PART B.

Assessment of Matters

7.0 Hydraulic Analysis and Assessment

Detailed hydraulic analysis and assessment has been undertaken for the Project to identify existing flooding conditions, the potential impacts from the Project and mitigation and management measures. Reporting of operation and maintenance requirements, as well as emergency response and failure analysis, has also been undertaken for the Project.

A number of technical reports have been produced and are included as appendices to this EAR. Table 7-1 provides a summary of the attached technical reports and the sections of the EAR where they are summarised.

Table 7-1 Summary of Hydraulic Assessment Technical Reporting

Technical Report	Author Year	Appendix	Section of EAR
2019 Fitzroy River Baseline Model Update Report	AECOM 2019	Appendix H	Section 7.2.1
South Rockhampton Local Catchment Baseline Flood Study	AECOM 2018	Appendix I	Section 7.2.2
SRFL Hydraulic Assessment Report (Volume 1) SRFL Hydraulic Assessment Report (Volume 2)	AECOM 2019	Appendix J	Section 7.3
SRFL Interior Drainage Hydraulic Assessment (Volume 1) SRFL Interior Drainage Hydraulic Assessment (Volume 2)	AECOM 2019	Appendix K	Section 7.4
SRFL Operations and Maintenance Manual	AECOM 2019	Appendix M	Section 7.6
SRFL Emergency Response Plan	AECOM 2019	Appendix N	Section 7.7
SRFL Failure Analysis Report	AECOM 2019	Appendix L	Section 7.8
SRFL Vulnerability and Tolerability Assessment Report (Volume 1) SRFL Vulnerability and Tolerability Assessment Report (Volume 2)	AECOM 2019	Appendix O	Section 7.9

7.1 Flood Mechanisms and Behaviour

Flooding in the Rockhampton region can occur from a number of different flooding mechanisms, including.

- Riverine flooding from the Fitzroy River (refer Section 7.1.1).
- Creek flooding from creek catchments (refer Section 7.1.2).
- Local catchment flooding from stormwater runoff refer Section 7.1.3).

7.1.1 Fitzroy River Flooding

The Fitzroy River catchment is capable of producing severe flooding following heavy rainfall events in any of its major tributaries. The most notable floods on record are listed in order of severity below:

- January 1918 – 10.11 m Rockhampton Gauge Datum (8.66mAHD).
- February 1954 – 9.40 m Rockhampton Gauge Datum (7.95mAHD).
- January 1991 – 9.30 m Rockhampton Gauge Datum (7.85mAHD).

- January 2011 – 9.20 m Rockhampton Gauge Datum (7.75mAHD) (refer Figure 7-1 showing flooding in the Project area during the 2011 event).
- April 2017 – 8.90 m Rockhampton Gauge Datum (7.45mAHD).

To the northwest of Rockhampton, at the Pink Lily meander, significant overbank flow occurs in major flood events where the discharge exceeds 6,200 m^3/s (approximately 1 in 6-year AEP). This results in flood flows spreading over a broad floodplain to the west and south of Rockhampton. This floodwater re-joins the Fitzroy River south of the city at Gavial Creek.

The inundation of the floodplain can result in the closure of Rockhampton Airport, the Bruce and Capricorn Highways and the North Coast Rail Line. The Bruce Highway and North Coast Rail Line can also be cut by floodwaters at the Alligator Creek Crossing near Yaamba (30 kilometres north of Rockhampton). As major floods can last for several weeks there is often an extensive disruption to road, rail and air traffic that results in extensive indirect losses. Extensive property damage can also occur within Rockhampton during flood events which can result in significant direct losses and pose a safety risk to the population. The recent construction of the Yeppen North and Yeppen South high level bridges has provided access into Rockhampton from the south, for Fitzroy River flood events up to and including the 1% AEP. This infrastructure has significantly reduced disruption to road traffic entering and exiting Rockhampton from the south.

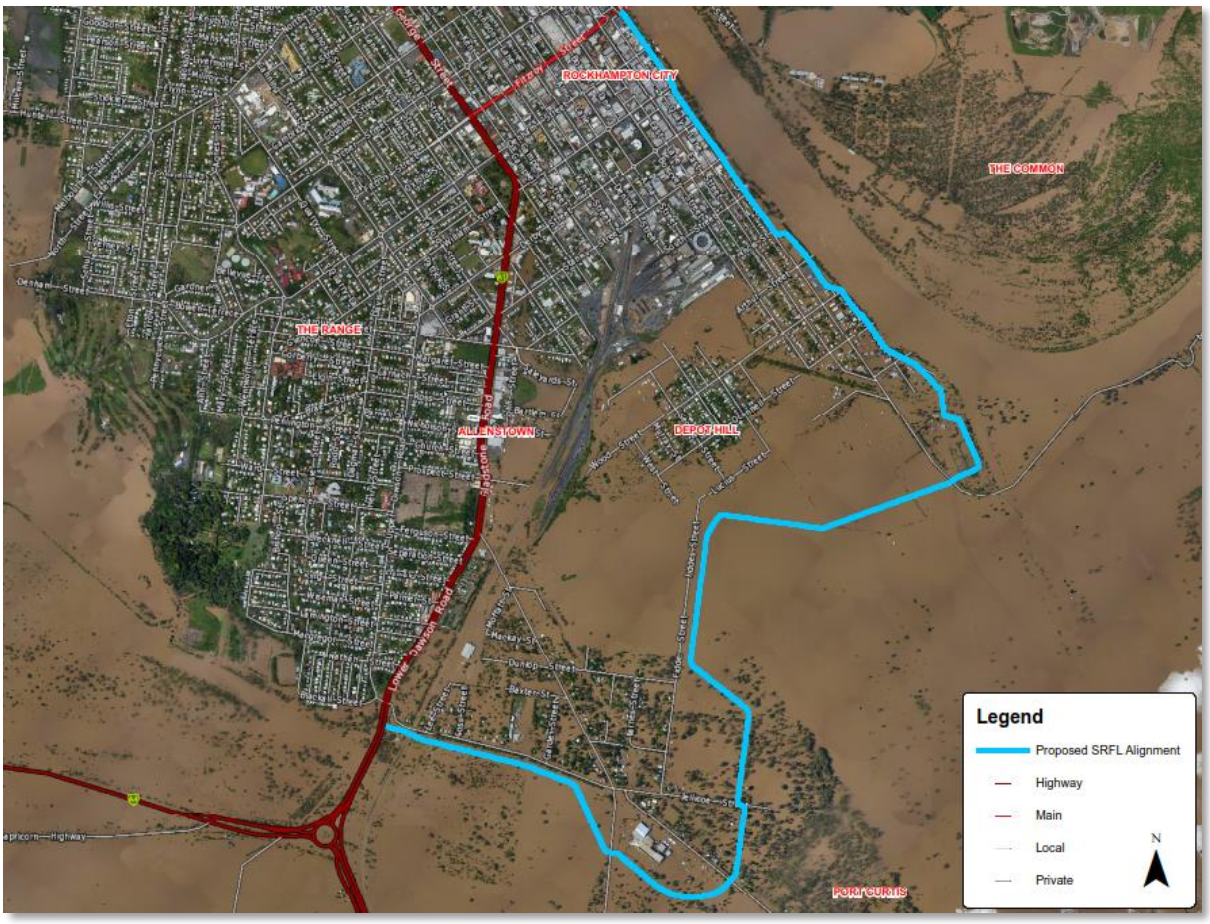

Figure 7-1 2011 Fitzroy River Flood Extent with Project overlain

7.1.2 Creek Flooding

There are a number of local tributaries which drain creek catchments to the Fitzroy River. These local tributaries, which typically have main channel widths of 10 m to 20 m and main channel depths of less than 4 m, include:

- Alligator Creek
- Limestone Creek
- Etna Creek
- Ramsay Creek
- Splitters Creek
- Lion Creek
- Moores Creek
- Frenchmans Creek and Thozets Creek
- Neerkol Creek
- Scrubby Creek
- Gavial Creek.

Significant quantities of runoff can be conveyed by the local tributaries following high rainfall in the local Rockhampton area. In some cases this runoff can intensify flooding at Rockhampton, however the local catchment runoff generally discharges through to the ocean prior to peak Fitzroy River floodwaters reaching Rockhampton from the major upstream tributaries.

The creek catchments encompass Rockhampton, Gracemere and Bouldercombe and cover varying land uses such as grazing areas, developed and rural residential areas, industrial areas, bushland, state forests and floodplain. The catchment is characterised by low lying areas across the floodplain to the west of Rockhampton and mountainous ranges to the east. Runoff from the creek catchments is conveyed via local tributaries, all of which discharge into the Fitzroy River.

Neerkol Creek and Lion Creek Flooding

Of particular interest to the Project are Neerkol Creek and Lion Creek, which are discussed in more detail below. The Neerkol Creek system stretches more than 21 km west of Rockhampton and conveys flows from several minor systems, including Gracemere Creek and Middle Creek at Gracemere. Flows from Neerkol Creek can quickly exceed the naturally-leveed creek banks and overtop towards the neighbouring lagoons and the broad lower Fitzroy floodplain.

Major expansion of the Neerkol Creek influence area occurs at Fairy Bower where a significant proportion of flow crosses Fairy Bower Road to the west of the Neerkol Creek crossing in large flood events. In such events, flows ultimately fill the lower Fitzroy floodplain and overtop Nine Mile Road into Lion Creek.

Some of this water later returns to the lower Fitzroy floodplain when it overtops Nine Mile Road for the second time (south of Nine Mile Road Bridge). Flows remaining within Neerkol Creek split downstream of Fairy Bower Road, with low flows directed to Scrubby Creek by the man-made weir situated at the end of Neerkol Creek. Floodwaters within the lower Fitzroy floodplain recede in a similar fashion to a Fitzroy River breakout event, in which waters traverse the Bruce Highway and follow Gavial Creek to join the Fitzroy River west of Depot Hill. Large events which result in widespread inundation of floodplain areas and rural assets occur following long storm durations of more than 24 hours.

The smaller catchment of Lion Creek meanders between the mountainous ranges (which entails Mount Lion) northwest of Gracemere and tends west towards Malchi Nine Mile Road. A large proportion of flows in large events tend to overtop the natural banks of Lion Creek and cross the low-lying Malchi Nine Mile Road which then recharge the downstream wetlands, including Lower Gracemere Lagoon (i.e. Paradise Lagoons). Flows reaching this point follow a similar pattern through the Yeppen Floodplain as described above.

Lion Creek flows remaining within the channel cross the floodway at Nine Mile Road and replenish storage levels within Lion Lagoons. As floodwaters exceed the available storage (large or long duration events involving high volumes of runoff) flows roughly follow Nine Mile Road towards the Rockhampton Airport, with much of the flow filling the Lotus Lagoons at Pink Lily. Rare events result in a second overtopping of Nine Mile Road (as with the Neerkol Creek catchment) south of Nine Mile Road Bridge, following the system of lagoons towards Gavial Creek and ultimately Fitzroy River.

Larger flood events from either creek system can influence the other system, resulting in a shared lower catchment extending between Gracemere and Rockhampton. Figure 7-2 shows an overview of the Neerkol Creek and Lion Creek catchments.

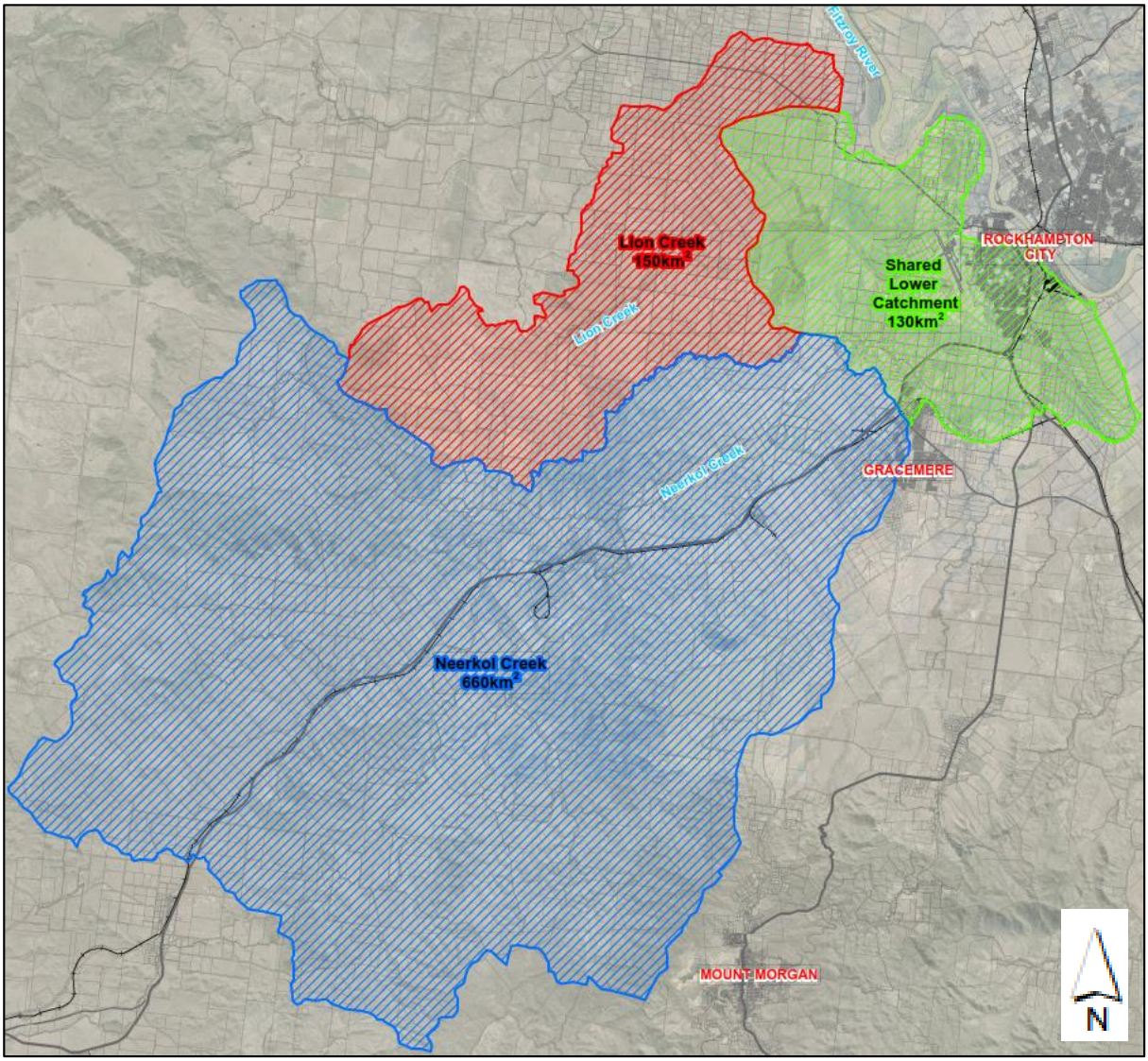

Figure 7-2 Neerkol Creek and Lion Creek Catchment Overview

Coincidental Riverine and Creek Catchment Flooding

Due to the large extent of the wider Fitzroy River catchment, flood flows take approximately 10 -14 days to reach the Rockhampton area following rainfall events in the upper catchments. As noted above, flood flows from creek tributaries generally discharge to the ocean during this period so it is uncommon for creek and river catchments to contribute to the flooding regime simultaneously.

Nevertheless, detailed sensitivity analysis was undertaken as part of the Fitzroy River Floodplain and Road Planning Study (AECOM, 2011) hydraulic assessment to evaluate the impact of a creek catchment event coinciding with a wider Fitzroy catchment event. The 1% AEP Fitzroy River flood event was modelled with the inclusion of the creek catchment inflows as source points within a two

dimensional hydraulic model and compared to the results of the Baseline 1% AEP Fitzroy River flood event. The peak of the creek catchment discharge hydrographs were applied to coincide with the Fitzroy River flood peak, representing a worst case scenario.

The relative increase caused by the additional creek inflow was found to be negligible. On this basis, it was concluded that velocities and discharges from a Fitzroy River flood event are the 'worst case' and should be adopted for the hydraulic assessment of the SRFL.

Figure 7-3 shows a comparison between the 1% AEP Fitzroy River inflows and the 1% AEP creek catchment inflows. It is noted that no assessment was undertaken on flood timings and the effect of creek catchment flooding on Fitzroy River flood rise and fall timings.

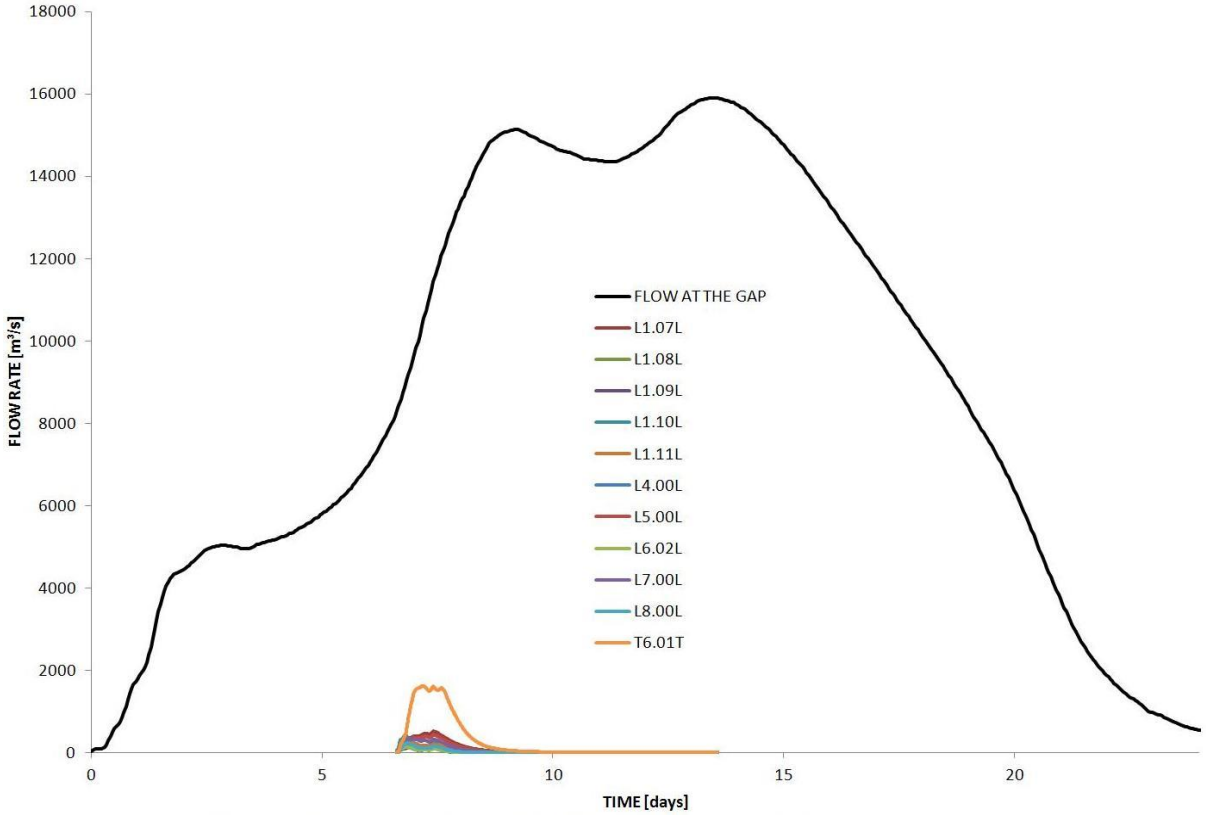

Figure 7-3 1% AEP Fitzroy River flow at the gap and 1% AEP Local Catchment Inflows

7.1.3 Local Catchment Flooding

The South Rockhampton urban catchment covers approximately 10.8 km^2 within the suburbs of The Range, Rockhampton City, Allenstown, Depot Hill and Port Curtis. The western catchment boundary follows the crest of the Range, which is generally aligned to Agnes Street. Elevations along this ridgeline reach up to 65mAHD with moderate slopes (5% - 10%) directing stormwater runoff east through the City towards the primary drainage path, known locally as the 'Main Drain'. For the purposes of this report the Main Drain upstream of the North Coast Rail Line (NCRL) is referred to as Upper Main Drain, with the area downstream of the NCRL referred to as Lower Main Drain.

The catchments within the Rockhampton City (adjacent to the Upper Main Drain) discharge towards the Fitzroy River, with runoff south of this catchment draining to both the Lower Main Drain (via overland flow paths) and the Fitzroy River (via an underground drainage system). These catchments have flat slopes in comparison to the upper reaches of the catchment.

The lower catchment south of the NCRL and Lower Main Drain has little natural grade with the majority of the terrain being below 6mAHD. This wetland area is known as the Fiddes Street Lagoon area and commonly retains water during the wet season. Most of the lagoon area drains to the south-east via cross-drainage and broad overtopping of Fiddes Street towards Gavial Creek, which outlets to the Fitzroy River.

Local catchment flooding in the South Rockhampton catchment is referred to as Interior Drainage for the Project.

Coincident Riverine and Local Catchment Flooding

Analysis of stream gauge and rainfall datasets was undertaken in order to gain an appreciation for the likelihood of high-stage Fitzroy River and local catchment rainfall occurring simultaneously at Rockhampton. River gauge data was collated from The Gap gauging station for the period of 1964 to present day and was compared to rainfall data at the Rockhampton Airport for the same period. The analysis intent was to identify if historical trends exist between Fitzroy River levels and local catchment rainfall.

Whilst it is recognised that Fitzroy River gauge levels at The Gap are not fully representative of timing and levels generated at Rockhampton, the data remains viable for the purpose of inspecting relationships between local catchment and riverine flood mechanisms. To better represent the flood wave at Rockhampton, the stream gauge data was translated forward by 24 hours. Further testing of translation values showed negligible change to the results.

Figure 7-4 shows the relationship between local catchment rainfall and Fitzroy River flood heights. This dataset is further refined in Figure 7-5 to represent the largest rainfall events on record (since 1964).

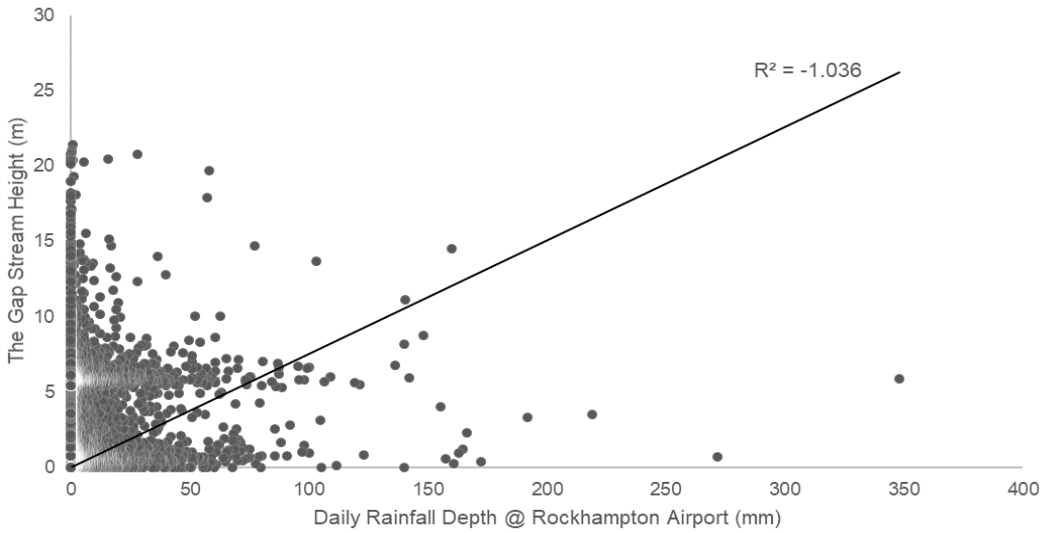

Figure 7-4 Scatter Plot of translated stream heights at The Gap (+24hrs) & Rockhampton Airport

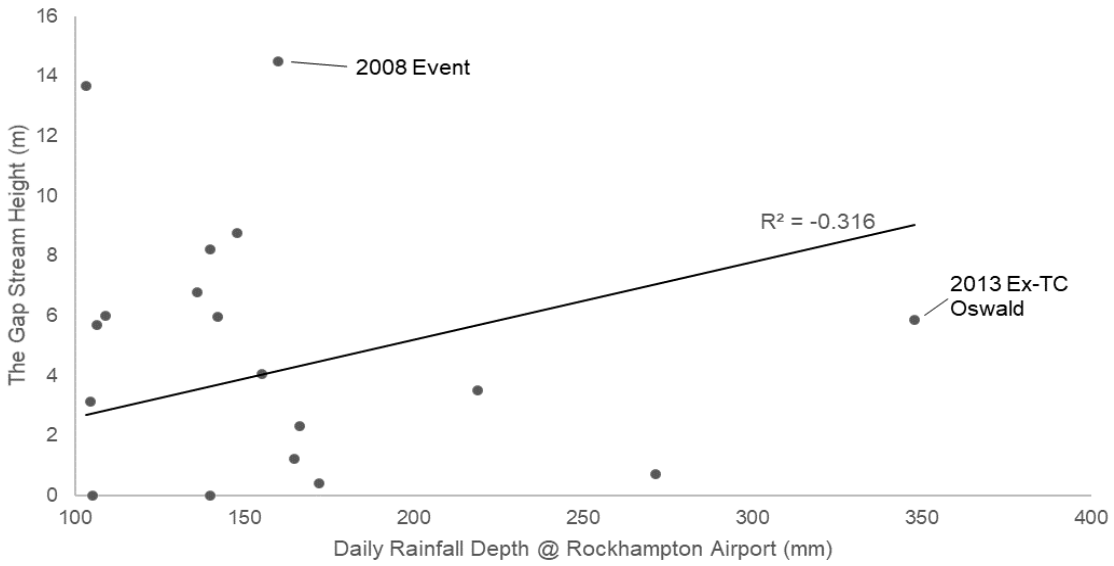

Figure 7-5 Scatter Plat screened to rainfall events greater than 100mm

In both instances, the relationship between rainfall and stream height is very poor and coincident flooding is considered unlikely based on the 55-year period assessed. Despite this, coincident Fitzroy River and Interior Drainage events of varying magnitudes have still occurred at Rockhampton.

7.2 Baseline Numerical Modelling

7.2.1 Fitzroy River Baseline Hydraulic Modelling

There is a long history of hydraulic investigations undertaken for the Fitzroy River:

- Fitzroy River Barrage Study (Department of Local Government, 1964)
- The Yeppen Model (Capricornia Institute of Advanced Education, 1977)
- Rockhampton Flood Management Study (CMPS&F, 1992)
- Rockhampton Floodplain Management Policy (Willing & Partners, 1999)
- Lower Splitters Creek Flood Study (Fisher Stewart, 2001)
- Fitzroy River Flood Study (Aurecon, 2011)
- Fitzroy River Floodplain and Road Planning Study (AECOM, 2012)
- SRFL Planning and Design (AECOM, 2014).

Hydraulic modelling of the Fitzroy River at Rockhampton has been undertaken by various consultants, using a number of different modelling software packages. Table 7-2 provides a chronological order of numerical hydraulic modelling undertaken since the original Rockhampton Flood Management Study.

Table 7-2 Hydraulic model development history

Year	Software	Study	Commissioned By	Developed By
1992	MIKE11	Rockhampton Flood Management Study	Queensland Water Resources	Camp Scott and Furphy
2011	TUFLOW Classic	Fitzroy River Flood Study	RRC	Aurecon
2011	MIKE FLOOD	FRFRPS	DTMR	AECOM
Oct 2013	*Memo prepared by AECOM for DTMR & RRC – Technical Comparison of the RFMS, FRFS and FRFRPS.*			
2014	TUFLOW Classic	SRFL Planning and Design	RRC	AECOM
	MIKE FLOOD		DTMR	
	SRFL Model Development and Comparison Report prepared by AECOM, for RRC and DTMR.			
2014-2017	TUFLOW Classic	Number of model refinements	RRC	AECOM
Dec 2017	*Decision made by DTMR Hydraulics Branch to adopt the TUFLOW model moving forward*			
2018/19	TUFLOW GPU HPC	Rockhampton Ring Road Planning	DTMR	AECOM

The updated 2019 Fitzroy River hydraulic model has been used for the Project and will be adopted by DTMR and Council for future infrastructure projects planned in the lower Fitzroy River floodplain.

Further details of the baseline hydraulic model are provided in the 2019 Fitzroy River Baseline Model Update Report, presented in Appendix H.

