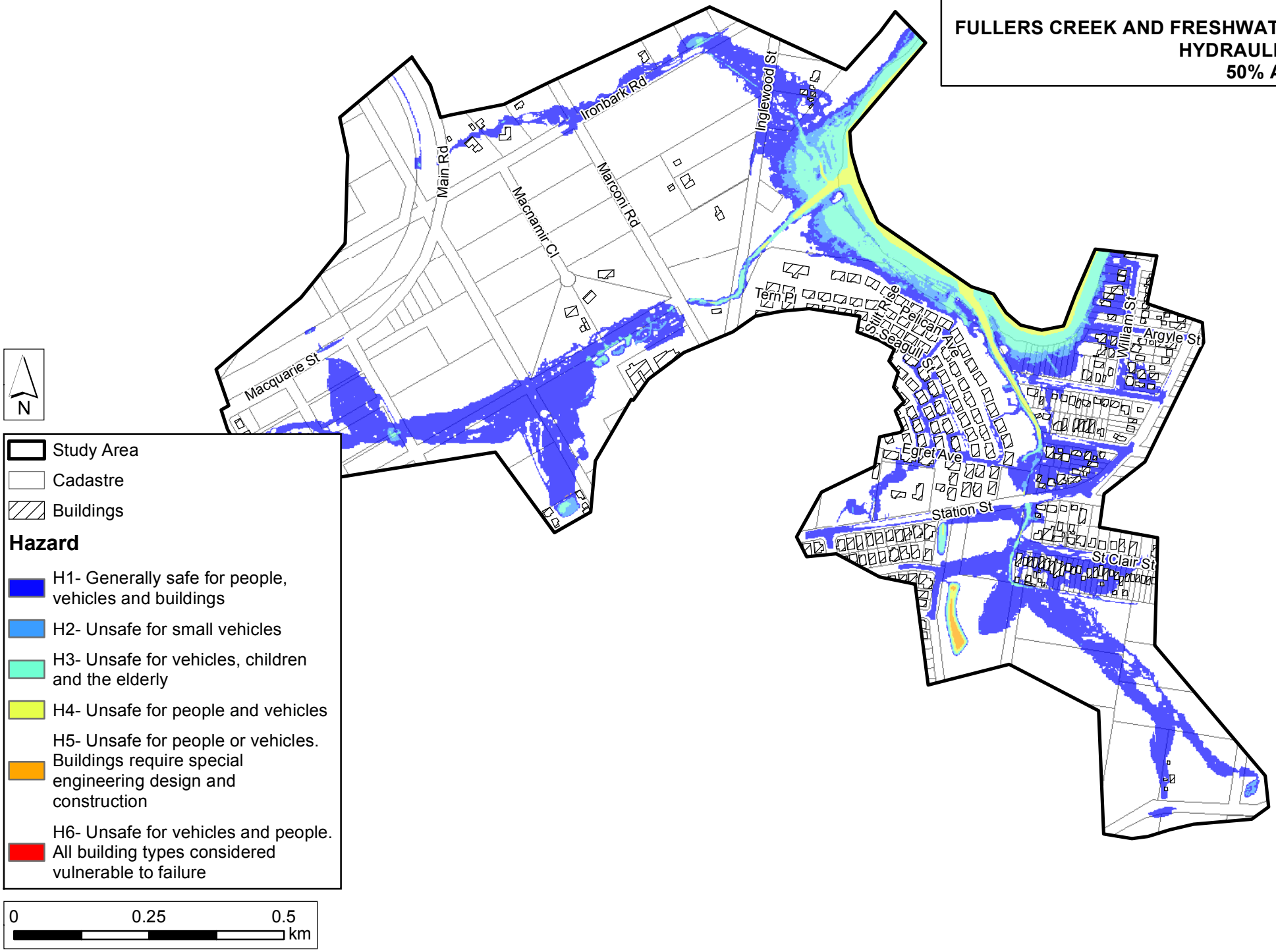
- Floodway
- Flood Storage
- Flood Fringe

0 0.25 0.5 km

J:\Jobs\1190776\ArcGIS\ArcMap\Working\Template\Appendix_G\FigureH23_FFC_Hydraulic_Categories_0.5%AEP.mxd

FIGURE H25

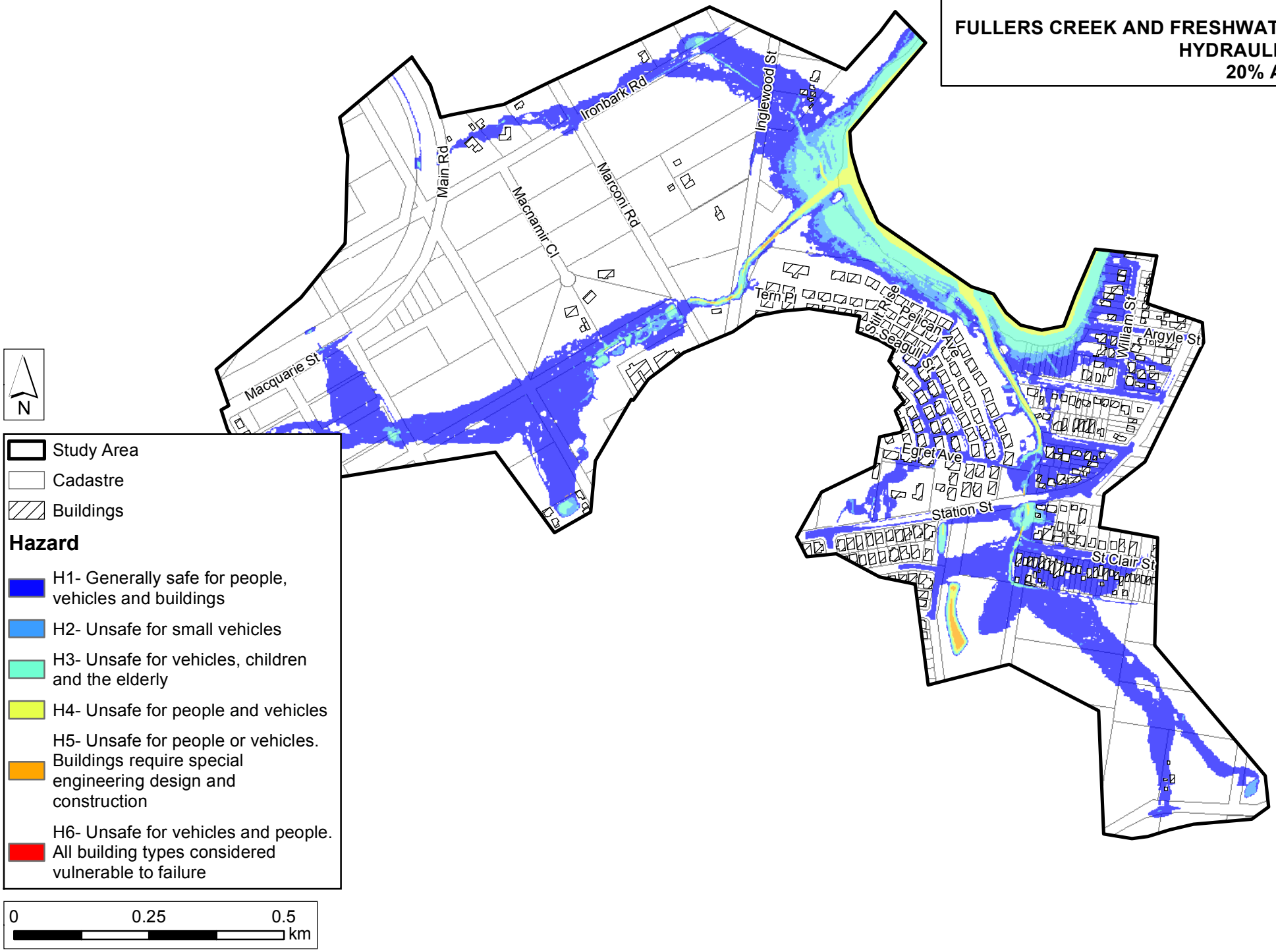
# FULLERS CREEK AND FRESHWATER CREEK HYDRAULIC HAZARD 50% AEP EVENT




J:\Jobs\119076\ArcGIS\ArcMap\Working\Template\Appendix_H\FigureH25_FFC_Provisional_Hazard_50%AEP.mxd

FIGURE H26

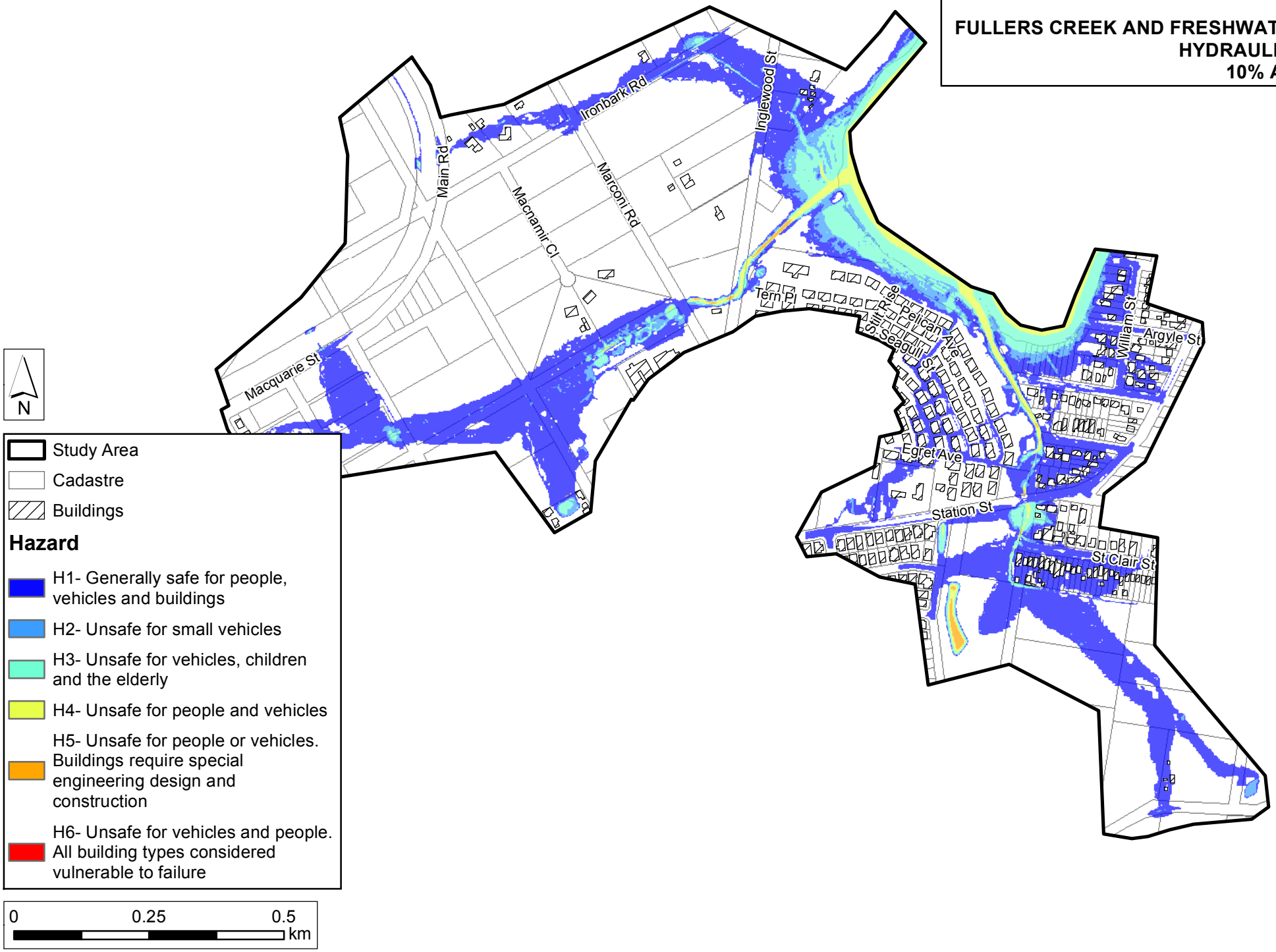
**FULLERS CREEK AND FRESHWATER CREEK**
**HYDRAULIC HAZARD**
**20% AEP EVENT**




J:\Jobs\119076\ArcGIS\ArcMap\Working\Template\Appendix_G\FigureH26_FFC_Provisional_Hazard_20%AEP.mxd

FIGURE H27

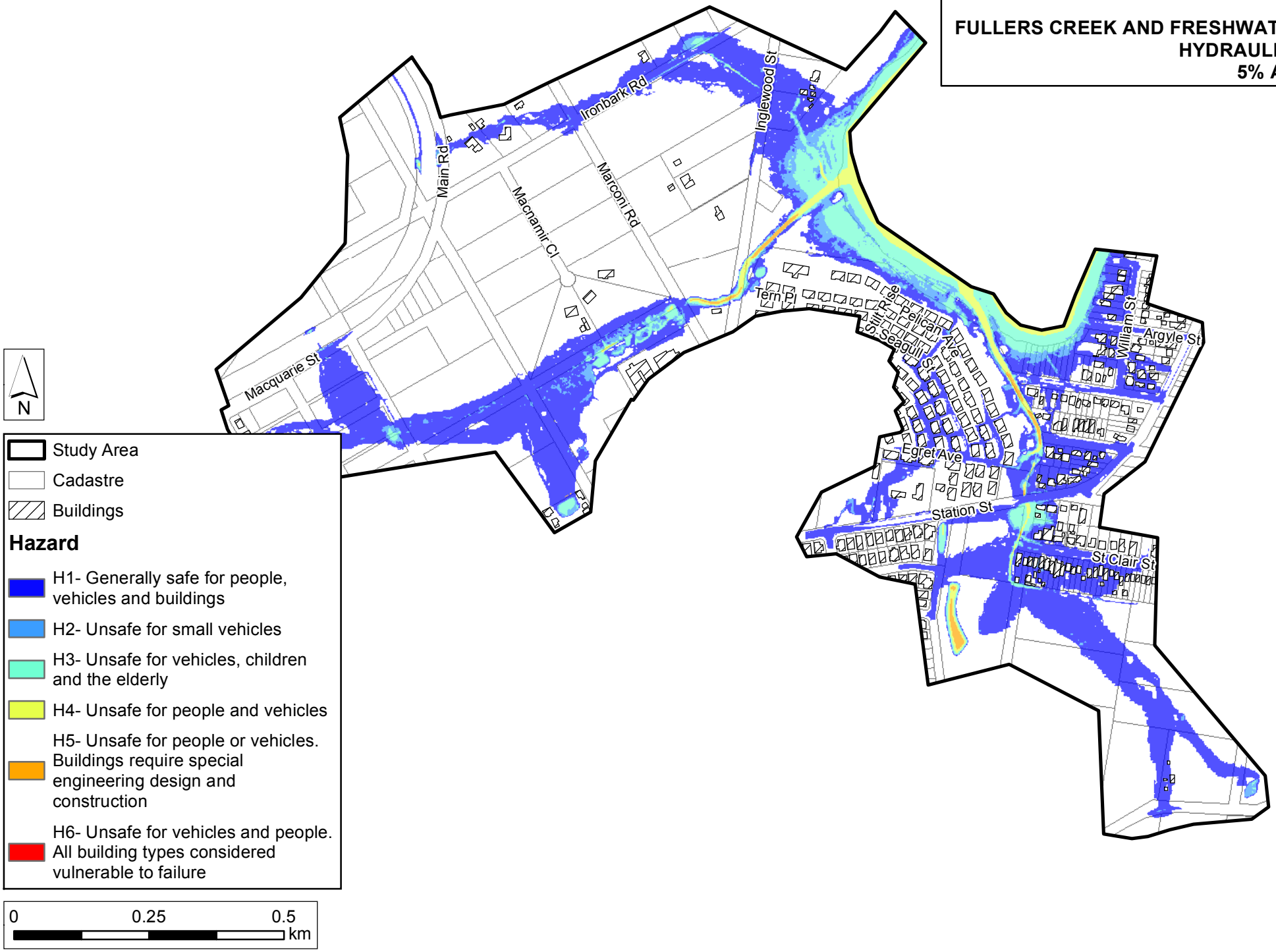
# FULLERS CREEK AND FRESHWATER CREEK HYDRAULIC HAZARD 10% AEP EVENT




J:\Jobs\119076\ArcGIS\ArcMap\Working\Template\Appendix_G\FigureH27_FFC_Provisional_Hazard_10%AEP.mxd

FIGURE H28

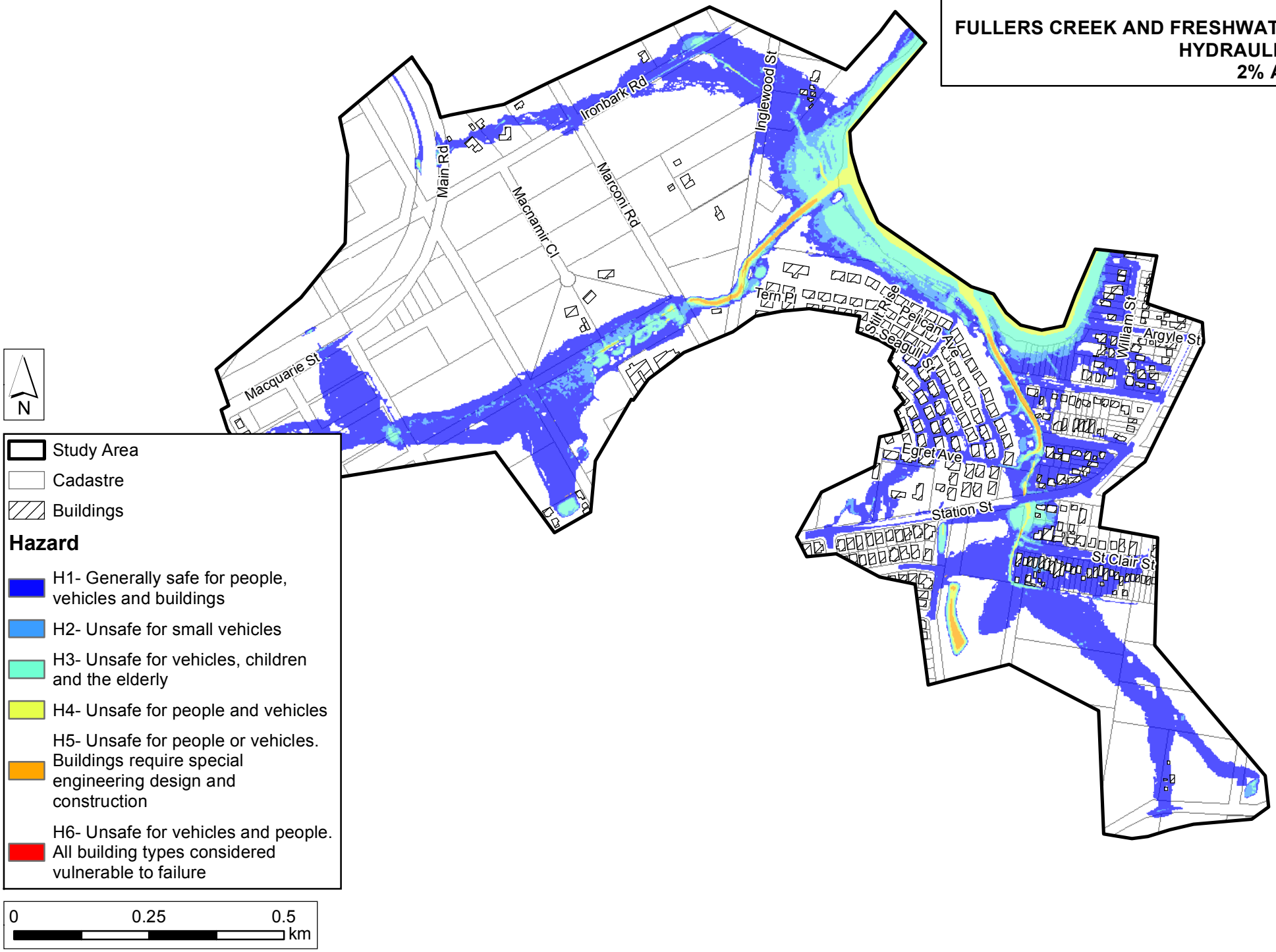
**FULLERS CREEK AND FRESHWATER CREEK**
**HYDRAULIC HAZARD**
**5% AEP EVENT**




J:\Jobs\119076\ArcGIS\ArcMap\Working\Template\Appendix_G\FigureH27_FFC_Provisional_Hazard_10%AEP.mxd

FIGURE H29

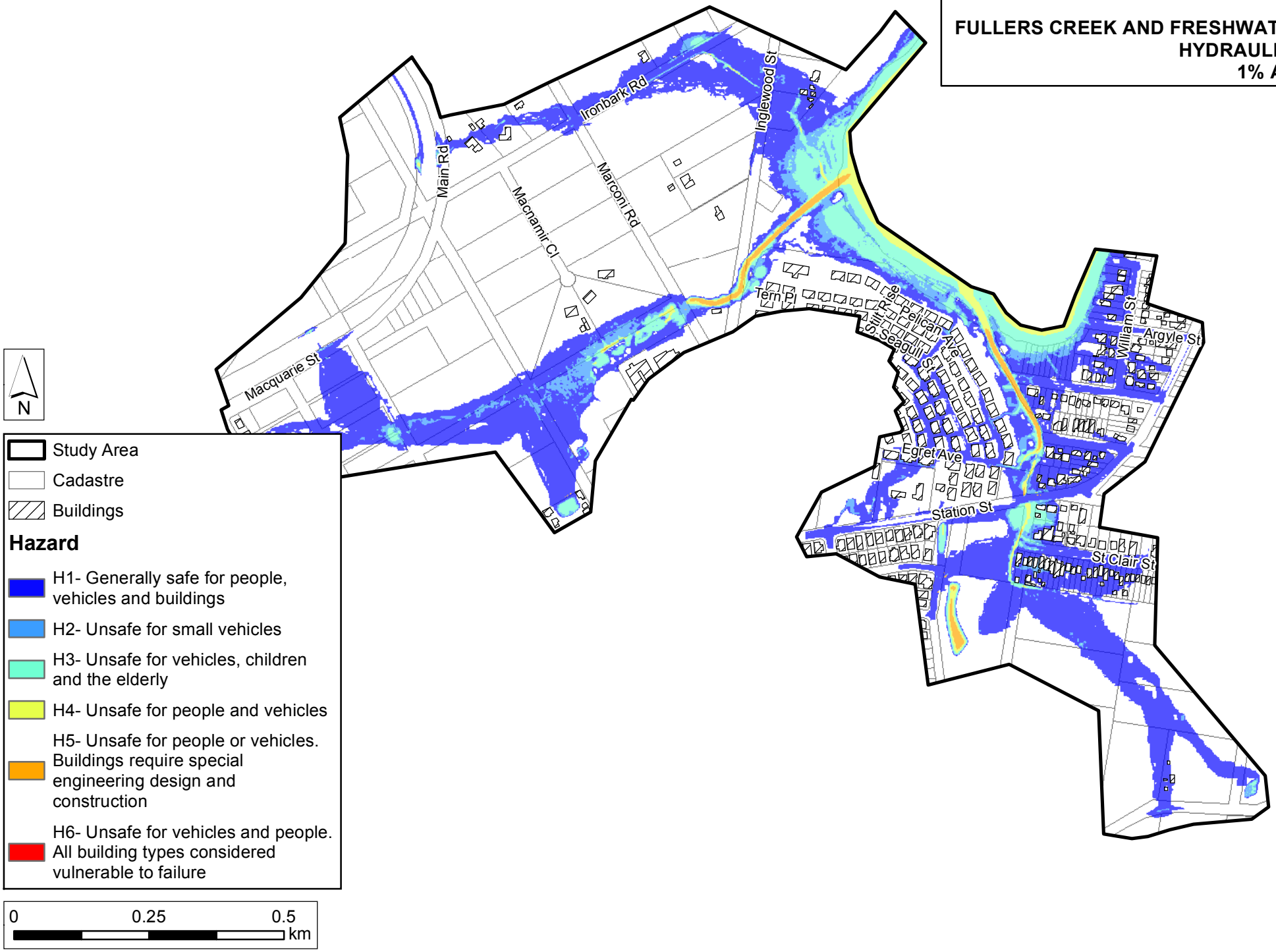
**FULLERS CREEK AND FRESHWATER CREEK**
**HYDRAULIC HAZARD**
**2% AEP EVENT**




J:\Jobs\119076\ArcGIS\ArcMap\Working\Template\Appendix_G\FigureH28_FFC_Provisional_Hazard_5%AEP.mxd

FIGURE H30

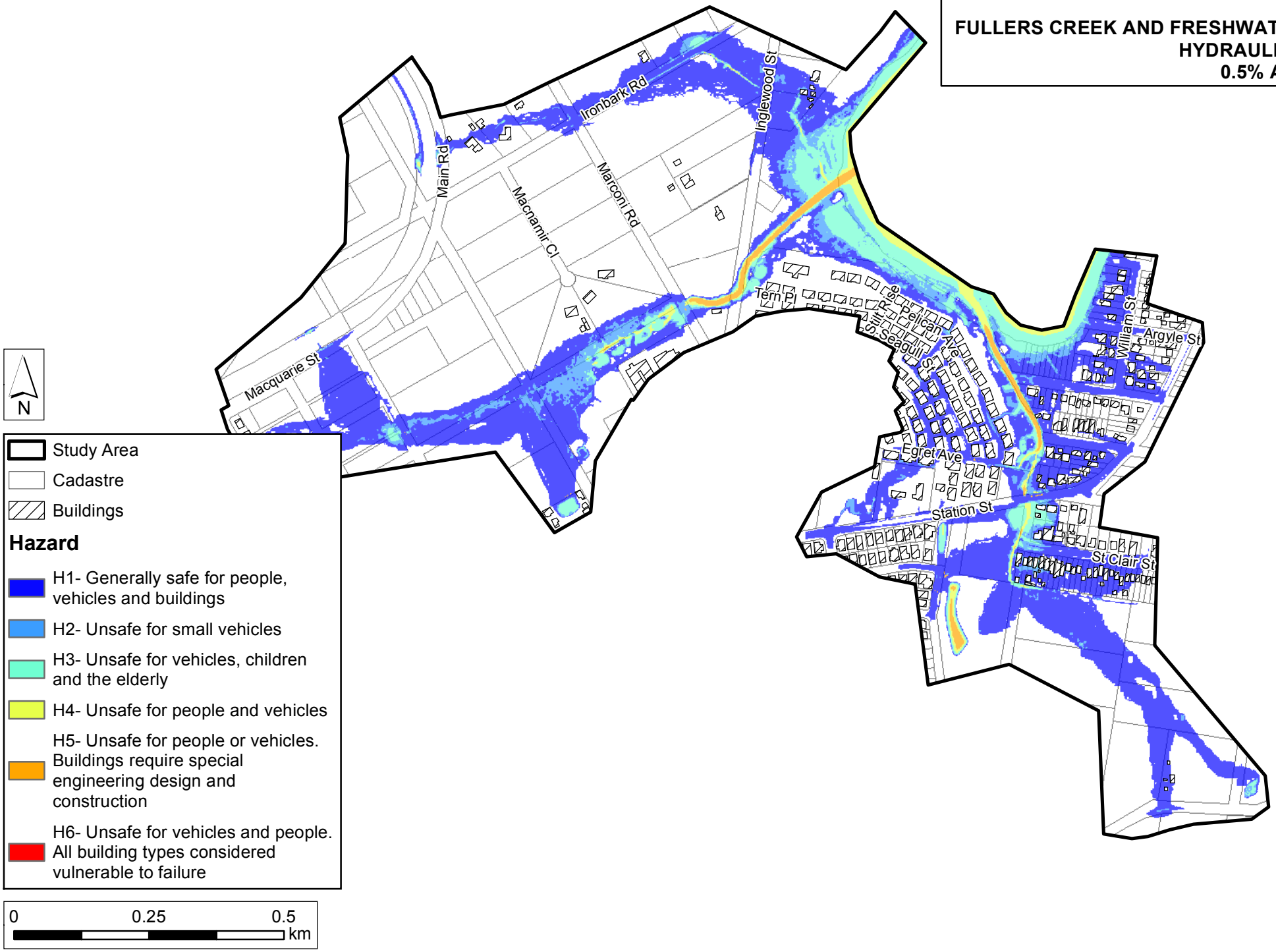
# FULLERS CREEK AND FRESHWATER CREEK HYDRAULIC HAZARD 1% AEP EVENT




J:\Jobs\119076\ArcGIS\ArcMap\Working\Template\Appendix_G\FigureH29_FFC_Provisional_Hazard_2%AEP.mxd

FIGURE H31

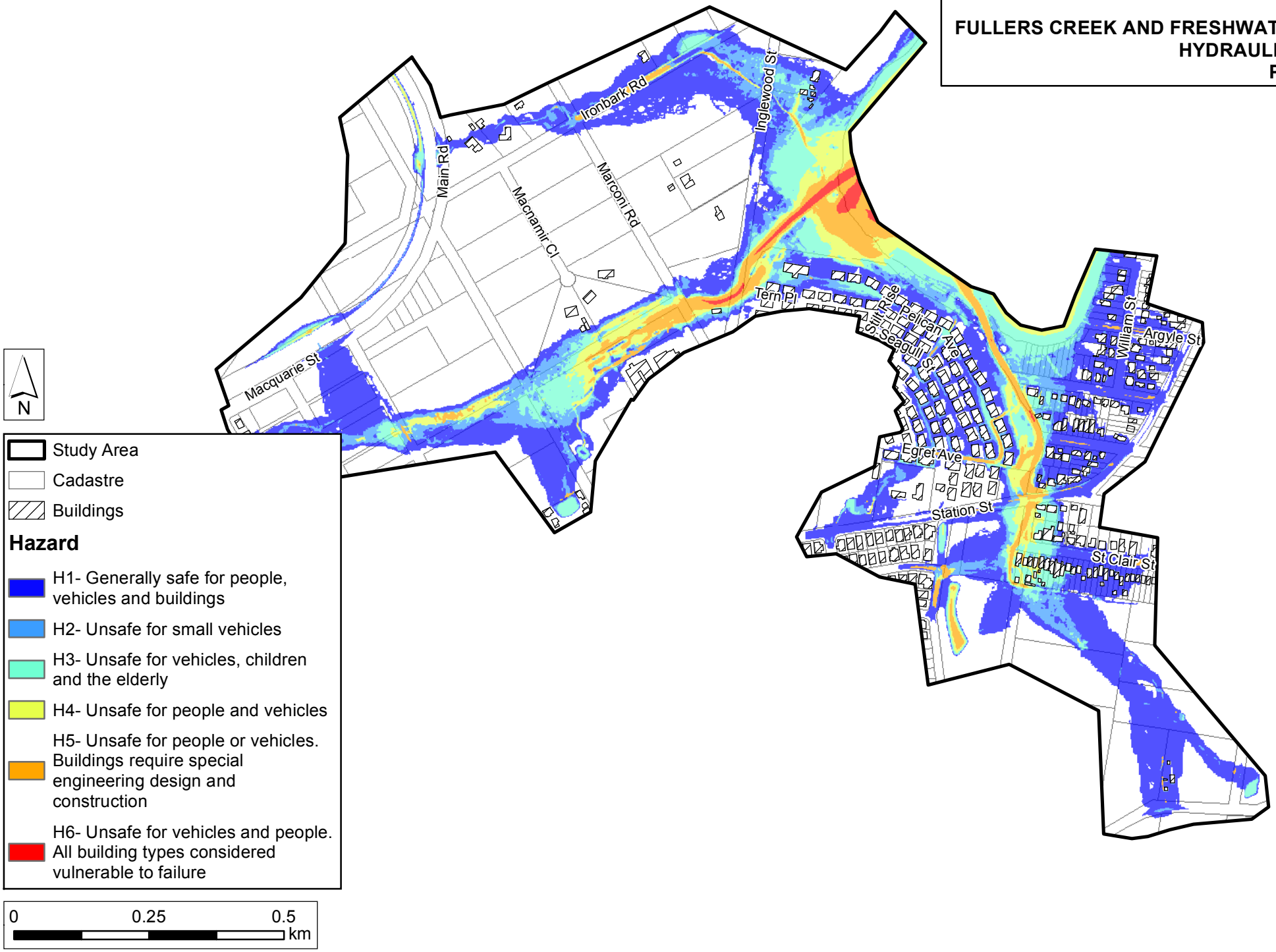
**FULLERS CREEK AND FRESHWATER CREEK**
**HYDRAULIC HAZARD**
**0.5% AEP EVENT**




J:\Jobs\1190776\ArcGIS\ArcMap\Working\Template\Appendix_G\FigureH30_FFC_Provisional_Hazard_1%AEP.mxd

FIGURE H32

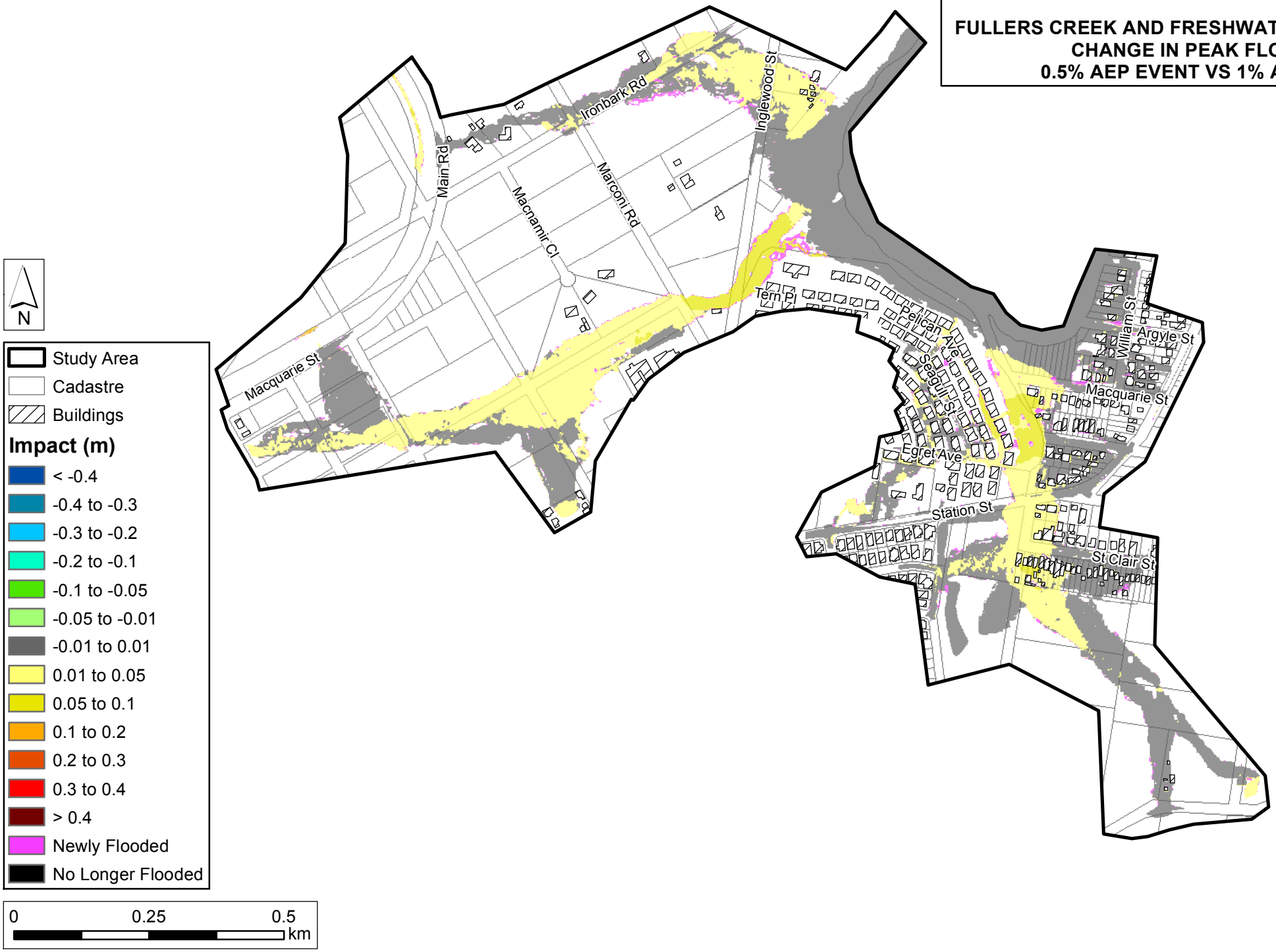
**FULLERS CREEK AND FRESHWATER CREEK**
**HYDRAULIC HAZARD**
**PMF EVENT**




J:\Jobs\1190776\ArcGIS\ArcMap\Working\Template\Appendix_G\FigureH31_FFC_Provisional_Hazard_0.5%AEP.mxd

FIGURE H33

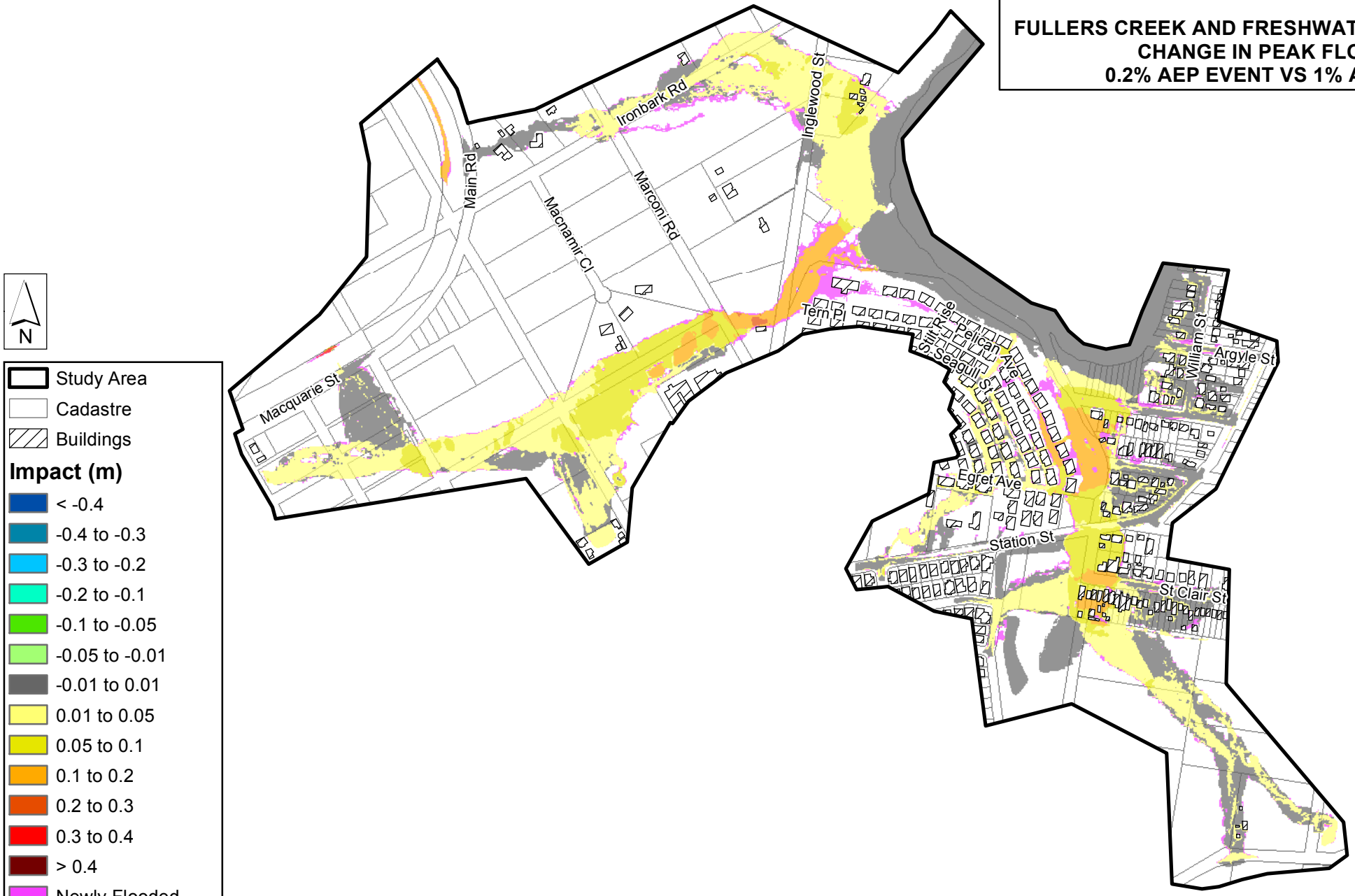
**FULLERS CREEK AND FRESHWATER CREEK**
**CHANGE IN PEAK FLOOD LEVEL**
**0.5% AEP EVENT VS 1% AEP EVENT**




J:\Jobs\1190776\ArcGIS\ArcMap\Working\Template\Appendix_H\FigureH33_FFC_Impact_CC_0.5%AEP_V_1%AEP.mxd

FIGURE H34

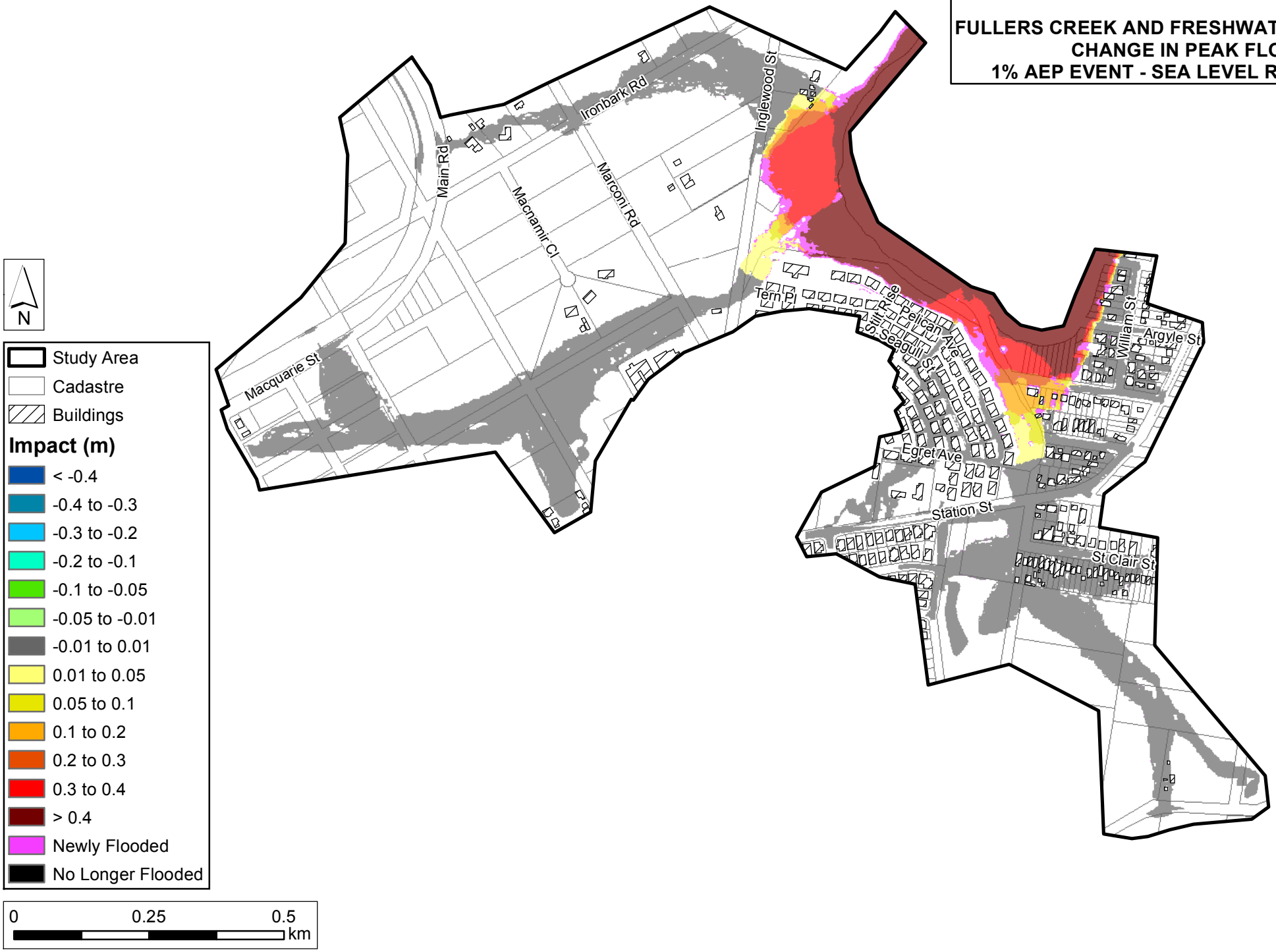
# FULLERS CREEK AND FRESHWATER CREEK
# CHANGE IN PEAK FLOOD LEVEL
# 0.2% AEP EVENT VS 1% AEP EVENT




J:\Jobs\1190776\ArcGIS\ArcMap\Working\Template\Appendix_H\FigureH33_FFC_Impact_CC_0.5%AEP_V_1%AEP.mxd

FIGURE H35

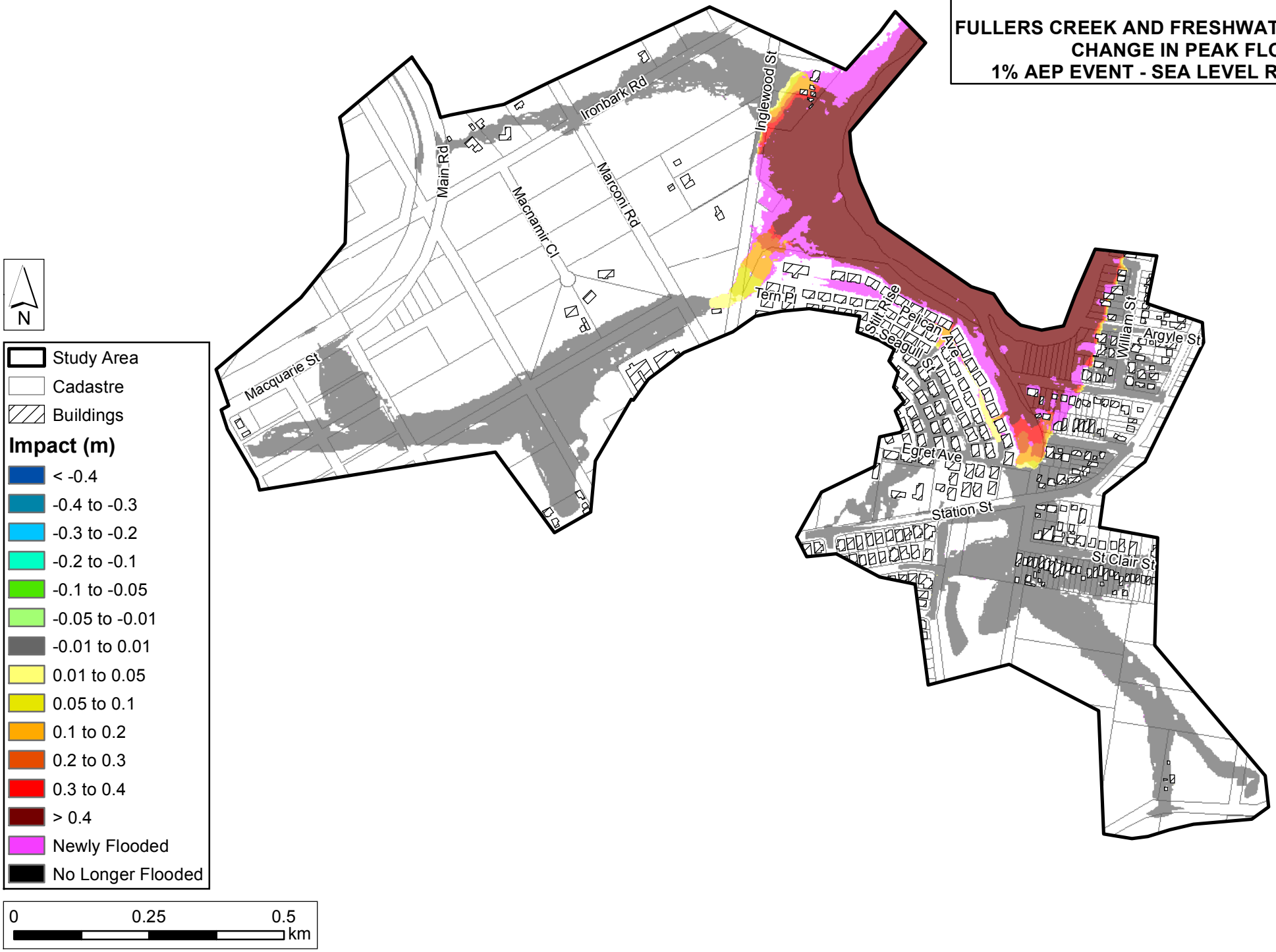
**FULLERS CREEK AND FRESHWATER CREEK**
**CHANGE IN PEAK FLOOD LEVEL**
**1% AEP EVENT - SEA LEVEL RISE 400MM**




J:\Jobs\1190776\ArcGIS\ArcMap\Working\Template\Appendix_H\FigureH34_FFC_Impact_CC_0.2%AEP_V_1%AEP.mxd

FIGURE H36

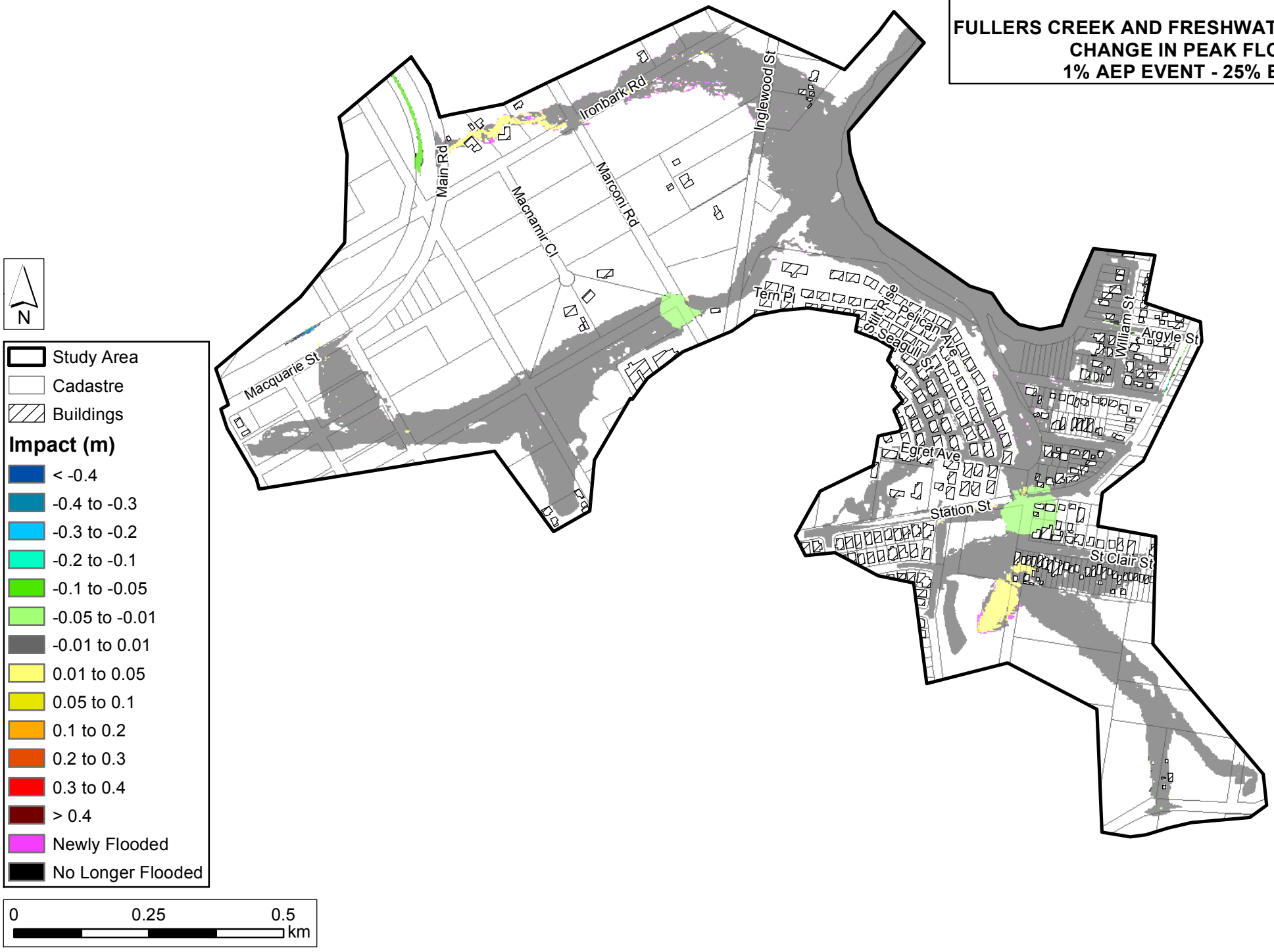
# FULLERS CREEK AND FRESHWATER CREEK
## CHANGE IN PEAK FLOOD LEVEL
## 1% AEP EVENT - SEA LEVEL RISE 900MM




