APPENDIX L.

Failure Analysis Report

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South Rockhampton Flood Levee Project
Rockhampton Regional Council
03-Apr-2019
Doc No. 60589157-REP-011

South Rockhampton Flood Levee

Failure Analysis Report (Volume 1) - 2019 Update

South Rockhampton Flood Levee

Failure Analysis Report (Volume 1) - 2019 Update

Client: Rockhampton Regional Council

ABN: 59 923 523 766

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Glossary / Abbreviations

AECOM AECOM Australia Pty Ltd

AEP Annual Exceedence Probability = $1 - \exp\left(\frac{-1}{ARI}\right)$

Table 1 ARI to AEP Conversion

ARI (Years)	AEP	AEP (%)
100	0.010	1
500	0.002	0.2

AHD Australian Height Datum

ARI Average Recurrence Interval

DFE Defined Flood Event

DNRM Department of Natural Resources and Mines

FAR Failure Analysis Report

FIA Failure Impact Assessment

GIS Geographical Information Systems

LiDAR Light Detecting and Ranging

PAR Population at Risk

PMF Probable Maximum Flood

RL Reduced Level

RRC Rockhampton Regional Council

SRFL South Rockhampton Flood Levee

TUFLOW 1D / 2D hydraulic modelling software

1.0 Introduction

1.1 Overview

In October 2018, Rockhampton Regional Council (RRC) re-engaged AECOM Australia Pty Ltd (AECOM) to deliver concept, detailed design updates and support the obtainment of Statutory Approvals for the South Rockhampton Flood Levee (SRFL) project.

1.2 Location and Context

Rockhampton is a large regional city located on the Fitzroy River approximately 640 kilometres north of Brisbane. The Rockhampton Regional Council area has a population of some 80,000 people and is a major service centre for the wider Central Queensland region. In addition to serving a range of industries including agriculture and mining, Rockhampton provides a full range of retail, education, health, social, government and professional services to a broad catchment.

The wider Central Queensland region that Rockhampton services and supports is experiencing continuing growth in mining and resources sectors, including Liquid Natural Gas and coal mining in particular. As a consequence, interruptions to logistics and services resulting from flooding in Rockhampton impact to varying degrees on the broader region and its industries.

The Central Queensland region is a world ranked producer and exporter of black coal and a major centre for mineral processing. The region hosts the coal-bearing Bowen and Galilee basins and also produces gold, silver, limestone, coal seam gas, magnesite and gemstones. There are currently 50 coal mines, 25 mineral mines and 30 medium to large (>50 000 tonnes per year) extractive quarries operating in Central Queensland.

1.3 Flooding from Fitzroy River Events

The Fitzroy River, which flows through the city of Rockhampton in the state of Queensland, drains a catchment of approximately 142,000 km^2 and is one of the largest catchments on the east coast of Australia. The catchment extends from the Carnarvon Gorge National Park in the West to Rockhampton on the central Queensland coast and is predominantly dominated by agriculture (grazing, dry land cropping, irrigated cotton and horticulture) and by mining (coal, magnesite, nickel and historically gold and silver).

Due to its immense size and fan-like shape, the Fitzroy River catchment is capable of producing severe flooding following heavy rainfall events in any of its major tributaries. These are the Dawson, Nogoa-Mackenzie and Connors-Isaacs Rivers which rise in the eastern coastal ranges and the Great Dividing Range and join together about 100 kilometres west of Rockhampton. Major floods can result from either the Dawson or the Connors-Mackenzie River catchments. Significant flooding in the Rockhampton area can also occur from heavy rain in the local area below Riverslea.

Rockhampton is the largest urban centre in Central Queensland and is located approximately 60 kilometres from the mouth of the Fitzroy River at Keppel Bay. The Fitzroy River at Rockhampton and adjacent townships has a long and well documented history of flooding with flood records dating back to 1859. The highest recorded flood occurred in January 1918 and reached 10.11 metres (8.65m AHD) on the Rockhampton flood gauge.

It must be noted that extensive social and economic impacts are also experienced in more frequent, flood events. As examples:

- Low lying areas of Port Curtis and Depot Hill are inundated at a gauge height of 7.0m which is equivalent to the Minor Classification given by BOM.
- The Depot Hill community is isolated at a gauge height of 7.5m which is equivalent to the Moderate Classification given by BOM.
- The Bruce Highway at Lower Dawson Road is cut at a gauge height of approximately 8.4m.
- Low lying areas of Allenstown are inundated at a gauge height of 8.5m which is equivalent to the Major Classification given by BOM.

- Depot Hill and Port Curtis have been impacted by 33 historical flood events over 7.0m in gauge height since records commenced in 1859.
- There have been 17 historical flood events over a gauge height of 8.0m in which the Bruce Highway (Lower Dawson Road) has been cut.

1.4 The South Rockhampton Flood Levee

The SRFL project represents one of the most significant regional flood mitigation projects currently proposed in Queensland. The SRFL was identified as a Priority 1 Structural Mitigation Measure in the 1992 Rockhampton Flood Management Study (CMPS&F, 1992). Construction of the levee will significantly reduce flood damage and social impacts for a large portion of the urban area in South Rockhampton.

The SRFL will be approximately 8.74km long, running from the Rockhampton CBD in the north (Fitzroy Street and Quay Street), to Jellicoe Street and Port Curtis Road in the south, and Upper Dawson Road (Yeppen North) in the west (refer to Figure 1). It will consist of sections of earth embankment, crib wall, vertical flood wall and temporary demountable levee structures (component lengths are summarised in Table 2).

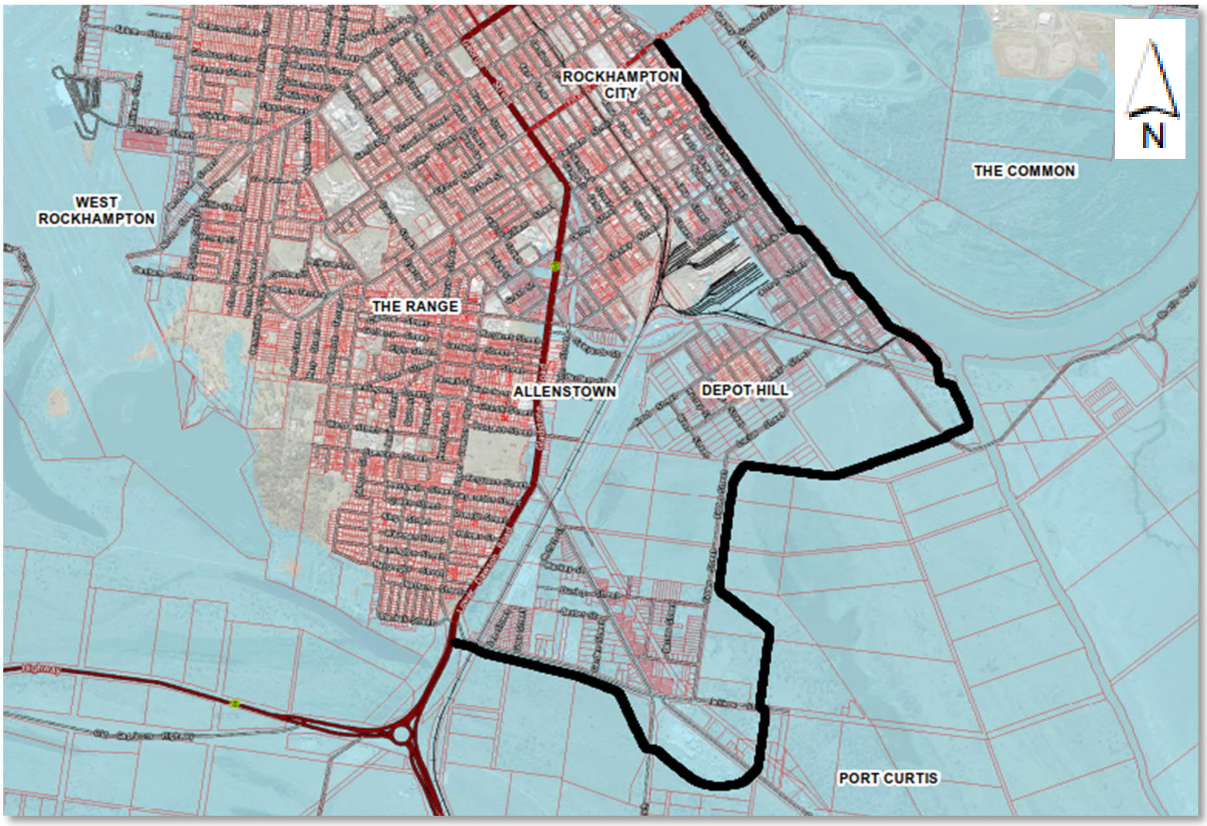


Figure 1 Location of the Proposed SRFL (Baseline Fitzroy River 1% AEP Flood Extents Shown)

The levee will be constructed to 1% Average Exceedance Probability (AEP) or 100 year Average Recurrence Interval (ARI) flood immunity with 600 mm freeboard. This will be equivalent to a 9.89 m gauge level (post SRFL construction).

The levee will incorporate flood gates on the major drainage channels and existing piped drainage networks that discharge outside the levee will be fitted with non-return devices to prevent river back-up. A system of landside drainage channels and three interior pump stations will discharge local catchment runoff should local rainfall events coincide with a regional Fitzroy River flood event.

Table 2 SRFL Component Lengths

Levee Type	Length (m)
Temporary Fully Demountable Wall	732
Composite Demountable / Permanent Levee Wall	967
Levee Emergency Spillway	420
Earth Embankment (incl. road ramps and gates)	5,892
Crib Retaining Wall	729
Total Levee Length	**8,740**

1.5 Project Delivery

The SRFL project is being delivered in two distinct stages, as detailed below.

1.5.1 Stage 1: Early Works (Pre-construction services)

Prior to construction starting on the SRFL project, early works will be completed. The works include land acquisition, stormwater, water and sewage relocations, river bank protection works, and drainage works. Early works are anticipated to commence in 2019 and will be undertaken progressively throughout the year.

1.5.2 Stage 2: Main Contract

Council is committed to finalising the consultation, environmental and planning approvals, technical investigations and design of the SRFL project, to facilitate tendering and construction. The SRFL construction works are anticipated to start in late 2019.

The SRFL project has been declared a prescribed project by the Minister for State Development, Manufacturing, Infrastructure and Planning. Approvals for the project are yet to be obtained and will be facilitated through the Infrastructure Designation process under the *Planning Act 2016*. This will include the preparation and exhibition of an Environment Assessment Report (EAR).

1.6 Scope of Works

This Failure Analysis Report (FAR) has been undertaken as part of the Concept Design Phase for the SRFL project to support the Draft EAR submission. The primary objective of this FAR is to provide information to RRC and the local disaster management group, for use in emergency planning. The FAR also aims to:

- Summarise the characteristics of the SRFL.
- Identify potential failure mechanisms.
- Summarise the hydrological and hydraulic modelling associated with the SRFL, which has been completed prior to the commencement of the FAR.
- Analyse the potential impact of a number of levee failure scenarios to assist emergency management personnel and supplement the SRFL Operations and Maintenance Manual (AECOM, 2019).
- Assist Council to manage the residual flood risk posed to the interior area following the construction of the SRFL.

1.6.1 Limitations

The following limitations are noted:

- The Guidelines for the Construction or Modification of Category 2 and 3 Levees (DNRM, 2014) notes that the risks associated with levee failure and overtopping are to be identified and incorporated into disaster management planning. The Guidelines do not however require that a formal Failure Impact Assessment (FIA) be undertaken. This FAR is therefore not presented as a conventional FIA, which is traditionally prepared for referable water dams.

- There has been no formal assessment undertaken for Population at Risk (PAR), as would be the case for a referable dam FIA.
  - It is noted however that the levee breach mapping shown in Volume 2 of this report identifies the inundation areas at risk from each of the levee breach scenarios.
  - Operation and maintenance activities to reduce the risk of levee failure are identified in the SRFL Operations and Maintenance Manual (AECOM, 2019).
  - Emergency response activities are identified in the SRFL Emergency Response Plan (AECOM, 2019).
- Only external hydraulic processes are covered in this report. The following are not addressed:
  - Internal hydraulic processes such as seepage, wave induced pore pressure and consolidated induced pore pressure are not discussed. They are the subjects of a separate Geotechnical Report (AECOM, 2019).
  - The local drainage network and effects of interior catchment flooding. These are addressed in a separate Interior Drainage Assessment Report (AECOM, 2019).
- Breach simulations have been completed assuming no remedial action is taken following the breach (i.e. no attempt to repair or block the breach and no attempt to pump out floodwaters from behind the leveed area during the event).
- Breach development times are assumed from other literature. No specific determination has been undertaken for this project.
- Any discussion on timings is related specifically to the design hydrograph adopted for the SRFL project. Actual results may vary depending on the catchment response to the spatial variability and temporal pattern of actual rainfall events.
- Several scenarios have been modelled, which do not reflect every possible breach location or combination.

1.7 Reference Documents

The following are reference documents to this report:

- SRFL Failure Analysis Report – Volume 2 (AECOM, 2019).
- SRFL Hydraulic Assessment Report – Volume 1 and 2 (AECOM, 2019).
- SRFL Internal Drainage Assessment Report (AECOM, 2019).
- SRFL Operations and Maintenance Manual (AECOM, 2019).
- SRFL Emergency Response Plan (AECOM, 2019).
- The International Levee Handbook (CIRIA, 2013).

1.8 Report Structure

This report is structured as follows:

- Section 2.0 provides background information and levee breach discussion.
- Section 3.0 summarises the SRFL configuration.
- Section 4.0 details the failure analysis and levee breach scenarios.
- Section 5.0 discusses levee breach analysis results.
- Section 6.0 provides recommendations of the analysis.
- Section 7.0 shows the references used in the analysis.

2.0 Background Information

2.1 SRFL General Information

A summary of the SRFL general information is provided in Table 3.

Table 3 SRFL General Information Summary

Name	South Rockhampton Flood Levee
Watercourse	Fitzroy River
Owner & Contact Details	Rockhampton Regional Council 232 Bolsover Street Rockhampton QLD 4700 PO Box 1860 Rockhampton QLD 4700 Phone: 1300 22 55 77 or (07) 4932 9000 Fax: 1300 22 55 79 or (07) 4936 8862 Email enquiries: enquiries@rrc.qld.gov.au

2.2 Levee Failure

The International Levee Handbook (CIRIA, 2013) defines a failure as '*the inability to achieve a defined performance threshold or performance indicator, for a given function*'. In simple terms a failure occurs when the levee can no longer achieve a defined level of performance. Levee failure modes can be broken into two categories; hydraulic failure and structural failure.

Hydraulic failure occurs when the area protected by the levee experiences water ingress, at a level lower than the planned protection level.

- Hydraulic failure of the levee can induce structural failure of the levee.
- Hydraulic failure may occur as the result of:
  - An error in design and/or construction.
  - Environmental changes; such as river bed level changes or settlement of the levee.
  - Operational failure; such as a flood gate being left open.
  - Poor maintenance of critical levee infrastructure; such as flood gates and pumps.
  - A structural failure.

Structural failure occurs when the levee is breached as a result of damage or defect.

- Structural failure of the levee can induce hydraulic failure of the levee.
- Structural failure may occur as a result of:
  - An error in design and/or construction.
  - Deterioration or damage caused by erosion or instability.
  - Poor maintenance.
  - A hydraulic failure.

2.2.1 Failure Mechanisms Considered

Due to the vast array of possible hydraulic failure scenarios, only a range of structural failure scenarios will be assessed in this FAR. It is considered that structural failure is more likely than a hydraulic failure, if adequate design, construction management, maintenance and operational procedures are implemented by the levee owner.

Structural failure is also likely to represent a 'worst case' scenario, as hydraulic failure may only render a portion of the levee inoperable whereas structural failure may involve the entire levee height at the breach site.

2.3 Levee Breach

The International Levee Handbook (CIRIA, 2013) defines a breach as '*a catastrophic collapse that results in significant loss of crest or the creation of a significant hole through the levee, causing a substantial loss of water*'.

It is noted that levee breach is not always considered a failure; there are examples whereby levee breach may be a deliberate design feature. One such example exists on the Mississippi River where portions of the levee are intended to breach at a designated location, to divert flood waters to floodways and away from the main river channel, thereby relieving pressure on the main channel.

2.3.1 Uncertainty

There can be a large degree of uncertainty associated with levee breach prediction, due to:

- the variabilities that exist in natural soils and constructed embankment materials.
- the complex nature of the breach processes, which involves interaction between hydraulic behaviour, soil characteristics (both natural and engineered embankments) and structural integrity (erosion and stability).
- the fact that any single levee breach scenario represents only one of a wider range of possibilities.

Differing breach prediction methods carry with them varying degrees of uncertainty. Understanding the level of acceptable uncertainty for a specific project is important in determining the appropriate breach prediction method. More complex methods are likely to be required where a greater degree of certainty is required, whereas a simpler method may be appropriate where a large degree of uncertainty is acceptable. Where a higher degree of certainty is required, sensitivity analysis should be undertaken to assist in more clearly understanding the uncertainty involved.

The most appropriate method for predicting levee breach is directly related to the requirements of the end user. These requirements may relate to:

- **High level flood risk assessment** – likely to be focussed on identifying areas of high flood risk across an inundation area, rather than identifying breach locations and specific details. In this case the estimation of the flood volumes and hydrograph are of more importance.
- **Local development flood risk assessment** – again identification of flood extents and high risk areas is of more importance than specific levee breach details. Reduction in flood volume and hydrograph uncertainty may be of even more importance for a local development flood risk assessment than a high level flood risk assessment.
- **Emergency planning** – specific flood details, such as lead in timing, flood duration and predicted peak levels are of high importance for emergency planning. Reduction of levee breach uncertainty becomes more important, as this is directly related to warning times and identification of potential evacuation areas.
- **Emergency event management, including evacuation and recovery** – specific flood details become even more important during emergency event management. Identification of areas requiring evacuation, as well as evacuation routes is imperative. In relation to repair and recovery, identification of breach locations and dimensions will be required.

2.3.2 Breaching Processes

The levee breaching process can be defined across three distinct stages:

1. **Breach initiation** – process by which surface erosion commences due to a failure of surface protection measures. In addition, seepage will increase within the levee as internal erosion increases. Outflow from the levee, while remaining relatively small, will increase as erosion increases. The breach initiation process can last from hours to months depending on the hydraulic load conditions imposed on the levee.
2. **Breach formation** – transition to the formation stage of the levee breaching process occurs when the levees hydraulic control is affected by the erosion. The formation process will often result in a catastrophic breach of the levee, as erosion and flow increase rapidly.
3. **Breach widening** – following the breach formation stage, during which the levee may have been eroded to its base resulting in increased flow through the levee, the breach widening stage will commence. During the breach widening stage, erosion will increase at the sides of the breach effectively increasing the width of the breach. This process will continue until such time as the flow through the levee is insufficient to erode any further material. This typically occurs due to either subsidence of flood waters or drowning of the levee.

2.3.3 Breach Growth and Inundation Hydrograph

The erosion characteristics of the levee material and the hydraulic loading stage duration relationship are directly related to the shape of the hydrograph of water flowing through the levee breach:

- A **low peak discharge** hydrograph will result, where the levee crest reduction (due to erosion) is closely related to the drop in upstream water levels. The breach discharge hydrograph will be relatively flat, with a long duration.
- A **high peak discharge** hydrograph will result, when upstream water levels are not immediately affected by discharge through the levee. This can be associated with a rapid increase in breach width due to a rapid increase in discharge.

Even though the total flood volume may not change, minimisation of the speed and peak of the discharge hydrograph may be possible if the soil erodibility and/or load conditions can be controlled. This may reduce the risk of damage and loss of life.

As noted above, breach widening will slow or even cease once the breach has become drowned by rising downstream flood waters. When the water level behind the levee is high enough flood waters will flow through the breach more slowly, thereby slowing and eventually ending continued levee erosion. The International Levee Handbook suggests breach drowning occurs when '*downstream levels raise above two-thirds the depth of the upstream level relative to the breach invert level*'.

2.3.4 Breach Timing

The timing of the flood event peak in relation to the levee breach initiation is significant. It is important to model a range of scenarios, in order to establish a worst case scenario for the proposed levee. The worst case scenario may result in higher flood levels than the actual flood event peak, had the levee not been present and breached. This is due to the higher flow velocities through the constricted levee breach and the sudden inundation of the area behind the levee. The differential height between the flood waters on the upstream and downstream sides of the levee, will result in rapid inundation of the area behind the levee, rather than a gradual increase in water surface elevations had the levee not been constructed.

The 2014 SRFL Failure Analysis assessed the following breach timing scenarios:

- the levee breach occurs early in the flood event, allowing for flood waters to build over time; or
- the levee breach coincides with the peak of the flood event.

Review of the 2014 failure analysis results showed that a levee breach that coincides with the peak of the flood event produced the highest increase in Peak Depth Averaged Velocity and Peak Hazard.

For this reason, only levee breach scenarios that coincide with the peak of the flood event were assessed in this 2019 FAR.

2.3.5 Breach Location

While it is possible for a levee breach to occur at any location along the levee route, the following may increase the likelihood of a breach occurring:

- **Low points** in the levee crest level will accentuate surface erosion due to concentrated overflow.
- **Surface protection quality variations** such as sparse grass cover, damaged or poorly fitting rock protection and areas of more erodible soils.
- **Transitions** provide a focal point for erosion and opportunity for seepage, particularly at structures through or over the levee.
- **Surface protection transitions** also provide a focal point for seepage and erosion.
- **High flow velocities** increase the risk of surface erosion and degradation.

3.0 Levee Configuration

The proposed SRFL includes sections of earth embankment, crib wall, demountable wall, composite wall and spillway. Figure 2 shows the location of the various levee types and Figure 3 to Figure 6 shows typical sections for each.

It is noted that any design details, typical sections, levee configurations and elevations are correct only at the time of preparation of this report and may be subject to change. SRFL design details should be sourced from the SRFL Concept Design Report (AECOM, 2019).

3.1.1 Earth Embankment

The SRFL earth embankment levee is a trapezoidal embankment consisting of a low permeability core encased in a shell material, laid on a prepared subgrade of either sand composition or clay composition. The low permeability core has 1V:2H batter slopes on both the wet side and dry side of the levee. The shell has a 1V:2.5H batter slope on the wet side of the levee and a 1V:3H batter slope on the dry side. The base of the dry side incorporates either a gravel drain or sand drain and collection ditch.

The embankment crest is 4 m wide with a 3% slope towards the dry side of the levee. The spillway crest level is positioned 0.3m above the earth embankment and set to the predicted 1% AEP flood level. A 0.9m high steel sheet pile wall (or equivalent) projects above the crest level, to provide 0.6m of freeboard.

The maximum height of the SRFL earth embankment above existing surface is approximately 5.8m to the top of the sheet pile wall.