7.2.2 Interior Drainage Baseline Hydraulic Model

To enable assessment of the internal drainage behind the levee, a 1D/2D TUFLOW hydraulic model was used to assess a range of design flood events including interior drainage events and combined interior drainage / Fitzroy River flood events. This model included a representation of the trunk underground drainage infrastructure within the urban area and included major culverts and hydraulic controls. Previous studies and the development of the associated hydraulic model are discussed in Table 7-3.

Table 7-3 Hydraulic model development history

Year	Software	Study	Commissioned By	Developed By
2014	TUFLOW Classic	South Rockhampton Flood Levee Interior Drainage Assessment – 2014 Design	RRC	AECOM
2018	TUFLOW Classic	South Rockhampton Local Catchment Flood Study	RRC	AECOM
2019	TUFLOW HPC GPU	South Rockhampton Flood Levee Interior Drainage Assessment – 2019 Update (presented in Appendix K)	RRC	AECOM

The baseline interior drainage model was simulated for the 18%, 10%, 5%, 2%, 1% and 0.5% AEP events. Further details of baseline interior drainage hydraulic modelling is contained in the South Rockhampton Local Catchment Baseline Flood Study (Appendix I) and Interior Drainage Report (Appendix K).

7.3 Fitzroy River Hydraulic Assessment

The scope of the Fitzroy River Hydraulic Assessment undertaken for the Project is as follows.

- Present updated Baseline and Developed Case flood depths and extents, water surface elevations, velocities and flood hazard across the range of AEP events.
- Provide a brief summary of the previous levee options analysis and the preferred option.
- Describe the likely hydraulic impacts of detailed refinements of the preferred option undertaken during the 2018/19 design update.
- Discuss the legislation and guidelines relevant to the project and confirm the parameters adopted in undertaking the assessment.
- Provide mapping and data to show the predicted impact of the SRFL on existing assets (buildings and public infrastructure) for a range of AEP events.
- Assess the potential impacts of the Project in **riverine flood events** and summarise the results in this report to support the Infrastructure Designation approvals process and satisfy the Ministers Guidelines and Rules under the *Planning Act 2016.*

7.3.1 SRFL Developed Case Model Schematisation

The SRFL has been schematised in the Developed Case model by a layered combination of the levee footprint superimposed with a thin break line representing the crest of the levee alignment, including freeboard. The thin break line method raises model cell sides, effectively blocking flood flows up to the assigned elevation. This approach accounts for loss of floodplain storage and conveyance due to the levee footprint.

The levee crest elevations were adopted based on water surface elevations from the 1% AEP Developed Case simulation with the freeboard of 0.6m added. The levee crest varies in elevation from approximately 9.87mAHD at the Yeppen North connection point to 8.05mAHD at the spillway near Fiddes Street. The crest gradually rises to an elevation of 9.15mAHD at the most northern section of the levee alignment, near the Fitzroy River Bridge connection.

A fixed crested spillway has been adopted at RL 8.05mAHD. The spillway elevation is position at the 1% AEP water surface level and is located along Fiddes Street between chainage 3,550m and chainage 3,950m.

7.3.2 Outcomes of the Fitzroy River Hydraulic Assessment

7.3.2.1 Peak Water Surface Elevations and Velocities

The hydraulic assessment of the Project was undertaken for a range of Fitzroy River design flood events to clearly demonstrate the benefits and impacts of the proposed Project alignment. Difference in Peak Water Surface Elevation (PWSE) and Peak Depth Averaged Velocity (PDAV) mapping was produced for the 5%, 2%, 1%, 0.5%, 0.2% 0.05% AEP and PMF events. Detailed mapping showing expected changes in PWSE and PDAV are contained within Volume 2 of the Hydraulic Assessment Report in Appendix J.

7.3.2.2 Implications for Other Infrastructure

Expected impacts (PWSE and Time Of Submergence - TOS) were extracted at the key locations of Rockhampton Flood Gauge, existing low level Bruce Highway, Yeppen North, Blackwater Rail Line, North Coast Rail Line and the Rockhampton Airport. The predicted difference in PWSE across the range of design events at the Rockhampton Flood Gauge is shown in Table 7-4 with key receptor impacts during the 1% AEP event shown in Table 7-5.

Table 7-4 Summary of predicted design event gauge levels

Design Flood Event AEP (%)	Predicted Peak Flood Level (m Rockhampton Gauge Datum)		Difference (m)
	Baseline Scenario	SRFL Design Scenario	
5	9.05	9.08	**+0.03**
2	9.54	9.57	**+0.03**
1	9.86	9.89	**+0.03**
0.5	10.16	10.19	**+0.03**
0.2	10.53	10.56	**+0.03**
0.05	11.02	11.02	-
PMF	13.28	13.28	-

Table 7-5 Difference in WSE and TOS at key receptors (1% AEP Event)

Key Receptor	Baseline WSE (mAHD)	Dev Case WSE (mAHD)	Increase (m)	Baseline TOS (days)	Increase (hrs)
Existing Low Level Bruce Highway	9.13	9.29	**+0.16**	12.2	**+4**
Bruce Highway (Yeppen North)	9.24	9.41	**+0.17**	0.0	-
Blackwater Rail Line	9.31	9.46	**+0.15**	12.2	**+4**
North Coast Rail Line	8.96	9.30	**+0.35**	13.7	**+4**
Rockhampton Airport	9.91	9.99	**+0.08**	12.3	**+2**

7.3.2.3 Building Impacts

The effect of the Project on private and public buildings was investigated through categorical analysis, in order to gain an appreciation for the predicted benefits and impacts associated with existing building floor levels. Five categories have been defined to assess the benefit / consequence of the Project and are summarised in Table 7-6.

Table 7-6 Building Impact Categories

Category	Description
1	**Category 1 – No Change / Building Not Flooded in Baseline or Design Case Scenarios^**
2	**Category 2 – Building inundated above floor level in Baseline Scenario, but not inundated above floor level in the Design Case Scenario**
3	**Category 3 – Building inundated above floor level in Baseline Scenario and receives a flood depth decrease of >=10mm in the Design Case Scenario^**
4	**Category 4 – Building not inundated above floor level in Baseline Scenario, but is inundated above floor level in the Design Case Scenario**
5	**Category 5 – Building inundated above floor level in Baseline Scenario and receives a flood depth increase of >=10mm in the Design Case Scenario^**

^ Note: Category 1, 3 and 5 buildings have been omitted from the building impact maps within Appendix J.

A spatial assessment of the building impacts for each scenario is provided in the building impact maps presented in the Project Hydraulic Assessment Report in Appendix J (Volume 2 mapping report).

Benefited Buildings

The number of benefited buildings is determined based on the criteria for Category 2 and 3, where:

- **Category 2** describes the **removal** of above floor flooding for the defined flood magnitude; and
- **Category 3** describes the **decrease** of flood height above floor (building remains flooded).

The total number of buildings determined to be within these categories due to construction of the Project are presented in Table 7-7.

Table 7-7 Building Benefits due to the Project

Event	Category 2		Category 3	
	Buildings	Sheds	Buildings	Sheds
5% AEP	74	1	0	0
2% AEP	165	1	5	0
1% AEP	312	1	24	0
0.5% AEP	139	0	496	1
0.2% AEP	119	0	788	1
0.05% AEP	48	0	1,772	1
PMF	0	0	10	0

Impacted Buildings

The number of impacted buildings are determined based on the criteria for Category 4 and 5, where:

- **Category 4** describes the **addition** of above floor flooding for the defined flood magnitude; and
- **Category 5** describes the **increase** of flood height above floor.

The total number of buildings determined to be within these categories due to construction of the Project are presented in Table 7-8.

Table 7-8 Building Impacts due to the Project

Event	Category 4		Category 5	
	Buildings	Sheds	Buildings	Sheds
5% AEP	1	0	58	8
2% AEP	7	0	114	18
1% AEP	10	0	223	31
0.5% AEP	26	0	601	75
0.2% AEP	33	0	1085	145
0.05% AEP	12	0	1058	149
PMF	0	0	305	19

The buildings predicted to experience additional above floor impacts during the 1% AEP event (design flood immunity) have been further investigated in Table 7-9. This detailed analysis reveals the following key points.

- **All impacted buildings are anticipated to have 50mm or less of flooding above floor during the 1% AEP post-Project construction scenario.**
- One of the structure's floor height was predicted to be level with the 1% AEP baseline peak flood height. It is noted that this flood height is static and does not include provision for debris, wave run-up or velocity head which may increase the peak flood height during an actual event.

Table 7-9 1% AEP Impacted Buildings Detail

Building Unique ID	Floor Height (mAHD)	Peak Flood Height (mAHD)		Baseline Depth Below Floor (m)	Post-Project Construction Depth Above Floor (m)
		Baseline	Post-Project Construction		
7929	9.99	9.91	10.00	-0.08	+0.01
5724	10.29	10.26	10.30	-0.03	+0.01
7042	10.01	9.95	10.03	-0.06	+0.02
7238	10.00	9.94	10.02	-0.06	+0.02
7146	9.99	9.94	10.02	-0.05	+0.03
7149	9.99	9.94	10.02	-0.05	+0.03
9654	9.66	9.57	9.69	-0.09	+0.03
2631	8.68	8.68	8.71	-	+0.03
6347	10.08	10.06	10.13	-0.02	+0.05
9684	9.12	9.02	9.17	-0.10	+0.05

Summary of Building Inundation

The anticipated number of buildings flooded above floor for the range of simulated design events is tabulated in Table 7-10 and plotted alongside the **Category 2** benefits and **Category 4** impacts. It can be seen that the number of benefited buildings heavily outweighs impacted buildings, especially during frequent events.

Table 7-10 Summary of Buildings Flooded Above Floor

Flood Event AEP (%)	Number of Buildings Flooded Above Floor^		Category 2: Above Floor to Not Flooded	Category 4: Not Flooded to Above floor	Net Difference
	Baseline	Post-Project Construction			
5	239	165	75	1	-74
2	507	348	166	7	-159
1	906	603	313	10	-303
0.5	1536	1423	139	26	-113
0.2	2369	2283	119	33	-86
0.05	3534	3498	48	12	-36
PMF	7607	7607	0	0	-

^ *Note: Buildings to be demolished prior to construction of the Project have been excluded from the analysis.*

Optimisation of the levee alignment has minimised hydraulic impacts as much as practicable without compromising the overall objectives of the project. The final alignment has seen additional refinement since the 2014 works as a result of additional stakeholder and community consultation. Other requirements including geotechnical, civil / structural, environmental, cultural heritage and visual amenity were also considered in selecting the final location of the alignment.

Ultimately there is a trade-off between the flood protection benefits and the impacts posed to people and infrastructure outside of the Project. Whether the impacts are acceptable or not does not form part of this technical assessment.

7.3.3 Recommendations and Limitations

The Fitzroy River Hydraulic Assessment presented a number of key recommendations and highlighted limitations of the analysis, which are detailed in the technical report presented in Appendix J.

7.4 Interior Drainage Hydraulic Assessment

The scope of the Interior Drainage Hydraulic Assessment undertaken for the Project is as follows.

- Detail the development of the hydraulic model which has been used to assess the existing flooding conditions of the South Rockhampton urban area and provide input into the design of the internal drainage infrastructure associated with the levee system.
- Assess the changes to the local catchment flooding regime with the proposed levee and internal drainage infrastructure in place.
- Quantify the potential flooding impacts and benefits to properties located within the internal catchment of the levee system. The impacts and benefits identified in the Interior Drainage Hydraulic Assessment report should be read in conjunction with those identified in the Fitzroy River Hydraulic Assessment Report (refer Section 7.3).
- The development of clear and easy to understand flood mapping products for use in future design and implementation phases of the Project.

Details of the Interior Drainage Hydraulic Assessment are included in Appendix K (Volume 1 technical report and Volume 2 mapping report).

7.4.1 Internal Drainage Strategy

The internal drainage strategy of the levee system incorporates a number of components that facilitate drainage of the protected area:

- Existing underground drainage infrastructure along the Fitzroy River will operate as normal during local rainfall events but will be retrofitted with backflow prevention devices (BPDs) to prevent backup of Fitzroy River during river flooding events.
- Existing overland flow paths are generally maintained through a combination of breaks in the levee and culvert structures that allow flow through the levee when Fitzroy River levels are not elevated.
- Landside open channels are to be constructed along the toe of the levee to discharge runoff longitudinally to three interior stormwater pump stations. The pump stations are to provide drainage of the internal area of the levee system once the outlets of the underground drainage and culvert structures are inundated and normal gravity flow ceases. The pump stations will also assist the existing drainage network during larger local catchment events.
- Optimisation of the pump station duty flow rates was undertaken in close consultation with RRC's project team in 2014 through a number of iterations and workshop sessions. Ultimately a duty flow rate for each pump station was selected based on a trade-off between pump station capital cost / ongoing expenditure vs increased flood damage to existing properties.

7.4.2 Interior Drainage Developed Case Model Schematisation

Two scenarios have been simulated for the Developed Case interior drainage assessment, as follows:

1. **Scenario D20a**: Levee in and **closed**, existing local catchment conditions, local catchment event with coincident Fitzroy River event.
    - This series of simulations was undertaken to determine the existing flooding conditions due to local catchment rainfall events with the levee system in place, assuming that this rainfall occurred while flood levels in the Fitzroy River were elevated.
    - As Fitzroy River levels are elevated during these scenarios it is assumed no gravity flow occurs through the pipe / culvert outlets and the temporary barriers at access points along the levee are in place. For this scenario, drainage of the internal area of the levee only occurs via the three interior drainage pump stations.
2. **Scenario D20b**: Levee in and **open**, existing local catchment conditions, local catchment event only.
    - This series of simulations was undertaken to determine the flooding conditions due to local catchment rainfall events with the levee system in place, assuming no concurrent Fitzroy River flooding. Initial conditions and tailwater levels within the Fitzroy River are set to 2.66mAHD, equivalent to MHWS.
    - As the Fitzroy River levels are not elevated, the culverts that drain through the levee are not inundated and can drain freely. Temporary barriers at access points along the Fitzroy River are not in place and drainage can occur through these openings in the levee.
    - For this scenario the Main Drain pump is not operating to allow for the rise and fall of the tide through the Main Drain culvert, however due to the magnitude of flows in the Fiddes Street and Hastings Deering areas these pump stations remain operational.

7.4.3 Outcomes of the Interior Drainage Hydraulic Assessment

7.4.3.1 Peak Water Surface Elevations and Velocities

A hydraulic assessment of the Project was undertaken for a range of interior drainage design flood events, to clearly demonstrate the benefits and impacts of the Project on local catchment flood behaviour. Difference in PWSE and PDAV mapping was produced for the 18%, 10% 5%, 2%, 1% and 0.5% AEP events.

7.4.3.2 Building Impacts

Building impacts were investigated in order to gain an appreciation for the predicted benefits and impacts associated with building floor levels. Five categories have been defined to assess the benefit / impact and are summarised in Table 7-11.

Table 7-11 Building Impact Categories

Category	Description
1	**Category 1 – No Change / Building Not Flooded in Baseline or Design Case Scenarios^**
2	**Category 2 – Building inundated above floor level in Baseline Scenario, but not inundated above floor level in the Design Case Scenario**
3	**Category 3 – Building inundated above floor level in Baseline Scenario and receives a flood depth decrease of >=10mm in the Design Case Scenario^**
4	**Category 4 – Building not inundated above floor level in Baseline Scenario, but is inundated above floor level in the Design Case Scenario**
5	**Category 5 – Building inundated above floor level in Baseline Scenario and receives a flood depth increase of >=10mm in the Design Case Scenario^**

^ Note: Category 1, 3 and 5 buildings have been omitted from the building impact maps within Appendix J.

Benefited Buildings

The number of benefited buildings is determined based on the criteria for Category 2 and 3, where:

- **Category 2** describes the **removal** of above floor flooding for the defined flood magnitude
- **Category 3** describes the **decrease** of flood height above floor (building remains flooded).

The total number of buildings determined to be within these categories due to construction of the Project are presented in Table 7-12.

Table 7-12 Building Benefits due to Project

Flood Event AEP (%)	Category 2		Category 3	
	D20a (levee closed)	D20b (levee open)	D20a (levee closed)	D20b (levee open)
18	1	4	0	1
10	1	4	0	0
5	0	4	1	0
2	0	3	1	4
1	0	2	1	3
0.5	1	5	1	4

Impacted Buildings

The number of impacted buildings are determined based on the criteria for Category 4 and 5, where:

- **Category 4** describes the **addition** of above floor flooding for the defined flood magnitude
- **Category 5** describes the **increase** of flood height above floor.

The total number of buildings determined to be within these categories due to construction of the Project are presented in Table 7-13.

Table 7-13 Building Impacts due to Project

Flood Event AEP (%)	Category 4		Category 5	
	D20a (levee closed)	D20b (levee open)	D20a (levee closed)	D20b (levee open)
18	26	0	11	0
10	28	0	17	0
5	34	0	20	0
2	35	0	26	0
1	31	0	35	0
0.5	31	0	42	0

Summary of Building Impact Assessment

The anticipated number of buildings flooded above floor for the range of simulated design events is tabulated in Table 7-14 and Table 7-15, for the D20a (levee closed) and D20b (levee open) scenarios respectively.

Table 7-14 Summary of Buildings Flooded Above Floor (D20a compared to Baseline)

Flood Event AEP (%)	Number of Buildings Flooded Above Floor^		Category 2: Above Floor to Not Flooded	Category 4: Not Flooded to Above floor	Net Difference
	Baseline	Post-Project Construction			
18	41	66	1	26	+25
10	56	83	1	28	+27
5	75	109	0	34	+34
2	114	149	0	35	+35
1	147	178	0	31	+31
0.5	176	206	1	31	+30

^ *Note: Buildings to be demolished prior to construction of the SRFL have been excluded from the analysis.*

Table 7-15 Summary of Buildings Flooded Above Floor (D20b compared to Baseline)

Flood Event AEP (%)	Number of Buildings Flooded Above Floor^		Category 2: Above Floor to Not Flooded	Category 4: Not Flooded to Above floor	Net Difference
	Baseline	Post-SRFL Construction			
18	41	37	4	0	-4
10	56	52	4	0	-4
5	75	71	4	0	-4
2	114	111	3	0	-3
1	147	145	2	0	-2
0.5	176	171	5	0	-5

^ *Note: Buildings to be demolished prior to construction of the SRFL have been excluded from the analysis.*

It can be seen in Table 7-15 there is predicted to be no additional above floor impacts during the levee open scenario, for the range of design events assessed.

While there is predicted to be above floor impacts during the interior drainage levee closed scenario, the fact remains that the levee system will reduce above floor impacts due to Fitzroy River flooding. Table 7-16 provides a summary of the net benefit of the levee system, for the area on the dry side of the levee. It can be seen that the levee system provides a net benefit across all design events assessed.

Table 7-16 Summary of Buildings Flooded Above Floor (Fitzroy River – to be compared to D20a)

Flood Event AEP (%)	Number of Buildings Flooded Above Floor^		Category 2: Above Floor to Not Flooded	Category 4: Not Flooded to Above floor	Net Difference
	Baseline	Post-Project Construction			
5	239	165	75	1	-74
2	507	348	166	7	-159
1	906	603	313	10	-303
0.5	1536	1423	139	26	-113

^ *Note: Buildings to be demolished prior to construction of the SRFL have been excluded from the analysis.*

Whether the SRFL represents an acceptable impact on people, property and other assets is outside the scope of this technical assessment.

7.4.4 Limitations and Recommendations

The Interior Drainage Hydraulic Assessment presented a number of key recommendations and highlighted limitations of the analysis, which are detailed in the technical report presented in Appendix K.

7.5 Levee Categorisation

For the purposes of regulation, levees in Queensland are classified into three categories based on their potential level of impact. The categorisation ensures that the level of assessment that a levee application will need to go through is proportionate to the level of risk that the levee poses to people, property and the catchment. The categories and assessment level are provided in Table 7-17.

Table 7-17 Levee categories (DNRME, 2018)

Category	Definition	Level of Assessment	Assessor
1	A levee that has no off-property impact	Self-assessment	Applicant
2	A levee that has an off-property impact and for which the affected population is less than 3	Code assessment	Local government
3	A levee that has an off-property impact and for which the affected population is at least 3	Impact assessment	Local government with Queensland Government as referral agency

The Guidelines state that the affected population needs to be calculated in order to classify a levee as category 2 or 3. The affected population, for a levee, means the total number of persons occupying the building or buildings on which the levee has a significant impact, as follows.

- An increase, caused by the levee, of more than 5 cm in the flow height of water over the floorboards of the building.
- An increase, caused by the levee, of more than 0.2 m/s in the flow velocity of water over the height of the floorboards of the building.

As noted above, a building Impact Assessment was undertaken to quantify the predicted number of building impacted from the Project. The results are summarised in Table 7-18 to meet the requirements of the Guidelines.

Table 7-18 Summary of Impacted Buildings – As per Queensland Levee Guidelines

Flood Event AEP (%)	Buildings Affected by Increased Water Surface Levels Above Floor Level (> 50 mm)	Buildings Affected by Increased Velocities Above Floor Level (> 0.2 m/s)	Total Number of Buildings Affected *
5	5	0	5
2	47	1	48
1	127	1	128
0.5	168	3	171
0.2	212	12	224
0.05	252	20	272
PMF	0	51	51

* Buildings affected by increased flood height have been cross checked against increased velocities to prevent double counting.

Hydraulic modelling and assessment has determined that the Project will be a Category 3 levee.

7.6 Operations and Maintenance

The SRFL Operations and Maintenance (O&M) Manual (refer Appendix M) should be read in conjunction with the SRFL Emergency Response Plan (AECOM, 2019).

Section 4.1.4 of The International Levee Handbook (CIRIA, 2013) states that a levee's O&M procedures should be defined during the design phase; **however the first version of the manual should not be issued until after completion of construction.**

It is noted that the O&M Manual has been prepared at the Design phase of the project and is related only to the available information at the conclusion of concept design. This document, and the associated Emergency Response Plan document, will need to be further developed and finalised during subsequent stages of detailed design, construction and operation.

7.6.1 Purpose

The purpose of the **SRFL Operations and Maintenance Manual** is to inform Council personnel of the correct operational procedures, required maintenance and appropriate management to ensure the continued viability and safety of the SRFL and associated infrastructure. The O&M:

- Defines the responsibilities for the safety of the levee.
- Details procedures for regular and scheduled activities, to ensure these activities are completed in a safe and consistent manner.

7.7 Emergency Management

The SRFL Emergency Response Plan (ERP) (refer Appendix N) should be read in conjunction with the SRFL O&M Manual (AECOM, 2019).

Section 4.1.4 of The International Levee Handbook (CIRIA, 2013) states that a levee's O&M Manual, and associated emergency planning procedures, should be defined during the design phase; however **the first version of the manual and emergency procedures should not be issued until after completion of construction.**

It is noted that the ERP document has been prepared at the concept design phase of the project and is related only to the available information at the conclusion of the concept design. This document, and the associated O&M Manual, will need to be further developed and finalised during subsequent stages of detailed design, construction and operation.

7.7.1 Purpose

The purpose of the ERP is to pre-plan the coordination of the roles, responsibilities and actions to be taken proceeding, during and following an emergency event. This may include a Fitzroy River flood event, an internal local catchment rainfall event or a levee failure. The ERP:

- Ensures appropriate notifications prior to, during and after an emergency event.
- Ensures necessary actions are taken prior to, during and after an emergency event.

7.8 Failure Analysis

The primary objective of the SRFL Failure Analysis Report (refer Appendix L) is to provide information to RRC and the local disaster management group, for use in emergency planning. The Failure Analysis 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.

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.

7.8.1 Failure Mechanisms Considered

Due to the vast array of possible hydraulic failure scenarios, only a range of structural failure scenarios have been assessed in the 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.

7.8.1.1 Levee Breach Scenarios

The SRFL design drawings were reviewed to identify potential locations for levee breach. 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 7-6shows the location of levee breach scenarios selected for analysis.

7.8.1.2 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 7-20.

Table 7-19 Levee Breach Scenario Simulation Summary

Simulation ID	Scenario No.	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

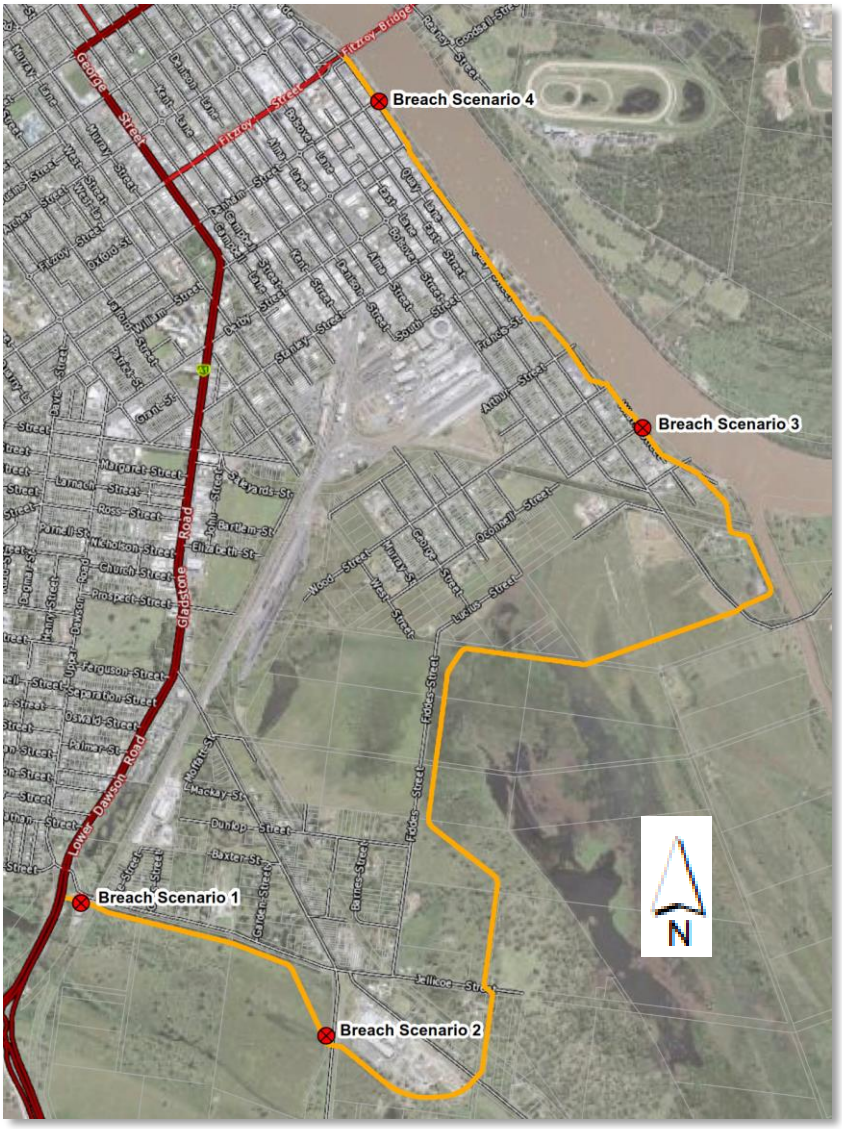

Figure 7-6 Levee breach scenario locations

7.8.2 Outcomes of the Failure Assessment

Analysis of the breach scenario results show the following.

- 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.

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 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.

7.8.3 Levee Overtopping

In addition to levee failure, the risks associated with levee overtopping were also assessed. The Project 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 ± 0.25m 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 9.9mAHD and internal ground surface levels is 8.9mAHD).
- 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.

7.8.4 Limitations and Recommendations

The Failure Assessment Report presented a number of key recommendations and highlighted limitations of the analysis, which are detailed in the technical report presented in Appendix L.

7.9 Changes to Flood Resilience

A Vulnerability and Tolerability assessment has been undertaken to establish the vulnerability and tolerability of the Lower Fitzroy Catchment community during a riverine flood event, for pre-levee and post-levee scenarios. This assessment is based on QRA's Planning for stronger, more resilient floodplains: Part 2 – Measures to support floodplain management in future planning schemes (2012). The Vulnerability and Tolerability Assessment Report is presented as Appendix O.

7.9.1 Flood Risk

The level of flood risk exposure is related to the likelihood of flooding and predicted consequence, as shown graphically below.