J:\Jobs\1190776\ArcGIS\ArcMap\Working\Template\Appendix_H\FigureH35_FFC_Impact_CC_SLR04_1%AEP.mxd

FIGURE H37

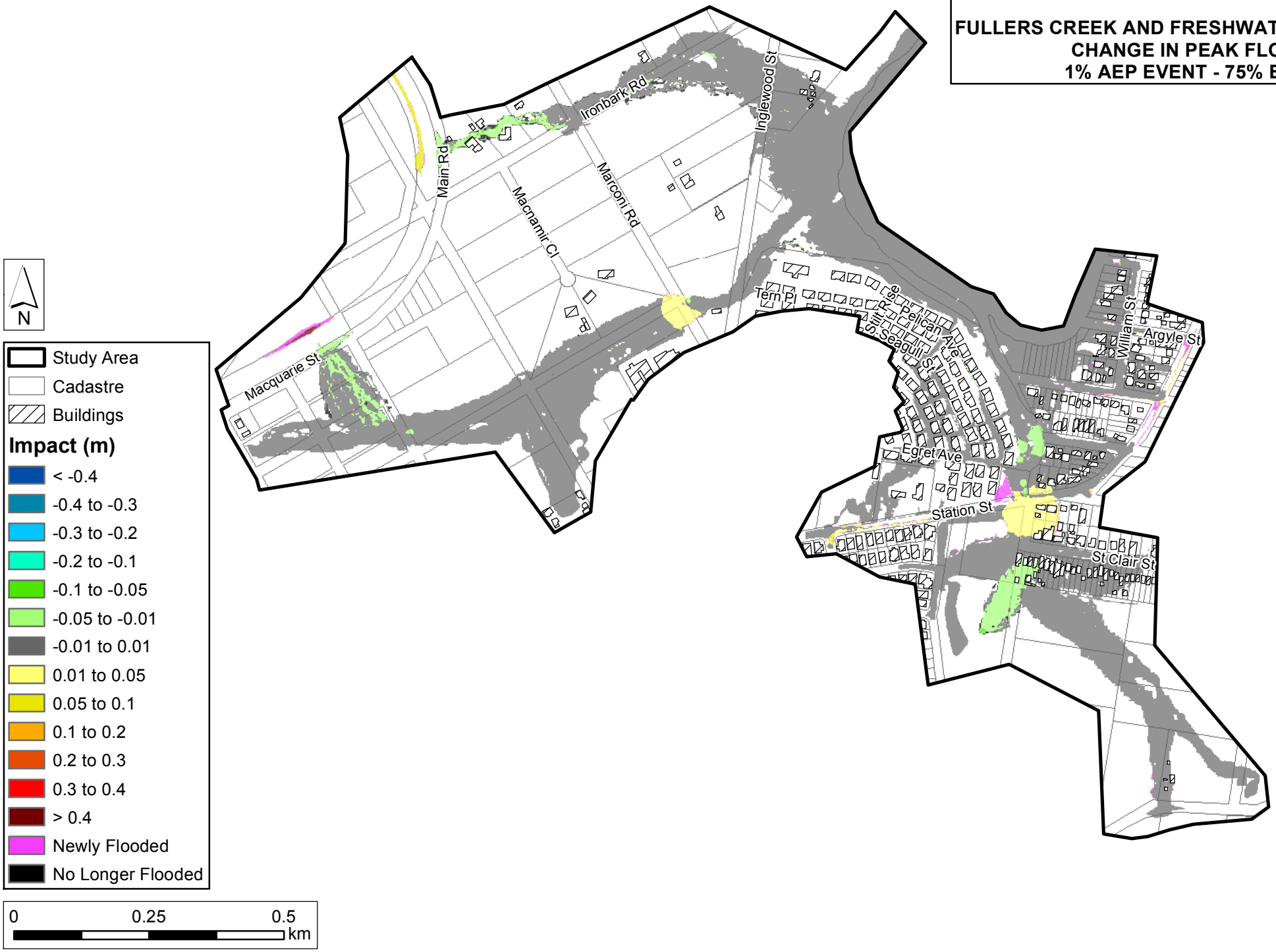
# FULLERS CREEK AND FRESHWATER CREEK
## CHANGE IN PEAK FLOOD LEVEL
## 1% AEP EVENT - 25% BLOCKAGE




J:\Jobs\1190776\ArcGIS\ArcMap\Working\Template\Appendix_H\FigureH36_FFC_Impact_CC_SLR09_1%AEP.mxd

FIGURE H38

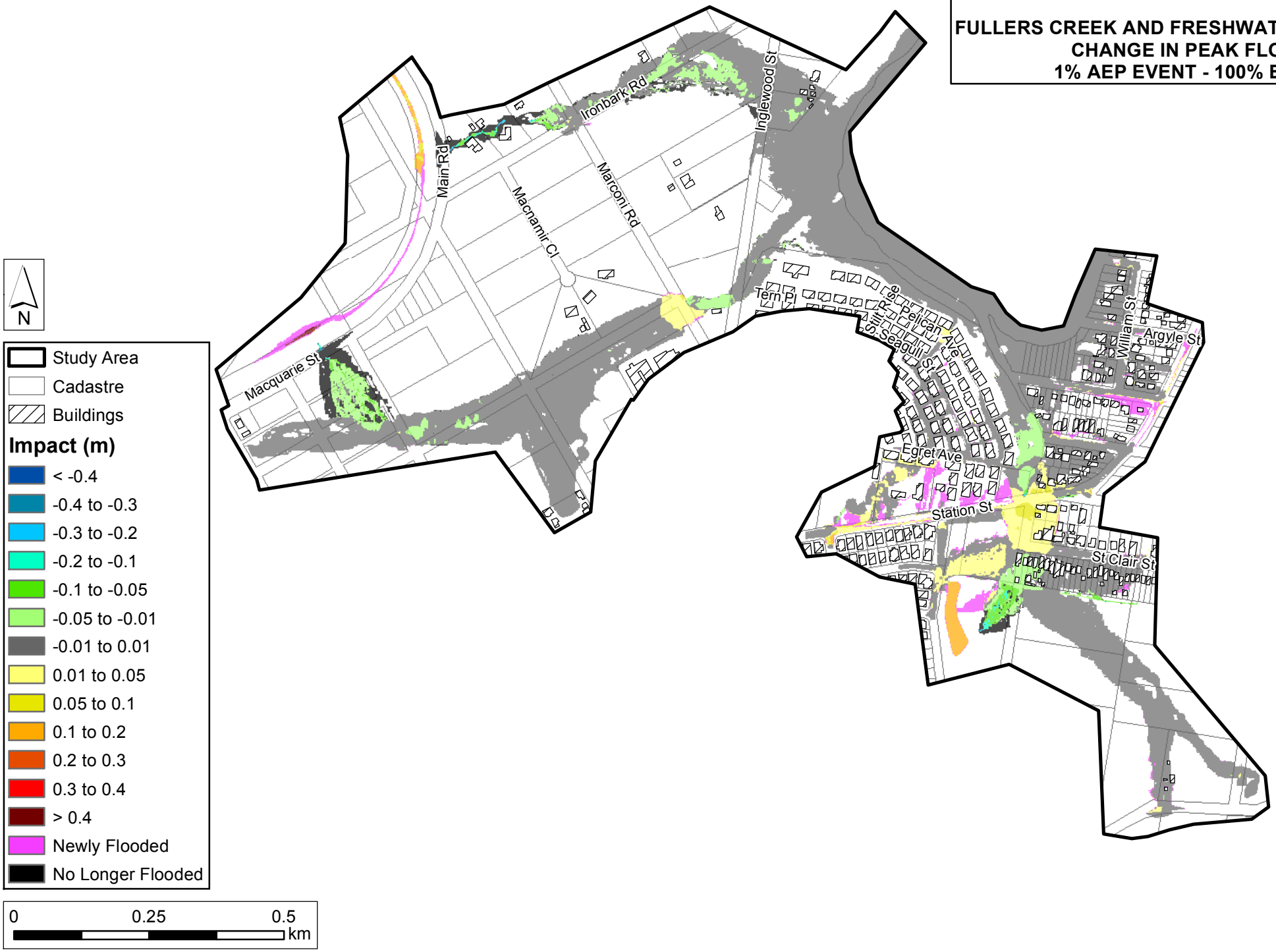
# FULLERS CREEK AND FRESHWATER CREEK
## CHANGE IN PEAK FLOOD LEVEL
## 1% AEP EVENT - 75% BLOCKAGE




J:\Jobs\1190776\ArcGIS\ArcMap\Working\Template\Appendix_H\FigureH37_FFC_Impact_1%AEP_Blockage25pc.mxd

FIGURE H39

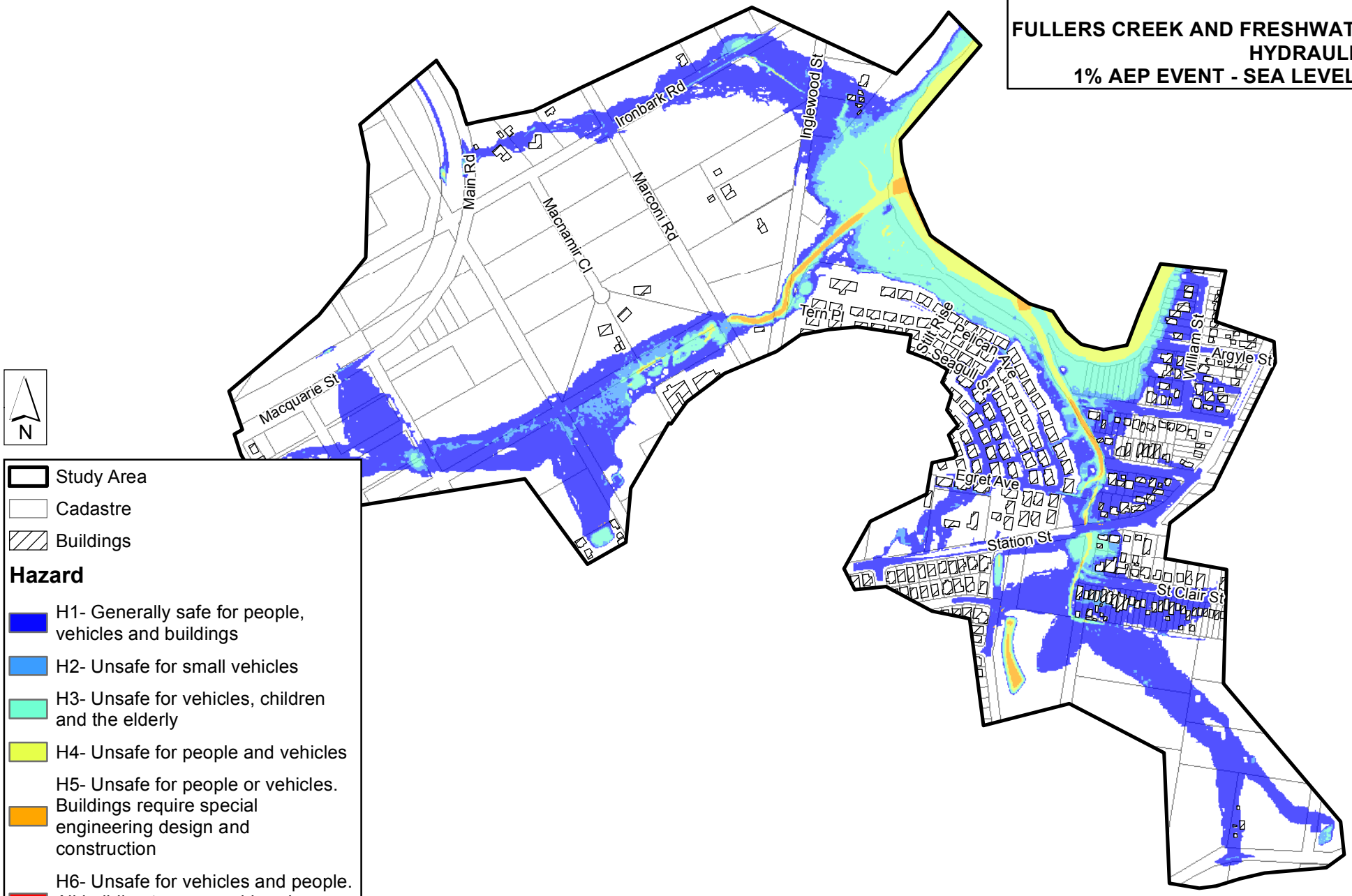
**FULLERS CREEK AND FRESHWATER CREEK**
**CHANGE IN PEAK FLOOD LEVEL**
**1% AEP EVENT - 100% BLOCKAGE**




J:\Jobs\1190776\ArcGIS\ArcMap\Working\Template\Appendix_H\FigureH38_FFC_Impact_1%AEP_Blockage75pc.mxd

FIGURE H40

**FULLERS CREEK AND FRESHWATER CREEK**
**HYDRAULIC HAZARD**
**1% AEP EVENT - SEA LEVEL RISE 0.4M**




N

- Study Area
- Cadastre
- Buildings

**Hazard**

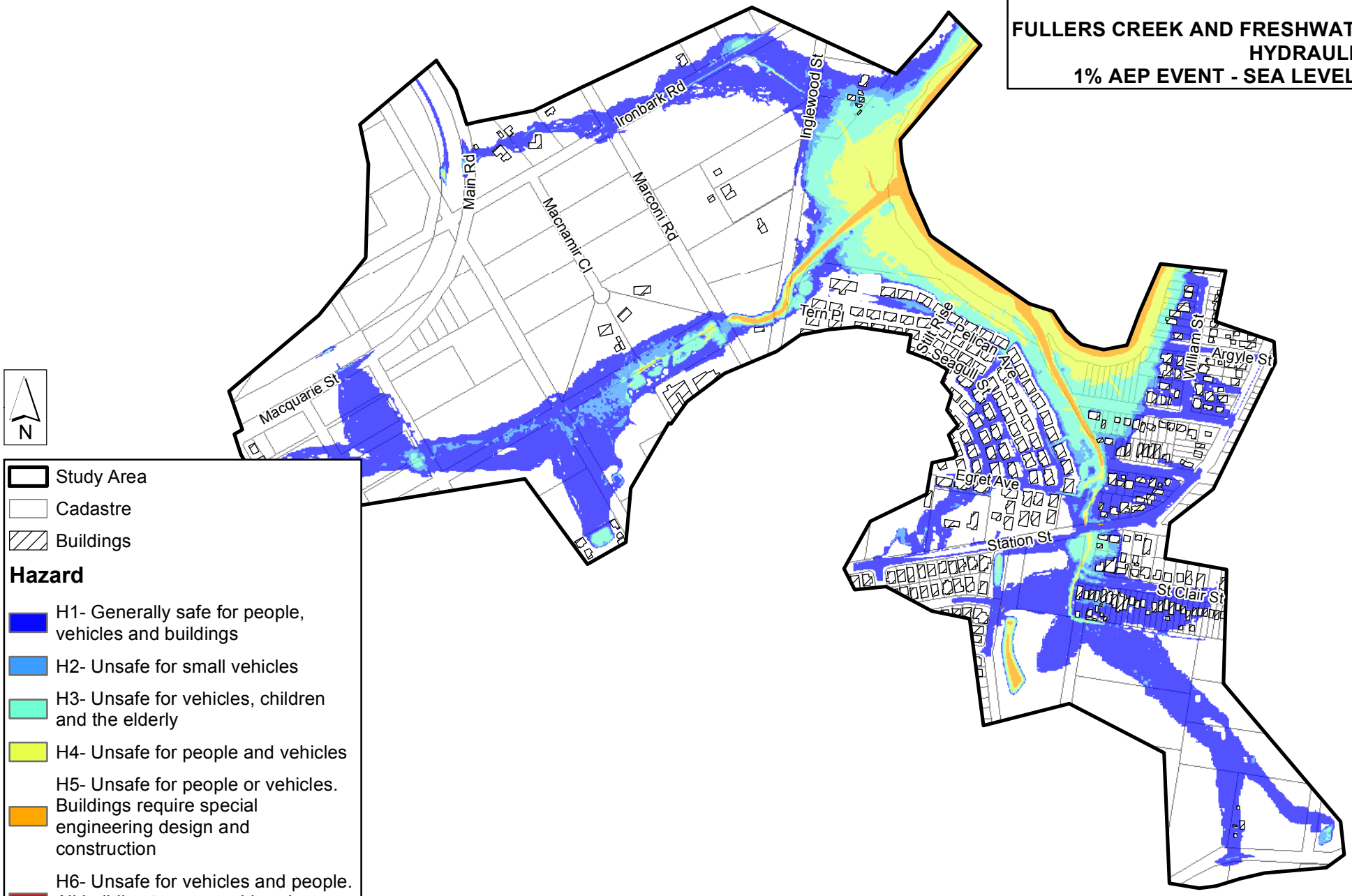
- H1- Generally safe for people, vehicles and buildings
- H2- Unsafe for small vehicles
- H3- Unsafe for vehicles, children and the elderly
- H4- Unsafe for people and vehicles
- H5- Unsafe for people or vehicles. Buildings require special engineering design and construction
- H6- Unsafe for vehicles and people. All building types considered vulnerable to failure

0 0.25 0.5 km

J:\Jobs\119076\ArcGIS\ArcMap\Working\Template\Appendix_H\FigureH25_FFC_Provisional_Hazard_50%AEP.mxd

FIGURE H41

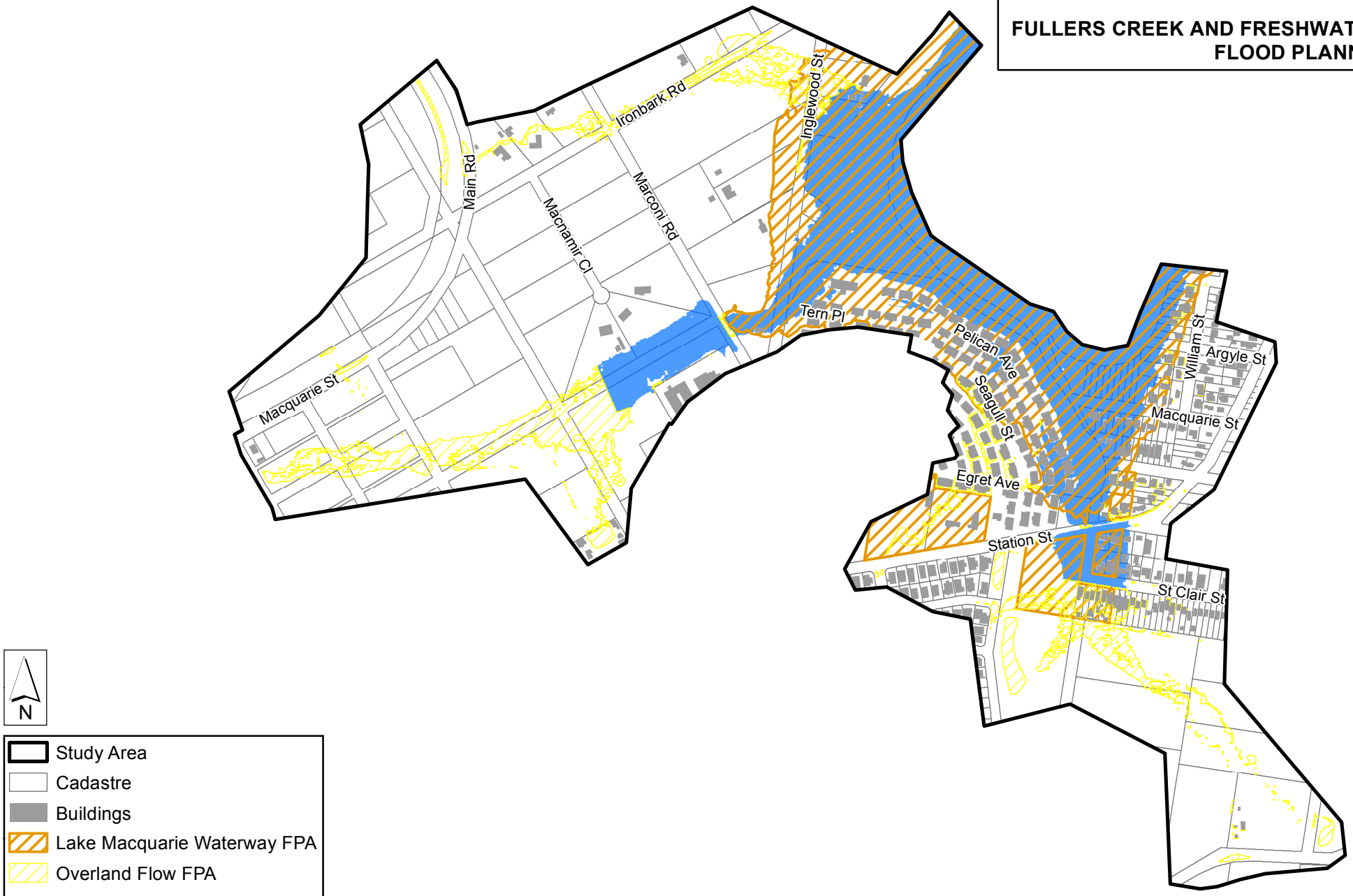
**FULLERS CREEK AND FRESHWATER CREEK**
**HYDRAULIC HAZARD**
**1% AEP EVENT - SEA LEVEL RISE 0.9M**




J:\Jobs\11907\6\ArcGIS\ArcMap\Working\Template\Appendix_H\FigureH40_FFC_Provisional_Hazard_1%AEP_SLR04.mxd

FIGURE H42

# FULLERS CREEK AND FRESHWATER CREEK FLOOD PLANNING AREA



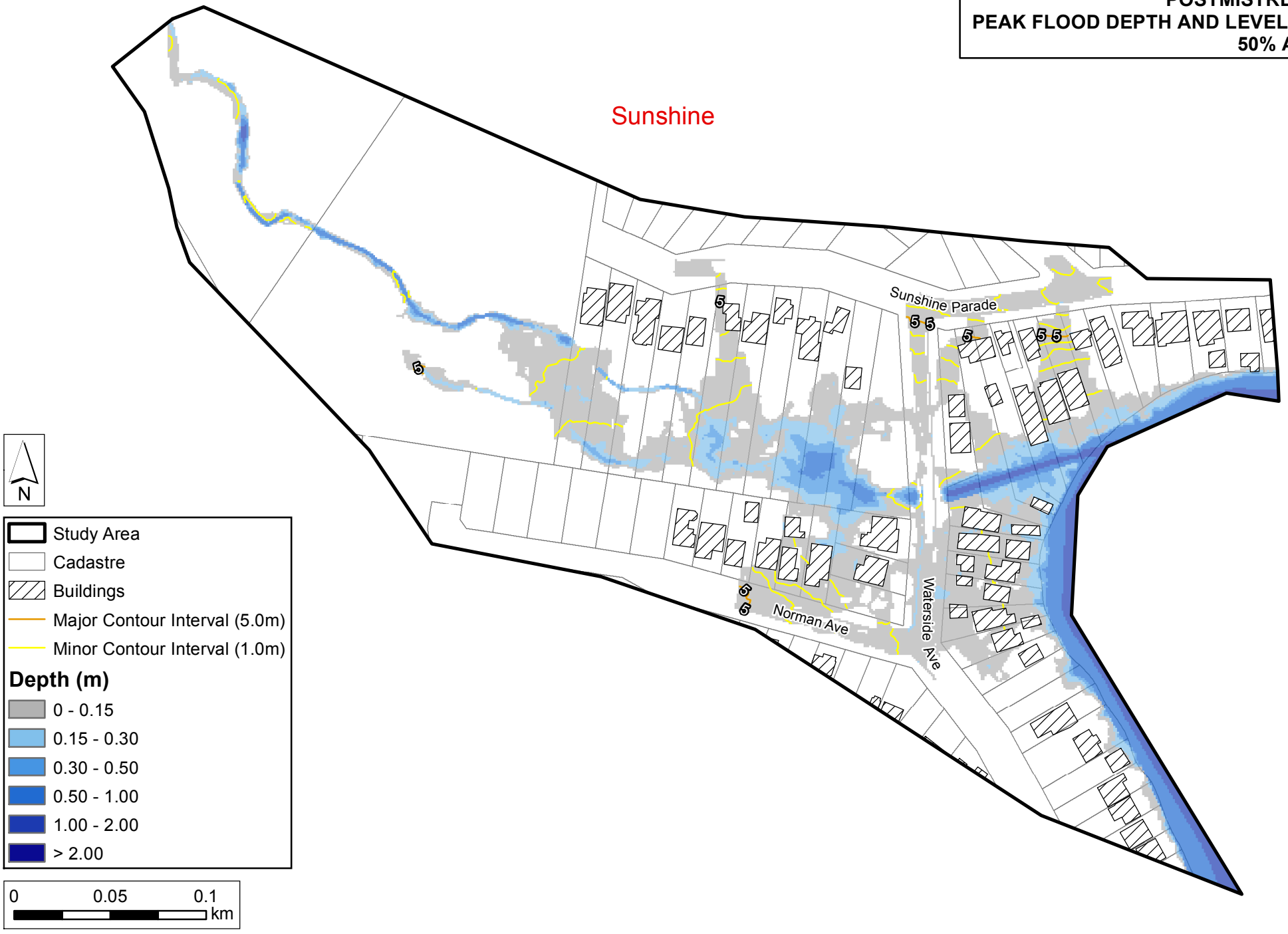

J:\Jobs\119076\ArcGIS\ArcMap\Report\Appendix_H\FigureH42_FFC_Flood_Planning_Area.mxd

**APPENDIX I: DESIGN FLOOD MAPS – POSTMISTRESS CREEK**

Appendix I

FIGURE I1

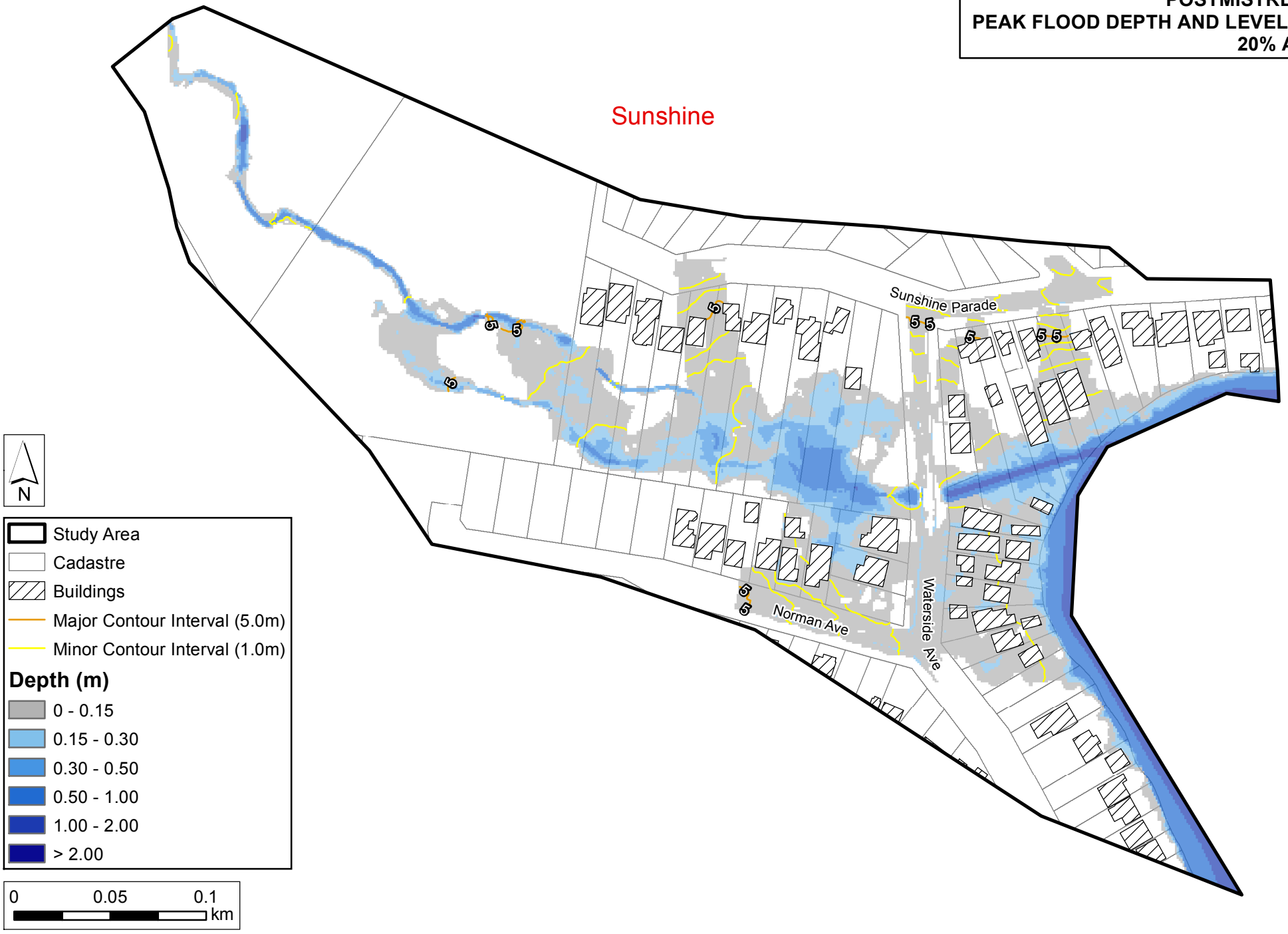
**POSTMISTRESS CREEK**
**PEAK FLOOD DEPTH AND LEVEL CONTOUR**
**50% AEP EVENT**




J:\Jobs\119076\ArcGIS\ArcMap\Working\Template\Appendix_I\Figure\01_PMC_Peak_Flood_Depth_50%AEP.mxd

FIGURE I2

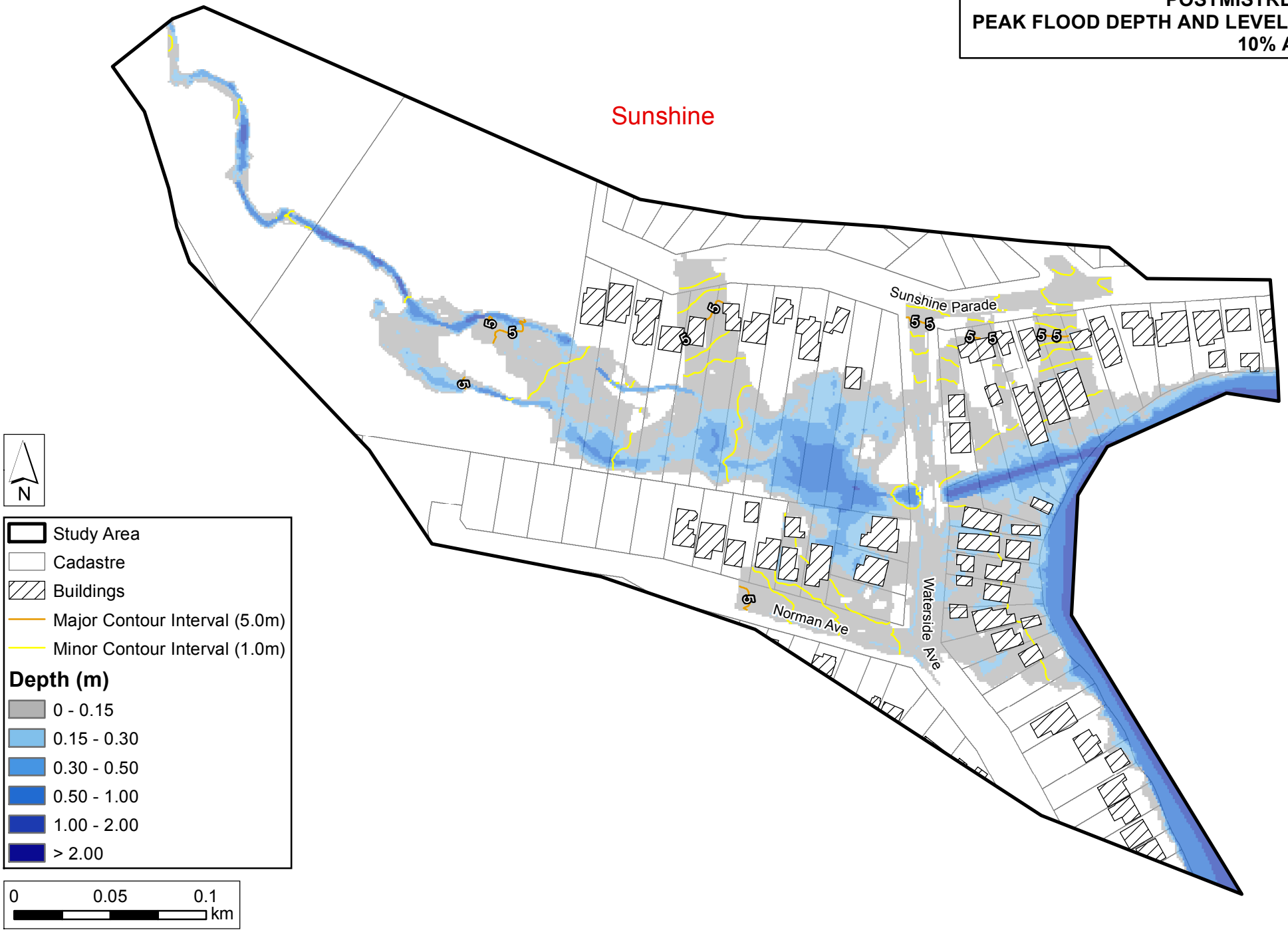
**POSTMISTRESS CREEK**
**PEAK FLOOD DEPTH AND LEVEL CONTOUR**
**20% AEP EVENT**




J:\Jobs\119076\ArcGIS\ArcMap\Working\Template\Appendix_I\Figure\02_PMC_Peak_Flood_Depth_20%AEP.mxd

FIGURE I3

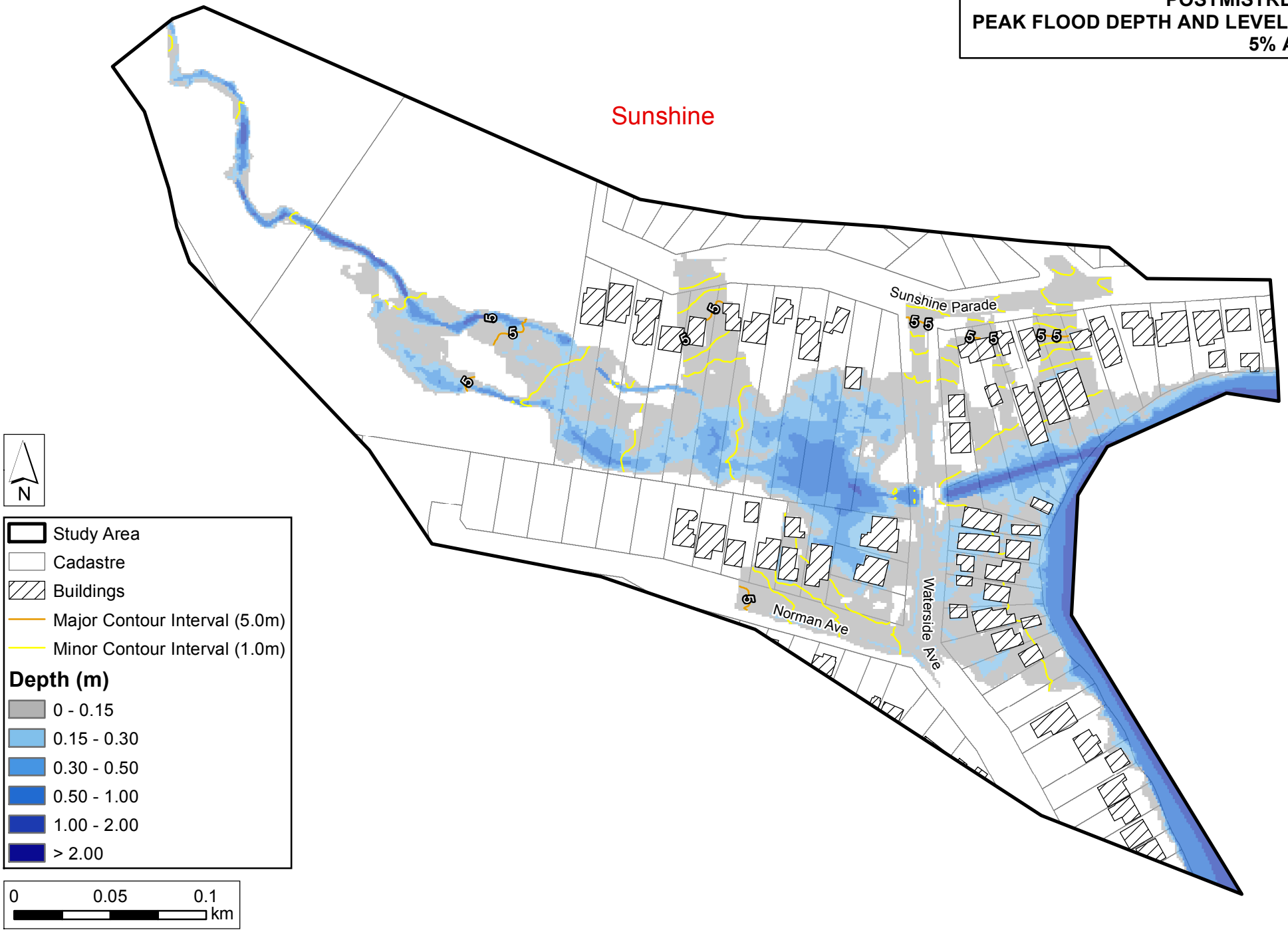
**POSTMISTRESS CREEK**
**PEAK FLOOD DEPTH AND LEVEL CONTOUR**
**10% AEP EVENT**




J:\Jobs\119076\ArcGIS\ArcMap\Working\Template\Appendix_I\Figure\I03_PMC_Peak_Flood_Depth_10%AEP.mxd

FIGURE I4

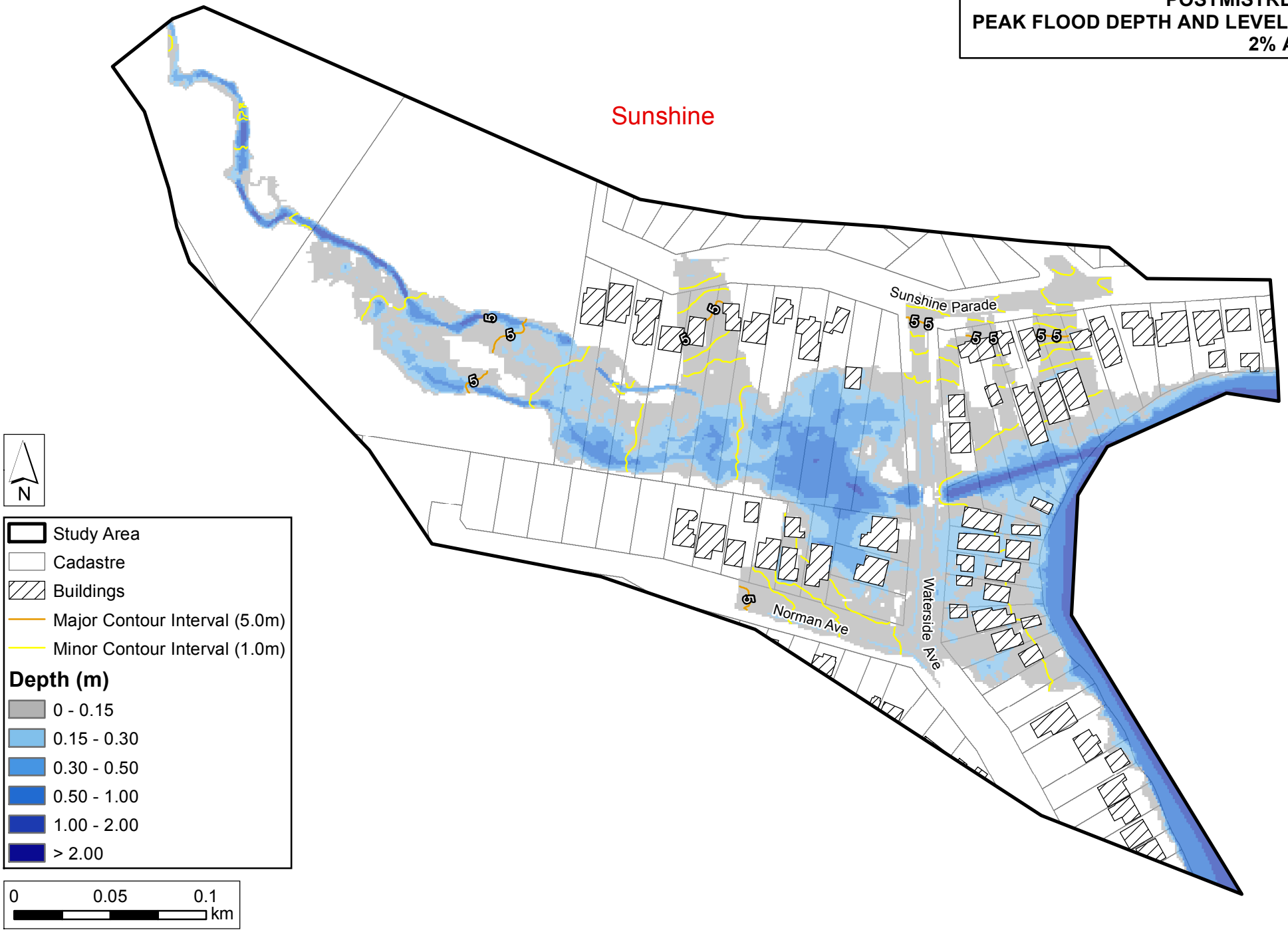
**POSTMISTRESS CREEK**
**PEAK FLOOD DEPTH AND LEVEL CONTOUR**
**5% AEP EVENT**




J:\Jobs\1190776\ArcGIS\ArcMap\Working\Template\Appendix_I\Figure\I04_PMC_Peak_Flood_Depth_5%AEP.mxd

FIGURE I5

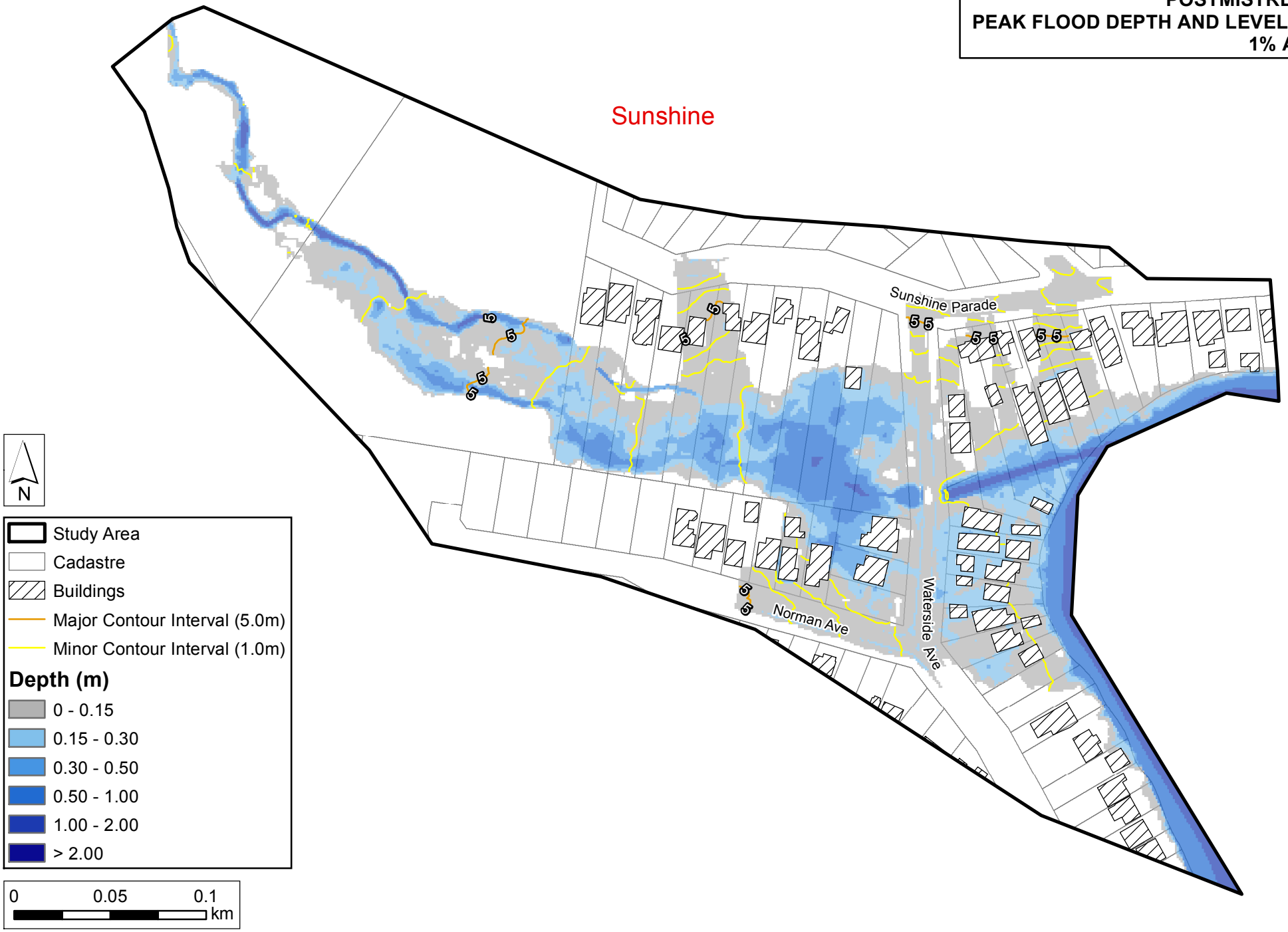
**POSTMISTRESS CREEK**
**PEAK FLOOD DEPTH AND LEVEL CONTOUR**
**2% AEP EVENT**




J:\Jobs\119076\ArcGIS\ArcMap\Working\Template\Appendix_I\Figure105_PMC_Peak_Flood_Depth_2%AEP.mxd

FIGURE I6

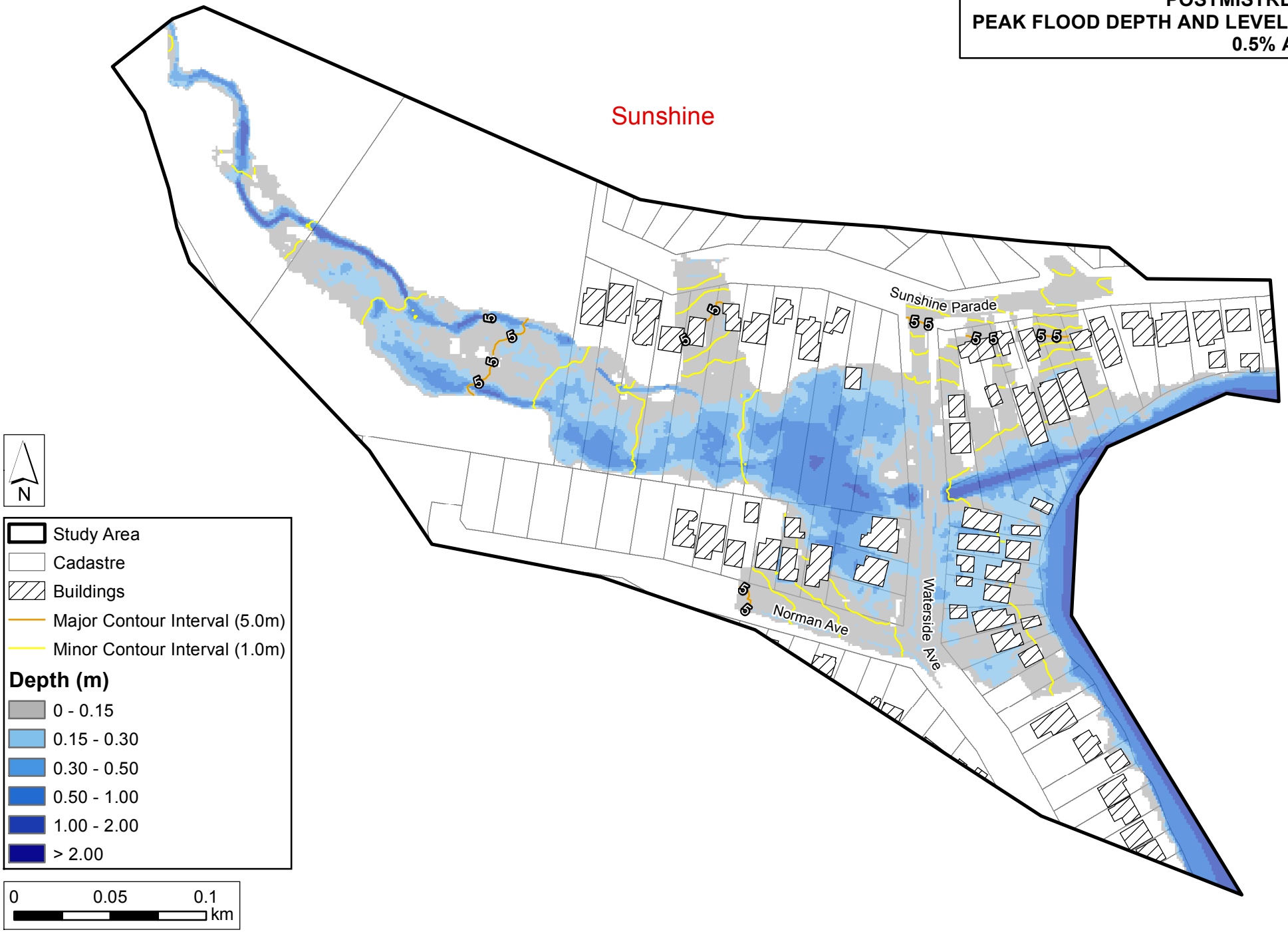
**POSTMISTRESS CREEK**
**PEAK FLOOD DEPTH AND LEVEL CONTOUR**
**1% AEP EVENT**




J:\Jobs\119076\ArcGIS\ArcMap\Working\Template\Appendix_I\Figure106_PMC_Peak_Flood_Depth_1%AEP.mxd