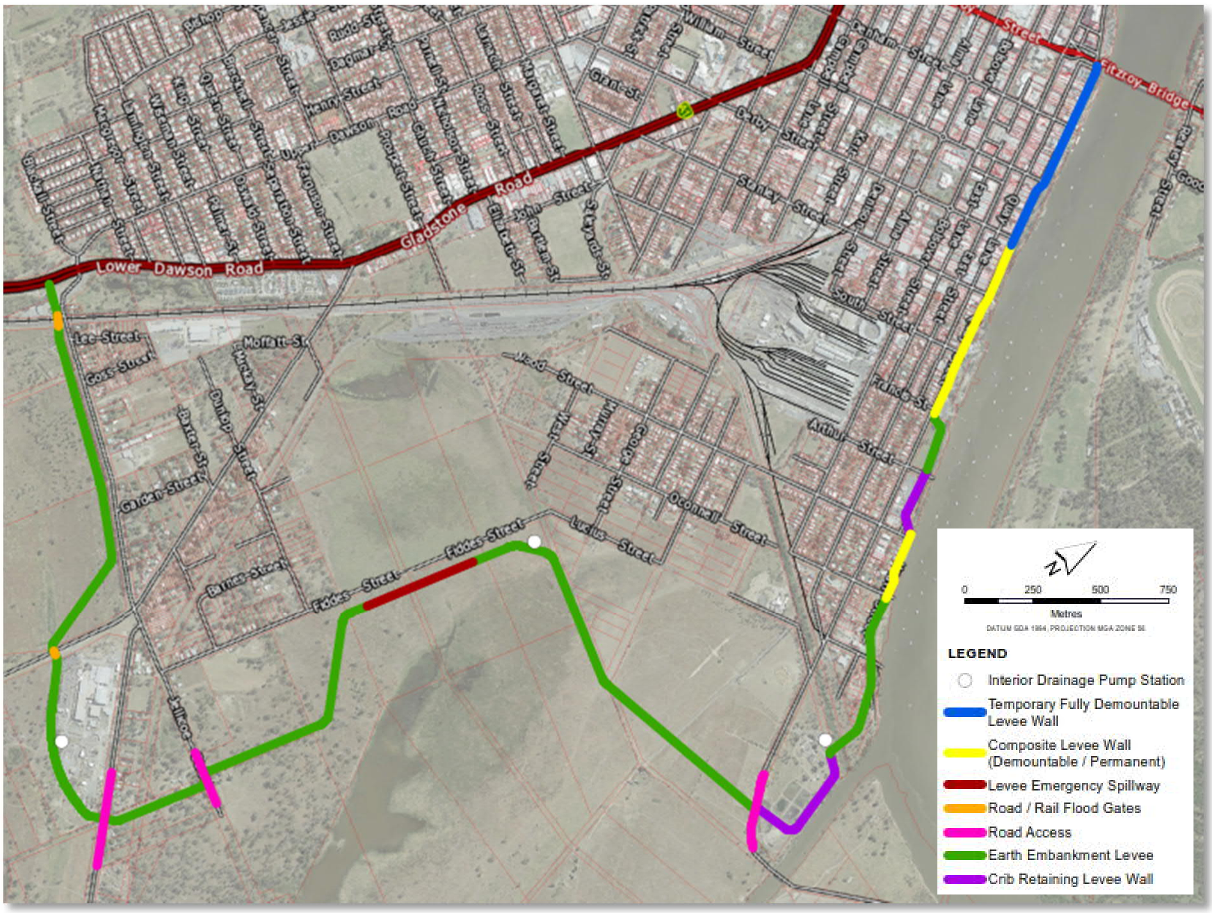
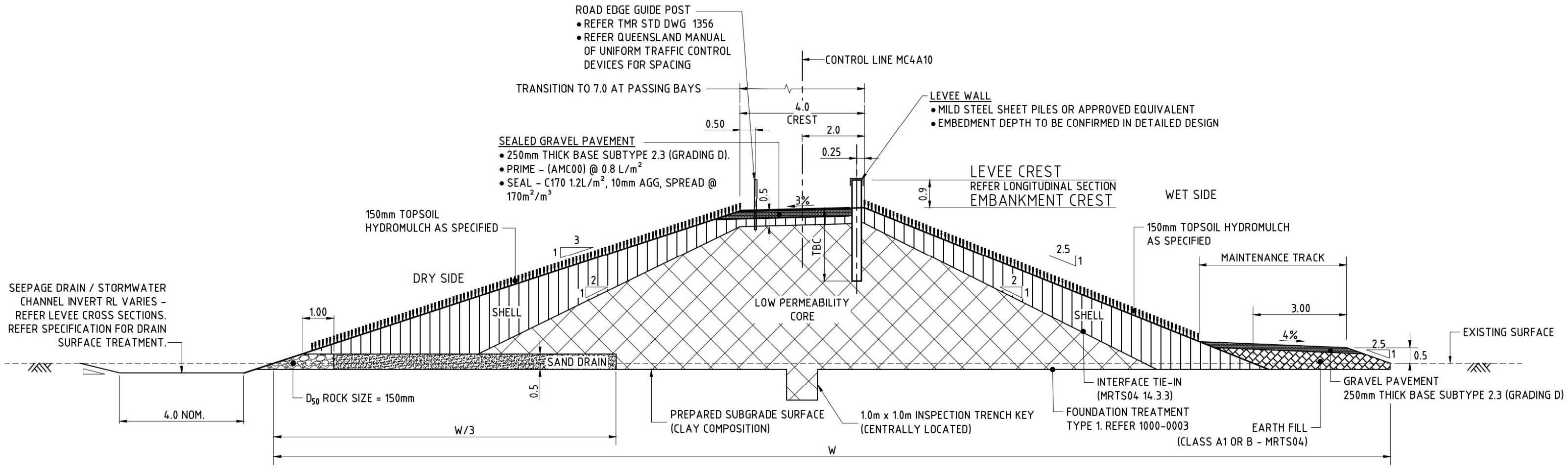


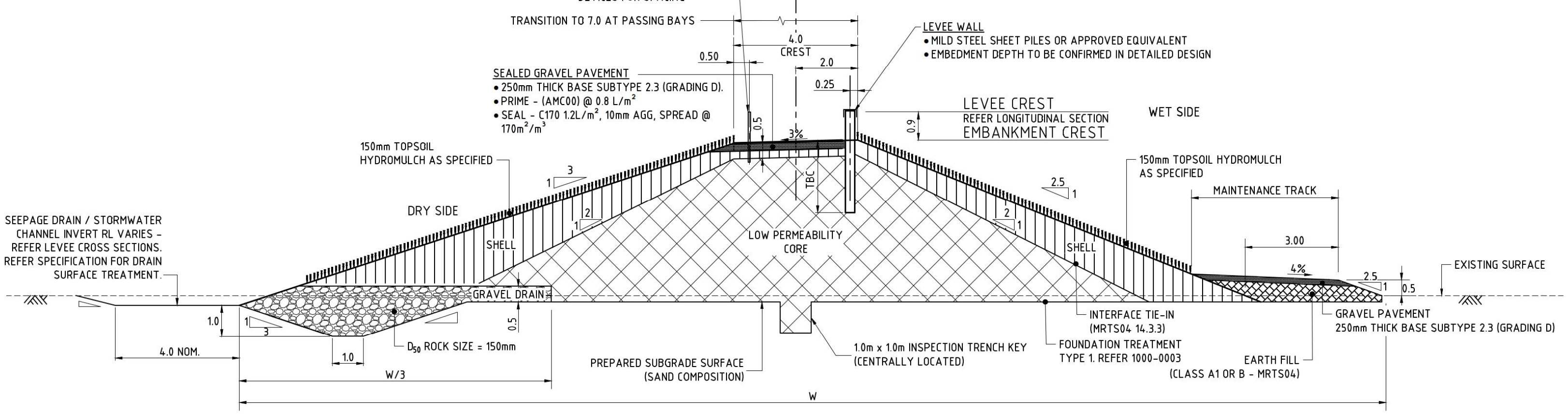
Figure 2 SRFL Overview



TYPE SECTION A1
EMBANKMENT LEVEE

NOTES

- REFER 60589157-SHT-20-0000-C-0003/0004 FOR NOTES
- REFER LONGITUDINAL SECTIONS FOR EXTENT OF TYPE SECTIONS
- SECTIONS ARE DETAILED LOOKING IN DIRECTION OF INCREASING CHAINAGE



TYPE SECTION A2
EMBANKMENT LEVEE

Figure 3 Typical Sections – SRFL Earth Embankment

3.1.2 Crib Wall

The SRFL crib wall consists of a triangular shaped low permeability core retained by a crib retaining wall on the dry side of the levee. The low permeability core is laid on a prepared subgrade and has either 1V:3H or 1V:4H batter slopes. The crest of the crib retaining wall is set to the 1% AEP flood level plus 0.6m of freeboard.

The maximum height of the SRFL crib wall above existing surface is approximately 4.2m.

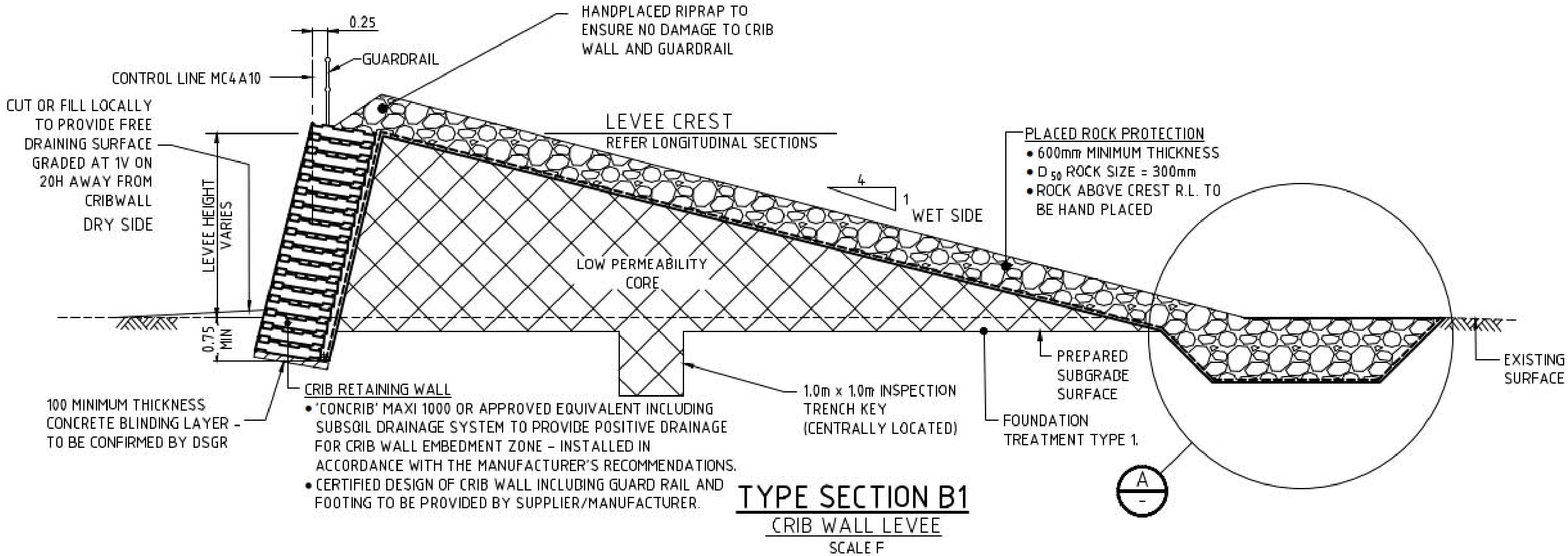


Figure 4 Typical Sections – SRFL Crib Wall

3.1.3 Demountable Wall and Composite Wall

The SRFL demountable wall is a flood control international demountable barrier (or equivalent), to a maximum height of 1.5 m above existing surface (including 0.6 m freeboard).

The SRFL composite wall consist of a permanent concrete wall, of 1.5m maximum height, with a 0.9m flood control international demountable barrier (or equivalent) placed on top of the permanent wall. The top of the demountable barrier (levee crest) is set to the 1% AEP flood level plus 0.6m freeboard. The maximum height of the composite wall above existing surface is 2.4m.

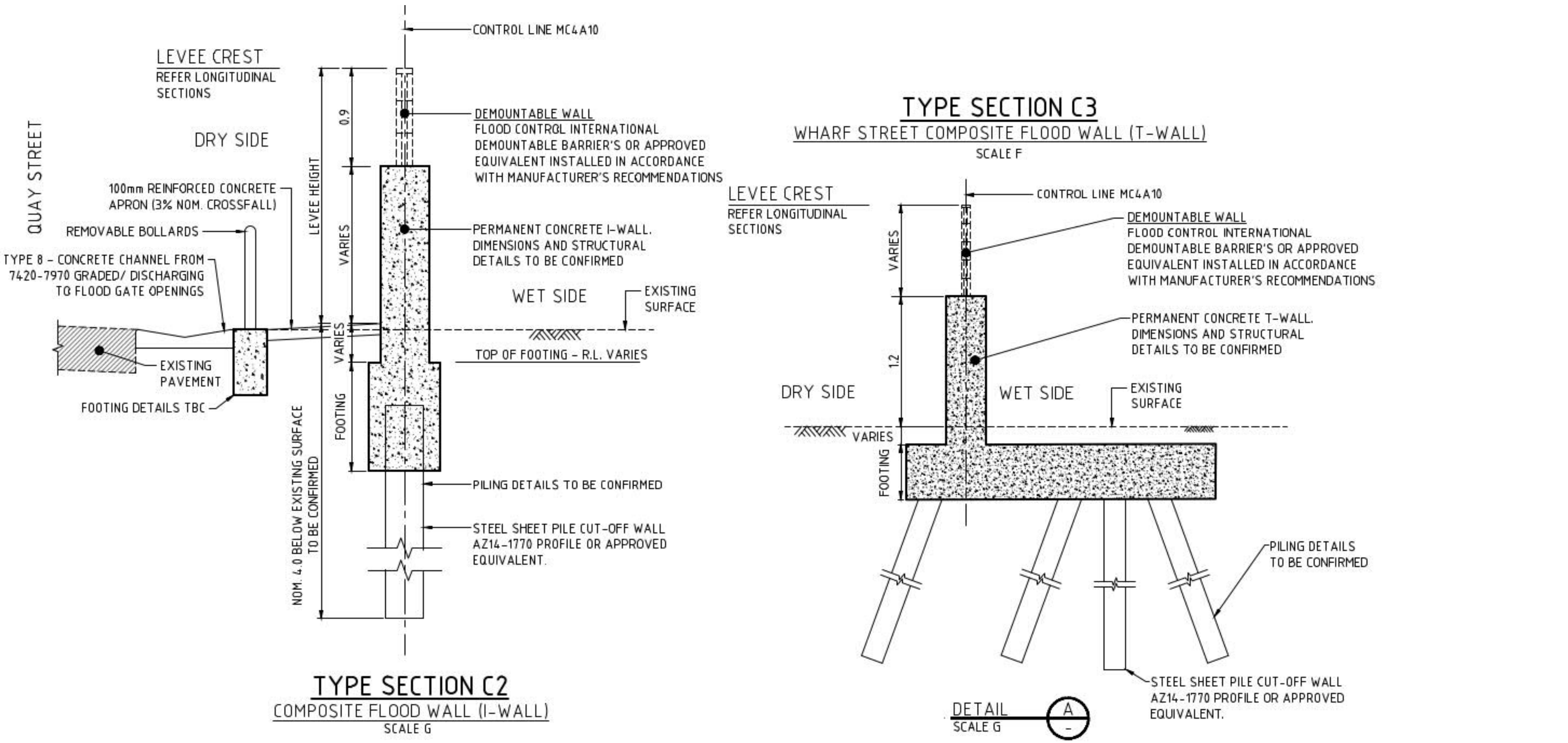


Figure 5 Typical Sections – SRFL Demountable Wall and Composite Wall

3.1.4 Spillway

The SRFL spillway consists of a trapezoidal shaped low permeability core encased in a shell. The low permeability core has 1V:2H batter sloped and is laid on a prepared subgrade of clay composition. The wet side of the spillway has a 1V:2.5H batter slope and is protected by Rip Rap, while the dry side has a 1V:3H batter slope and is protected by Reno Mattress. The dry side of the spillway incorporates a sand drain and collection ditch, which is also protected by Reno Mattress. These details will be subject to final hydraulic design. Further details can be found in the SRFL Concept Design Report (AECOM, 2019).

The crest of the spillway embankment is level, 4 m wide and set 0.3m below the 1% AEP flood level. The reinforced concrete nib wall (**level control**) is set at the 1% AEP flood level. The purpose of the spillway is to allow for controlled flow into the leveed area at a level lower than the levee crest, to facilitate a balance in flood water surface elevations on either side of the levee. The maximum height of the spillway above existing surface is approximately 4.2m.

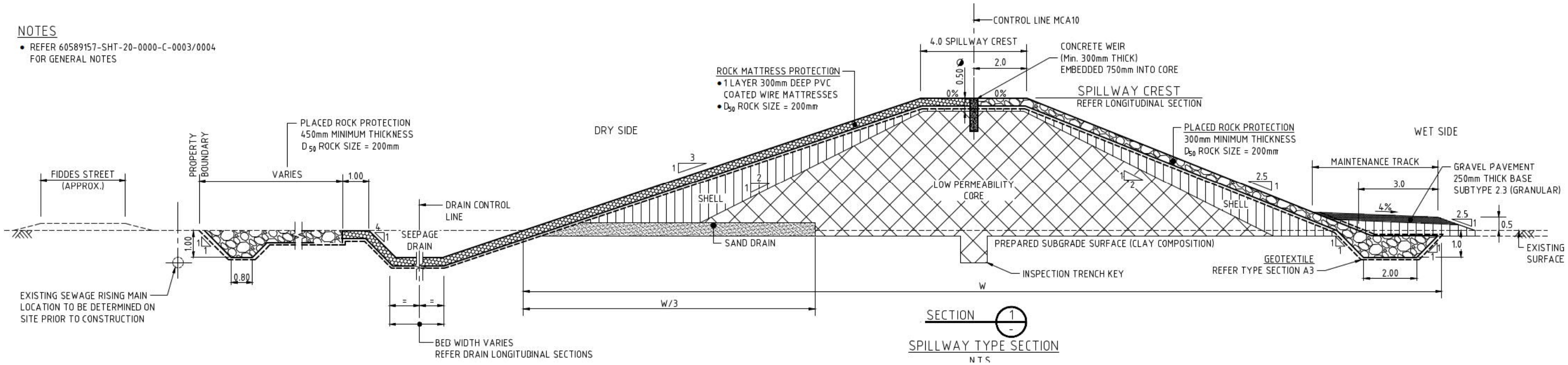


Figure 6 Typical SRFL Spillway Section and Details

Table 4 summarises the flow over the spillway for each flood event, based on model simulation results. This has been checked against the calculated flow using the broad crested weir equation.

As the spillway represents a complex overtopping shape, with a 0.3m high concrete nib wall centrally positioned within a 4 m wide spillway embankment, the discharge has been calculated using a range of weir coefficients for broad crested weirs. An acceptable weir coefficient for this type of structure and its size is 1.4.

Submerged tailwater conditions were also observed at the peak modelled discharge which warrants incorporation of the discharge reduction factor, ψ (Fritz & Hager, 1998), which varies between 0 and 1 based on the upstream and downstream tailwater levels. The adopted values have been included in Table 4.

Table 4 Flow Over Spillway

Flood Event (AEP)	Reduction Factor (ψ)	Modelled Flow Depth (m)	Modelled Discharge (m^3/s)	Calculated Discharge* (m^3/s)	Difference (%)
0.5%	0.54	0.32	38	54	-16 (-30%)
0.2%	0.59	0.74	188	210	-22 (-10%)
0.05%	0.50	1.33	390	429	-39 (9%)
PMF	0.45	3.69	1,591	1,798	-207 (12%)

* Using the Broad Crested Weir Equation.

It can be seen that:

- The modelled discharge for the 0.5% AEP event has large disparity with the calculated discharge, which is likely due to the coarse output interval over the peak discharge period. As such, the actual modelled discharge may be higher.
- The modelled discharge is generally within 10% of the calculated discharge for the 0.2% AEP to the PMF events.

4.0 Failure Analysis

4.1 Methodology

The Department of Natural Resources, Mines ad Energy (DNRME) Guidelines for the Construction or Modification of Category 2 and 3 Levees (DNRME, 2018) identifies levee failure mechanisms and deterioration modes. The current guidelines do not specifically require that a Failure Impact Assessment be completed. In addition, as the SRFL is not a water dam there is no specific requirement to follow the DNRME Guidelines for Failure Impact Assessment of Water Dams (DNRME, 2012).

Guidance on failure analysis, breach identification and breach assessment was therefore obtained from The International Levee Handbook (CIRIA, 2013). The handbook was used to identify high risk sections of the levee where breaches are more likely to occur.

Although not specifically followed, the DNRME guidelines did provide guidance on breach development times, which was used to estimate the breach development time for levee breach scenarios relating to earth embankment erosion and degradation.

4.2 Design Flood Hydrology and Hydraulics

For details of the design flood hydrology and hydraulics, refer to the SRFL Hydraulic Assessment Report (AECOM, 2019).

4.3 Levee Hazard Category

The levee hazard category needs to be defined in order to establish design requirements. The Water Act 2000 provides the following categories:

- Hazard Category 1: levee does not have any off-property impacts.
- Hazard Category 2: levee does have off-property impacts and an affected population of less than 3 people.
- Hazard Category 3: levee does have off-property impacts and an affected population of at least 3 people.

With reference to the SRFL Hydraulic Assessment Report (AECOM, 2019) it is clear that the South Rockhampton Flood Levee will be a Hazard Category 3.

4.4 Levee Breach Scenarios

The SRFL design drawings were reviewed to identify potential locations for levee breach. As noted in Section 2.3.5, low points in the levee, transitions, areas of high velocity and surface protection quality all influence the location of potential levee breaches.

The proposed SRFL design has been graded to ensure no localised low points exist along the levee alignment. The only designated low point is the spillway, which is protected by a concrete nib wall, rock gabions and rock protection. As there are no unprotected low points in the levee, breach scenarios were based on transitions and areas of increased velocity.

The design case model simulations were used to identify areas of increased velocity, in particular those that corresponded with transitions. Figure 7 shows the location of levee breach scenarios selected for analysis.

Figure 7 Levee Breach Scenario Locations

It is noted that the selected levee breach scenarios represent only a small number of the possible levee breach locations and scenarios. Due to model simulation runtime and project timeframe constraints, it is not practical to simulate and analyse all possible levee breach scenarios. Additional scenarios could be undertaken in the future, at the discretion of RRC and the LDMG.

The following levee breach scenarios were selected as a representative cross-section of potential levee breach scenarios:

- **Levee Breach Scenario 1**: assumes the levee embankment between the northern abutment of the Yeppen North bridge and the North Coast Rail Line is completely eroded. Increased flow velocities through the Yeppen Lagoon crossing, could result in erosion commencing at the embankment connection to the western North Coast Line concrete end structure. Due to the large volume of floodwater and extended flood duration, it is assumed that the breach will continue to widen until this section of embankment is completely eroded. It is also noted that this area experiences the highest hydraulic grade along the levee alignment. Figure 8 shows the location of Levee Breach Scenario 1.

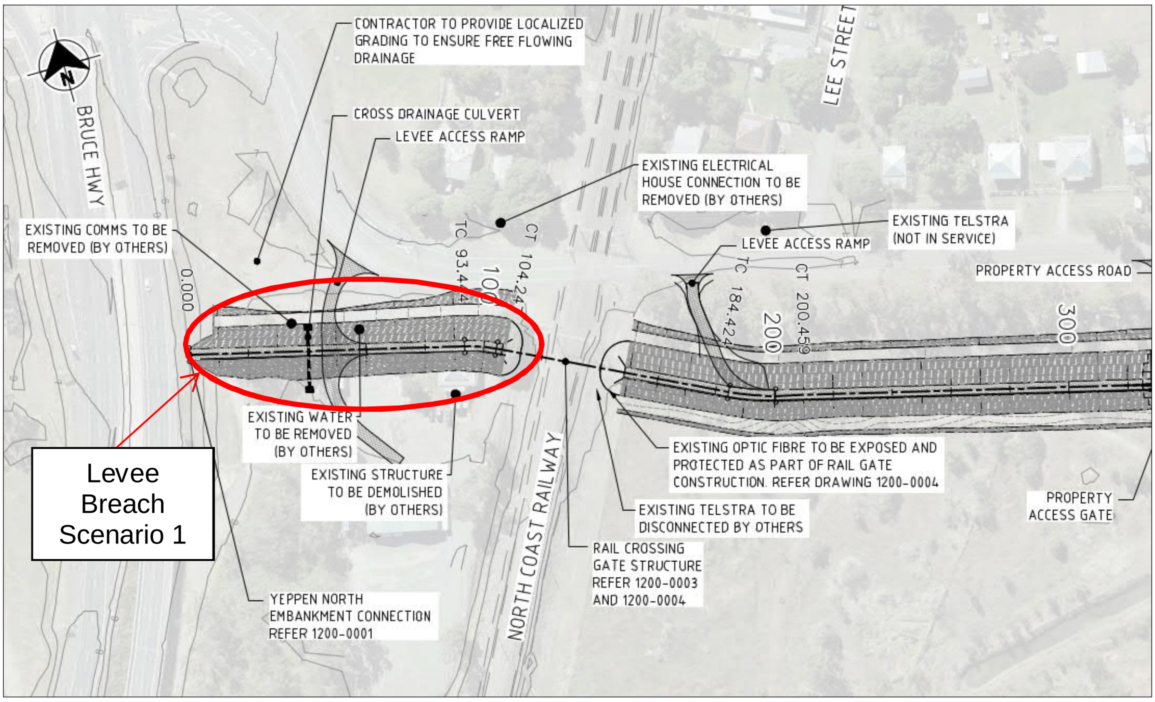


Figure 8 **Levee Breach Scenario 1 Location**

- **Levee Breach Scenario 2**: assumes approximately 100m of embankment is eroded, from approximately CH1300 to the connection with Old Bruce Highway. Increased flow velocities on the southern side of the Hastings levee embankment, coupled with the Old Bruce Highway ramp, could result in erosion commencing on the western side of Old Bruce Highway.
- Hydraulic modelling was used to check the breach width adopted, in which it was noted that the breach becomes drowned by rising downstream flood waters approximately 2 hours after initiation. It is assumed that further breach widening would cease at this point. Figure 9 shows the location of Levee Breach Scenario 2.