7.9.2 Likelihood

The likelihood of a specific flood event taking place within a given time period is described in terms of the probability of occurrence of that event, usually described as AEP. Unless the Project is designed to the PMF level, there is a residual risk that the levee will be overtopped. Furthermore, a decline in flood awareness and preparedness may result from the future perception of flood 'protection' offered by the Project. This could significantly influence flood damage costs, evacuation efficiency and overall community mindset.

The concept of "encounter probability" which, when linked with the AEP, also provides a useful framework for risk management decision making. Figure 7-7has been provided to show the percentage likelihood of a 1% AEP flood event (or greater) occurring during a 30 year, 50 year and 100 year period. The 1% AEP represents the Design Flood Event for the Project.

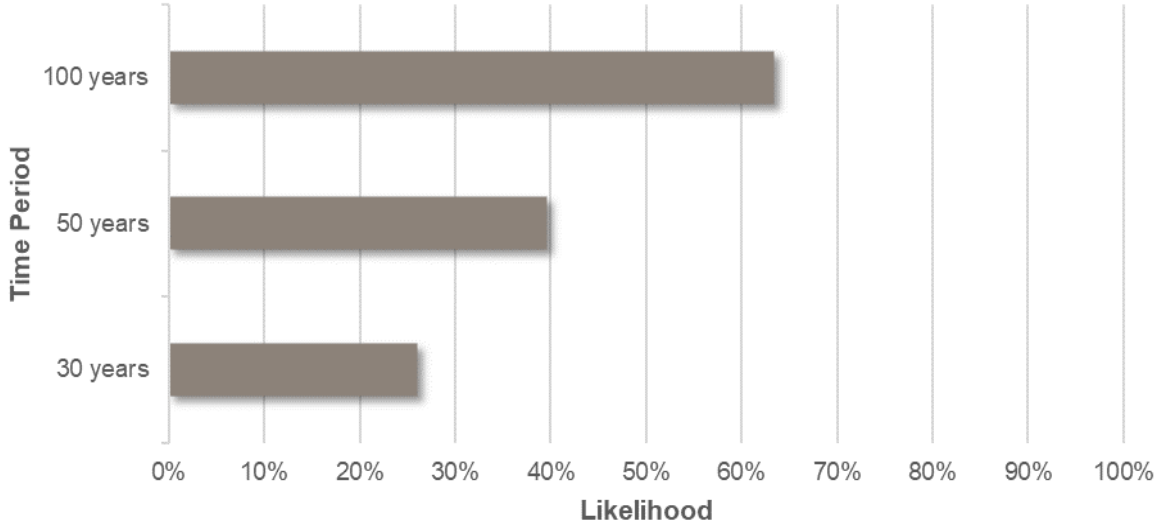

Figure 7-7 Likelihood of a flood event exceeding the 1% AEP during the specified number of years

The figure shows:

- There is a 26% chance that a 1% AEP flood event (or greater) will occur in the 30 years following construction of the Project.
- There is a 39% chance that a 1% AEP flood event (or greater) will occur in the 50 years following construction of the Project.
- There is a 63% chance that a 1% AEP flood event (or greater) will occur in the 100 years following construction of the Project.

The period of 30 years has been chosen to align with typical residential mortgage timeframes and 100 years has been chosen as it represents the design life of the Project.

It is highly recommended that Council clearly communicate this residual flood risk to the community via awareness campaigns and education materials. 'So you live behind a levee' (American Society of Civil Engineers) is a good example of public education and awareness materials adopted in other communities protected by levee structures.

7.9.3 Consequences of Flooding

The consequence of flooding is a reflection of who, what and how people, property and infrastructure are impacted by flooding. Consequences are described in terms of exposure to flood hazard and the vulnerability to impacts as a result of that flood event.

As shown graphically below, the consequences of flooding are reduced by the tolerability of people, property and infrastructure to the impacts of flood hazard.

7.9.3.1 Exposure

Exposure is a measure of the potential for flood hazard to create flood risk. Exposure is measured using a combination of flood hazard severity and land use. Exposure has been measured using a combination of hazard severity (in accordance with ARR 2016, see Figure 7-8) and land use type as shown in Table 7-20.

Table 7-20 Assessment of exposure to hazard (QRA, 2012)

Hazard Severity (at selected likelihood)	Built Form & Associated Safety	Score
H1 – generally safe for people, vehicles and buildings	Landscape	0
H2 – unsafe for small vehicles	Open space and recreation/Rural	1
H3 – unsafe for vehicles, children and the elderly	Industrial	2
H4 – unsafe for people and vehicles	Commercial	3
H5 – unsafe for vehicles and people. All buildings vulnerable to structural damage. Some less robust building types vulnerable to failure.	Infrastructure & Utilities/Rural Residential	4
H6 – unsafe for vehicles and people. All building types considered vulnerable to failure.	Residential/Community & Cultural	5

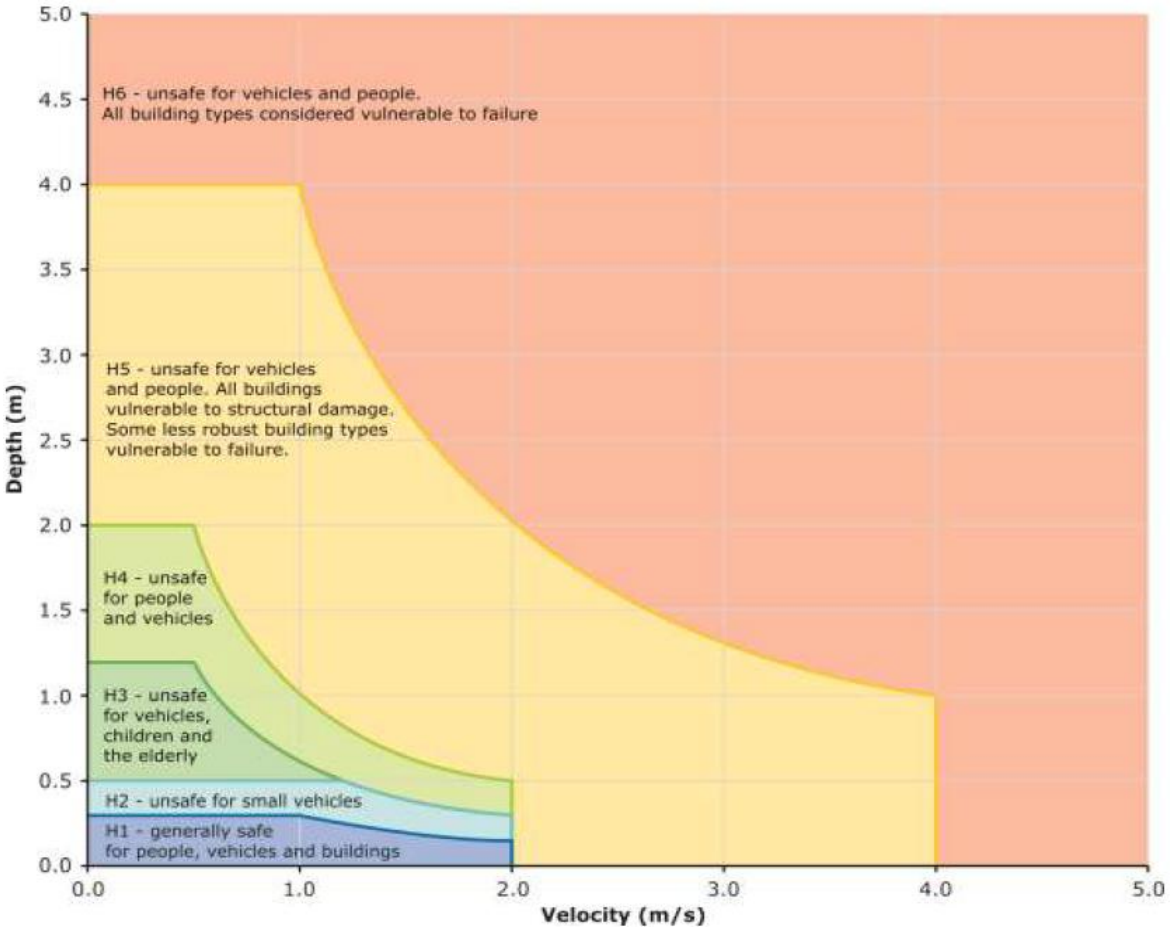

Figure 7-8 Flood hazard classification (ARR, 2016)

7.9.3.2 Vulnerability

The Australian Emergency Management Institute (AEMI) defines vulnerability as '*the degree of susceptibility and resilience of a community, its social setting, and the natural and built environments to flood hazards*' (AEMI, 2014). Vulnerable communities are impacted by flooding more than non-vulnerable communities due to the inherent characteristics of the community.

Vulnerability is assessed in terms of ability of the community and environment to anticipate, cope and recover from flood events. Flood awareness is an important indicator of vulnerability and is defined as '*an appreciation of the likely effects of flooding, and a knowledge of the relevant flood warning, response and evacuation procedures*' (AEMI, 2014).

In communities with a high degree of flood awareness, the response to flood warnings is prompt and effective. In communities with a low degree of flood awareness, flood warnings are liable to be ignored or misunderstood and residents are often confused about what they should do, when to evacuate, what to take with them and where it should be taken.

Vulnerability within the context of the assessment is measured using a combination of vulnerable land use types and built form & associated safety as shown in Table 7-21. These criteria are of particular interest for the Project area as above floor flooding and inundation of critical services are key issues known by the local community.

Table 7-21 Assessment of vulnerability to hazard severity (QRA, 2012)

Vulnerable Land Use	Built Form & Associated Safety	Score
Existing / proposed built form not affected by hazard (regardless of use), or no existing/proposed vulnerable land use or affected persons (e.g. Landscape, Open Space and Recreation)	Existing built form not affected by hazard	0
Commercial, Industrial, Rural, Rural Residential and Residential without vulnerable persons	At grade – industrial	1
Hazardous Materials / Warehousing	Elevated (elevated above selected flood)	2
Community & Cultural with Vulnerable Property, or Minor infrastructure	At grade – commercial	3
Community & Cultural with Vulnerable Persons, or Residential with Vulnerable Persons	At grade – community	4
Evacuation Centres / Airports / Other Critical Infrastructure or	Not elevated above selected flood – residential	5

7.9.3.3 Tolerability

Flood tolerability relates to the attitudes and level of resilience within a community, which can reduce the impacts of flood exposure when an event occurs. This can include both qualitative and quantitative metrics, including personal attitudes to and awareness of flood events, levels of insurance, prevalence of use of flood emergency plans and the extent to which people assist each other in times of flood.

Tolerability within the context of the assessment is measured using the criteria shown in Table 7-22. These criteria are:

- Level of Protection from Existing / Proposed Structural Works.
- Ability of use to remain operational during / after selected flood event (critical infrastructure only).

The assessment was not able to quantify the following criteria due to limitations of spatial data:

- Community Awareness / Understanding, Perception of Hazard and Preparedness.
- Emergency Management Procedures / Evacuation.

Table 7-22 Assessment of tolerability to hazard (QRA, 2012)

Community Awareness / Understanding[1]	Community Perception of Hazard[1]	Community Preparedness[1]	Emergency Management Procedures / Evacuation[1]	Level of Protection from Existing / Proposed Structural Works	Ability of use to remain operational during / after selected flood event (critical infrastructure only)	Score
Unaware	Intolerant and not resilient	No individual preparedness business continuity & social networks	For residential/critical infrastructure - no emergency services access to lot, or For non-residential - no evacuation procedures in place on lot	None	Not able to remain operational	0
Partially Aware	Fearful and generally not resilient	As above, but limited	As above, but limited	< 2% AEP	N/A	1
Moderately Aware	Cautious and moderately resilient	As above, but acceptable	As above, but acceptable	2% - 1% AEP	Reduced but acceptable operations	2
Generally Aware	Generally tolerant and resilient	As above, but strong	As above, but strong	1% AEP	N/A	3
Very Aware	Tolerant and Resilient	As above, but very strong	As above, but very strong	> 1% AEP	Able to remain fully operational	4
No persons or property affected, or emergency services/evacuation procedures and structural controls unnecessary						5

[1] *Not included within the assessment due to data limitations.*

7.9.4 Risk Level Score

The risk level score has been assessed based on QRA's risk matrix, which multiplies consequence by risk and categorizes the result as follows:

- Risk Level < 4 = **Broadly Acceptable**
- Risk Level ≥ 4 *and* < 8 = **Tolerable, subject to ALARP (As Low as Reasonably Possible)**
- Risk Level > 8 = **Generally Intolerable.**

The adopted risk matrix shown in Figure 7-9 has been used in the assessment to inform the impacts of the Project as it takes into account variation in vulnerability and tolerability across a range of likelihoods, enabling quantification and evaluation of the project's effect on risk to the existing community.

	Consequence Score										
Likelihood	0	1	2	3	4	5	6	7	8	9	10
10%	0	10	20	30	40	50	60	70	80	90	100
5%	0	5	10	15	20	25	30	35	40	45	50
2.5%	0	2.5	5	7.5	10	12.5	15	17.5	20	22.5	25
2%	0	2	4	6	8	10	12	14	16	18	20
1%	0	1	2	3	4	5	6	7	8	9	10
0.5%	0	0.5	1	1.5	2	2.5	3	3.5	4	4.5	5
0.2%	0	0.2	0.4	0.6	0.8	1	1.2	1.4	1.6	1.8	2
0.1%	0	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9	1

Broadly Acceptable
Tolerable subject to ALARP
Generally Intolerable

Figure 7-9 Adopted risk matrix (QRA, 2012)

7.9.5 Results

The count of buildings for each risk category are summarised in Table 7-23 and Table 7-24 with the change quantified in Table 7-25.

Table 7-23 Count of Buildings – Existing Conditions

Category	5% AEP	2% AEP	1% AEP	0.5% AEP	0.2% AEP
Broadly Acceptable	8,752	8,126	7,456	6,699	9,767
Tolerable, subject to ALARP	5	7	280	3,068	0
Generally Intolerable	1,010	1,634	2,031	0	0

Table 7-24 Count of Buildings – Post-Project Construction Conditions

Category	5% AEP	2% AEP	1% AEP	0.5% AEP	0.2% AEP
Broadly Acceptable	9,298	8,829	8,459	6,826	9,767
Tolerable, subject to ALARP	43	85	65	2,941	0
Generally Intolerable	426	853	1,243	0	0

Table 7-25 Difference in Count of Buildings between Assessed Conditions

Category	5% AEP	2% AEP	1% AEP	0.5% AEP	0.2% AEP
Broadly Acceptable	+546 ▲	+703 ▲	+1,003 ▲	+127 ▲	-
Tolerable, subject to ALARP	+ 38 ▲	+ 78 ▲	- 215 ▼	-127 ▼	-
Generally Intolerable	-584 ▼	-781 ▼	-788 ▼	-	-

The change in building results between assessed conditions presented in Table 7-25 has been further categorised to clearly present the number of buildings benefited (risk level reduced) and impacted (risk level increased) due to construction of the Project. Buildings identified as being impacted have been further delineated to separate those increased to a 'Tolerable, subject to ALARP' level and those increased to 'Generally Intolerable'. These results are presented in Table 7-26 and show:

- Benefits heavily outweigh impacts across all events.
- The 1% AEP event realises the most benefited buildings.
- A total of 38 building's risk level are anticipated to increase to 'Tolerable, subject to ALARP'.
- A total of 29 building's risk level are anticipated to increase to 'Generally Intolerable'.
- No benefits or impacts to risk level are anticipated during the 0.2% AEP event (or rarer) due to the low likelihood (see Figure 7-10).

These results have also been visualised in the Vulnerability and Tolerability Report, presented in Appendix O.

Table 7-26 Categorised Impacts and Benefits to Building Risk Levels

Category	5% AEP	2% AEP	1% AEP	0.5% AEP	0.2% AEP
Risk Level Reduced	592	799	1,011	164	0
Risk Level Unchanged	9,169	8,952	8,748	9,566	9,767
Risk Level Increased to Tolerable, subject to ALARP[1]	0	1	0	37	0
Risk Level Increased to Generally Intolerable[1]	6	15	8	0	0

[1] *Results have been cross-checked between assessed likelihoods to remove double-counting.*

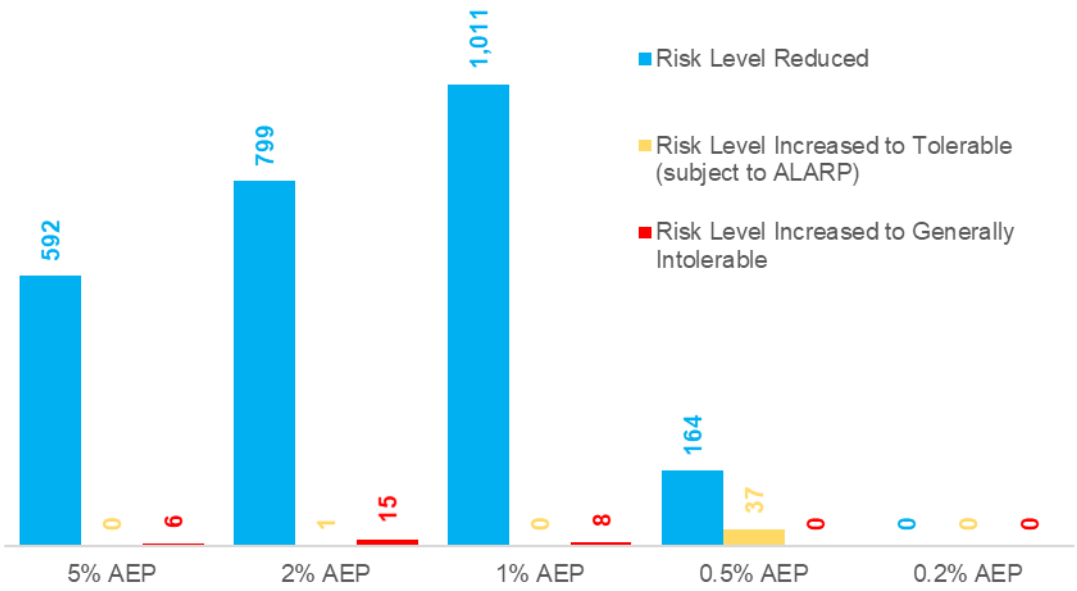

Figure 7-10 Categorised Impacts and Benefits to Building Risk Levels

7.10 Implications of Other Floodplain Infrastructure

Currently, there are a number of infrastructure projects either underway or planned within the lower Fitzroy floodplain. Refer to Table 7-27 and Figure 7-11 for a summary of these projects.

Table 7-27 Floodplain Infrastructure Planned Works Timeline

Project	Flood Immunity (ARI)	Status
Capricorn Highway Duplication	~1 in 17 year (close to existing flood immunity)	Design & Construct. Due for completion in October 2020
South Rockhampton Flood Levee	1 in 100 year	Approvals, Detailed Design and Early Works. Commencing construction in late 2019 (this Project)
Rockhampton Airport Levee	To be determined, likely to be either 1 in 50 or 1 in 100 year	Feasibility Study to commence in May 2019
Splitters Creek Levee	To be determined, likely to be 1 in 100 year	High Level Concept Evaluation Complete
Eastern Rail Corridor	To be determined, likely to be 1 in 100 year	High Level Concept Evaluation Complete
Rockhampton Ring Road	To be determined, likely to be 1 in 100 year	Preliminary Evaluation and Business Case Underway

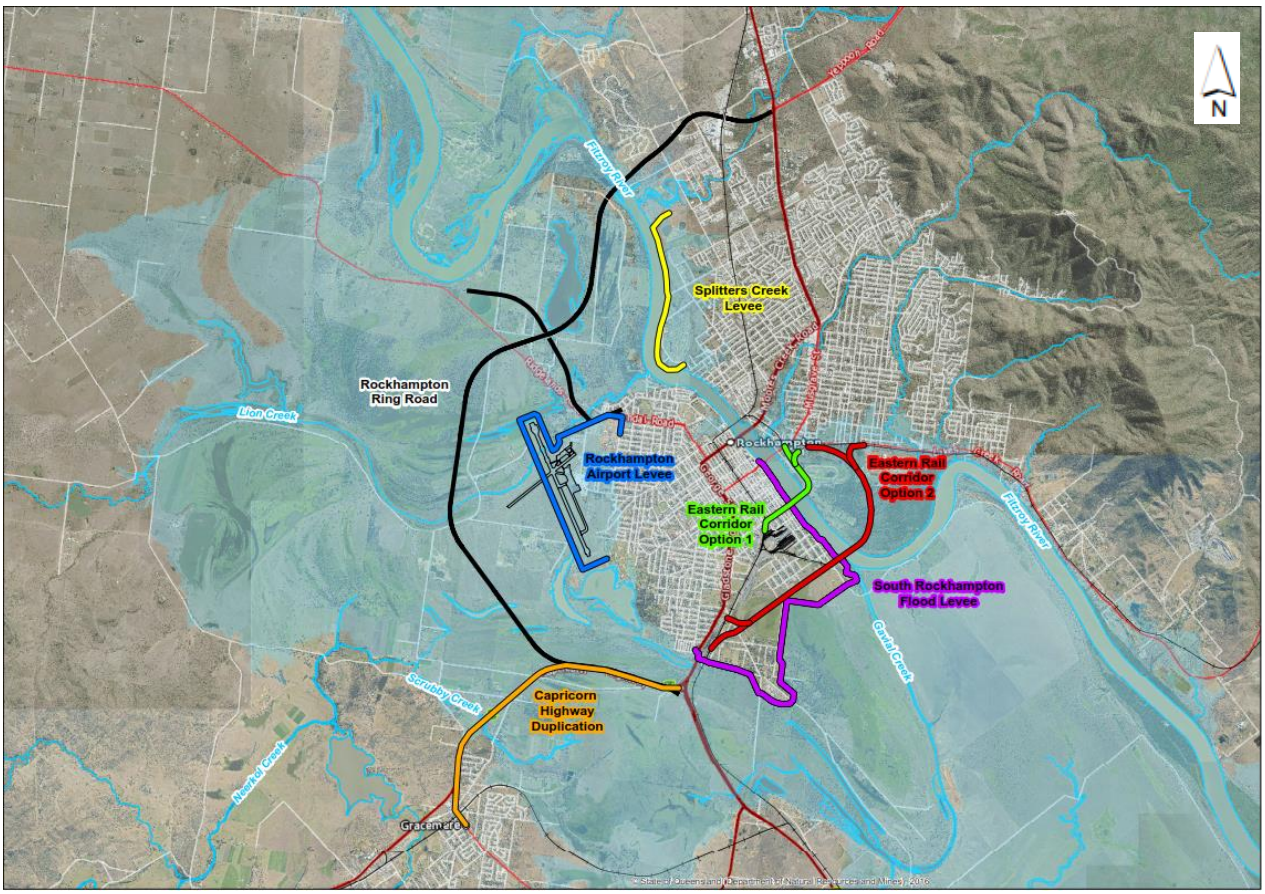

Figure 7-11 Floodplain Infrastructure Planned Works Overview

7.10.1 Capricorn Highway Duplication

SMEC and Fulton Hogan are currently undertaking the Design and Construct Contract for the Capricorn Highway Duplication, which extends from the Yeppen Roundabout to Gracemere and includes duplicating 'at grade' with some minor grade line raising and culverts. The overview of the Capricorn Highway Duplication is shown in Figure 7-12.

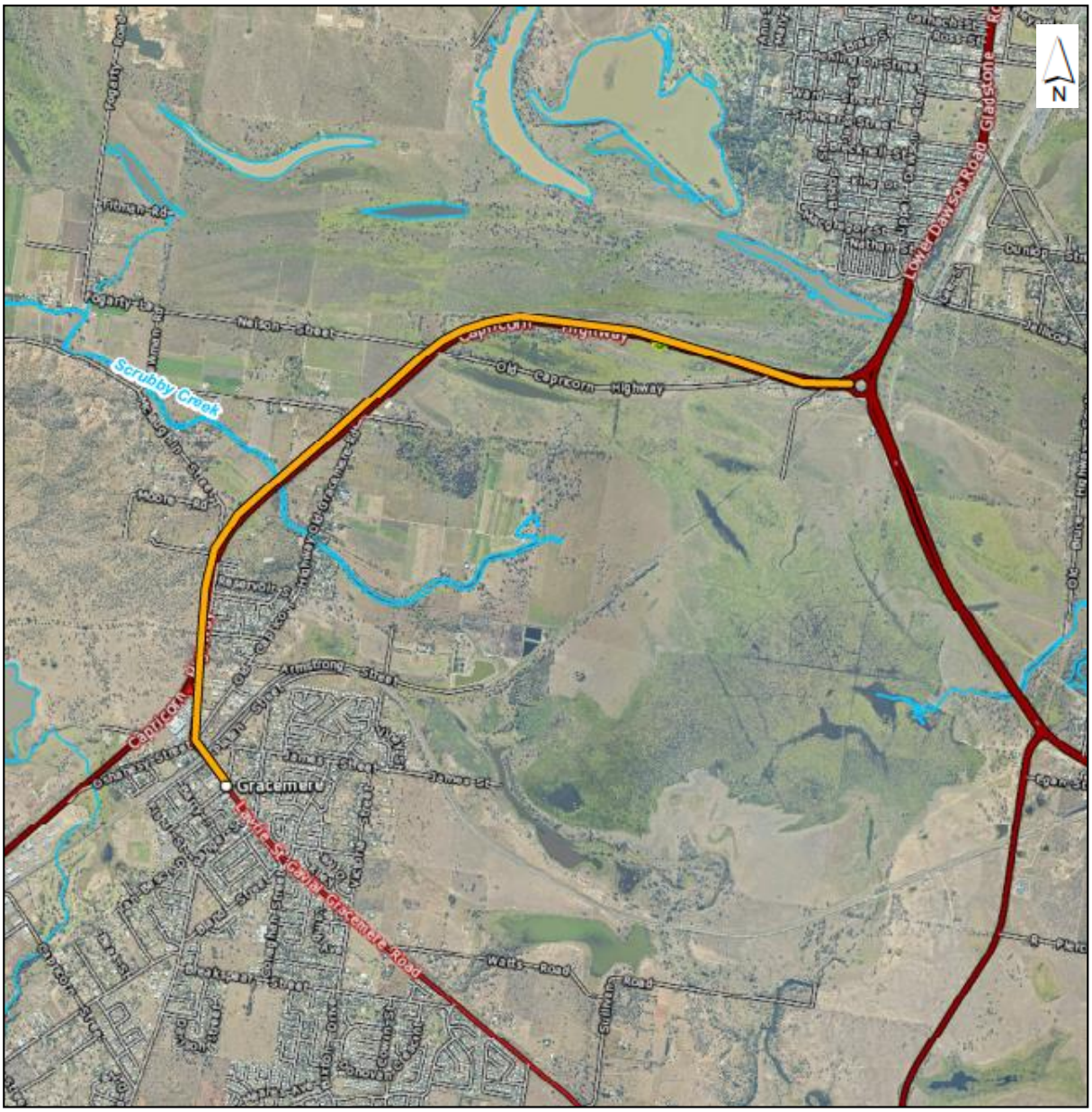

Figure 7-12 Capricorn Highway Duplication

7.10.2 Rockhampton Ring Road

The Rockhampton Ring Road (RRR) project commences on the Capricorn Highway approximately 2km west of the intersection of the Bruce and Capricorn Highways at the Yeppen Roundabout. The RRR alignment traverses north through the lower Fitzroy floodplain sweeping around the Rockhampton Airport at Pink Lily and intersecting the Rockhampton - Ridgelands Road before crossing the Fitzroy River north of Limestone Creek. After crossing the Fitzroy River, the RRR intersects Alexandra Street in Parkhurst and connects with the Bruce Highway at the Bruce Highway and Rockhampton - Yeppoon Road intersection (refer Figure 7-13).