FIGURE I7

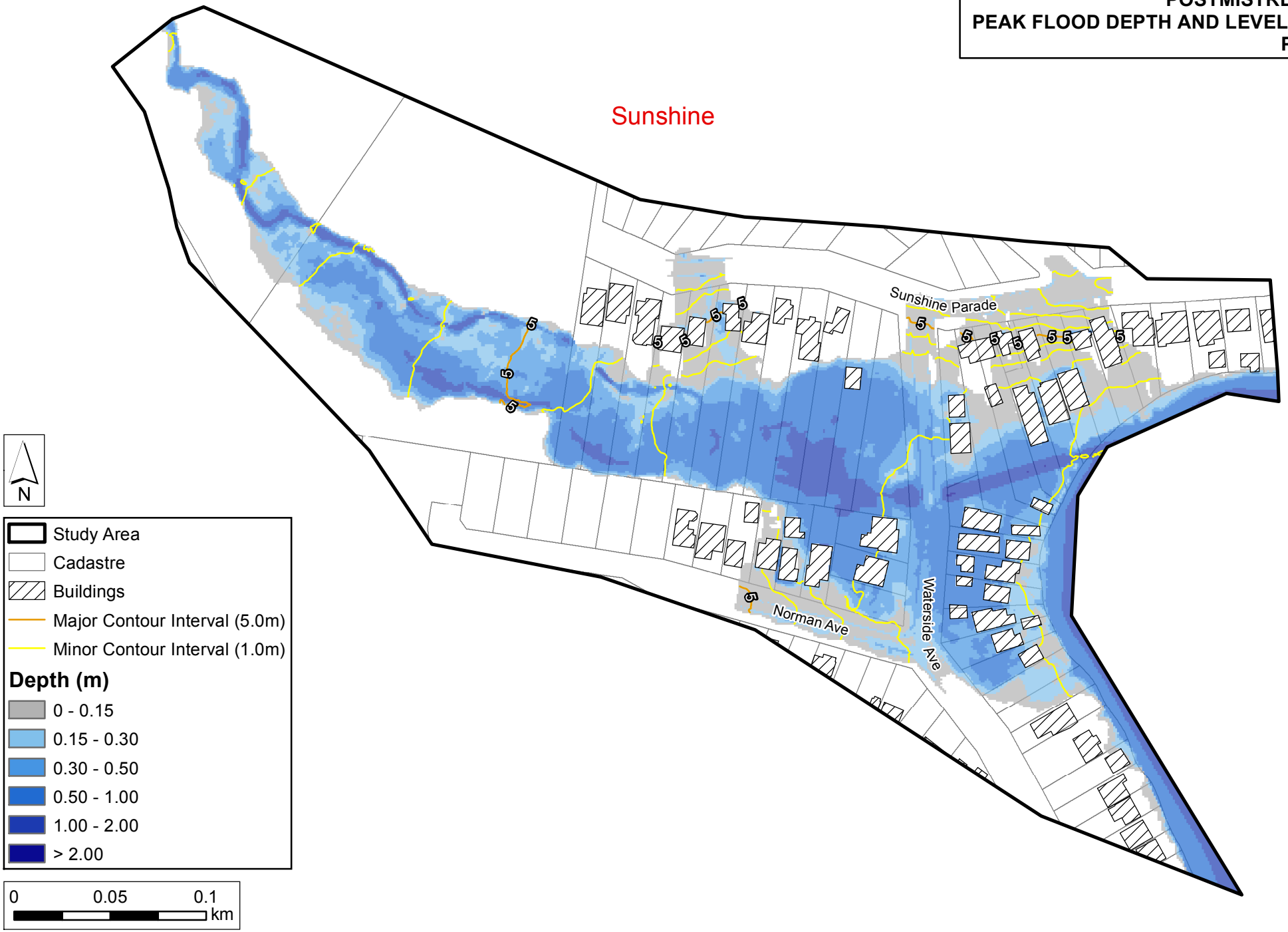
**POSTMISTRESS CREEK**
**PEAK FLOOD DEPTH AND LEVEL CONTOUR**
**0.5% AEP EVENT**




J:\Jobs\1190776\ArcGIS\ArcMap\Working\Template\Appendix_I\Figure107_PMC_Peak_Flood_Depth_0.5%AEP.mxd

FIGURE I8

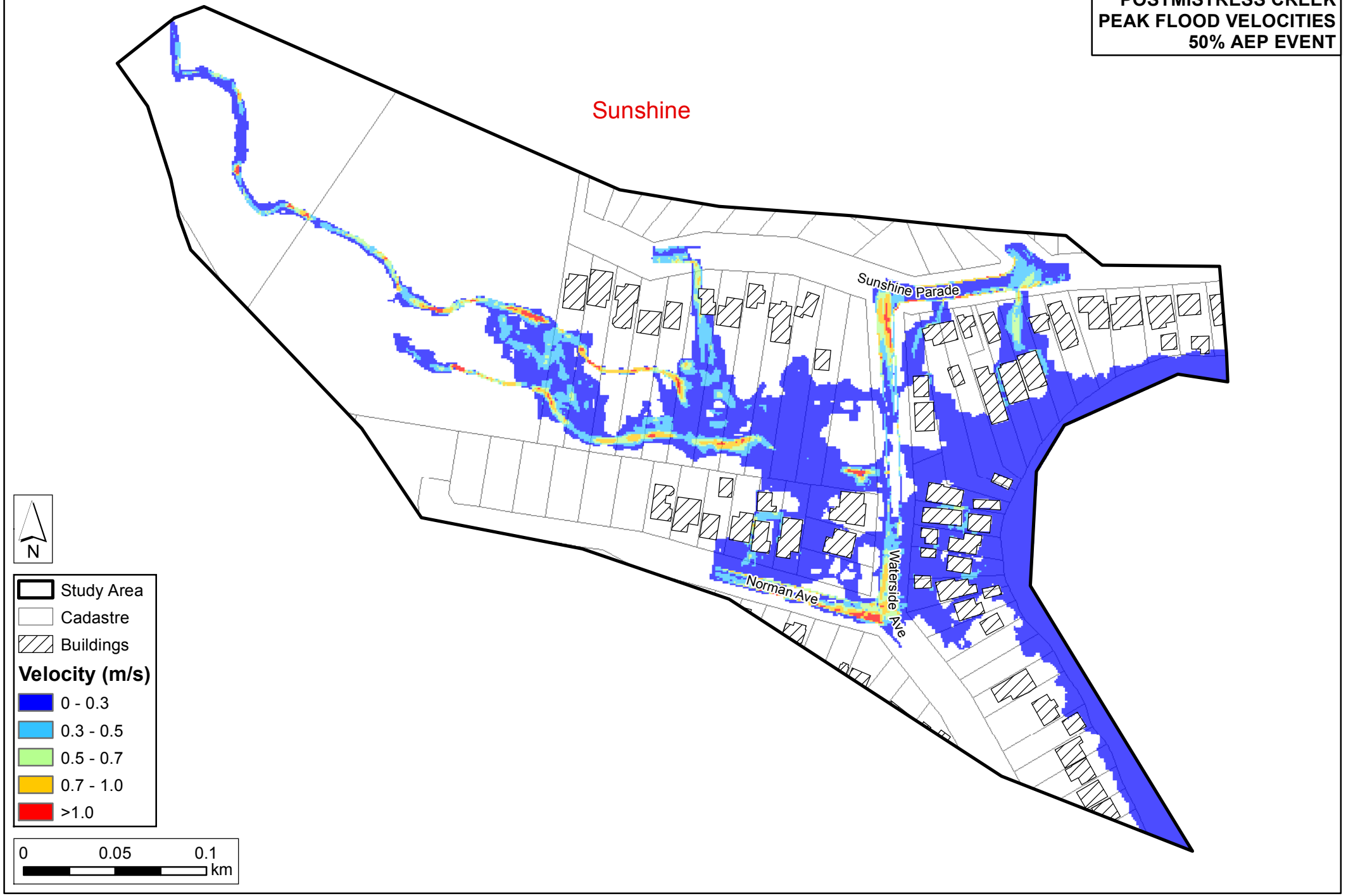
**POSTMISTRESS CREEK**
**PEAK FLOOD DEPTH AND LEVEL CONTOUR**
**PMF EVENT**




J:\Jobs\119076\ArcGIS\ArcMap\Working\Template\Appendix_I\Figure\I08_PMC_Peak_Flood_Depth_PMF.mxd

FIGURE I9

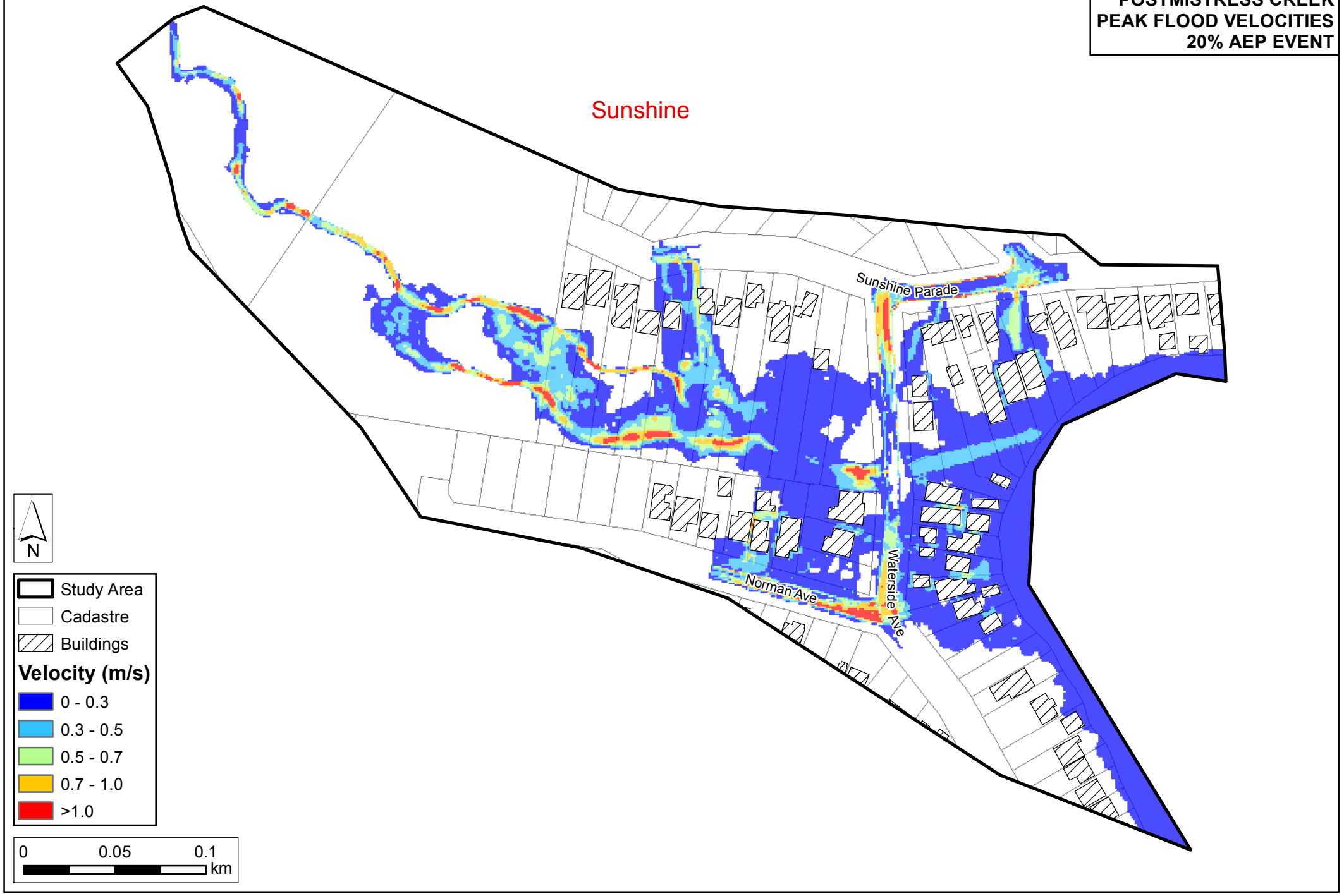
**POSTMISTRESS CREEK**
**PEAK FLOOD VELOCITIES**
**50% AEP EVENT**




J:\Jobs\119076\ArcGIS\ArcMap\Working\Template\Appendix_I\Figure\I08_PMC_Peak_Flood_Depth_PMF.mxd

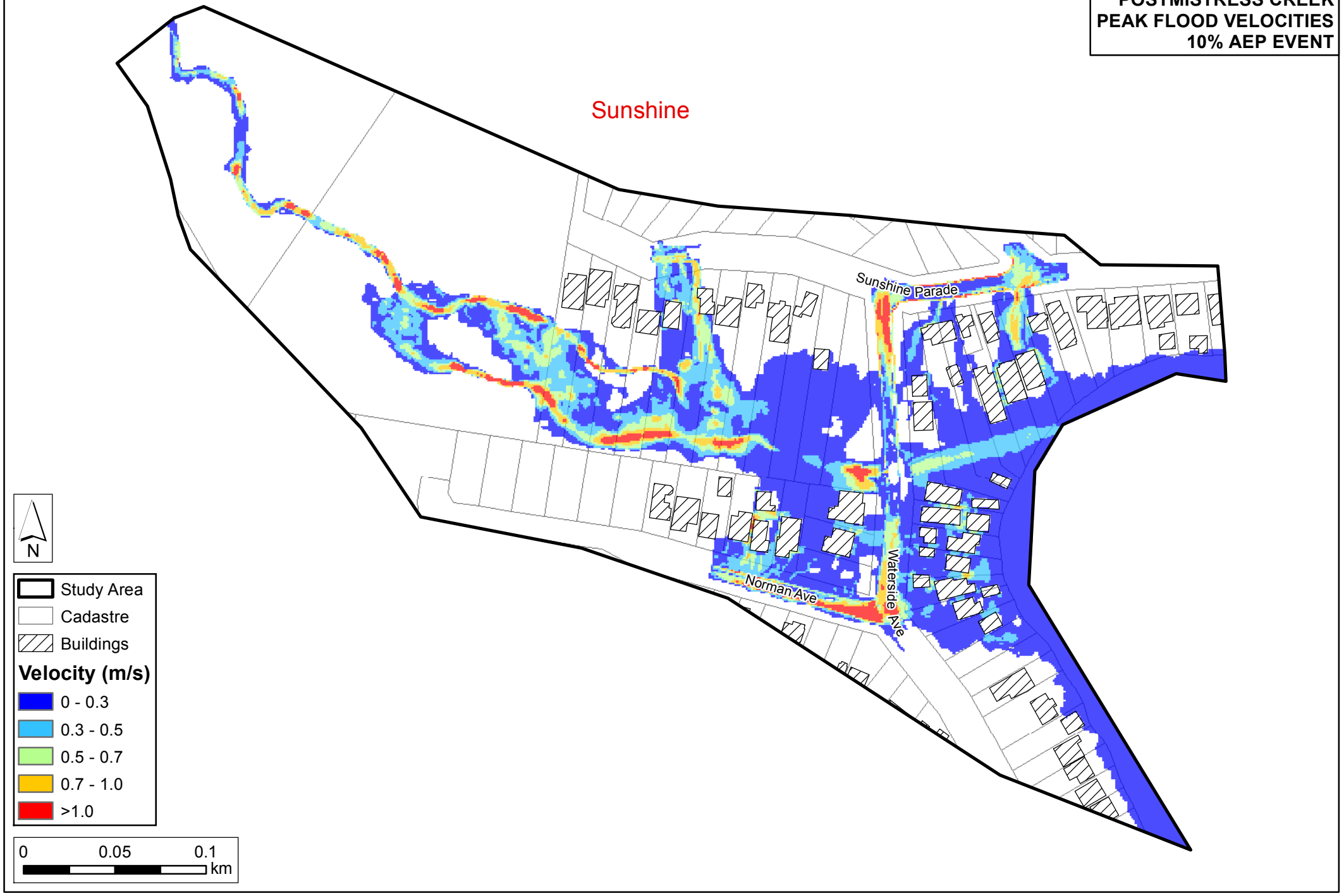
FIGURE I10

**POSTMISTRESS CREEK**
**PEAK FLOOD VELOCITIES**
**20% AEP EVENT**




J:\Jobs\119076\ArcGIS\ArcMap\Working\Template\Appendix_I\Figure\09_PMC_Peak_Flood_Velocity_50%AEP.mxd

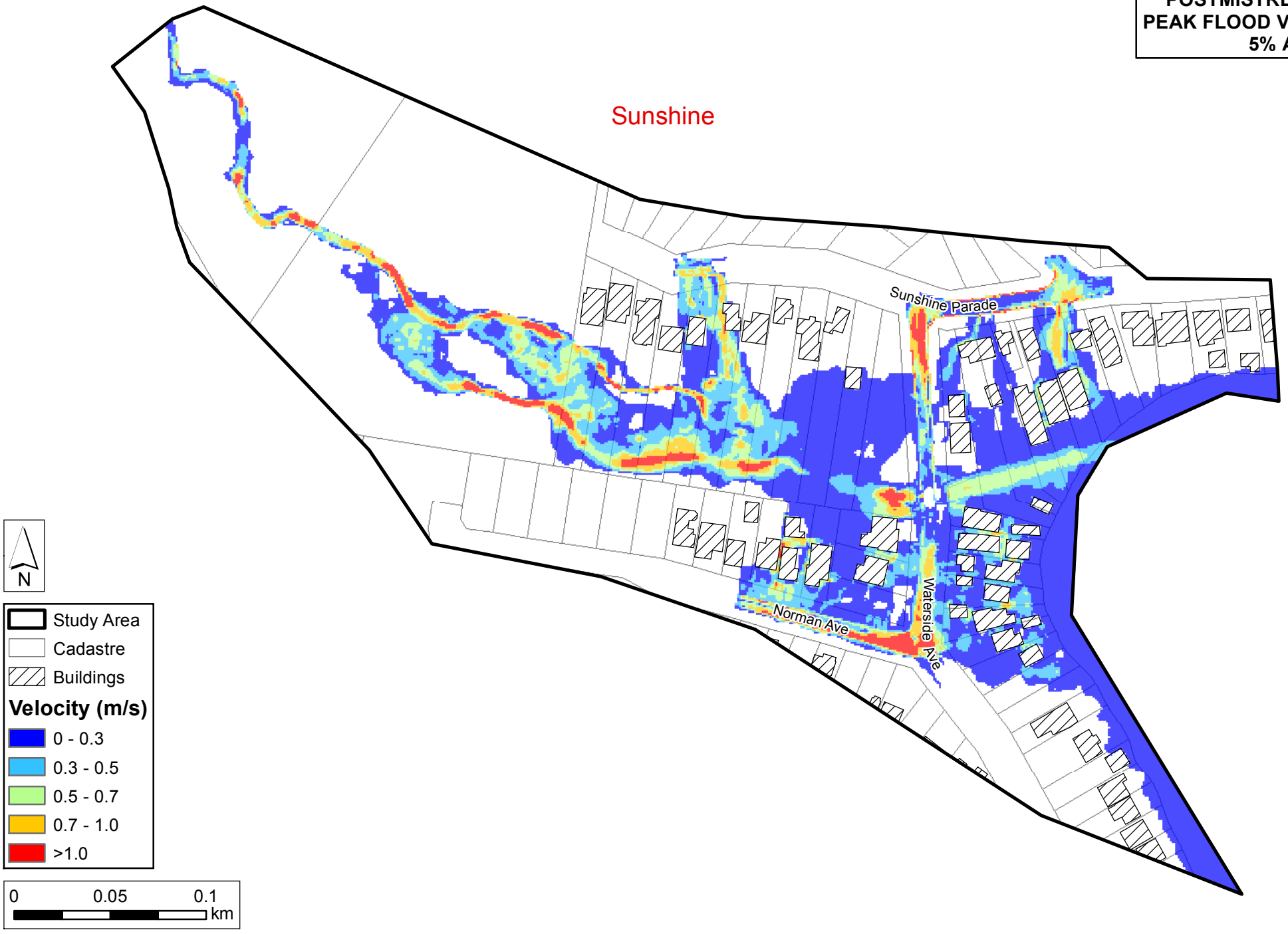
FIGURE I11
**POSTMISTRESS CREEK**
**PEAK FLOOD VELOCITIES**
**10% AEP EVENT**




J:\Jobs\119076\ArcGIS\ArcMap\Working\Template\Appendix_I\Figure\I10_PMC_Peak_Flood_Velocity_20%AEP.mxd

FIGURE I12

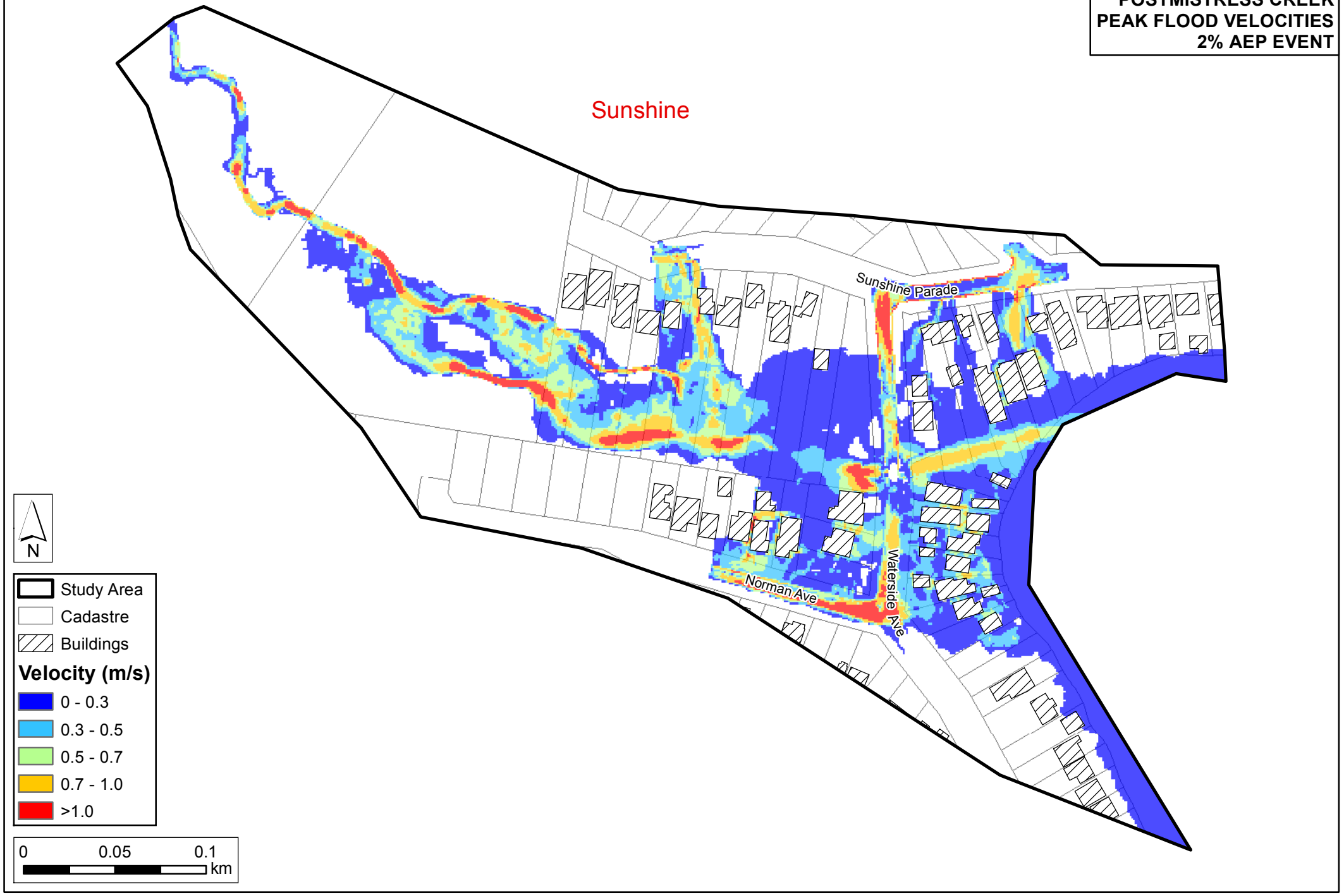
**POSTMISTRESS CREEK**
**PEAK FLOOD VELOCITIES**
**5% AEP EVENT**




J:\Jobs\119076\ArcGIS\ArcMap\Working\Template\Appendix_I\Figure11_PMC_Peak_Flood_Velocity_10%AEP.mxd

FIGURE I13

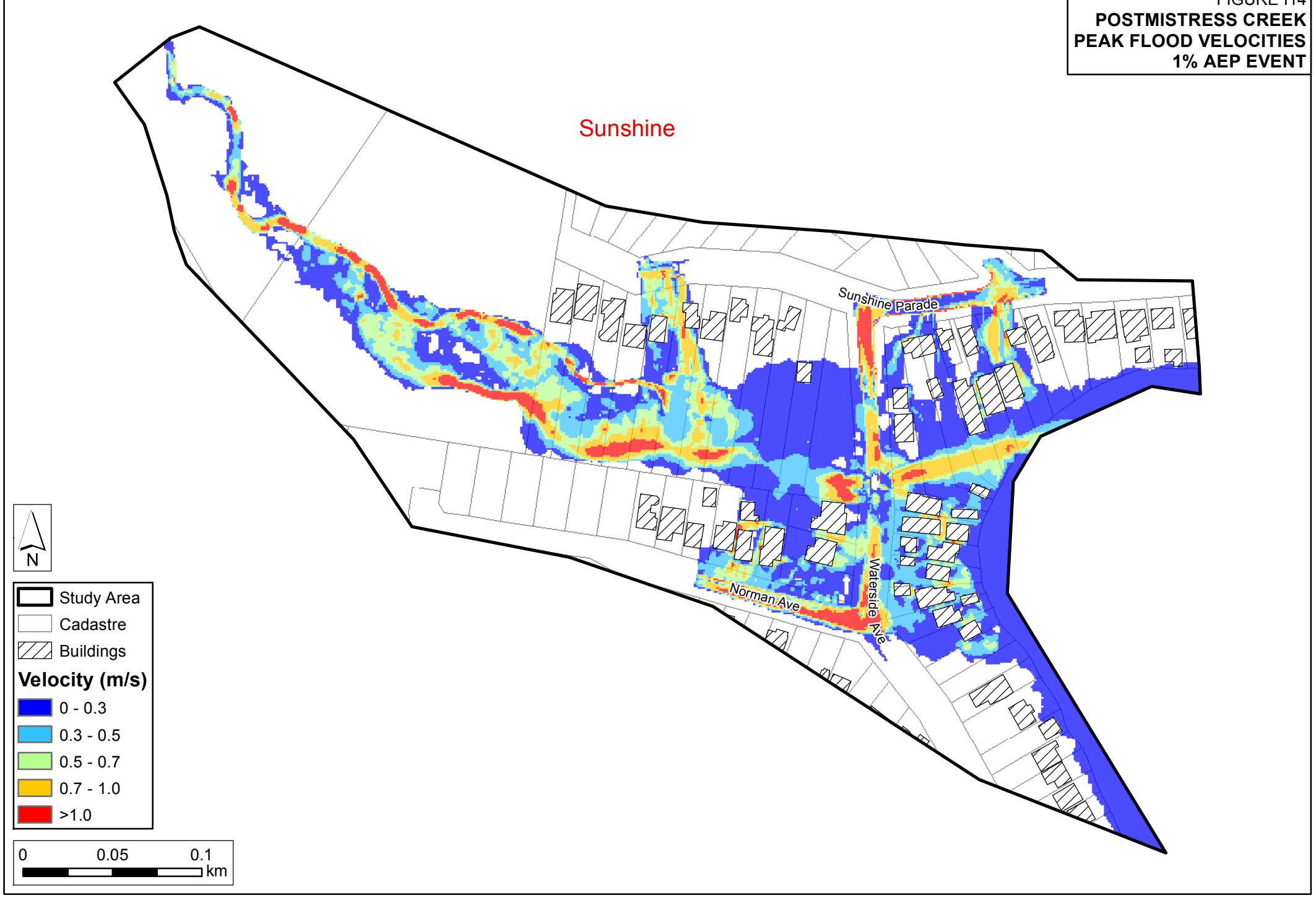
**POSTMISTRESS CREEK**
**PEAK FLOOD VELOCITIES**
**2% AEP EVENT**




J:\Jobs\119076\ArcGIS\ArcMap\Working\Template\Appendix_I\Figure\I12_PMC_Peak_Flood_Velocity_5%AEP.mxd

FIGURE I14

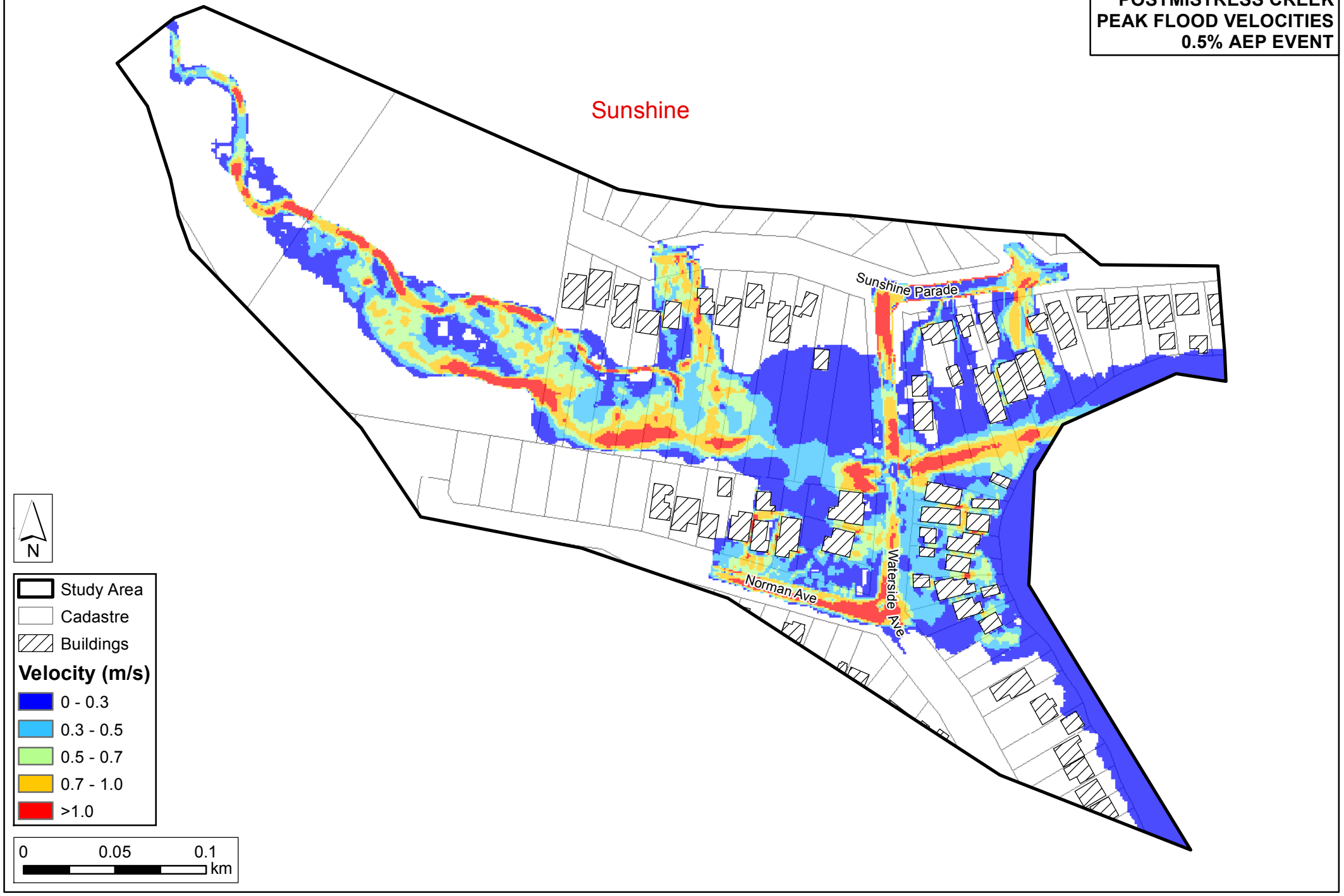
**POSTMISTRESS CREEK**
**PEAK FLOOD VELOCITIES**
**1% AEP EVENT**




J:\Jobs\119076\ArcGIS\ArcMap\Working\Template\Appendix_I\Figure113_PMC_Peak_Flood_Velocity_2%AEP.mxd

FIGURE I15

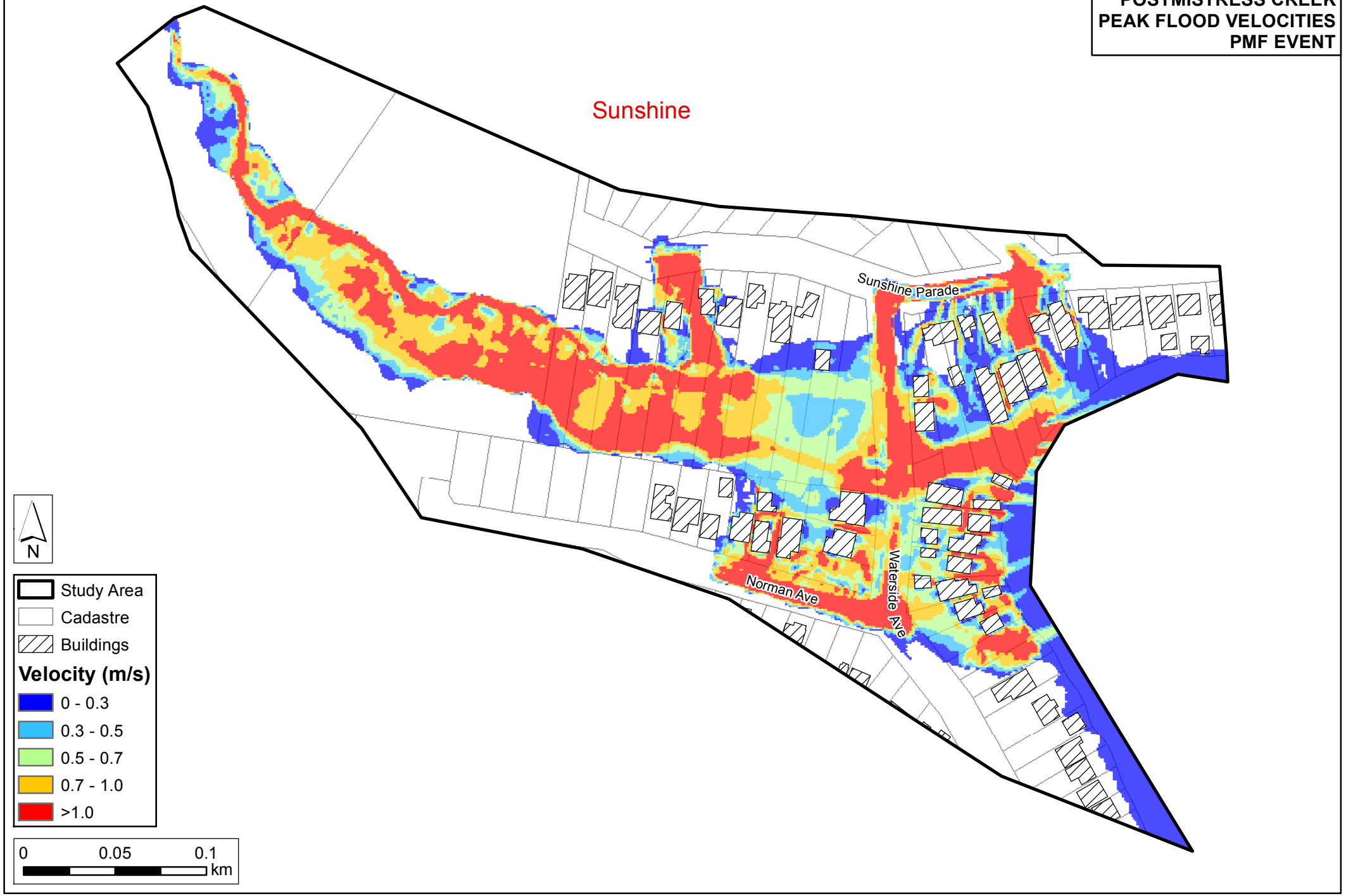
**POSTMISTRESS CREEK**
**PEAK FLOOD VELOCITIES**
**0.5% AEP EVENT**




J:\Jobs\119076\ArcGIS\ArcMap\Working\Template\Appendix_I\Figure114_PMC_Peak_Flood_Velocity_1%AEP.mxd

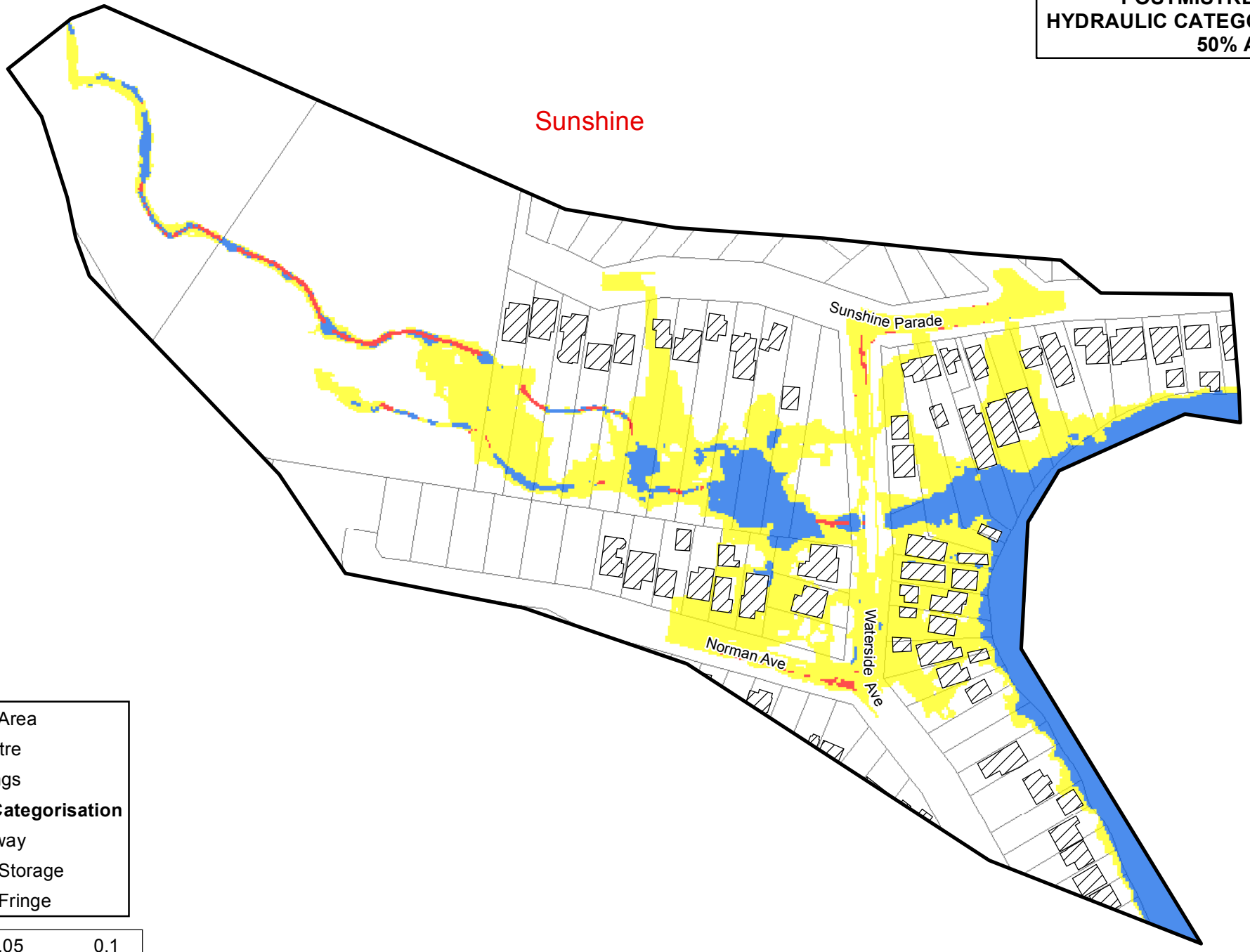
FIGURE I16

**POSTMISTRESS CREEK**
**PEAK FLOOD VELOCITIES**
**PMF EVENT**



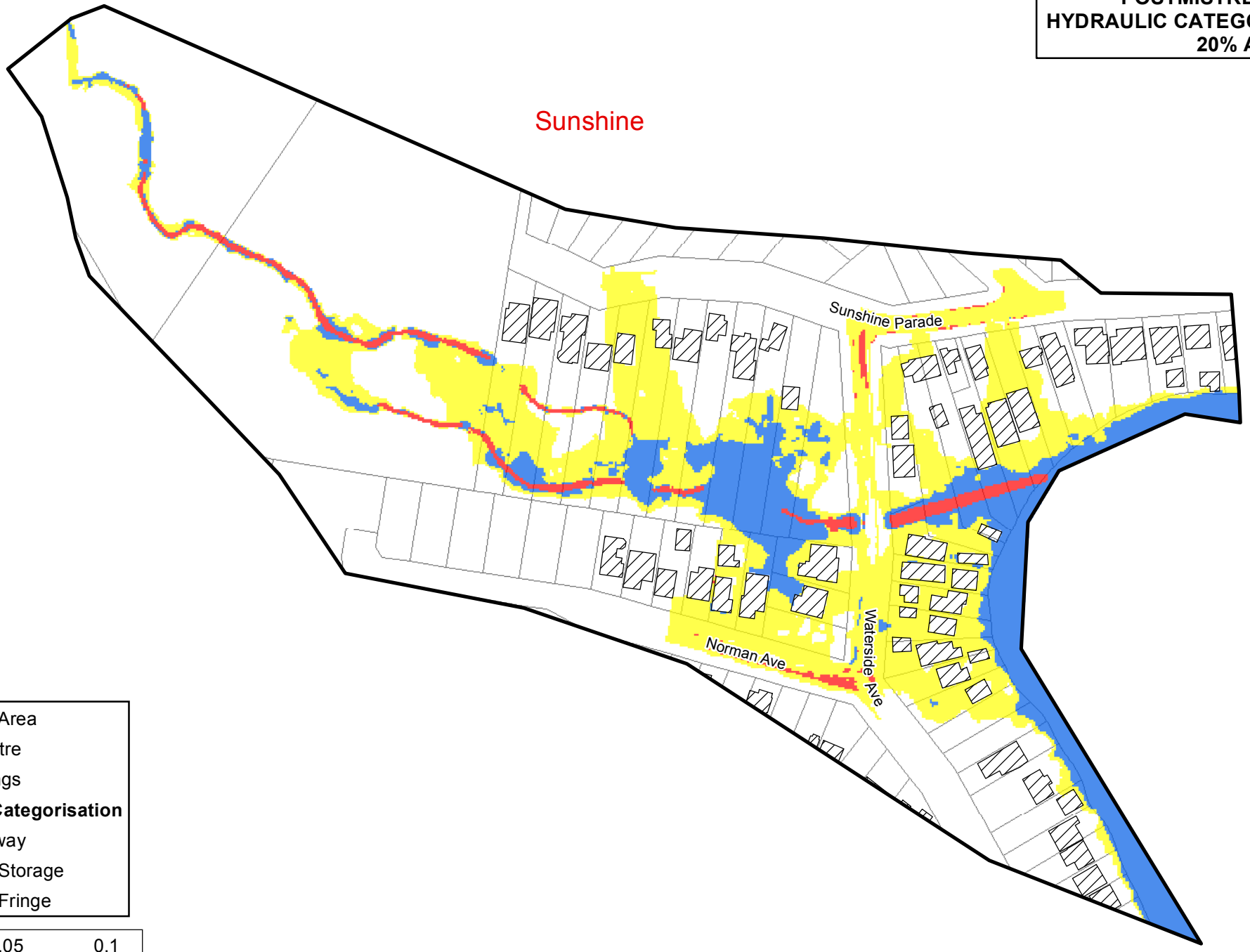

J:\Jobs\119076\ArcGIS\ArcMap\Working\Template\Appendix_I\Figure115_PMC_Peak_Flood_Velocity_0.5%AEP.mxd

FIGURE I17
**POSTMISTRESS CREEK**
**HYDRAULIC CATEGORISATION**
**50% AEP EVENT**



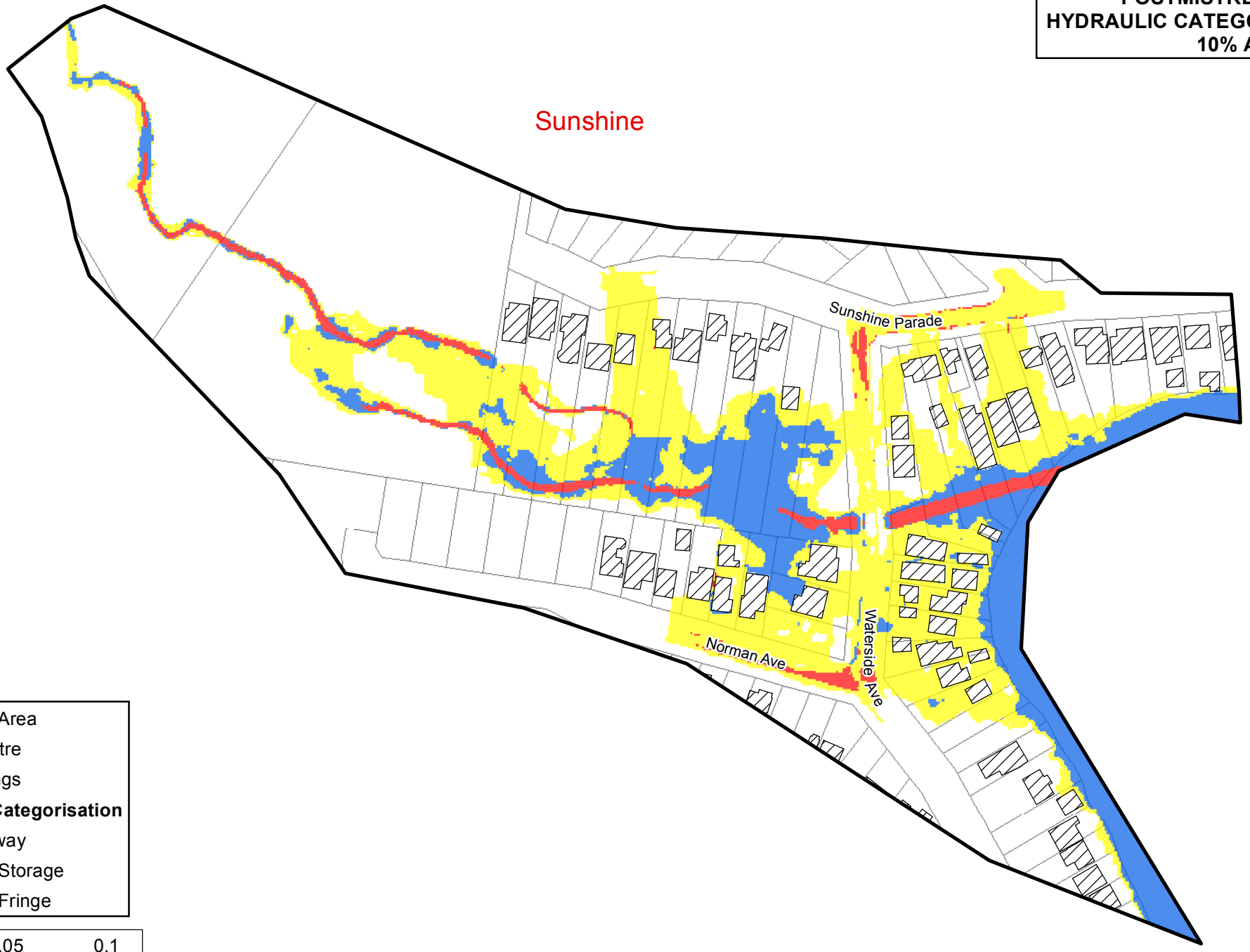

J:\Jobs\119076\ArcGIS\ArcMap\Working\Template\Appendix_I\Figure117_PMC_Hydraulic_Categories_50%AEP.mxd

FIGURE I18
**POSTMISTRESS CREEK**
**HYDRAULIC CATEGORISATION**
**20% AEP EVENT**



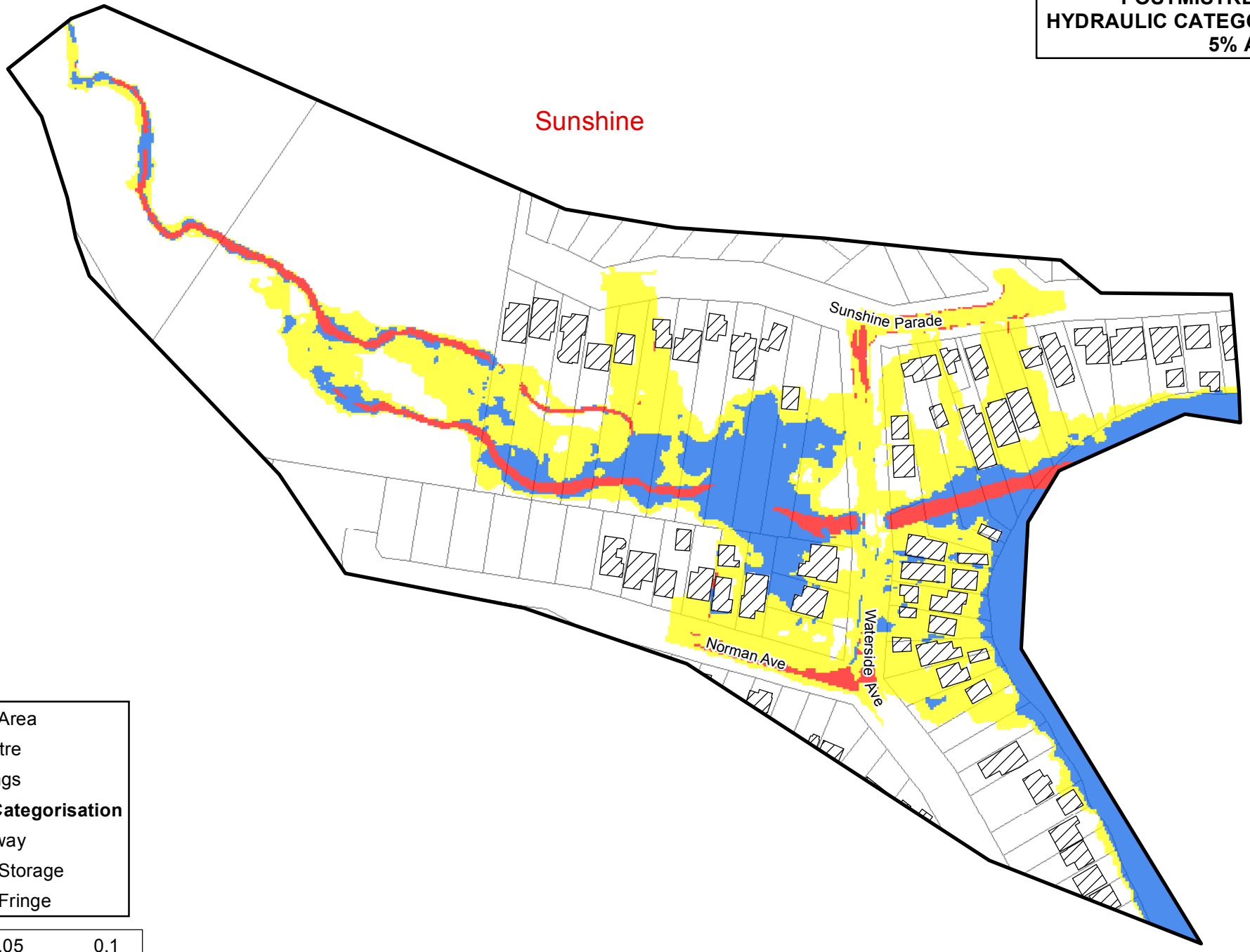

J:\Jobs\119076\ArcGIS\ArcMap\Working\Template\Appendix_I\Figure117_PMC_Hydraulic_Categories_50%AEP.mxd