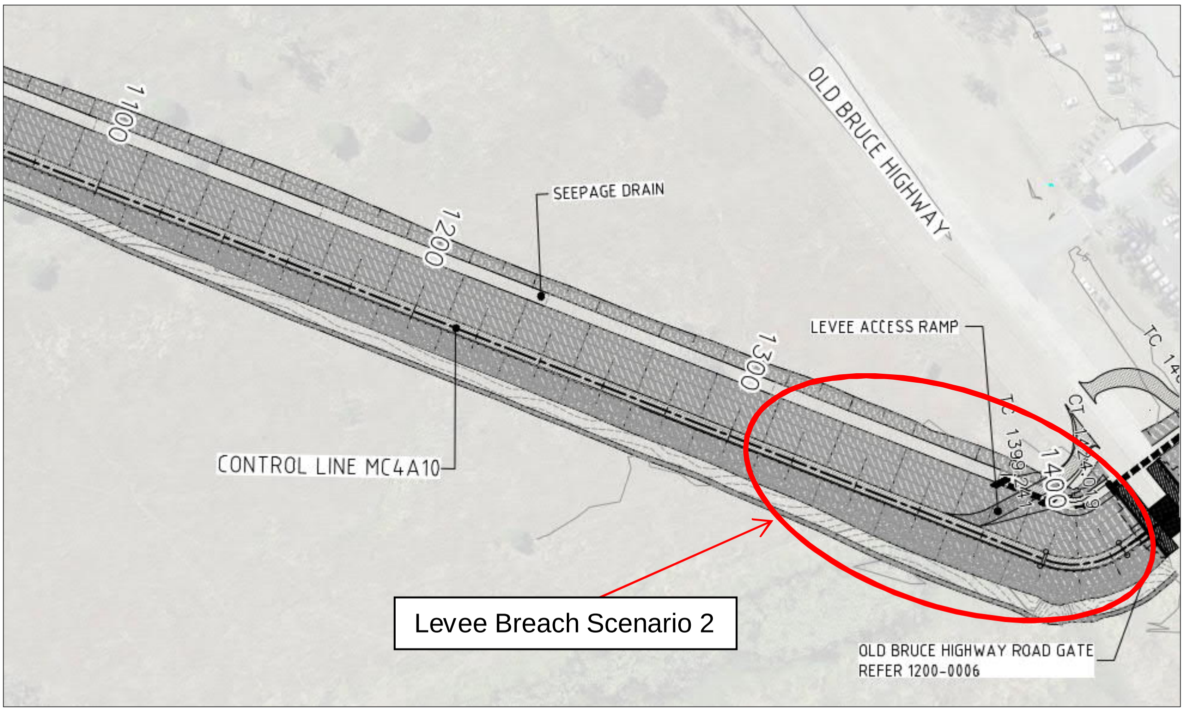


Figure 9 Levee Breach Scenario 2 Location

- **Levee Breach Scenario 3**: assumes a 30m section of composite wall collapses (demountable portion only), at the transition to embankment at the corner of Wharf Street and O'Connell Street. A 30m breach width represents an impact failure (from a boat or floating debris) of two wall columns that collapses the 6m wide section of demountable wall (2 x 3m sections). This then triggers the collapse of an additional four demountable wall section on either side of the initial collapse. Levee Breach Scenario 3 therefore assumes a total of eight sections of demountable wall collapse, resulting in a breach width of 30m.
- As the composite wall is comprised of a permanent concrete wall with a 0.9m high demountable wall on top, it is assumed that only the demountable portion of the wall will collapse. As the TUFLOW model has a 15m grid size, it was assumed that two entire grids will collapse. Figure 10 shows the location of Levee Breach Scenario 3.

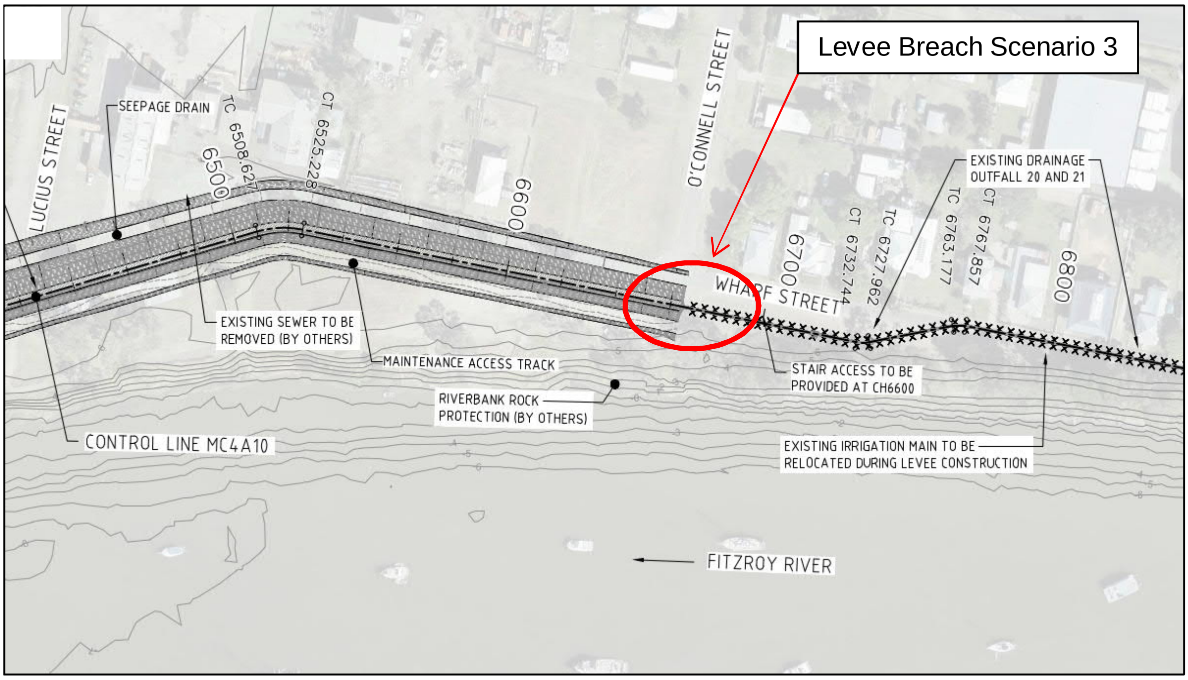


Figure 10 Levee Breach Scenario 3 Location

- **Levee Breach Scenario 4**: assumes a 30m section (refer above) of demountable wall collapses, at the corner of Quay Street and Denham Street. This location was selected as the existing above ground and below ground infrastructure in this area may cause increased localised turbulence / velocity. Figure 11 shows the location of Levee Breach Scenario 4.
  - It is noted that this breach location will not be inundated in the 1% AEP event, however it was felt important to include a scenario within a section of demountable wall fails. This location was deemed the most likely due to the existing infrastructure and will be inundated in the 0.2% AEP event.

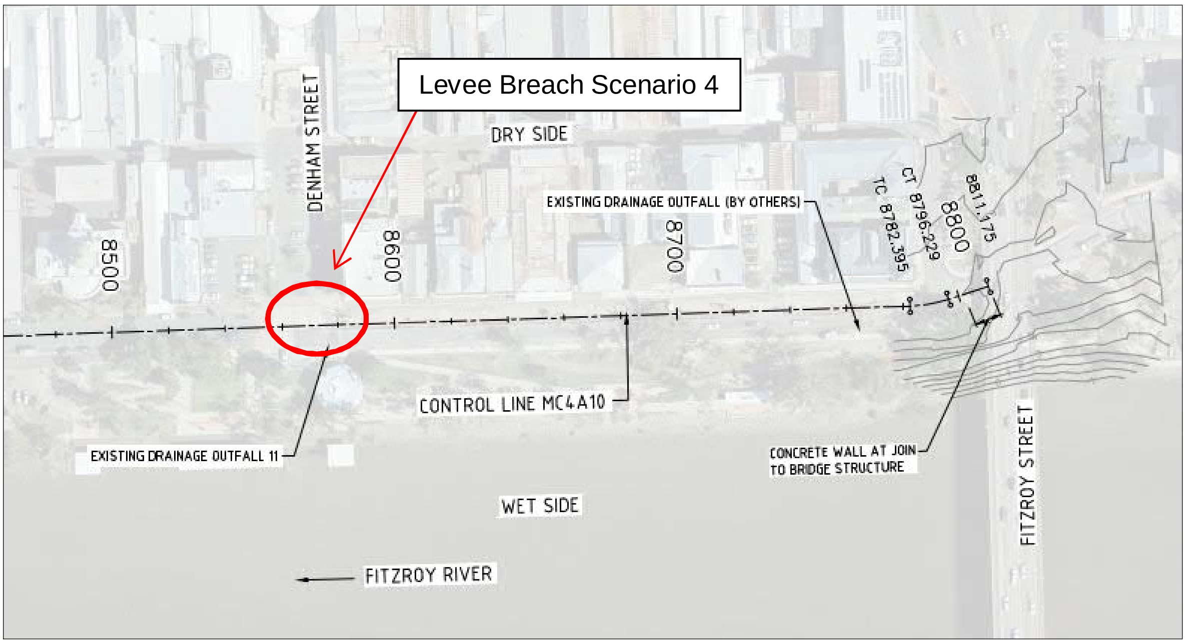


Figure 11 Levee Breach Scenario 4 Location

4.4.1 Flood Event Simulations

Each of the levee breach scenarios was simulated for the 1% AEP and 0.2% AEP flood events. The 1% AEP was selected as it is the defined flood event (DFE). The 0.2% AEP was selected as the peak water surface elevations for the 0.2% AEP event are very close to the finished levee crest level (which includes 0.6m of freeboard), without actually overtopping the levee.

A summary of the levee breach scenario simulations is shown in Table 5.

Table 5 Levee Breach Scenario Simulation Summary

Simulation ID	Scenario No.	Fitzroy River Flood Event	Breach Initiation Timing
B101a	1	1% AEP	Coincide with Flood Peak
B101b	1	0.2% AEP	Coincide with Flood Peak
B102a	2	1% AEP	Coincide with Flood Peak
B102b	2	0.2% AEP	Coincide with Flood Peak
B103a	3	1% AEP	Coincide with Flood Peak
B103b	3	0.2% AEP	Coincide with Flood Peak
B104a	4	1% AEP	Coincide with Flood Peak
B104b	4	0.2% AEP	Coincide with Flood Peak

4.4.2 Breach Scenario Development Time

Figure 13 of the DNRME *Guidelines for Failure Impact Assessment of Water Dams* (November 2018) provides a graphical correlation between the volume of material removed and the breach development time. The volume of material removed for levee breach scenarios 1 and 2 is estimated to be 2,200 m^3, which corresponds to a breach development time of just less than one hour. A breach development time of one hour was therefore adopted for scenarios 1 and 2.

As breach scenarios 3 and 4 represent the impact failure and consequent collapse of ten sections of demountable wall, the breach development time will be short. A value of 6 minutes was adopted for the scenario 3 and 4 breach development time, to incorporate both the initial impact failure and the consequent failure of the adjacent sections of demountable wall.

4.4.3 Breach Scenario Schematisation

The levee breach scenarios were each simulated in the hydraulic model using a variable z-shape (vzsh). Variable z-shapes allow the user to set a final 'z' level for a polygon, the simulation hour at which the z-shape is to initialise and the time it takes for the surface level to be altered from its original level to the finished level.

Table 6 provides a summary of the variable z-shape parameters for each levee breach scenario.

Table 6 Breach Scenario Variable Z-Shape Parameters

Scenario	Finished 'z' Level	Breach Development Time
1	Existing Natural Surface, Prior to Construction of the SRFL	1 Hour
2	Existing Natural Surface, Prior to Construction of the SRFL	1 Hour
3	Top of Permanent Concrete Wall	6 Minutes
4	Existing Natural Surface, Prior to Construction of the SRFL	6 Minutes

4.5 Levee Overtopping

In addition to levee failure, the risks associated with levee overtopping should also be assessed. The SRFL design incorporates a 400m spillway to allow controlled inundation of the leveed area to minimise differential water levels between the dry and wet side of the levee.

As the spillway crest is positioned at the 1% AEP water surface elevation, the hydraulic modelling shows that the levee would provide protection up to the 1% AEP flood event.

- However, it should be noted that the hydraulic modelling provides still water levels and does not account for wave run up and other local factors which could contribute to higher water levels at the spillway. As the 1% AEP water surface elevation is predicted to at the spillway crest, it is possible some overtopping of the spillway would occur during the 1% AEP event. The discharge quantity will vary in time as the unsteady discharge will be a function of wave height, wave period and surge elevation relative to the spillway crest.

In the 0.5% AEP flood event the spillway concentrates, and controls overflow into the large natural basin adjacent to the Fiddes Street (inside the levee).

- Inundation of the interior occurs as a result of the spillway discharge. The analysis showed that it takes approximately 20 hours for flood water levels to balance across the spillway.
- Water surface levels along the southern portion of the levee alignment (chainage 0m to chainage 1,800m) are generally within ± 0.25 m of the levee crest elevations. It is likely that some overtopping of this portion of the levee would occur during the peak of the event due to wave run up and other local factors.

In the 0.2% AEP flood event the spillway concentrates, and controls overflow into the large natural basin adjacent to the Fiddes Street (inside the levee) during the initial phase of the event.

- Overtopping of the levee crest occurs along the southern portion of the alignment between the Yeppen North bridge and Port Curtis Road (chainage 0 m to chainage 2000 m). Differential water surface levels are predicted to be up to 1.0m at the point of overtopping (i.e. external water surface levels are 9.9 m AHD and internal ground surface levels is 8.9 m AHD).
- Minor overtopping of the levee crest later occurs along the northern portion of the levee alignment. Differential water surface levels are predicted to be up to 0.30m at the point of overtopping (i.e. external water surface levels are 9.10mAHD and internal ground surface levels is 8.80mAHD).

For events less frequent than the 0.2% AEP, there is likely to be minimal controlled inundation of the interior area prior to overtopping of the levee crest. This is the result of the increased rate of rise associated with these events. Therefore, the risk of levee failure due to overtopping significantly increases for events less frequent than the 0.2% AEP. It is noted that there is a 18% chance that a 0.2% AEP flood event (or greater) will occur in the 100 year design life of the SRFL.

Further discussion on levee overtopping events is provided in the SRFL Hydraulic Assessment Report – Volume 1 (AECOM, 2019).

5.0 Breach Analysis Results

5.1 Overview

The following report sections discuss the results of each breach scenario simulation. Associated maps have been included in Volume 2 of this report for each breach scenario:

- Peak flood depths and extents.
- Predicted difference in Peak Flood Height, calculated by subtracting the SRFL Baseline Peak Flood Height from the Breach Case Peak Flood Height.
- Predicted difference in peak depth averaged velocities (PDAV), calculated by subtracting the SRFL Baseline PDAV from the Breach Case PDAV.

In creating the difference maps for Peak Flood Height and PDAV, the SRFL Baseline results were subtracted from the Breach Case results to show the net effect of a levee breach as compared to the existing situation. The 1% AEP Developed Case results show the leveed area being completely dry, so a comparison of the Breach Case to the Developed Case would provide no real benefit.

The maps in this Failure Analysis Report (Volume 2) are focussed on the leveed area to show the direct impact of the levee breach scenarios. Maps showing the SRFL Baseline results and Developed Case impacts are included in the Hydraulic Assessment Report – Volume 2 (AECOM, 2019).

It is noted that the Baseline referred to in this Failure Analysis Report includes the Yeppen North and Yeppen South high level bridges and associated earthen embankments. Reference should be made to Maps 1 to 29 of the Hydraulic Assessment Report – Volume 2 (AECOM, 2019) for Baseline mapping.

Full hydraulic model outputs for each scenario have been provided to Council to allow the development of animation files for use by emergency planners and managers.

5.2 Simulation Results Summary

Analysis of the breach scenario results shows:

- For earth embankment breach scenarios, the difference in Peak Flood Height is greater in the 1% AEP simulations than in the 0.2% AEP simulations. This is likely attributed to additional flow over the spillway, from the interior region of the levee to the exterior of the levee, in 0.2% AEP simulations.
    - Flow across the breach and through the leveed area is greater than the backup flow entering the leveed area from the eastern side of the spillway in the 0.2% AEP breach scenarios, resulting in floodwaters flowing west to east across the spillway.
- For earth embankment breach scenarios, the difference in PDAV is generally larger in the 1% AEP breach simulations than in the 0.2% AEP breach simulations. Again, this is likely attributed to increased flow over the spillway (from west to east) in the less frequent event.
    - The exception to the above is the localised increase in velocity at the breach site, which is larger in the 0.2% AEP than in the 1% AEP. The differential height between the Peak Flood Height on the ‘wet side’ of the levee and the ground level on the ‘dry side’ of the levee is greater for the 0.2% AEP events than the 1% AEP events. This results in a velocity increase as flood waters flow through the breach.
- Breach scenarios simulating demountable wall collapse generally result in reduced Peak Flood Height and reduced PDAV when compared to Baseline. This is due to the relatively small breach area assumed (30m) and the direction of external flow being parallel to the levee wall in these locations.

5.3 Levee Breach Scenario 1

5.3.1 Simulation B101a – 1% AEP (Levee Breach Coincides with Fitzroy River Peak)

Peak Flood Height

A substantial increase in Peak Flood Height of up to 0.4m (in the Rosel Park and Fiddes Street detention basin area) is shown on Map FA-5, as a result of flood waters building up behind the leveed area after the breach. The extent of flooding in the 1% AEP event has increased due to the breach the Aurizon Rail Depot and Upper Main Drain areas.

Inundation Timing

As the breach occurs at the peak of the flood, there is a significant difference in level between the upstream flood height and the downstream ground level. When the breach initiates there is a rush of flood waters into the leveed area. Within 2 hours of the breach initiation flood waters have travelled along the North Coast Rail Line and into the Main Drain, filled a majority of the area between Jellicoe Street and Port Curtis Road and inundated low lying areas in Fiddes Street and Lucius Street.

It takes only a further 12 hours to inundate the full flood extent within the leveed area, after which flood waters start to recede as the flood peak passes.

Map FA-1 shows the progressive inundation extents for Simulation B101a.

Peak Depth Averaged Velocity

Map FA-6 shows significant increases in PDAV along the western side of the North Coast Rail Line, along Jellicoe Street, Fiddes Street and Lucius Street, throughout the low areas of Port Curtis and the Main Drain area of Deport Hill. Velocities have increased to more than 2.4m/s along the North Coast Rail Line and more than 2.1m/s north of Port Curtis Road.

5.3.2 Simulation B101b – 0.2% AEP (Levee Breach Coincides with Fitzroy River Peak)

Peak Flood Height

Simulation B101b shows a reduced impact for the 0.2% AEP event levee breach, in comparison to the 1% AEP event with a levee breach coinciding with the flood peak. This is due to increased flow over the spillway from west to east in the 0.2% event in comparison to the 1% AEP event. Map FA-8 shows minimal differences in Peak Flood Height across the majority of the leveed area and a reduction in Peak Flood Height in the Jellicoe Street and Bolsover Street areas.

Inundation Timing

In the 0.2% AEP event, flood waters flow over the spillway from east to west approximately 11 days prior to the flood peak and modelled levee breach, resulting in the leveed area being fully inundated prior to the levee breach initiation. Once the breach has occurred there is a slight increase in Peak Flood Height and flood extent, however this is not significant.

Peak Depth Averaged Velocity

Map FA-9 shows a localised increase in PDAV at the Breach Scenario 1 location, from 1.6m/s in the Baseline to 2.3m/s in the Breach Case. In general, however there is a reduction in PDAV throughout the leveed area.

5.4 Levee Breach Scenario 2

5.4.1 Simulation B102a – 1% AEP (Levee Breach Coincides with Fitzroy River Peak)

Peak Flood Height

Map FA-11 indicates that the impact of Scenario B102a is very similar, if not slightly increased, to that of Scenario B101a. Peak Flood Height have increased by up to 0.51m in the Rosel Park area, as a result of flood waters building up behind the leveed area. A corresponding increase in flood extents occurs at the Aurizon Rail Depot and along the Bruce Highway.

Inundation Timing

Rapid inundation and flood depth increases occur immediately following the breach initiation, as the breach coincides with the flood peak. Significant areas within the levee are inundated within 2 hours of the breach and the entire leveed area is inundated within approximately 10 hours of the breach.

The orientation of Breach Scenario 2 is across the direction of flow through the Yeppen Crossing; whereas Breach Scenario 1 was orientated parallel to flows though the Yeppen area. This is why the leveed area is fully inundated within 10 hours during Simulation B102a, compared to 14 hours for Simulation B101a.

Map FA-2 shows the progressive inundation extents for Simulation B102a.

Peak Depth Averaged Velocity

Significant increases in PDAV can be seen on Map FA-12 in the vicinity of Hastings Deering, Port Curtis Road, Fiddes Street, Lucius Street, Depot Hill, the Main Drain and along the western side of the North Coast Rail Line. Velocities have increased to more than 2.5m/s in some areas.

5.4.2 Simulation B102b – 0.2% AEP (Levee Breach Coincides with Fitzroy River Peak)

Peak Flood Height

Map FA-14 confirms that levee breach simulations for the 0.2% AEP events result in a smaller impact than simulations for the 1% AEP event. In each case this is due to additional flow over the spillway from west to east in the less frequent event.

Inundation Timing

As was the case for Simulation B101b, the results of Simulation B102b show that flow over the spillway in the 0.2% AEP from east to west precedes the modelled levee breach by approximately 11 days. The leveed area is therefore fully inundated prior to the levee breach occurring. Once the breach has commenced there is a slight increase in Peak Flood Height and flood extent, however this is not significant.

Peak Depth Averaged Velocity

Map FA-15 also confirms that the 0.2% AEP event generally result in reduced PDAV throughout the leveed area, with a localised increase in PDAV at the breach site and along Fiddes Street.

5.5 Levee Breach Scenario 3

5.5.1 Simulation B103a – 1% AEP (Levee Breach Coincides with Fitzroy River Peak)

Peak Flood Height and PDAV

Map FA-17 and Map FA-18 show the minor inundation area for Breach Simulation B103a, with a net reduction in Peak Flood Height and PDAV across the leveed area. There remains a slight area of 'Was Wet Now Dry' within the leveed area north of the Aurizon Rail Yard.

5.5.2 Simulation B103b – 0.2% AEP (Levee Breach Coincides with Fitzroy River Peak)

Peak Flood Height and PDAV

There is a reduction in Peak Flood Height and PDAV across the leveed area, around the Jellicoe Street and Hastings Deerings area, shown in Map FA-20 and Map FA-21, for the 0.2% AEP event levee breach Scenario 3.

Inundation Timing

The leveed area is fully inundated by flows across the spillway, from east to west, prior to the Breach Scenario 3 initiation. As was discussed for Simulation B101b and Simulation B102b; this results in only a very small increase in Peak Flood Height within the leveed area following the breach.

5.6 Levee Breach Scenario 4

5.6.1 Simulation B104a – 1% AEP (Levee Breach Coincides with Fitzroy River Peak)

Peak Flood Height and PDAV

Map FA-23 and Map FA-24 confirms that no flood waters pass through the breach during Simulation B104a during the 1% AEP event. The leveed area is shown as dry during the event.

5.6.2 Simulation B104b – 0.2% AEP (Levee Breach Coincides with Fitzroy River Peak)

Peak Flood Height and PDAV

As was the case for Simulation B103b, the relatively small flow through Breach Scenario 4 in the 0.2% AEP event shows a net decrease in Peak Flood Height and PDAV in comparison to the Baseline, as demonstrated on Map FA-26 and Map FA-27.

Inundation Timing

The leveed area is fully inundated by flow across the spillway from east to west prior to the flood peak, resulting in the breach having little effect once initiated at the peak.

5.7 Discussion

There are a number a elements that contribute to a 'worst case' levee breach scenario, including

- increase in Peak Flood Height.
- increase in PDAV.
- the timing associated with inundation and the arrival of Peak Flood Height and PDAV.

Modelling undertaken in 2014 has shown that the worst case increase in Peak Flood Height occurs during earth embankment breaches along the southern portion of the levee which breach early in the flood event, allowing flood waters to build up within the leveed area over time.

In contrast, the worst case increase in PDAV has been shown to occur when levee breaching coincides with the flood peak, resulting in rapid inundation of the leveed area. Breach scenarios that coincide with the flood peak also result in the shortest lead in time for inundation and arrival of flood peaks.

Of the scenarios modelled, **Breach Scenario 2 – 1% AEP event coinciding with the flood peak** shows the shortest lead time; just 10 hours to inundate the leveed area. This simulation also shows a significant increase in Peak Flood Height and PDAV across the leveed area. From an emergency evacuation perspective, this would represent a worst case scenario of those modelled in the analysis.

The width of the breach is likely to have a direct effect on inundation timing, PDAV and to a lesser extent Peak Flood Height. Although breach scenarios were modelled under the assumption that no remedial works would be completed to repair or reduce the breach width, it is likely in reality that some remedial works would be attempted. It may therefore be the case that the results shown in this report are conservative and actual events may differ.

6.0 Recommendations

It is recommended that:

- RRC and the LDMG review the breach scenario outputs and incorporate the findings into their emergency action plans. In particular, key findings should be included in the final SRFL Emergency Response Plan (AECOM, 2019).
- RRC and the LDMG undertake an assessment of potential evacuation routes, with reference to possible breach scenarios and lead in timing. This should be included in the final SRFL Emergency Response Plan (AECOM, 2019).
- An assessment of a wider range of breach scenarios is undertaken, during Detail Design. This will be subject to any LDMG requirements.
  - This could be focussed on the earth embankment between the Yeppen North Bridge (approximately CH0) and Hastings Deering (approximately CH1800).
  - This should include a range of breach widths, as the extent of breaching is likely to have a significant effect on the impact of the breach.
  - Assessment of crib wall failure – specifically near the South Rockhampton Sewage Treatment Plant.
- An assessment of a wider range of design events is undertaken, during Detail Design. This could potentially include the 2% AEP event and 0.5% AEP event.
- The SRFL Operations and Maintenance Manual (O&M Manual) should detail maintenance activities which reduce the likelihood of levee failure. In addition, the O&M Manual should identify routine inspections whereby signs of potential levee failure can be identified and mitigation measures can be implemented.

7.0 References

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South Rockhampton Flood Levee Project
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South Rockhampton Flood Levee

Failure Analysis Report (Volume 2) - 2019 Update

South Rockhampton Flood Levee

Failure Analysis Report (Volume 2) - 2019 Update

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Explanatory Notes and Disclaimer

These maps are to be read in conjunction with the Failure Analysis Report – Volume 1 (AECOM, 2019). Assessment methodology and assumptions are outlined in this report.

This mapping has been developed to represent Fitzroy River flood behaviour from Pink Lily to Port Curtis. It is noted that flooding occurs upstream and downstream of these locations which are outside the extent of the two-dimensional hydraulic model.