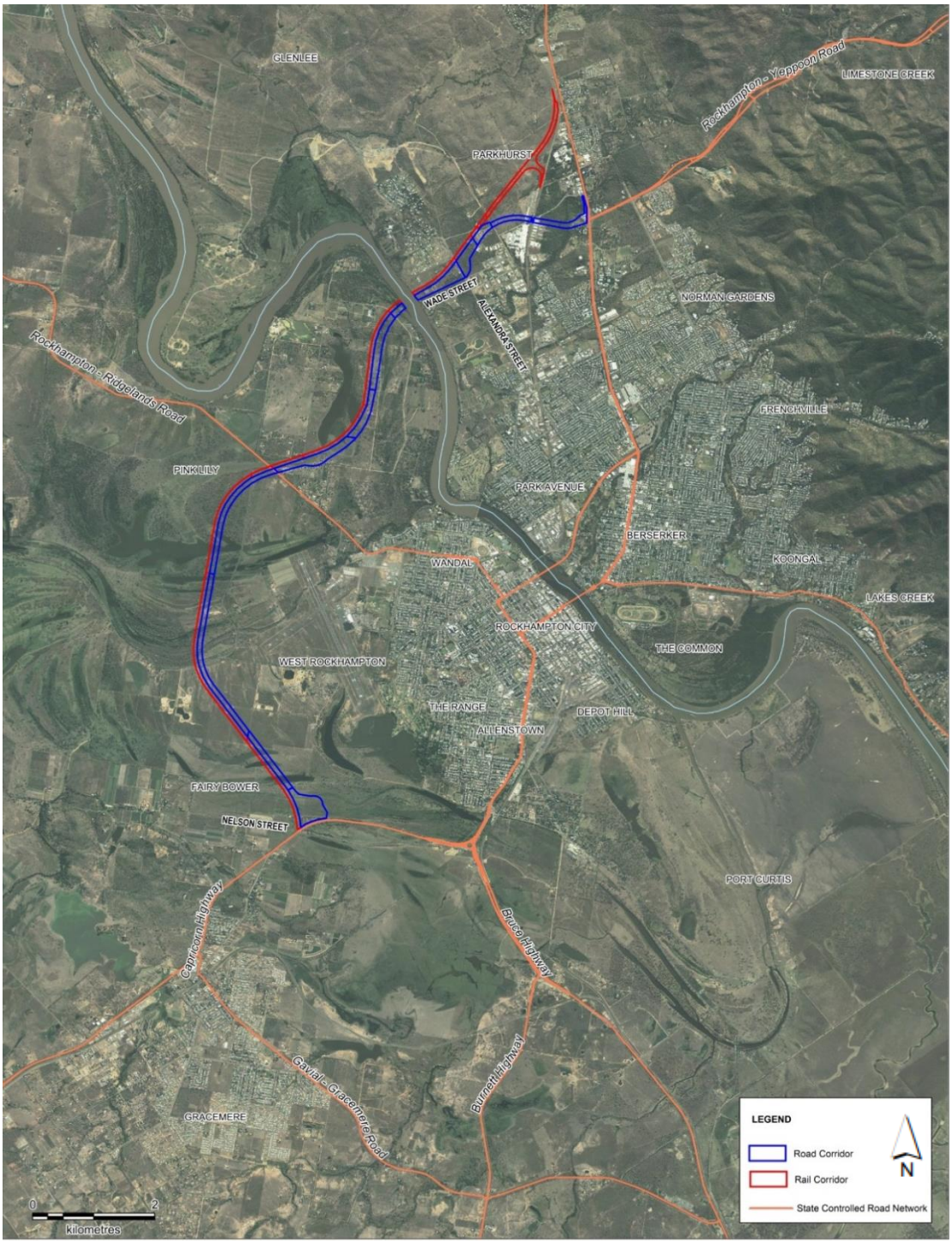

Figure 7-13 Rockhampton Ring Road

7.10.3 Rockhampton Airport Levee

The Rockhampton Airport Levee currently has 2% AEP and 1% AEP flood immunity options, which have been assessed only at a high level concept stage. It protects low-lying areas of West Rockhampton occupied by the Rockhampton Airport, businesses, schools, parks and infrastructure from breakout flows originating from the Pink Lily Meander. For an overview of the Rockhampton Airport Levee refer to Figure 7-14.

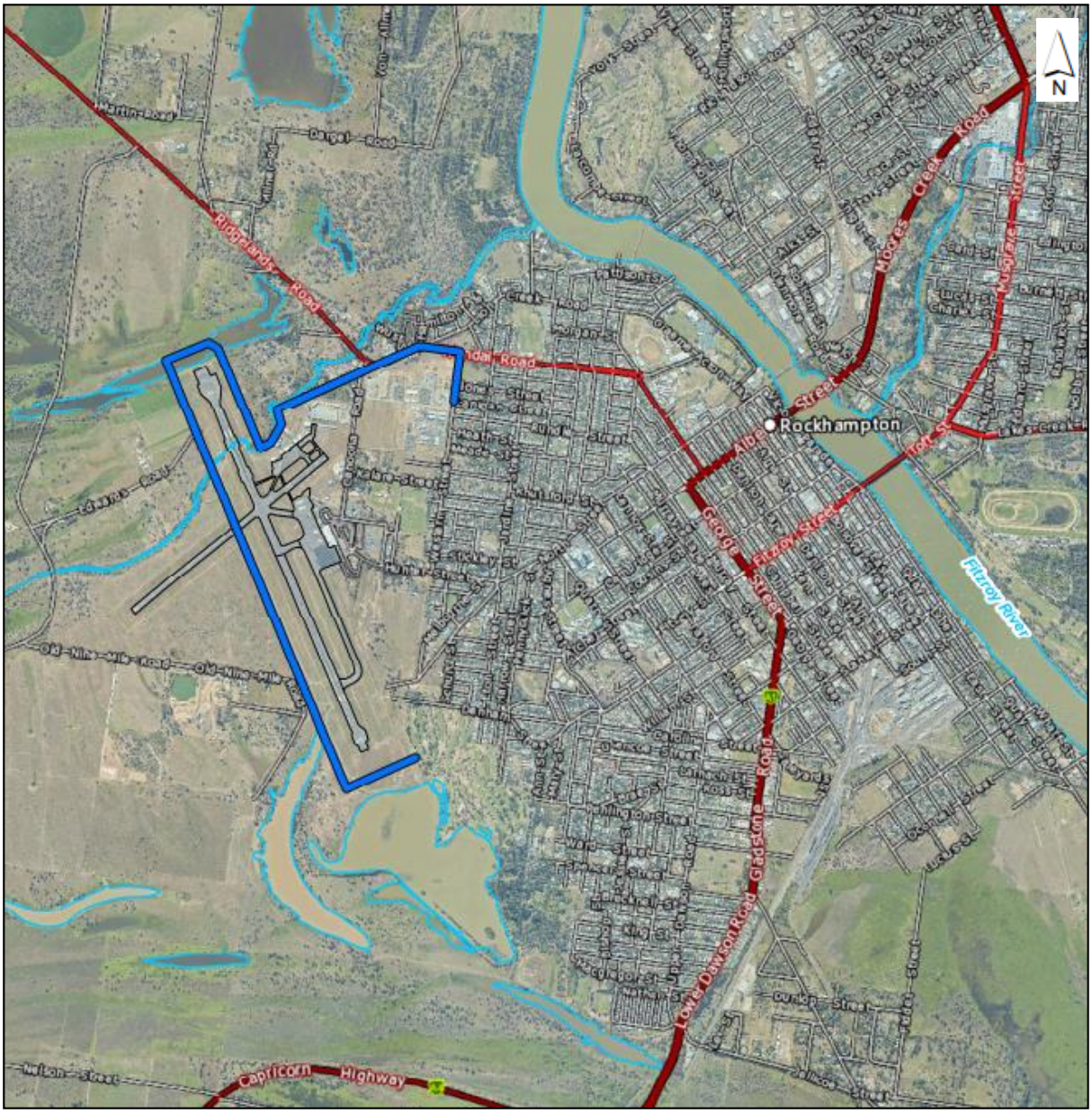

Figure 7-14 Rockhampton Airport Levee

7.10.4 Splitters Creek Flood Levee

The Splitters Creek Flood Levee is currently planned for a 1% AEP flood immunity. The levee is intended to prevents Fitzroy River breakout flows between Limestone Creek and Splitters Creek and protects properties behind levee by reducing Peak Water Surface Elevation. Refer to Figure 7-15 for an overview of the Splitters Creek Levee.

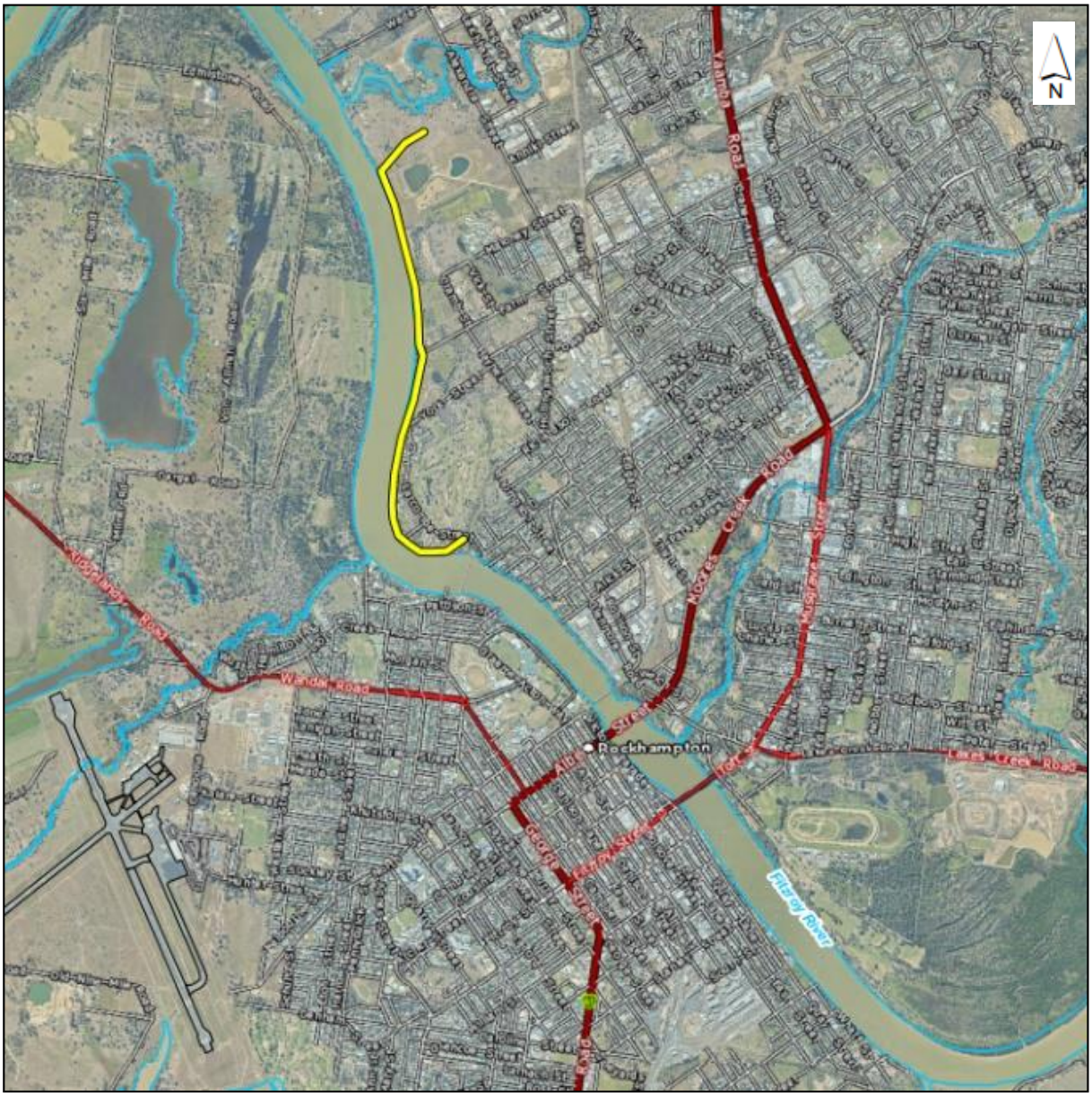

Figure 7-15 Splitters Creek Levee

7.10.5 Eastern Rail Corridor

AECOM was recently engaged by Queensland Rail (QR) to further investigate eastern rail corridor options to undertake a high-level assessment focussed on identifying key issues, constraints and risks. Currently, eastern rail options are subject to further planning phases at QR's discretion. Refer to Figure 7-16 for an overview of the Eastern Rail Corridor options.

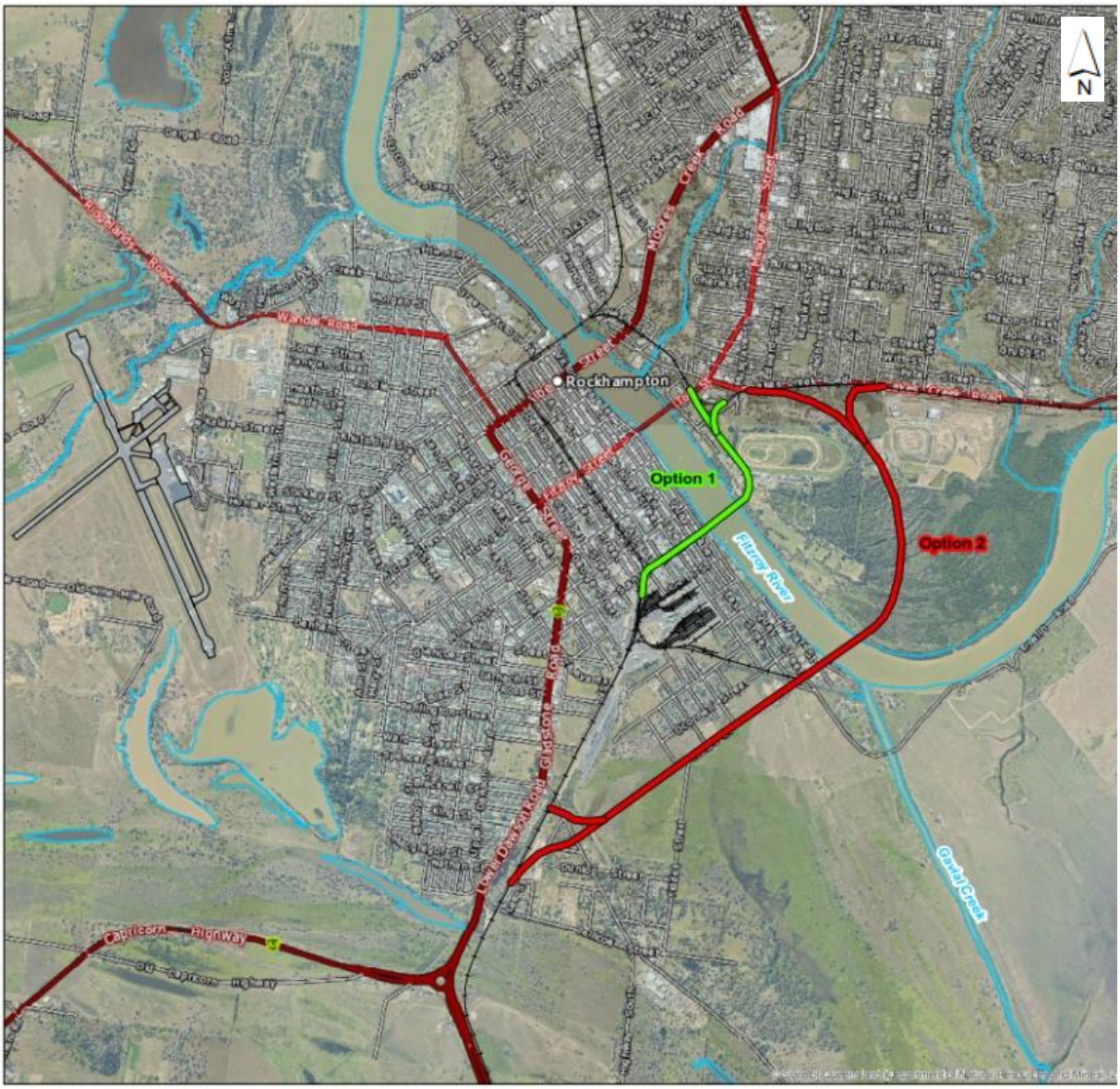

Figure 7-16 Eastern Rail Corridor Options

7.10.6 Summary of Implications

A detailed assessment of all floodplain infrastructure has not been undertaken as part of the Project, due to the various agencies involved and the broad range of planning / design / construction phases across the planned projects.

It is noted however that initial works undertaken during the FRFRPS OA Update (AECOM, 2018) showed limited impact of other infrastructure on the Project as well as limited impact of the Project on other planned infrastructure.

8.0 Land Tenure

8.1 Tenure Arrangements

The Project area traverses a number of land parcels, wholly located within the Rockhampton Regional Council Local Government Area. Land tenure arrangements vary along the alignment, and include freehold; reserve; leasehold land; road reserve and rail corridor. A plan and full list of roads, lot on plans and associated tenure is provided in Appendix A.

Throughout the process of advancing this Project, Council have worked with directly affected landowners and surrounding community, to arrange suitable tenure for the Project. Table 8-1 detail the process and status of obtaining suitable tenure for the Project.

Table 8-1 Summary of proposed tenure measures

Tenure	Measure
Freehold	Council have purchased the majority of the freehold land that is subject to the Project. Council is currently in negotiation with the outstanding freehold property owners. Where voluntary agreement for purchase cannot be achieved, Council will pursue land acquisition avenues through the *Acquisition of Land Act 1967*.
Reserve	Where the Project area passes through reserve tenure, Council is the trustee for the land under the *Land Act 1994*. Council is currently working with Department of Natural Resource, Mines and Energy (DNRME) to obtain appropriate tenure for the Project in reserve land parcels.
Leasehold	The Project area traverses some leasehold parcels. Lot 2 SP 234061 is the North Coast Rail Line, and is discussed in the line items below. Lot 6 R262239 is currently being converted to freehold land, of which Council will purchase a portion of it for the Project.
Road Reserve	The Project area traverses both State and local road reserves. Where the Project area traverses State road reserves, no formal tenure is obtained. The infrastructure will be subject to design and operational approvals issued by the Department of Transport and Main Roads. Where the Project area traverse local road reserves, Council is working with the DNRME to ensure appropriate tenure and approvals are in place under the *Land Act 1994*.
Rail Corridor	The Project area traverses the North Coast Railway on Lot 2 SP234061. Formal tenure will not be obtained over the rail corridor. The infrastructure will be subject to design and operational approvals issued by Queensland Rail and the Department of Transport and Main Roads.

For Freehold Land Tenure, Council have consulted with directly affected land owners to arrange suitable tenure for the Project. A number of land acquisitions have already been undertaken and the remainder will be acquired through the formal Notice of Intention to Resume (NIR) process. NIR correspondence to landholders was issued on 17th April 2019. Please refer to the RRC Letter in Appendix A that indicates the land being acquired through the NIR process.

Resumption Plans defining the levee corridor and a table of affected allotments are presented in Appendix A.

8.2 Native Title

Native title is defined under the Commonwealth *Native Title Act 1993*. Native title rights and interests are rights and interests in relation to land or waters held by Aboriginal peoples or Torres Strait Islanders under their traditional laws and customs, and recognised by the common law of Australia.

Native title rights may exist regardless of whether there is a native title claim or determination in relation to the relevant land or waters, and may be exclusive or non-exclusive rights. Non-exclusive

rights may co-exist with the rights of others. Non-exclusive native title rights and interests have been determined to exist in relation to parts of the Project area. Table 8-2 details the native title determination, and Figure 8-1 illustrates the location of the determinations in relation to the Project area. There are no current native title claims within proximity of the Project area.

Table 8-2 Native title determinations subject to the Project area.

Name	NNTT Ref	Date Determined	Outcome	Rights
Darumbal People	QCD2016/006	21/06/2016	Native title exists in parts of the determination area	Non-exclusive

The lots covered by the claim detailed in Table 8-2 include the following:

- Lot 439 on LN2827 (Rosel Park)
- Lot 288 on R26113 (South Rockhampton Sewage Treatment Plant)
- Lot 4 on LN2766 (Littler-Cum-Ingham Park)
- Part Lot 42 on SP106518 (Littler-Cum-Ingham Park)
- Lot 1 on SP294309
- Fitzroy River Bed and Banks
- The “Main Drain”.

Native title rights may also be present on other tenure along the alignment, in which is not subject to a current claim or determination. These tenures include lands lease and reserve land. Any acts or dealings in relation to land and waters that affect native title must comply with the *Native Title Act 1993* in order to be validly done.

It is anticipated that the construction of the Project will fall under section 24KA of the *Native Title Act 1994* which applies to facilities for services to the public. Under 24KA, native title is not extinguished, but is suppressed where the Project area occurs.

Where the Project area is proposed on freehold land, native title is understood to be already extinguished. Where the Project area traverses the reserve, road reserve of leasehold land, native title will be addressed though applications for suitable tenure with DNRME.

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LEGEND

- Road
- Watercourse
- Cadastral Boundary
- Project Area

Native Title

- Native title exists (non-exclusive)
- Native title extinguished

Data sources:

Base Data: DCDB, Baseline Roads and Tracks, Watercourse, QLD Gov, 2018.
Aecom 2018, Alignment. Native Title, QLD Gov 2018

SOUTH ROCKHAMPTON FLOOD LEVEE PROJECT

Native Title Determinations

PROJECT ID	60589157
CREATED BY	bathurstj
LAST MODIFIED	11-Apr-2019
VERSION	<version number>

Figure 8 -1

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9.0 Land

Project activities that involve the disturbance of soil, such as vegetation clearing, excavation, and civil works have the potential to impact on environmental land values. The following section provides a description of the existing environmental land values, potential impacts from the Project, and proposed mitigation and management measures.

During the planning and concept design phases of the Project, a number of alignment options were assessed against a range of criteria including constructability, cost and environmental impact reduction. One of the main benefits of the selected alignment is that it avoids most of the environmental issues. From a land perspective this has meant the following.

- Due to its location, a large proportion of the levee is either an earth or crib wall embankment which requires minimal disruption to the natural surface.
- For the composite walls along Quay Street, the footings will be constructed using piles, resulting in minimal disruption of the soils.
- Most of the levee along Quay Street is temporary, resulting in no disruption to land values.

9.1 Topography

The topography of the Project area includes both natural and manmade features. The natural topography features are characterised by mostly flat, low lying land, including wetlands and low areas subject to inundation. Other natural topography features include waterway features associated with the Fitzroy River banks. Man-made topography features associated with the location of the Project include a range of built infrastructure elements including sealed and unsealed roads, rail lines and park lands.

Construction of the Project will involve cut and fill earth works for the establishment of the levee structures and ancillary infrastructure (Section 4.0). The Project will permanently change the topography of footprint of the Project area with the addition of the man-made structure. The exception to this is the location of the temporary levee, which will not experience a topographic change. Outside of the Project area, impacts to topography are considered negligible. No operational impacts on topography are anticipated from the Project.

9.2 Geology and Soils

A large portion of the Project area is located within the Fitzroy River floodplain. The Fitzroy River floodplain consists of the Gavial and Coolibah land systems. Gavial land systems are distinguished by extensive back plains traversed by a dense network of distributary channels and discontinuous linear depressions. Coolibah land systems comprise the active inner flood-plains of the Fitzroy River. In common with Ghavial land systems, Coolibah land systems have extensive back plains, but differs in that these are less broken by drainage lines and levees are of considerable extent

The geology of South Rockhampton mostly comprises Quaternary Fitzroy floodplain alluvium characterised by clay, silt, sand and gravel. Geotechnical assessments conducted for the Project in 2014 encountered a subsurface profile consisting of fine to coarse grained alluvial soils overlying bedrock along the entire Project area.

The Australian Soil Classification is the classification system currently used to describe and classify soils in Australia. According to the Australian Soil Resource Information System (ASRIS), there is one soil type for the entire Project area, known as vertosols. Vertosols are the most common soil in Queensland, display shrink-swell features and are known as cracking clay soils.

Any activity which exposes the ground surface, such as earthworks, may potentially result in soil erosion or other soil management issues if not appropriately managed. Vertosols are considered to be susceptible to erosion due to the dispersive nature of these soils and present an erosion risk during construction and operation of the Project.

Where topsoil is lost, this may lead to a reduced ability of the soil to store water and nutrients, result in higher runoff rates, and the exposure of subsoil. The deposition of eroded soil also has the potential to impact on local waterways and wetlands through siltation and a potential reduction in water quality.

Soils on the banks and approaches to watercourses are generally considered to be prone to erosion when disturbed. During the design process undertaken in 2014, several sections of the Fitzroy River and Gavial Creek were identified as experiencing bank slumping and scour failures. Two sections located adjacent to Wharf Street (within the Fitzroy River) and adjacent to the West Rockhampton Sewage Treatment Plant (within Gavial Creek) have been identified as requiring protection from further scour and erosion.

A Development Permit for riprap protection (rocks, or similar material, on an embankment slope to prevent erosion) was obtained from Council on 13 December 2018. Construction of these works is anticipated to occur in conjunction (but funded separately) with the construction of the Project, in line with relevant conditions of the received Development Permit. Riprap and revegetation is consistent with previously successful bank protection works along the Fitzroy River.

Soil compaction may occur during construction of the project through the introduction of both light and heavy machinery during construction and the storage of materials. Potential impacts associated with soil compaction include a decline in soil structural stability, a decrease in water entering the soil either as rain or irrigation, and subsequent issues with poor root growth, soil cultivation and seedbed preparation.

Management and mitigation measures relevant to geology and soils are discussed in Section 9.7.

9.3 Acid Sulfate Soils

Acid sulfate soils (ASS) are soils that contain iron sulfides and are generally found in low-lying coastal areas below 5.0 m Australian Height Datum (AHD). ASS have been reviewed based on the Rockhampton Regional Council Planning Scheme 2015 (Planning Scheme), and the National ASS Atlas from the ASRIS.

The ASS Overlay contained within the Planning Scheme identifies the majority of the Project area as 'land above 5m AHD and below 20m AHD'. No classification is mapped over the beds and bank of the Fitzroy River.

ASS are mapped on the Atlas of Australian Sulfate Soils, available on ASRIS. The probability of occurrence of ASS is categorised on the mapping as follows:

- high probability of occurrence: >70% chance of occurrence in mapping unit
- low probability of occurrence: 6-70% chance of occurrence in mapping unit
- extremely low probability of occurrence: 1-5% chance of occurrence in mapping unit
- no probability of occurrence: <1% chance of occurrence in mapping unit.

There is an area mapped as having a "high probability" of containing ASS where the Project interacts with the Fitzroy River, with the remainder of the Project mapped as "extremely low probability" (Figure 9-1). Table 9-1 provides a description of the mapped ASS soil classifications and probabilities of occurrence.

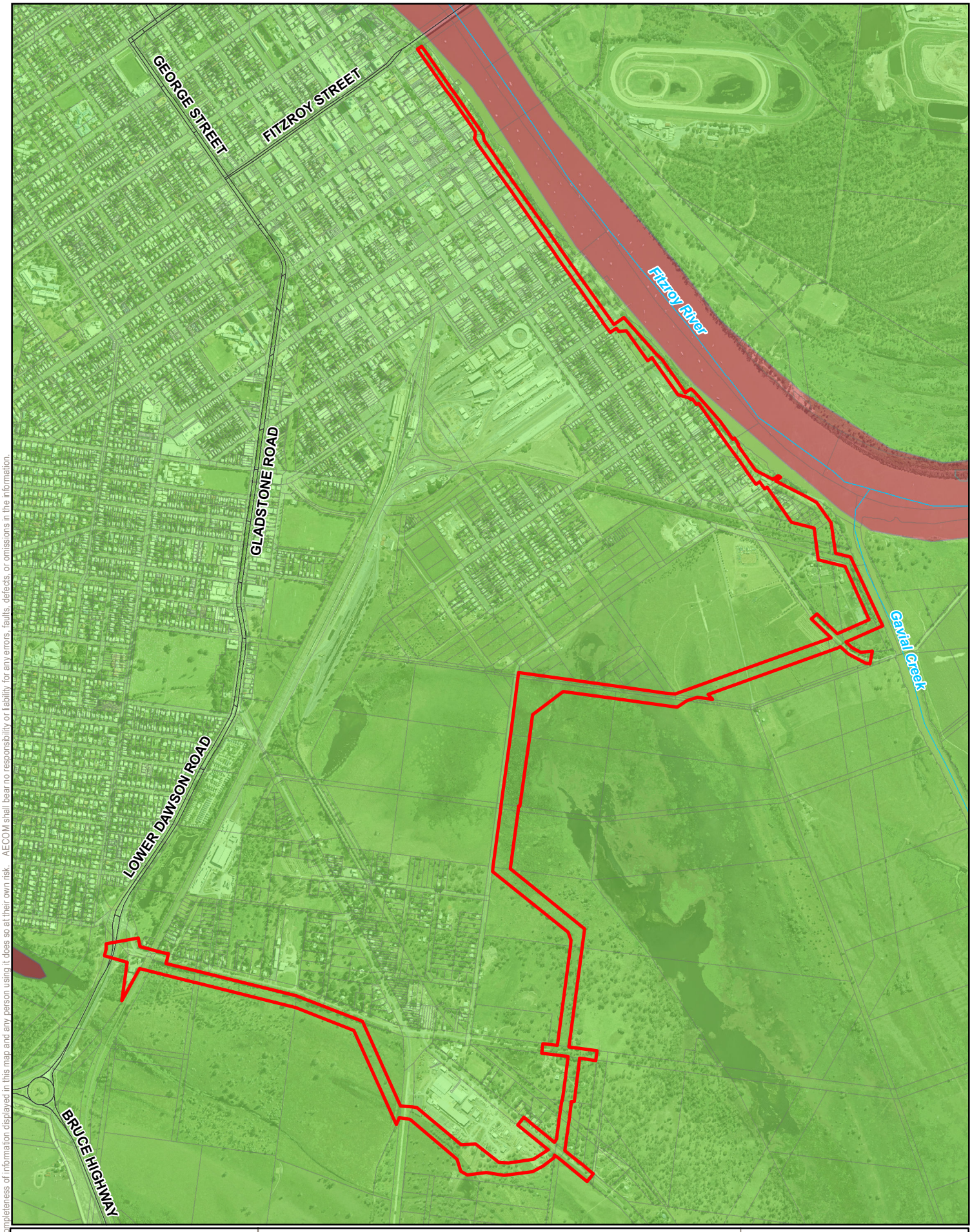
Table 9-1 ASS soil classification and probability of occurrence

Location	ASS Soil Class	Probability
Fitzroy River	Ao(p4)	High Probability of Occurrence
Remainder of Project area	Co(p4)	Extremely Low Probability of Occurrence

ASS testing along Quay Street was undertaken in late 2018 as there was potential for deep excavations in this area for stormwater drainage works (undertaken under separate approval). Quay Street is also considered a higher risk for ASS due to its proximity to the River. The recent testing has found that there is a risk of ASS being present (Butler Partners, 2019). However, most of the levee along Quay Street is temporary levee, and no disruption of the soil profile, or potential ASS, is required.