FIGURE I19
**POSTMISTRESS CREEK**
**HYDRAULIC CATEGORISATION**
**10% AEP EVENT**



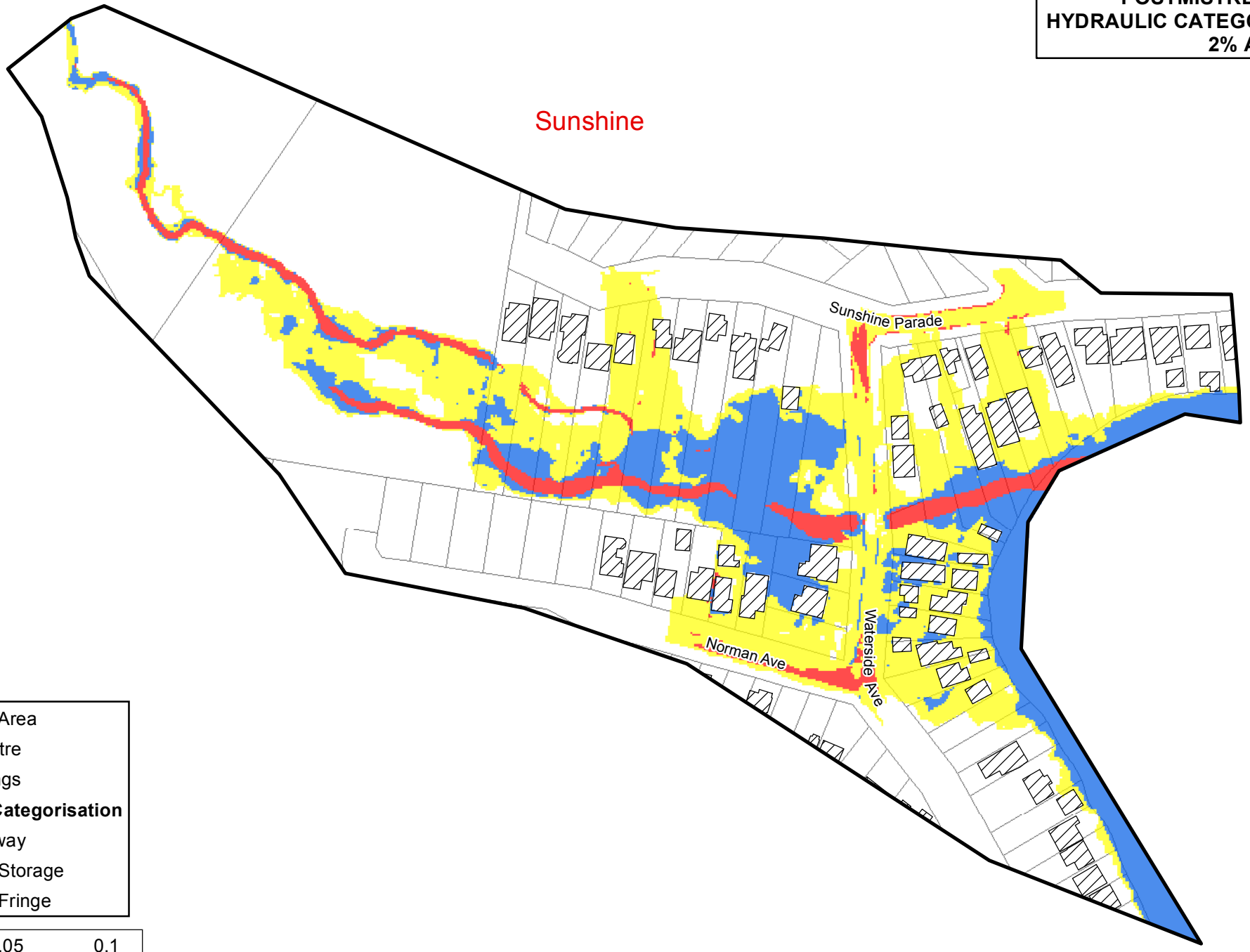

J:\Jobs\119076\ArcGIS\ArcMap\Working\Template\Appendix_I\Figure118_PMC_Hydraulic_Categories_20%AEP.mxd

FIGURE I20
**POSTMISTRESS CREEK**
**HYDRAULIC CATEGORISATION**
**5% AEP EVENT**



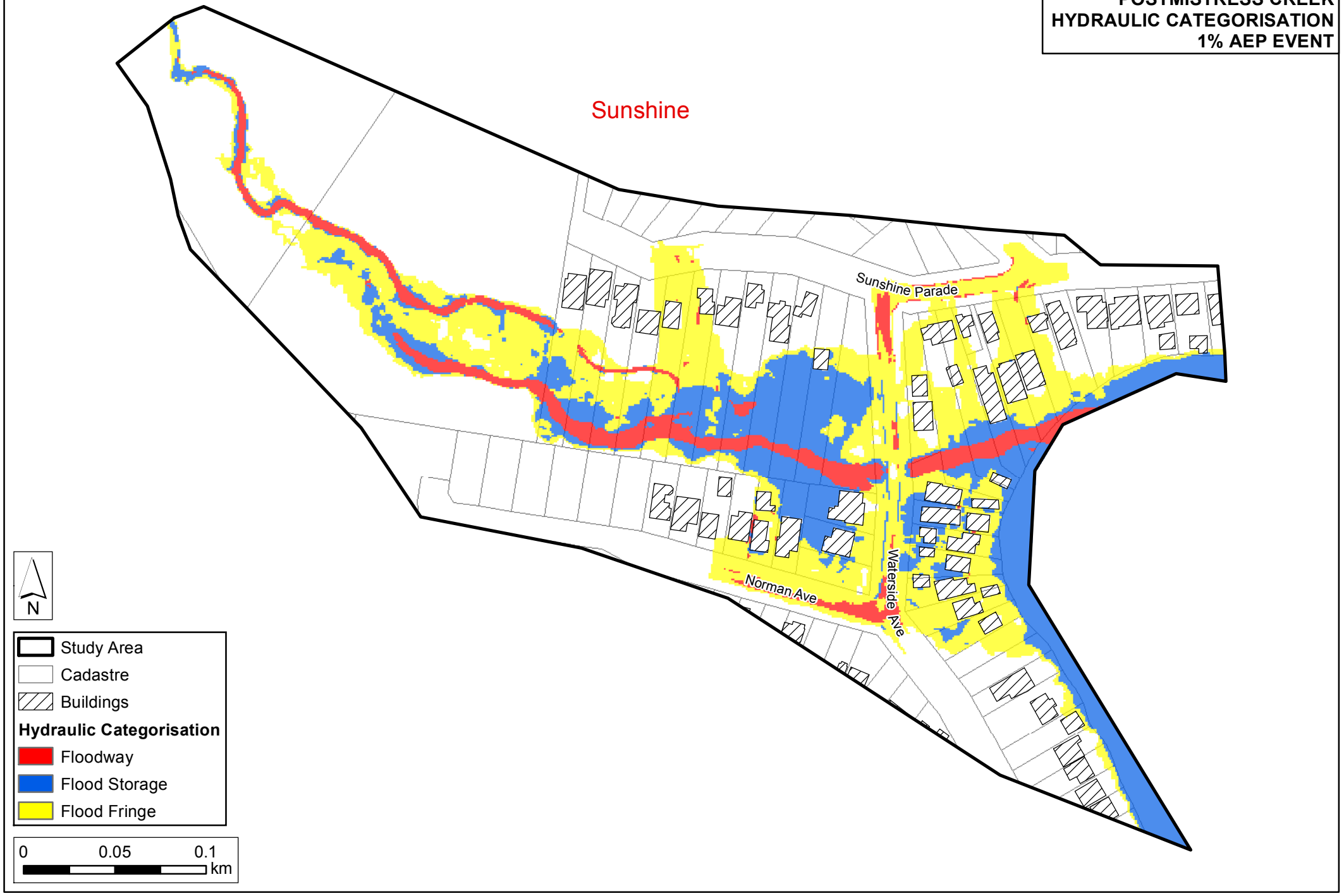

J:\Jobs\1190776\ArcGIS\ArcMap\Working\Template\Appendix_I\Figure\19_PMC_Hydraulic_Categories_10%AEP.mxd

FIGURE I21
**POSTMISTRESS CREEK**
**HYDRAULIC CATEGORISATION**
**2% AEP EVENT**



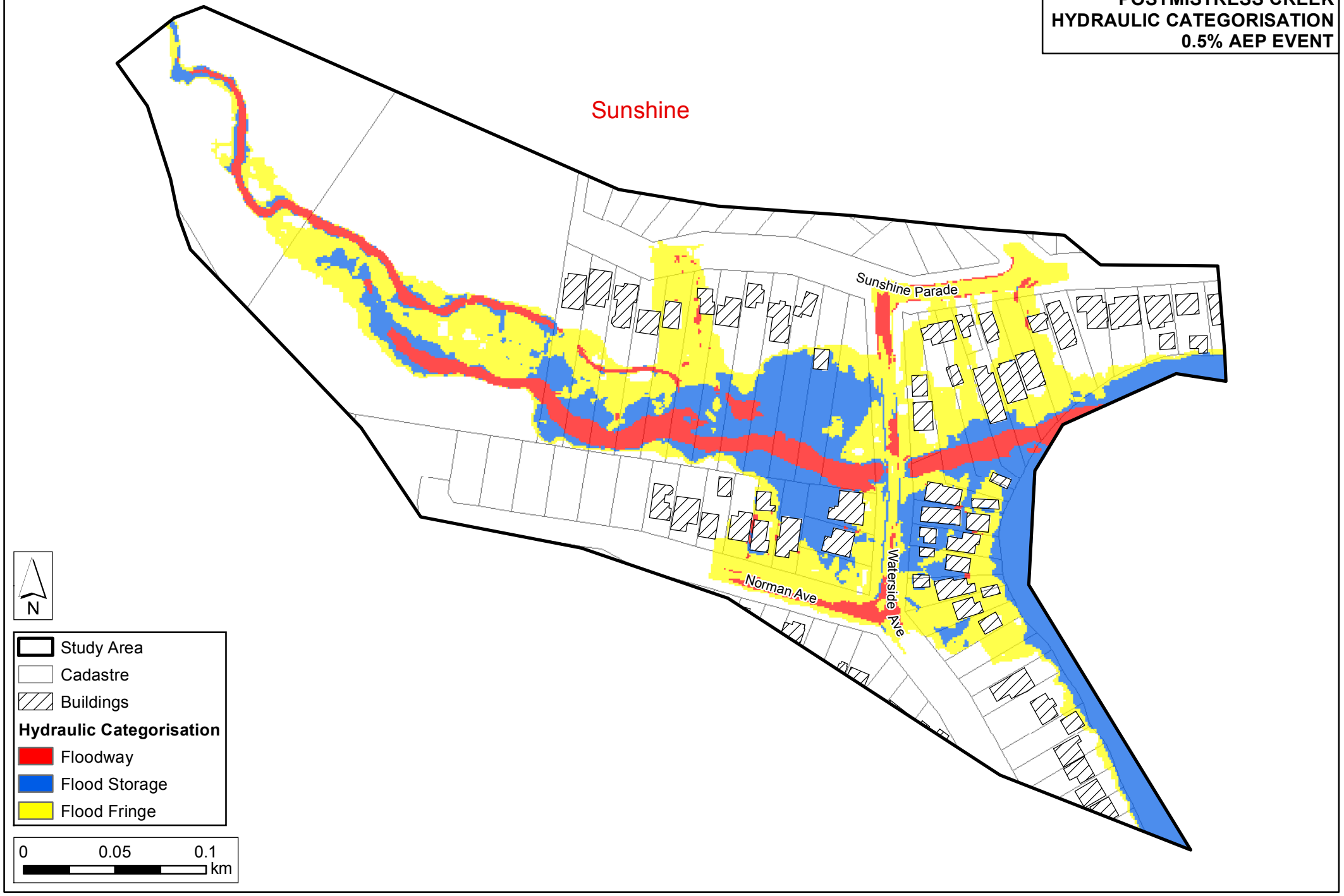

J:\Jobs\119076\ArcGIS\ArcMap\Working\Template\Appendix_I\Figure\I20_PMC_Hydraulic_Categories_5%AEP.mxd

FIGURE I22
**POSTMISTRESS CREEK**
**HYDRAULIC CATEGORISATION**
**1% AEP EVENT**



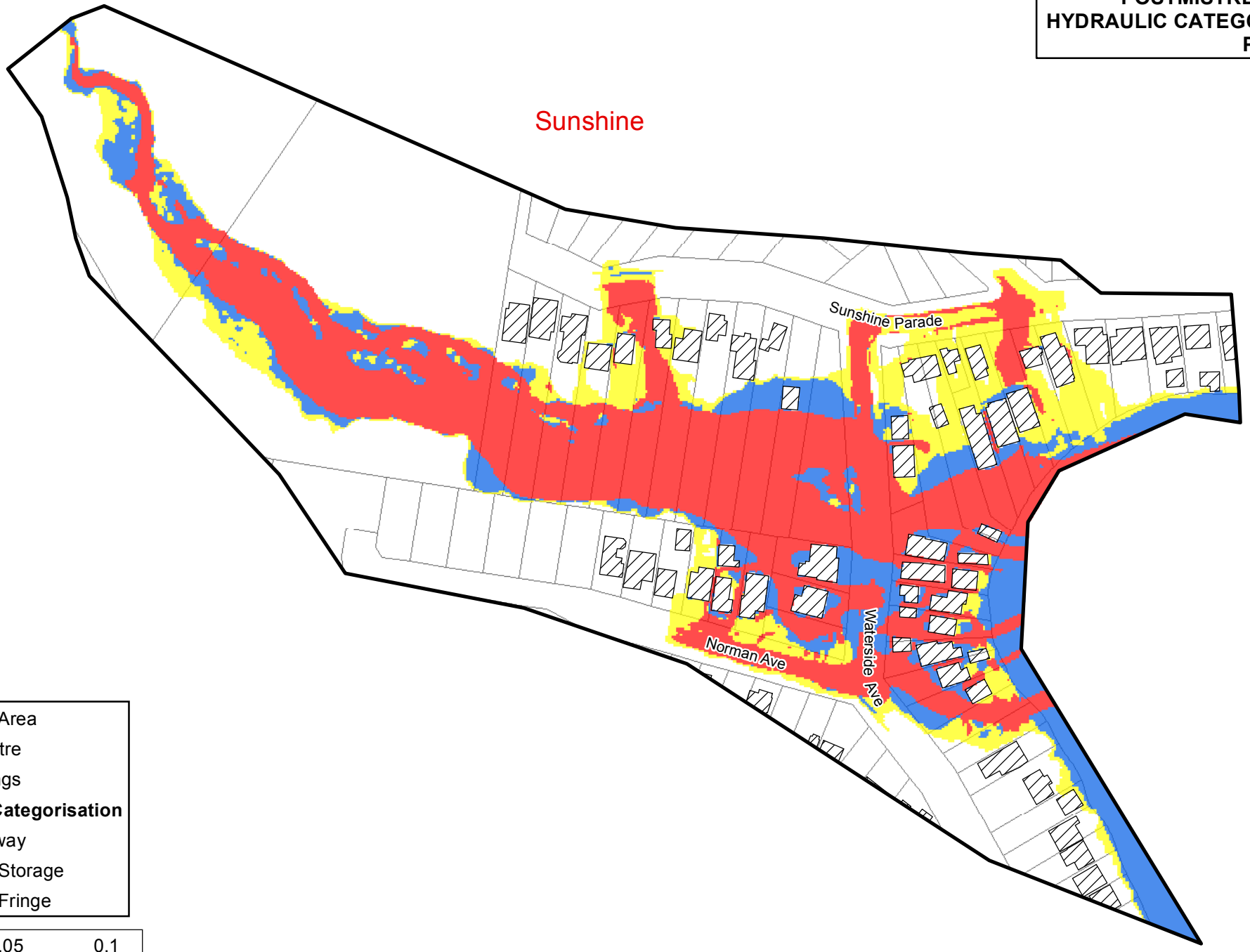

J:\Jobs\119076\ArcGIS\ArcMap\Working\Template\Appendix_I\Figure\21_PMC_Hydraulic_Categories_2%AEP.mxd

FIGURE I23
**POSTMISTRESS CREEK**
**HYDRAULIC CATEGORISATION**
**0.5% AEP EVENT**




J:\Jobs\119076\ArcGIS\ArcMap\Working\Template\Appendix_I\Figure\I22_PMC_Hydraulic_Categories_1%AEP.mxd

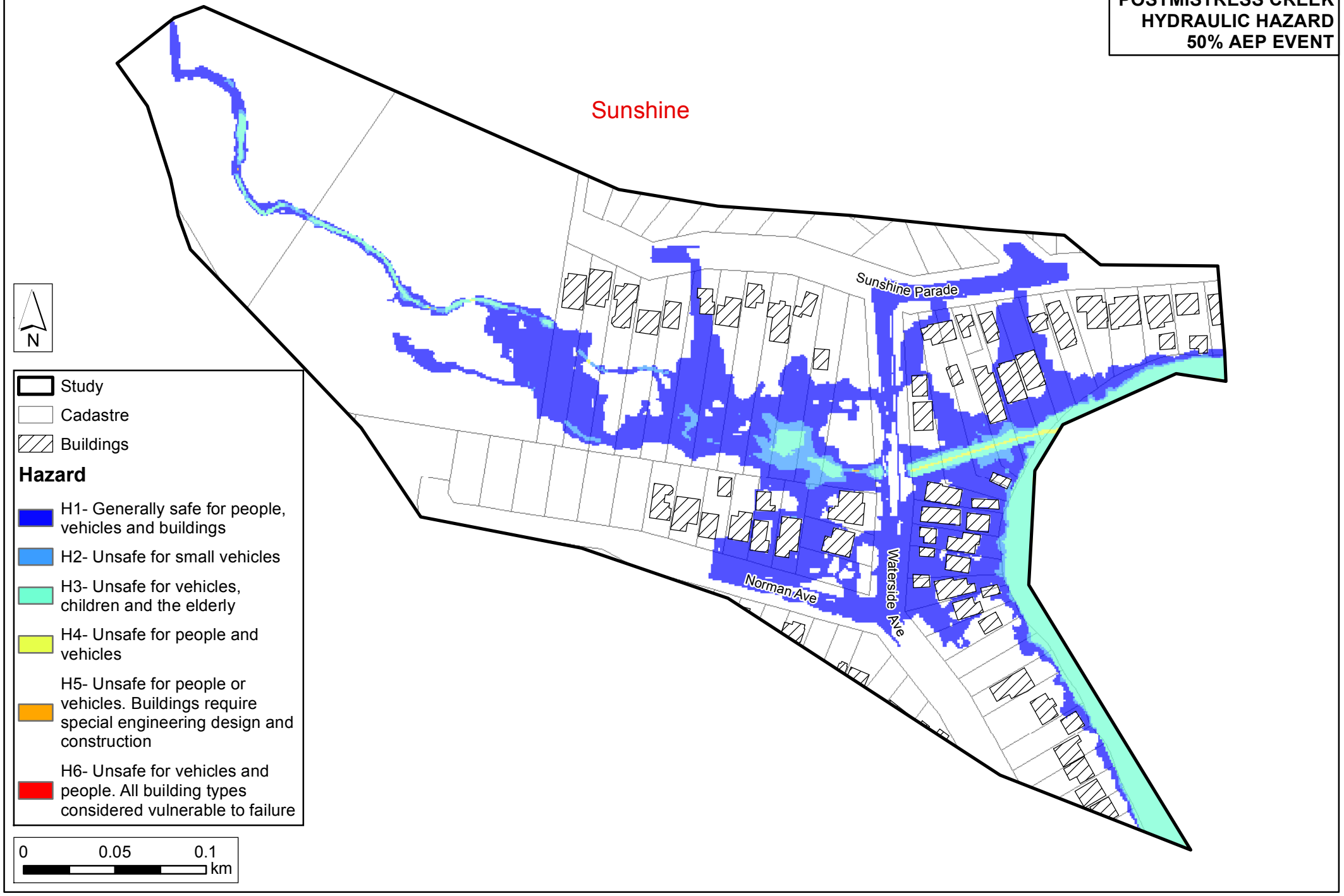
FIGURE I24
**POSTMISTRESS CREEK**
**HYDRAULIC CATEGORISATION**
**PMF EVENT**




J:\Jobs\1190776\ArcGIS\ArcMap\Working\Template\Appendix_I\Figure\I23_PMC_Hydraulic_Categories_0.5%AEP.mxd

FIGURE I25

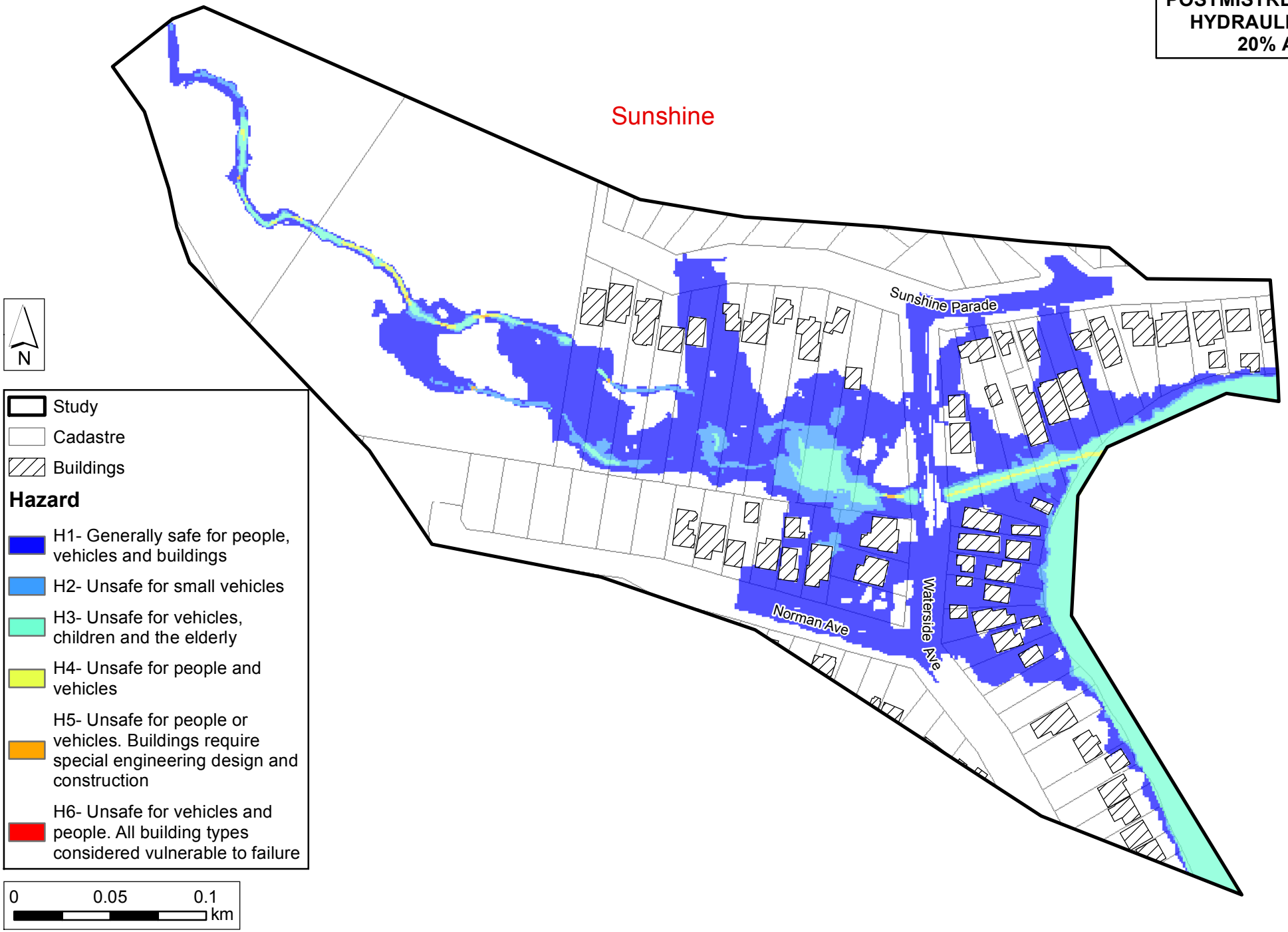
**POSTMISTRESS CREEK**
**HYDRAULIC HAZARD**
**50% AEP EVENT**




J:\Jobs\119076\ArcGIS\ArcMap\Working\Template\Appendix_I\Figure\I25_PMC_Provisional_Hazard_50%AEP.mxd

FIGURE I26

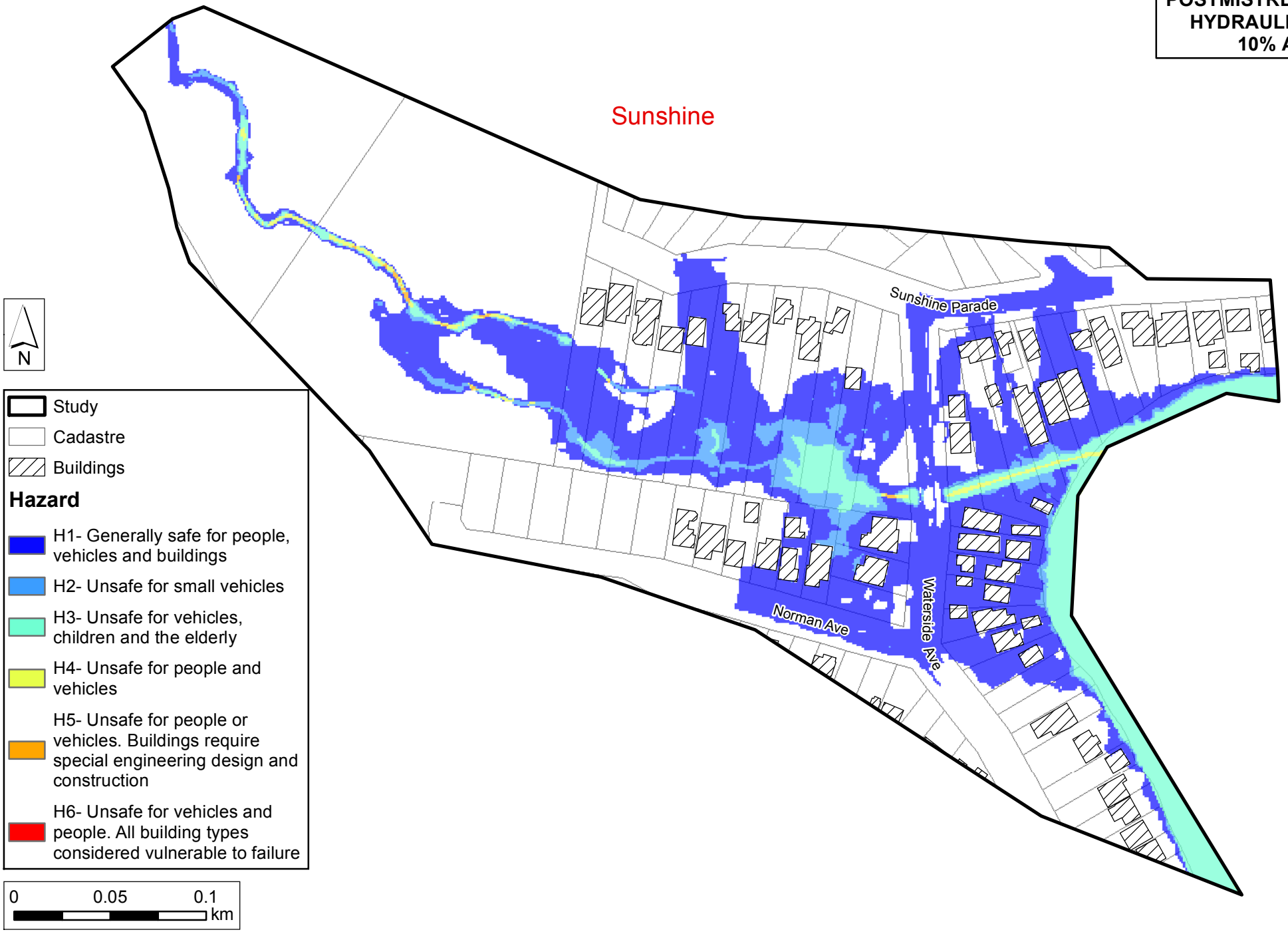
**POSTMISTRESS CREEK**
**HYDRAULIC HAZARD**
**20% AEP EVENT**




J:\Jobs\119076\ArcGIS\ArcMap\Working\Template\Appendix_I\Figure\I25_PMC_Provisional_Hazard_50%AEP.mxd

FIGURE I27

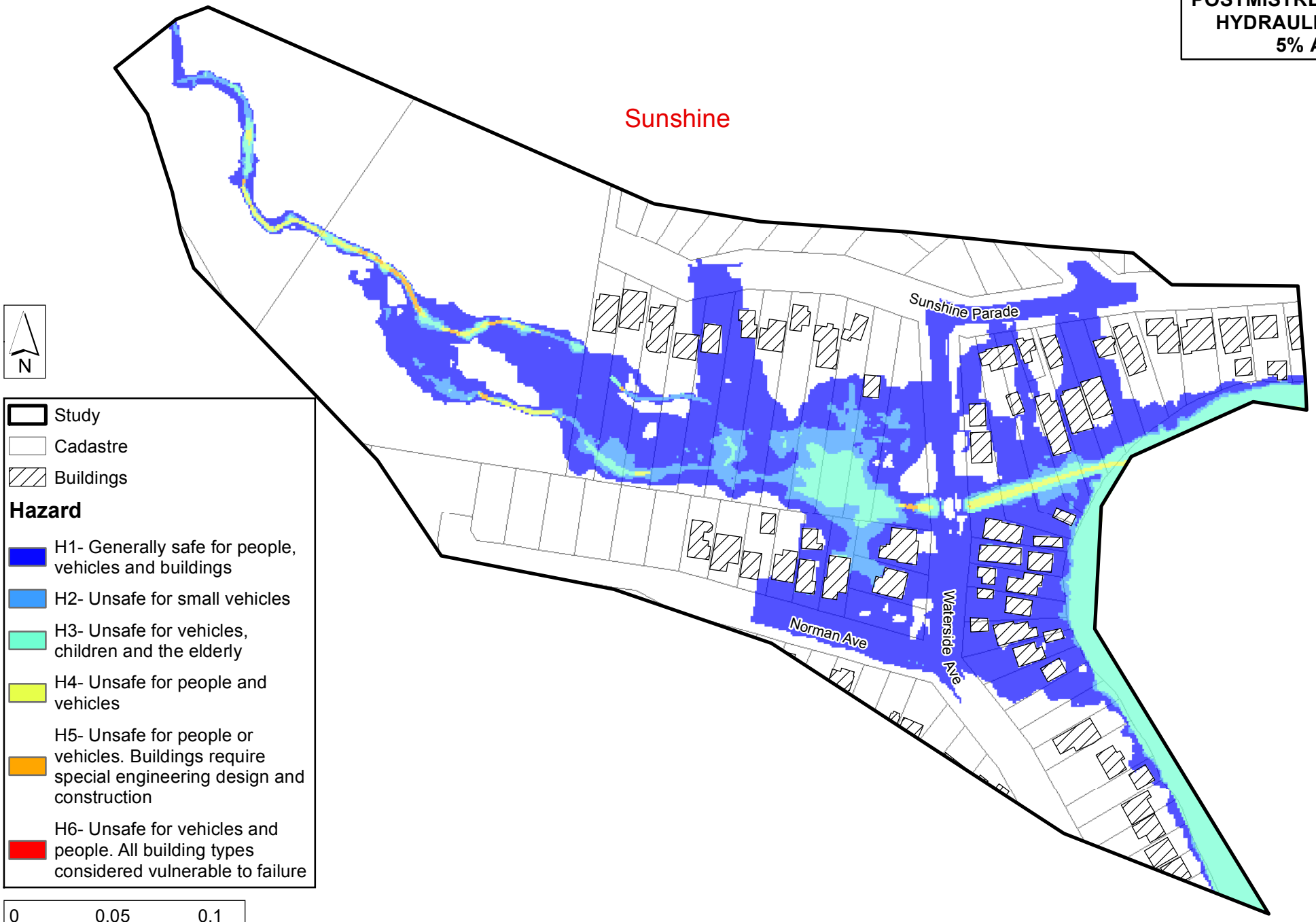
**POSTMISTRESS CREEK**
**HYDRAULIC HAZARD**
**10% AEP EVENT**




J:\Jobs\119076\ArcGIS\ArcMap\Working\Template\Appendix_I\Figure\I26_PMC_Provisional_Hazard_20%AEP.mxd

FIGURE I28

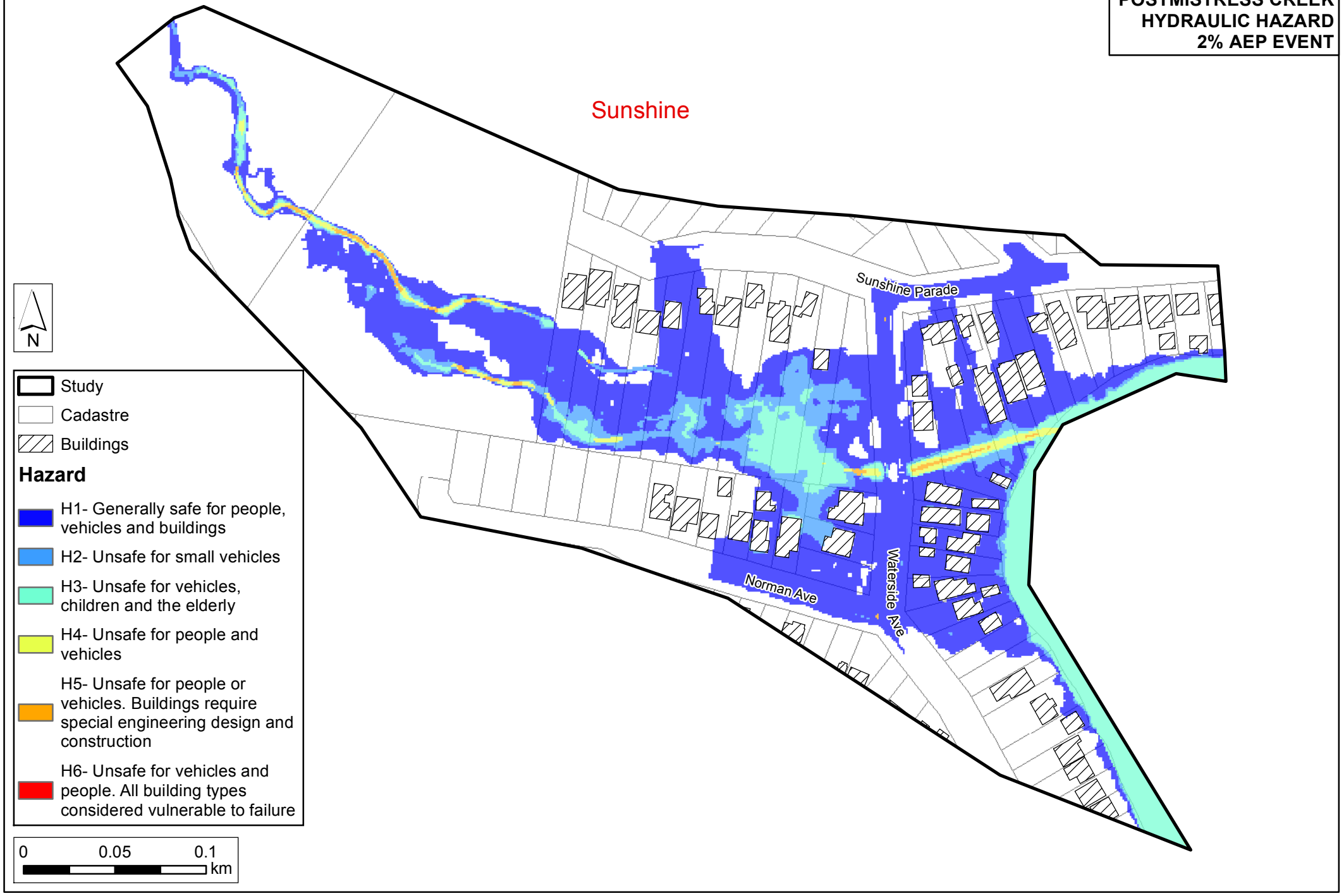
**POSTMISTRESS CREEK**
**HYDRAULIC HAZARD**
**5% AEP EVENT**




J:\Jobs\119076\ArcGIS\ArcMap\Working\Template\Appendix_I\Figure\I27_PMC_Provisional_Hazard_10%AEP.mxd

FIGURE I29

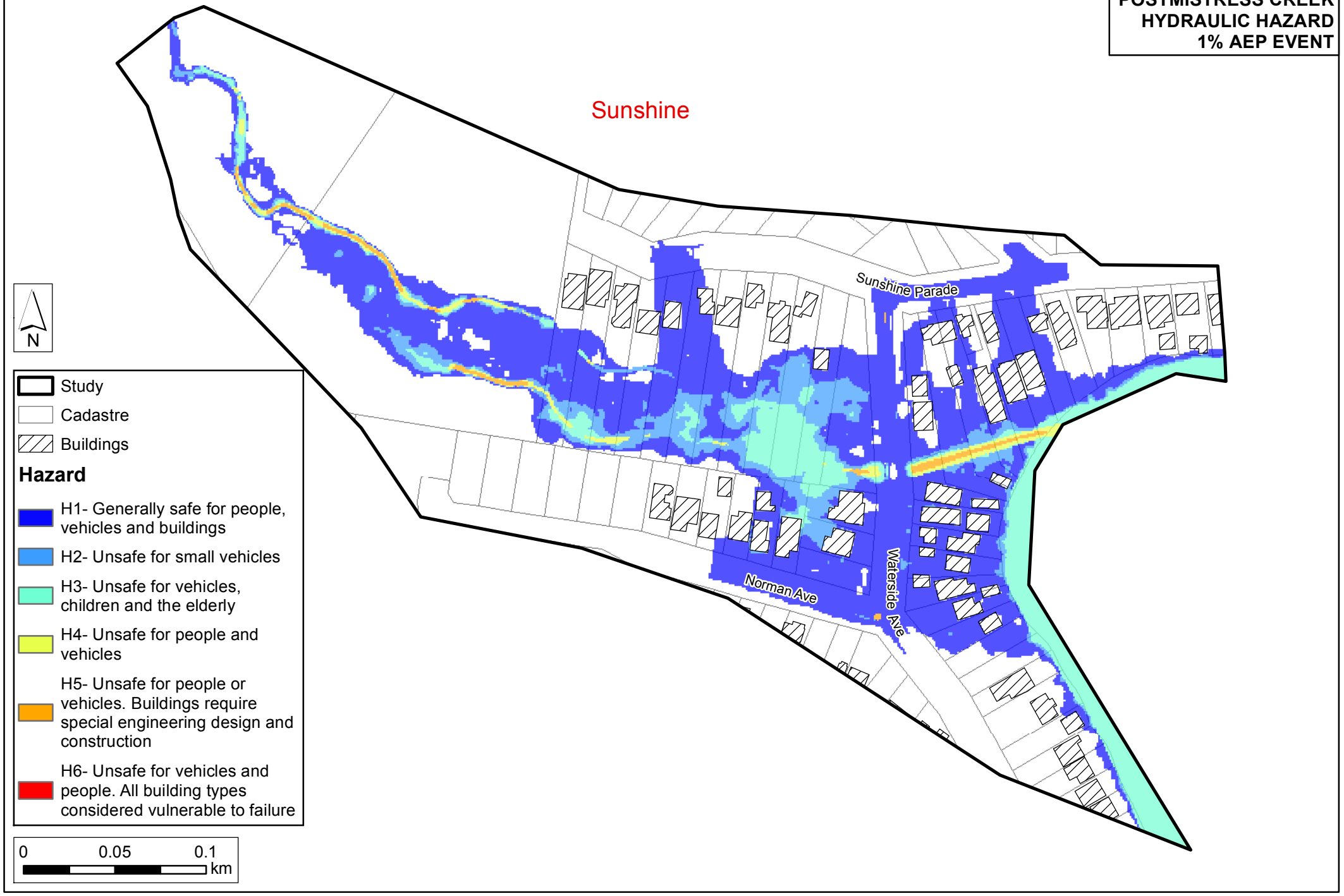
**POSTMISTRESS CREEK**
**HYDRAULIC HAZARD**
**2% AEP EVENT**




J:\Jobs\119076\ArcGIS\ArcMap\Working\Template\Appendix_I\Figure\I29_PMC_Provisional_Hazard_2%AEP.mxd

FIGURE I30

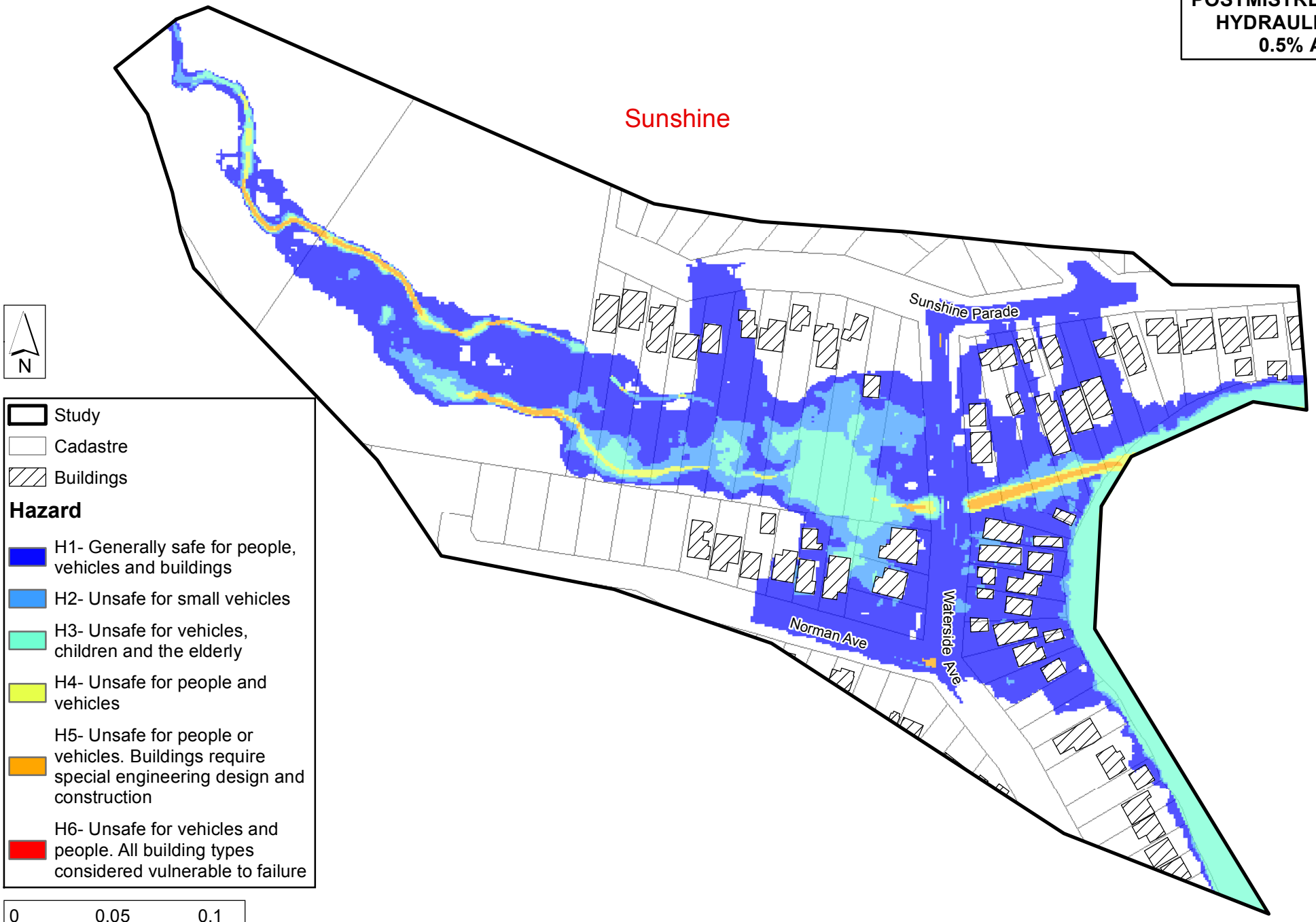
**POSTMISTRESS CREEK**
**HYDRAULIC HAZARD**
**1% AEP EVENT**




J:\Jobs\119076\ArcGIS\ArcMap\Working\Template\Appendix_I\Figure\I29_PMC_Provisional_Hazard_2%AEP.mxd

FIGURE I31

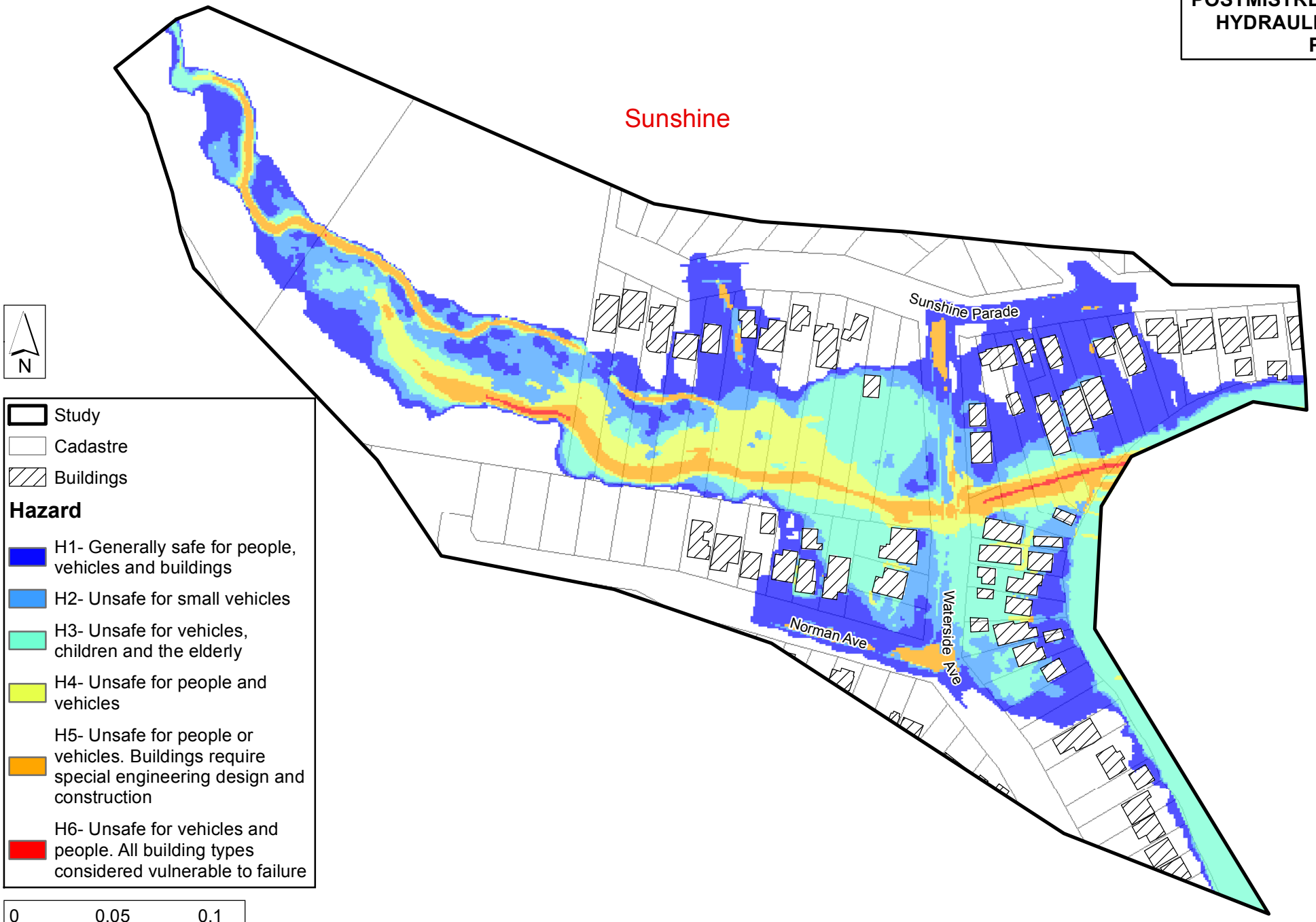
**POSTMISTRESS CREEK**
**HYDRAULIC HAZARD**
**0.5% AEP EVENT**




J:\Jobs\119076\ArcGIS\ArcMap\Working\Template\Appendix_I\Figure\I30_PMC_Provisional_Hazard_1%AEP.mxd

FIGURE I32

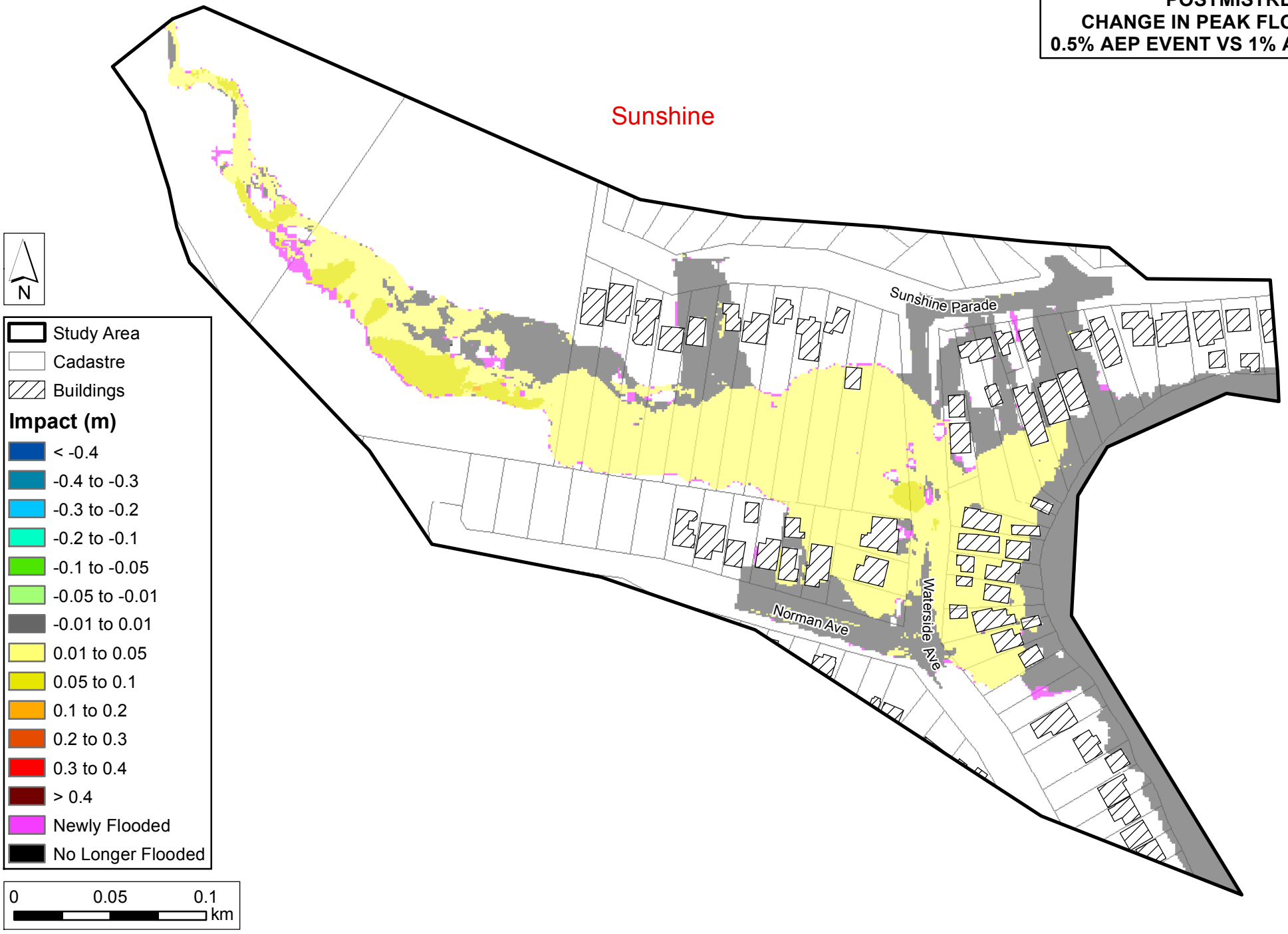
**POSTMISTRESS CREEK**
**HYDRAULIC HAZARD**
**PMF EVENT**




J:\Jobs\119076\ArcGIS\ArcMap\Working\Template\Appendix_I\Figure\I31_PMC_Provisional_Hazard_0.5%AEP.mxd