Local catchment flooding has not been considered in preparing these maps. A property may be affected by other sources of flooding such as overland flow from adjoining land, main stream creek flooding or through the surcharge of existing stormwater drainage networks.

Information presented in this mapping may vary, depending upon development within the floodplain over time. It is suggested that the TUFLOW model and these associated maps be updated by Rockhampton Regional Council as development occurs.

The development of the TUFLOW hydraulic model is detailed in the Hydraulic Assessment Report (AECOM, 2019). This report outlines input data, modelling assumptions and schematisation parameters adopted.

All information presented in this mapping is expressed in meters Australian Height Datum (AHD). Note that Rockhampton Gauge Datum = AHD plus 1.448 m.

Hydraulic model results used in this mapping was based on a 15 m fixed Cartesian grid hydraulic model. Use of the mapping to determine hydraulic parameters in sub-grid scale applications is not recommended.

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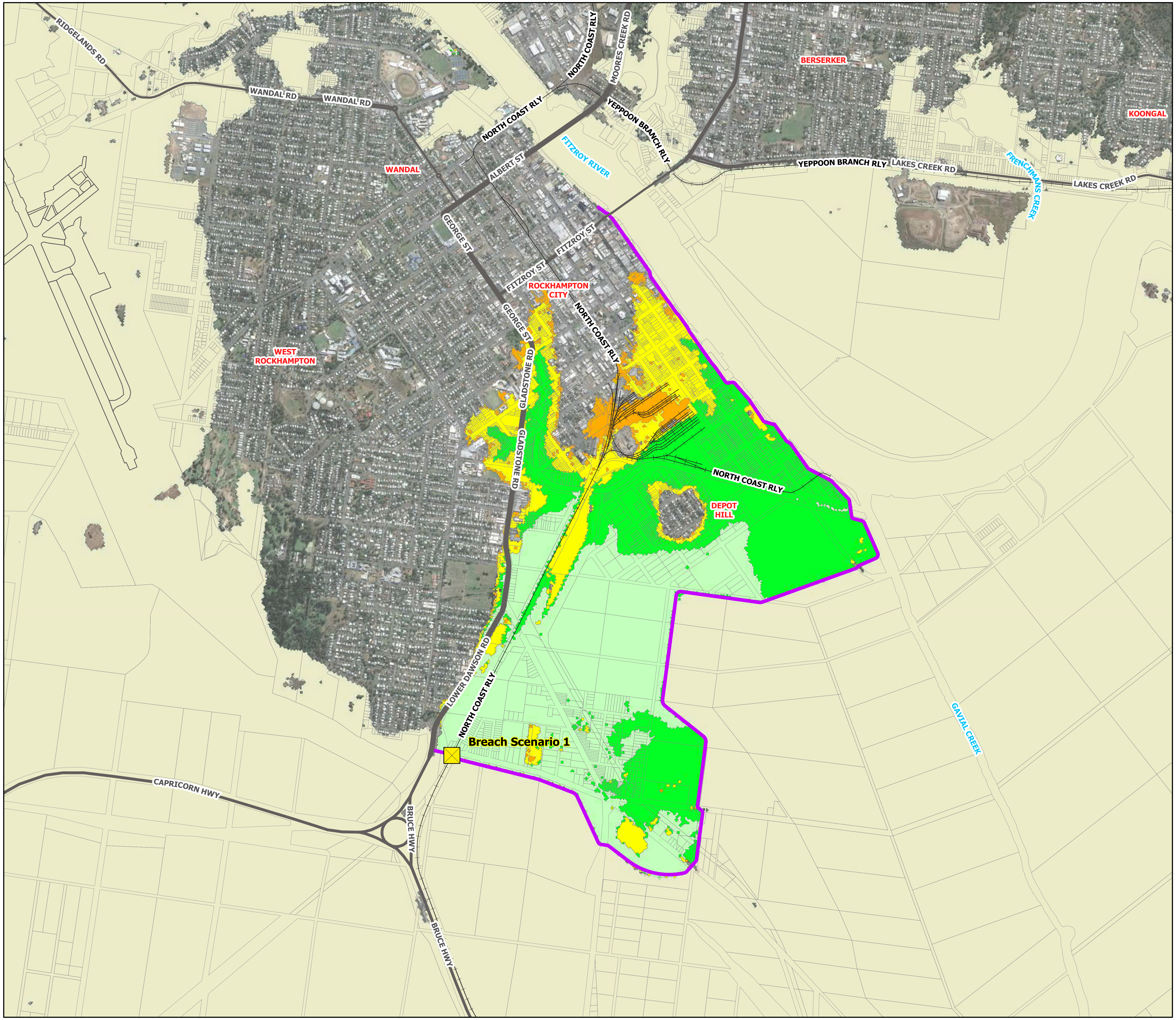
Inundation Area Propagation Mapping

Map Number	Title
FA-1	Inundation Extent Comparison– Levee Breach Scenario 1 (1% AEP – Flood Peak Levee Breach)
FA-2	Inundation Extent Comparison – Levee Breach Scenario 2 (1% AEP – Flood Peak Levee Breach)

Flood Peak Breach Scenario Mapping

Map Number	Title
FA-3	Peak Flood Depth and Extent – Levee Breach Scenario 1 (1% AEP – Flood Peak Levee Breach)
FA-4	Difference in Peak Flood Height – Levee Breach Scenario 1 (1% AEP – Flood Peak Levee Breach)
FA-5	Difference in Peak Depth Averaged Velocity – Levee Breach Scenario 1 (1% AEP – Flood Peak Levee Breach)
FA-6	Peak Flood Depth and Extent – Levee Breach Scenario 1 (0.2% AEP – Flood Peak Levee Breach)
FA-7	Difference in Peak Flood Height – Levee Breach Scenario 1 (0.2% AEP – Flood Peak Levee Breach)
FA-8	Difference in Peak Depth Averaged Velocity – Levee Breach Scenario 1 (0.2% AEP – Flood Peak Levee Breach)
FA-9	Peak Flood Depth and Extent – Levee Breach Scenario 2 (1% AEP – Flood Peak Levee Breach)
FA-10	Difference in Peak Flood Height – Levee Breach Scenario 2 (1% AEP – Flood Peak Levee Breach)
FA-11	Difference in Peak Depth Averaged Velocity – Levee Breach Scenario 2 (1% AEP – Flood Peak Levee Breach)
FA-12	Peak Flood Depth and Extent – Levee Breach Scenario 2 (0.2% AEP – Flood Peak Levee Breach)
FA-13	Difference in Peak Flood Height – Levee Breach Scenario 2 (0.2% AEP – Flood Peak Levee Breach)
FA-14	Difference in Peak Depth Averaged Velocity – Levee Breach Scenario 2 (0.2% AEP – Flood Peak Levee Breach)
FA-15	Peak Flood Depth and Extent – Levee Breach Scenario 3 (1% AEP – Flood Peak Levee Breach)
FA-16	Difference in Peak Flood Height – Levee Breach Scenario 3 (1% AEP – Flood Peak Levee Breach)
FA-17	Difference in Peak Depth Averaged Velocity – Levee Breach Scenario 3 (1% AEP – Flood Peak Levee Breach)
FA-18	Peak Flood Depth and Extent – Levee Breach Scenario 3 (0.2% AEP – Flood Peak Levee Breach)
FA-19	Difference in Peak Flood Height – Levee Breach Scenario 3 (0.2% AEP – Flood Peak Levee Breach)
FA-20	Difference in Peak Depth Averaged Velocity – Levee Breach Scenario 3 (0.2% AEP – Flood Peak Levee Breach)
FA-21	Peak Flood Depth and Extent – Levee Breach Scenario 4 (1% AEP – Flood Peak Levee Breach)
FA-22	Difference in Peak Flood Height – Levee Breach Scenario 4 (1% AEP – Flood Peak Levee Breach)
FA-23	Difference in Peak Depth Averaged Velocity – Levee Breach Scenario 4 (1% AEP – Flood Peak Levee Breach)
FA-24	Peak Flood Depth and Extent – Levee Breach Scenario 4 (0.2% AEP – Flood Peak Levee Breach)
FA-25	Difference in Peak Flood Height – Levee Breach Scenario 4 (0.2% AEP – Flood Peak Levee Breach)

Map Number	Title
FA-26	Difference in Peak Depth Averaged Velocity – Levee Breach Scenario 4 (0.2% AEP – Flood Peak Levee Breach)



LEGEND

- Breach Scenario Location
- Highways
- Main Roads
- Railway Lines
- SRFL Alignment
- Cadastre
- Hydraulic Model Extent

Extent of Flooding

- Prior to Breach
- 0 - 2 hours
- 2 - 6 hours
- 6 - 10 hours
- 10 - 14 hours

Data Sources:

DCDB (c) 2016 QLD Government
Imagery (c) 2016 RRC

SOUTH ROCKHAMPTON FLOOD LEVEE
Failure Analysis Report

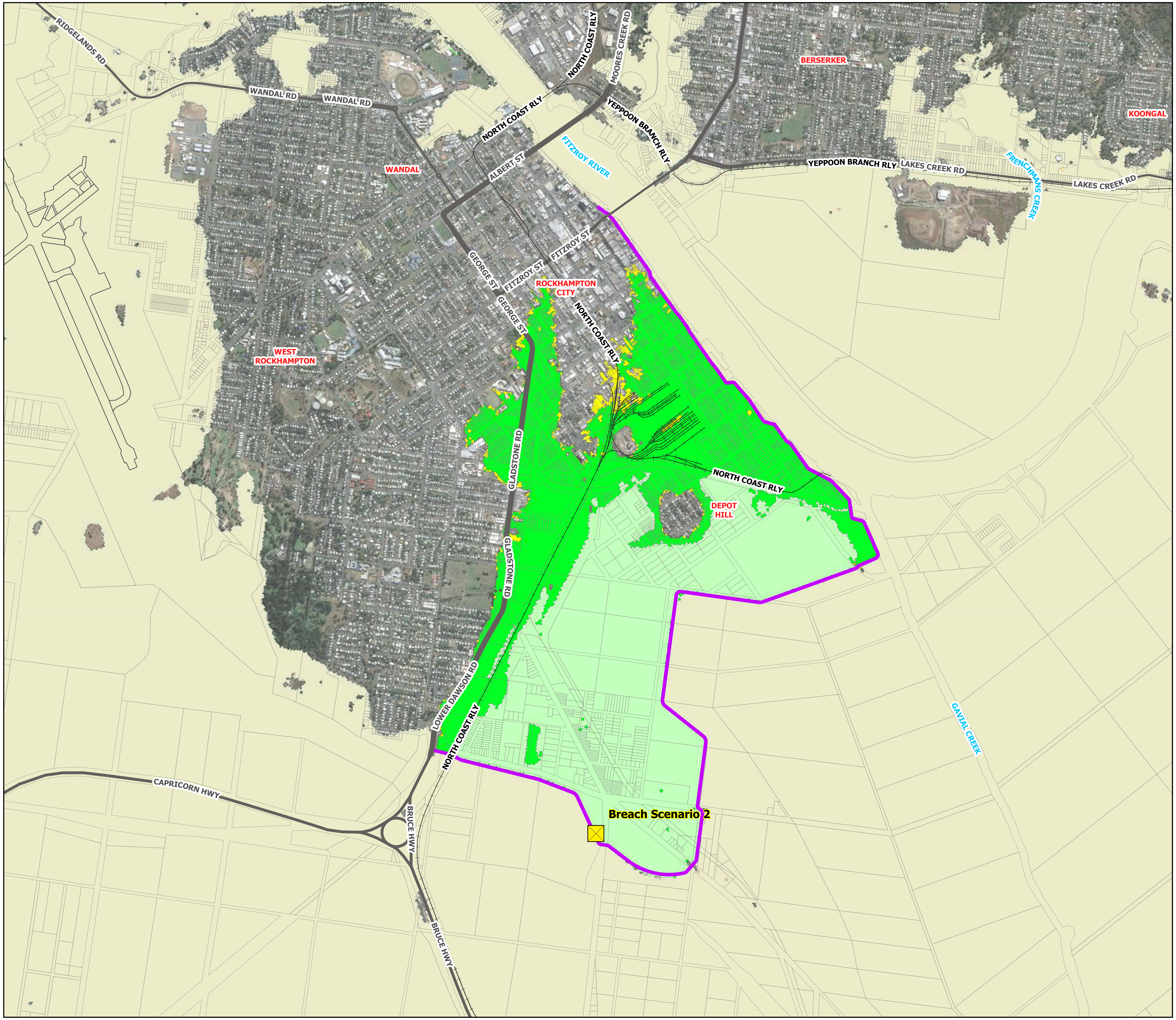
Peak Flood Extent
Levee Breach Scenario 1
1% AEP - Flood Peak Levee Breach

PROJECT ID	60589157
CREATED BY	JensenK2
LAST MODIFIED	03-04-2019
VERSION	01

Map
FA-1

A3

File Path \\aurok1fp001\Projects\605x\60589157\900_CAD_GIS\923_QGIS\Hydraulic Assessment Report



DATUM GDA 1994, PROJECTION MGA ZONE 56

0 0.5 1 Kilometers

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LEGEND

- Breach Scenario Location
- Highways
- Main Roads
- Railway Lines
- SRFL Alignment
- Cadastre
- Hydraulic Model Extent

Extent of Flooding

- Prior to Breach
- 0 - 2 hours
- 2 - 6 hours
- 6 - 10 hours
- 10 - 14 hours

Data Sources:

DCDB (c) 2016 QLD Government
Imagery (c) 2016 RRC

SOUTH ROCKHAMPTON FLOOD LEVEE
Failure Analysis Report

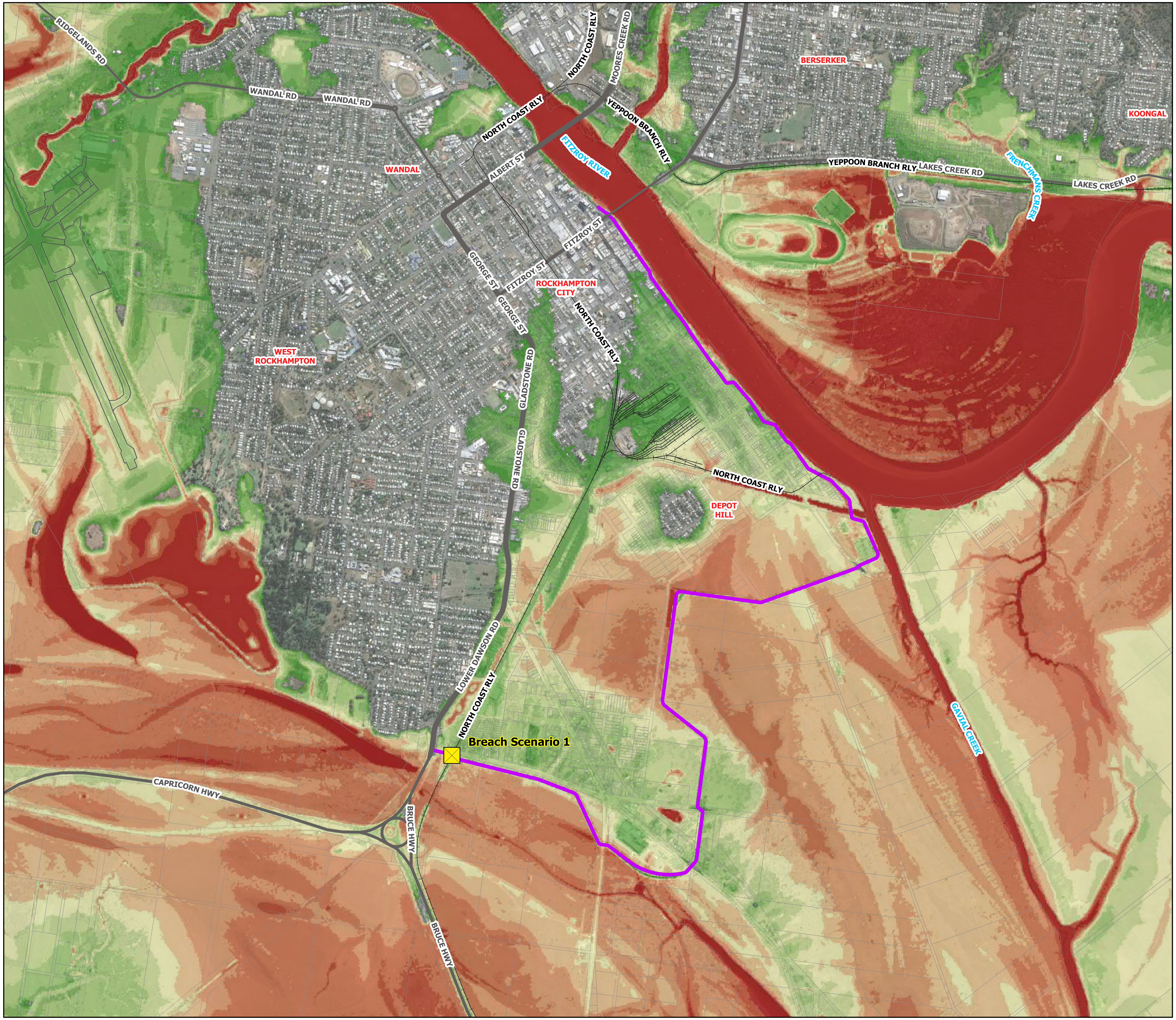
Peak Flood Extent
Levee Breach Scenario 2
1% AEP - Flood Peak Levee Breach

PROJECT ID	60589157
CREATED BY	JensenK2
LAST MODIFIED	03-04-2019
VERSION	01

Map FA-2

File Path \\aurok1fp001\Projects\605x\60589157\900_CAD_GIS\923_QGIS\Hydraulic Assessment Report

A3



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DATUM GDA 1994, PROJECTION MGA ZONE 56

0 0.5 1 Kilometers

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LEGEND

- Breach Scenario Location
- Highways
- Main Roads
- Railway Lines
- SRFL Alignment
- Cadastre
- Hydraulic Model Extent

Peak Flood Depth (m)

- < 0.5
- 0.5 - 1.0
- 1.0 - 1.5
- 1.5 - 2.0
- 2.0 - 2.5
- 2.5 - 3.0
- 3.0 - 3.5
- 3.5 - 4.0
- 4.0 - 4.5
- 4.5 - 5.0
- > 5.0

Data Sources:

DCDB (c) 2016 QLD Government
Imagery (c) 2016 RRC

SOUTH ROCKHAMPTON FLOOD LEVEE
Failure Analysis Report

Peak Flood Depth and Extent
Levee Breach Scenario 1
1% AEP - Flood Peak Levee Breach

PROJECT ID	60589157	Map
CREATED BY	JensenK2	FA-3
LAST MODIFIED	03-04-2019	
VERSION	01	

A3

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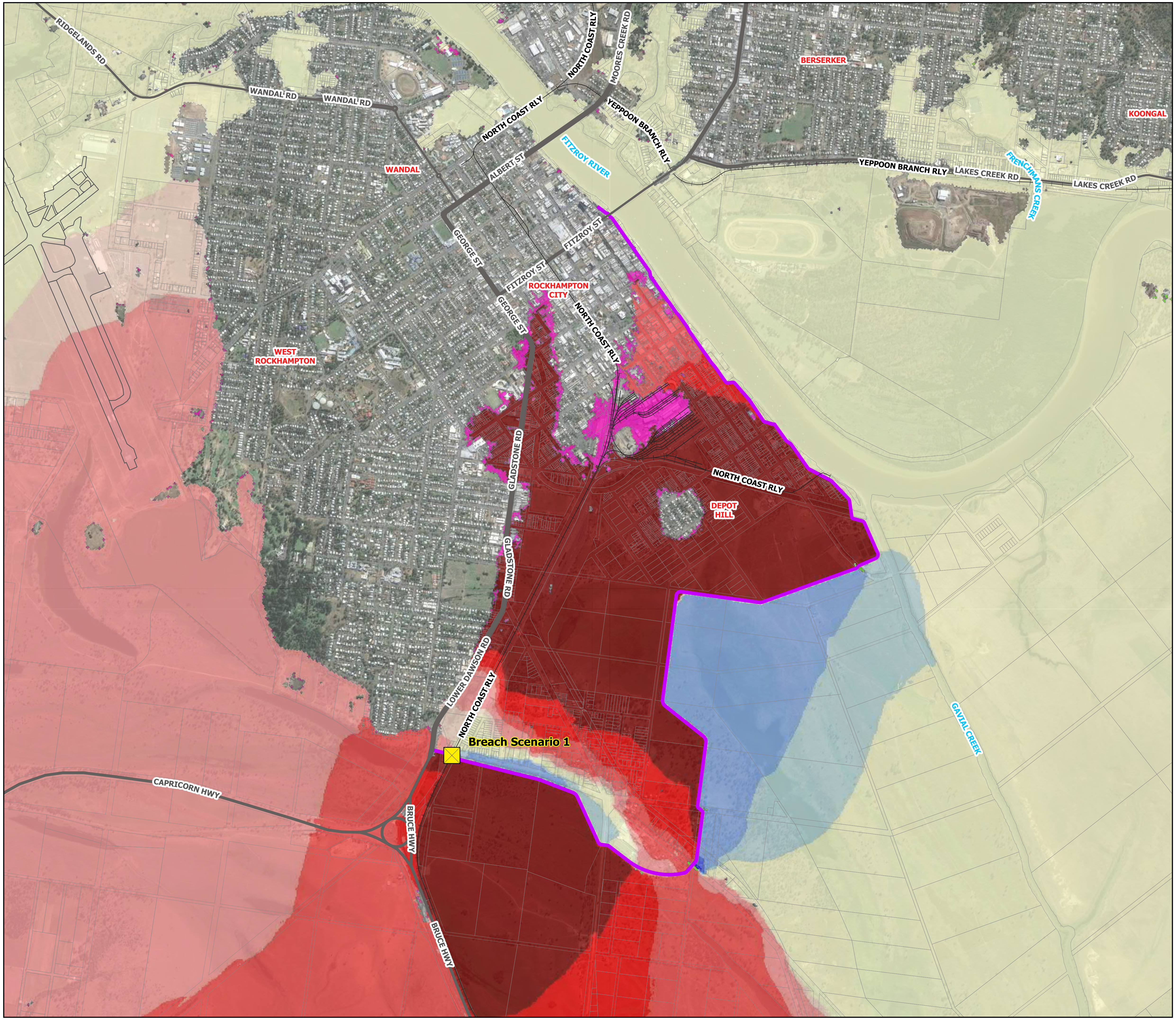

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DATUM GDA 1994, PROJECTION MGA ZONE 56

0 0.5 1 Kilometers

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LEGEND

- Breach Scenario Location
- Highways
- Main Roads
- Railway Lines
- SRFL Alignment
- Cadastre
- Hydraulic Model Extent

Difference in Peak Flood Height (m)

- < -0.3
- -0.3 to -0.225
- -0.225 to -0.15
- -0.15 to -0.075
- -0.075 to -0.05
- -0.05 to 0.05
- 0.05 to 0.075
- 0.075 to 0.15
- 0.15 to 0.225
- 0.225 to 0.3
- > 0.3
- Was Dry Now Wet
- Was Wet Now Dry

Data Sources:

DCDB (c) 2016 QLD Government
Imagery (c) 2016 RRC

SOUTH ROCKHAMPTON FLOOD LEVEE
Failure Analysis Report

Difference in Peak Flood Height
Levee Breach Scenario 1
1% AEP - Flood Peak Levee Breach