When ASS are disturbed, they can generate large amounts of sulfuric acid, iron, aluminium and sometimes heavy metals, which has the potential to impact on the environment and infrastructure. Low levels of acidity may weaken aquatic plants and animals, with high levels of acidity potentially causing death. Sulfuric acid may also impact on infrastructure containing concrete and steel, slowly destroying pipes, roads, and building foundations. In areas where ASS are not treated properly before construction, repairs may be required, or infrastructure may need to be replaced before the end of its intended lifespan.

The areas within and adjacent the Fitzroy River are mapped as having a “high probability” of containing ASS. Avoidance of areas which may contain ASS cannot be achieved for this Project, as works are required within and adjacent to the Fitzroy River to achieve the overall objectives of the Project, being flood mitigation and protection. Management and mitigation measures relevant to acid sulphate soils are discussed in Section 9.7. In areas mapped as containing low probability of ASS occurring, impacts are not anticipated.



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LEGEND

- Road
- Watercourse
- Cadastral Boundary
- Project Area

Acid Sulfate Soil - Probability Class

- High Probability of occurrence
- Extremely low probability of occurrence

Data sources:

Base Data: DCDB, Baseline Roads and Tracks, Watercourse, QLD Gov, 2018. Aecom 2018, Alignment. ASS data QLD Gov 2019.

SOUTH ROCKHAMPTON FLOOD LEVEE PROJECT

ASS in the Project area

PROJECT ID	60589157
CREATED BY	bathurstj
LAST MODIFIED	11-Apr-2019
VERSION	<version number>

Figure 9-1

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9.4 Contaminated Land

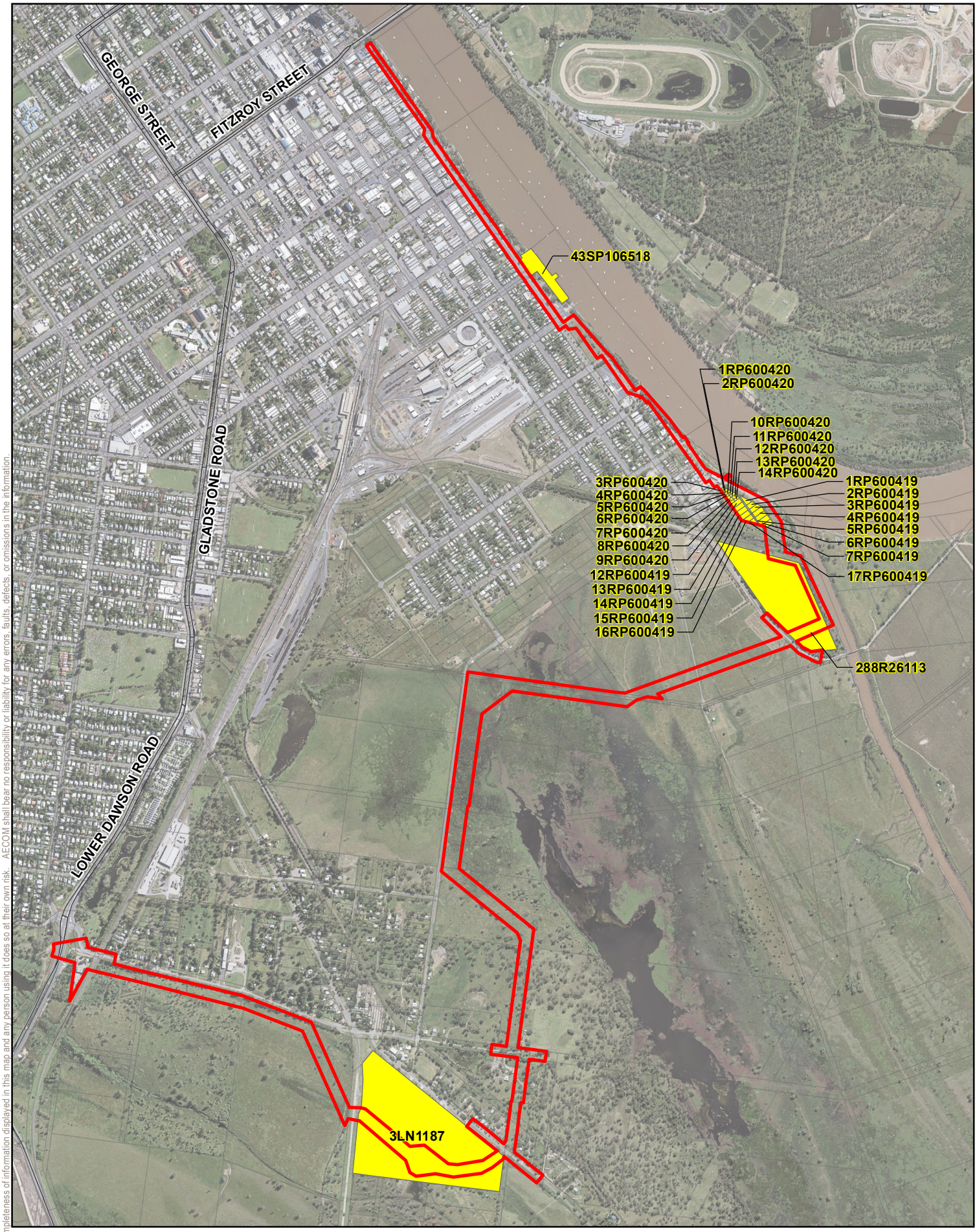
A search of the Department of Environment and Science (DES) Environmental Management Register (EMR) and the Contaminated Land Register (CLR) was undertaken late 2018. The EMR and CLR are public registers which contain information about contaminated land in Queensland. The searches identified thirty-one of the lots affected by the Project on the EMR/CLR (Figure 9-2).

A preliminary assessment of risks associated with contaminated land has been undertaken for the Project. The preliminary assessment includes both desktop review and site inspection. The assessment was undertaken in accordance with the National Environmental Protection Council (NEPC) *National Environment Protection (Assessment of Contamination) Measure 1999* and as amended 2013, with the purpose to inform Council about potential contamination risks specific to disturbances resulting from the construction of the Project.

Table 9-2 provides a summary of the potentially contaminating activities and contamination sources from the preliminary assessment which may be present for each identified site address listed on the EMR.

Table 9-2 Summary of potentially contaminating activities on existing lots

Location	Use	Description
117 Wharf Street (28 lots)	Unused Rockhampton Regional Council depot	• Former railway lines • Former fuel storage and refuelling • Former drum storage • Former washdown area and interceptor pit • Use of hazardous building materials (asbestos) • Waste storage and uncontrolled fill beneath the site
305-375 Quay Street, Depot Hill (1 lot)	Fitzroy Motor Boat Club	• Potential historical abrasive blasting and TBT containing paints • Current minor fuel, paint and chemical storage • Uncontrolled fill beneath the site
150 Port Curtis Road, Port Curtis (1 lot)	Hastings Deering	• Storage and use of chemicals, paints and petroleum products • Wastewater treatment • Vehicle and parts washing • Generation of regulated wastes
503 Quay Street, Depot Hill (1 lot)	Sewage Treatment Plant	• Sewage treatment facility chemical use and storage • Potential disposal of biosolids onsite



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LEGEND

- Road
- Watercourse
- Land Parcel Listed on Environmental Management Register
- Cadastral Boundary
- Project Area

Data sources:

Base Data: DCDB, Baseline Roads and Tracks, Watercourse, QLD Gov, 2018.
Aecom 2018, Alignment.

SOUTH ROCKHAMPTON FLOOD LEVEE PROJECT

Lots Listed on the by the CLR or EMR Register

PROJECT ID	60589157
CREATED BY	bathurstj
LAST MODIFIED	12-Apr-2019
VERSION	<version number>

Figure 9-2

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Landholders and occupiers of land which is listed on the EMR or CLR, or suspected of being contaminated, must ensure that they meet their general environmental duty under the *Environmental Protection Act 1994* when using the land to ensure that any risks to human health and the environment are known and managed.

The preliminary contaminated land assessment identified that there are potentially complete exposure pathways which are relevant to construction within the Project area include the following.

- Direct contact with impacted soils.
- Direct contact or incidental ingestion of surface water runoff within the construction area.
- Potential for spills of chemicals or hydrocarbons products to ground resulting in direct contact or leaching to soils or surface water runoff.
- Direct contact with and incidental ingestion of extracted groundwater during construction dewatering.
- Inhalation of dust/fibres from disturbed soils or unsealed surfaces.

Additionally, there is potential for contamination to be caused by construction activities associated with the Project. The chemicals used during the construction of the Project will include fuel (predominantly diesel and some small quantities of unleaded petrol), oil, lubricants, coatings/paint, minor quantities of solvents and acids and degreasers. The accidental release of these materials during storage, use or transport has the potential to result in land contamination.

During operation, the potential for impact from contamination and / or the cause of contamination is considered to be low. Nonetheless, management and mitigation measures relevant to contaminated land are discussed in Section 9.7.

9.5 Unexploded Ordinance

A search of Department of Defence unexploded ordinance (UXO) sites did not identify any areas with substantial potential for UXO. UXO have not been considered further in this EAR.

9.6 Resource Interests

No active or historical resource interests have been identified within the area of the Project. Resource interests have not been considered further in this EAR.

9.7 Mitigation and Management Measures

Potential impacts to land values during construction will be managed in accordance with controls outlined in the Environmental Management Plan (Planning) (Appendix T). The following measures are anticipated.

- Suitable erosion and sediment control measures will be implemented through the construction stage.
- Where practicable, existing roadways and access tracks will be used for the Project in preference to creating new tracks. Where possible, these existing access tracks will include either new and / or maintain established erosion and control measures.
- Minimising vegetation clearing where possible and clear delineation of clearing areas.
- Reinstatement will be undertaken progressively during construction, where practicable, and all disturbed areas impacted from construction are reinstated at the end of the Project. Reinstatement works will be undertaken in accordance with the landscape plan which will be developed by the Construction Contractor.
- Prior to soil excavation work, testing for ASS in accordance with the Queensland Acid Sulphate Soils Technical Manual will be undertaken to determine the presence of ASS.
- Where ASS are identified and confirmed, an ASS Management Plan is to be developed in accordance with the Queensland Acid Sulphate Soils Technical Manual.

- Where ASS is present, all soil disturbance work is to occur in accordance with the ASS Management Plan.
- Testing for the presence of contamination prior to excavation or other earthworks will be undertaken on the lots identified in Section 9.4, where known or suspected contamination exists.
- An unexpected contamination finds procedure is to be documented and implemented during the construction phase, to account for potential contamination that may arise.
- Inclusion of occupational health and safety controls addressing human health risks arising from potential contamination during construction, as relevant.

10.0 Land Use

The Project area is located within the Rockhampton Regional Council Local Government Area, and falls under the *Rockhampton Regional Planning Scheme 2015* (the Planning Scheme). Rockhampton, with its history of sporadic expansion from its rural industry foundations to its now traditional city characteristics, provides for a diverse range of mixed land uses that reflects the historical patterns of settlement over time.

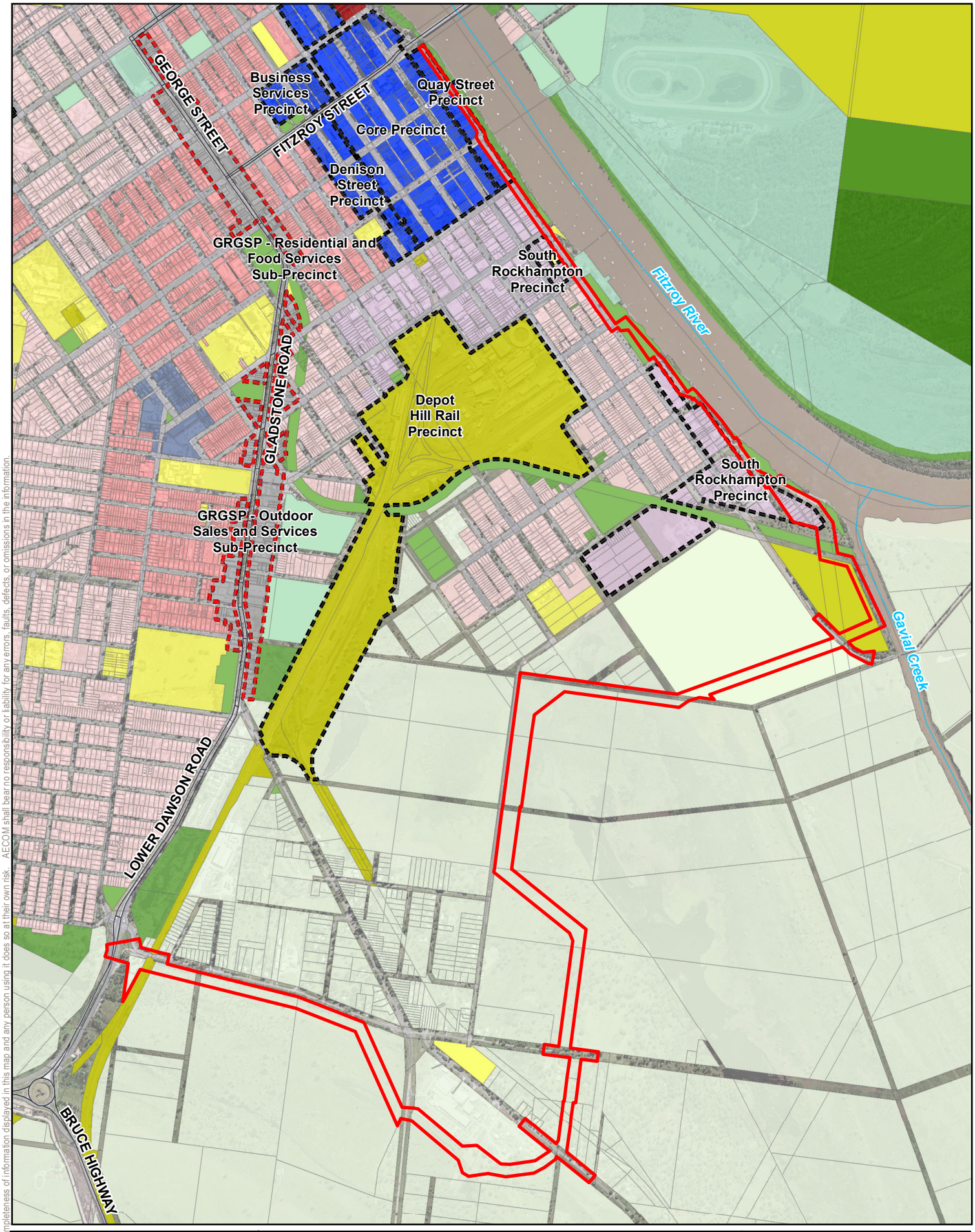
The Project traverses the Yeppen Floodplain between the suburbs of Port Curtis and Depot Hill. This area is subject to a range of different zones and overlays under the Planning Scheme. These are illustrated on the following figures:

- Zoning (Figure 10-1)
- Cultural Heritage Overlay (Figure 10-2)
- Flood Hazard Overlay (Figure 10-3).

The Project area passes through a range of land uses, including grazing land, industrial land, around residential areas, along the bank of the Fitzroy River and through the Rockhampton Central Business District along Quay Street. The Project area can be characterised into two main land use types, being rural and urban. The following assessment describes the existing rural and urban land uses, including zoning and overlays under the Planning Scheme, as they relate to the design, construction and operation of the Project.

Throughout the design development process, a number of levee alignments and types were considered, and assessed through a multi-criteria analysis to determine the final alignment. Land use directly affected by the Project area is not anticipated to materially be impacted by the infrastructure itself.

For the purposes of this assessment the Project area has been separated into logical sections (one rural and five urban).



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DATUM GDA 1994, PROJECTION MGA ZONE 56

0 175 350 700

metres

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LEGEND

- Road
- Watercourse
- Cadastral Boundary
- Project Area
- Sub Precincts
- Precincts
- Low density residential
- Low-Medium density residential
- High density residential
- Principal centre
- District centre
- Sport and recreation
- Open space
- Environmental management and conservation
- Low impact industry
- Community facilities
- Rural
- Special purpose
- Specialised centre
- Reserves

Data sources:
Base Data: Rockhampton Regional Council, Planning Scheme 2018. DCDB, Baseline Roads and Tracks, Watercourse, QLD Gov, 2018. Aecom 2018. Alignment.

SOUTH ROCKHAMPTON FLOOD LEVEE PROJECT

Planning Scheme Zoning

PROJECT ID	60589157
CREATED BY	bathurstj
LAST MODIFIED	11-Apr-2019
VERSION	<version number>

Figure 10-1

A4 size

Filename: G:\TSV_GIS\Projects\60589157\02_MXDs_60589157_FX_SRFL_PlanningScheme_Levee_A4.mxd

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0 185 370 740

metres

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LEGEND

- Road
- Watercourse
- Cadastral Boundary
- Project Area
- Heritage Place Areas

Data sources:

Base Data: DCDB, Baseline Roads and Tracks, Watercourse, QLD Gov, 2018.
Aecom 2018, Alignment. Heritage Overlay Rockhampton Regional Council

SOUTH ROCKHAMPTON FLOOD LEVEE PROJECT

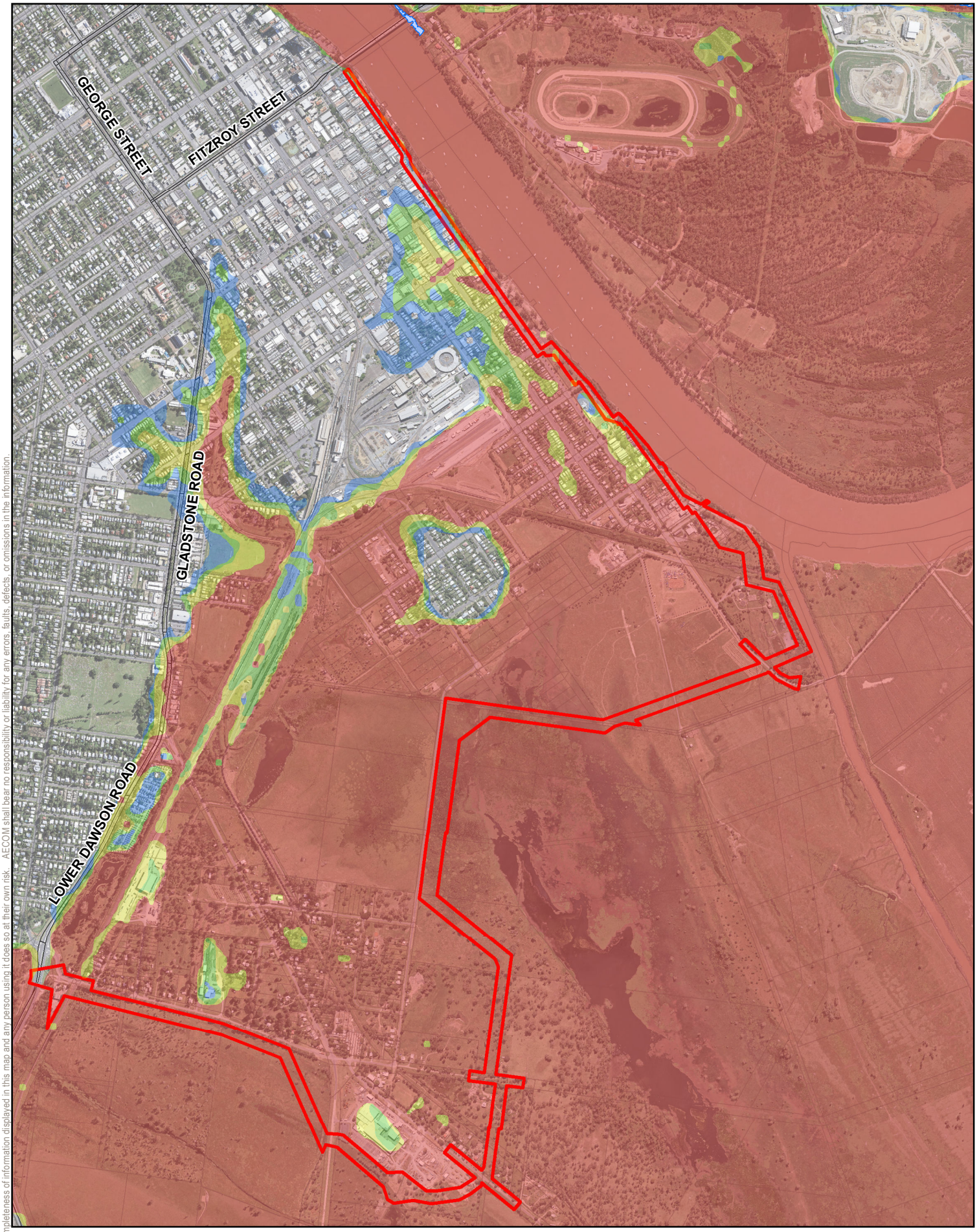
Planning Scheme Cultural Heritage Overlay

PROJECT ID	60589157
CREATED BY	bathurstj
LAST MODIFIED	12-Apr-2019
VERSION	<version number>

Figure 10-2

A4 size

Filename: G:\TSV_GIS\Projects\60589157\02_MXDs_60589157_FX_SRFL_PlaningScheme_HeritageOverlay_A4.mxd



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DATUM GDA 1994, PROJECTION MGA ZONE 56

0 175 350 700
metres

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LEGEND

- Road
- Watercourse
- Cadastral Boundary
- Project Area

Hazard Classification

- Extreme
- High
- Medium
- Low

Data sources:

Base Data: DCDB, Baseline Roads and Tracks, Watercourse, QLD Gov, 2018.
Aecom 2018, Alignment. Heritage Overlay Rockhampton Regional Council

SOUTH ROCKHAMPTON FLOOD LEVEE PROJECT

Planning Scheme Flood Hazard Overlay

PROJECT ID	60589157
CREATED BY	bathurstj
LAST MODIFIED	12-Apr-2019
VERSION	<version number>

Figure 10-3

Filename: G:\TSV_GIS\Projects\60589157\02_MXDs_60589157_FX_SRFL_PlaningScheme_FloodHazardOverlay_A4.mxd

A4 size

10.1 Rural Land Uses

A large portion of the Project area is located within areas dominated by rural land uses, which can be seen on the aerial imagery shown on (Figure 10-4). The area is rural in character and accommodates a number of rural and agricultural pursuits. The rural land uses largely consist of open grazing paddocks with typical rural operations infrastructure. No identifiable cropping operations areas are present. The rural areas surrounding the city of Rockhampton represent fringing transitional zones which are considered important areas in preserving the area as a rural edge and entry into the city.

The rural area is also characterised as including a number of creeks and tributaries of the Fitzroy River, severely flood prone (BVC, 2011), with limited occurrence of rural development. The intent is for the area to continue to be used for agricultural purposes and is considered unsuitable for other forms of development due to flooding (BVC, 2011).

Figure 10-4 Aerial view of rural sections of the Project area

10.1.1 Agricultural State Interests

The Project area does not include any land mapped with State, regional or local agricultural significance (i.e. Important Agricultural Areas, Agricultural Land Classification - Class A or B; stock route networks; Strategic Cropping Area or Priority Agricultural Areas).

There is limited existing intensive rural land uses within and adjoining the Project area. This is anticipated to be due to the following reasons:

- Proximity and inclusion of the environmentally sensitive areas which co-exist with the rural locality in this part of the Rockhampton region, including ecologically significant wetlands.
- Proximity to nearby sensitive land uses of South Rockhampton.
- Severely flood prone nature of the area is not conducive to intensive agricultural developments (i.e. cropping activities).

10.1.2 Planning Scheme Zoning and Overlays

A large portion of the Project area is located within an area zoned as ‘Rural’ under the current Planning Scheme, with no identified sub precincts (Figure 10-1). Under the previous Planning Scheme, this area was identified as the ‘South Rockhampton rural area’.

The purpose of the Rural Zone Code includes (but not limited to) to prevent the establishment of development which may limit the productive capacity of the land, and maintain the environmental values of all rural land. This purpose is aimed to be achieved through development which aligns with the following:

- Is responsive to the environmental characteristics and constraints of the land, and minimises impacts on natural features such as waterways, wetlands and remnant vegetation.
- Has legal and practical access to the road hierarchy.
- Is serviced by infrastructure that is commensurate with the needs of the use.
- Does not alienate or impact on the productive agricultural capacity of rural areas and agricultural land is protected from incompatible development.

The Rural Zone Code also envisages that rural land is maintained in large land holdings to protect the agricultural production capacity, identifying 100 hectares (ha) as the minimum lot size. The subject portion of rural land acts as a "rural edge" to the city, consequently the existing trend in lot sizes are considerably smaller than the 100 ha, which would typically be seen in rural zones further afield.

The pattern in rural lots across the Project area range from approximately 2 ha to 30 ha. Although the lot sizes are considerably smaller than prescribed from rural areas, the pattern of ownership and rural operations across multiple adjoining lots reflects the desired size in an operational sense.

10.1.3 Potential Impacts, Mitigation and Management

Earth embankments are preferred within the rural area for a number of reasons, including cost and land availability. The potential impacts with an earth embankment levee in rural locations include.

- Physical loss of rural land from the infrastructure and changes to productive capacity of agricultural land from ground disturbing activities.
- Potential disruptions to agricultural operations and changes to on ground operational infrastructure.

As identified in the Rural Zone Code, development which limits the productive agricultural capacity of the land is not encouraged in the Local Government Area. The productive capacity of grazing land can be characterised through a number of variables, including components such as climatic features, land types and land condition (MLA, 2006), as well as land availability, access and infrastructure.

The Project will lead to an unavoidable direct loss in rural land where the Project and associated infrastructure is developed. Apart from the direct loss in land, the Project is not anticipated to impact on the climatic features, soil conditions and / or condition of the surrounding agricultural land. Therefore, changes to the productive capacity of agricultural land are not anticipated.

The Project has been located to adjoin existing road reserves and lot boundaries to the greatest extent practical, whilst balancing hydraulic requirements, environmental characteristics and landowner needs. For a large portion of the Project, the infrastructure will act as an extension to formed roads (i.e. Jellicoe Street, Old Bruce Highway and Fiddes Street) and development (i.e. Hastings Deering). For the remaining portions of the Project, the lot boundaries are followed where possible, however the infrastructure will lead to a severance of some land parcels.

Where severance has occurred, in consultation with landowners, road access points (i.e. up and over ramps) have been included to allow access over the levee for these properties. The severance is not anticipated to result in an impact to the ongoing viability of the agricultural land uses in these locations.