FIGURE I33

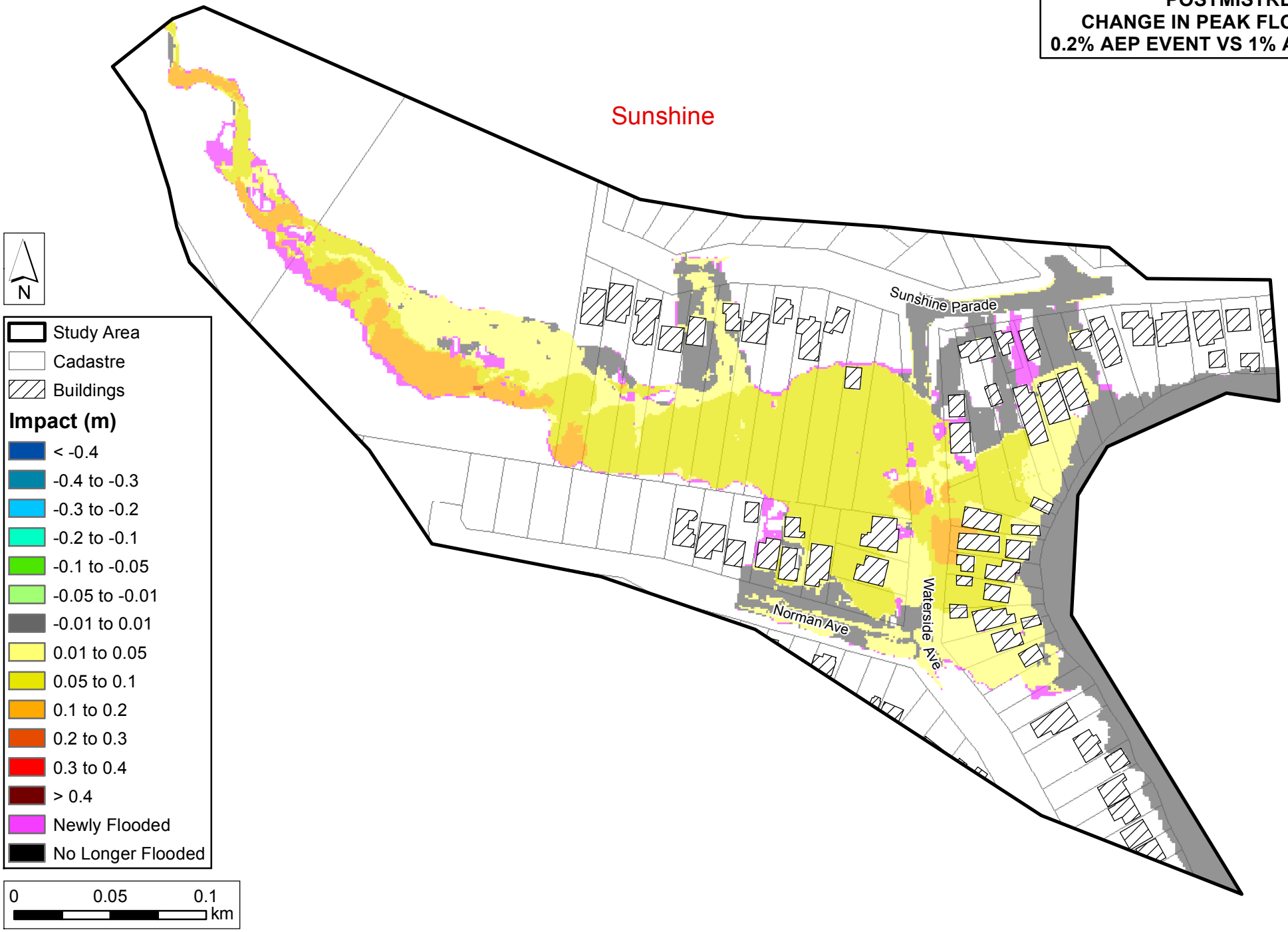
**POSTMISTRESS CREEK**
**CHANGE IN PEAK FLOOD LEVEL**
**0.5% AEP EVENT VS 1% AEP EVENT**




J:\Jobs\119076\ArcGIS\ArcMap\Working\Template\Appendix_I\Figure133_PMC_Impact_CC_0.5%AEP_V_1%AEP.mxd

FIGURE I34

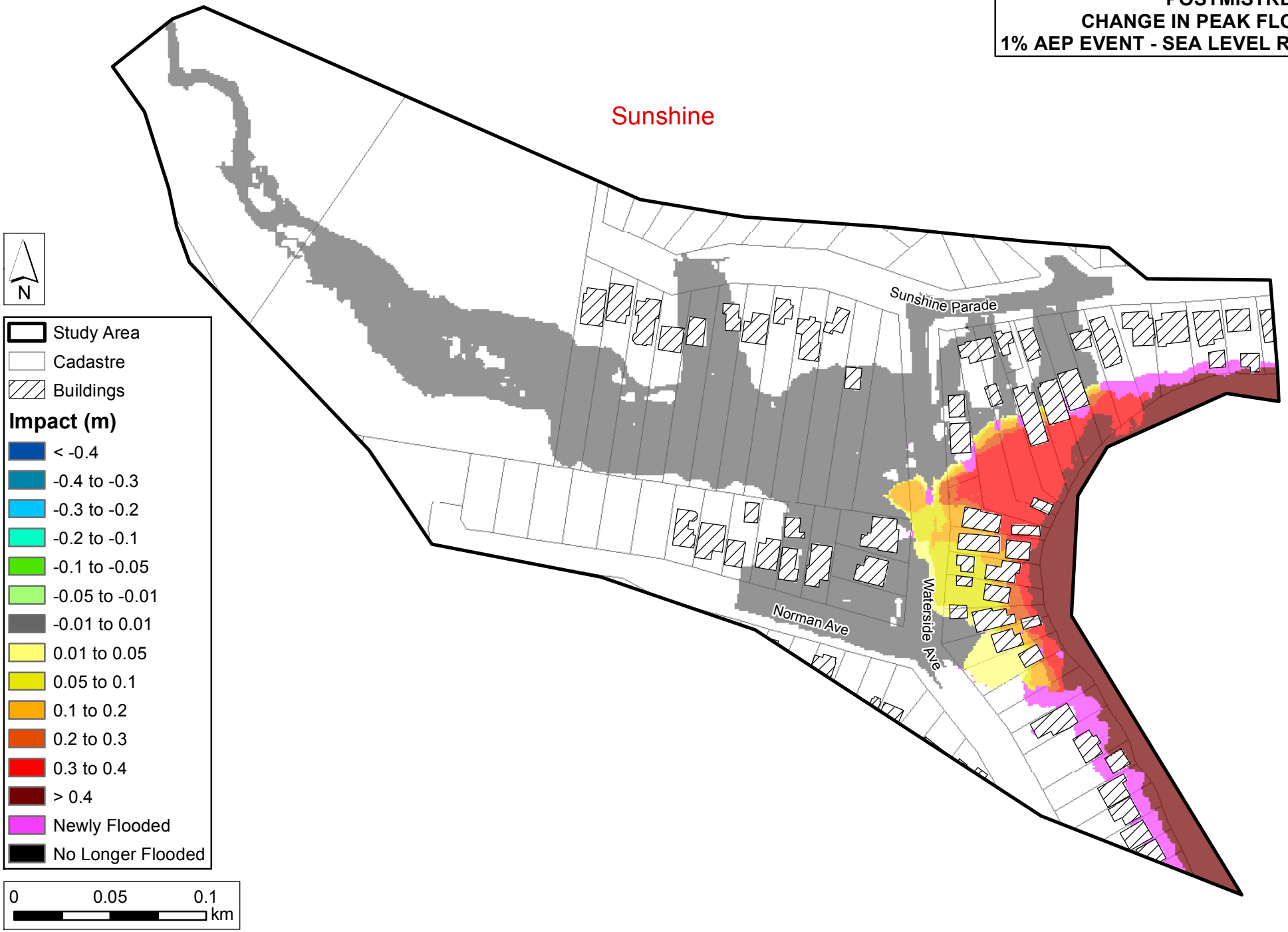
**POSTMISTRESS CREEK**
**CHANGE IN PEAK FLOOD LEVEL**
**0.2% AEP EVENT VS 1% AEP EVENT**




J:\Jobs\1190776\ArcGIS\ArcMap\Working\Template\Appendix_I\Figure133_PMC_Impact_CC_0.5%AEP_V_1%AEP.mxd

FIGURE I35

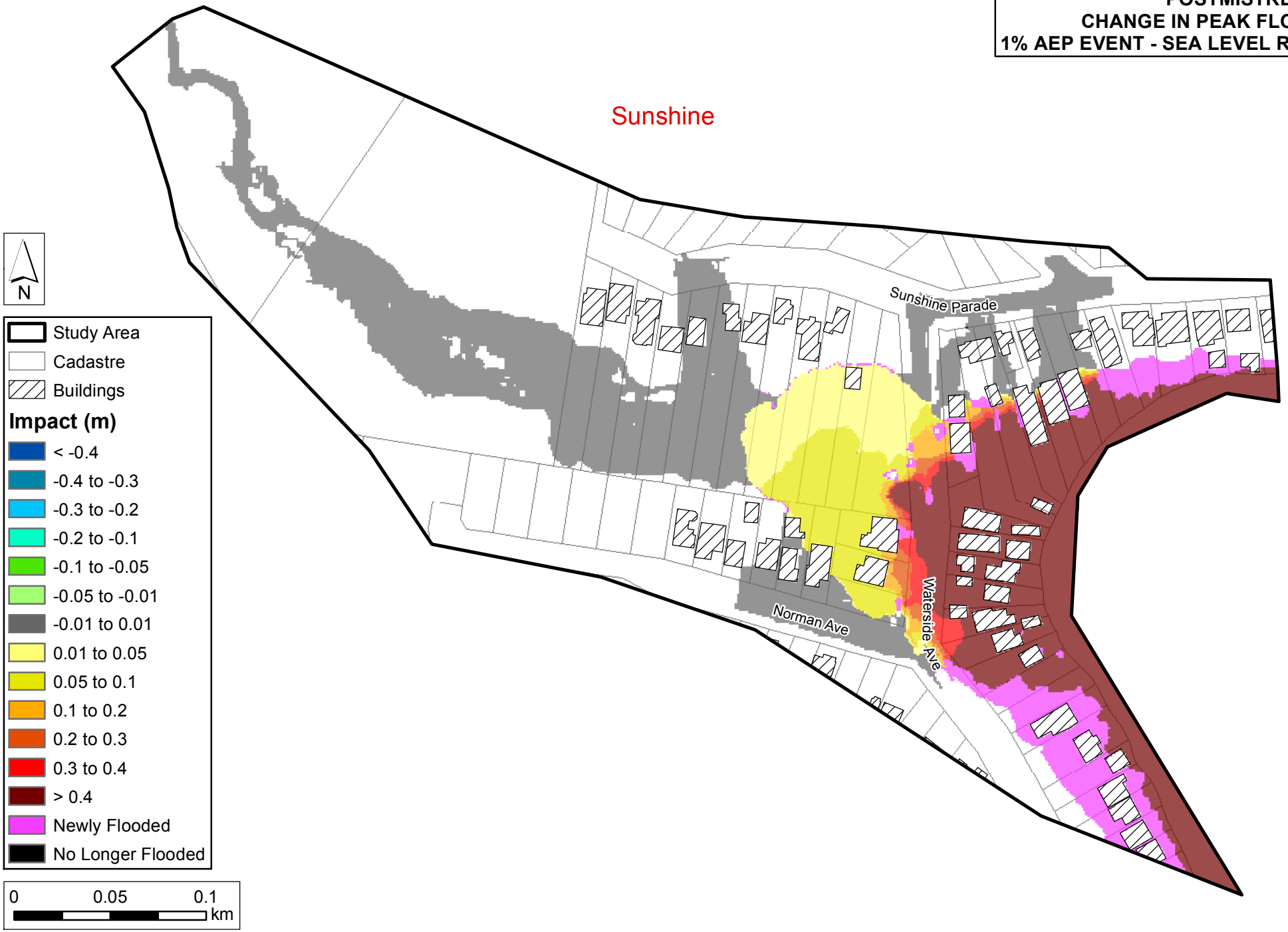
**POSTMISTRESS CREEK**
**CHANGE IN PEAK FLOOD LEVEL**
**1% AEP EVENT - SEA LEVEL RISE 400MM**




J:\Jobs\119076\ArcGIS\ArcMap\Working\Template\Appendix_I\Figure\I34_PMC_Impact_CC_0.2%AEP_V_1%AEP.mxd

FIGURE I36

**POSTMISTRESS CREEK**
**CHANGE IN PEAK FLOOD LEVEL**
**1% AEP EVENT - SEA LEVEL RISE 900MM**




J:\Jobs\119076\ArcGIS\ArcMap\Working\Template\Appendix_I\Figure\I35_PMC_Impact_CC_SLR04_1%AEP.mxd

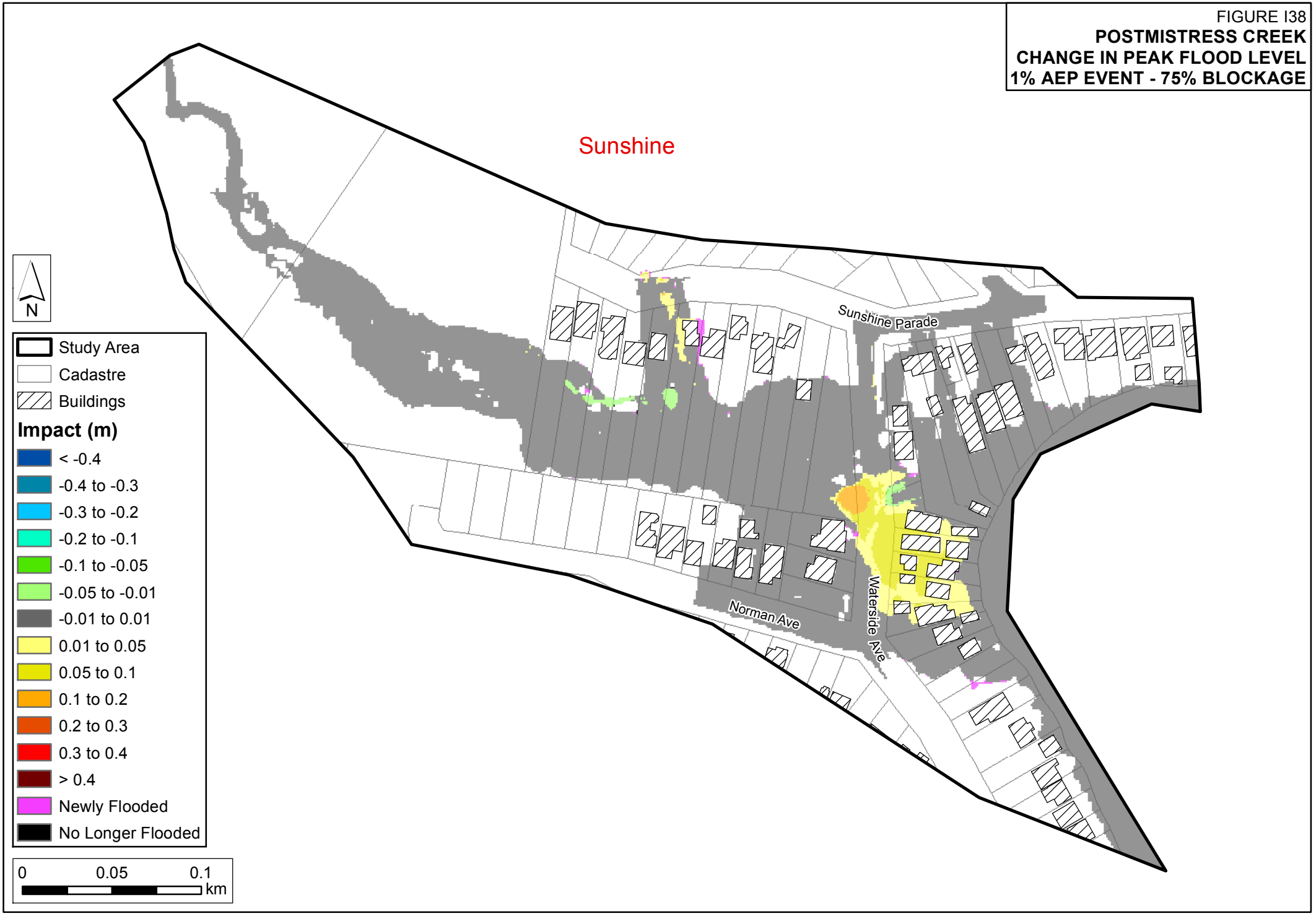
FIGURE I37

**POSTMISTRESS CREEK**
**CHANGE IN PEAK FLOOD LEVEL**
**1% AEP EVENT - 25% BLOCKAGE**

J:\Jobs\119076\ArcGIS\ArcMap\Working\Template\Appendix_I\Figure\I36_PMC_Impact_CC_SLR09_1%AEP.mxd

FIGURE I38

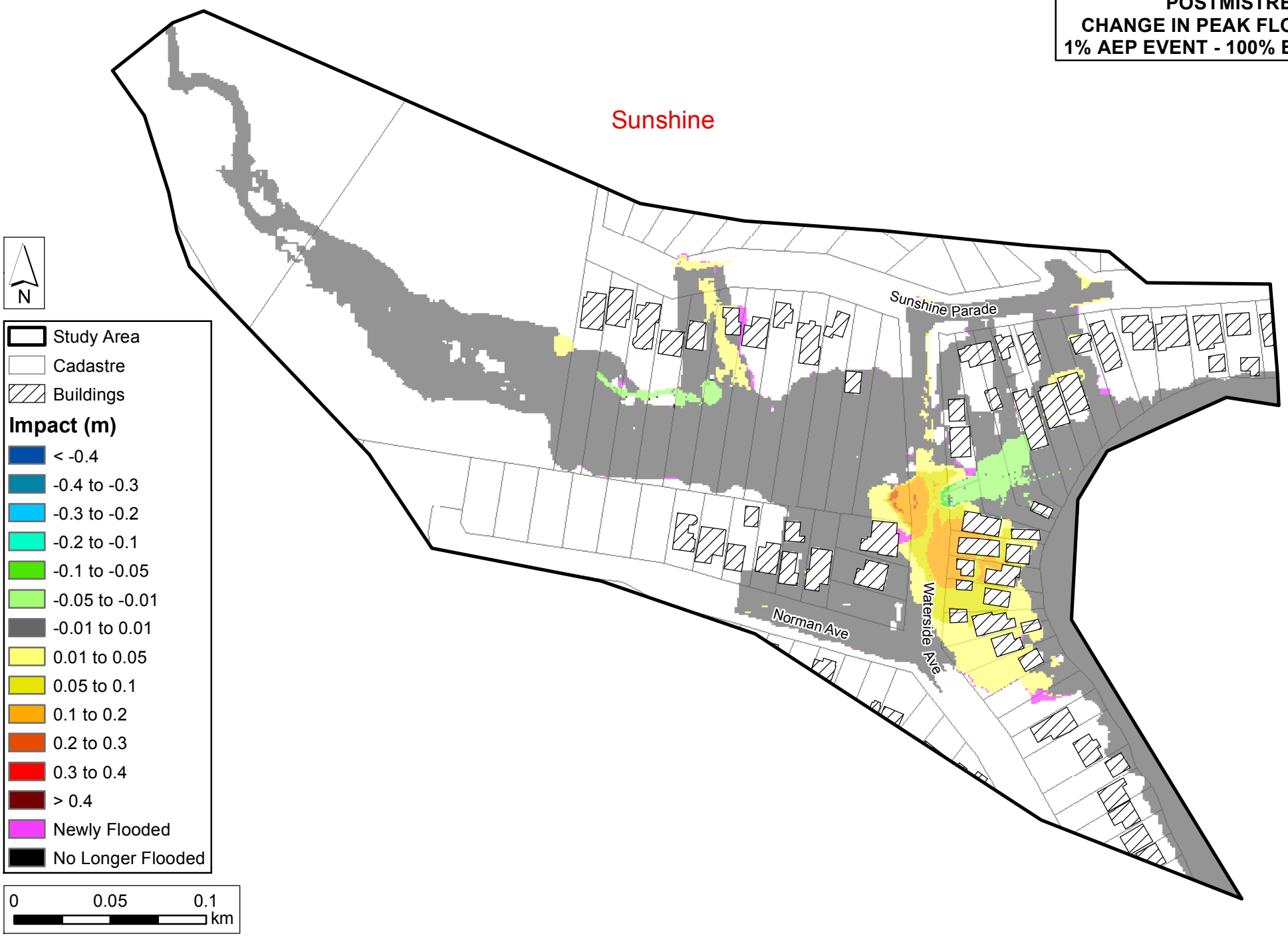
**POSTMISTRESS CREEK**
**CHANGE IN PEAK FLOOD LEVEL**
**1% AEP EVENT - 75% BLOCKAGE**




J:\Jobs\1190776\ArcGIS\ArcMap\Working\Template\Appendix_I\Figure137_PMC_Impact_1%AEP_Blockage25pc.mxd

FIGURE I39

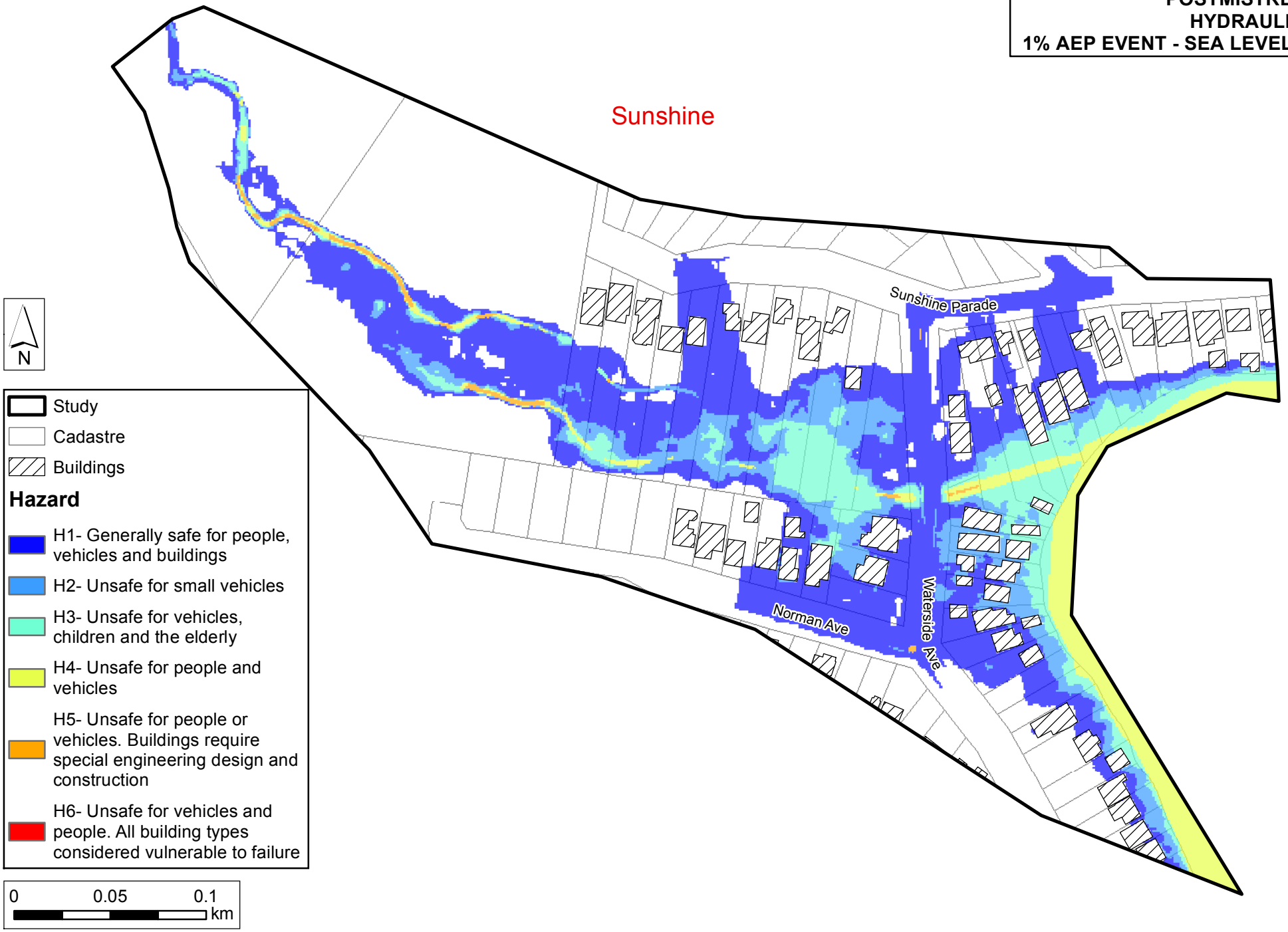
**POSTMISTRESS CREEK**
**CHANGE IN PEAK FLOOD LEVEL**
**1% AEP EVENT - 100% BLOCKAGE**




J:\Jobs\119076\ArcGIS\ArcMap\Working\Template\Appendix_I\Figure\I38_PMC_Impact_1%AEP_Blockage75pc.mxd

FIGURE I40

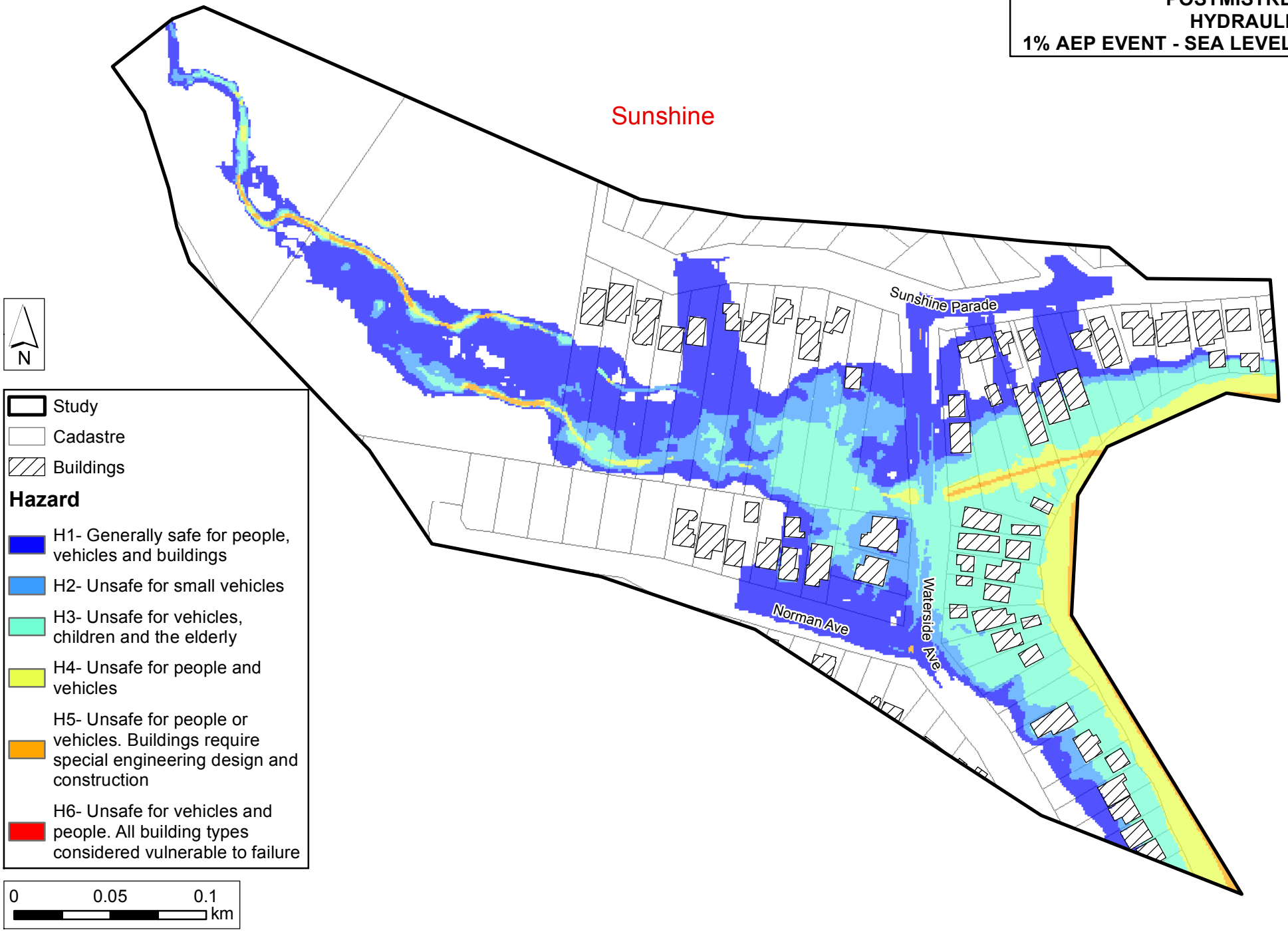
**POSTMISTRESS CREEK**
**HYDRAULIC HAZARD**
**1% AEP EVENT - SEA LEVEL RISE 0.4M**




J:\Jobs\119076\ArcGIS\ArcMap\Working\Template\Appendix_I\Figure\I25_PMC_Provisional_Hazard_50%AEP.mxd

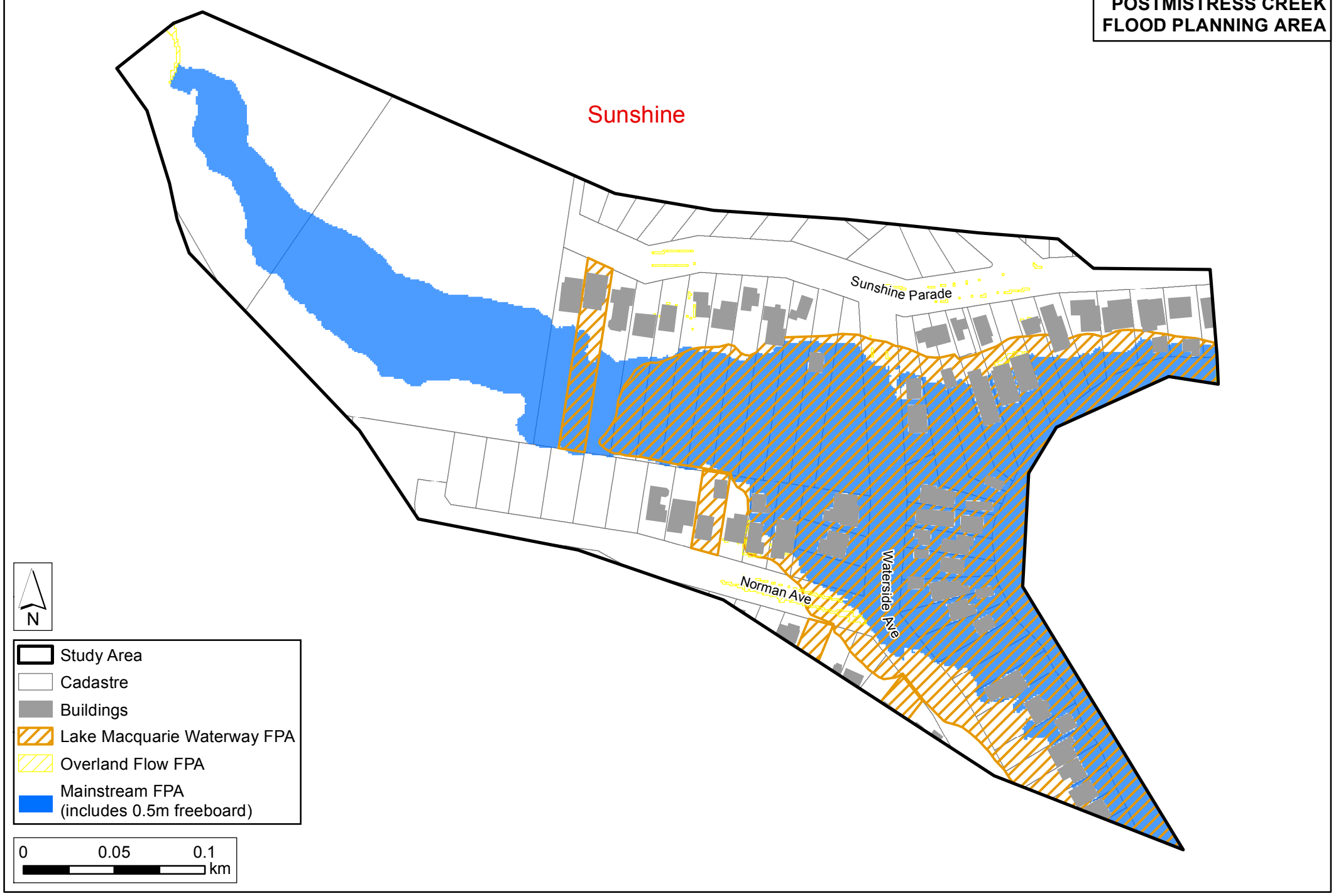
FIGURE I41

**POSTMISTRESS CREEK**
**HYDRAULIC HAZARD**
**1% AEP EVENT - SEA LEVEL RISE 0.9M**




J:\Jobs\119076\ArcGIS\ArcMap\Working\Template\Appendix_I\Figure140_PMC_Provisional_Hazard_1%AEP_SLR04.mxd

FIGURE I42
**POSTMISTRESS CREEK FLOOD PLANNING AREA**



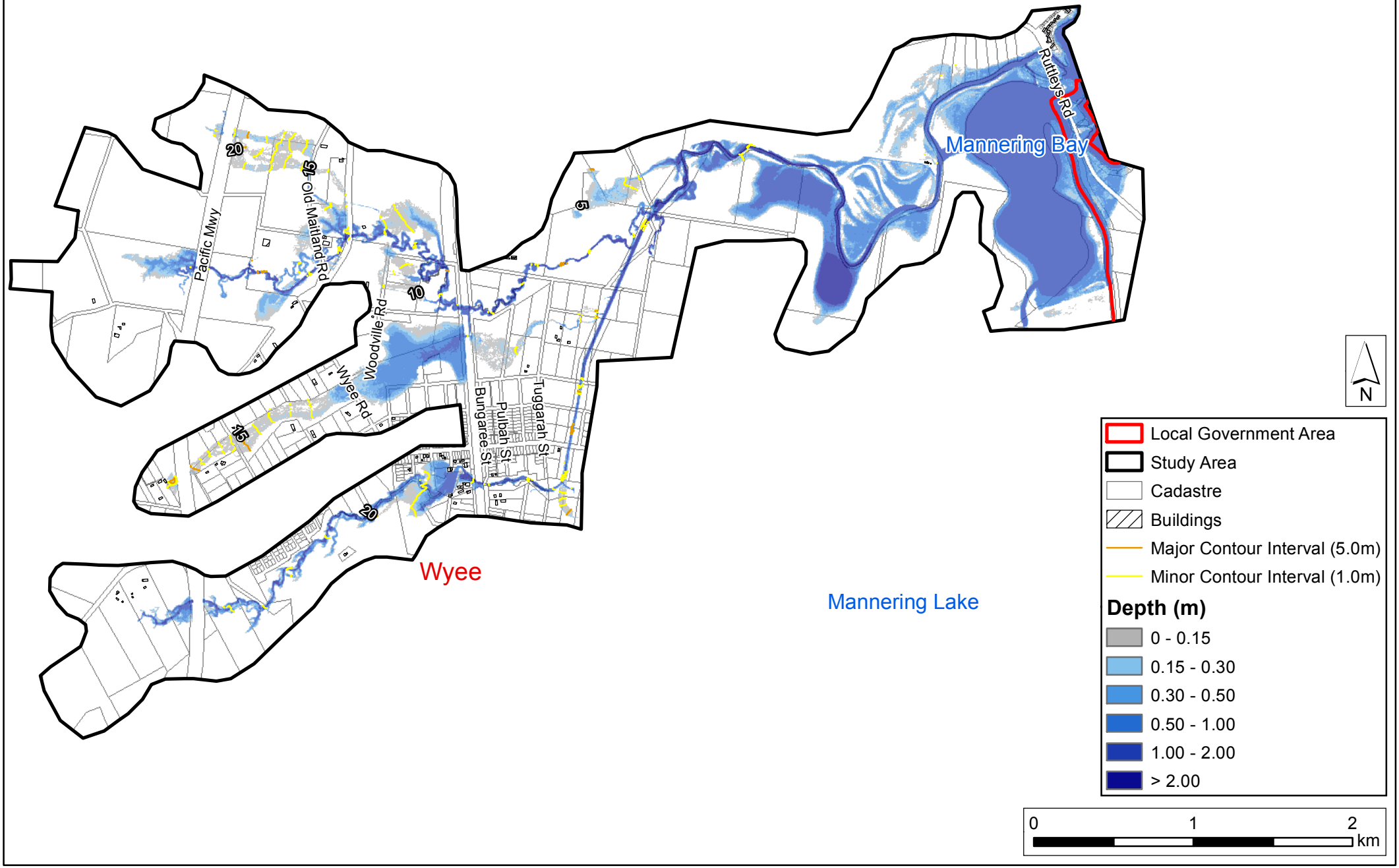

J:\Jobs\119076\ArcGIS\ArcMap\Report\Appendix_I\Figure142_PMC_Flood_Planning_Area.mxd

# APPENDIX J: DESIGN FLOOD MAPS – MANNERING CREEK, SWAMPY CREEK AND WYEE CREEK

Appendix J

FIGURE J1

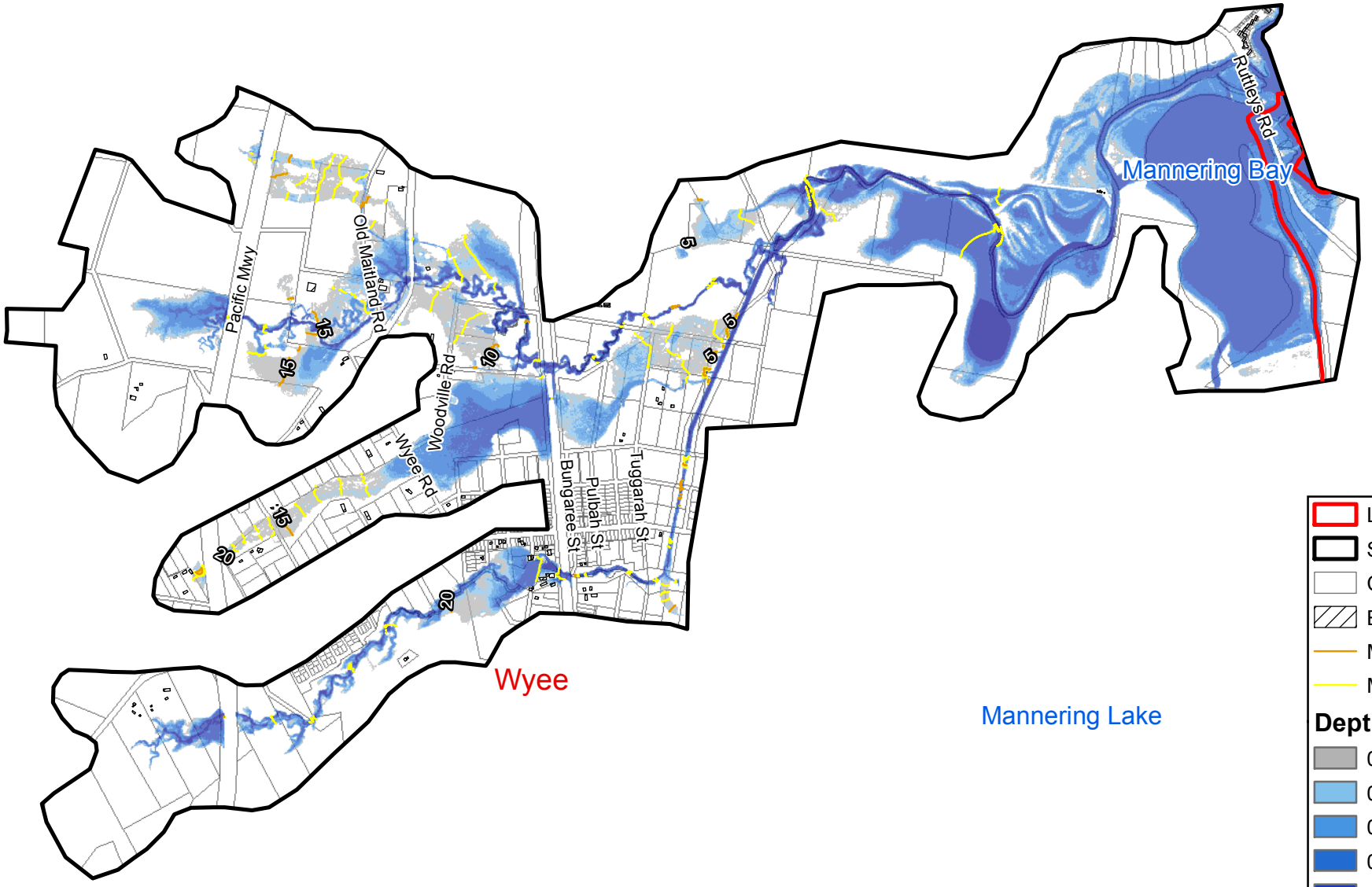
**MANNERING CREEK, SWAMPY CREEK AND WYEE CREEK**
**PEAK FLOOD DEPTH AND LEVEL CONTOUR**
**50% AEP EVENT**




J:\Jobs\1190776\ArcGIS\ArcMap\Working\Template\Appendix_J\FigureJ01_MSWC_Peak_Flood_Depth_50%AEP.mxd

FIGURE J2

**MANNERING CREEK, SWAMPY CREEK AND WYEE CREEK**
**PEAK FLOOD DEPTH AND LEVEL CONTOUR**
**20% AEP EVENT**




N

- Local Government Area
- Study Area
- Cadastre
- Buildings
- Major Contour Interval (5.0m)
- Minor Contour Interval (1.0m)

**Depth (m)**

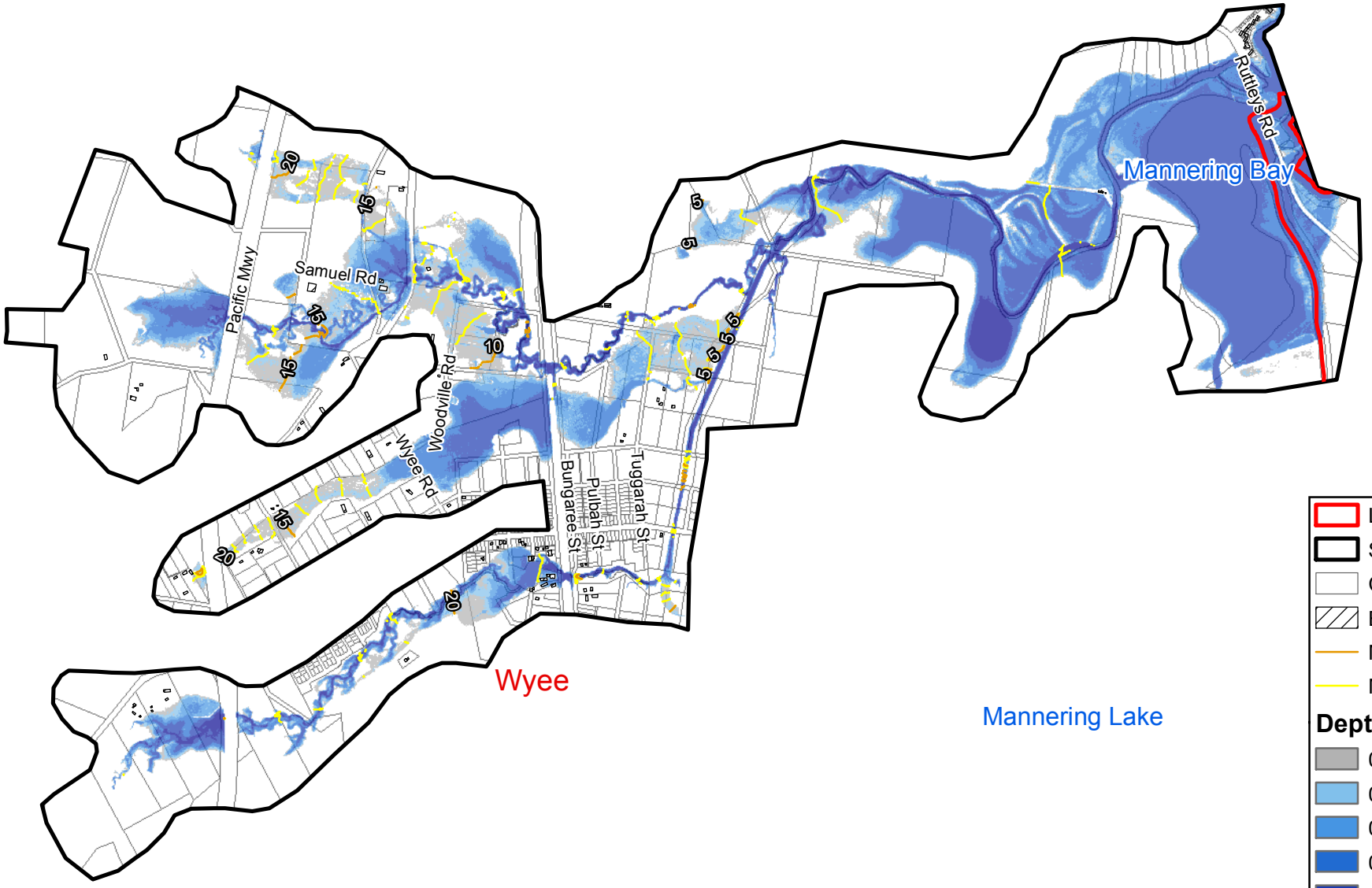
- 0 - 0.15
- 0.15 - 0.30
- 0.30 - 0.50
- 0.50 - 1.00
- 1.00 - 2.00
- > 2.00

0 1 2 km

J:\Jobs\119076\ArcGIS\ArcMap\Working\Template\Appendix_J\FigureJ01_MSWC_Peak_Flood_Depth_50%AEP.mxd

FIGURE J3

**MANNERING CREEK, SWAMPY CREEK AND WYEE CREEK**
**PEAK FLOOD DEPTH AND LEVEL CONTOUR**
**10% AEP EVENT**




N

- Local Government Area
- Study Area
- Cadastre
- Buildings
- Major Contour Interval (5.0m)
- Minor Contour Interval (1.0m)

**Depth (m)**

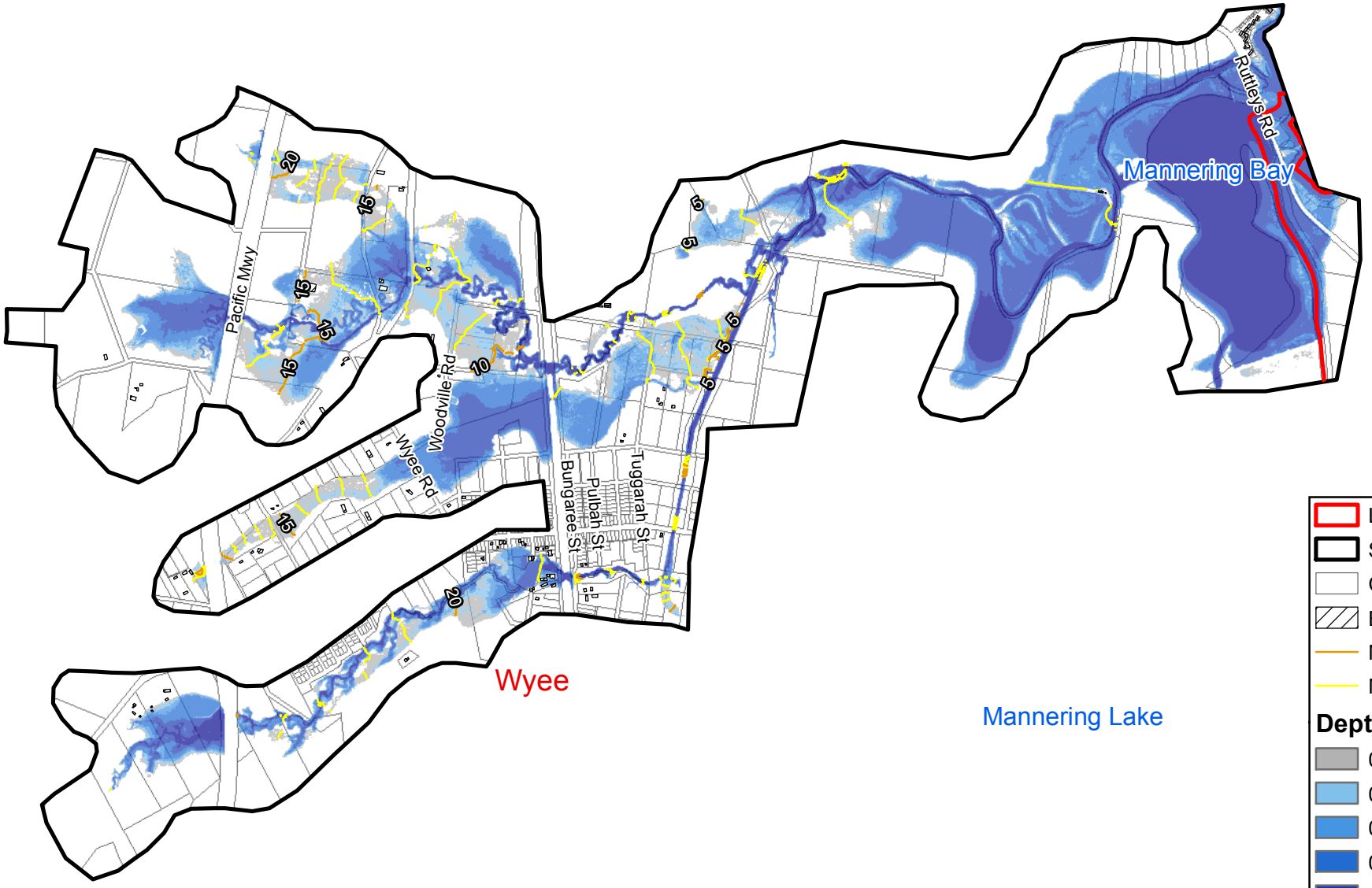
- 0 - 0.15
- 0.15 - 0.30
- 0.30 - 0.50
- 0.50 - 1.00
- 1.00 - 2.00
- > 2.00

0 1 2 km

J:\Jobs\119076\ArcGIS\ArcMap\Working\Template\Appendix_J\FigureJ02_MSWC_Peak_Flood_Depth_20%AEP.mxd

FIGURE J4

**MANNERING CREEK, SWAMPY CREEK AND WYEE CREEK**
**PEAK FLOOD DEPTH AND LEVEL CONTOUR**
**5% AEP EVENT**




N

- Local Government Area
- Study Area
- Cadastre
- Buildings
- Major Contour Interval (5.0m)
- Minor Contour Interval (1.0m)

**Depth (m)**

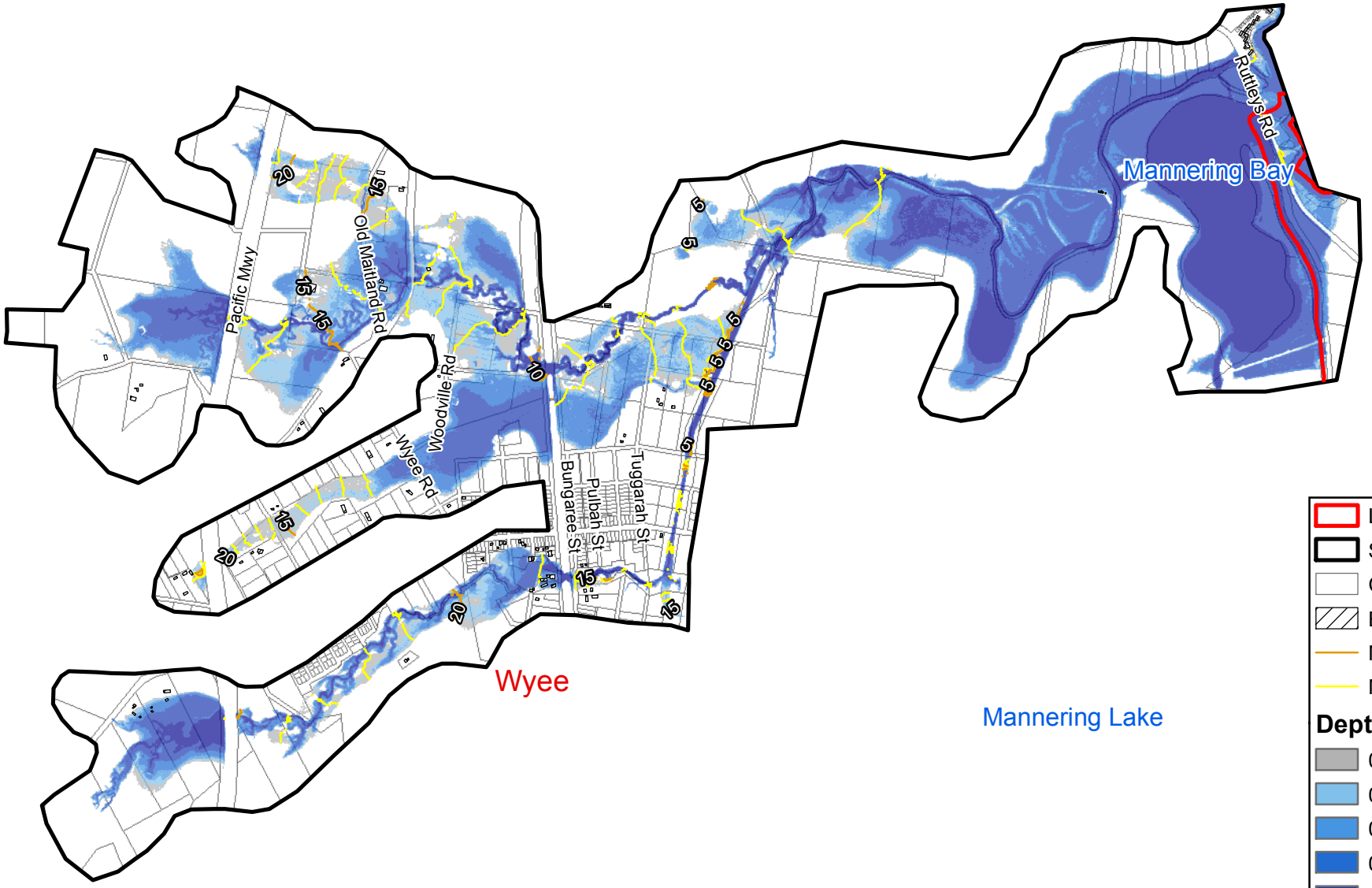
- 0 - 0.15
- 0.15 - 0.30
- 0.30 - 0.50
- 0.50 - 1.00
- 1.00 - 2.00
- > 2.00