PROJECT ID	60589157
CREATED BY	JensenK2
LAST MODIFIED	03-04-2019
VERSION	01

Map
FA-4

A3

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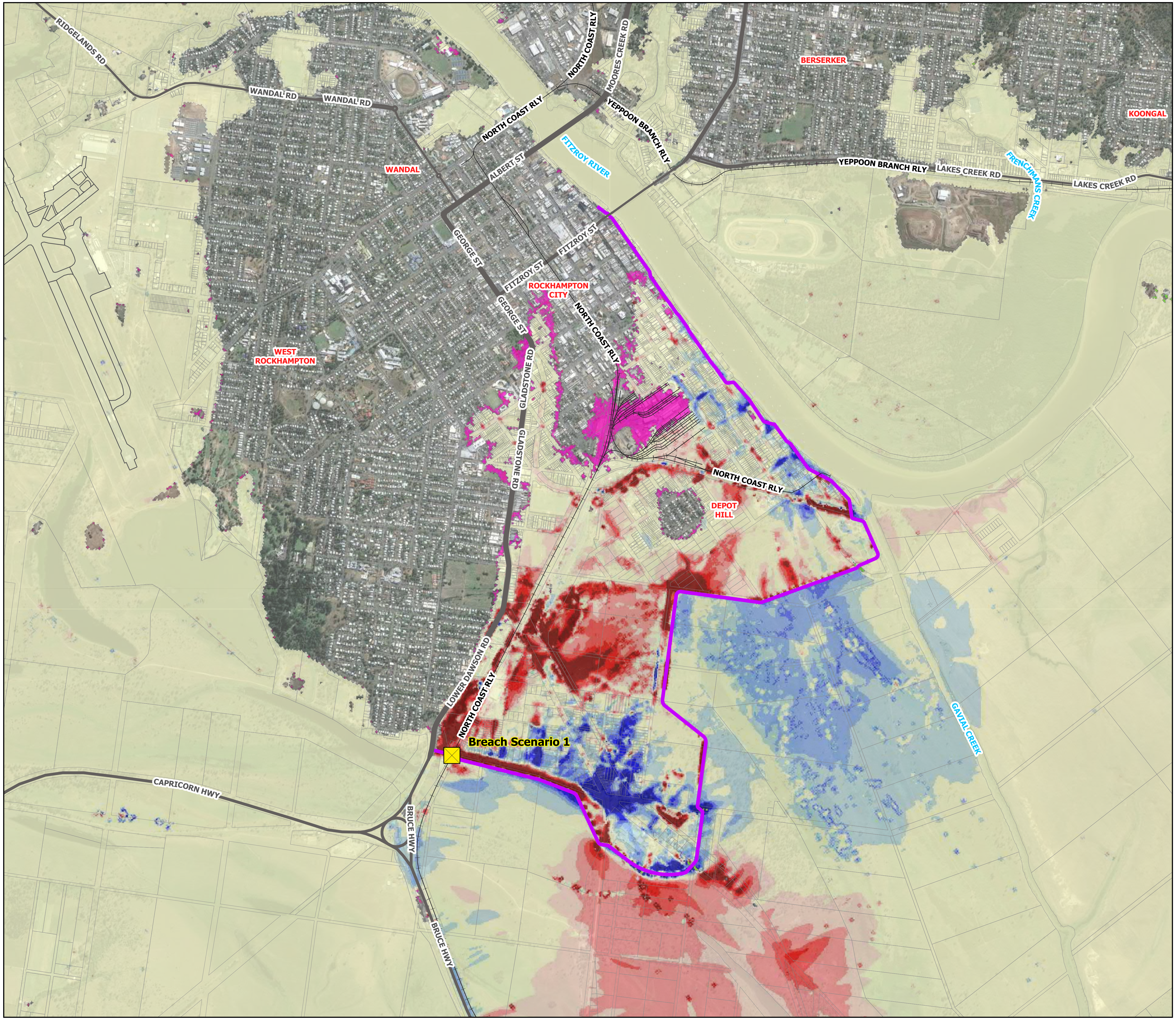

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DATUM GDA 1994, PROJECTION MGA ZONE 56

0 0.5 1 Kilometers

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LEGEND

- Breach Scenario Location
- Highways
- Main Roads
- Railway Lines
- SRFL Alignment
- Cadastre
- Hydraulic Model Extent

Peak Depth Average Velocity (m/s)

- < -0.5
- -0.5 to -0.4
- -0.4 to -0.3
- -0.3 to -0.2
- -0.2 to -0.1
- -0.1 to 0.1
- 0.1 to 0.2
- 0.2 to 0.3
- 0.3 to 0.4
- 0.4 to 0.5
- > 0.5
- Was Dry Now Wet
- Was Wet Now Dry

Data Sources:

DCDB (c) 2016 QLD Government
Imagery (c) 2016 RRC

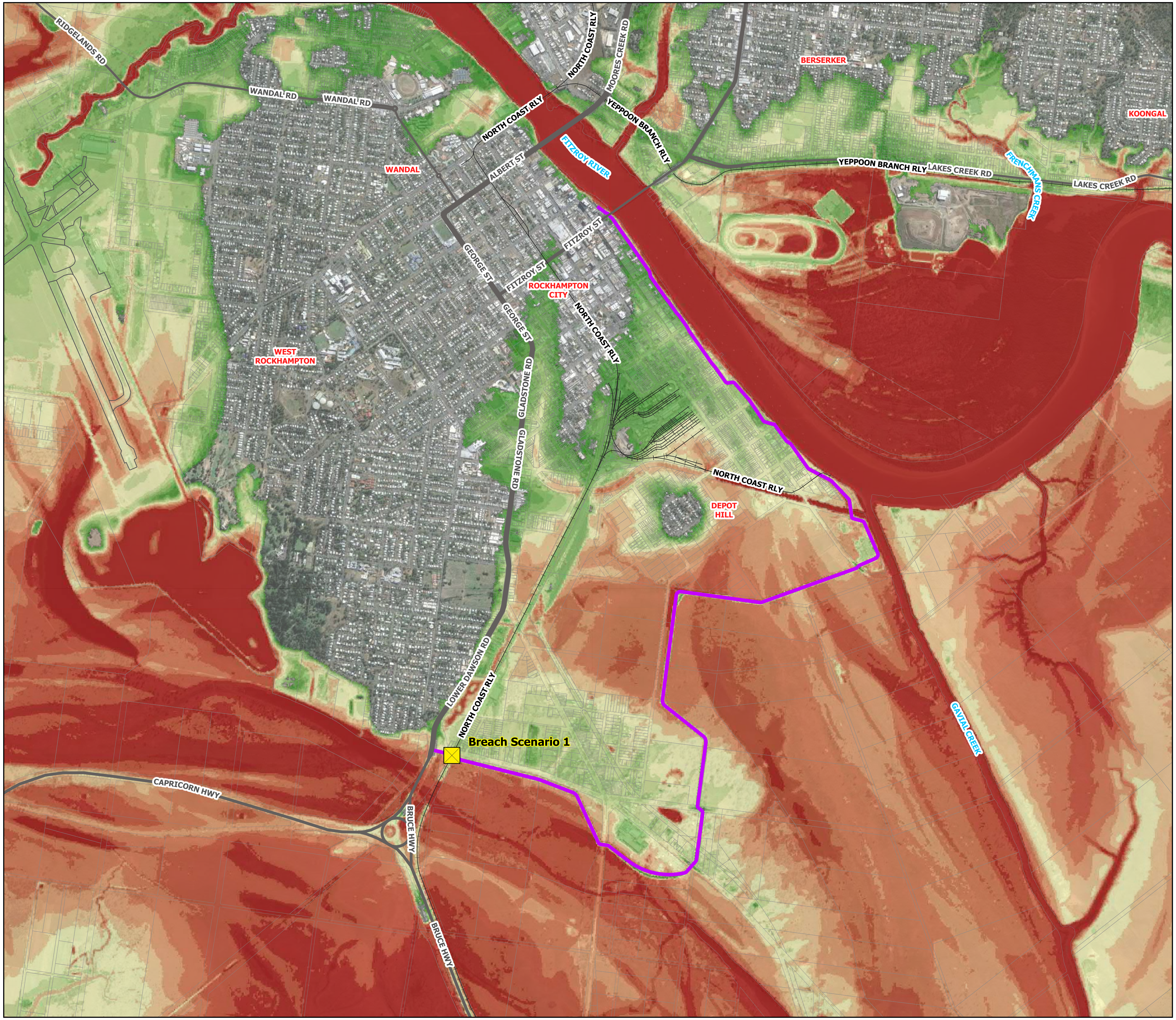
SOUTH ROCKHAMPTON FLOOD LEVEE
Failure Analysis Report

Difference in Peak Depth Averaged Velocity
Levee Breach Scenario 1
1% AEP - Flood Peak Levee Breach

PROJECT ID	60589157
CREATED BY	JensenK2
LAST MODIFIED	03-04-2019
VERSION	01

Map
FA-5

A3



N

DATUM GDA 1994, PROJECTION MGA ZONE 56

0 0.5 1 Kilometers

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LEGEND

- Breach Scenario Location
- Highways
- Main Roads
- Railway Lines
- SRFL Alignment
- Cadastre
- Hydraulic Model Extent

Peak Flood Depth (m)

- < 0.5
- 0.5 - 1.0
- 1.0 - 1.5
- 1.5 - 2.0
- 2.0 - 2.5
- 2.5 - 3.0
- 3.0 - 3.5
- 3.5 - 4.0
- 4.0 - 4.5
- 4.5 - 5.0
- > 5.0

Data Sources:

DCDB (c) 2016 QLD Government
Imagery (c) 2016 RRC

SOUTH ROCKHAMPTON FLOOD LEVEE
Failure Analysis Report

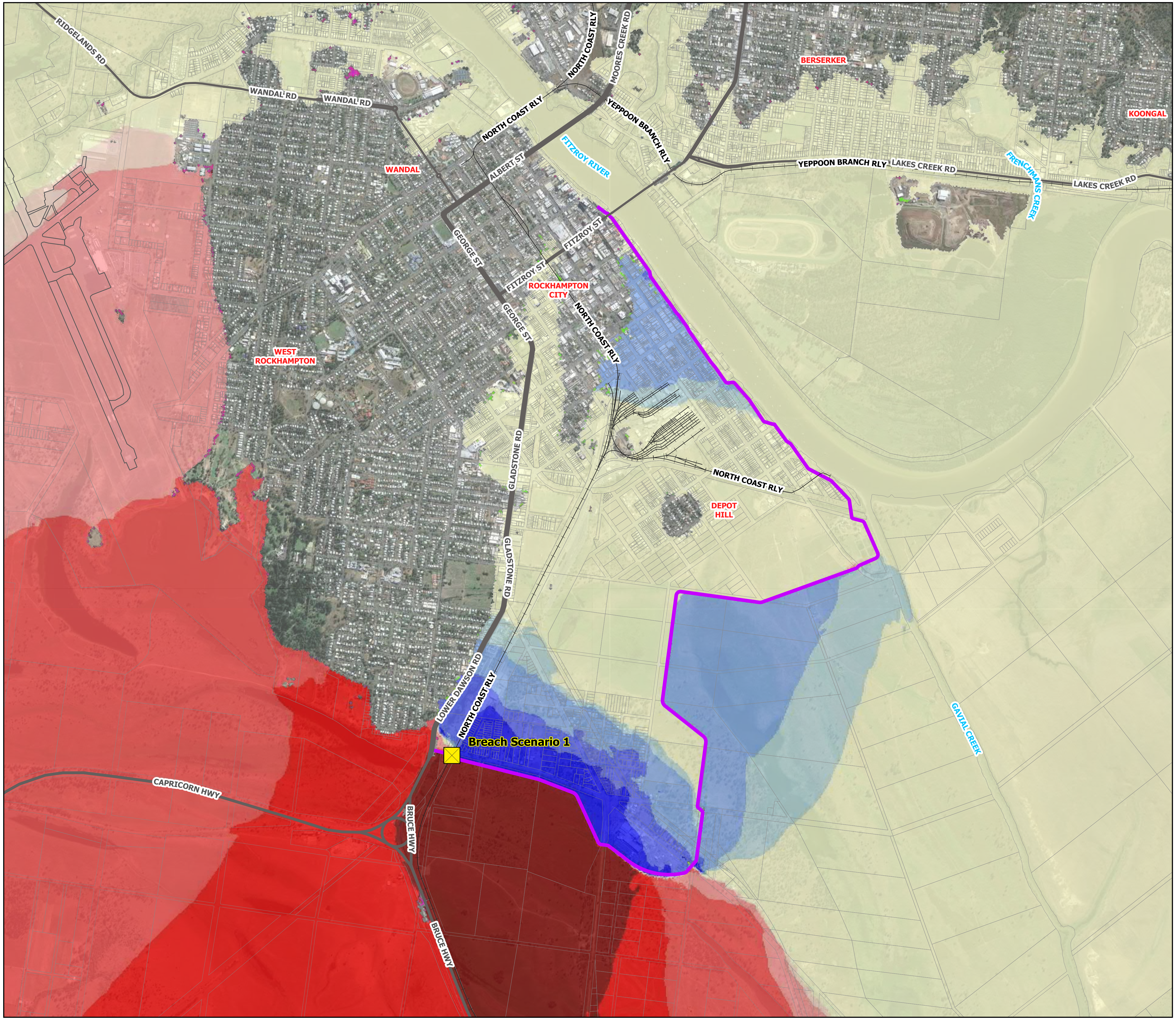
Peak Flood Depth and Extent
Levee Breach Scenario 1
0.2% AEP - Flood Peak Levee Breach

PROJECT ID	60589157
CREATED BY	JensenK2
LAST MODIFIED	03-04-2019
VERSION	01

Map
FA-6

A3

File Path \\aurok1fp001\Projects\605x\60589157\900_CAD_GIS\923_QGIS\Hydraulic Assessment Report



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DATUM GDA 1994, PROJECTION MGA ZONE 56

0 0.5 1 Kilometers

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LEGEND

- Breach Scenario Location
- Highways
- Main Roads
- Railway Lines
- SRFL Alignment
- Cadastre
- Hydraulic Model Extent

Difference in Peak Flood Height (m)

- < -0.3
- -0.3 to -0.225
- -0.225 to -0.15
- -0.15 to -0.075
- -0.075 to -0.05
- -0.05 to 0.05
- 0.05 to 0.075
- 0.075 to 0.15
- 0.15 to 0.225
- 0.225 to 0.3
- > 0.3
- Was Dry Now Wet
- Was Wet Now Dry

Data Sources:

DCDB (c) 2016 QLD Government
Imagery (c) 2016 RRC

SOUTH ROCKHAMPTON FLOOD LEVEE
Failure Analysis Report

Difference in Peak Flood Height
Levee Breach Scenario 1
0.2% AEP - Flood Peak Levee Breach

PROJECT ID	60589157
CREATED BY	JensenK2
LAST MODIFIED	03-04-2019
VERSION	01

Map
FA-7

A3

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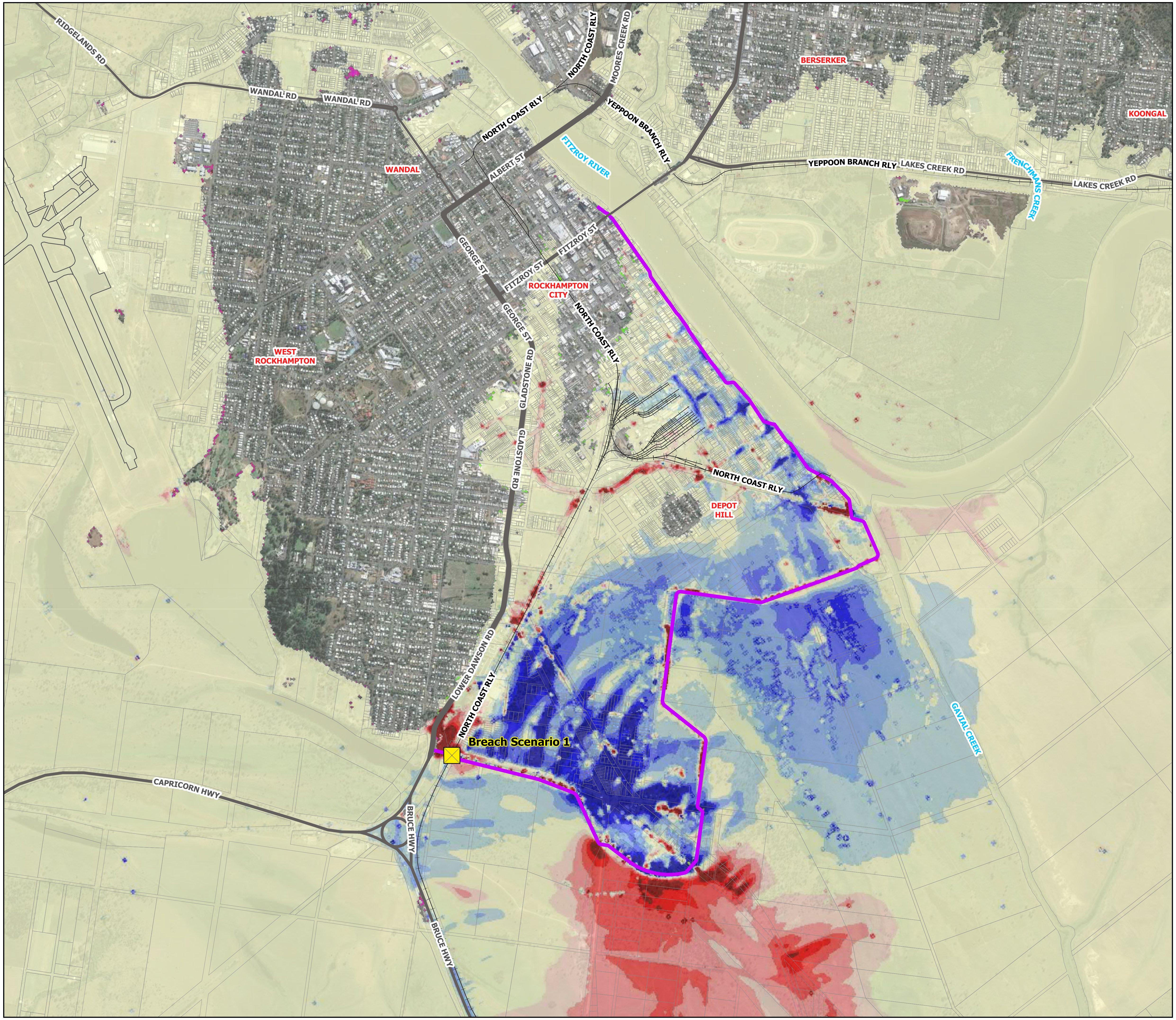

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DATUM GDA 1994, PROJECTION MGA ZONE 56

0 0.5 1 Kilometers

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LEGEND

- Breach Scenario Location
- Highways
- Main Roads
- Railway Lines
- SRFL Alignment
- Cadastre
- Hydraulic Model Extent

Peak Depth Average Velocity (m/s)

- < -0.5
- -0.5 to -0.4
- -0.4 to -0.3
- -0.3 to -0.2
- -0.2 to -0.1
- -0.1 to 0.1
- 0.1 to 0.2
- 0.2 to 0.3
- 0.3 to 0.4
- 0.4 to 0.5
- > 0.5
- Was Dry Now Wet
- Was Wet Now Dry

Data Sources:

DCDB (c) 2016 QLD Government
Imagery (c) 2016 RRC

SOUTH ROCKHAMPTON FLOOD LEVEE
Failure Analysis Report

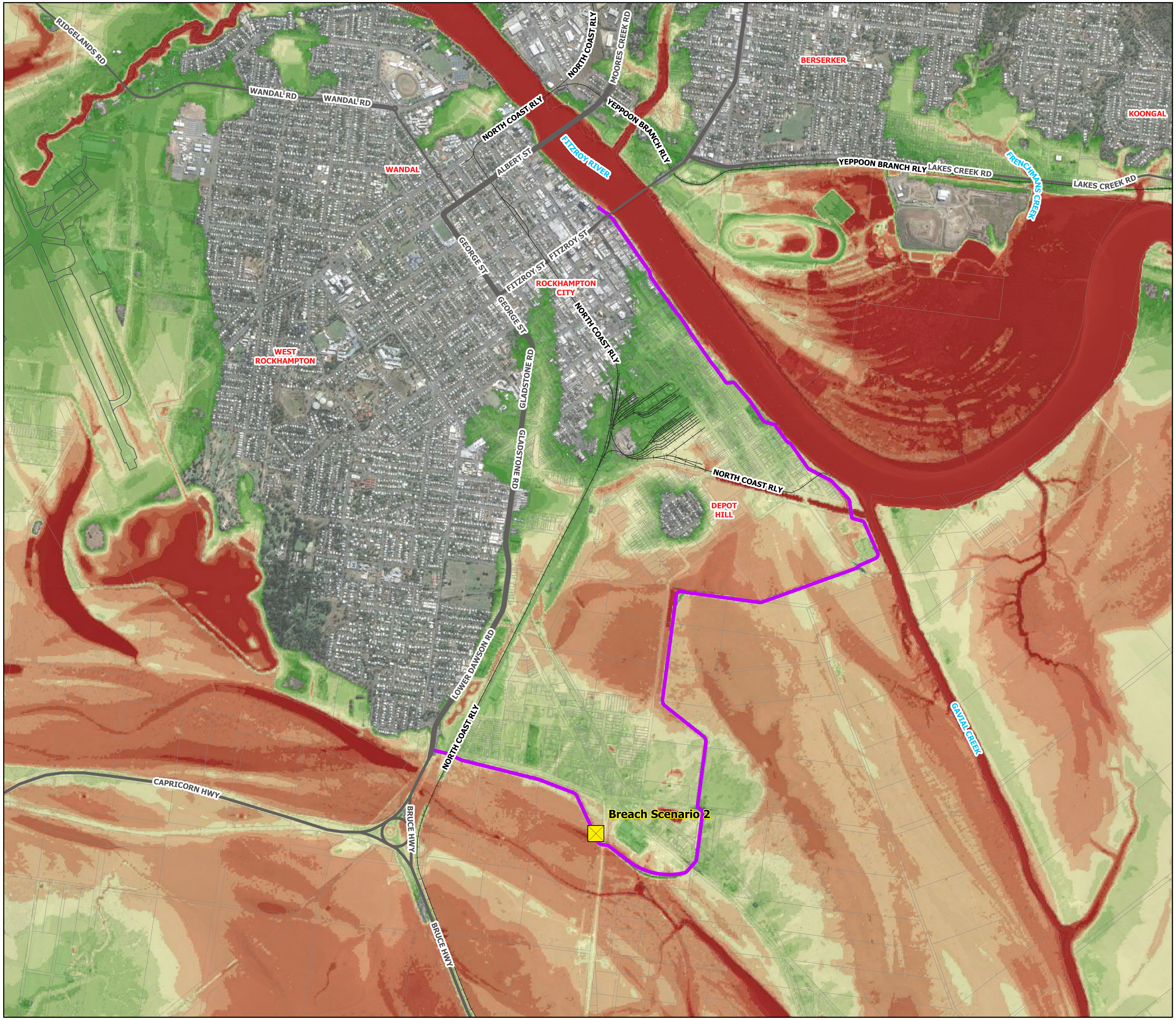
Difference in Peak Depth Averaged Velocity
Levee Breach Scenario 1
0.2% AEP - Flood Peak Levee Breach

PROJECT ID	60589157
CREATED BY	JensenK2
LAST MODIFIED	03-04-2019
VERSION	01

Map
FA-8

File Path \\aurok1fp001\Projects\605x\60589157\900 CAD GIS\923 QGIS\Hydraulic Assessment Report

A3



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DATUM GDA 1994, PROJECTION MGA ZONE 56

0 0.5 1 Kilometers

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LEGEND

- Breach Scenario Location
- Highways
- Main Roads
- Railway Lines
- SRFL Alignment
- Cadastre
- Hydraulic Model Extent

Peak Flood Depth (m)

- < 0.5
- 0.5 - 1.0
- 1.0 - 1.5
- 1.5 - 2.0
- 2.0 - 2.5
- 2.5 - 3.0
- 3.0 - 3.5
- 3.5 - 4.0
- 4.0 - 4.5
- 4.5 - 5.0
- > 5.0

Data Sources:

DCDB (c) 2016 QLD Government
Imagery (c) 2016 RRC

SOUTH ROCKHAMPTON FLOOD LEVEE
Failure Analysis Report

Peak Flood Depth and Extent
Levee Breach Scenario 2
1% AEP - Flood Peak Levee Breach

PROJECT ID	60589157	Map
CREATED BY	JensenK2	FA-9
LAST MODIFIED	03-04-2019	
VERSION	01	

A3

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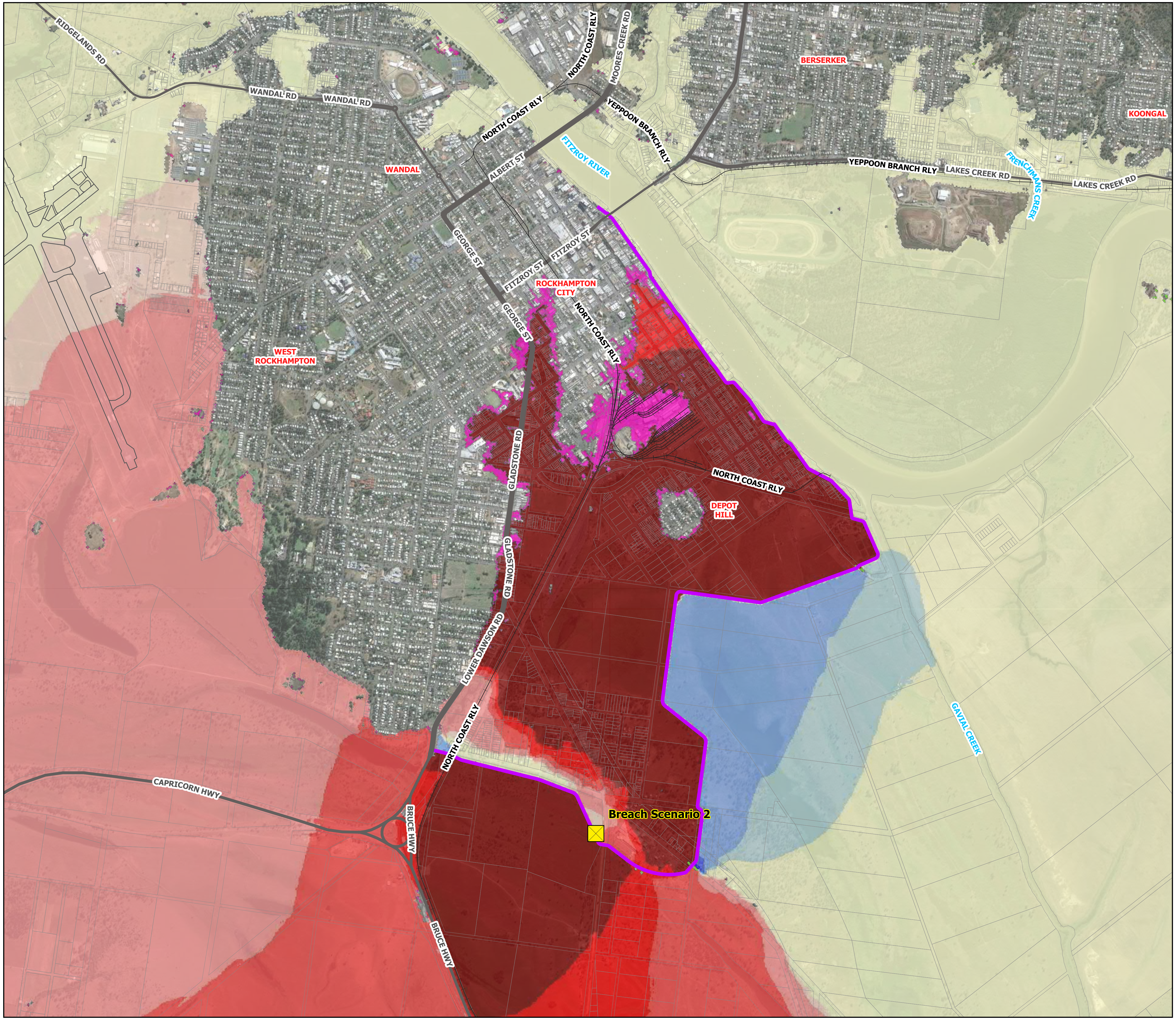