10.2 Urban Land Uses

The Project will interact with a range of urban land uses, primarily along the frontage of the Fitzroy River. This portion of the Project area includes a mix of commercial, recreational / open space, residential and urban industrial land uses. The following section describes the urban land uses, including the zoning and overlays, based on five sections of the urban area.

- Quay Street – Northern Extent
- Quay Street – Middle Extent
- Quay Street – Southern Extent
- Wharf Street
- The Bend and Treatment Plant.

Potential impacts associated with these urban land uses classified further by levee types in Section 10.2.6.

10.2.1 Quay Street – Northern Extent

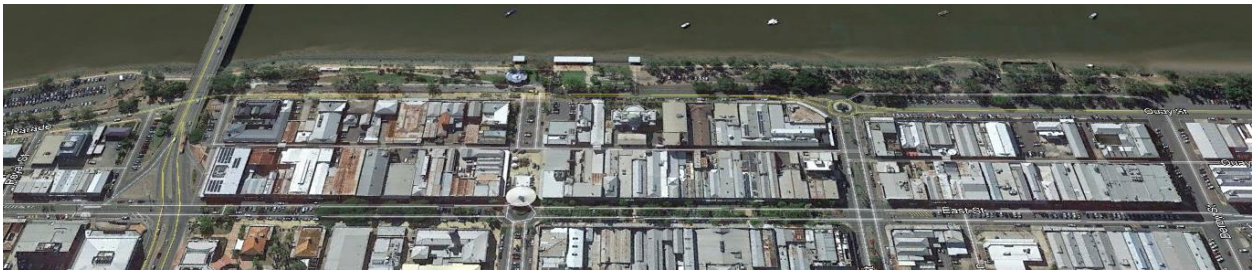


Figure 10-5 Aerial view of Quay Street – Northern Extent

The Project area begins within the road reserve of Quay Street on the northern side of the Fitzroy River bridge, and continues to travel south down the Fitzroy River. This section of the Project area is zoned as both 'Principle Centre' and 'Open Space' (Figure 10-1).

Principle Centre

The Planning Scheme Strategic Framework identified Principle Centres are the highest order centre within the Local Government Area. A Principle centre is to include the primary administrative, civic, commercial, retail, service, cultural and entertainment functions that align with the primary intent of each precinct, and service the planning scheme area and beyond.

This section of the Project area is included within the Quay Street Precinct. The Quay Street Precinct is identified in Figure 10-1. The primary intent of the Quay Street Precinct is detailed in the overall outcomes of the Principle Centre Zone Code, and can be summarised as follows.

- Development of commercial and residential uses above or behind ground level to encourage active uses such as restaurant, cafes or shops at ground floor level.
- Active uses on the ground floor level are to maximise the use of the footpath and river front to the greatest extend practical.
- Preservation and adaptation of heritage buildings fronting Quay Street for commercial uses.

Heritage Place Overlay

The Quay Street Precinct is heavily dominated by State and Local heritage values identified on the Heritage Place Overlay, illustrated in Figure 10-2. The purpose of the Heritage Place Overlay Code can be summarised as ensuring development retains the significance of the heritage places. The Planning Scheme aims to achieve this through a range of overall outcomes. They key overall outcomes as relevant to this Project include the following:

- Ensuring adjoining and surrounding land uses and developments are of a nature and scale that does not compromise the heritage significance of a site or area.
- Development adjoining a heritage place does not visually detract or cause adverse impacts on significant views of the visual setting.

Open Space

The Fitzroy River side of the Project area is dominated by the Open Space Zone (Figure 10-1), made up of recreational areas and green zones. This open space area primarily includes a constructed network of pathways both beyond, and within the bank of the Fitzroy River. The network provides access to areas of passive outdoor recreation, places of interest and appreciation points for the Fitzroy River.

The Planning Scheme identifies that one of the key purposes in achieving the overall outcomes of the Open Space Zone is to support development which responds to the regional climate, local heritage features, natural landscape features and environmental constraints. The open space area adjacent to the Project area is subject to inundation during Fitzroy River flood events, and the existing

developments and infrastructure within the zone are anticipated to be consistent with inundation events.

Flood Hazard Overlay

The Project area in this section is within, but primarily adjacent to the Flood Hazard Overlay for the Planning Scheme. The Flood Hazard Overlay includes the Defined Flood Event (DFE) of the Fitzroy River and hazard categories associated with the event (Figure 10-3). The overlay mainly covers the open space area, however does intrude into the wider Quay Street Precinct (Principle Centre Zone).

The purpose of the Flood Hazard Overlay is to manage development outcomes in flood prone areas so that risk to life, property, community and the environment as a result of the flood is avoided or minimised. The DFE extends into Quay Street along the length of this section of the Project area. The areas subject to extreme flood hazard are primarily contained within the Open Space Zone, with small portions of the high hazard area and medium hazard area extending into Quay Street. The southern extend of this section between William Street and Derby Street is identified with high, medium and low hazard areas.

10.2.2 Quay Street – Middle Extent

Figure 10-6 Aerial view Quay Street - Middle Extent

The Project area continues along the Quay Street road reserve, lining the Fitzroy River between Derby Street and South Street. For the purpose of this assessment, the portion of the Project area is described as Quay Street – Middle Extent. This section of the Project area is surrounded by land zoned as a combination of Low Impact Industry, Open Space and Community Facilities under the Planning Scheme (Figure 10-1).

South Rockhampton Precinct

The Planning Scheme Strategic Framework identifies majority of this section of the area as an Industrial Area, including the South Rockhampton Precinct. The Strategic Framework identifies this area as a key industrial area within Rockhampton, stating that the South Rockhampton Industrial Area will continue to provide for predominantly service and low impact industries. However, also stating that future development within the South Rockhampton Precinct will be limited due to the impact from flooding. It is also noted, that although the area is zoned for light industrial, there is a range of residential buildings also located on the west side of the Project area.

The overall outcomes of the South Rockhampton Precinct are heavily dependent on flood and amenity constraints. No further intensification of industrial uses is permitted within the area, or development of higher intensity uses. This is to protect the adjoining residential areas from increased traffic, as well as managing risk associated with flooding.

Flood Hazard Overlay

The Flood Hazard Overlay identified the Project area in this location as subject to a combination of all hazard categories (Figure 10-3). The DFE in this location extends approximately 6 blocks inland from the banks of the Fitzroy River.

Heritage Place Overlay

Similar to the Quay Street – North, described in Section 10.2.1 above, the Project area in this location is adjacent to heritage places on the eastern side of the Project area and is adjacent to Open Space

areas on the Fitzroy River side of the alignment. The commentary on heritage places, and open space is Section 10.2.1 is applicable in this section also.

Community Facilities and Sport and Recreation

This section of Quay Street includes Community Facilities land uses and Sport and Recreational land uses. These areas include the navy cadets and park land (west side of Project area) and Rockhampton Coast Guard (east side of Project area).

10.2.3 Quay Street – Southern Extent

Figure 10-7 Aerial view Quay Street - Southern Extent

The southern extent of Quay Street is characterised by a mix of low density residential, and open space and recreational land uses, which is reflected in the zoning (Figure 10-1). The eastern side of the Project area is made up of a mix of Sport and Recreation and Open Space zoning.

Low Density Residential

This location represents the only zoned low density residential in close proximity to the Fitzroy River. The low density residential zone is intended for predominantly single detached one and two storey dwelling houses on individual lots.

The Planning Scheme states that the low density residential areas are to be conserved through (but not limited to) allowing development that do not compromise the residential character and existing amenity of the surrounding area; are small-scale and consistent with the surrounding urban form; and primarily function to service the needs of the immediate local residential community.

Sport and Recreation Zone

The Sport and Recreation Zone is intended to provide for a range of sport and recreational uses, easily accessible by the local community and protect important sport and recreational sites from the establishment of inappropriate land uses. The Sport and Recreational Zoning primarily includes the Motor Boat Club and associated uses. It is understood that the facility is membership based, and the location is used for boat maintenance and storage in addition to typical club functions.

Open Space

The land identified as Open Space is Littler-Cum-Ingham Park. This park includes a 4 lane boat ramp facilities, with a pontoon, parking facilities, landscaped park land, amenities and picnic tables. The landscaped park land is used for local markets and events periodically throughout the year. The intent of the open space zoning is discussed in Section 10.2.1 above.

Flood Hazard Overlay

The entirety of this area is subject to the high hazard area on the Flood Hazard Overlay in the Planning Scheme (Figure 10-3). During a Fitzroy River Flood event the present land uses within this area would typically be inundated.

10.2.4 Wharf Street

Figure 10-8 Aerial view – Wharf Street

The Wharf Street section is characterised by a mix of both residential and industrial properties. The zoning differs from the ongoing land uses, and includes the whole area on the land side of Wharf Street as Low Impact Industry zoning (Figure 10-1). The Wharf Street section is also contained in the South Rockhampton Precinct, being a sub precinct.

South Rockhampton Industrial Area

The Strategic Intent of the Planning Scheme states that the South Rockhampton industrial area will continue to provide for predominantly service and low impact industries. Future development within the South Rockhampton Industrial Area will be limited due to the impact from flooding. The Wharf Street section and surrounds are heavily constrained by the Flood Hazard Overlay (Figure 10-3).

The Wharf Street section includes the locally known “gas works” site, which is now used as a gas distribution site. The residential section of Wharf Street is located directly adjacent the gas distributor and includes approximately 12 residential lots fronting the Wharf Street and the Fitzroy River. The majority of these houses are “Queenslander” style houses or raised off ground level, due to historical flooding occurrences. The Fitzroy River side of Wharf Street is lined with riparian vegetation which adds to the character and amenity of the residential area. An image for Wharf Street is provided in Figure 10-9. The Wharf Street section has limited space between the developed area and the high bank of the Fitzroy River.

Figure 10-9 Wharf Street facing north (Source: Google Earth)

10.2.5 The Bend and South Rockhampton Sewage Treatment Plant

Figure 10-10 Aerial view The Bend and South Rockhampton Sewage Treatment Plant

This section is characterised by a range of utilities and industrial uses, including the South Rockhampton Sewage Treatment Plant, Main Drain, and an industrial precinct. This section also includes Powerlink's transmission infrastructure as it crosses the Fitzroy River.

Low Impact Industry

"The Bend" refers to the southern extent of the Low Impact Industry, South Rockhampton Precinct discussed above. The industrial area is located between the bend of the Fitzroy River and the main drain.

Fitzroy River Water, a commercial business unit of Council, own and operate the South Rockhampton Sewage Treatment Plant. The South Rockhampton SewageTreatment Plant services a catchment of approximate 19,000 equivalent persons, and includes commercial and industrial treatment. The treatment plant is zoned as Special Purpose of which the purpose to facilitate developments of this type in a suitable location, avoiding potential land use conflicts with sensitive receptors, and ensuring appropriate services are provided. This entire section is subject to extreme flood hazard events associated with a Fitzroy River Flood Event (Figure 10-3).

10.2.6 Potential Impacts, Mitigation and Management Measures

The following describes the potential impacts associated with the levee types on land uses.

Table 10-1 Levee types proposed for urban land use sections of Project area

Levee Type	Urban Land Use Section
Temporary fully demountable	Quay Street – Northern Extent
Composite	Quay Street – Middle Extent
Composite and earth embankment	Quay Street – Southern Extent
Crib retaining and composite	Wharf Street
Earth embankment and crib retaining wall	The Bend and Treatment Plant.

10.2.6.1 Temporary full demountable

The temporary fully demountable levees are proposed for the section of Quay Street – Northern Extent. Due to the hydraulics and geometry of the area, a temporary levee is feasible in this section of Quay Street. The temporary system will not result in any permanent infrastructure located on Quay Street.

A temporary levee in this location provides a range of land use benefits, including the following.

- Supporting the overall outcomes of the Principle Centre zoning in the Planning Scheme.
- Preservation of heritage buildings and streetscape on Quay Street.

- Continued access to open space areas and footpaths which promote active uses on ground floors and recreational usage of the area.
- Providing a level of flood protection to enable ongoing ground floor uses to occur with lessor risk of inundation.

10.2.6.2 Composite levee system

Composite levee systems are proposed in Quay Street – Middle Extent, part of Quay Street – Southern Extent, and part of Wharf Street. The composite levee system has been selected where there is either insufficient space for an earth embankment or crib wall, and a temporary levee is not capable of handling the flood heights expected for the area.

The Project is not anticipated to adversely impact on the overall intent of the South Rockhampton Industrial Area. The Project will provide protection to the existing low impact industry and residential land uses in the area.

The composite wall will be located within the road reserves and include an approximately 1.2 m height permanent wall. There are existing vehicle access points along the length of this section of levee alignment, and these access points from the dry-side to the wet-side of the levee will be maintained. Although the permanent wall will provide a fixed barrier to access to the open space and recreational areas on the wet-side of the levee, as well as a permanent inclusion in the view shed associated with the Fitzroy River, access is not anticipated to be adversely impacted, but rather channelled to the formal vehicle access points.

The inclusion of a composite levee system is a preferred design solution for the Wharf Street area, where residential blocks are located close to the Fitzroy River. A composite levee system will result in a lessor impact than that of a crib retaining wall or an earth embankment.

10.2.6.3 Crib retaining wall

Crib retaining wall are proposed in part of the industrial area of Wharf Street (in front the old gas works) and behind the South Rockhampton Sewage Treatment Plant. Crib retaining walls are proposed where there is minimal land availability and land uses place less emphasis on visual and amenity impacts.

The Project will provide protection to the South Rockhampton Sewage Treatment Plan during flooding events which will allow a level of service to continue during an event and post an event. Council have consulted with Fitzroy Water in order to achieve an acceptable design solution in this part of the Project area.

10.2.6.4 Operation of the levee

During a flooding event, the area outside of the levee (i.e. wet-side) is typically inundated with floodwaters, as it is under existing flood conditions. This evidently leads to a major restriction in land use activities in flooding conditions. The Project is not anticipated to impact on the existing land use activities on the wet-side of the Project area.

On the inside of the levee (i.e. dry-side), the Project is anticipated to provide protection to the areas which would typically be inundated in a base case scenario (i.e. without the levee in place) (refer Section 7.0). This leads to a land use benefit, allowing operation of land use activities to continue without a risk of flooding. The Planning Scheme restriction on any further intensification of land use within the area subject to flood hazard events provides additional mitigation, by reducing risks in the case of levee overtopping or failure events.

11.0 Waterways

11.1 Receiving Environment Overview

The Project area is located within the Fitzroy Basin. The Fitzroy River and the Gavial Creek tributary directly adjoin the Project area. These two waterway systems have a range of values identified by the local, State and Commonwealth Government. The Fitzroy River and Gavial Creek in vicinity of the Project area is a tidal system which is governed through the State Governments *Coastal Protection and Management Act 1995*. One of the objectives of this Act is to provide for the protection, conservation, rehabilitation and management of the coastal zone, including its resources and biological diversity.

The Fitzroy Basin discharges to the Great Barrier Reef World Heritage Area and National Heritage Area (which covers the Fitzroy River bed and banks) approximately 45 km downstream of the Project area. Inland waters associated with the Great Barrier Reef are important in terms of water quality, sediment quality and nutrient inputs in the system. Areas associated with the Great Barrier Reef and Fitzroy River Delta are managed under the *Environment Protection and Biodiversity Conservation Act 1999*.

The bed and banks of the Fitzroy River also forms part of the Fitzroy River Delta, which is listed on the Directory of Important Wetlands. The Fitzroy River Delta covers a large geographic area and includes the delta and coastal floodplain of the Fitzroy River downstream of the barrage in Rockhampton through to the coast line (DoEE, 2010).

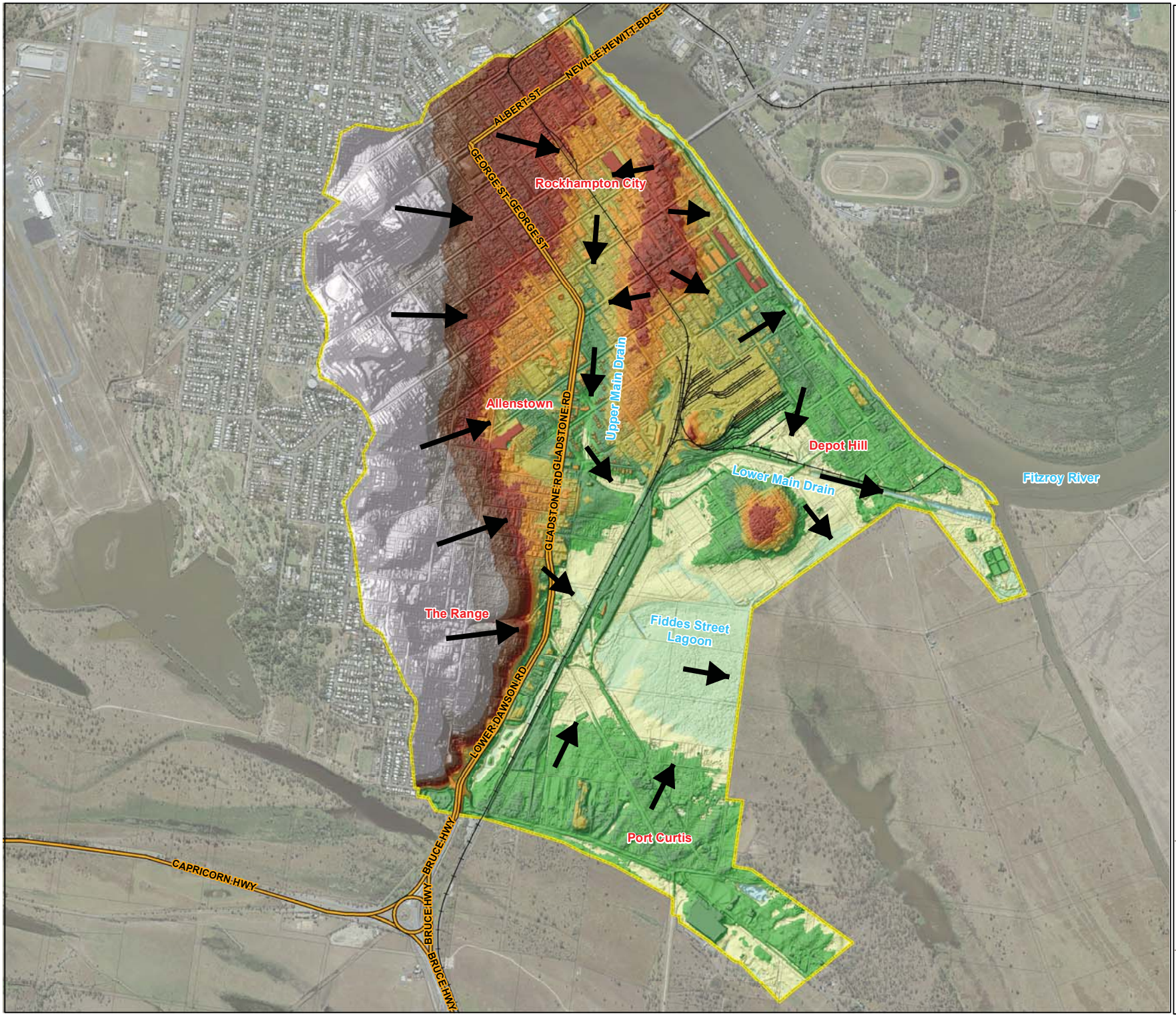
The Fitzroy River is mapped as a waterway under the Biodiversity Overlay Code in the Planning Scheme. The Biodiversity Overlay Code seeks to protect, rehabilitate and manage areas of environmental significance and the ecological processes and biodiversity values of waterways.

11.2 Local Catchment Description

Figure 11-1 provides a visual representation of key flow patterns within the study area during local catchment rainfall events. A description of catchment drainage is provided below.

- The eastern area of Rockhampton City discharges directly to the Fitzroy River.
- The western area of Rockhampton City, along with Allenstown and the northern section of The Ranges discharge to the Upper Main Drain, which flows into the Lower Main Drain. The Lower Main Drain also receives runoff from Depot Hill before discharging to the Fitzroy River via Gavial Creek.
- The area south of the North Coast Rail Line and Lower Main Drain has little natural grade with the majority of the terrain being below 6m AHD. This wetland area is known as the Fiddes Street Lagoon area and commonly retains water during the wet season. Most of the lagoon area drains to the southeast via cross-drainage and broad overtopping of Fiddes Street towards Gavial Creek, which outlets to the Fitzroy River. Further detail regarding Fiddes Street Lagoon is provided in Section 12.0.

Wider catchment details are described in Section 7.1.3.



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Rockhampton Regional Council

DATUM GDA 1994, PROJECTION MGA ZONE 56

0 200 400 600 800 1,000

Metres

1:20,000
(when printed at A3)

AECOM
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LEGEND

- Natural Flow Lines
- Highways
- Railway Lines
- Cadastre
- Hydraulic Model Extent

Topography (mAHD)

- < 4
- 4 - 5
- 5 - 6
- 6 - 7
- 7 - 8
- 8 - 9
- 9 - 10
- 10 - 11
- 11 - 12
- 12 - 13
- 13 - 15
- 15 - 20
- 20 - 40
- > 40

Data Sources:

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

SOUTH ROCKHAMPTON FLOOD LEVEE PROJECT

Subcatchment Flow Paths

PROJECT ID	60534898
CREATED BY	maultbyj
LAST MODIFIED	20/03/2019
VERSION:	A

Figure 11-1

Filename: P:\605x\60589157\900_CAD_GIS\920_GIS\MXD's\Interior Drainage Report Figures\Fig02_Sub_Catchment_Delineation.mxd

11.3 Surface Water Environmental Values

Environmental values (EVs) for water are the qualities of water that make it suitable for supporting aquatic ecosystems and human water uses. These EVs need to be protected from the effects of habitat alteration, waste releases, contaminated runoff and changed flows to ensure healthy aquatic ecosystems and waterways that are safe for community use. EVs for the Fitzroy River Sub-basin and corresponding water quality objectives (WQOs) have been developed in accordance with *Environmental Protection Act 1994* and Schedule 1 of the Environmental Protection Policy (EPP) (Water) 2009 under the 2011 document titled "*Fitzroy River Sub-basin Environmental Values and Water Quality Objectives Basin No. 130 (part), including all waters of the Fitzroy River Sub-basin*".

The EVs described in the above-mentioned documents have been developed by the Queensland Government as a representation of the values of the waterway to the community and description of the qualities of the waterway to be protected from the impacts of industry, urbanisation and other activities.

The Fitzroy River upper and middle estuaries are within the area mapped as '*Fitzroy main channel below barrage (estuarine)*'. Gavial Creek is within the area mapped as '*Fitzroy south/central tributaries*'. Coastal waters at the outlet of the Fitzroy River are within the area mapped '*Lower Fitzroy River (estuarine reaches)'.* The EVs applicable to these areas are provided in Table 11-1.

Table 11-1 Environmental values applicable to the Project area (Source: EHP, 2013)

Section	Environmental Values
Fitzroy main channel below barrage (estuarine)	• Aquatic ecosystems • Stock water (flood event) • Aquaculture • Human consumer • Secondary recreation • Visual recreation • Cultural and spiritual values
Fitzroy south / central tributaries	• Aquatic ecosystems • Irrigation • Farm supply/use • Stock water • Aquaculture • Human consumer • Primary recreation • Secondary recreation • Visual recreation • Drinking water • Industrial use • Cultural and spiritual values
Lower Fitzroy River (estuarine reaches)	• Aquatic ecosystems • Human consumer • Secondary recreation • Visual recreation • Industrial use • Cultural and spiritual values

11.4 Water Quality Objectives

WQOs are long-term goals for water quality management. They are numerical concentration levels or narrative statements of indicators established for receiving waters to support and protect the designated EVs for those waters (EHP, 2013). WQOs for aquatic ecosystem protection can be derived from either published guidelines or site-specific guidelines derived from long term monitoring data for an unimpacted 'reference' site, while WQOs for human use EVs (e.g. stock watering, irrigation, drinking water) are solely derived from published guidelines.

The 2011 published WQOs for relevant receiving waters in the Fitzroy River Sub-Basin are provided in Table 11-2. The applicable WQOs are designed for the protection of aquatic ecosystems (moderately disturbed).

Table 11-2 Water quality objectives applicable to aquatic ecosystem protection (2011)

Parameter	Unit	Fitzroy River Upper Estuary	Fitzroy River Middle Estuary	Gavial Creek (Freshwater)
Ammonia N	µg/L	30	10	20
Oxidised N	µg/L	15	10	60
Organic N	µg/L	400	260	420
Total nitrogen	µg/L	450	300	500
Filterable reactive phosphorus (FRP)	µg/L	10	8	20
Total phosphorus	µg/L	40	25	50
Chlorophyll a	µg/L	10	4.0	5.0
Dissolved oxygen:	% saturation	70–100	85–100	85–110
Turbidity	NTU	30*	30*	50
Secchi Disk	m	0.4*	0.4*	NA
Suspended solids	Mg/L	NA	NA	85
pH	pH units	7.0–8.4	7.0–8.4	6.5–8.5
Conductivity (EC) baseflow	µS/cm	NA	NA	445
Conductivity (EC) high flow	µS/cm	NA	NA	250
Sulfate	mg/L	NA	NA	15

* under baseflow conditions, i.e. where conductivity > 5mS/cm
NA = Not applicable; no WQO established

A commitment was made to review the 2011 scheduled WQOs when additional water quality information became available. Since scheduling of freshwaters in 2011, considerable additional data has been obtained from datasets held by Queensland Government departments and the Fitzroy Partnership for River Health. In March 2017, the Queensland Department of Science, Information Technology and Innovation (DSITI) published "*Draft environmental values and water quality guidelines: Fitzroy Basin fresh, estuarine and marine waters, including Keppel Bay for consultation.*" The draft WQOs applicable to the surface waters within the Project area and immediately downstream are provided in Table 11-3. Bracketed numbers represent 20th, 50th and 80th percentiles, and all other numbers represent either a range or a single value. No changes to EVs were made as a result of the 2017 publication and the EVs presented in Section 11.3 remain applicable.

Table 11-3 Draft water quality objectives applicable to aquatic ecosystem protection (2017)

Parameter	Unit	Fitzroy River Upper Estuary	Fitzroy River Middle Estuary	Gavial Creek		Keppel Bay Enclosed Coastal/ Lower Estuary[3]
				Baseflow[1]	Event Flow[2]	
Ammonia N	µg/L	30	10	(10-10-20)	(10-10-17)	8
Oxidised N	µg/L	15	10	(10-60-145)	(70-110-185)	3
Total nitrogen	µg/L	450	300	(250-500-730)	(805-950-1145)	200
Filterable reactive phosphorus (FRP)	µg/L	10	8	(20-40-80)	(85-105-135)	6
Total phosphorus	µg/L	40	25	(55-85-180)	(280-360-460)	20
Chlorophyll a	µg/L	10	4	5	NA	2
Dissolved oxygen:	% saturation	70-100	85-100	85-110	NA	90-100
Turbidity	NTU	30*	30*	(3-10-55)	(25-85-210)	NA
Secchi Disk	m	0.4*	0.4*	NA	NA	NA
Suspended solids	mg/L	NA	NA	(7-16-75)	(55-150-280)	NA
pH	pH units	7.0-8.4	7.0-8.4	6.5-8.5	6.5-8.5	8.0-8.4
Electrical Conductivity (EC)	µS/cm	NA	NA	(190-280-480)[#]	(170-240-340)[#]	NA
Sulfate	mg/L	NA	NA	(20-20-28)	(20-20-20)	NA

1 Baseflow <75.9m^3/s (cumecs) at gauge 130005A - Fitzroy River at The Gap

2 Event Flow <75.9m^3/s (cumecs) at gauge 130005A - Fitzroy River at The Gap

3 3 Moderately disturbed (MD) level of protection (i.e. excludes slightly disturbed (SD) or high ecological value (HEV) areas).

* under baseflow conditions, i.e. where conductivity > 5mS/cm

[#] Conductivity water quality guidelines are provided as 20th–50th–75th percentile

NA = Not applicable; no WQO established

11.5 Baseline Receiving Environment Quality

Baseline water quality data for the Project area receiving environment will be collated as part of a water quality management plan which will be developed for the construction phase of the project. A search of the Queensland Government Water Monitoring Information Portal indicated that there are no monitoring stations located downstream of the barrage on the Fitzroy River.