0 1 2 km

J:\Jobs\119076\ArcGIS\ArcMap\Working\Template\Appendix_J\FigureJ03_MSWC_Peak_Flood_Depth_10%AEP.mxd

FIGURE J5

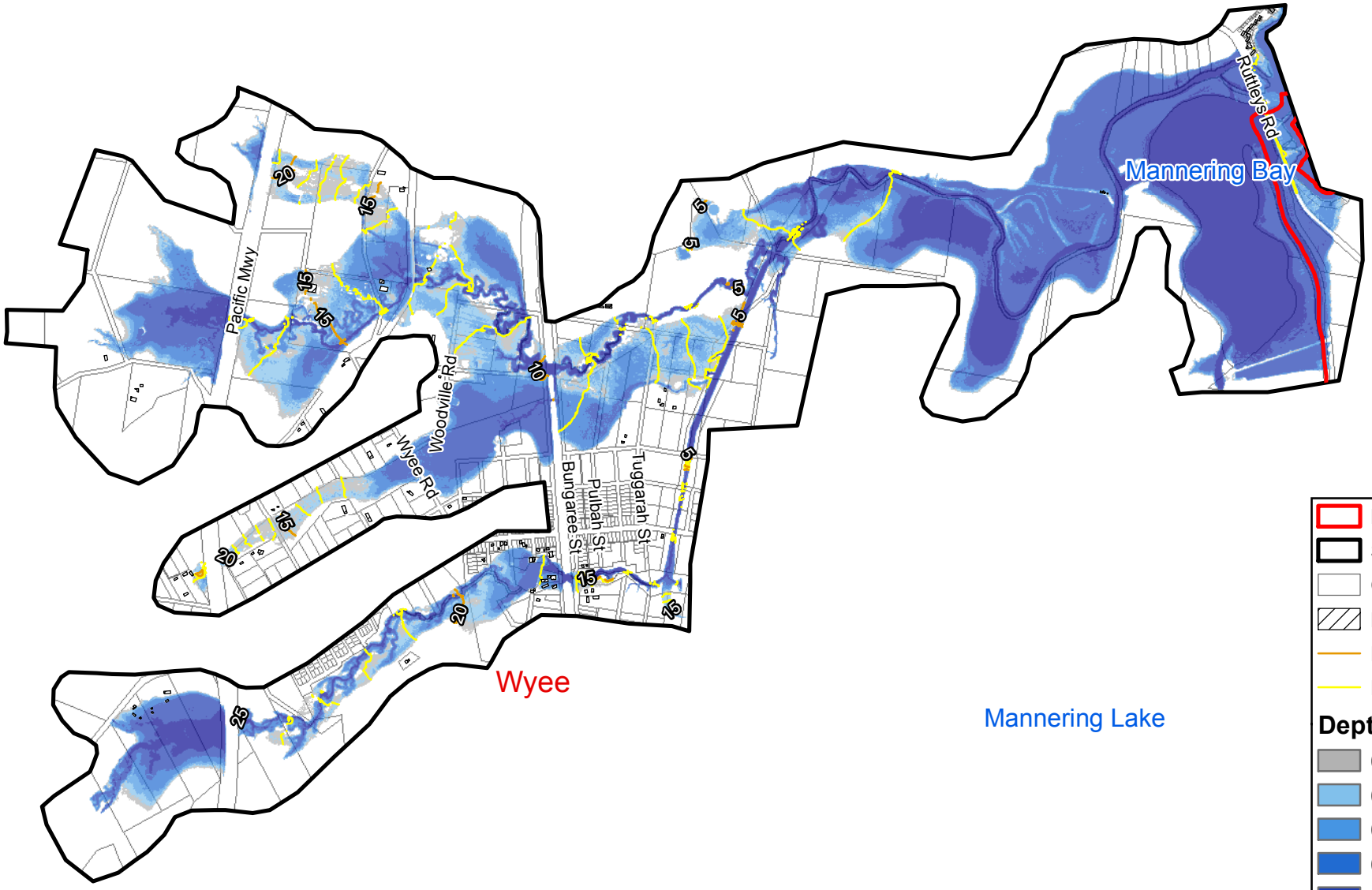
**MANNERING CREEK, SWAMPY CREEK AND WYEE CREEK**
**PEAK FLOOD DEPTH AND LEVEL CONTOUR**
**2% AEP EVENT**




J:\Jobs\1190776\ArcGIS\ArcMap\Working\Template\Appendix_J\FigureJ04_MSWC_Peak_Flood_Depth_5%AEP.mxd

FIGURE J6

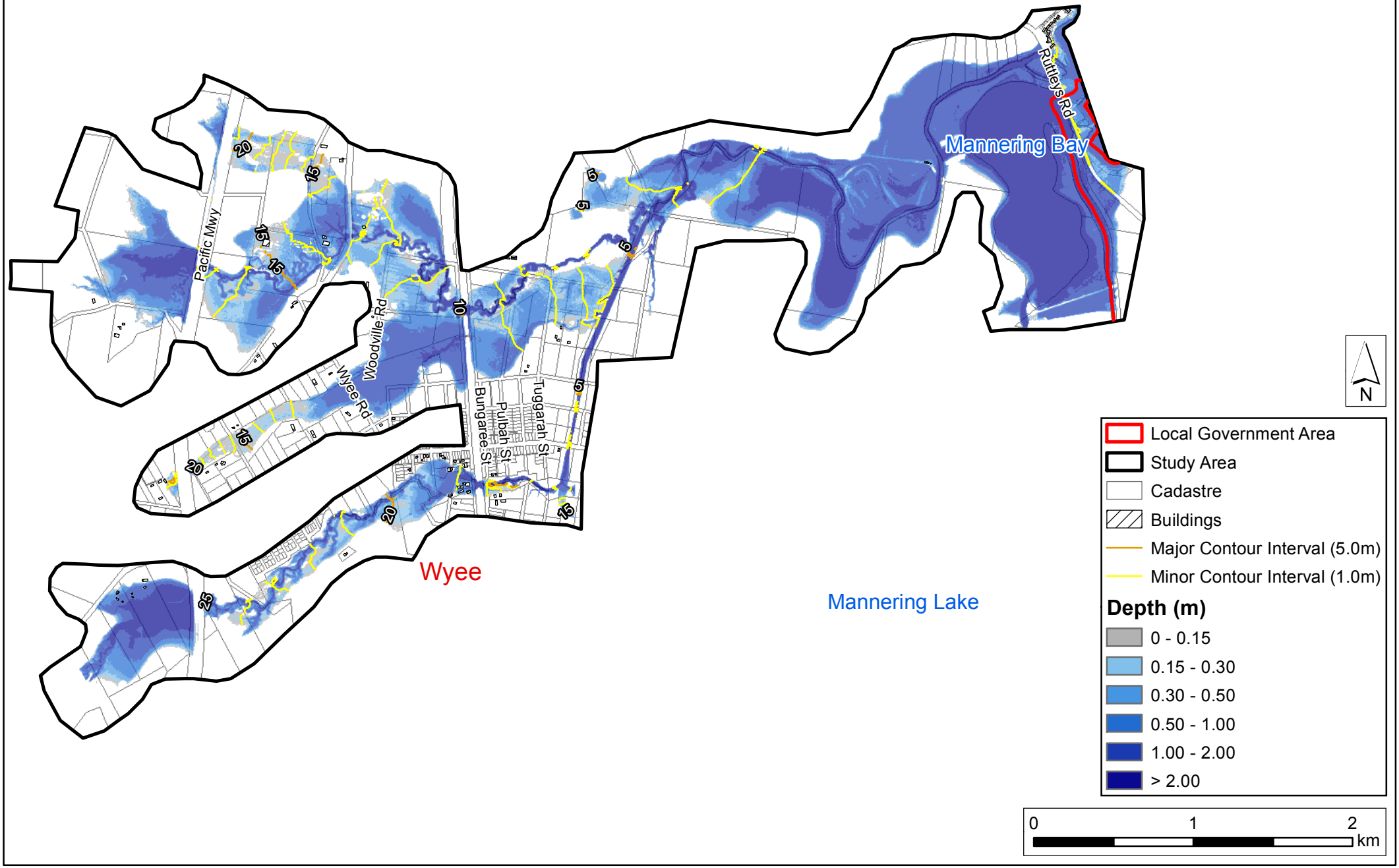
**MANNERING CREEK, SWAMPY CREEK AND WYEE CREEK**
**PEAK FLOOD DEPTH AND LEVEL CONTOUR**
**1% AEP EVENT**




J:\Jobs\119076\ArcGIS\ArcMap\Working\Template\Appendix_J\FigureJ05_MSWC_Peak_Flood_Depth_2%AEP.mxd

FIGURE J7

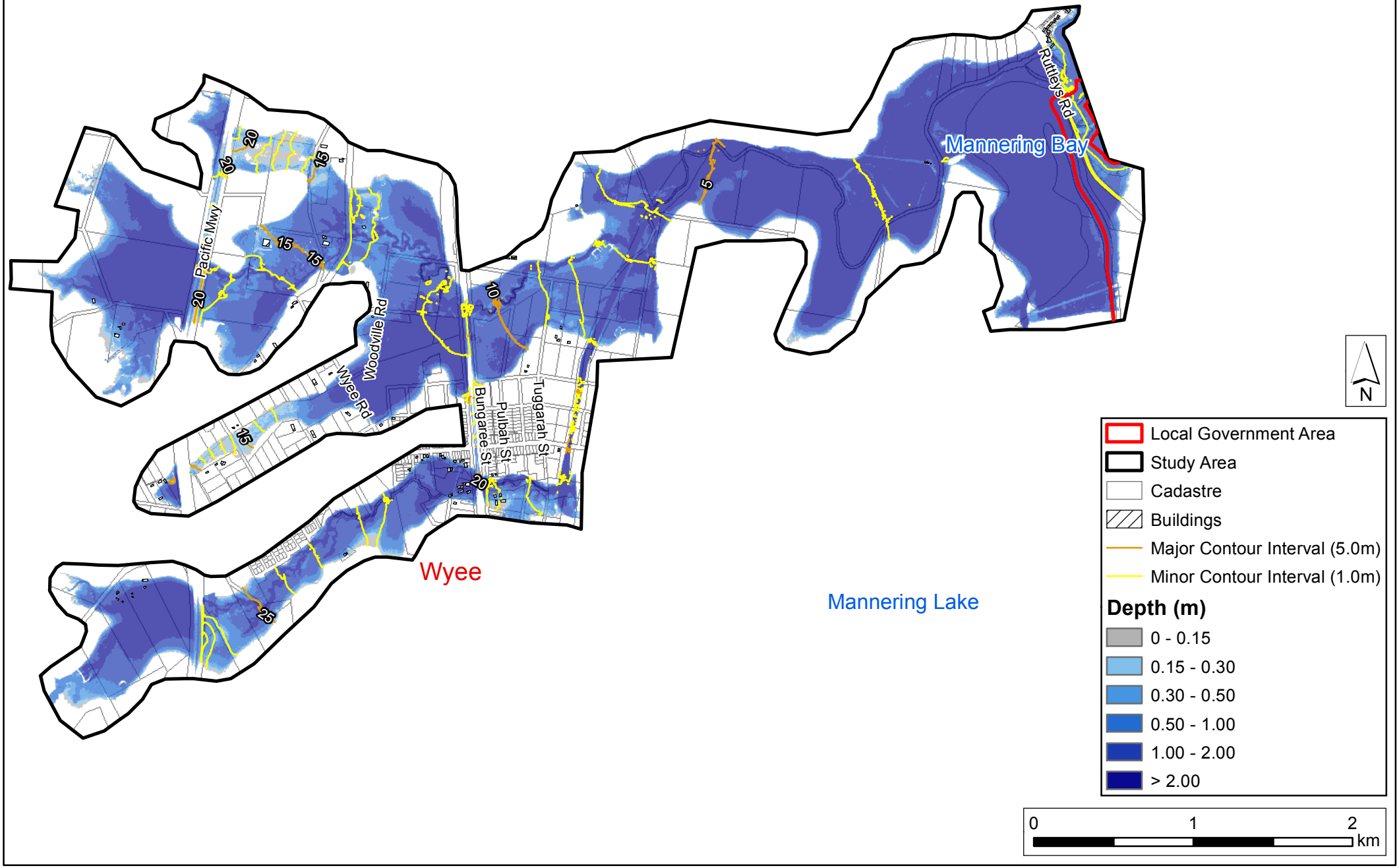
**MANNERING CREEK, SWAMPY CREEK AND WYEE CREEK**
**PEAK FLOOD DEPTH AND LEVEL CONTOUR**
**0.5% AEP EVENT**




J:\Jobs\1190776\ArcGIS\ArcMap\Working\Template\Appendix_J\FigureJ06_MSWC_Peak_Flood_Depth_1%AEP.mxd

FIGURE J8

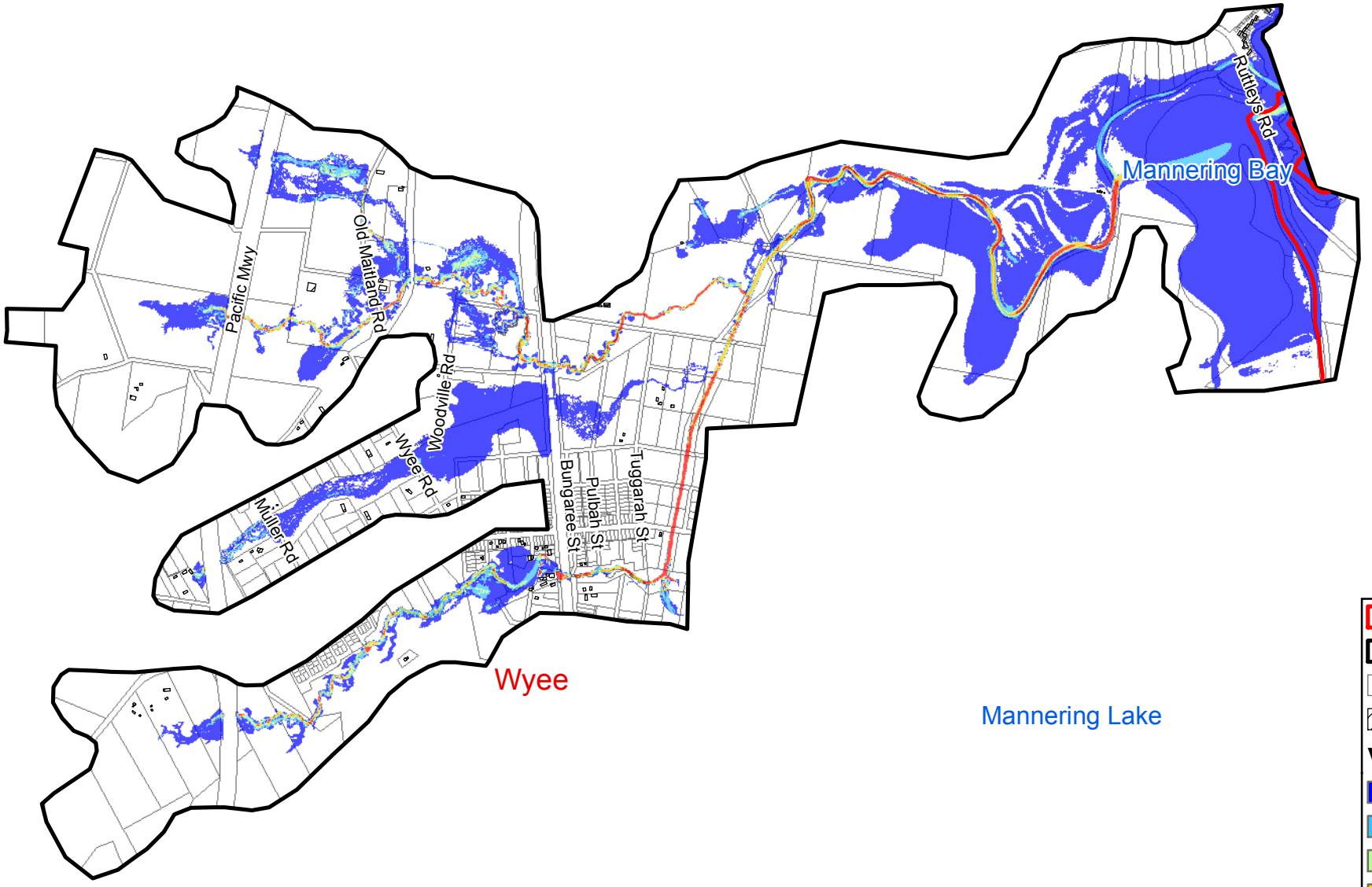
**MANNERING CREEK, SWAMPY CREEK AND WYEE CREEK**
**PEAK FLOOD DEPTH AND LEVEL CONTOUR**
**PMF EVENT**




J:\Jobs\1190776\ArcGIS\ArcMap\Working\Template\Appendix_J\FigureJ07_MSWC_Peak_Flood_Depth_0.5%AEP.mxd

FIGURE J9

**MANNERING CREEK, SWAMPY CREEK AND WYEE CREEK**
**PEAK FLOOD VELOCITIES**
**50% AEP EVENT**




N

Local Government Area
Study Area
Cadastre
Buildings

**Velocity (m/s)**

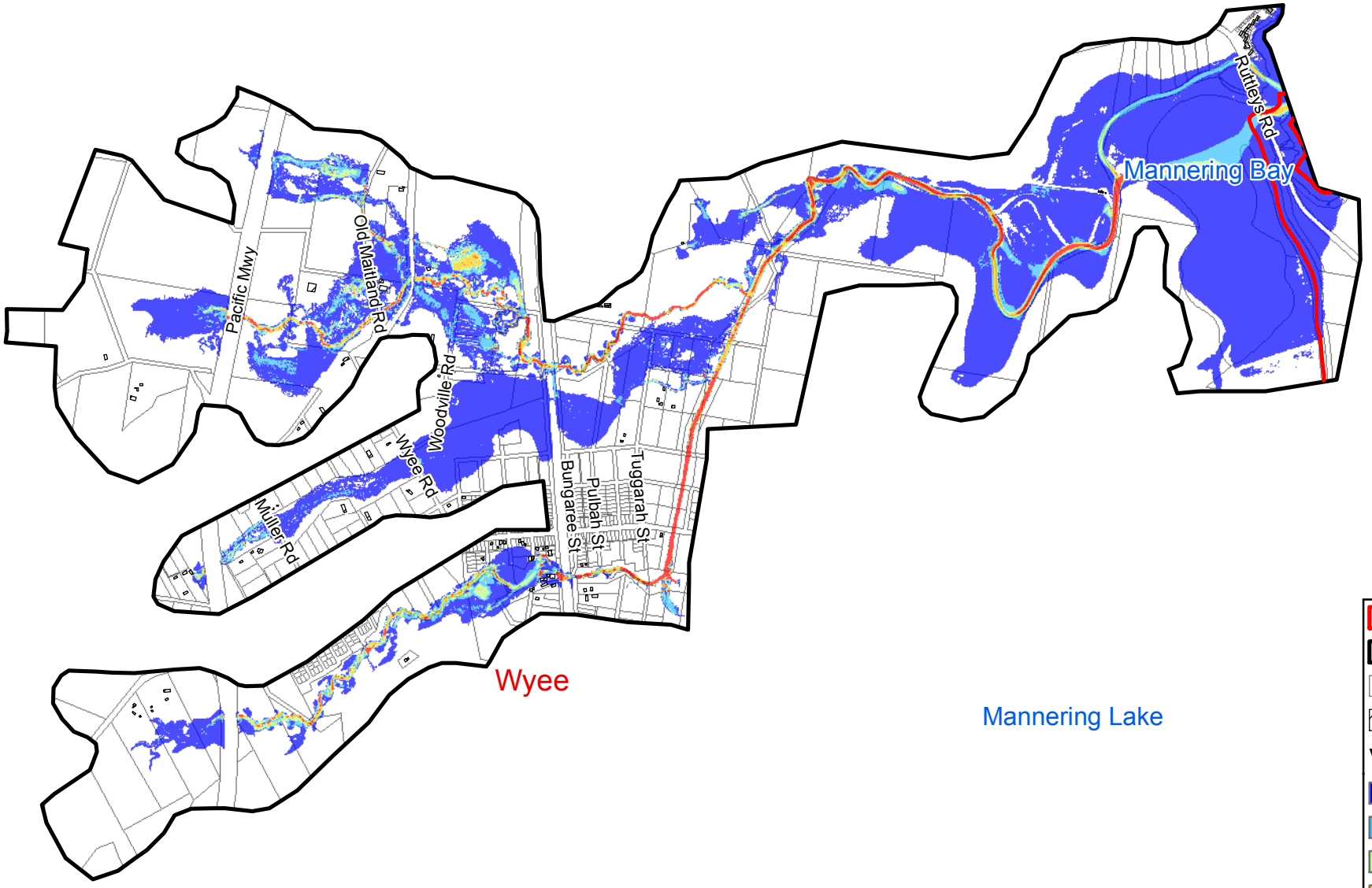
0 - 0.3
0.3 - 0.5
0.5 - 0.7
0.7 - 1.0
>1.0

0 1 2 km

J:\Jobs\1190776\ArcGIS\ArcMap\Working\Template\Appendix_J\FigureJ08_MSWC_Peak_Flood_Depth_PMF.mxd

FIGURE J10

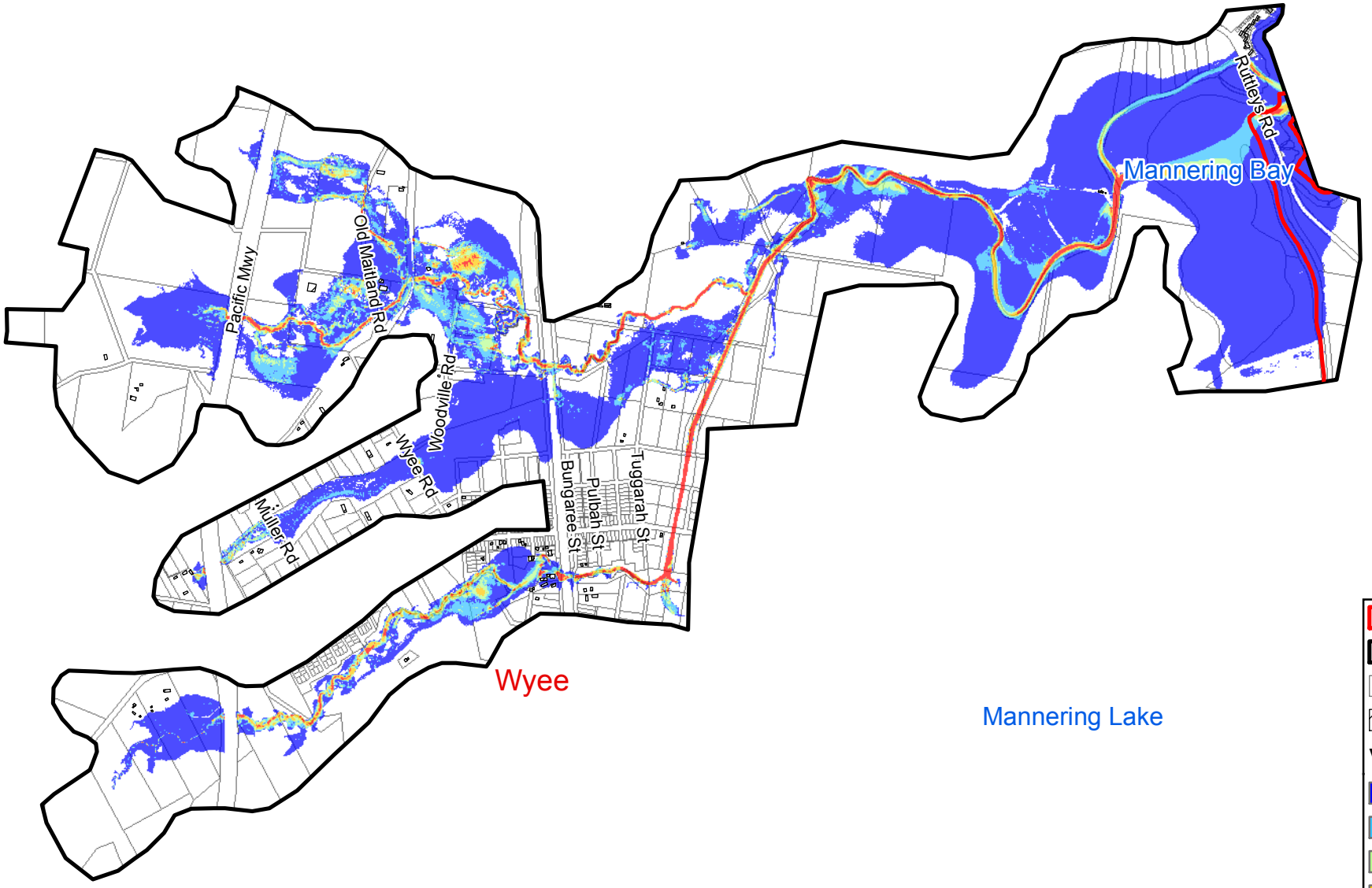
**MANNERING CREEK, SWAMPY CREEK AND WYEE CREEK**
**PEAK FLOOD VELOCITIES**
**20% AEP EVENT**




J:\Jobs\1190776\ArcGIS\ArcMap\Working\Template\Appendix_J\FigureJ09_MSWC_Peak_Flood_Velocity_50%AEP.mxd

FIGURE J11

**MANNERING CREEK, SWAMPY CREEK AND WYEE CREEK**
**PEAK FLOOD VELOCITIES**
**10% AEP EVENT**




N

Local Government Area
Study Area
Cadastre
Buildings

**Velocity (m/s)**

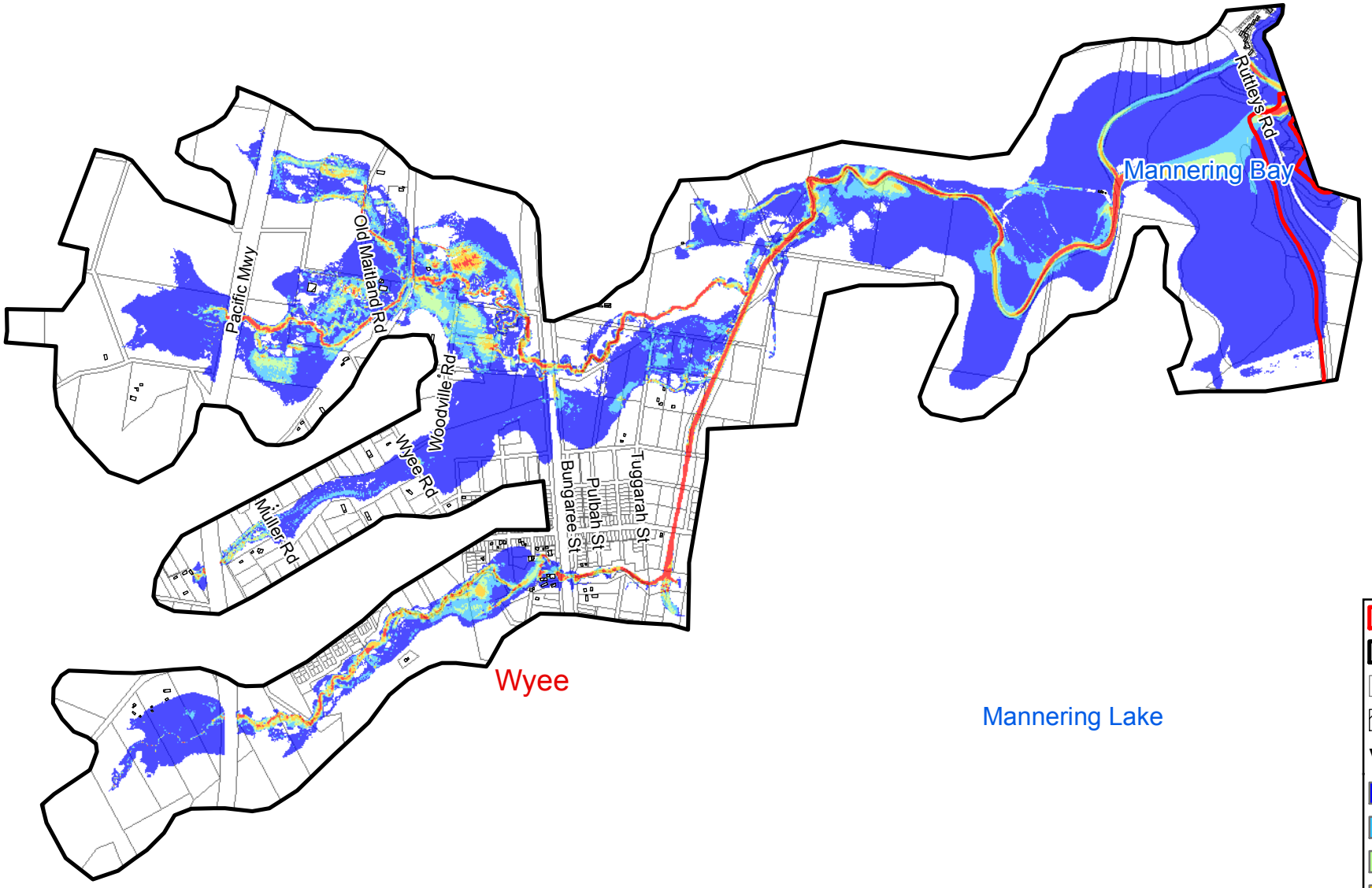
0 - 0.3
0.3 - 0.5
0.5 - 0.7
0.7 - 1.0
>1.0

0 1 2 km

J:\Jobs\1190776\ArcGIS\ArcMap\Working\Template\Appendix_J\FigureJ10_MSWC_Peak_Flood_Velocity_20%AEP.mxd

FIGURE J12

**MANNERING CREEK, SWAMPY CREEK AND WYEE CREEK**
**PEAK FLOOD VELOCITIES**
**5% AEP EVENT**




N

Local Government Area
Study Area
Cadastre
Buildings

**Velocity (m/s)**

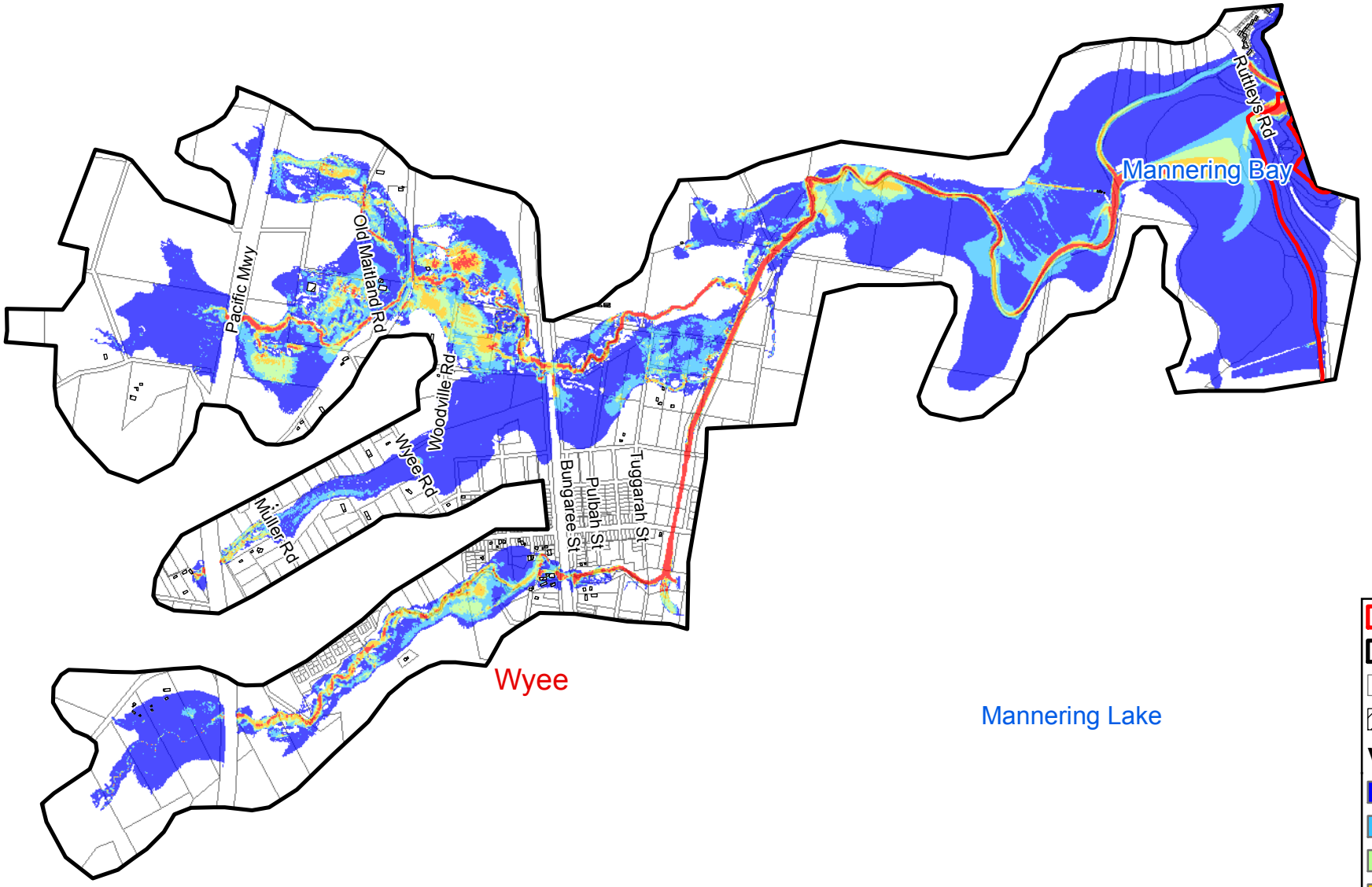
0 - 0.3
0.3 - 0.5
0.5 - 0.7
0.7 - 1.0
>1.0

0 1 2 km

J:\Jobs\1190776\ArcGIS\ArcMap\Working\Template\Appendix_J\FigureJ11_MSWC_Peak_Flood_Velocity_10%AEP.mxd

FIGURE J13

**MANNERING CREEK, SWAMPY CREEK AND WYEE CREEK**
**PEAK FLOOD VELOCITIES**
**2% AEP EVENT**




N

Local Government Area
Study Area
Cadastre
Buildings

**Velocity (m/s)**

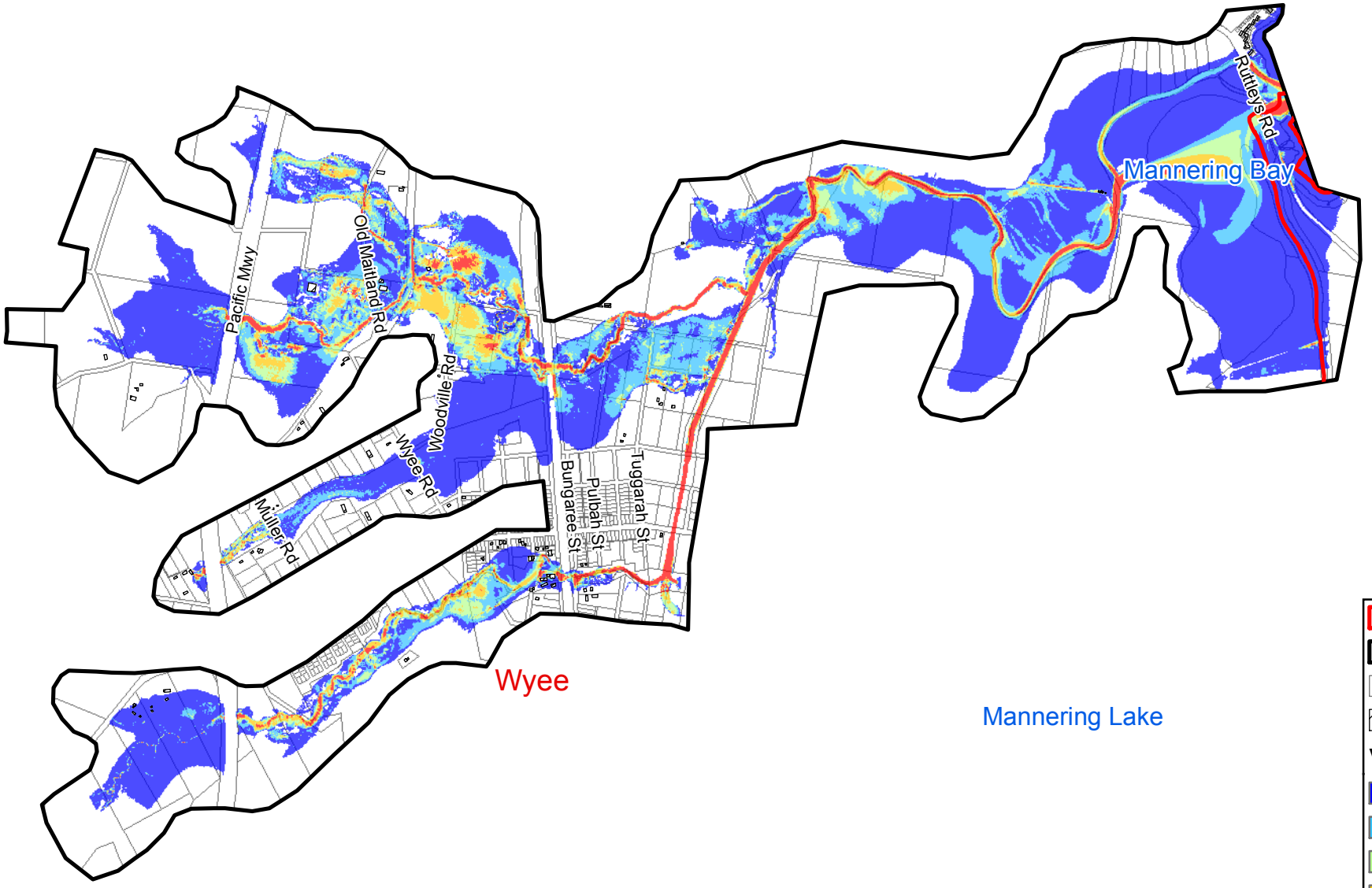
0 - 0.3
0.3 - 0.5
0.5 - 0.7
0.7 - 1.0
>1.0

0 1 2 km

J:\Jobs\1190776\ArcGIS\ArcMap\Working\Template\Appendix_J\FigureJ12_MSWC_Peak_Flood_Velocity_5%AEP.mxd

FIGURE J14

**MANNERING CREEK, SWAMPY CREEK AND WYEE CREEK**
**PEAK FLOOD VELOCITIES**
**1% AEP EVENT**




N

Local Government Area
Study Area
Cadastre
Buildings

**Velocity (m/s)**

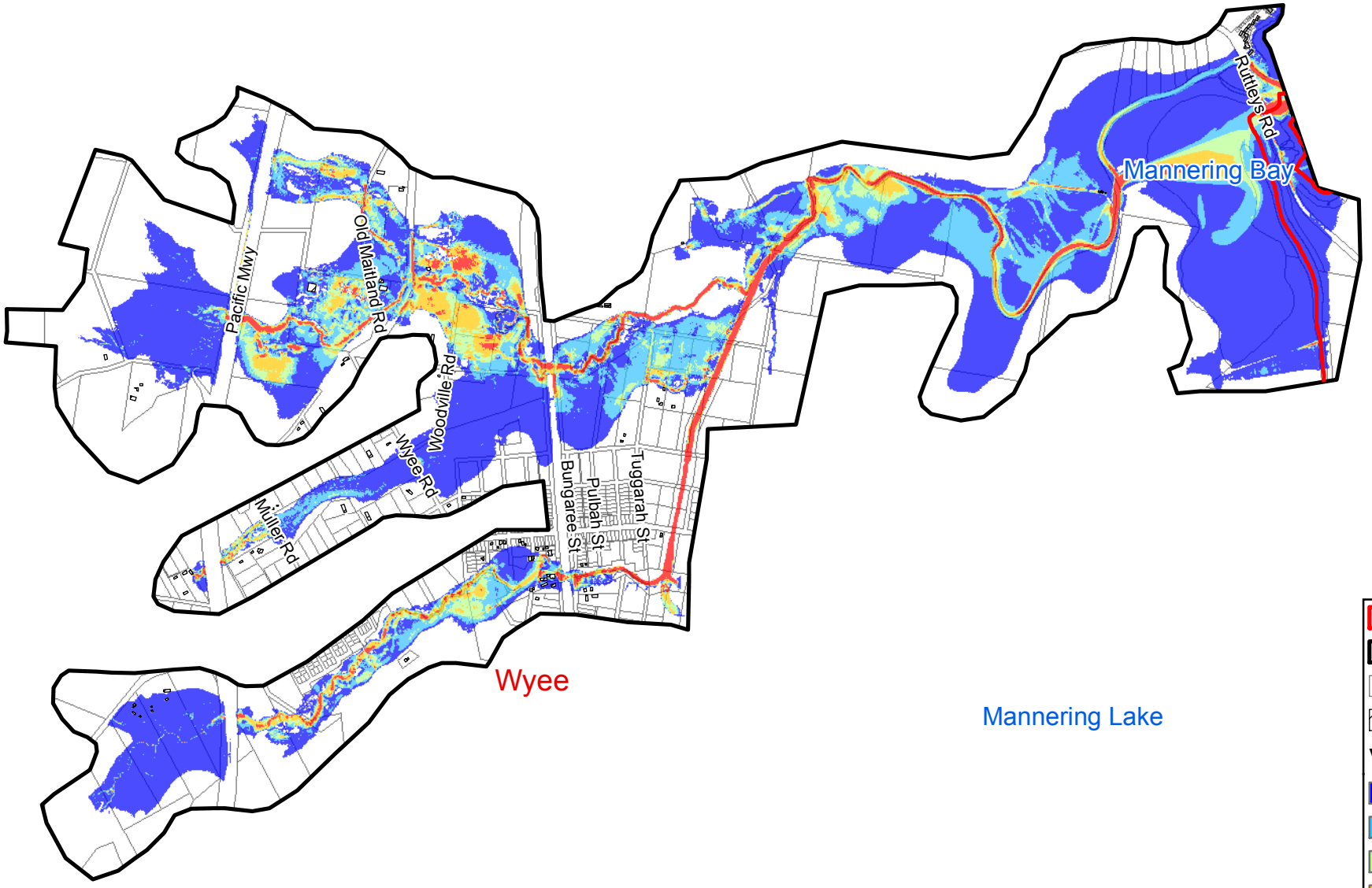
0 - 0.3
0.3 - 0.5
0.5 - 0.7
0.7 - 1.0
>1.0

0 1 2 km

J:\Jobs\1190776\ArcGIS\ArcMap\Working\Template\Appendix_J\FigureJ13_MSWC_Peak_Flood_Velocity_2%AEP.mxd

FIGURE J15

**MANNERING CREEK, SWAMPY CREEK AND WYEE CREEK**
**PEAK FLOOD VELOCITIES**
**0.5% AEP EVENT**




N

Local Government Area
Study Area
Cadastre
Buildings

**Velocity (m/s)**

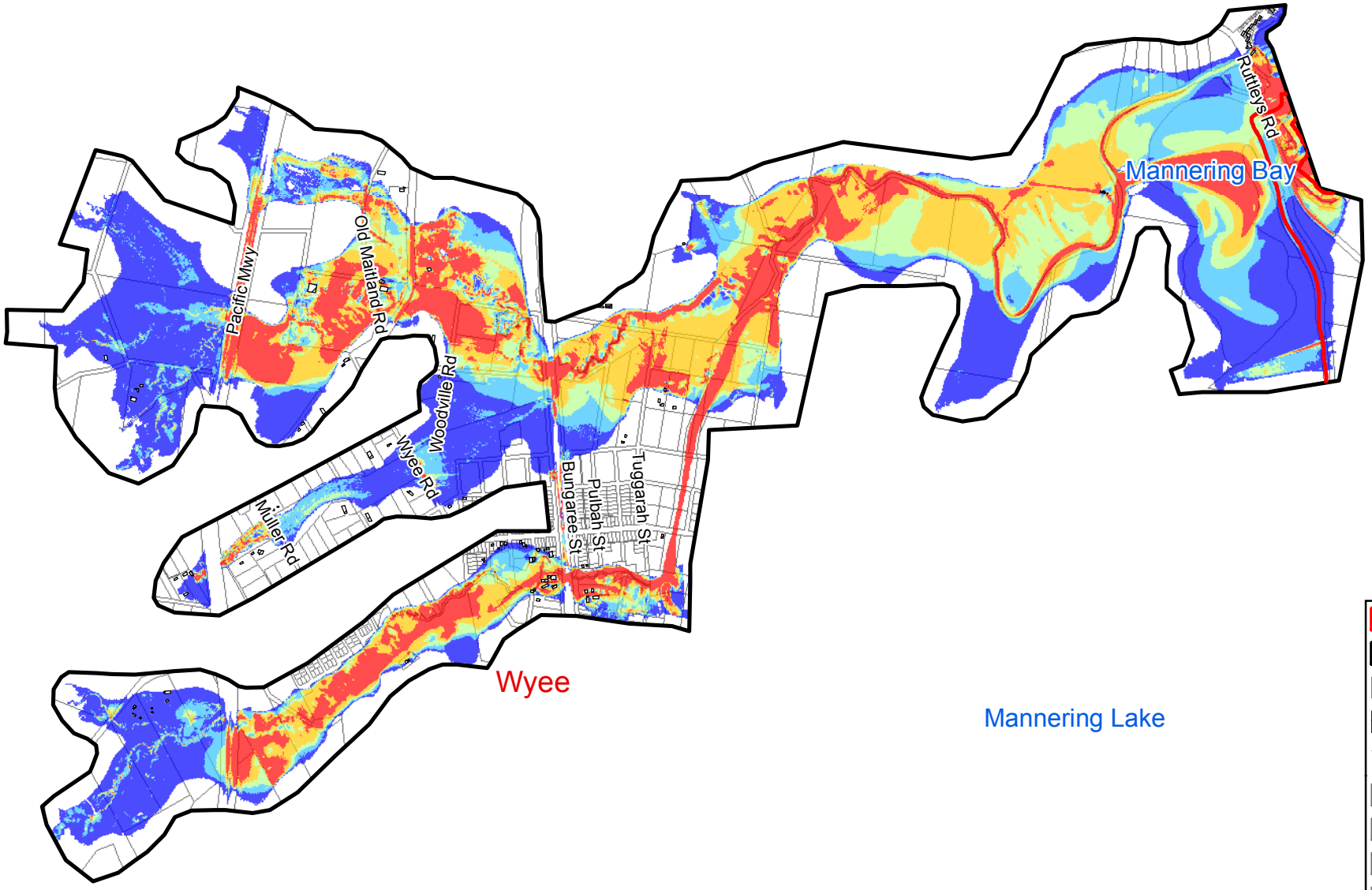
0 - 0.3
0.3 - 0.5
0.5 - 0.7
0.7 - 1.0
>1.0

0 1 2 km

J:\Jobs\119076\ArcGIS\ArcMap\Working\Template\Appendix_J\FigureJ14_MSWC_Peak_Flood_Velocity_1%AEP.mxd

FIGURE J16

**MANNERING CREEK, SWAMPY CREEK AND WYEE CREEK**
**PEAK FLOOD VELOCITIES**
**PMF EVENT**




N

Local Government Area
Study Area
Cadastre
Buildings

**Velocity (m/s)**

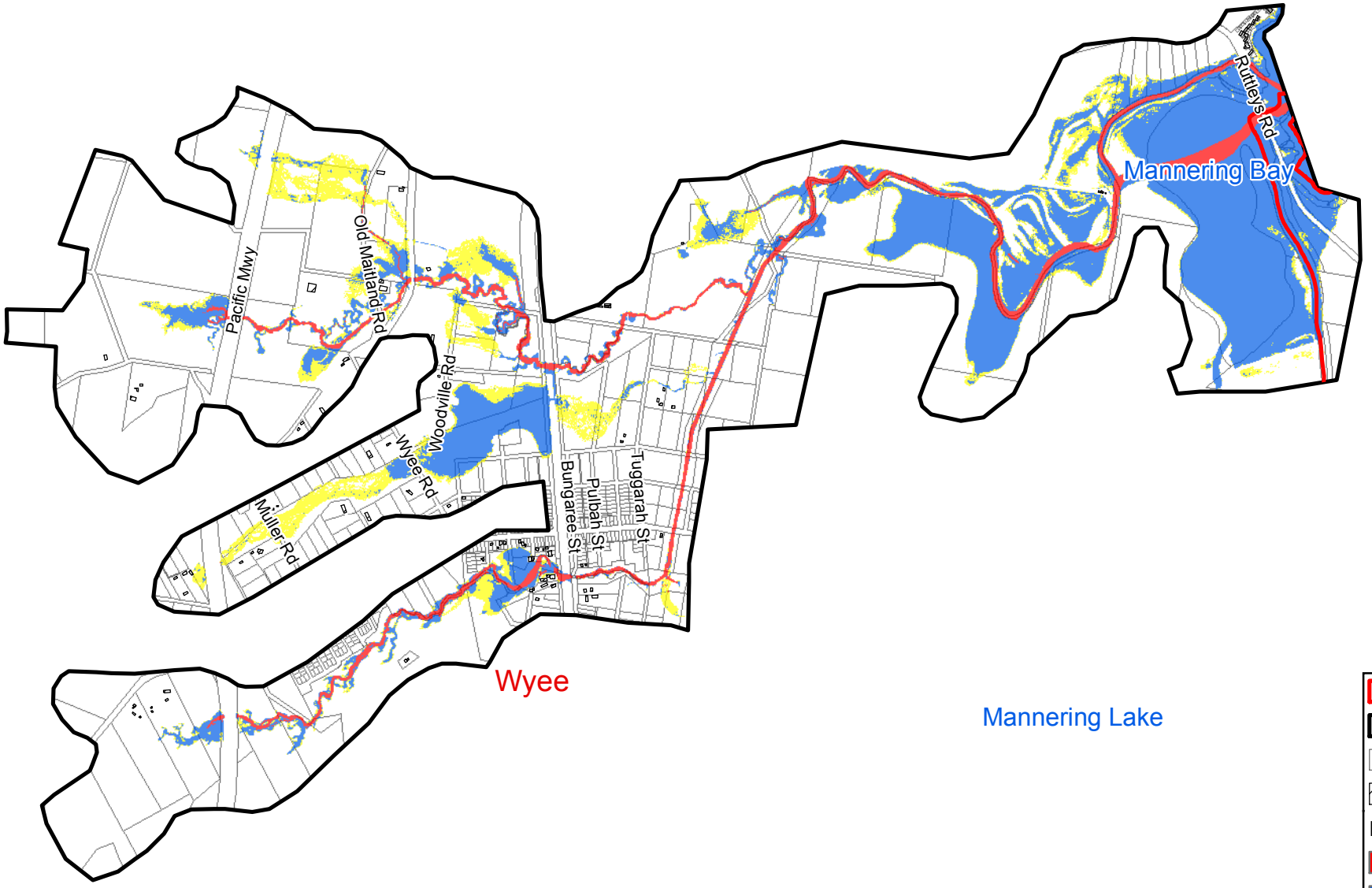
0 - 0.3
0.3 - 0.5
0.5 - 0.7
0.7 - 1.0
>1.0