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DATUM GDA 1994, PROJECTION MGA ZONE 56

0 0.5 1 Kilometers

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LEGEND

- Breach Scenario Location
- Highways
- Main Roads
- Railway Lines
- SRFL Alignment
- Cadastre
- Hydraulic Model Extent

Difference in Peak Flood Height (m)

- < -0.3
- -0.3 to -0.225
- -0.225 to -0.15
- -0.15 to -0.075
- -0.075 to -0.05
- -0.05 to 0.05
- 0.05 to 0.075
- 0.075 to 0.15
- 0.15 to 0.225
- 0.225 to 0.3
- > 0.3
- Was Dry Now Wet
- Was Wet Now Dry

Data Sources:

DCDB (c) 2016 QLD Government
Imagery (c) 2016 RRC

SOUTH ROCKHAMPTON FLOOD LEVEE
Failure Analysis Report

Difference in Peak Flood Height
Levee Breach Scenario 2
1% AEP - Flood Peak Levee Breach

PROJECT ID	60589157
CREATED BY	JensenK2
LAST MODIFIED	03-04-2019
VERSION	01

Map
FA-10

A3

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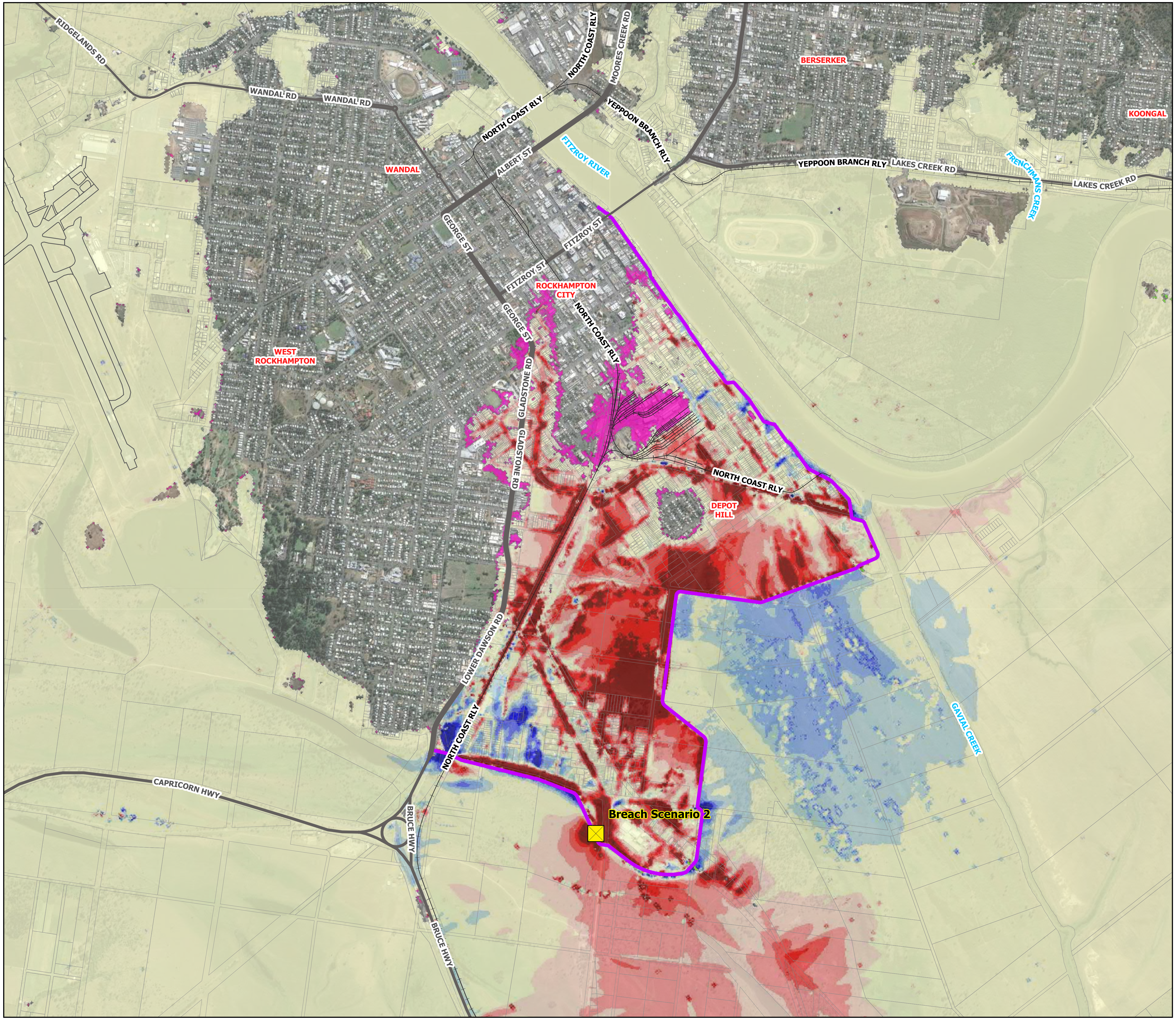

N

DATUM GDA 1994, PROJECTION MGA ZONE 56

0 0.5 1 Kilometers

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LEGEND

- Breach Scenario Location
- Highways
- Main Roads
- Railway Lines
- SRFL Alignment
- Cadastre
- Hydraulic Model Extent

Peak Depth Average Velocity (m/s)

- < -0.5
- -0.5 to -0.4
- -0.4 to -0.3
- -0.3 to -0.2
- -0.2 to -0.1
- -0.1 to 0.1
- 0.1 to 0.2
- 0.2 to 0.3
- 0.3 to 0.4
- 0.4 to 0.5
- > 0.5
- Was Dry Now Wet
- Was Wet Now Dry

Data Sources:

DCDB (c) 2016 QLD Government
Imagery (c) 2016 RRC

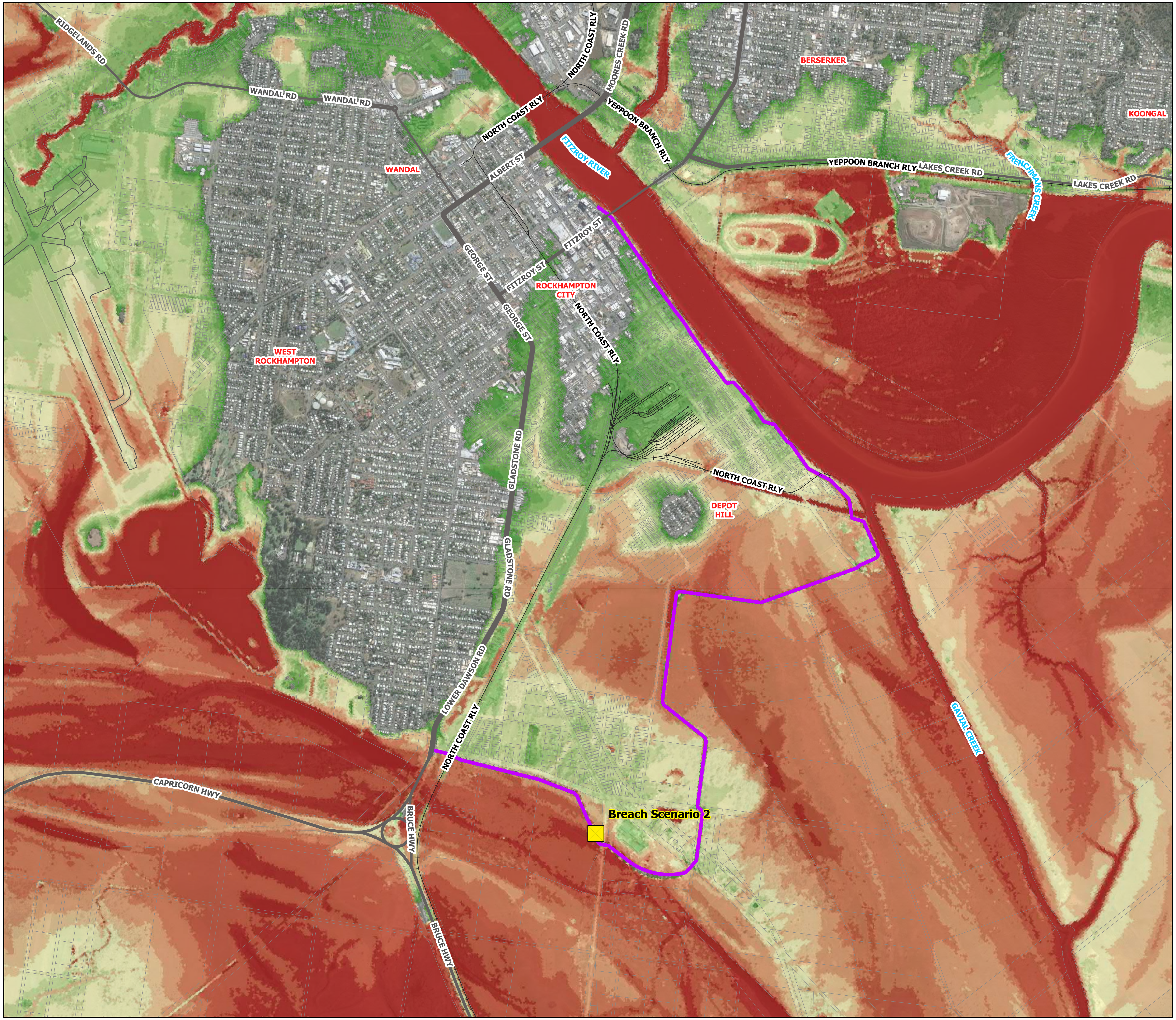
SOUTH ROCKHAMPTON FLOOD LEVEE
Failure Analysis Report

Difference in Peak Depth Averaged Velocity
Levee Breach Scenario 2
1% AEP - Flood Peak Levee Breach

PROJECT ID	60589157
CREATED BY	JensenK2
LAST MODIFIED	03-04-2019
VERSION	01

Map
FA-11

File Path \\aurok1fp001\Projects\605x\60589157\900 CAD GIS\923 QGIS\Hydraulic Assessment Report



N

DATUM GDA 1994, PROJECTION MGA ZONE 56

0 0.5 1 Kilometers

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LEGEND

- Breach Scenario Location
- Highways
- Main Roads
- Railway Lines
- SRFL Alignment
- Cadastre
- Hydraulic Model Extent

Peak Flood Depth (m)

- < 0.5
- 0.5 - 1.0
- 1.0 - 1.5
- 1.5 - 2.0
- 2.0 - 2.5
- 2.5 - 3.0
- 3.0 - 3.5
- 3.5 - 4.0
- 4.0 - 4.5
- 4.5 - 5.0
- > 5.0

Data Sources:

DCDB (c) 2016 QLD Government
Imagery (c) 2016 RRC

SOUTH ROCKHAMPTON FLOOD LEVEE
Failure Analysis Report

Peak Flood Depth and Extent
Levee Breach Scenario 2
0.2% AEP - Flood Peak Levee Breach

PROJECT ID	60589157	Map	
CREATED BY	JensenK2	FA-12	
LAST MODIFIED	03-04-2019		
VERSION	01		

A3

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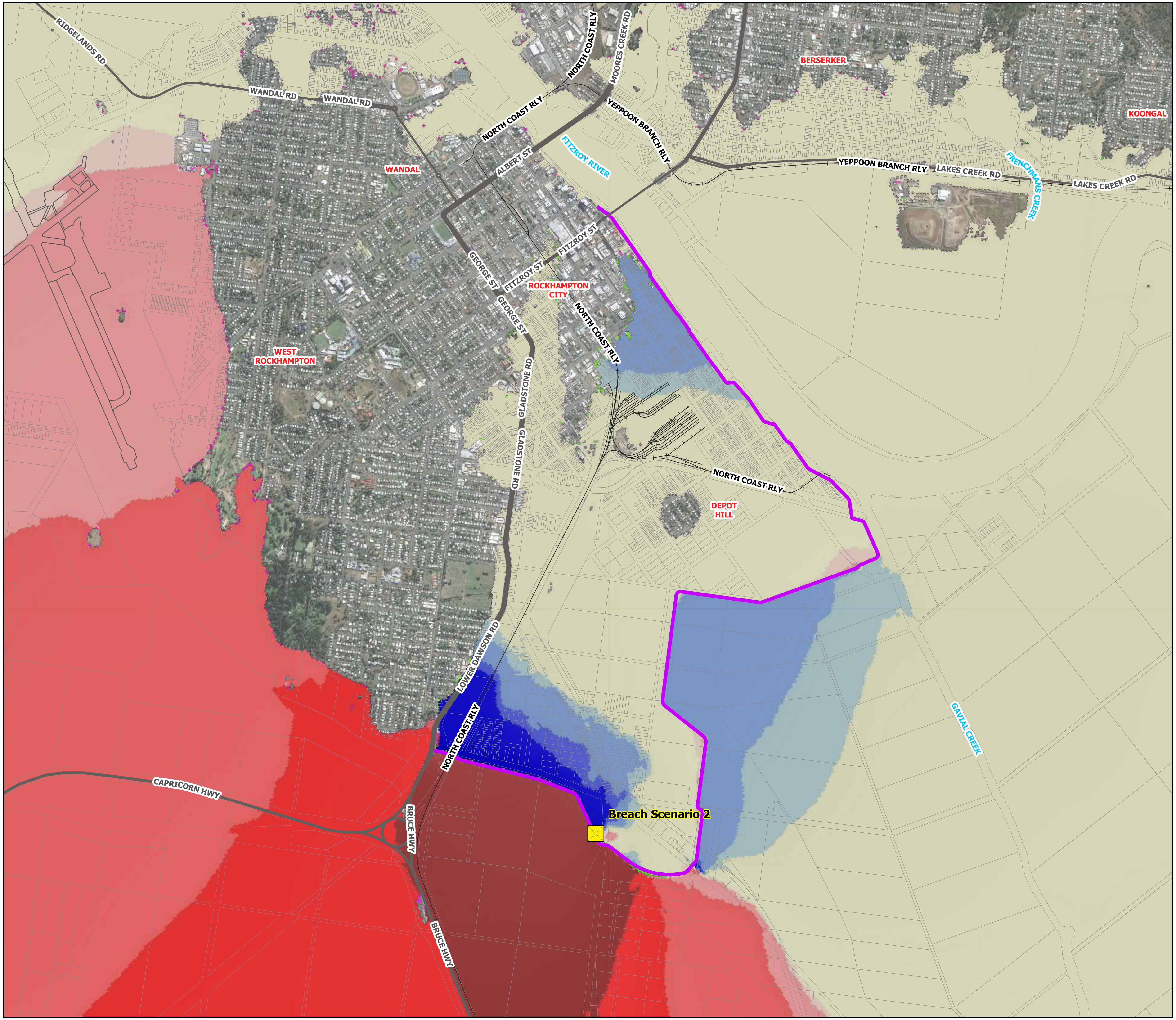

N

DATUM GDA 1994, PROJECTION MGA ZONE 56

0 0.5 1 Kilometers

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LEGEND

- Breach Scenario Location
- Highways
- Main Roads
- Railway Lines
- SRFL Alignment
- Cadastre
- Hydraulic Model Extent

Difference in Peak Flood Height (m)

- < -0.3
- -0.3 to -0.225
- -0.225 to -0.15
- -0.15 to -0.075
- -0.075 to -0.05
- -0.05 to 0.05
- 0.05 to 0.075
- 0.075 to 0.15
- 0.15 to 0.225
- 0.225 to 0.3
- > 0.3
- Was Dry Now Wet
- Was Wet Now Dry

Data Sources:

DCDB (c) 2016 QLD Government
Imagery (c) 2016 RRC

SOUTH ROCKHAMPTON FLOOD LEVEE
Failure Analysis Report

Difference in Peak Flood Height
Levee Breach Scenario 2
0.2% AEP - Flood Peak Levee Breach

PROJECT ID	60589157
CREATED BY	JensenK2
LAST MODIFIED	03-04-2019
VERSION	01

Map
FA-13

A3

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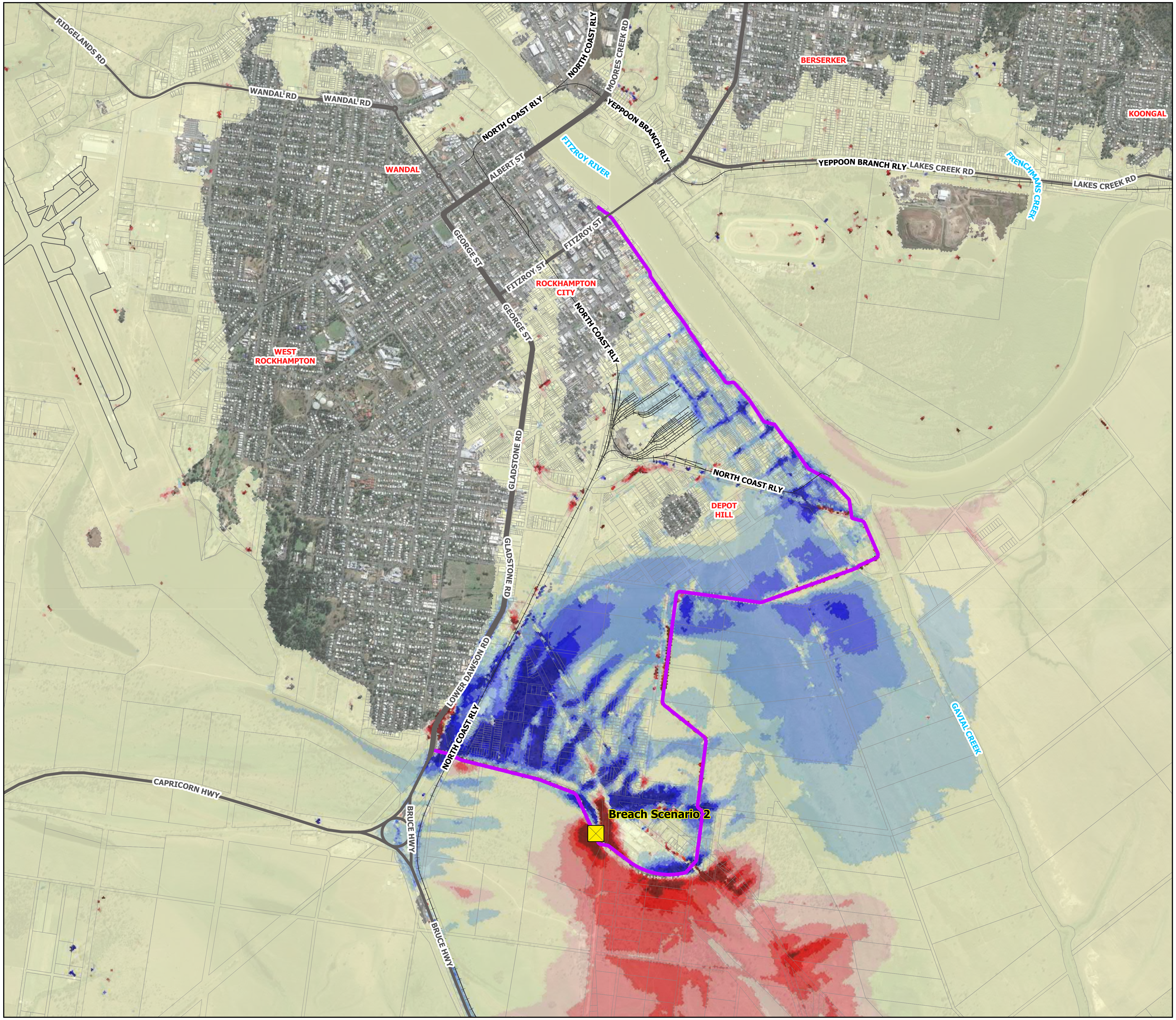

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DATUM GDA 1994, PROJECTION MGA ZONE 56

0 0.5 1 Kilometers

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LEGEND

- Breach Scenario Location
- Highways
- Main Roads
- Railway Lines
- SRFL Alignment
- Cadastre
- Hydraulic Model Extent

Peak Depth Average Velocity (m/s)

- < -0.5
- -0.5 to -0.4
- -0.4 to -0.3
- -0.3 to -0.2
- -0.2 to -0.1
- -0.1 to 0.1
- 0.1 to 0.2
- 0.2 to 0.3
- 0.3 to 0.4
- 0.4 to 0.5
- > 0.5
- Was Dry Now Wet
- Was Wet Now Dry

Data Sources:

DCDB (c) 2016 QLD Government
Imagery (c) 2016 RRC

SOUTH ROCKHAMPTON FLOOD LEVEE
Failure Analysis Report

Difference in Peak Depth Averaged Velocity
Levee Breach Scenario 2
0.2% AEP - Flood Peak Levee Breach

PROJECT ID	60589157	Map
CREATED BY	JensenK2	FA-14
LAST MODIFIED	03-04-2019	
VERSION	01	

A3

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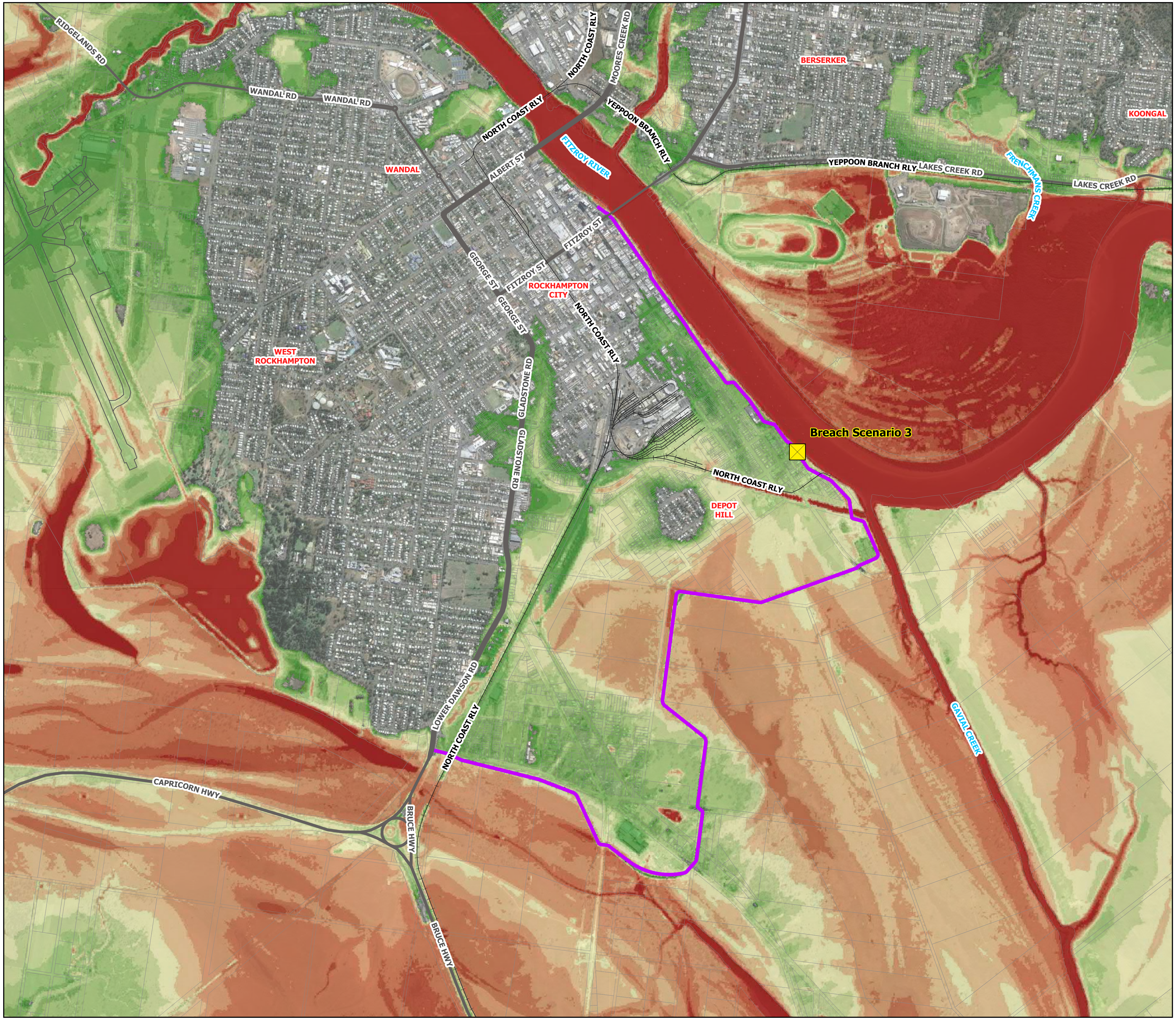