11.6 Potential Impacts, Mitigation and Management Measures

11.6.1 Hydrology

Potential impacts to catchment hydrology could occur as a result of development on the levee, where effective drainage mitigation is not included to ensure overland flow storage capacity is not increased. Impacts could include the following.

- Stream bed and bank erosion resulting from increased flow depth and/or velocity or increased overland flow storage capacity.
- Flooding impacts resulting from increased flow depth and/or velocity or increased overland flow storage capacity.

An Interior Drainage Study (Appendix K) was undertaken for the Project, and is detailed further in Section 7.4. This study identified an internal drainage strategy, which includes a number of components that facilitate drainage of the protected area. These components are detailed further in Section 7.4.1 and Appendix K. Key components include the following.

- Existing overland flow paths are generally maintained through a combination of flood gates in the levee and culvert structures that allow flow through the levee when Fitzroy River levels are not elevated.
- Landside open channels are to be constructed along the toe of the levee to discharge runoff longitudinally to three interior stormwater pump stations.
- The pump stations are to provide drainage of the internal area of the levee system once the outlets of the underground drainage and culvert structures are inundated and normal gravity flow ceases. The pump stations will also assist the existing drainage network during larger local catchment events.

The purpose of the Project is to mitigate the impacts associated with the well documented flooding from the Fitzroy River system. As a result of this, the infrastructure will lead to a change in hydraulic regimes on the Project area during the operational life of the Project.

The Hydraulic Assessment Report identifies the predicted differences in velocities (Appendix J). Detailed peak depth averaged velocity mapping has been undertaken for the Project in order to demonstrate any alterations to the velocity regime within the Project area. The assessment highlighted the following:

- Floodplain velocities are expected to increase in areas adjacent to the southern portion of the levee alignment between chainage 1200 m and chainage 2300 m (south of Hastings Deering).
    - This is the result of constriction of the Yeppen North flow path.
    - Modelling indicates that the difference in floodplain velocities will increase in response to increased western floodplain discharge until wide scale overtopping of the levee crest occurs (which is expected to occur in the 0.05% AEP events).
- Floodplain velocities upstream of the southern portion of the levee (between chainage 0 m and chainage 1200 m) are expected to reduce in response to the downstream constriction of the Yeppen North flow path. This is particularly evident at the Rockhampton Roundabout and Yeppen Lagoon road and rail crossing.
- Floodplain velocities adjacent to the central portions of the levee (between Port Curtis Road and the SRSTP) are expected to reduce due to the redistribution of flows to this area as a result of the southern portion of the levee alignment.
- There is predicted to be some increase in floodplain velocity on the northern and southern banks of the lower river meander, adjacent to the Gavial Creek confluence.
- Velocities in the remainder of the floodplain are expected to remain unchanged with reference to the Baseline conditions (± 0.1 m/s difference in velocity).

Where erosion potential has been identified as a result of increased velocities, design measures have been incorporated to minimise the risk of erosion impacts associated with the waterways. This includes the following.

- Bank stabilisation (under a separate approval process) to protect areas adjacent to the levee which are at risk of slumping or failure along the Fitzroy River and Gavial Creek.
- The wet-side of the earth embankment levee will include rock protection at locations where high river velocities increase potential for scouring.
- The wet-side of the crib wall will include rock protection at locations where higher river velocities increase the potential risk of scouring.

During construction, erosion and sediment control will be managed through the Environmental Management Plan (Planning) provided in Appendix T. Measures to reduce and manage the risk of erosion and sedimentation impacts on the adjoining Project area, including the Fitzroy River and Gavial Creek include the following.

- Manage disturbance in accordance with the IECA Best Practice Guidelines.
- Develop and implement an Erosion and Sediment Control plan prior to ground disturbance.
- Diversion drains/bunds and associated infrastructure are to be designed in accordance to the International Erosion Control Association (IECA) Best Practice Erosion and Sediment Control Guidelines (2009).
- Undertake progressive rehabilitation of disturbed areas as soon as practicable to establish ground cover.

11.6.2 Water Quality

Potential impacts to water quality in adjoining waterways can occur as a result of the Project. Impacts may include the following as a result of run off during construction.

- Discharge of sediments (both air and water-borne) from exposed ground during construction phase resulting in adverse impacts on receiving environment surface water quality.
- Spills/leaks from chemical (e.g. fuel and oil) storage areas into surface water bodies during construction/ operational phases resulting in adverse impacts on receiving environment surface water quality.

Mitigation and management measures proposed to minimise potential impacts on water quality in the surface water receiving environment are detailed below.

- A water quality management plan is developed for the construction of the Project and surface water quality baseline sampling will be completed prior to construction.
- Clean water diversions around local stockpiles and exposed areas to be implemented.
- Divert clean, non-impacted storm water runoff around any activities that have the potential to add contaminants.
- Spill kits are to be kept at each work area. Ensure that all personnel are trained in the location and use of spill kits.
- All hazardous and flammable materials are to be stored in accordance with AS1940:2004.
- Erosion and sediment controls as described above.

12.0 Wetlands

Three wetlands are located within and / or directly adjacent to the Project area. A wetlands assessment has been undertaken for the Project to identify the existing wetland values present, the potential impacts from the Project and mitigation and management measures to reduce potential impacts. The full assessment is provided in Appendix P, and the following section provides a summary of the key outcomes.

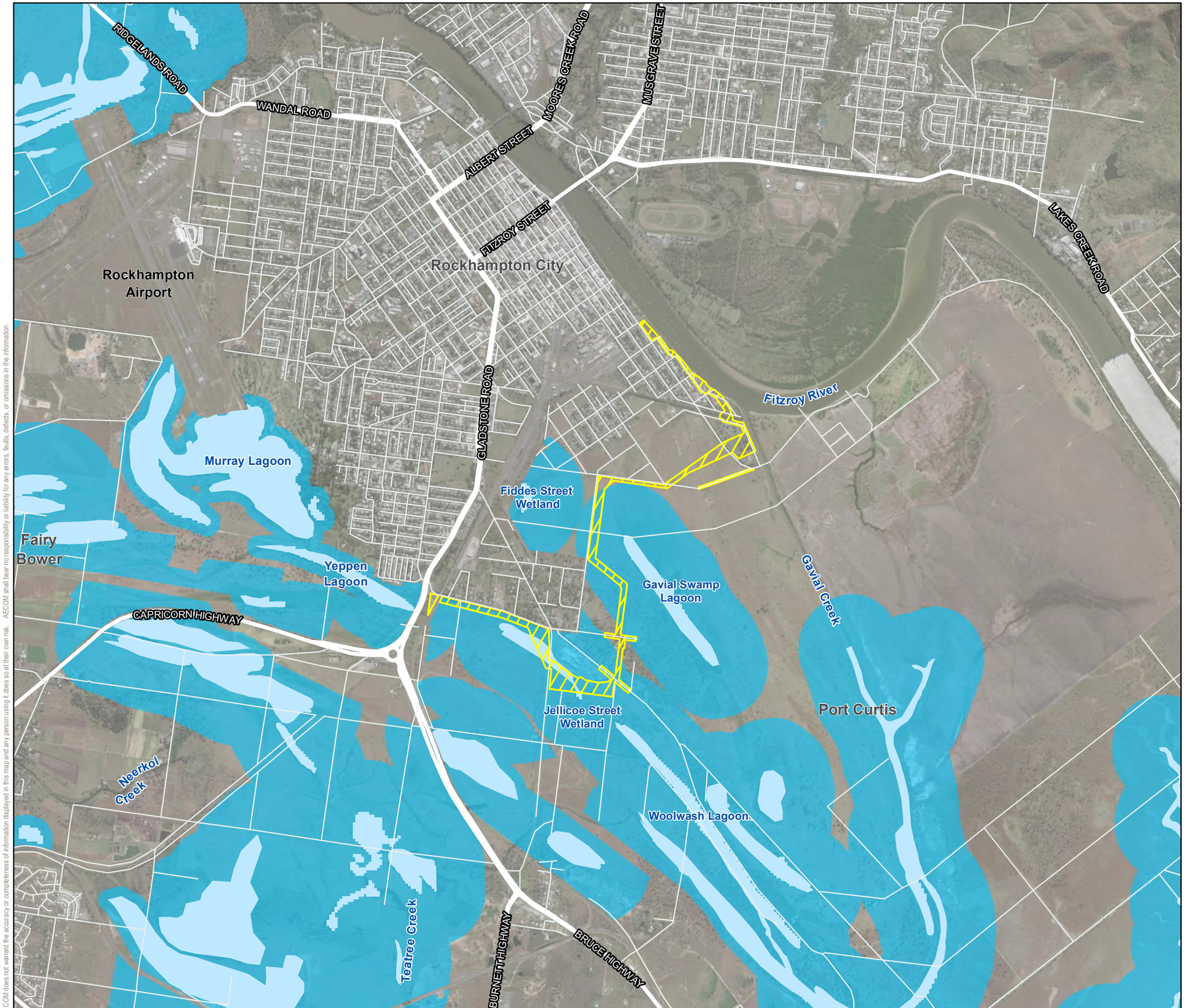
The locations of these wetlands and the names attributed for the purpose of this assessment are identified on Figure 12-1. The extent of the hydrological influence of the wetland is identified as the trigger area. This trigger area and the wetland boundaries are collectively referred to as a Wetland Protection Area.

These wetlands are all identified as High Ecological Significance wetlands, and therefore considered a Matter of State Environmental Significance. Table 12-1 outlines the key characteristics of each wetland. All three wetlands are considered Palustrine with Gavial Swamp Lagoon also incorporating some Lacustrine areas. Two of the wetlands display ephemeral natures while the third (Fiddes Street Wetland) is perennial, possibly associated with urban development in the surrounding catchment area.

All three wetlands have associated alluvial aquifers and are considered Groundwater Dependent Ecosystems with each wetland likely presenting as a surface extension of the underlying aquifer. The wetlands will also act as a recharge point for each of the associated aquifers. Despite no water quality data, all three wetlands (and their associated aquifers) have been assessed as freshwater systems based on the floristic communities and known source waters for each wetland.

The Project involves the development of a flood levee across the Yeppen Floodplain with direct influence on the three targeted wetlands. The levee will intersect the Jellicoe Street wetland as well as the buffer areas associated with Fiddes Street Wetland and Gavial Swamp Lagoon. As such, the potential impacts associated with the Project to aquatic ecology values and wetland function are as follows.

- Altered hydrological (both surface waters and groundwater in alluvial palaeochannels) regime and corresponding limited connectivity.
- Loss of habitat.
- Altered soil erosion and sediment deposition regimes.



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LEGEND

- Major Roads
- Minor Roads
- SRFL Alignment
- High Ecological Significance Wetlands
- Wetland Protection Trigger Area

Data sources:
Imagery: QLDBase Imagery WMS
Ornamental Snake & Shorebired Records: Atlas of Living Australia, eBird.

SOUTH ROCKHAMPTON FLOOD LEVEE PROJECT

Wetland Protection Areas in the Project area

PROJECT ID	60589157
CREATED BY	WeirW
LAST MODIFIED	11-Apr-2019
VERSION	<version number>

Figure 12-1

A3 size

Table 12-1 Wetland Characteristics

Wetland Name	Type	Period of Inundation	Upstream Catchment	Description
Fiddes Street Wetland	Palustrine	Perennial	Recharged, potentially year-round, by urban runoff. The system can also receiving flooding flows from the Fitzroy River with the duration lasting up to two weeks.	This wetland was likely ephemeral prior to urban development within its surrounding catchment area. The wetland now receives runoff, potentially year-round, from the adjacent upstream urban areas while also displaying increased ponding from a historic downstream road embankment that effectively acts as a dam. The wetland is heavily vegetated and of moderate size. The perennial pool is surrounded by a dense sedgeland. This vegetation within the wetland would filter the urban runoff as it passes through. This system is potentially hydraulically connected to the same aquifer associated with the Gavial Swamp Lagoon based on paleo-channels observed during a review of historic aerial photographs. During flood events from the urban area the wetland overtops the road embankment and enters the Gavial Swamp Lagoon.
Jellicoe Street Wetland	Palustrine	Ephemeral	Receives flows from Yeppon Lagoon during flood/overtopping events as well as potentially receiving some industrial runoff from an adjacent facility.	The Jellicoe Street Wetland is a small, highly ephemeral wetland that is recharged from the Yeppen Lagoon overtopping during large inflow events. These two wetlands inhabit the same paleo-channel within the floodplain. Based on the perennial nature of Yeppen Lagoon compared to that of the Jellicoe Street Wetland, the alluvial aquifer associated with the Yeppen Lagoon likely expands to include the Jellicoe Street Wetland during floods. It is likely the alluvial aquifer associated with this wetland is also ephemeral. The wetland likely supports a limited aquatic flora community due to its highly ephemeral nature. However, it is unclear from the results of the surveys as the wetland was dry during sampling. The wetland is encompassed by historic grazing land with an industrial estate located immediately to the north.
Gavial Swamp Lagoon	Palustrine / Lacustrine	Ephemeral	This wetland displays a localised catchment area receiving runoff from	Gavial Swamp Lagoon is the largest of the three lagoons targeted by this assessment. It is characterised by Queensland

Wetland Name	Type	Period of Inundation	Upstream Catchment	Description
			adjacent grazing paddocks and overflow from Fiddes Street Wetland. However, it also receives flooding flows from the Woolwash Lagoon and the Fitzroy River with the duration lasting up to two weeks.	Government's wetland mapping as a long Lacustrine wetland surrounded by a Palustrine wetland. However, this delineation is highly dependent on the timing of the assessment as the system is ephemeral. For example, as the systems dries out over the course of each year the mapped Lacustrine component (i.e. the deep waterbody relatively clear of aquatic plants) becomes shallower with increased utilisation by aquatic flora, thereby reverting to a Palustrine system. The fringing vegetation was comprised on introduced grasses and the declared weed *Parthenium hysterophorus*. These impacts area likely related to the extensive use of the system for cattle grazing. Historic aerial photographs show that the centre of the mapped Lacustrine section of the wetland has been excavated to extend the permanency of water likely for stock drinking purposes. The wetland possibly has an extensive associated alluvial aquifer that may also be ephemeral. This aquifer potentially has limited connectivity to the Fiddes Street Wetland aquifer.

12.1 Hydrological Change/Reduced Connectivity

The Project may influence the natural surface and sub-surface hydrological process across the area. Potential impacts differ across the area, and are detailed further in Table 12-2.

Table 12-2 Potential impacts – hydrological change / reduced capacity

Wetland	Impact
Fiddes Street Wetland and Gavial Swamp Lagoon	Currently these two wetlands have connectivity during large localised flow events (i.e. runoff coming from urban catchments, entering Fiddes Street Lagoon, and overtopping into Gavial Swamp Lagoon) as well as during flooding from the Fitzroy River pushing back into Fiddes Street Wetland from downstream reaches (refer to Table 12-1. Installing a physical barrier above ground has the potential to alter surface flows entering both systems, consequently limiting periods of inundation and associated connectivity, and altering flow velocities. Note; Fiddes Street Wetland is the only wetland assessed (of the three) that has a perennial water body and, as such, can act as a refuge for aquatic fauna during the dry season. Further, it is likely that the aquifers associated with the two wetlands also currently have periods of connectivity. The weight of the surface structure (i.e. levee), together with the as-built compaction factor and the associated below ground key have the potential to influence water movement between these two aquifers. The extent to which this may influence the period of inundation of these aquifers and their associated surficial wetlands (i.e. GDEs) is not able to be quantified. However, the wetlands themselves (as well as much of the surrounding catchment area) will continue to act as recharge points for these aquifers.
Jellicoe Street Wetland	The Jellico Street Wetland is within the proposed alignment of the levee with the part of the wetland to be lost during development. This will also impact the underlying aquifer potentially causing waters to pool on the southern side of the levee. It is unlikely to significantly affect the hydraulic connectivity between Yeppen Lagoon and Woolwash Lagoon.

Altered hydrology and reduced connectivity may limit the ability for aquatic fauna to move (i.e. migrate) into these systems. As these systems (except Fiddes Street Wetland) do not generally provide refuge for aquatic fauna throughout the dry season, the impacts to fish and turtle populations across the greater Fitzroy Sub-basin will likely be minimal. However, less recruits also infers less food availability to migratory birds/terrestrial species that utilise the wetlands during wet periods.

Several hard engineering solutions have been designed into the proposed levee to ensure the current surface hydrological regime (during non-Fitzroy River flood events) is relatively unimpeded by the development. Such measures include the following.

- Pump stations: These will maintain base water levels within Fiddes Lagoon while facilitating local recharge of the Gavial Swamp Lagoon as flows persist.
- One-way culverts: That will be positioned at a similar height and location to the current culverts under Fiddes Street that provide surface water connectivity between the Fiddes Street Wetland and Gavial Swamp Lagoon.

These mitigation methods aim to ensure current surface flow patterns between Fiddes Street Wetland and Gavial Swamp Lagoon during non-flooding events are maintained post development.

Such structures can act as a barrier to fish passage if inappropriately designed. Current fish movement patterns between Gavial Swamp Lagoon and the perennial Fiddes Street Wetland during periods of flow are not well understood. Further investigation of the potential for the development to influence fish migration across the floodplain may be required to guide final culvert designs.

12.2 Loss of Habitat

Partial removal of wetland habitat by the development of the levee (during the construction and operational phases) may also have an impact on wetland values as discussed in Table 12-3.

Table 12-3 Potential impacts – loss of habitat

Wetland	Impact
Fiddes Street Wetland	Fiddes Street Wetland will not be directly impacted by loss of habitat as the proposed alignment occurs on the downstream (external) side of the current Fiddes Street road alignment that encompasses the downstream end of the wetland.
Gavial Swamp Lagoon	Gavial Swamp Lagoon will lose a section of the mapped WPA from within the Project area. The WPA is the buffer zone of hydraulic influence around the HES wetland. The levee crosses the outer edge of this buffer. This area would have limited surface aquatic ecology values as it probably dries out rapidly after inflows cease each year (based on a review of historic aerial photographs). However, it may impede alluvial aquifer flows associated with the wetland, potentially altering the period of inundation within the associated wetlands.
Jellicoe Street Wetland	Jellicoe Street Wetland is within the proposed alignment of the levee with part of the wetland to be lost during development. This will, however, only slightly reduce the coverage of wetland habitat within the overall Yeppen Floodplain. Taking into account the available wetland habitats throughout the entire Yeppen Floodplain, the highly ephemeral nature and relatively small size of this mapped wetland indicates any impact on the aquatic ecology values and wetland function of the large Yeppen Floodplain system is not considered to be significant.

The design of the levee has been based on detailed modelling, community consultation and consideration of the identified environmental values. While several different designs alterations were reviewed, the current proposed alignment best meets the requirements of flood mitigation, the expectations of stakeholders and limited the impacts on HES wetlands across the greater Yeppen Floodplain.

Further, the design of the levee with a relatively minor key structure (~1m below ground) is likely to limit any impacts on the associated alluvial aquifer flows through the area.

12.3 Soil Erosion and Sediment Deposition

Increased soil erosion and an altered sediment deposition regime has the potential to occur during construction processes (i.e. from vegetation clearing) as well as the operational phase (i.e. from altered flow velocities). Further ponding in Fiddes Street Lagoon has the potential to increase sedimentation rates, while increased velocities in Gavial Swamp Lagoon during flood events has the potential to increase erosion rates.

Elevated erosion rates can adversely impact primary production within a water body by increasing suspended sediment loads (i.e. reducing light attenuation), while increased sedimentation often leads to the smothering of habitats impacting both primary production and macroinvertebrate communities, with flow-on effects up the food chain (Gleason *et al.*, 2003; Gray & Ward 1982; Wood & Armitage 1997).

Construction of the levee will be undertaken during the dry season to limit the potential for soil erosion from cleared areas entering the neighbouring wetlands. On completion the earthen levee will be appropriately rehabilitated with grass species to avoid erosion. Once the levee has been constructed, the current surface hydrological regime of Fiddes Street Wetland, during non-flood flow events, will be mirrored as closely as possible by the operation of pump stations and cross drainage culverts.

13.0 Terrestrial Ecology

13.1 Ecological Values

An Ecological Assessment Report has been prepared to document the terrestrial flora and fauna species and vegetation communities within and adjacent to the Project area, with particular reference to the occurrence of conservation significant and migratory species. This section has been prepared as a summary, and the complete report is provided in Appendix Q.

The Ecology Assessment Report was a two stage process involving a desktop assessment followed by a flora and fauna survey in November 2018. A subsequent targeted fauna survey for the ornamental snake (*Denisonia maculata*) and migratory shorebirds was undertaken in January 2019. Detailed methodologies for the desktop assessment and field surveys, as well as survey limitations for each field survey, are provided in Appendix Q.

13.1.1 Fauna

The November 2018 and January 2019 field surveys recorded 97 fauna species, comprising 88 bird, 3 mammal, 4 reptile and 2 amphibian species. All observed fauna were typical for the region and habitat types recorded on site. The following provides a summary of the findings from the desktop assessment and field surveys, and further details on fauna within the Project area are provided in Appendix Q.

13.1.1.1 Conservation Significant Fauna

The desktop assessment identified 34 conservation significant fauna species (excluding those species that are exclusively marine) with the potential to occur within the Project area. No conservation significant fauna species were identified during the field surveys.

Essential habitat for the ornamental snake (*Denisonia maculata*) is mapped within the Project area. Weather conditions during the targeted ornamental snake survey were considered to be poor to adequately survey for the ornamental snake and none were identified during the January 2019 survey. The habitat that was accessed during the field survey was not considered to be suitable habitat for the ornamental snake. The vegetation adjacent to the surveyed wetlands was heavily impacted by cattle and weeds, and were considered unlikely to support a population of ornamental snake.

One property, that was unable to be accessed during the field survey (including Gavial Swamp Lagoon), contains a large area of mapped essential habitat for the ornamental snake and aerial photography of the property indicates that it contains gilgai. Gavial Swamp Lagoon was dry at the time of the field survey; however during times of rainfall, this wetland may contain suitable habitat for the ornamental snake.

13.1.1.2 Migratory Birds

The desktop assessment identified 25 migratory species with the potential to occur within the Project area (excluding those species that are also listed as Critically Endangered, Endangered, Vulnerable or Near Threatened). Marine species were also excluded from this assessment.

A total of 31 waterbirds were recorded during the January 2019 field survey. Three species are listed as migratory:

- Latham's snipe (*Gallinago hardwickii*); Migratory under the EPBC Act. This species was recorded at Murray Lagoon and Fiddes Street Wetland.
- Caspian tern (*Hydroprogne caspia*); Migratory under the EPBC Act. This species was recorded at Fiddes Street Wetland.
- Glossy ibis (*Plegadis falcinellus*); Migratory under the EPBC Act. This species was recorded at Yeppen Lagoon, Fiddes Street Wetland and Woolwash Lagoon.

Key outcomes of the migratory birds survey include the following.

- None of the migratory bird species present where found to occur as ecologically significant proportions of the overall population of the species.

- There do not appear to be any especially significant population characteristics or processes occurring within the Project area that indicate ecological significance of the site.
- No distributional limits for any of the migratory bird species occur within the Project area.
- The habitat within the Project area is mostly ephemeral and is heavily impacted by cattle and weeds, and is therefore not considered especially important to any of the migratory species.

13.1.1.3 Non-indigenous Fauna

The November 2018 and January 2019 field surveys recorded six introduced species:

- Feral pigeon (*Columba livia*)
- Common myna (*Sturnus tristis*)
- Cane toad (*Rhinella marina*)
- Asian house gecko (*Hemidactylus frenatus*)
- Dingo/dog (*Canis lupus*); listed as Categories 3, 4, 5, 6 Restricted Matter under the *Biodiversity Act 2014*
- Cat (*Felis catus*); listed as Categories 3, 4, 6 Restricted Matter under the *Biodiversity Act 2014.*

Additionally, the field survey undertaken in 2014 recorded the red fox (*Vulpes vulpes*); listed as Categories 3, 4, 5, 6 Restricted Matter under the *Biodiversity Act 2014,* and the nutmeg manikin (*Lonchura punctulata*) (AECOM, 2014a).

A number of other introduced species, restricted under the *Biodiversity Act 2014*, are likely to occur within the Project area including black rat (*Rattus rattus*) and European rabbit (*Oryctolagus cuniculus*).

Details relevant to biosecurity for the Project are provided in Section 14.0.

13.1.1.4 Likelihood of Occurrence Assessment

A likelihood assessment performed during the desktop assessment was refined following confirmation of habitat values during the field surveys. The resulting occurrence assessment identified 21 fauna species as present or having a moderate or high likelihood of occurring. The full assessment is presented in Appendix Q.

Table 13-1 Likelihood of occurrence assessment summary

Value	Likelihood of Occurrence		
	Moderate	**High**	**Present**
Conservation Significant Fauna	• Australasian bittern (*Botaurus poiciloptilus*) • Curlew sandpiper (*Calidris ferruginea*) • Western Alaskan bar-tailed godwit (*Limosa lapponica bauera*) • Koala (*Phascolarctos cinereus*) • Ornamental snake (*Denisonia maculata*)	• Australian painted snipe (*Rostratula australis*) • Squatter pigeon (southern) (*Geophaps scripta scripta*)	-

Value	Likelihood of Occurrence		
	Moderate	High	Present
Migratory Fauna	• Common sandpiper (*Actitis hypoleucos*) • Pectoral sandpiper (*Calidris melanotos*) • Black-tailed godwit (*Limosa limosa*) • Little curlew (*Numenius minutus*) • Wood sandpiper (*Tringa glareola*)	• Sharp-tailed sandpiper (*Calidris acuminate*) • Red-necked stint (*Calidris ruficollis*) • Little tern (*Sterna albifrons*) • Common greenshank (*Tringa nebularia*) • Marsh sandpiper (*Tringa stagnatilis*)	• Latham's snipe (*Gallinago hardwickii*) • Caspian tern (*Hydroprogne caspia*) • Eastern osprey (*Pandion cristatus*) • Glossy ibis (*Plegadis falcinellus*)

13.1.2 Flora

The field survey identified 41 flora species from 21 families. The following provides a summary of the findings from the desktop assessment and field surveys, and further details on flora within the Project area are provided in Appendix Q.

13.1.2.1 Regional Ecosystems

Based on the Queensland Herbarium RE mapping (Version 11), the Project area is predominantly located within non-remnant vegetation, intersecting two heterogeneous polygons of REs along the Project alignment, as listed in Table 13-2 below.

Table 13-2 Mapped REs within the Project area

RE	Short Description[1]	*Vegetation Management Act 1999* Status
11.3.2	*Eucalyptus populnea* woodland on alluvial plains.	Of Concern
11.3.3	*Eucalyptus coolabah* woodland on alluvial plains.	Of Concern
11.3.3c	*Eucalyptus coolabah* woodland to open woodland (to scattered trees) on alluvial plains or levees.	Of Concern
11.3.4	*Eucalyptus tereticornis* and/or *Eucalyptus* spp. woodland on alluvial plains.	Of Concern
11.3.27c	Mixed grassland or sedgeland with areas of open water +/- aquatic species on closed depressions on alluvial plains.	Least Concern
11.3.27x1b	Sedgelands to grasslands on Quaternary deposits.	Least Concern

[1] Description of REs as contained in the REDD Version 11 (Queensland Herbarium, 2018)

REs were ground-truthed during the field survey, with one RE mapped as occurring within the Project area. The short description of the RE is presented in Table 13-3 below and the extent of the RE is illustrated on Figure 13-1.

Table 13-3 RE mapped within the Project area

RE	Short description[1]	*Vegetation Management Act 1999* Status
11.3.4	*Eucalyptus tereticornis* and/or *Eucalyptus* spp. woodland on alluvial plains.	Of Concern

[1] Description of REs as contained in the REDD Version 11 (Queensland Herbarium, 2018)

13.1.2.2 Threatened Ecological Communities

The desktop assessment identified four TECs as potentially occurring within the Project area. No TECs were identified within the Project area during the field survey and none are considered likely to occur.

13.1.2.3 Marine Plants

Marine plants were identified during the field survey at one location within the Project area in a tributary to Gavial Creek. The extent of the marine plants was mapped and is shown in Figure 13-1. The marine plants identified along the Fitzroy River are discussed and mapped within the Marine Plant Assessment report (AECOM, 2018).

Dominant marine plant species found within the Project area during the field survey are outlined in Table 13-4 below.