0 1 2 km

J:\Jobs\1190776\ArcGIS\ArcMap\Working\Template\Appendix_J\FigureJ15_MSWC_Peak_Flood_Velocity_0_5%AEP.mxd

FIGURE J17

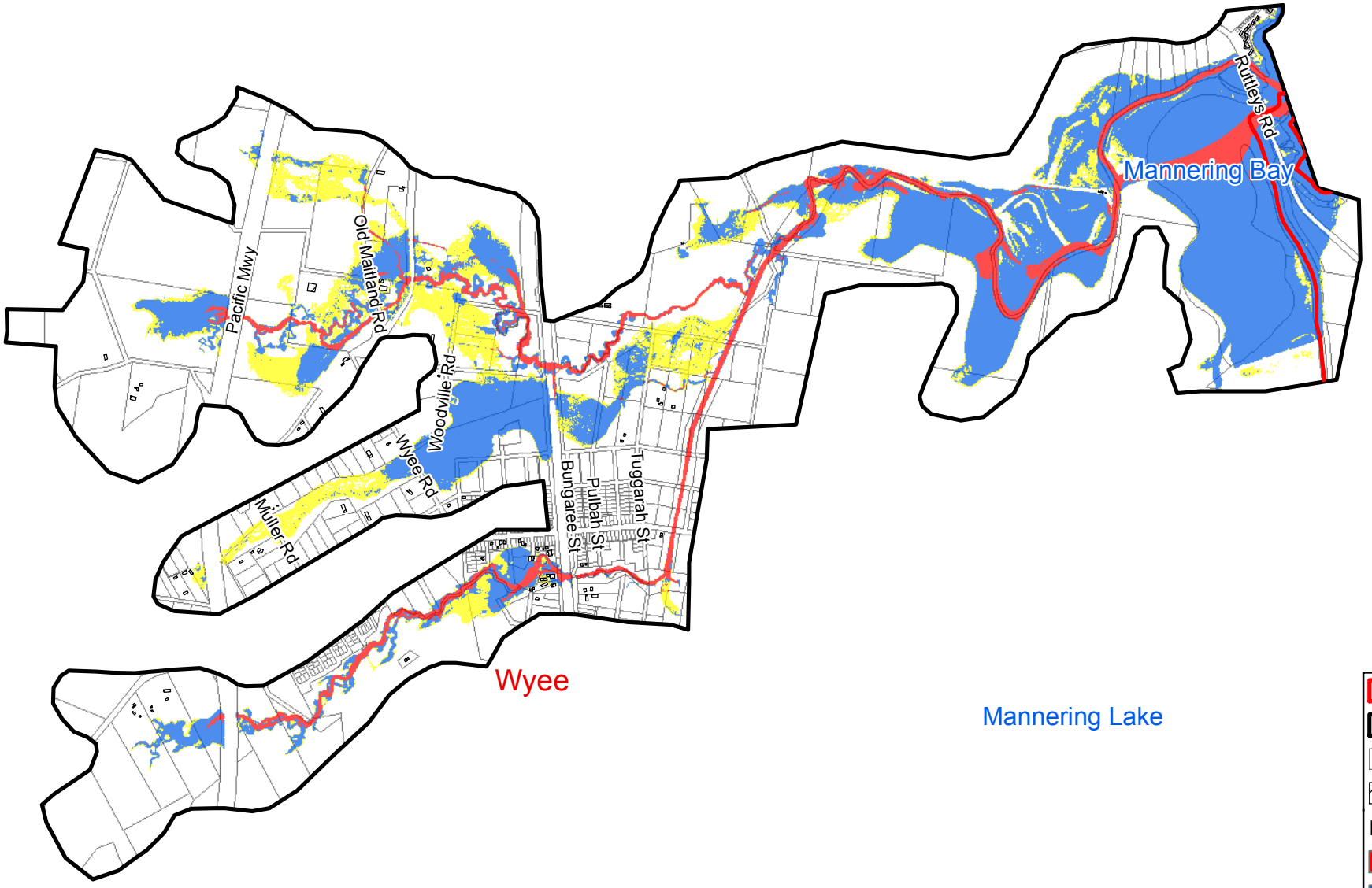
**MANNERING CREEK, SWAMPY CREEK AND WYEE CREEK**
**HYDRAULIC CATEGORISATION**
**50% AEP EVENT**




J:\Jobs\1190776\ArcGIS\ArcMap\Working\Template\Appendix_J\FigureJ16_MSWC_Peak_Flood_Velocity_PMF.mxd

FIGURE J18

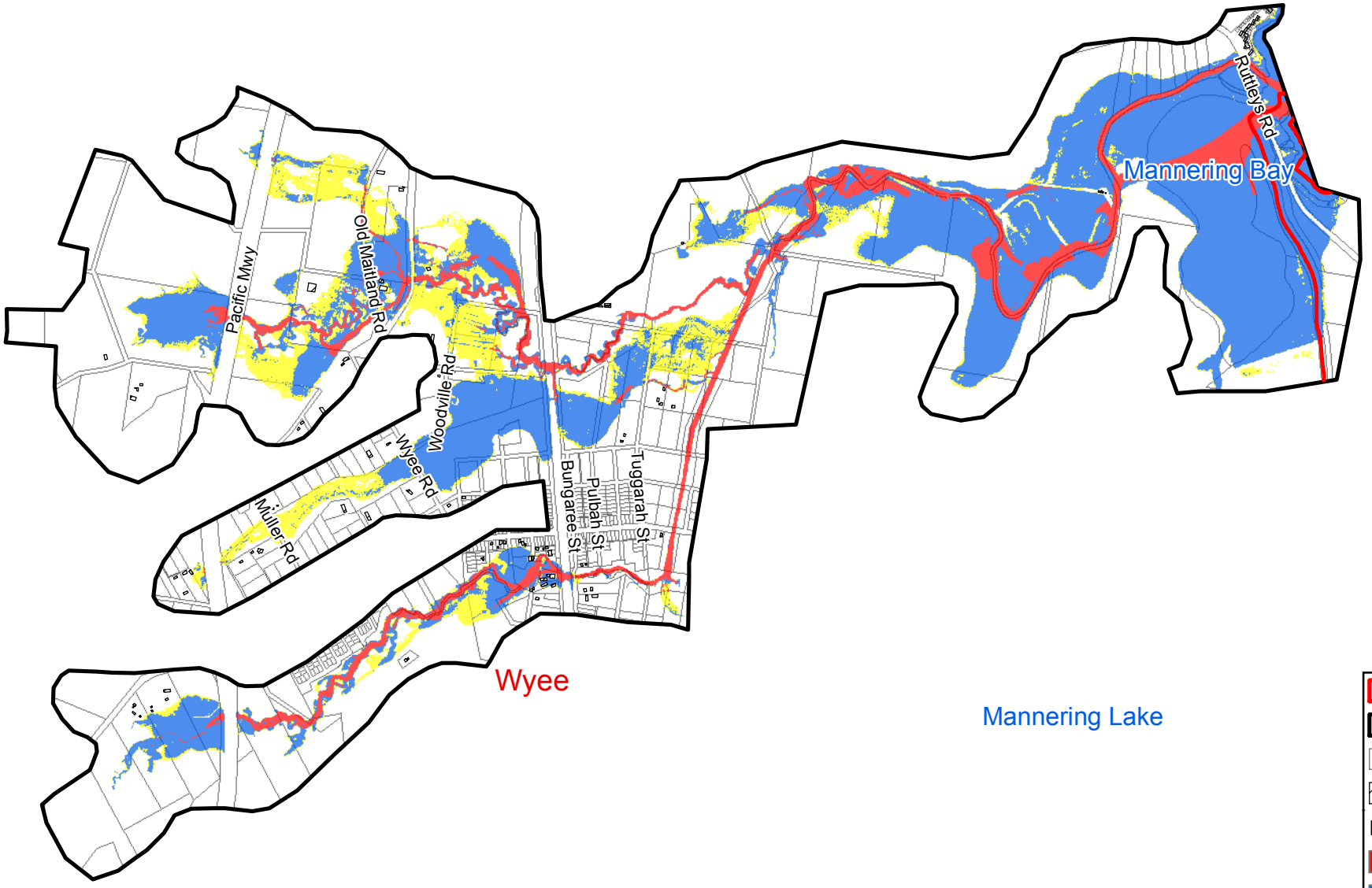
**MANNERING CREEK, SWAMPY CREEK AND WYEE CREEK**
**HYDRAULIC CATEGORISATION**
**20% AEP EVENT**




J:\Jobs\1190776\ArcGIS\ArcMap\Working\Template\Appendix_J\FigureJ17_MSWC_Hydraulic_Categories_50%AEP.mxd

FIGURE J19

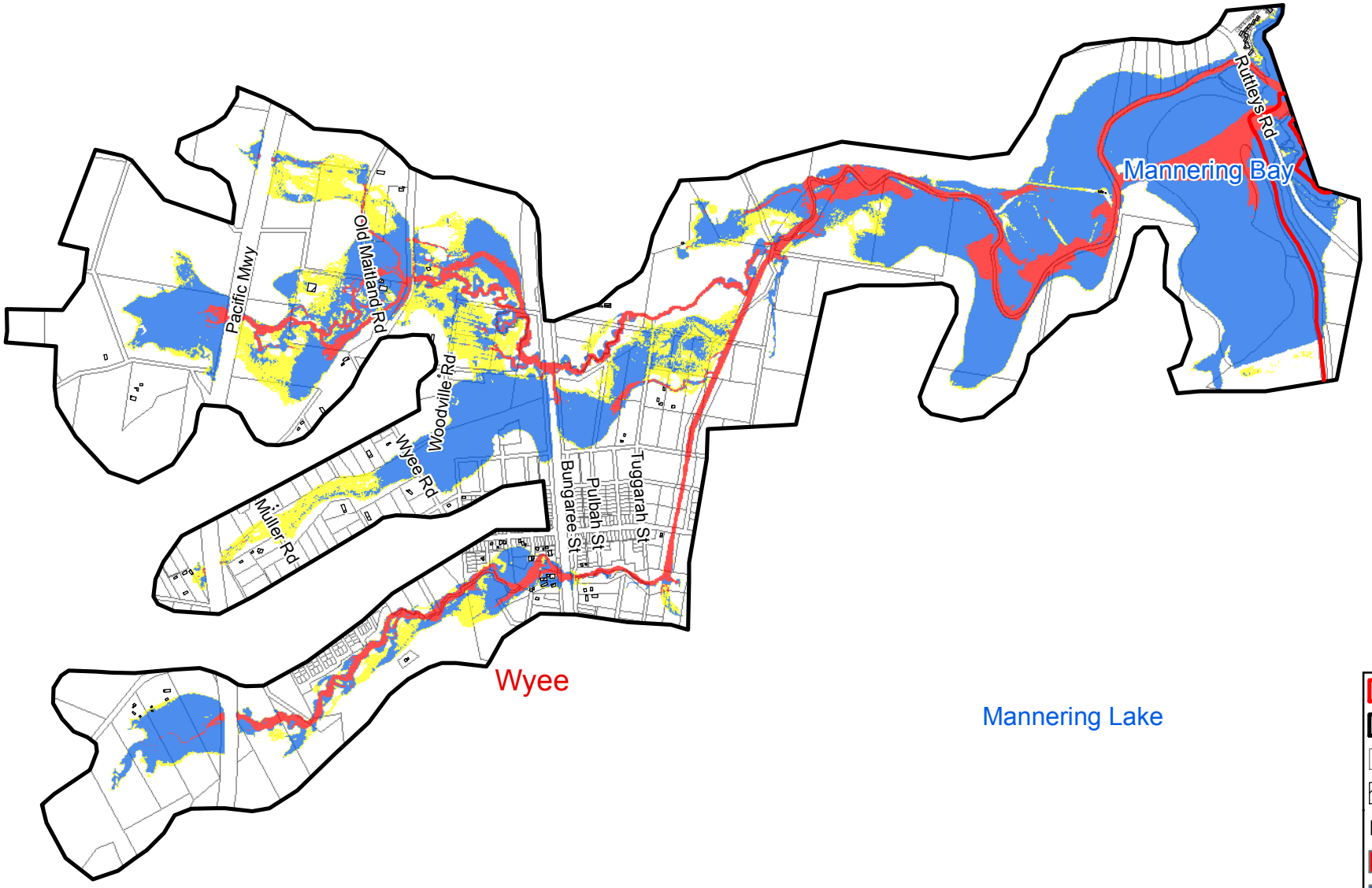
**MANNERING CREEK, SWAMPY CREEK AND WYEE CREEK**
**HYDRAULIC CATEGORISATION**
**10% AEP EVENT**




J:\Jobs\119076\ArcGIS\ArcMap\Working\Template\Appendix_J\FigureJ18_MSWC_Hydraulic_Categories_20%AEP.mxd

FIGURE J20

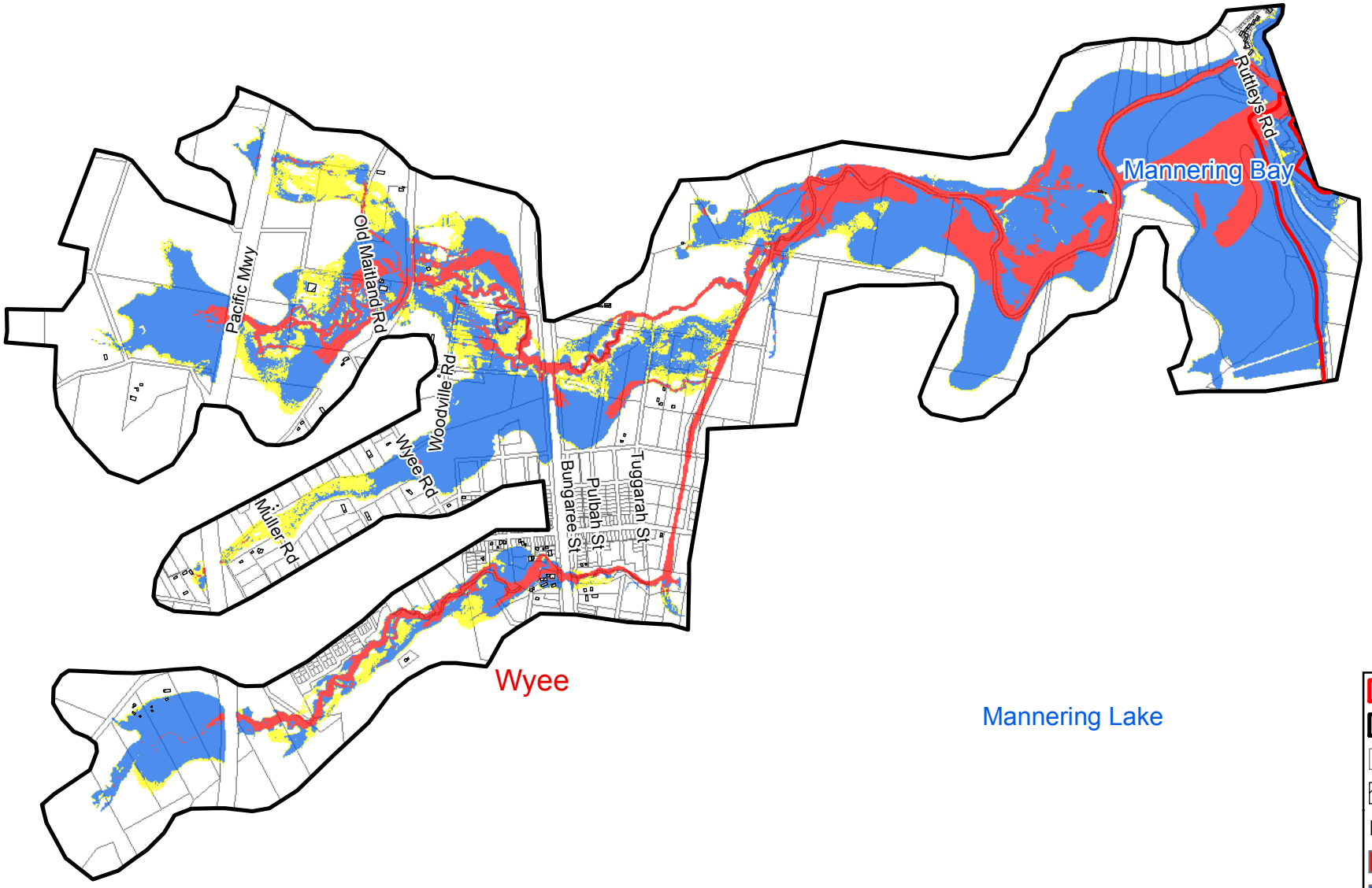
**MANNERING CREEK, SWAMPY CREEK AND WYEE CREEK**
**HYDRAULIC CATEGORISATION**
**5% AEP EVENT**




J:\Jobs\119076\ArcGIS\ArcMap\Working\Template\Appendix_J\FigureJ19_MSWC_Hydraulic_Categories_10%AEP.mxd

FIGURE J21

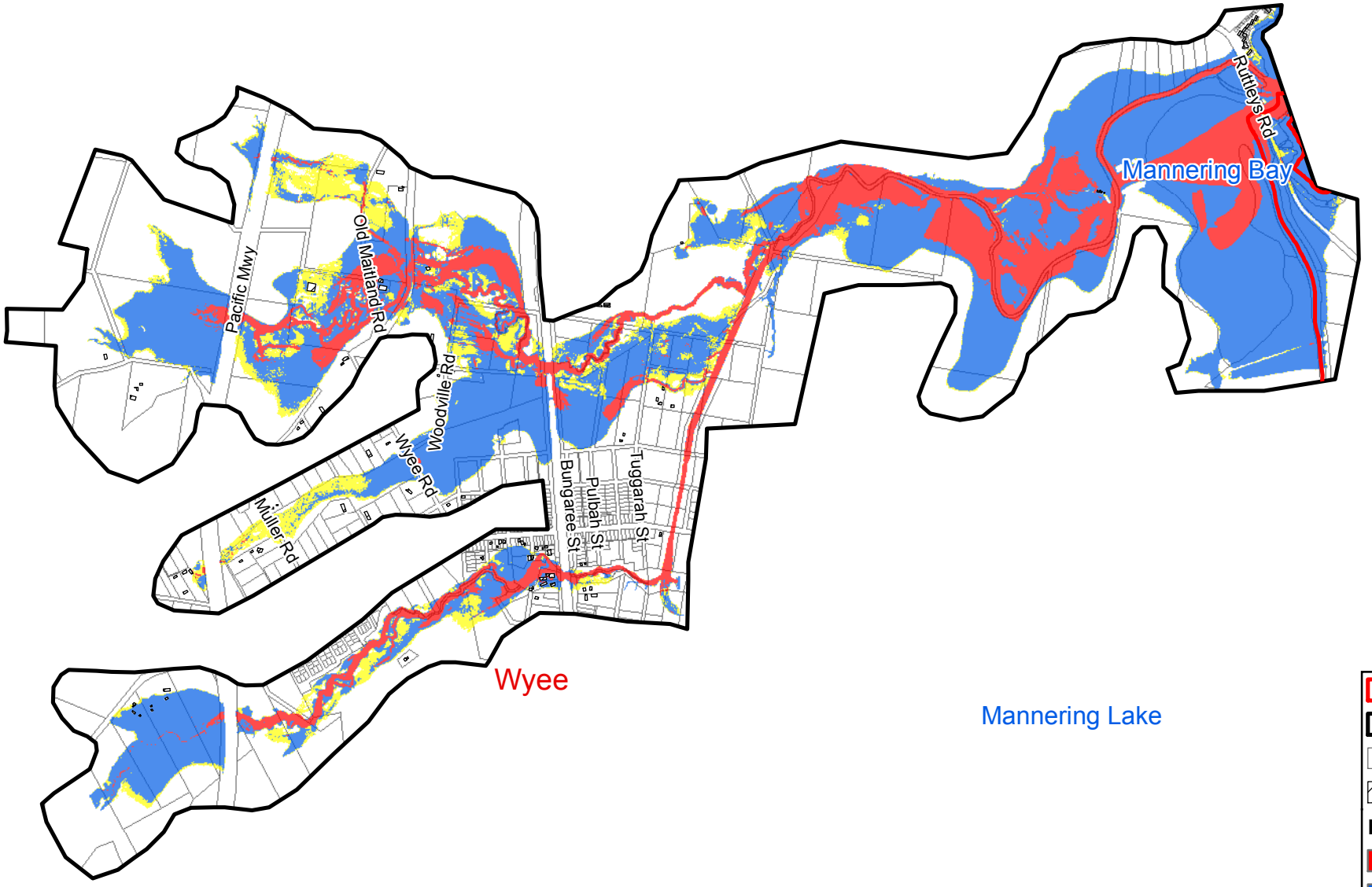
**MANNERING CREEK, SWAMPY CREEK AND WYEE CREEK**
**HYDRAULIC CATEGORISATION**
**2% AEP EVENT**




J:\Jobs\119076\ArcGIS\ArcMap\Working\Template\Appendix_J\Figure\J20_MSWC_Hydraulic_Categories_5%AEP.mxd

FIGURE J22

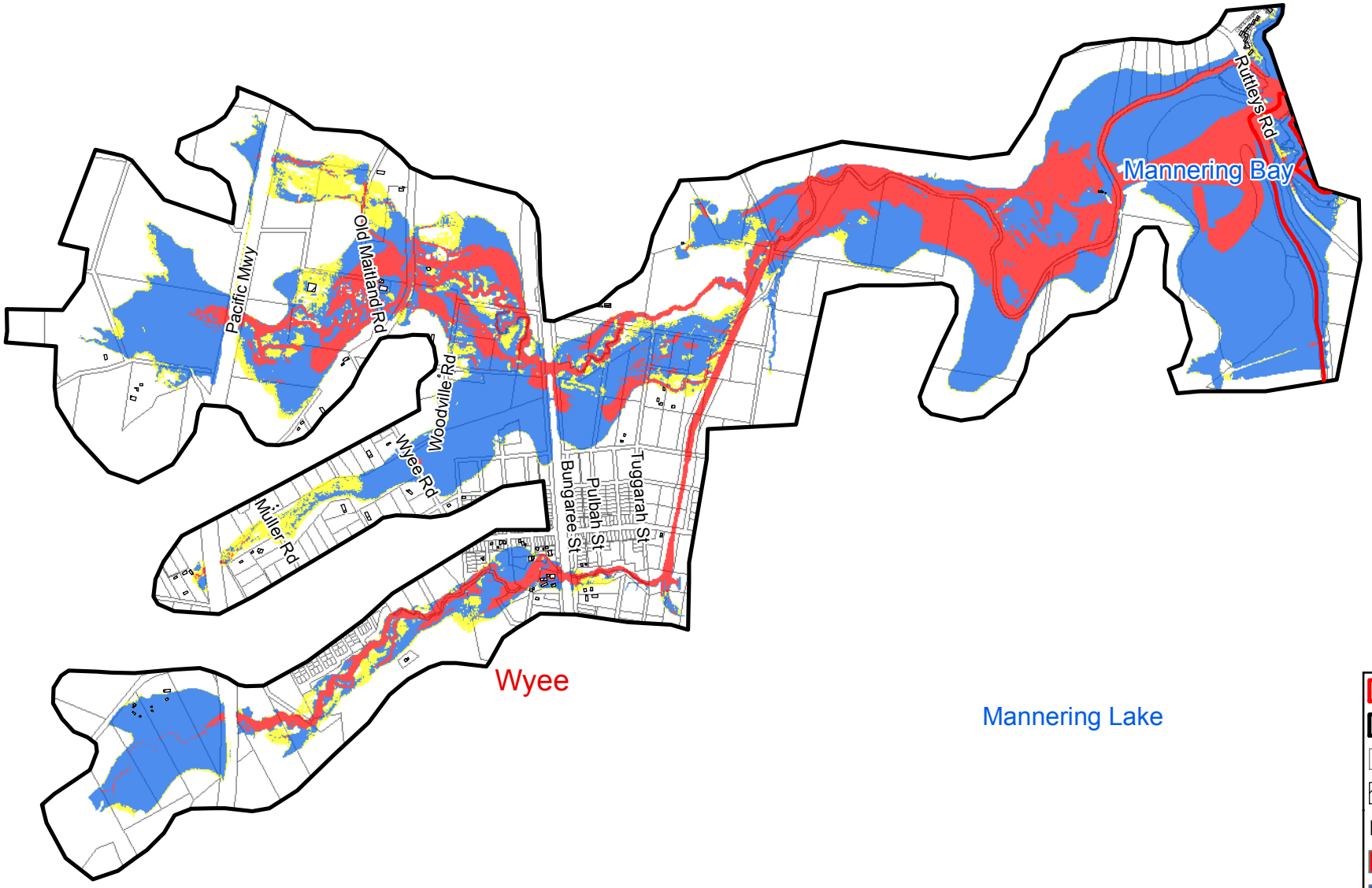
**MANNERING CREEK, SWAMPY CREEK AND WYEE CREEK**
**HYDRAULIC CATEGORISATION**
**1% AEP EVENT**




J:\Jobs\119076\ArcGIS\ArcMap\Working\Template\Appendix_J\FigureJ21_MSWC_Hydraulic_Categories_2%AEP.mxd

FIGURE J23

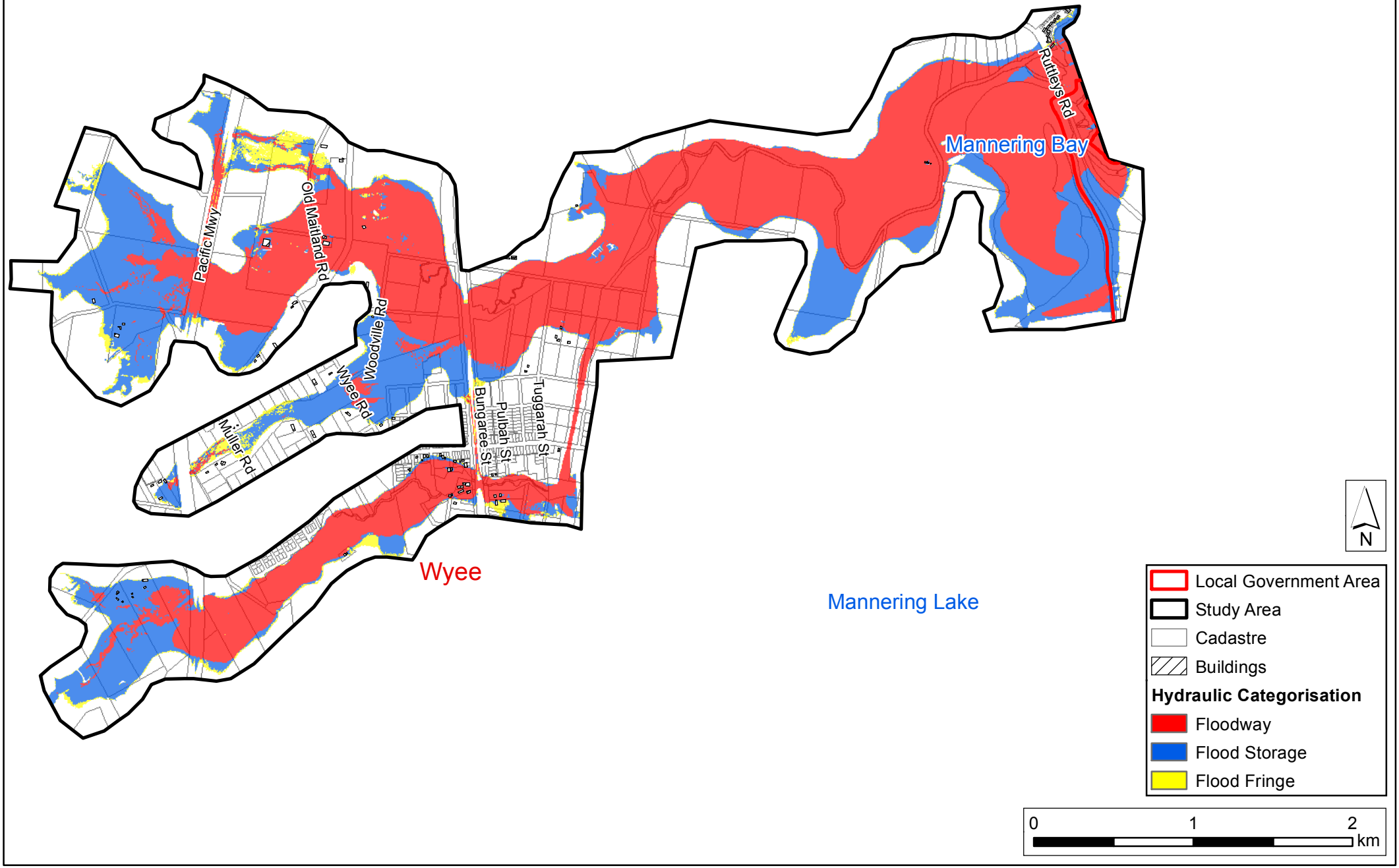
**MANNERING CREEK, SWAMPY CREEK AND WYEE CREEK**
**HYDRAULIC CATEGORISATION**
**0.5% AEP EVENT**




J:\Jobs\119076\ArcGIS\ArcMap\Working\Template\Appendix_J\FigureJ22_MSWC_Hydraulic_Categories_1%AEP.mxd

FIGURE J24

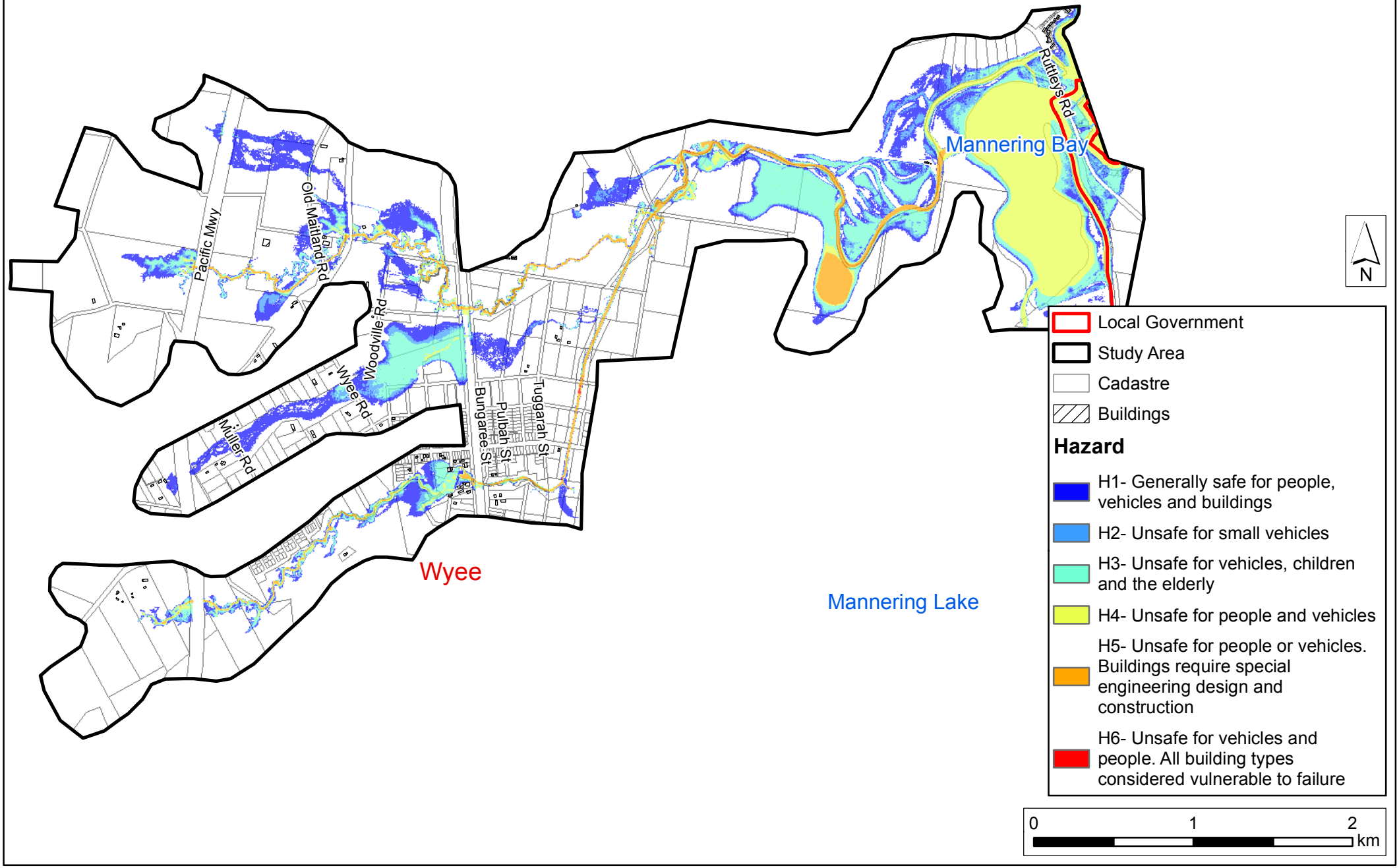
**MANNERING CREEK, SWAMPY CREEK AND WYEE CREEK**
**HYDRAULIC CATEGORISATION**
**PMF EVENT**




J:\Jobs\119076\ArcGIS\ArcMap\Working\Template\Appendix_J\FigureJ23_MSWC_Hydraulic_Categories_0.5%AEP.mxd

FIGURE J25

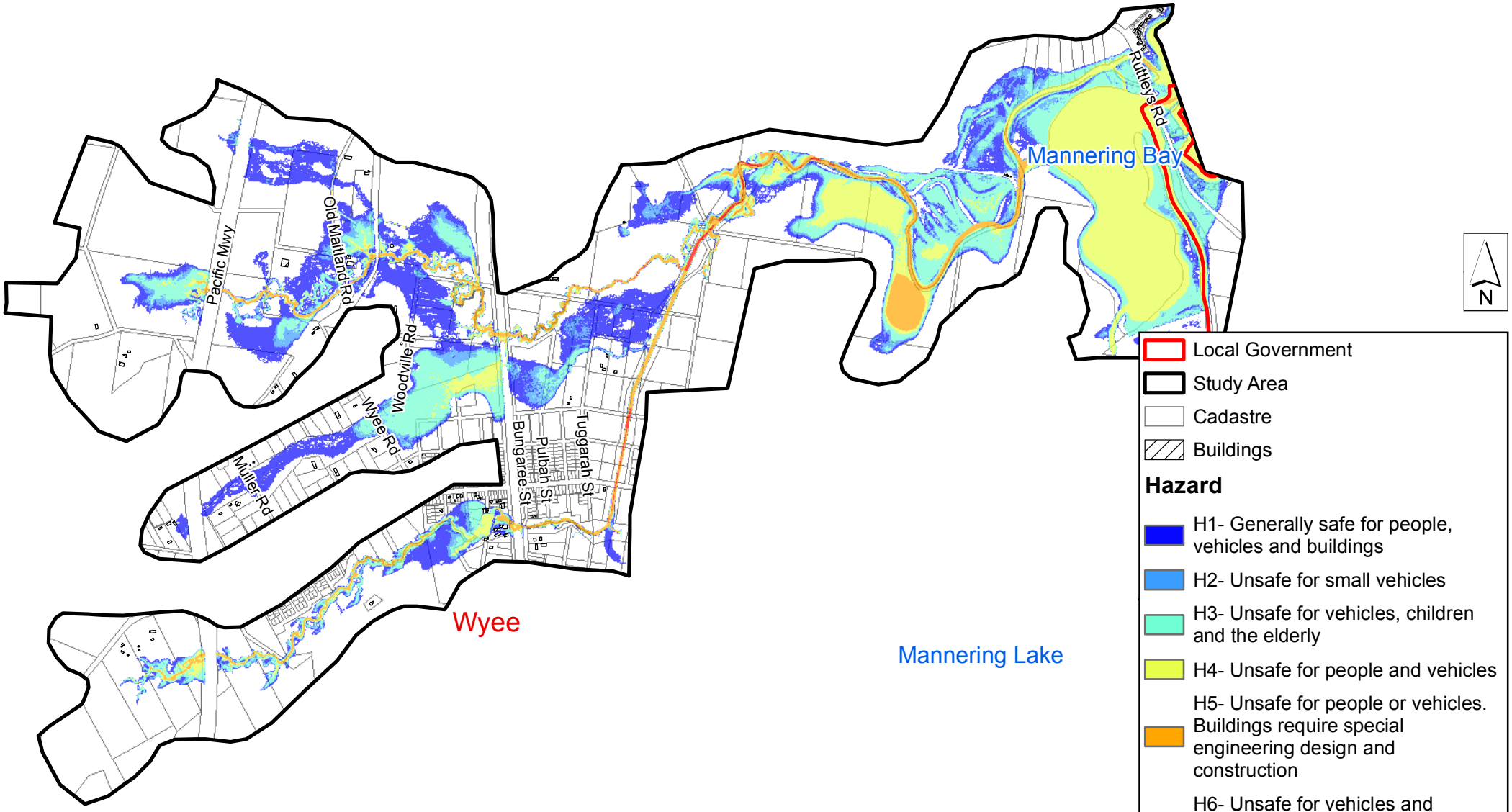
**MANNERING CREEK, SWAMPY CREEK AND WYEE CREEK**
**HYDRAULIC HAZARD**
**50% AEP EVENT**




J:\Jobs\119076\ArcGIS\ArcMap\Working\Template\Appendix_J\FigureJ41_MSWC_Provisional_Hazard_1%AEP_SLR09.mxd

FIGURE J26

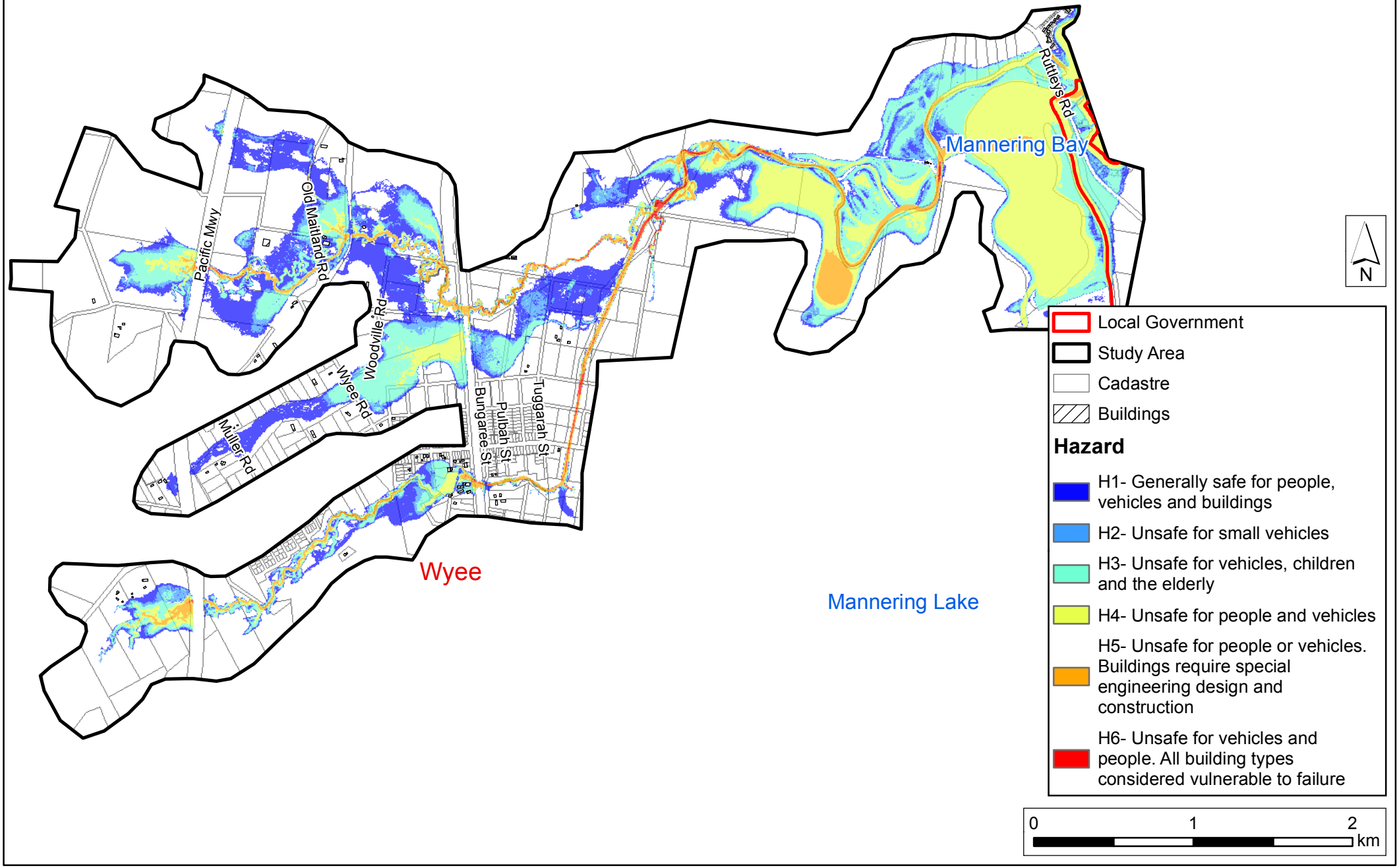
**MANNERING CREEK, SWAMPY CREEK AND WYEE CREEK**
**HYDRAULIC HAZARD**
**20% AEP EVENT**




J:\Jobs\119076\ArcGIS\ArcMap\Working\Template\Appendix_J\FigureJ25_MSWC_Provisional_Hazard_50%AEP.mxd

FIGURE J27

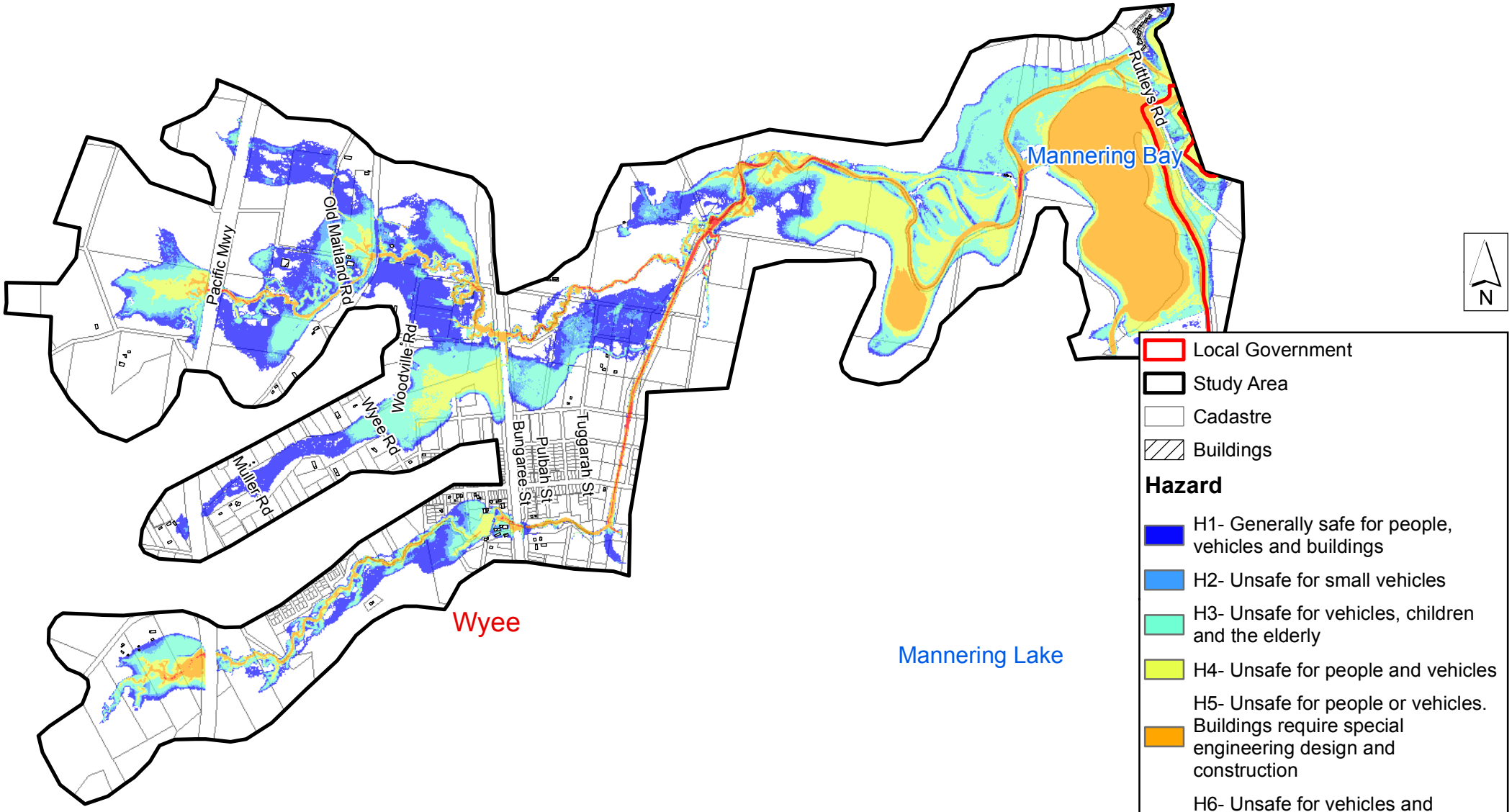
**MANNERING CREEK, SWAMPY CREEK AND WYEE CREEK HYDRAULIC HAZARD 10% AEP EVENT**




J:\Jobs\119076\ArcGIS\ArcMap\Working\Template\Appendix_J\FigureJ26_MSWC_Provisional_Hazard_20%AEP.mxd

FIGURE J28

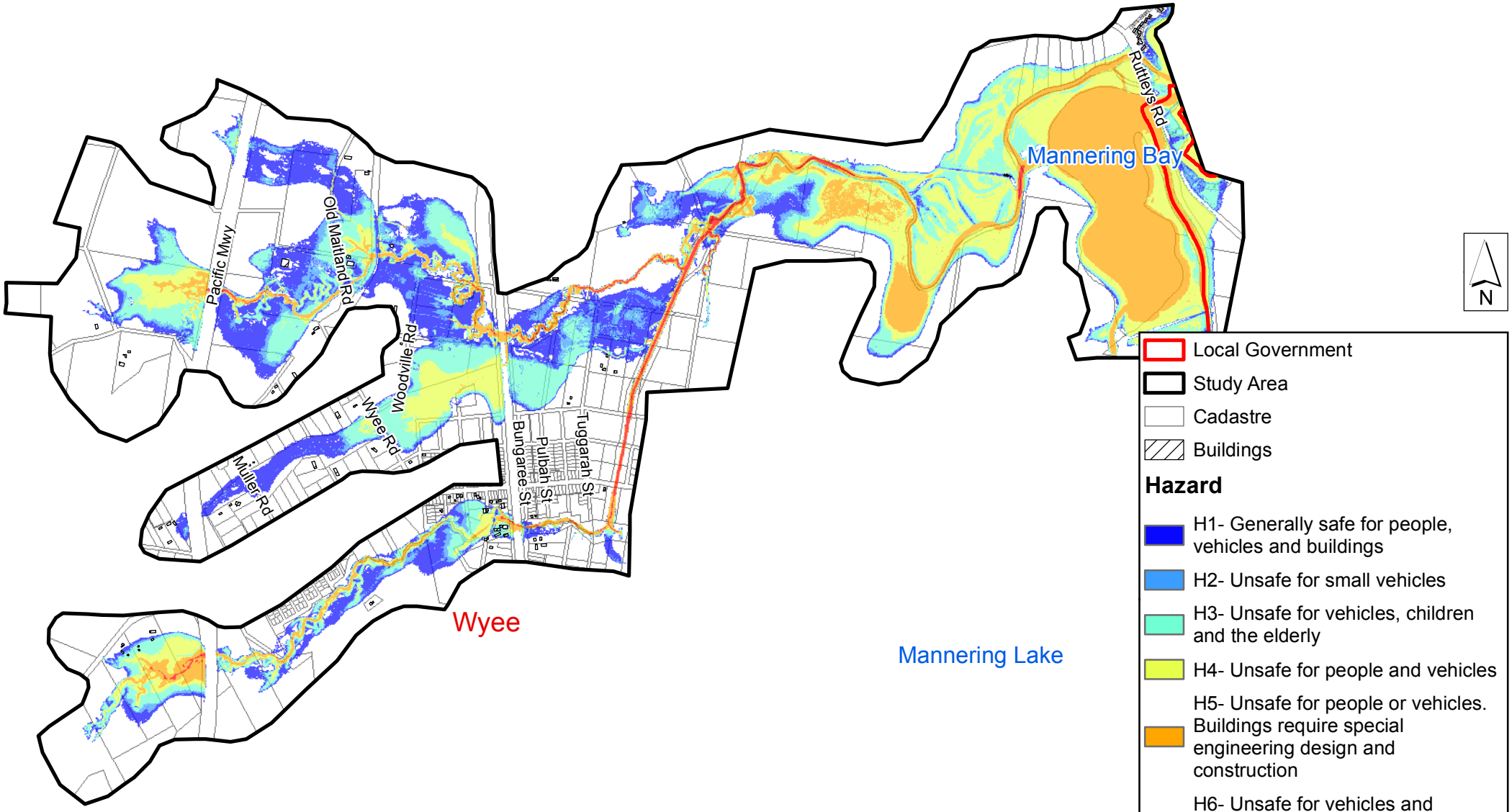
# MANNERING CREEK, SWAMPY CREEK AND WYEE CREEK HYDRAULIC HAZARD 5% AEP EVENT




J:\Jobs\119076\ArcGIS\ArcMap\Working\Template\Appendix_J\FigureJ27_MSWC_Provisional_Hazard_10%AEP.mxd

FIGURE J29

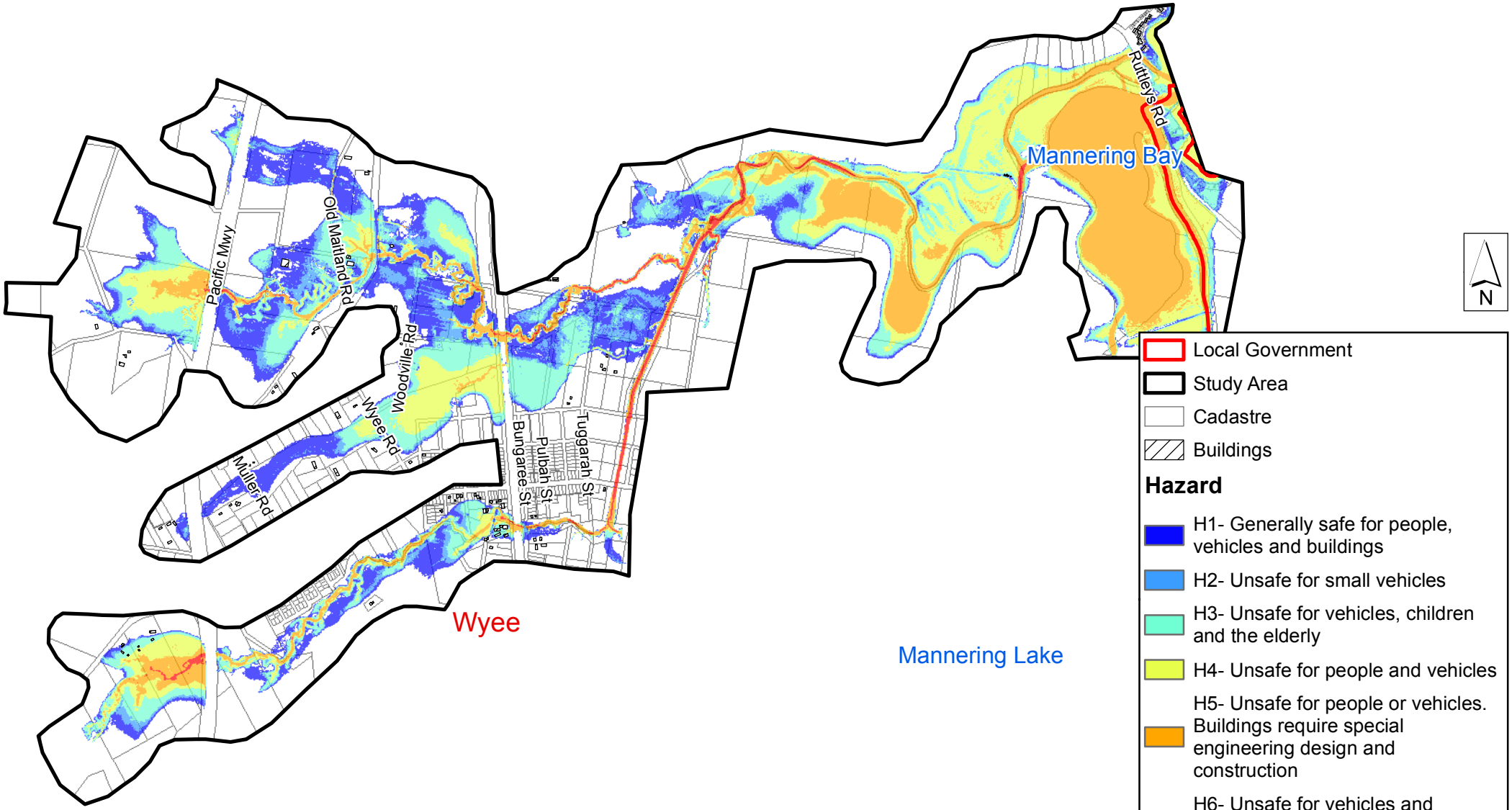
**MANNERING CREEK, SWAMPY CREEK AND WYEE CREEK HYDRAULIC HAZARD 2% AEP EVENT**




J:\Jobs\119076\ArcGIS\ArcMap\Working\Template\Appendix_J\FigureJ28_MSWC_Provisional_Hazard_5%AEP.mxd