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DATUM GDA 1994, PROJECTION MGA ZONE 56

0 0.5 1 Kilometers

AECOM

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LEGEND

- Breach Scenario Location
- Highways
- Main Roads
- Railway Lines
- SRFL Alignment
- Cadastre
- Hydraulic Model Extent

Peak Flood Depth (m)

- < 0.5
- 0.5 - 1.0
- 1.0 - 1.5
- 1.5 - 2.0
- 2.0 - 2.5
- 2.5 - 3.0
- 3.0 - 3.5
- 3.5 - 4.0
- 4.0 - 4.5
- 4.5 - 5.0
- > 5.0

Data Sources:

DCDB (c) 2016 QLD Government
Imagery (c) 2016 RRC

SOUTH ROCKHAMPTON FLOOD LEVEE
Failure Analysis Report

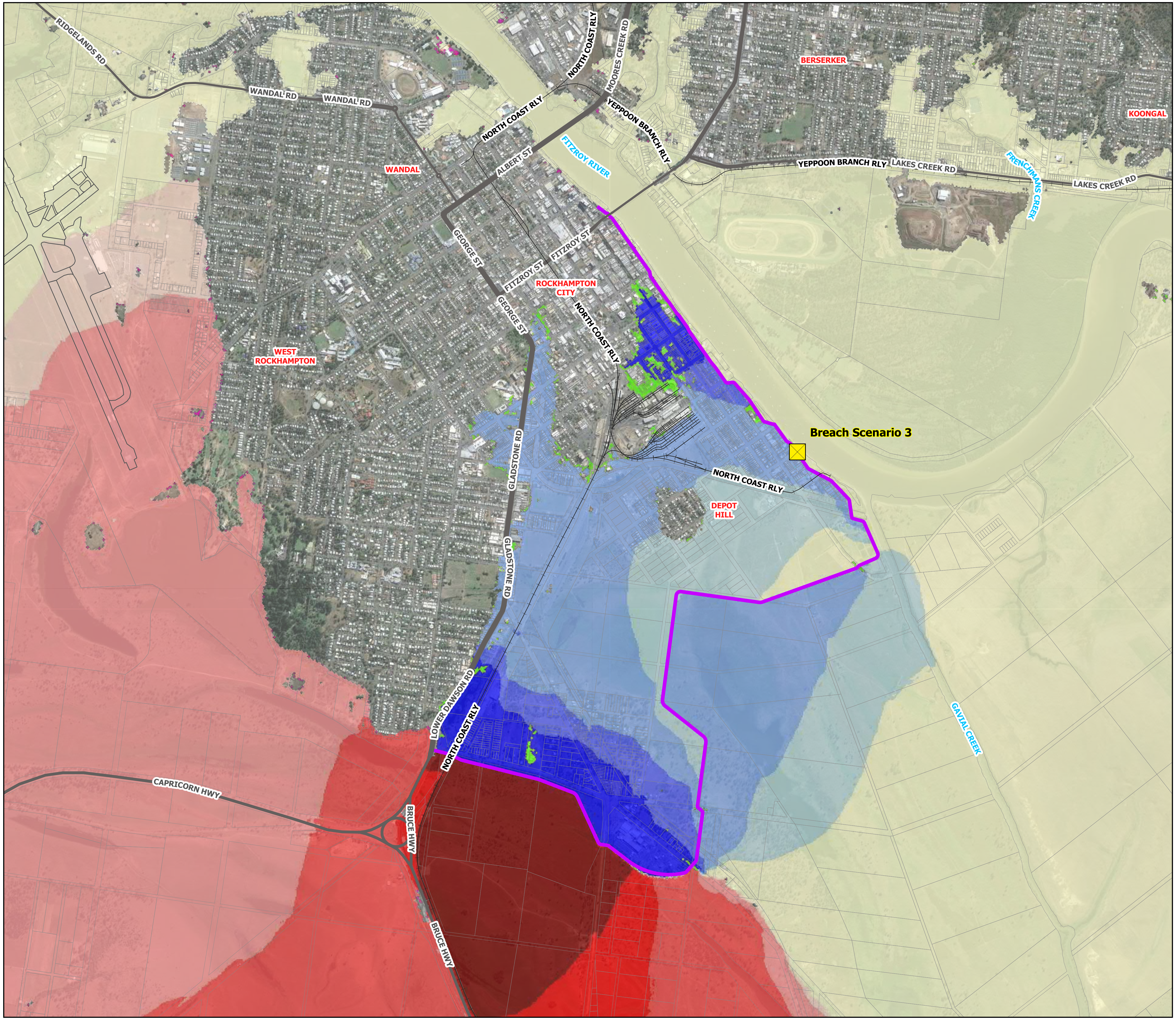
Peak Flood Depth and Extent
Levee Breach Scenario 3
1% AEP - Flood Peak Levee Breach

PROJECT ID	60589157
CREATED BY	JensenK2
LAST MODIFIED	03-04-2019
VERSION	01

Map
FA-15

A3

File Path \\aurok1fp001\Projects\605x\60589157\900_CAD_GIS\923_QGIS\Hydraulic Assessment Report



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DATUM GDA 1994, PROJECTION MGA ZONE 56

0 0.5 1 Kilometers

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LEGEND

- Breach Scenario Location
- Highways
- Main Roads
- Railway Lines
- SRFL Alignment
- Cadastre
- Hydraulic Model Extent

Difference in Peak Flood Height (m)

- < -0.3
- -0.3 to -0.225
- -0.225 to -0.15
- -0.15 to -0.075
- -0.075 to -0.05
- -0.05 to 0.05
- 0.05 to 0.075
- 0.075 to 0.15
- 0.15 to 0.225
- 0.225 to 0.3
- > 0.3
- Was Dry Now Wet
- Was Wet Now Dry

Data Sources:

DCDB (c) 2016 QLD Government
Imagery (c) 2016 RRC

SOUTH ROCKHAMPTON FLOOD LEVEE
Failure Analysis Report

Difference in Peak Flood Height
Levee Breach Scenario 3
1% AEP - Flood Peak Levee Breach

PROJECT ID	60589157
CREATED BY	JensenK2
LAST MODIFIED	03-04-2019
VERSION	01

Map
FA-16

A3

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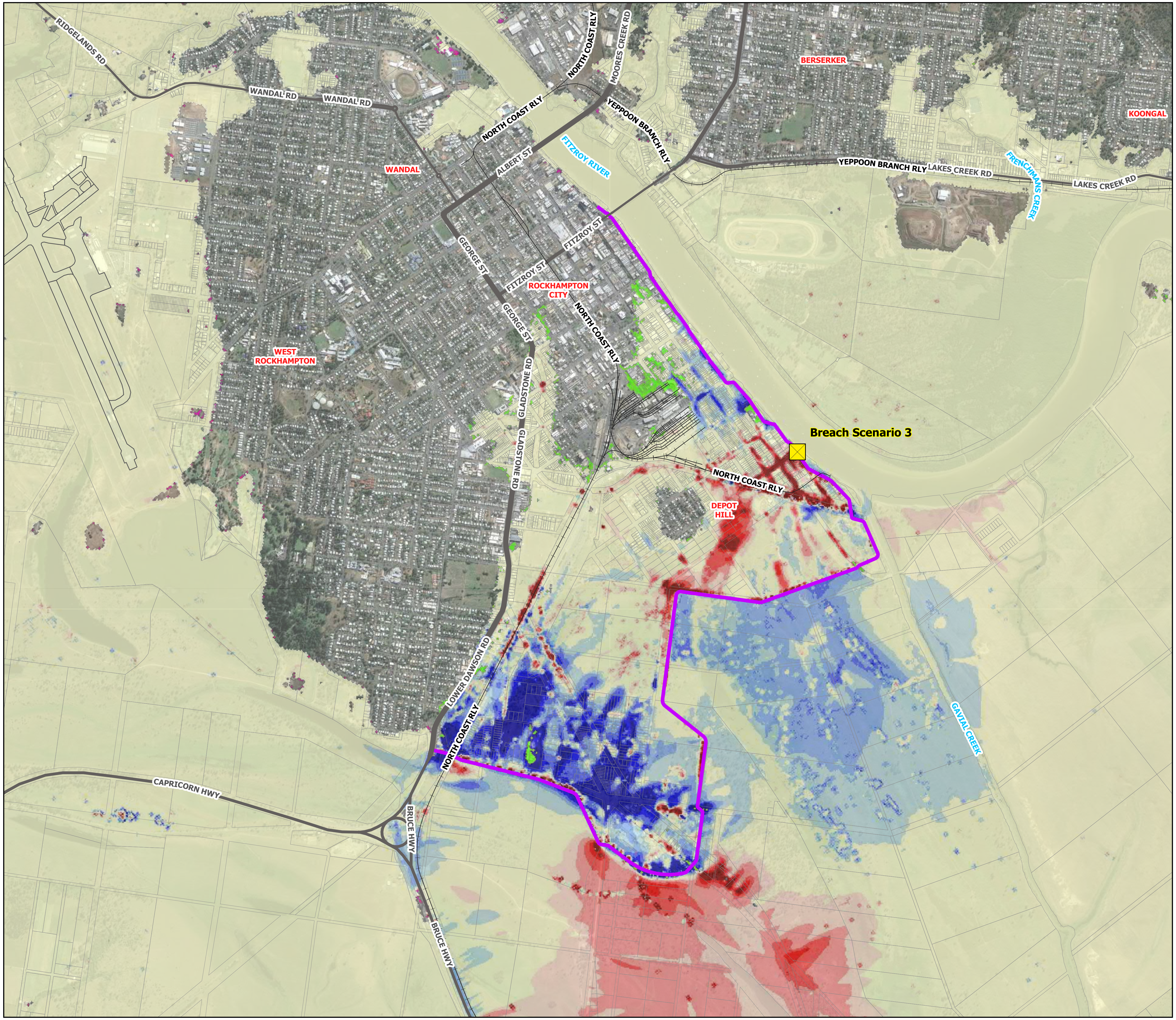

N

DATUM GDA 1994, PROJECTION MGA ZONE 56

0 0.5 1 Kilometers

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LEGEND

- Breach Scenario Location
- Highways
- Main Roads
- Railway Lines
- SRFL Alignment
- Cadastre
- Hydraulic Model Extent

Peak Depth Average Velocity (m/s)

- < -0.5
- -0.5 to -0.4
- -0.4 to -0.3
- -0.3 to -0.2
- -0.2 to -0.1
- -0.1 to 0.1
- 0.1 to 0.2
- 0.2 to 0.3
- 0.3 to 0.4
- 0.4 to 0.5
- > 0.5
- Was Dry Now Wet
- Was Wet Now Dry

Data Sources:

DCDB (c) 2016 QLD Government
Imagery (c) 2016 RRC

SOUTH ROCKHAMPTON FLOOD LEVEE
Failure Analysis Report

Difference in Peak Depth Averaged Velocity
Levee Breach Scenario 3
1% AEP - Flood Peak Levee Breach

PROJECT ID	60589157
CREATED BY	JensenK2
LAST MODIFIED	03-04-2019
VERSION	01

Map
FA-17

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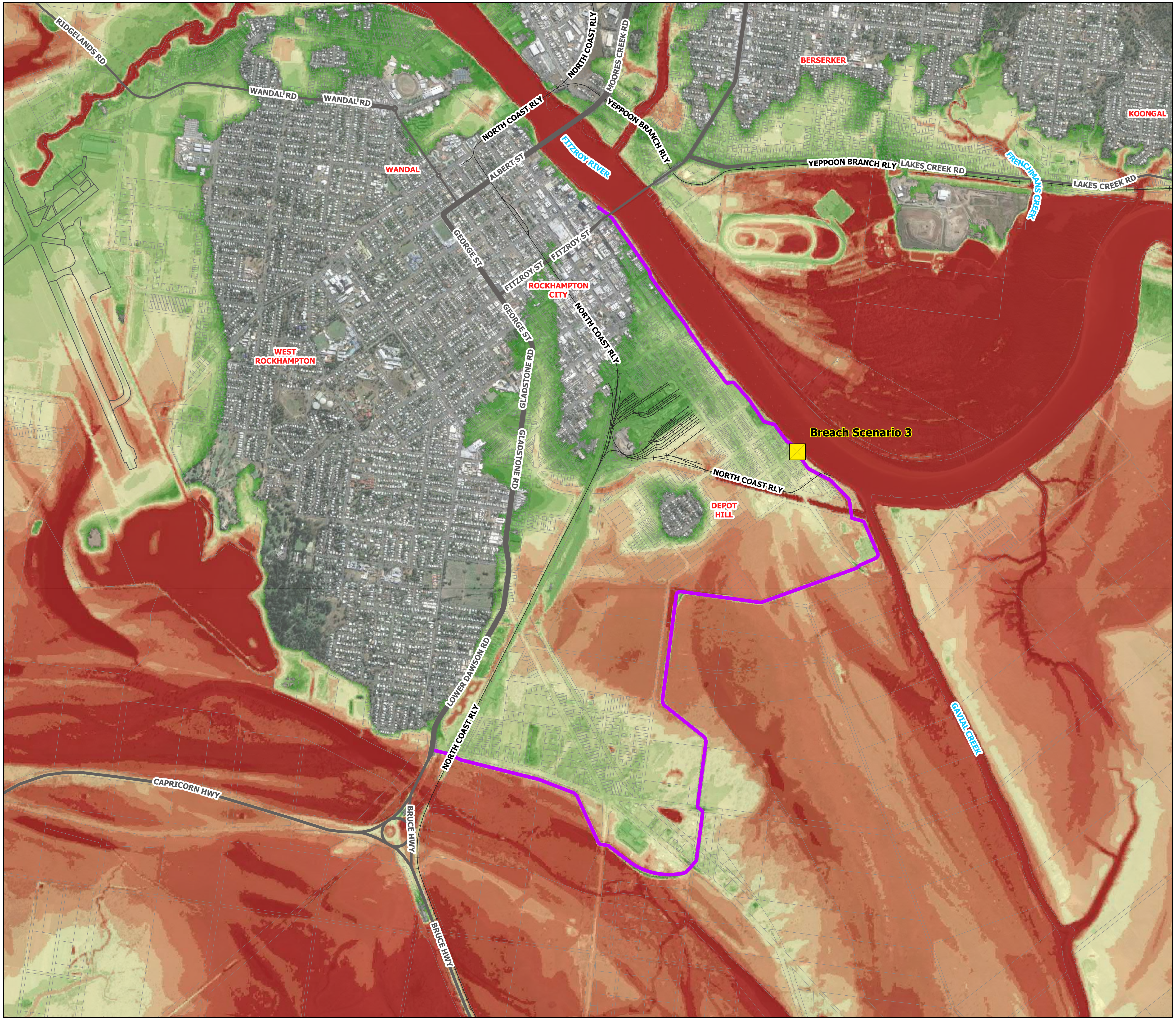

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DATUM GDA 1994, PROJECTION MGA ZONE 56

0 0.5 1 Kilometers

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LEGEND

- Breach Scenario Location
- Highways
- Main Roads
- Railway Lines
- SRFL Alignment
- Cadastre
- Hydraulic Model Extent

Peak Flood Depth (m)

- < 0.5
- 0.5 - 1.0
- 1.0 - 1.5
- 1.5 - 2.0
- 2.0 - 2.5
- 2.5 - 3.0
- 3.0 - 3.5
- 3.5 - 4.0
- 4.0 - 4.5
- 4.5 - 5.0
- > 5.0

Data Sources:

DCDB (c) 2016 QLD Government
Imagery (c) 2016 RRC

SOUTH ROCKHAMPTON FLOOD LEVEE
Failure Analysis Report

Peak Flood Depth and Extent
Levee Breach Scenario 3
0.2% AEP - Flood Peak Levee Breach

PROJECT ID	60589157	Map FA-18
CREATED BY	JensenK2	
LAST MODIFIED	03-04-2019	
VERSION	01	

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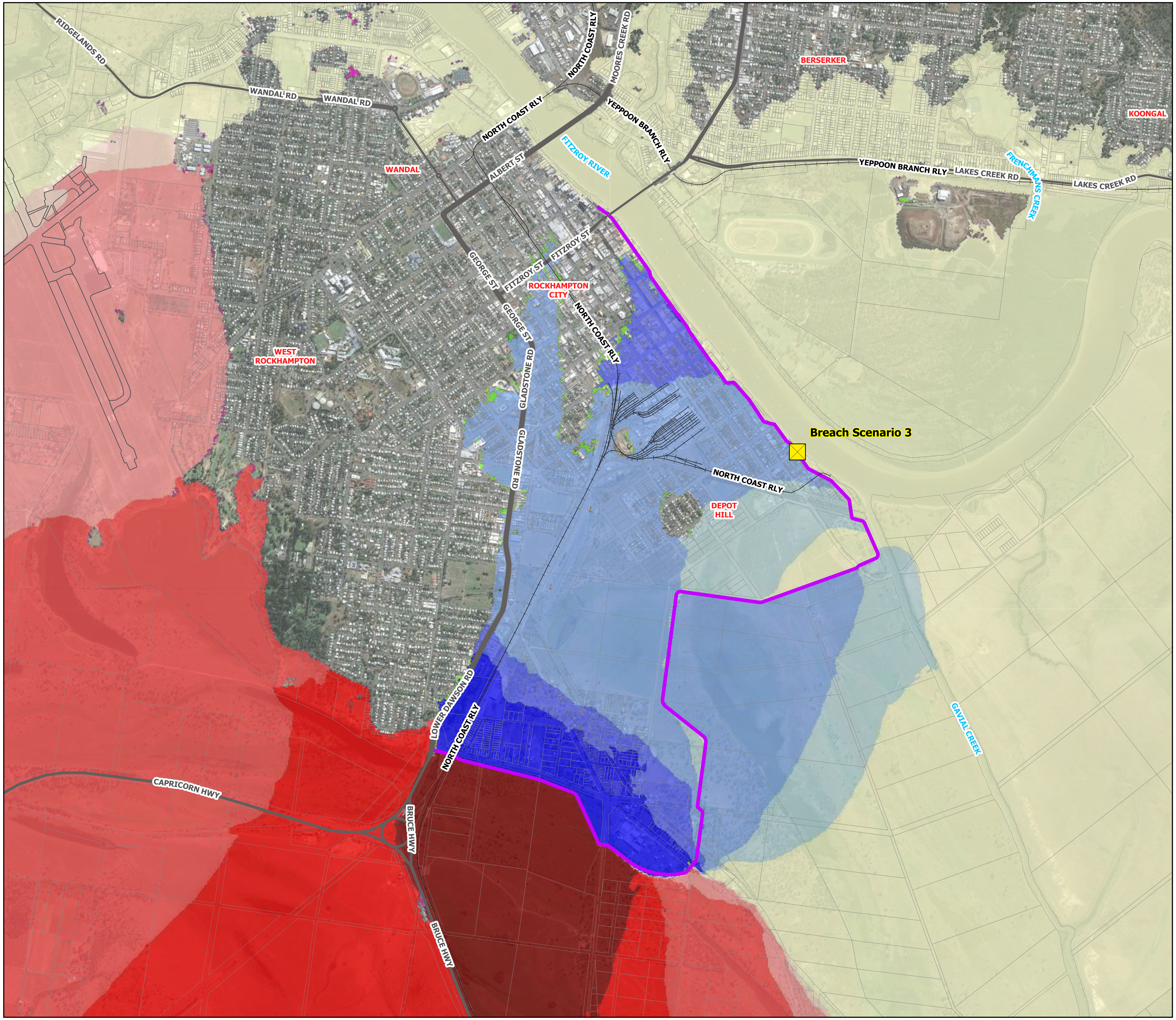

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DATUM GDA 1994, PROJECTION MGA ZONE 56

0 0.5 1 Kilometers

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LEGEND

- Breach Scenario Location
- Highways
- Main Roads
- Railway Lines
- SRFL Alignment
- Cadastre
- Hydraulic Model Extent

Difference in Peak Flood Height (m)

- < -0.3
- -0.3 to -0.225
- -0.225 to -0.15
- -0.15 to -0.075
- -0.075 to -0.05
- -0.05 to 0.05
- 0.05 to 0.075
- 0.075 to 0.15
- 0.15 to 0.225
- 0.225 to 0.3
- > 0.3
- Was Dry Now Wet
- Was Wet Now Dry

Data Sources:

DCDB (c) 2016 QLD Government
Imagery (c) 2016 RRC

SOUTH ROCKHAMPTON FLOOD LEVEE
Failure Analysis Report

Difference in Peak Flood Height
Levee Breach Scenario 3
0.2% AEP - Flood Peak Levee Breach

PROJECT ID	60589157
CREATED BY	JensenK2
LAST MODIFIED	03-04-2019
VERSION	01

Map
FA-19

A3

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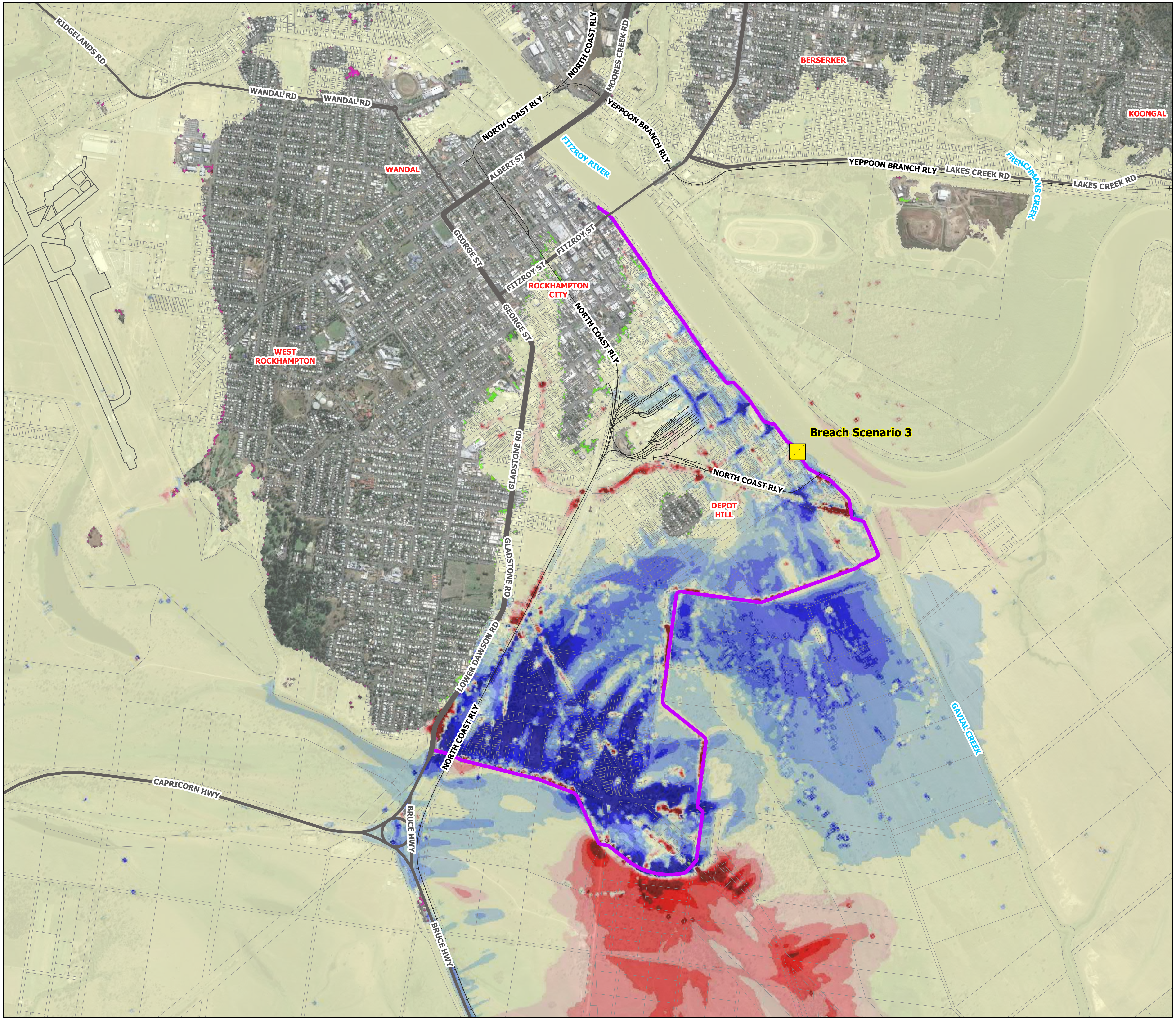

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DATUM GDA 1994, PROJECTION MGA ZONE 56

0 0.5 1 Kilometers

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LEGEND

- Breach Scenario Location
- Highways
- Main Roads
- Railway Lines
- SRFL Alignment
- Cadastre
- Hydraulic Model Extent

Peak Depth Average Velocity (m/s)

- < -0.5
- -0.5 to -0.4
- -0.4 to -0.3
- -0.3 to -0.2
- -0.2 to -0.1
- -0.1 to 0.1
- 0.1 to 0.2
- 0.2 to 0.3
- 0.3 to 0.4
- 0.4 to 0.5
- > 0.5
- Was Dry Now Wet
- Was Wet Now Dry

Data Sources:

DCDB (c) 2016 QLD Government
Imagery (c) 2016 RRC

SOUTH ROCKHAMPTON FLOOD LEVEE
Failure Analysis Report

Difference in Peak Depth Averaged Velocity
Levee Breach Scenario 3
0.2% AEP - Flood Peak Levee Breach

PROJECT ID	60589157
CREATED BY	JensenK2
LAST MODIFIED	03-04-2019
VERSION	01

Map
FA-20

A3

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LEGEND

- Breach Scenario Location
- Highways
- Main Roads
- Railway Lines
- SRFL Alignment
- Cadastre
- Hydraulic Model Extent

Peak Flood Depth (m)

- < 0.5
- 0.5 - 1.0
- 1.0 - 1.5
- 1.5 - 2.0
- 2.0 - 2.5
- 2.5 - 3.0
- 3.0 - 3.5
- 3.5 - 4.0
- 4.0 - 4.5
- 4.5 - 5.0
- > 5.0

Data Sources:

DCDB (c) 2016 QLD Government
Imagery (c) 2016 RRC

SOUTH ROCKHAMPTON FLOOD LEVEE
Failure Analysis Report

Peak Flood Depth and Extent
Levee Breach Scenario 4
1% AEP - Flood Peak Levee Breach

PROJECT ID	60589157	Map
CREATED BY	JensenK2	FA-21
LAST MODIFIED	03-04-2019	
VERSION	01	

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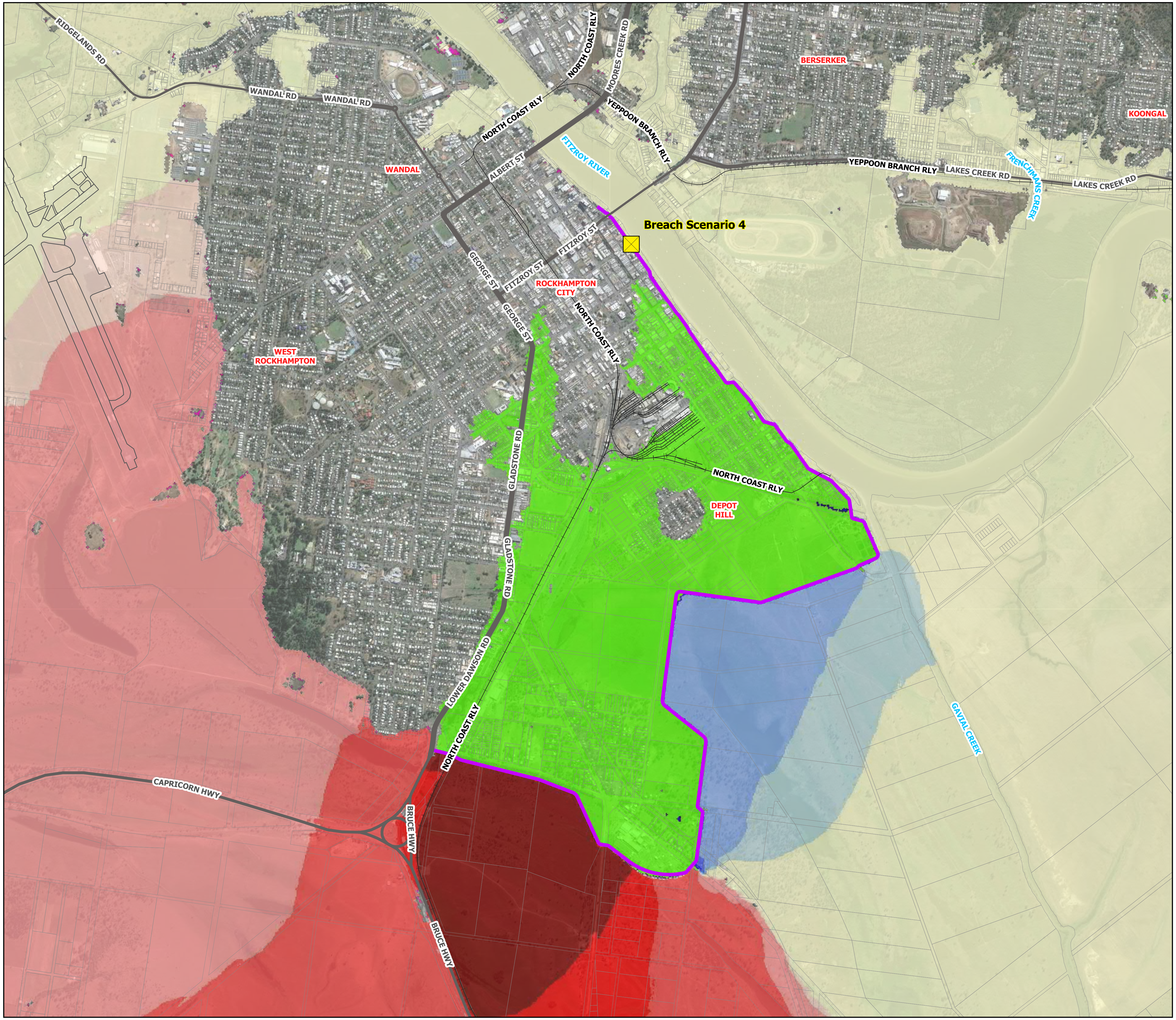

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DATUM GDA 1994, PROJECTION MGA ZONE 56

0 0.5 1 Kilometers

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LEGEND

- Breach Scenario Location
- Highways
- Main Roads
- Railway Lines
- SRFL Alignment
- Cadastre
- Hydraulic Model Extent

Difference in Peak Flood Height (m)

- < -0.3
- -0.3 to -0.225
- -0.225 to -0.15
- -0.15 to -0.075
- -0.075 to -0.05
- -0.05 to 0.05
- 0.05 to 0.075
- 0.075 to 0.15
- 0.15 to 0.225
- 0.225 to 0.3
- > 0.3
- Was Dry Now Wet
- Was Wet Now Dry

Data Sources:

DCDB (c) 2016 QLD Government
Imagery (c) 2016 RRC

SOUTH ROCKHAMPTON FLOOD LEVEE
Failure Analysis Report

Difference in Peak Flood Height
Levee Breach Scenario 4
1% AEP - Flood Peak Levee Breach

PROJECT ID	60589157
CREATED BY	JensenK2
LAST MODIFIED	03-04-2019
VERSION	01

Map
FA-22

A3

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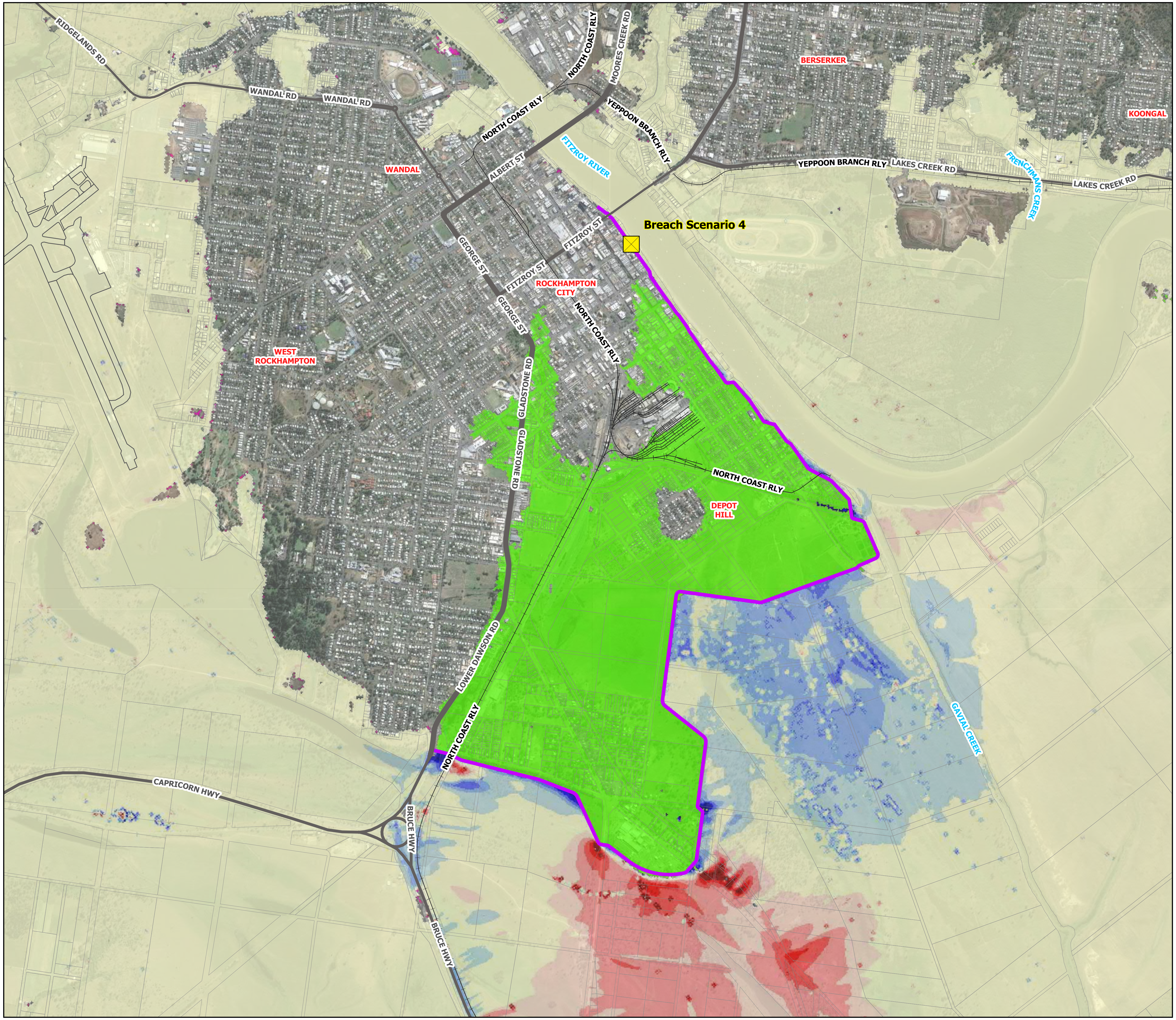

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DATUM GDA 1994, PROJECTION MGA ZONE 56

0 0.5 1 Kilometers

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LEGEND

- Breach Scenario Location
- Highways
- Main Roads
- Railway Lines
- SRFL Alignment
- Cadastre
- Hydraulic Model Extent

Peak Depth Average Velocity (m/s)

- < -0.5
- -0.5 to -0.4
- -0.4 to -0.3
- -0.3 to -0.2
- -0.2 to -0.1
- -0.1 to 0.1
- 0.1 to 0.2
- 0.2 to 0.3
- 0.3 to 0.4
- 0.4 to 0.5
- > 0.5
- Was Dry Now Wet
- Was Wet Now Dry

Data Sources:

DCDB (c) 2016 QLD Government
Imagery (c) 2016 RRC

SOUTH ROCKHAMPTON FLOOD LEVEE
Failure Analysis Report

Difference in Peak Depth Averaged Velocity
Levee Breach Scenario 4
1% AEP - Flood Peak Levee Breach

PROJECT ID	60589157
CREATED BY	JensenK2
LAST MODIFIED	03-04-2019
VERSION	01

Map
FA-23

A3

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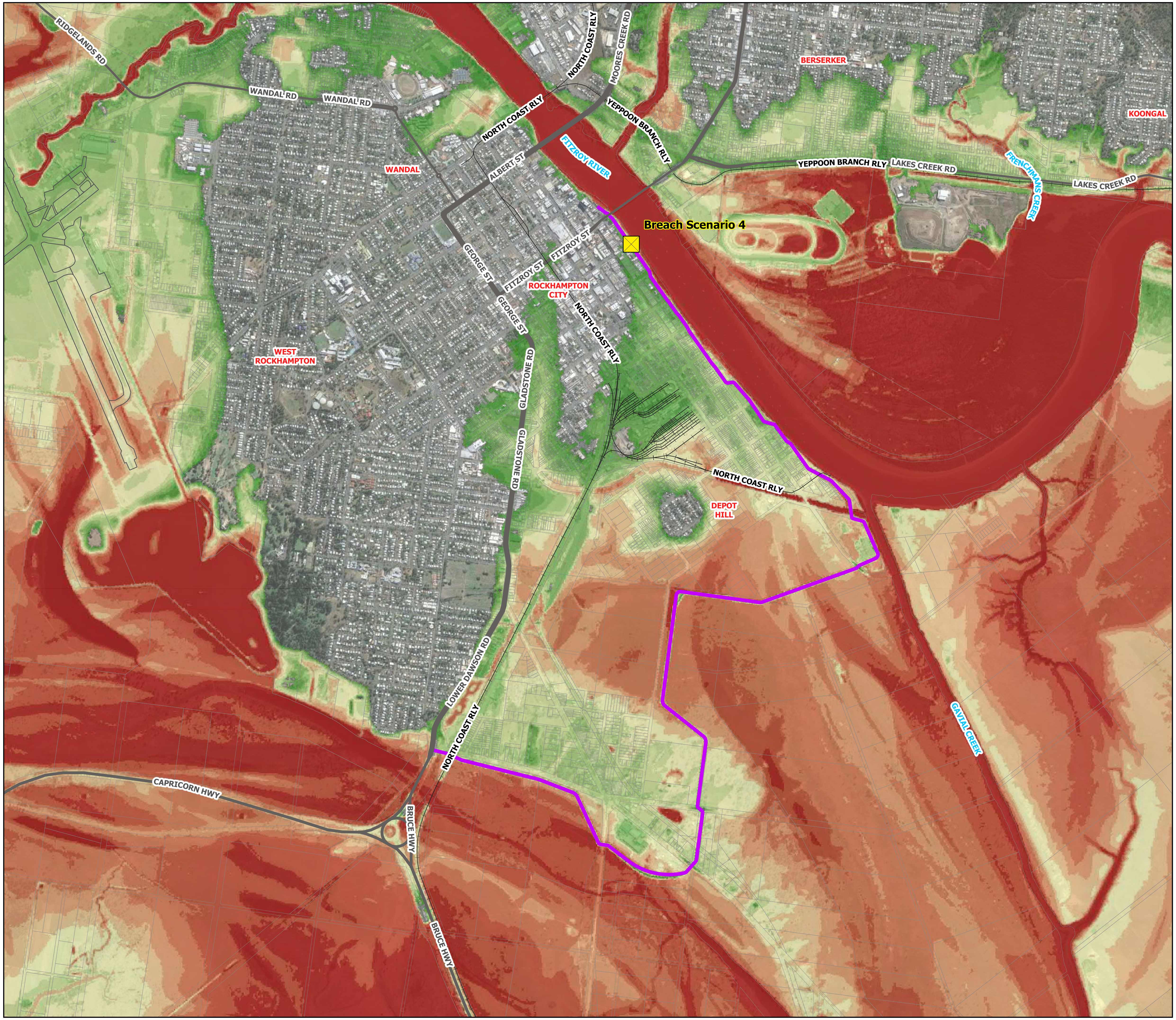

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0 0.5 1 Kilometers

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LEGEND

- Highways
- Main Roads
- Railway Lines
- SRFL Alignment
- Cadastre
- Hydraulic Model Extent

Peak Flood Depth (m)

- < 0.5
- 0.5 - 1.0
- 1.0 - 1.5
- 1.5 - 2.0
- 2.0 - 2.5
- 2.5 - 3.0
- 3.0 - 3.5
- 3.5 - 4.0
- 4.0 - 4.5
- 4.5 - 5.0
- > 5.0

Data Sources:

DCDB (c) 2016 QLD Government
Imagery (c) 2016 RRC

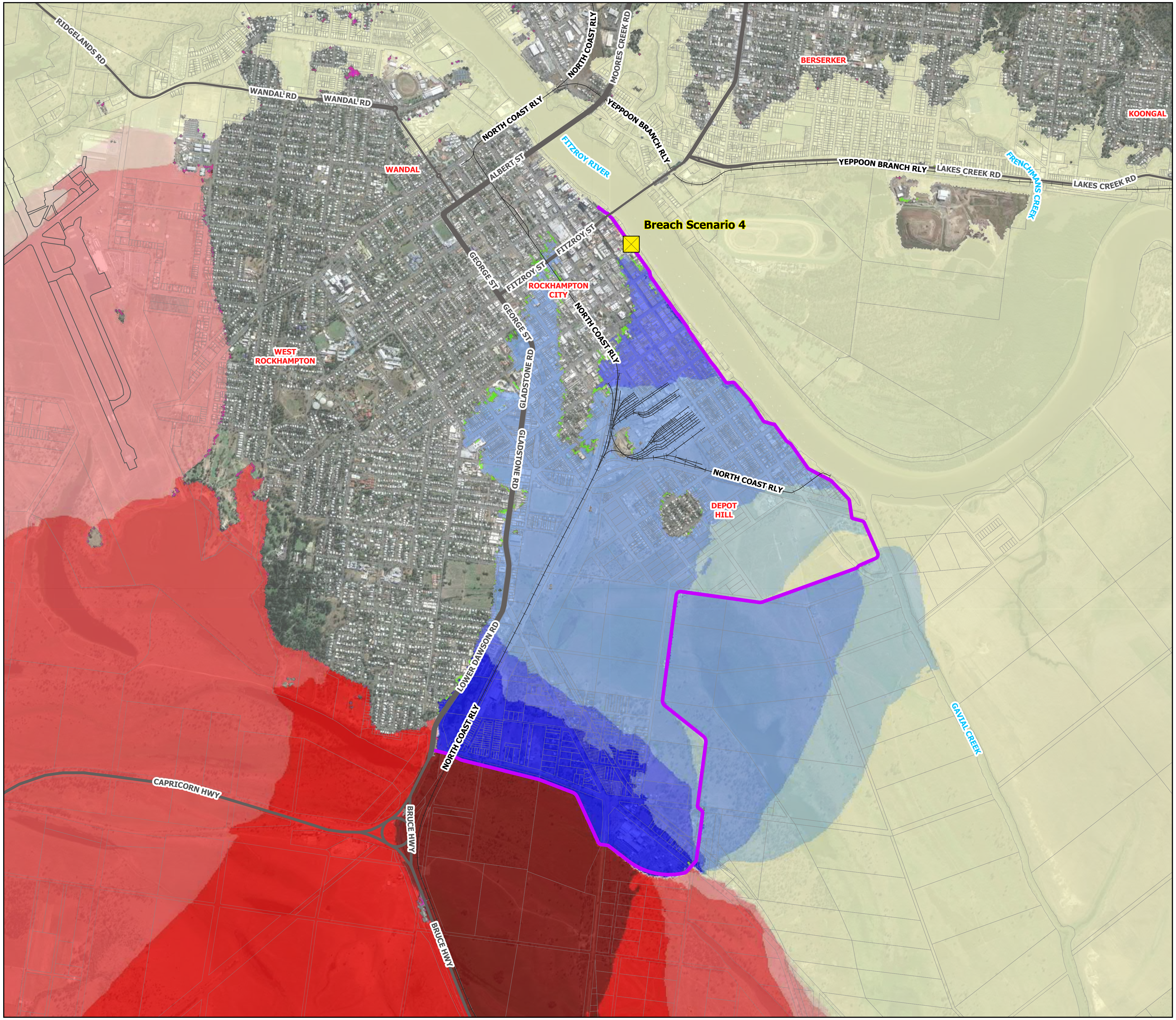
SOUTH ROCKHAMPTON FLOOD LEVEE
Failure Analysis Report

Peak Flood Depth and Extent
Levee Breach Scenario 4
0.2% AEP - Flood Peak Levee Breach

PROJECT ID	60589157
CREATED BY	JensenK2
LAST MODIFIED	03-04-2019
VERSION	01

Map
FA-24

A3



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0 0.5 1 Kilometers

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LEGEND

- Breach Scenario Location
- Highways
- Main Roads
- Railway Lines
- SRFL Alignment
- Cadastre
- Hydraulic Model Extent

Difference in Peak Flood Height (m)

- < -0.3
- -0.3 to -0.225
- -0.225 to -0.15
- -0.15 to -0.075
- -0.075 to -0.05
- -0.05 to 0.05
- 0.05 to 0.075
- 0.075 to 0.15
- 0.15 to 0.225
- 0.225 to 0.3
- > 0.3
- Was Dry Now Wet
- Was Wet Now Dry

Data Sources:

DCDB (c) 2016 QLD Government
Imagery (c) 2016 RRC

SOUTH ROCKHAMPTON FLOOD LEVEE
Failure Analysis Report

Difference in Peak Flood Height
Levee Breach Scenario 4
0.2% AEP - Flood Peak Levee Breach

PROJECT ID	60589157
CREATED BY	JensenK2
LAST MODIFIED	03-04-2019
VERSION	01

Map
FA-25

A3

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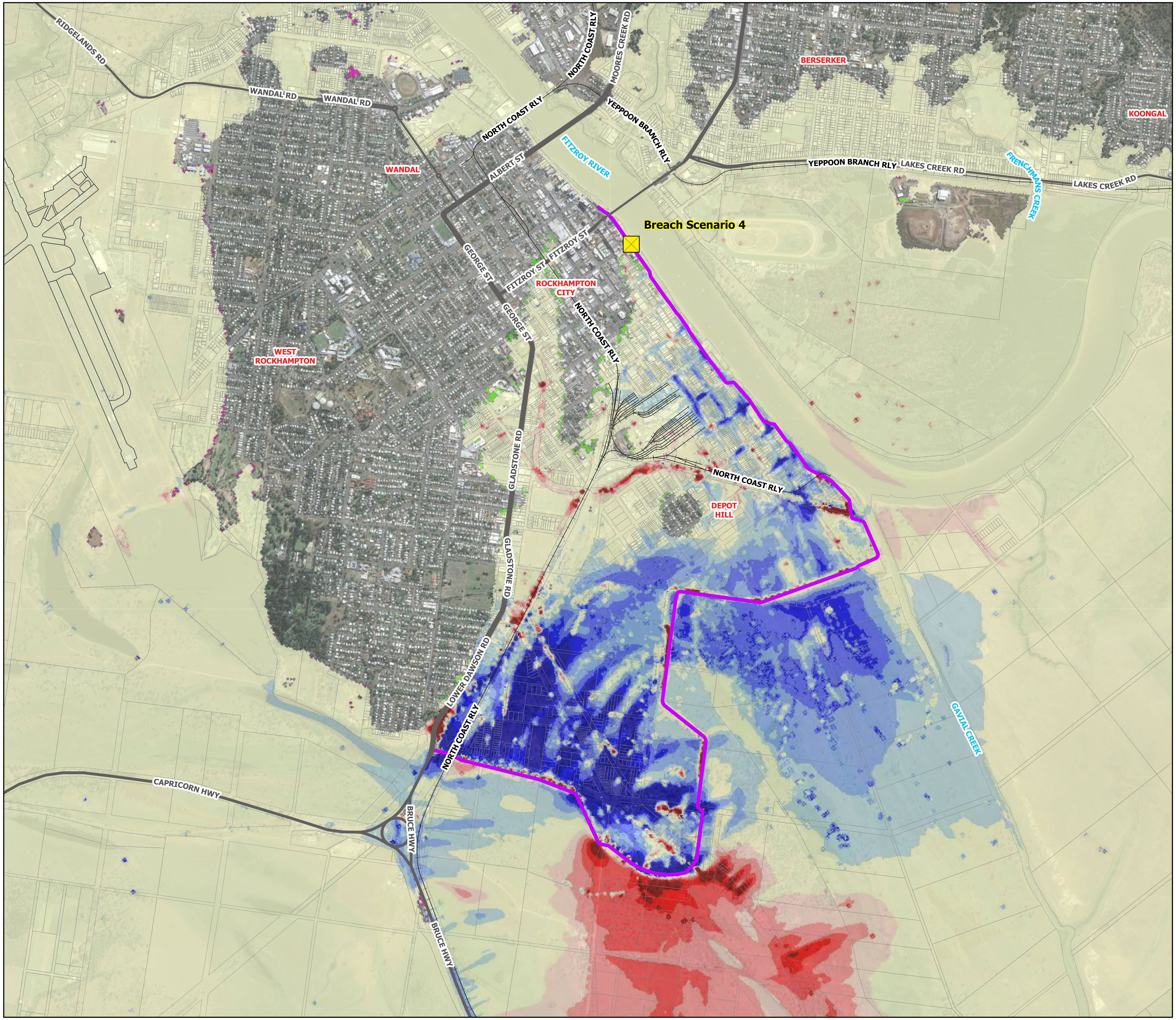

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DATUM GDA 1994, PROJECTION MGA ZONE 56

0 0.5 1 Kilometers

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LEGEND

- Breach Scenario Location
- Highways
- Main Roads
- Railway Lines
- SRFL Alignment
- Cadastre
- Hydraulic Model Extent

Peak Depth Average Velocity (m/s)

- < -0.5
- -0.5 to -0.4
- -0.4 to -0.3
- -0.3 to -0.2
- -0.2 to -0.1
- -0.1 to 0.1
- 0.1 to 0.2
- 0.2 to 0.3
- 0.3 to 0.4
- 0.4 to 0.5
- > 0.5
- Was Dry Now Wet
- Was Wet Now Dry

Data Sources:

DCDB (c) 2016 QLD Government
Imagery (c) 2016 RRC

SOUTH ROCKHAMPTON FLOOD LEVEE
Failure Analysis Report

Difference in Peak Depth Averaged Velocity
Levee Breach Scenario 4
0.2% AEP - Flood Peak Levee Breach

PROJECT ID	60589157
CREATED BY	JensenK2
LAST MODIFIED	03-04-2019
VERSION	01

Map
FA-26

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