FIGURE J30

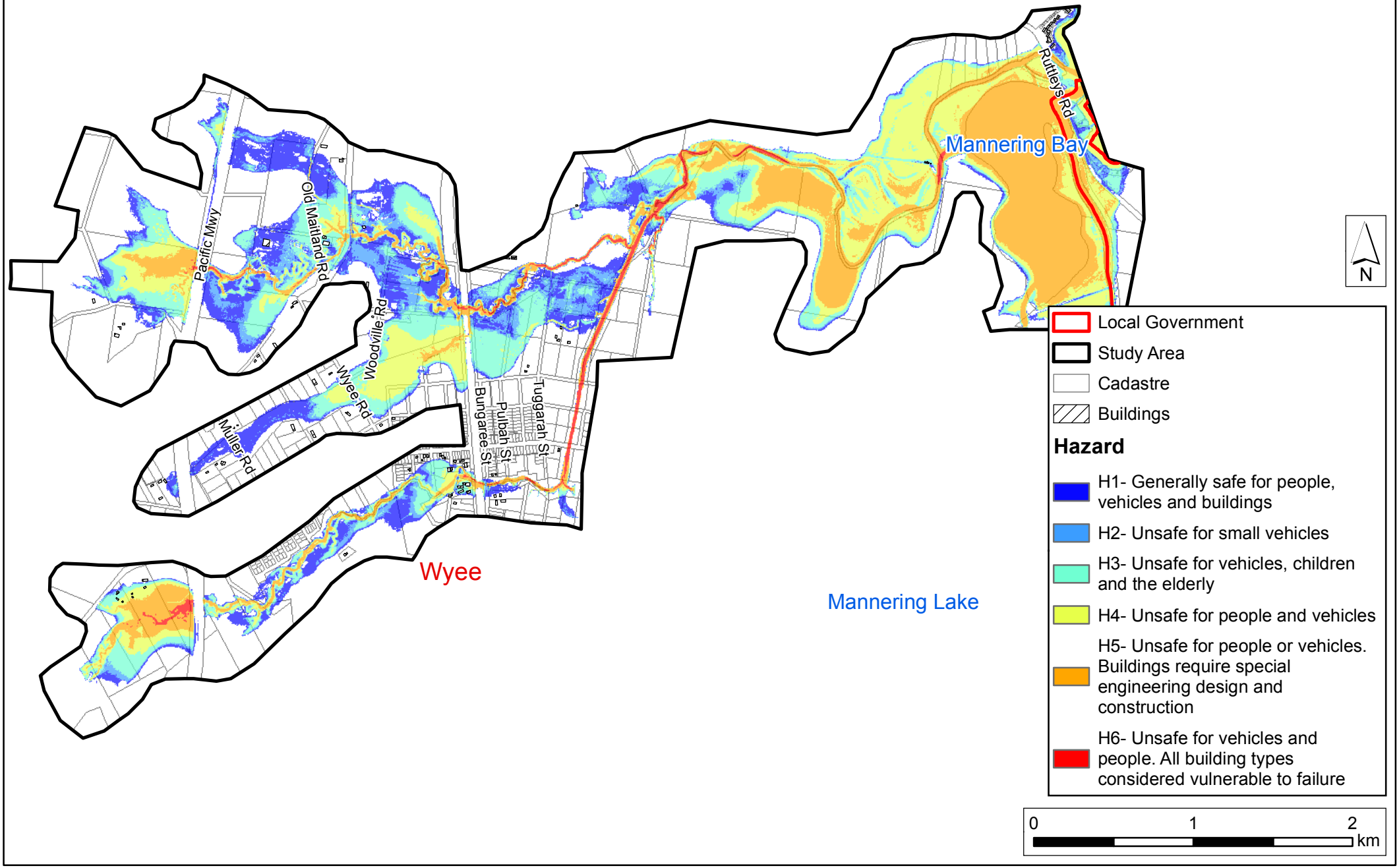
**MANNERING CREEK, SWAMPY CREEK AND WYEE CREEK**
**HYDRAULIC HAZARD**
**1% AEP EVENT**




J:\Jobs\119076\ArcGIS\ArcMap\Working\Template\Appendix_J\FigureJ29_MSWC_Provisional_Hazard_2%AEP.mxd

FIGURE J31

**MANNERING CREEK, SWAMPY CREEK AND WYEE CREEK HYDRAULIC HAZARD 0.5% AEP EVENT**




J:\Jobs\1190776\ArcGIS\ArcMap\Working\Template\Appendix_J\FigureJ30_MSWC_Provisional_Hazard_1%AEP.mxd

FIGURE J32

**MANNERING CREEK, SWAMPY CREEK AND WYEE CREEK**
**HYDRAULIC HAZARD**
**PMF EVENT**

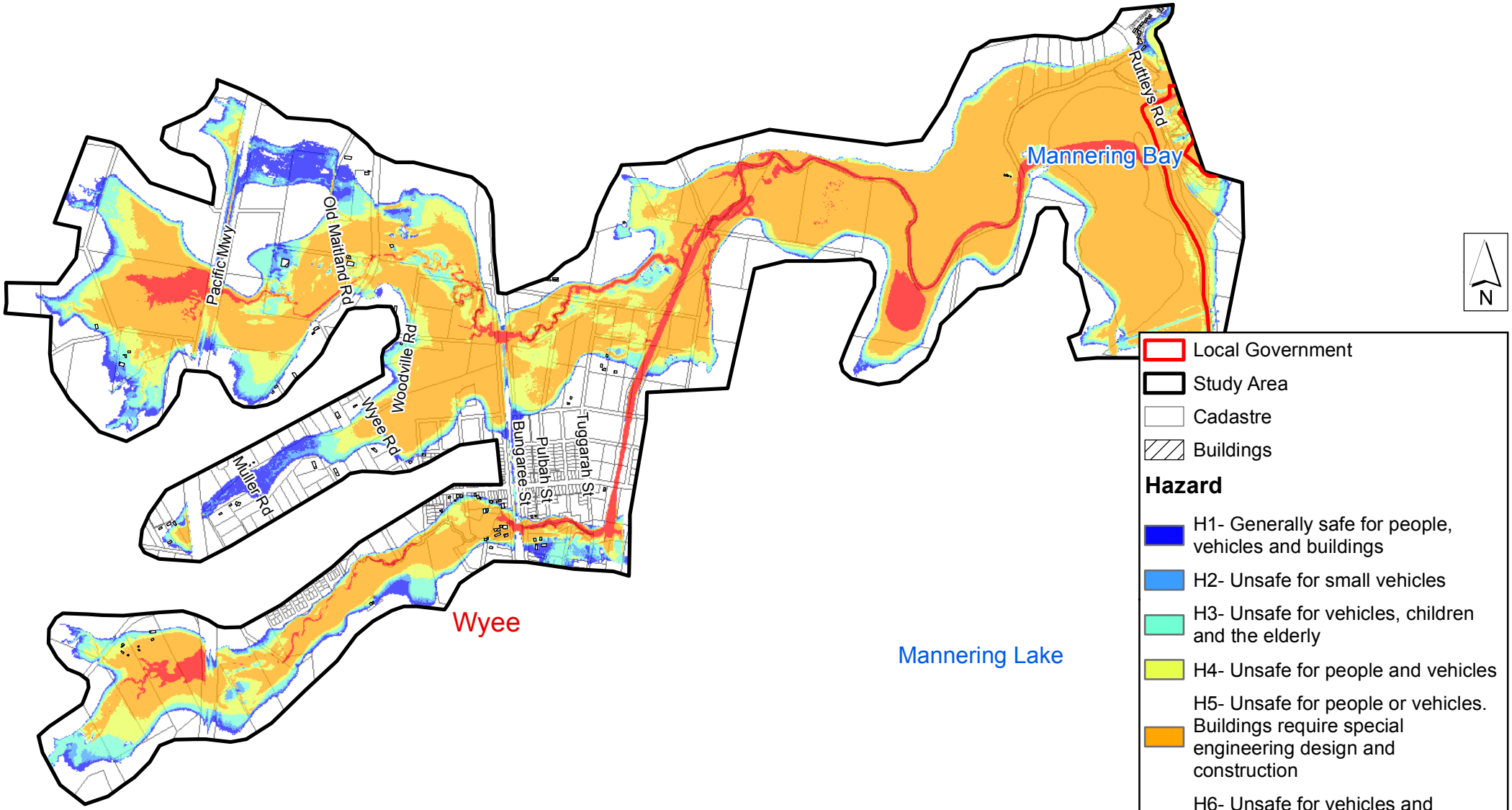



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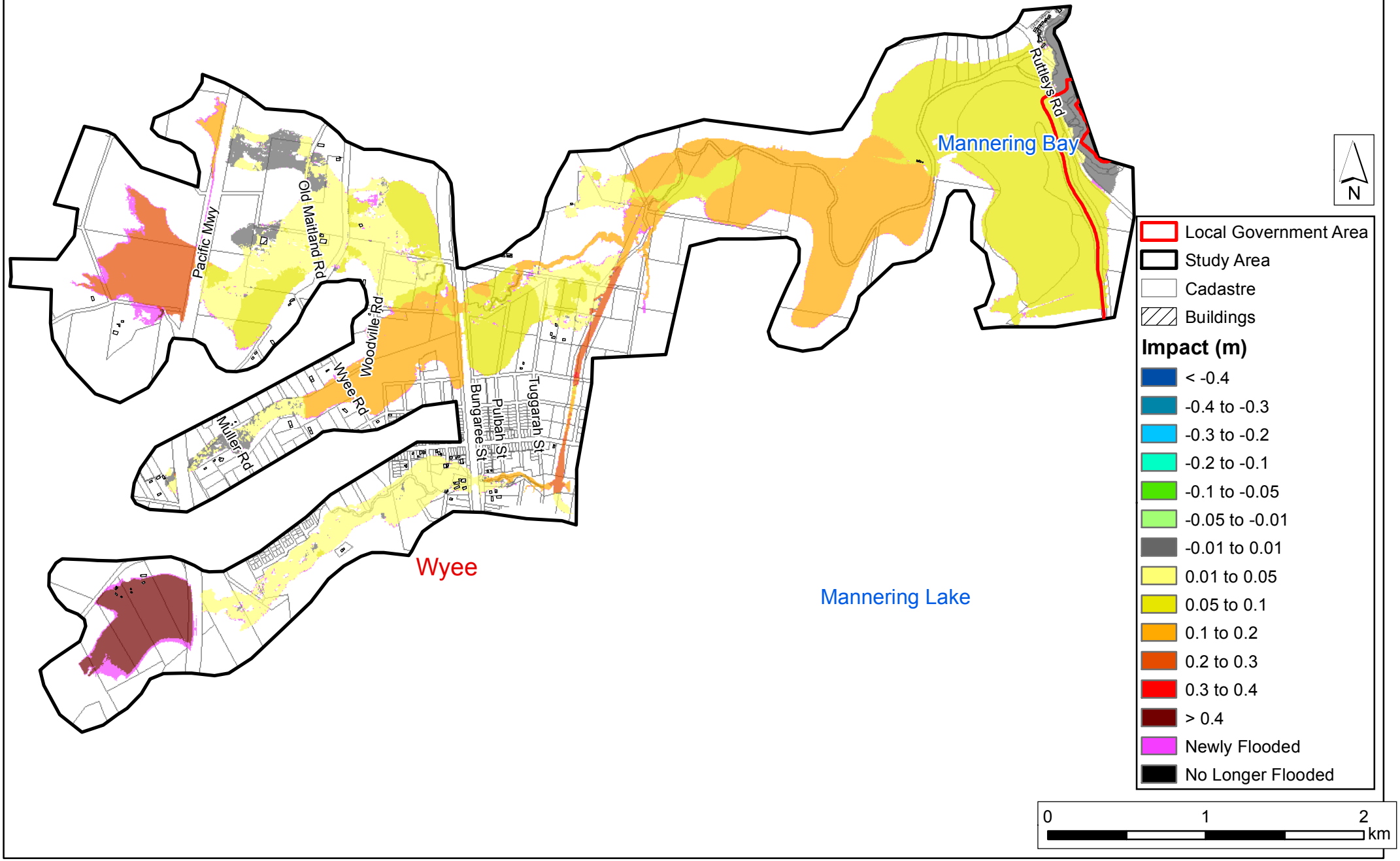
FIGURE J33

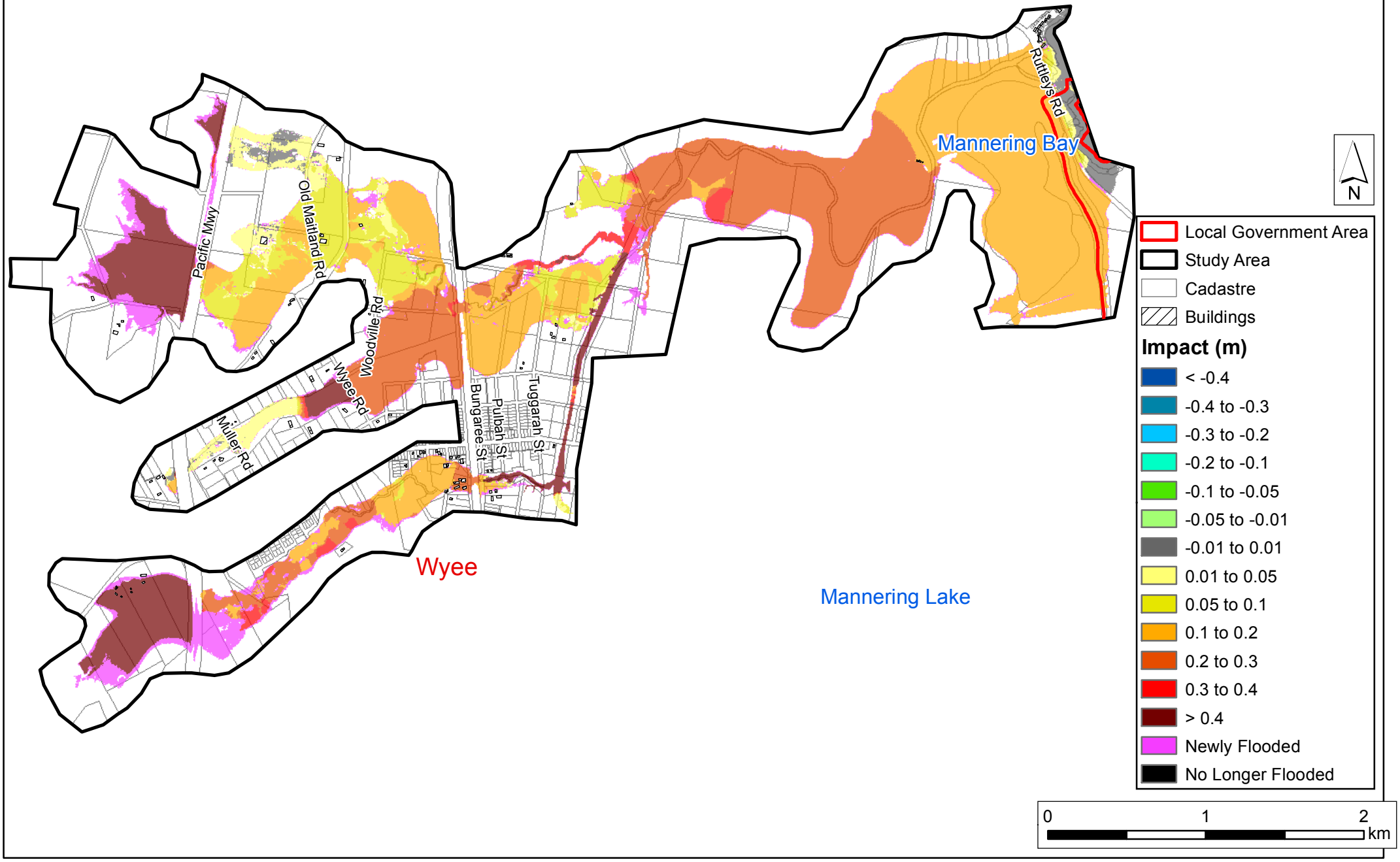
**MANNERING CREEK, SWAMPY CREEK AND WYEE CREEK**
**CHANGE IN PEAK FLOOD LEVEL**
**0.5% AEP EVENT VS 1% AEP EVENT**




J:\Jobs\119076\ArcGIS\ArcMap\Working\Template\Appendix_J\FigureJ33_MSWC_Impact_CC_0.5%AEP_V_1%AEP.mxd

FIGURE J34

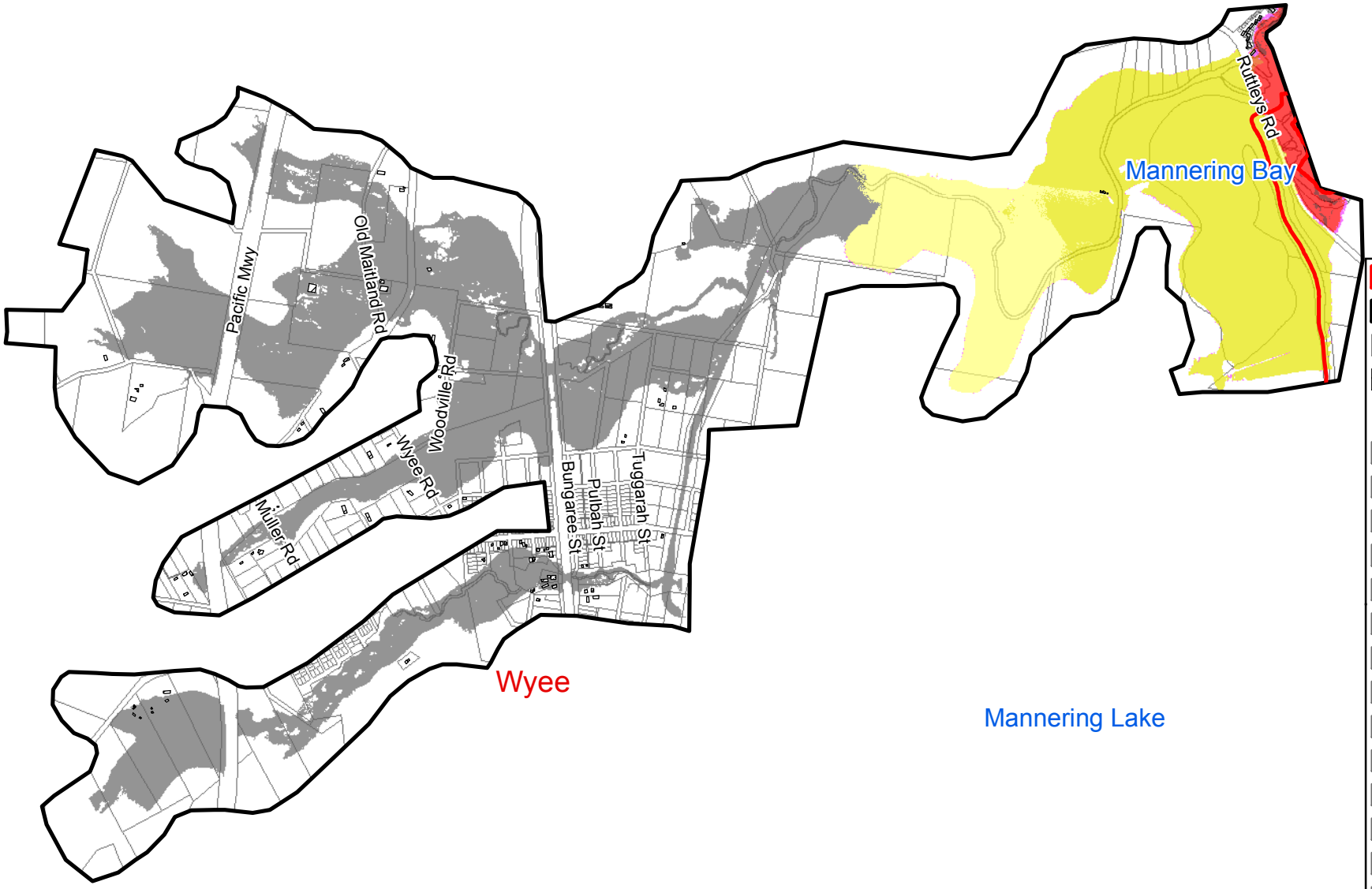
**MANNERING CREEK, SWAMPY CREEK AND WYEE CREEK**
**CHANGE IN PEAK FLOOD LEVEL**
**0.2% AEP EVENT VS 1% AEP EVENT**




J:\Jobs\119076\ArcGIS\ArcMap\Working\Template\Appendix_J\FigureJ33_MSWC_Impact_CC_0.5%AEP_V_1%AEP.mxd

FIGURE J35

**MANNERING CREEK, SWAMPY CREEK AND WYEE CREEK**
**CHANGE IN PEAK FLOOD LEVEL**
**1% AEP EVENT - SEA LEVEL RISE 400MM**




N

Local Government Area
Study Area
Cadastre
Buildings

**Impact (m)**

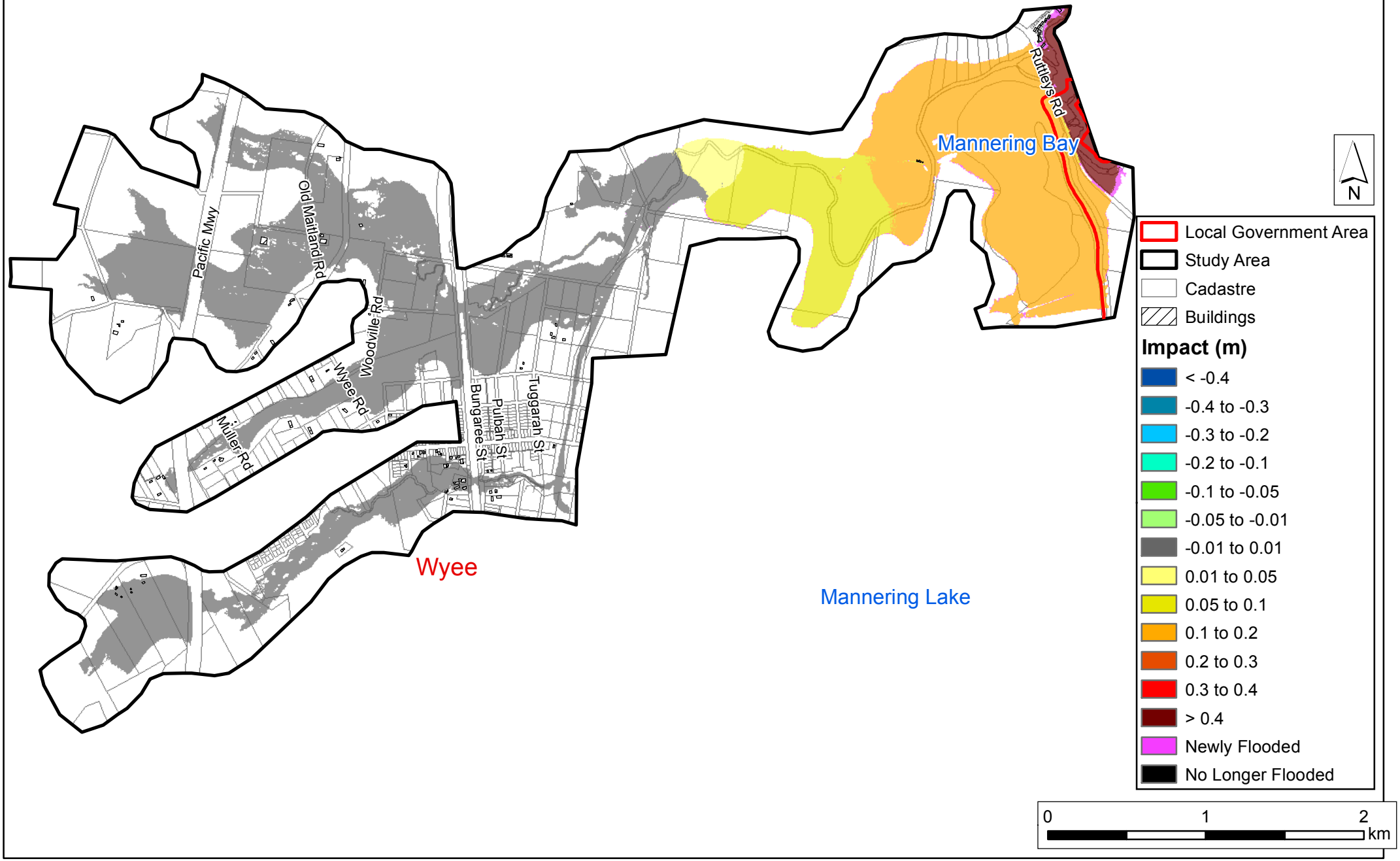
- < -0.4
- -0.4 to -0.3
- -0.3 to -0.2
- -0.2 to -0.1
- -0.1 to -0.05
- -0.05 to -0.01
- -0.01 to 0.01
- 0.01 to 0.05
- 0.05 to 0.1
- 0.1 to 0.2
- 0.2 to 0.3
- 0.3 to 0.4
- > 0.4
- Newly Flooded
- No Longer Flooded

0 1 2 km

J:\Jobs\1190776\ArcGIS\ArcMap\Working\Template\Appendix_J\FigureJ34_MSWC_Impact_CC_0.2%AEP_V_1%AEP.mxd

FIGURE J36

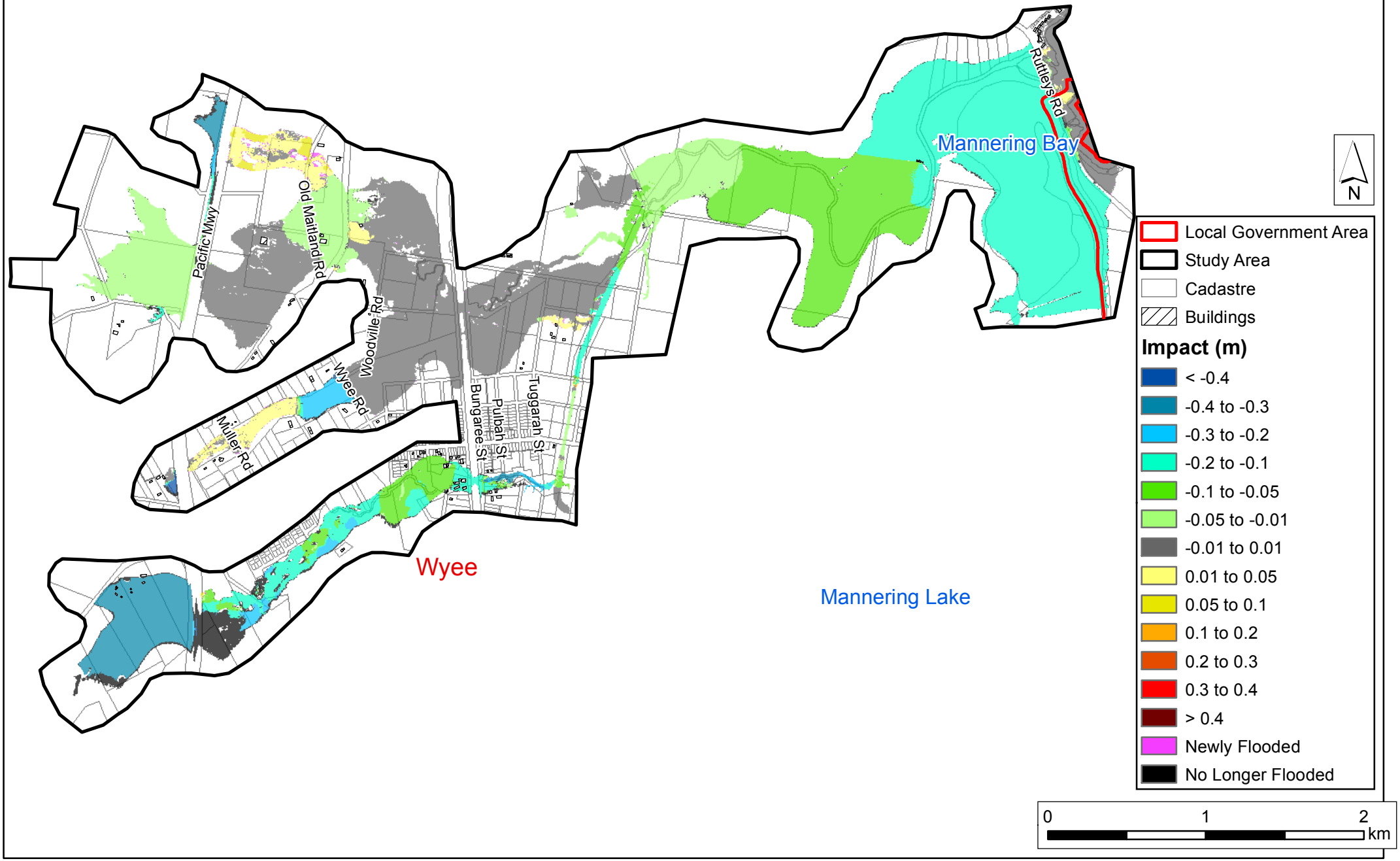
**MANNERING CREEK, SWAMPY CREEK AND WYEE CREEK**
**CHANGE IN PEAK FLOOD LEVEL**
**1% AEP EVENT - SEA LEVEL RISE 900MM**




J:\Jobs\1190776\ArcGIS\ArcMap\Working\Template\Appendix_J\FigureJ35_MSWC_Impact_CC_SLR04_1%AEP.mxd

FIGURE J37

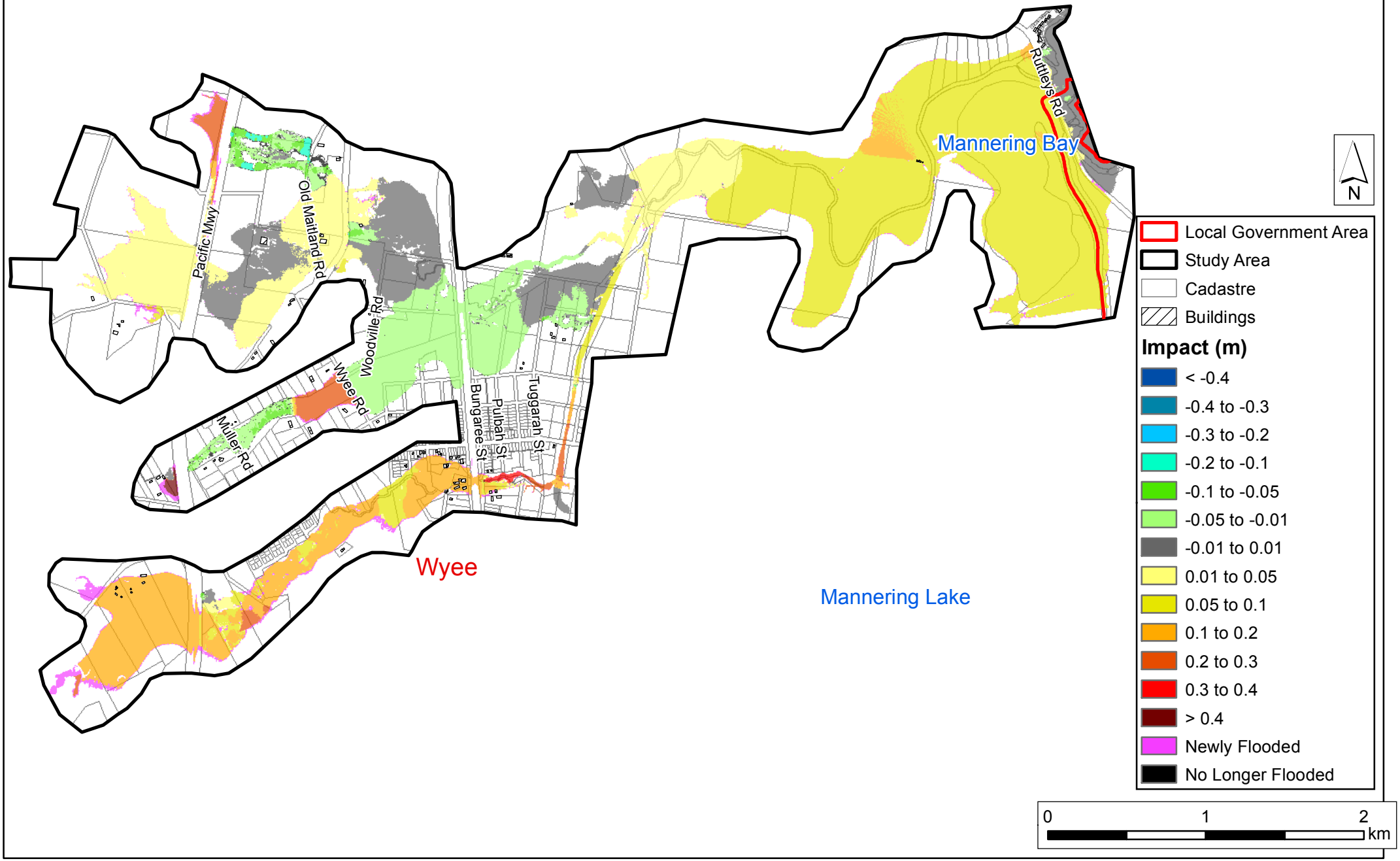
**MANNERING CREEK, SWAMPY CREEK AND WYEE CREEK**
**CHANGE IN PEAK FLOOD LEVEL**
**1% AEP EVENT - 25% BLOCKAGE**




J:\Jobs\1190776\ArcGIS\ArcMap\Working\Template\Appendix_J\FigureJ36_MSWC_Impact_CC_SLR09_1%AEP.mxd

FIGURE J38

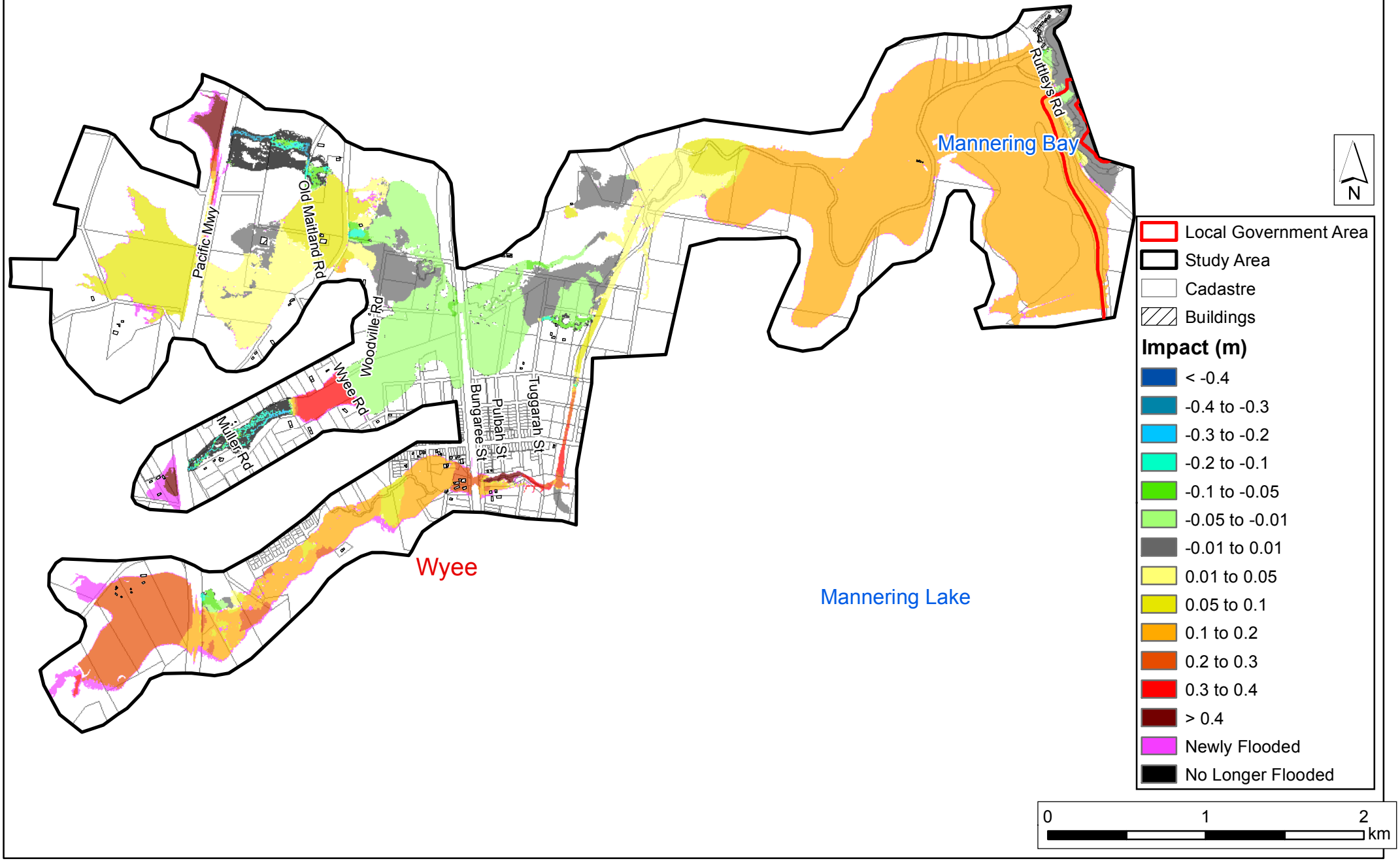
**MANNERING CREEK, SWAMPY CREEK AND WYEE CREEK**
**CHANGE IN PEAK FLOOD LEVEL**
**1% AEP EVENT - 75% BLOCKAGE**




J:\Jobs\119076\ArcGIS\ArcMap\Working\Template\Appendix_J\FigureJ37_MSWC_Impact_1%AEP_Blockage25pc.mxd

FIGURE J39

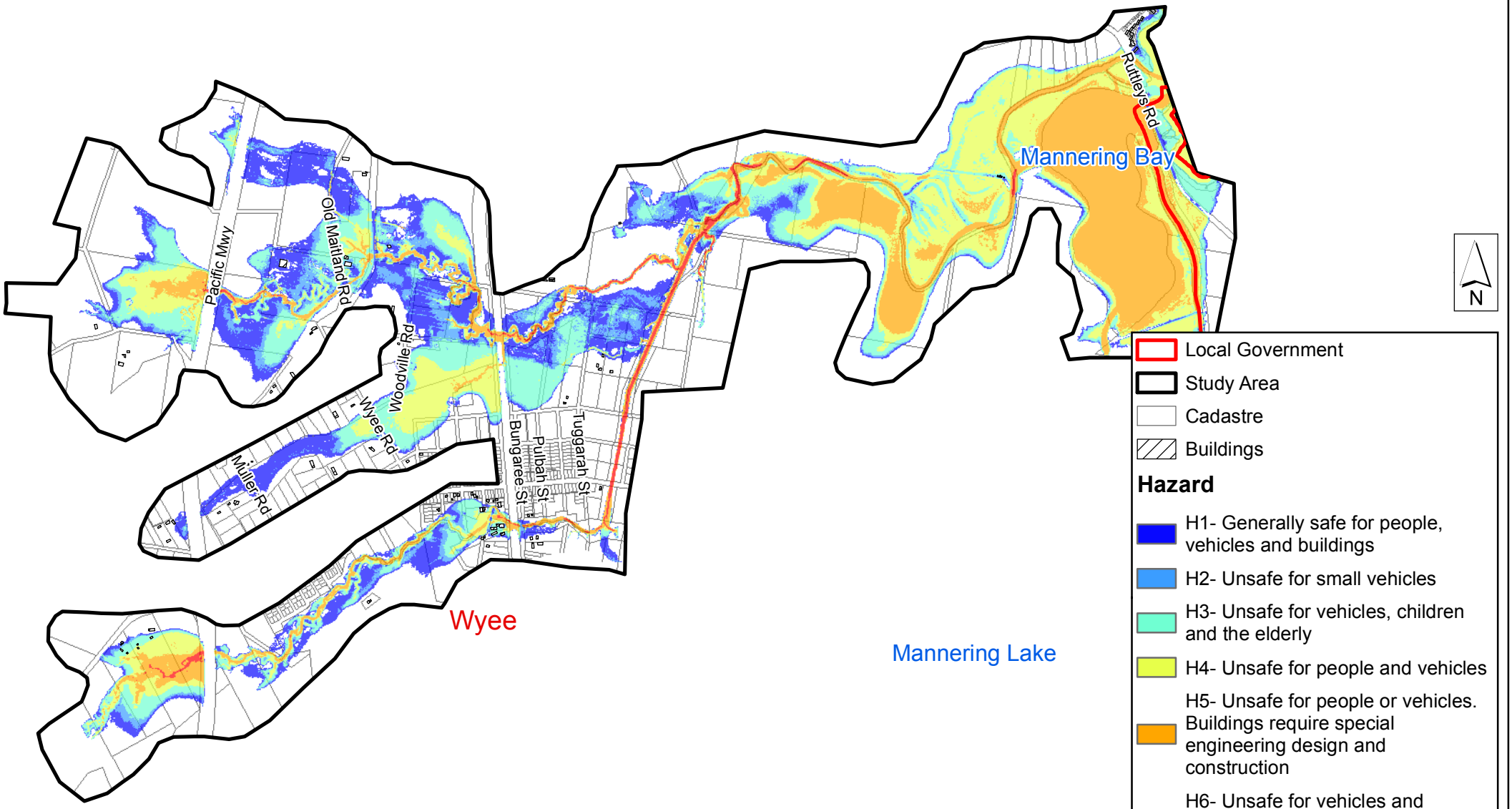
**MANNERING CREEK, SWAMPY CREEK AND WYEE CREEK**
**CHANGE IN PEAK FLOOD LEVEL**
**1% AEP EVENT - 100% BLOCKAGE**




J:\Jobs\119076\ArcGIS\ArcMap\Working\Template\Appendix_J\FigureJ38_MSWC_Impact_1%AEP_Blockage75pc.mxd

FIGURE J40

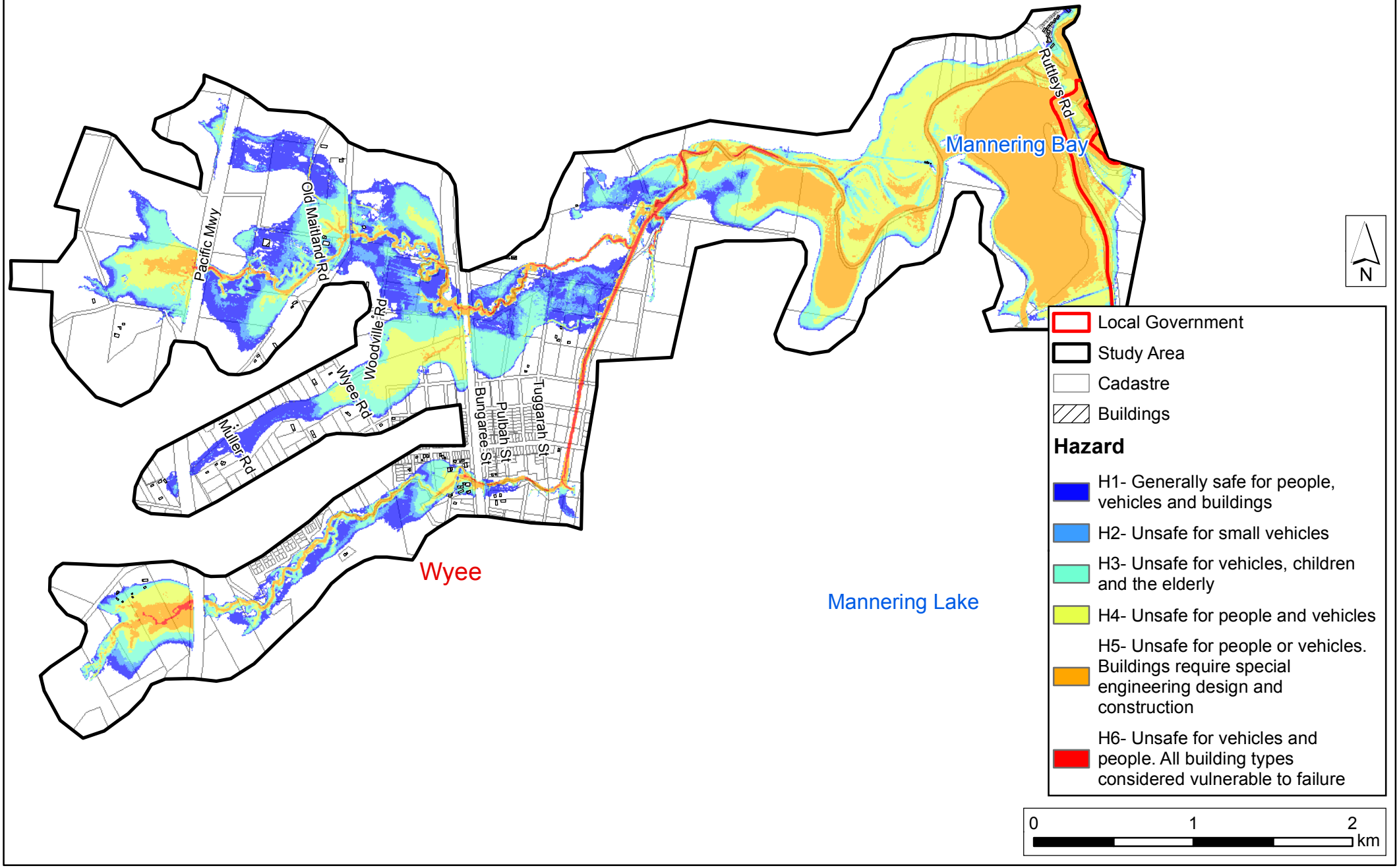
**MANNERING CREEK, SWAMPY CREEK AND WYEE CREEK**
**HYDRAULIC HAZARD**
**1% AEP EVENT - SEA LEVEL RISE 0.4M**




J:\Jobs\1190776\ArcGIS\ArcMap\Working\Template\Appendix_J\Figure\J25_MSWC_Provisional_Hazard_50%AEP.mxd

FIGURE J41

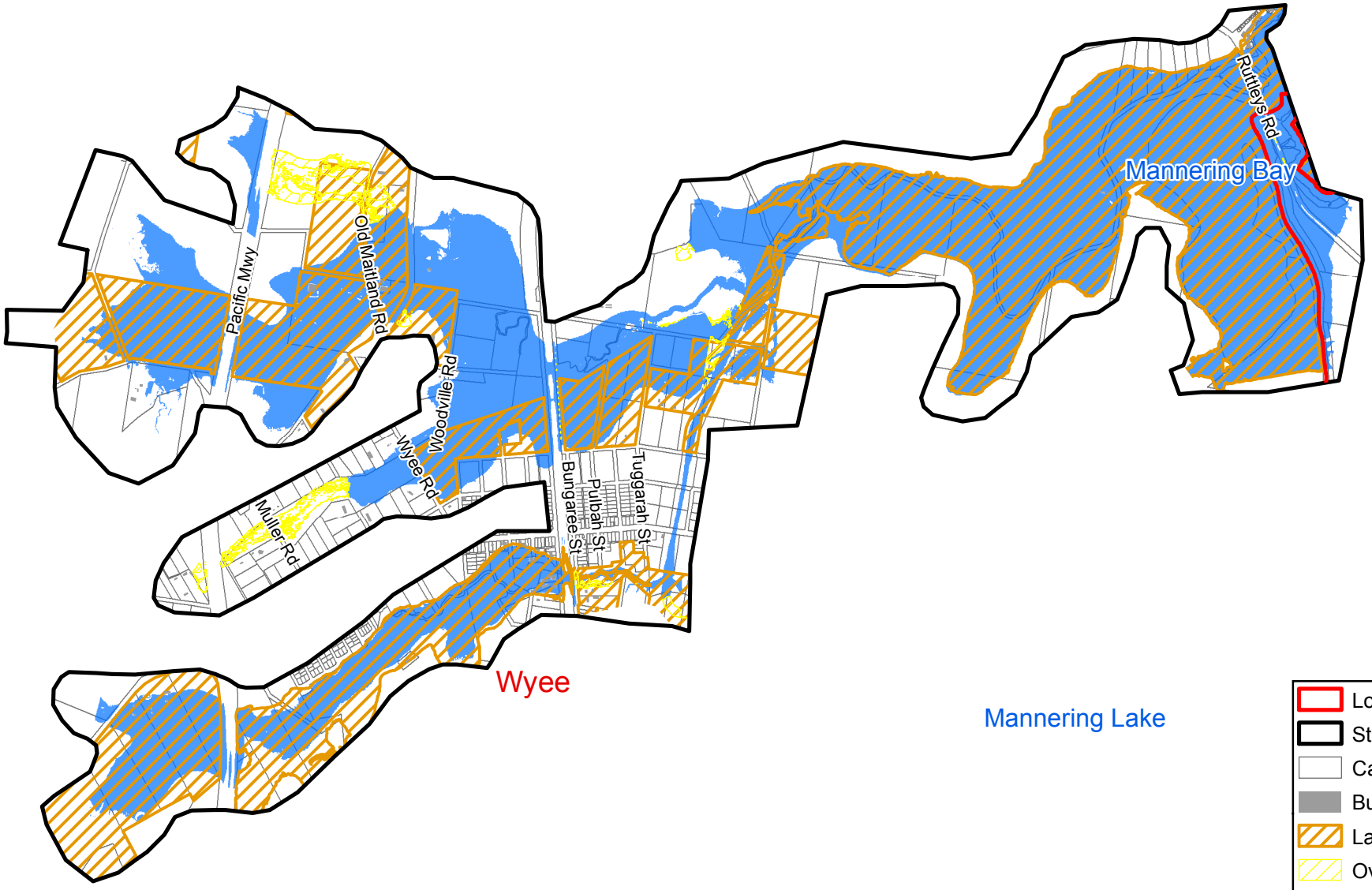
**MANNERING CREEK, SWAMPY CREEK AND WYEE CREEK**
**HYDRAULIC HAZARD**
**1% AEP EVENT - SEA LEVEL RISE 0.9M**




J:\Jobs\119076\ArcGIS\ArcMap\Working\Template\Appendix_J\FigureJ40_MSWC_Provisional_Hazard_1%AEP_SLR04.mxd

FIGURE J42

**MANNERING CREEK, SWAMPY CREEK AND WYEE CREEK FLOOD PLANNING AREA**




J:\Jobs\119076\ArcGIS\ArcMap\Report\Appendix_J\FigureJ42_MSWC_Flood_Planning_Area.mxd