Table 13-4 Dominant marine plants identified within the Project area

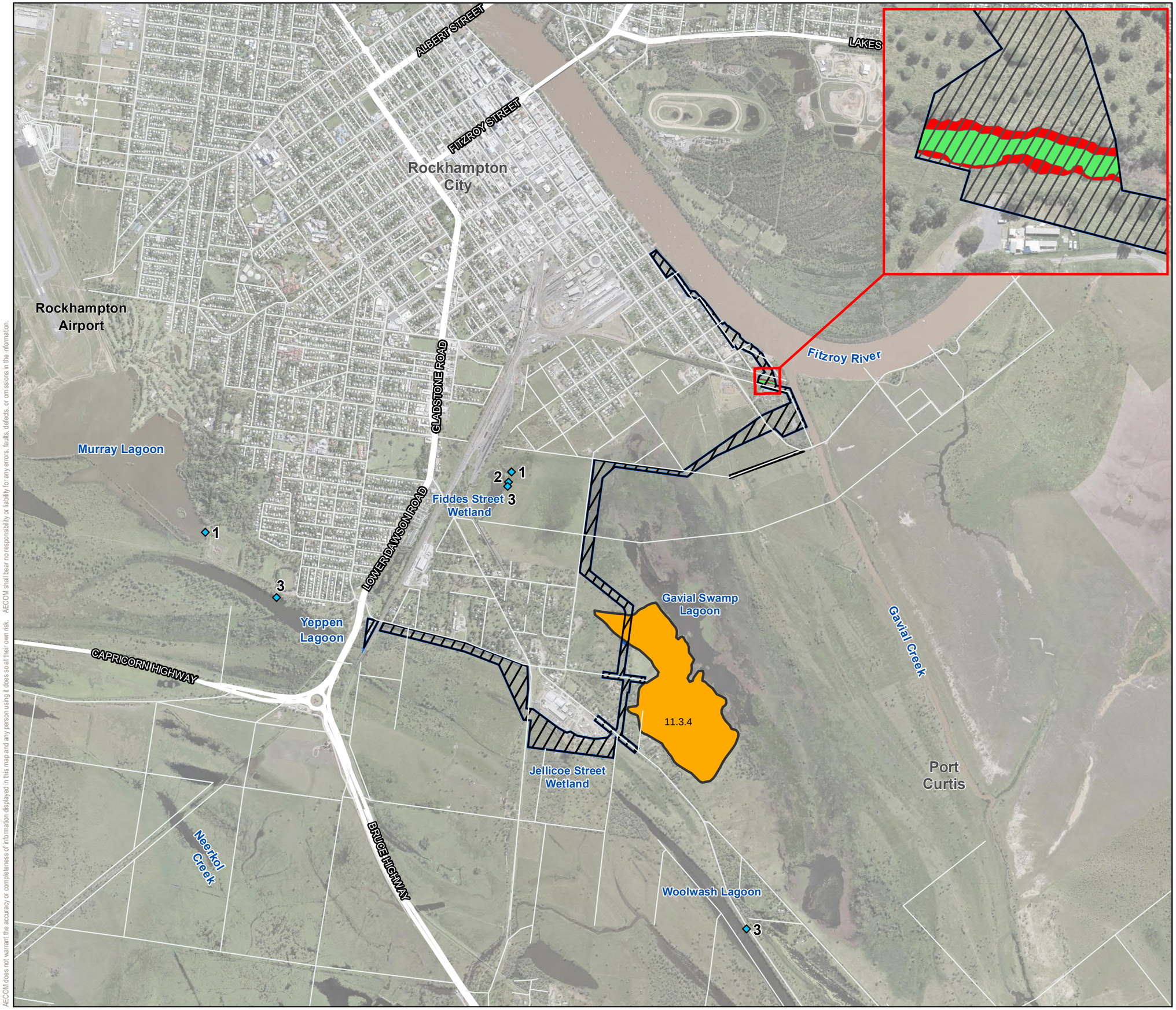
Scientific Name	Common Name
Aegiceras corniculatum	River mangrove
Excoecaria agallocha	Milky mangrove
Phragmites australis	Common reed

13.1.2.4 Conservation Significant Flora

The desktop assessment identified 13 conservation significant flora species with the potential to occur within the Project area. No conservation significance species or protected plants were recorded within the Project area during the field survey.

13.1.2.5 Non-indigenous Flora

Eighteen introduced species were identified during the flora survey. Five species identified are listed as Category 3 Restricted Matter under the *Biosecurity Act 2014* and three species are listed as Weeds of National Significance (WoNS). Details relevant to biosecurity for the Project, including mitigation measures for the control of weed spread, are provided in Section 14.0.



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DATUM GDA 1994, PROJECTION MGA ZONE 56

0 310 620 1,240
Metres

1:25,000 (when printed at A3)

LEGEND

- Conservation Significant Species
- Major Roads
- Minor Roads
- SRFL Alignment

Marine Plants Mapping

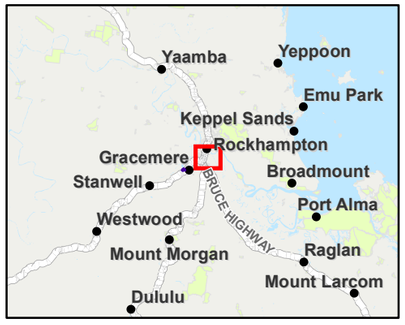
- Mangroves
- *Phragmites australis*

Ground-truthed RE mapping

- 11.3.4 (Of Concern)
- Non-rem

Conservation Significant Species

1 Latham's Snipe (*Gallinago hardwickii*)
2 Caspian Tern (*Hydroprogne caspia*)
3 Glossy Ibis (*Plegadis falcinellus*)



Data sources:
Imagery: QLDBase Imagery WMS
Ornamental Snake & Shorebired Records: Atlas of Living Australia, eBird.

SOUTH ROCKHAMPTON FLOOD LEVEE PROJECT

Terrestrial ecology values in the Project area

PROJECT ID	60589157
CREATED BY	WeirW
LAST MODIFIED	11-Apr-2019
VERSION	<version number>

Figure 13-1

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A3 size

13.2 Potential Impacts, Mitigation and Management Measures

The following provides a summary of the potential impacts to ecological values, and mitigation and management measures. Further details are provided in Appendix Q. Potential impacts to ecological values may occur in the construction and operational phases of the Project, including the following:

- Construction Phase
  - Vegetation clearing
  - Loss of fauna habitat and fragmentations
  - Fauna mortality or injury
  - Activity and noise
  - Establishment of introduced species.
- Operation and Maintenance Phase
  - Hydrological Change and Potential Ecological Impact.

No significant impacts to conservation significant or migratory species were identified.

13.2.1 Construction Phase

The Project will potentially clear the entire Project area, with a maximum clearing area of approximately 54.72 ha of vegetation. This includes:

- 0.95 ha of “Of Concern” Regional Ecosystem (RE) 11.3.4
- 53.44 ha of non-remnant vegetation.
- 0.33 ha of marine plants.

The clearance of native vegetation can adversely affect native fauna species, through loss of habitat, fragmentation of populations, and loss of food resources. Clearing of vegetation can also result in injury or mortality of fauna, particularly ground dwelling fauna (e.g. reptiles), that may be crushed by machinery or struck by vehicles. Arboreal mammals may be trapped in trees as they are felled. Whilst a local impact on fauna may occur, the impact on fauna populations within the broader landscape is considered minimal.

While the extent of vegetation clearing for the Project will mean that potential impacts on fauna habitat are unavoidable, there are a range of measures that may be taken to minimise the level of impact. These include the following.

- Vegetation clearing will be minimised in sensitive environments, specifically riparian areas around creek lines and wetlands.
- Identification and mapping clear no-go zones will be undertaken to avoid unauthorised disturbance of areas of sensitive vegetation and habitat; such as identified nests and trees that are to be retained.
- Pre-clearance surveys will be completed to identify shelters and breeding places potentially utilised by Least Concern species, colonial breeders and conservation significant fauna will be undertaken.
- Suitably qualified fauna spotter catchers must be engaged to undertake pre-clearance habitat searches and be present during vegetation clearing activities to minimise fauna harm.
- Significant habitat features such as felled trees and logs will be considered for relocation to other areas where practical to provide microhabitat for fauna.
- Any injured, sick and dead vertebrate fauna will be recorded during (by fauna spotter-catchers) and during construction and operation.

During the construction phase, there will be an increase in noise and activity in the Project area as machinery undertakes clearing, access and general construction activities. It is important to note that these potential impacts will not affect the entire Project area simultaneously.

Potential impacts associated with increased activity and noise include reduced foraging ability by auditory predators, increased risk of predation by visual predators; increased potential for collisions with vehicles, and disturbance to foraging or breeding behaviours. It is anticipated that excavation, construction and earthmoving associated with the Project will potentially cause disturbance to all groups of fauna, especially birds and may result in avoidance of the area for the duration of these activities.

Eighteen introduced flora species were identified during field surveys, including five species listed as Category 3 Restricted Matter and three species as WoNS. Construction activities may increase the risk of establishment of new infestations and exacerbation of existing infestations through soil disturbance, increased pedestrian and vehicular traffic through the area, and importation of construction materials to the site which may harbour introduced species. It is unlikely that further introductions of feral vertebrate species would occur as a result of the Project. It is also unlikely that the proposed development would exacerbate current pest populations given they are well established in the region. Biosecurity for the Project, including mitigation measures for the control of weed spread is provided in Section 14.0.

13.2.2 Operation and Maintenance Phases

The hydraulic assessment determined that the Project will not result in significant changes to the hydrological processes of the Project area during times of typical rainfall. The wetlands within the Project area are recharged from the local catchment, as well as the Fitzroy River and its tributaries.

Potential hydrological changes during flood events, to mapped wetlands which occur immediately adjacent and within the Project area, are discussed in Section 12.0. The following provides a brief summary of potential ecological impacts associated with these changes:

- Fiddes Street Wetland: No loss to the size and extent of the waterhole and sedgeland is expected. Connectivity between Fiddes Street Wetland and Gavial Creek for reptiles such as turtles is expected to be disrupted during Fitzroy River flood events when the culverts are closed.
- Gavial Swamp Lagoon: The natural regime (ephemeral wetland) will be maintained. The capacity of this wetland to support wetland birds and other associated fauna is unlikely to be significantly impacted.
- Jellicoe Street Wetland: This wetland occurs within the Project area and this low ecological value wetland is likely to be lost. Given the low value of this wetland, and the availability of similar wetlands in the immediate area, it is unlikely that ecological impacts will be significant.
- Woolwash Lagoon, Yeppen Lagoon and Murrary Lagoon: The regime and recharging of this wetland is unlikely to be impacted. The potential ecology impacts are thus unlikely to impacted.

14.0 Biosecurity

This section outlines the proposed detailed measures to remove, control and limit the spread of pests, weeds, disease and pathogens on the proposed Project area.

14.1 Biosecurity Zones

A biosecurity zone is a part of Queensland that has legal movement restrictions placed on it to limit the spread of pests and diseases within the state. Queensland has several biosecurity zones for different pests and diseases. The Project area is within three existing biosecurity zones:

- Cattle Tick Biosecurity Zone
- Sugar Cane Biosecurity Zone 3
- State Grape Phylloxera Risk Zone.

A biosecurity certificate may be required to move risk items originating in the zones above (including machinery and soil) into and around Queensland. A biosecurity certificate can only be issued by an accredited certifier and must be issued before the movement takes place. The biosecurity certificate provides evidence that the risk minimisation requirements have been met for that movement. The Queensland Biosecurity Manual sets out how to treat, inspect, source and/or pack materials that present a biosecurity risk in order to receive a biosecurity certificate.

Under the *Biosecurity Act 2014*, a person who deals with biosecurity matter or a carrier, or carries out an activity, if the person knows or ought reasonably to know that the biosecurity matter, carrier or activity poses or is likely to pose a biosecurity risk have a 'general biosecurity obligation' (GBO). Under the GBO, individuals and organisations whose activities pose a biosecurity risk must:

- take all reasonable and practical steps to prevent or minimise each biosecurity risk
- minimise the likelihood of causing a 'biosecurity event', and limit the consequences if such an event is caused
- prevent or minimise the harmful effects a risk could have, and not do anything that might make any harmful effects worse.

14.2 Non-indigenous Fauna and Flora

An Ecological Assessment Report has been prepared by AECOM which documents the presence of non-indigenous fauna and flora within the Project area. This section has been prepared as a summary, and the complete report is provided in Appendix Q.

The November 2018 and January 2019 field surveys recorded six introduced fauna species. The field survey undertaken in 2014 identified a further two species. It is anticipated that a number of other introduced fauna species are likely to occur within the Project area. A species list is provided in Appendix Q.

Eighteen introduced flora species were identified during the flora survey. Five species identified are listed as Category 3 Restricted Matter under the *Biosecurity Act 2014* and three species are listed as WoNS. A species list is provided in Appendix Q.

14.3 Potential Impacts, Mitigation and Management Measures

Construction activities may increase the risk of establishment of new infestations and exacerbation of existing infestations through soil disturbance, increased pedestrian and vehicular traffic through the area, and importation of construction materials to the site which may harbour introduced species. It is unlikely that further introductions of feral vertebrate species would occur as a result of the Project. It is also unlikely that the proposed development would exacerbate current pest populations given they are well established in the region.

Biosecurity will be managed in accordance with Rockhampton Regional Council's Biosecurity Plan for Pest Management 2017-2021.

A Project-specific Biosecurity Management Plan will be developed to support construction and operation of the Project and to achieve the general biosecurity obligation under the *Biosecurity Act 2014*. The Biosecurity Management Plan will include the following.

- Alignment with key national, state and local biosecurity priorities.
- Clean down protocols, including accepted methodology for any vehicles, plant, equipment or machinery entering site.
- Nominated permanent and temporary clean down locations established for construction work within or in the vicinity of the Project area.
- Known WoNS, Restricted, Invasive or Regionally Declared weeds identified in the Project area.
- Identification of the origin of high risk construction materials, machinery and equipment and treatment where required to mitigate introduction of weed species.
- Any imported material and equipment from outside of Australia must refer to the Biosecurity Import Conditions System and comply with import conditions.
- Management methods to control spread of weeds considered to be Restricted Matters in keeping with regional management practice or Queensland Department of Agriculture and Fisheries pest control prescriptions.
- Management methods to control spread of weeds, including routine weed monitoring during construction and operation to identify any new incidence of weeds.
- Promotion of awareness of weed management, by inclusion of weed issues, pictures and procedures into the Project's site induction program.

15.0 Matters of Environmental Significance

This section discusses matters of environmental significance, their presence and legislative framework, as they relate to the Project. Three levels of matters of environmental significance are considered within Queensland, these include the following.

- Matters of national environmental significance (MNES), under the *Environmental Protection and Biodiversity Conservation Act 1999* (EPBC Act).
- Matters of state environmental significance (MSES) under the *Environmental Offsets Act 2014*.
- Matters of local environmental significance (MLES), under the Rockhampton Regional Council Local Planning Instrument (the Planning Scheme).

15.1 Matters of National Environmental Significance

Under the EPBC Act, actions that have, or are likely to have a significant impact on a MNES require approval from the Australian Government Minister for the Environment. The Minister will decide whether assessment and approval is required under the EPBC Act. MNES identified as potentially present and/or impacted by the Project are summarised in Table 15-1.

Table 15-1 MNES relevant to the Project

MNES Category	Relevance to Project
World heritage properties	Great Barrier Reef World Heritage Area
National heritage places	Great Barrier Reef National Heritage Place
	ABC Studios Commonwealth Heritage Place
Wetlands of international importance	Nil.
Commonwealth marine areas	Nil.
Great Barrier Reef Marine Park.	Nil.
Nationally threatened species and ecological communities	A likelihood of occurrence assessment was undertaken as a result of desktop and field survey and concluded: • 2 species with a high likelihood of being present • 5 species with a moderate likelihood of being present.
Migratory species	A likelihood of occurrence assessment was undertaken as a result of desktop and field survey and concluded: • 4 species present • 5 species with a high likelihood of being present • 5 species with a high likelihood of being present.

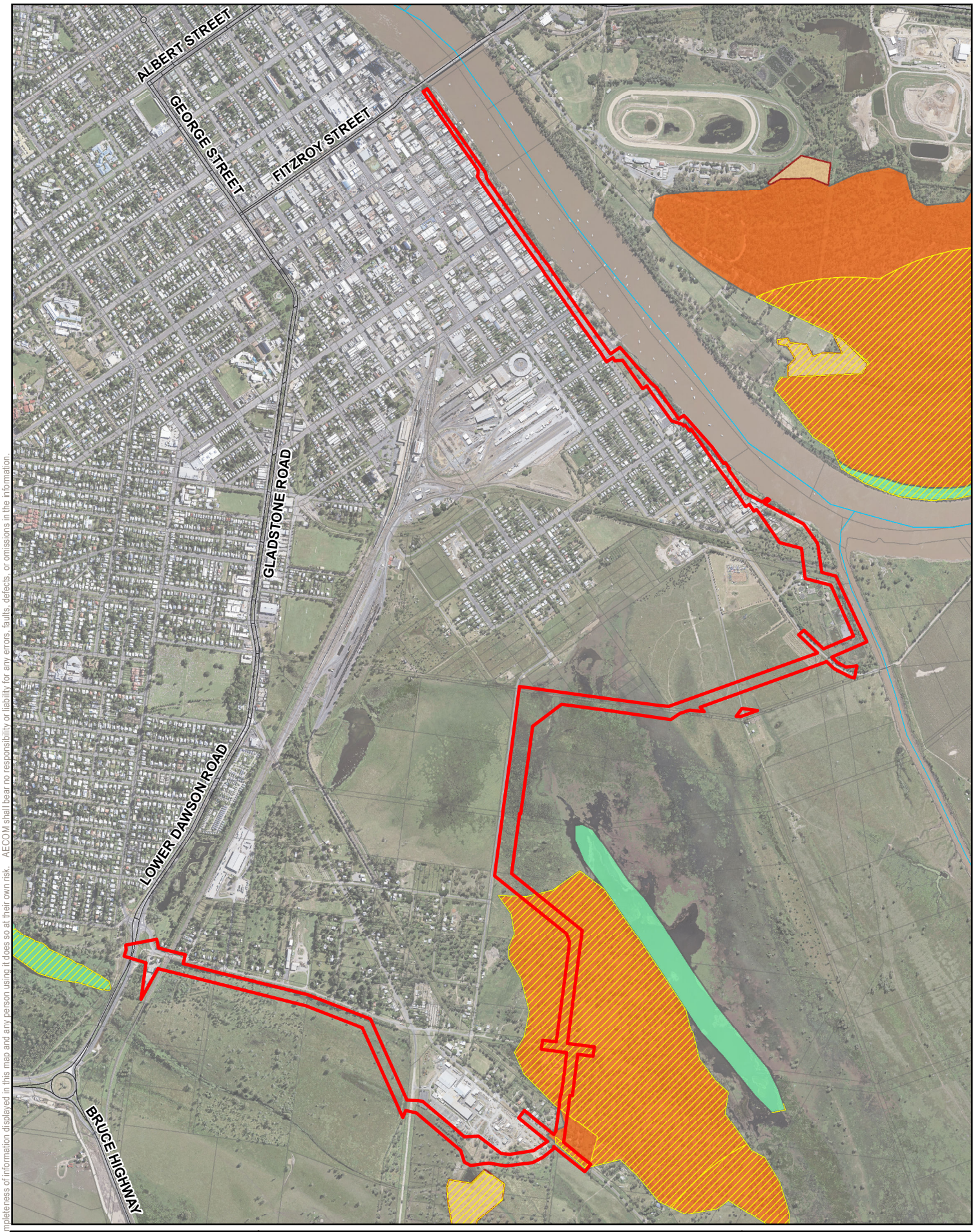
The Department of Environment and Energy provide a guideline to assist proponents proposing an action, to decide whether a project is likely to result in a significant impact of a MNES. The guideline, referred to as *Matters of National Environmental Significance: Significant Impact Guidelines 1.1* provides a significant impact criteria for each MNES. An assessment of the Projects potential impacts against this Guideline will form the basis of the Referral to be lodged with the Commonwealth Government.

15.2 Matters of State Environmental Significance

MSES are defined under the Environmental Offsets Regulation 2014. MSES include certain environmental values that are protected under Queensland legislation. MSES that are present or potentially present are detailed in Table 15-2, and shown in Figure 15-1 and Figure 15-2. Table 15-2 identifies the MSES present, the area present where possible, a summary of the impact, and the relevant section of the EAR in which it is discussed further.

Table 15-2 MSES within the Project area

MSES	Presence (ha approx.)	Impact	Section of EAR
Regulated Vegetation			
Of Concern Regional Ecosystem (ground-truthed)	1.82	Direct loss	Section 13.0
Essential Habitat for Ornamental Snake (mapped)	6.14	Determined to not be present	Section 13.0
Connectivity areas			
State-wide Biodiversity Corridors	13.00	Layer is present on, and adjoining the Fitzroy River bed and banks. The Project is not anticipated to result in an impact to this biodiversity corridor.	N/A
Wetlands and Watercourses			
Wetland Protection Area	2.81	The Project directly intersects with Jellico Street wetland, leading to a direct loss in wetland area.	Section 12.0
Wetland Protection Trigger Area	22.06	The Project intersects the buffer area of the Gavial Swamp Wetland a Fiddes Street Wetland. Indirect impacts may occur.	Section 12.0
Marine plants			
Marine Plants	18.01	Direct loss of marine plants.	Section 13.0
Protected wildlife habitat			
A habitat for an animal that is: • endangered wildlife • vulnerable wildlife • special least concern animal	• 2 conservation significant species were identified as present during field surveys. • 5 conservation significant species are considered to have a moderate or high likelihood of occurring in the Project area based on the habitat assessed during the field surveys.		Section 13.0



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LEGEND

- Road
- Watercourse
- Cadastral Boundary
- Levee Alignment
- Essential Habitat

Vegetation Management Regional Ecosystem

- Category A or B area containing of
- Category A or B area that is least
- Category C area containing of concern

Data sources:

Base Data: DCDB, Baseline Roads and Tracks, Watercourse, QLD Gov, 2018.
Aecom 2018, Alignment.

SOUTH ROCKHAMPTON FLOOD LEVEE PROJECT

MSES (Vegetation) Present within the Project area

PROJECT ID	60589157
CREATED BY	bathurstj
LAST MODIFIED	10-Apr-2019
VERSION	<version number>

Figure 15-1

A4 size

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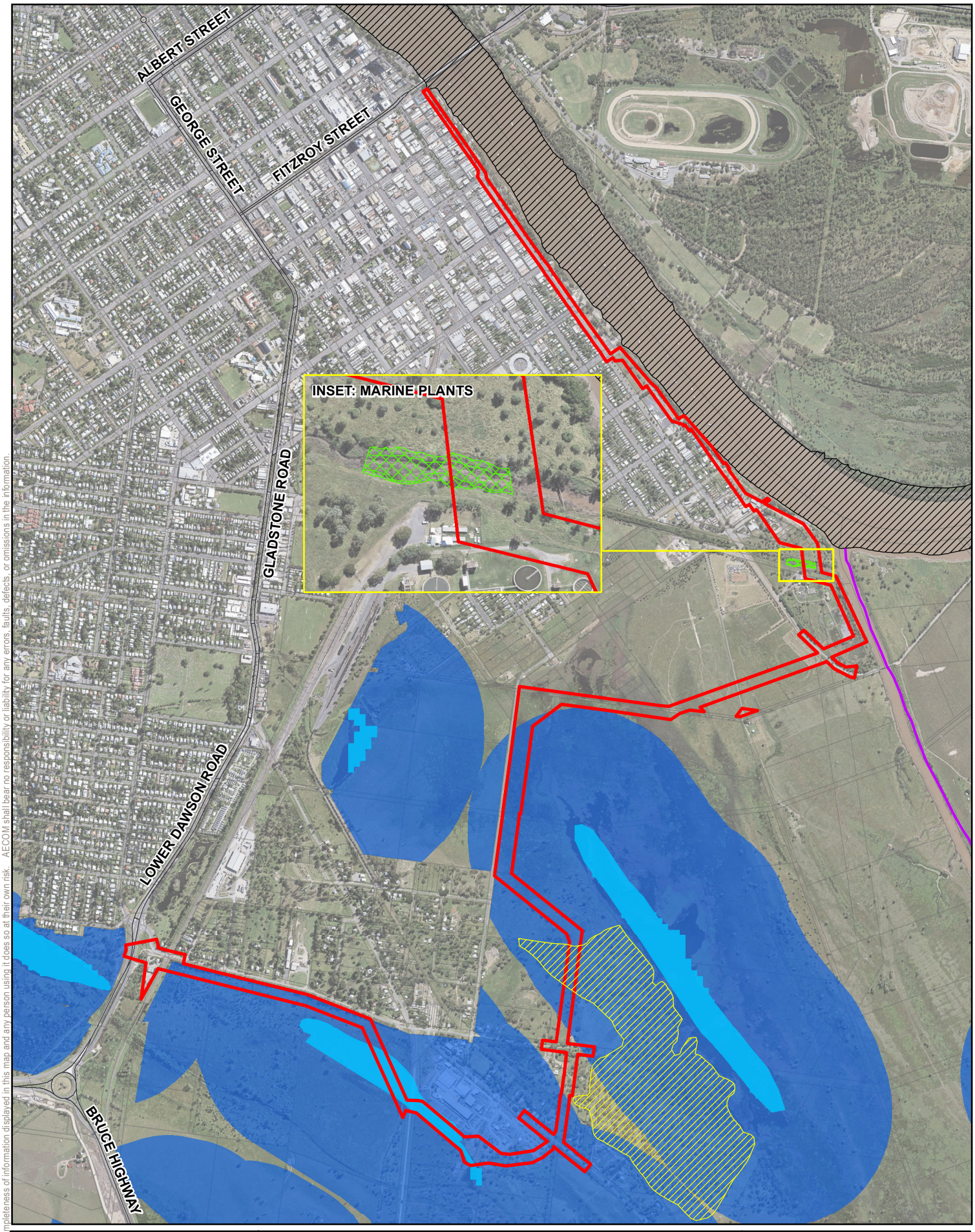

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LEGEND

- Road
- Cadastral Boundary
- Levee Alignment
- Tidal Waterways
- Ground Truthed REs
- Marine Plant
- Wetland Protection Area - High Ecological Signifcance Wetland area
- Wetland Protection Area - Trigger area

Waterways for water barrier works

- 4 - Major

Data sources:

Base Data: DCDB, Baseline Roads and Tracks, Watercourse, QLD Gov, 2018. Aecom 2018, Alignment.

SOUTH ROCKHAMPTON FLOOD LEVEE PROJECT

MSES (Wetlands) Present within the Project area

PROJECT ID	60589157
CREATED BY	bathurstj
LAST MODIFIED	10-Apr-2019
VERSION	<version number>

Figure 15-2

A4 size

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15.3 Matters of Local Environmental Significance

Matters of Local Environmental Significance (MLES) are natural values and / or area defined through the Planning Scheme. MLES present within the Project area directly correspond with areas mapped as MSES, being Category B 'Of Concern' vegetation mapped in the rural section of land between Hastings Deering and Fiddes Street (Figure 15-1). This MLES is classified as 'General' under the Planning Scheme.

The Planning Scheme identifies that MLES General areas should be retained to the greatest extent possible, through minimising impacts. Avoidance in this location cannot be achieved, and vegetation will be required to be removed to facilitate the Project.

The Gavial Swamp wetland is also identified as a MLES (High) in the Planning Scheme, however the Project does not directly traverses this area. The Planning Scheme identifies MLES (High) areas should be avoided and development should be located outside of a wetland. A key requirement of the design throughout the development of the alignment has included avoiding and minimising impacts to the adjoining wetland areas to the greatest extent possible. The Project has avoided the wetland in this location which is identified a MLES High.

15.4 Avoid, Minimise, Mitigate

Council have employed the 'avoid, minimise, and mitigate' approach throughout the Project, including the following.

- Avoiding impacts on environmental values as far as reasonably practical throughout the alignment options assessment and concept design process.
- Applying mitigation through design, by allocating of levee type which interacts appropriately with the urban and rural environments.
- Levee drainage infrastructure aims to ensure current surface flow patterns are maintained post development.
- Mitigating and managing environment impacts through implementation of Environmental Management Plans.

16.0 Non-Indigenous Heritage

The following section draws on the 2014 *South Rockhampton Flood Levee Cultural Heritage Desktop Review Report* (the AECOM 2014 Report) undertaken by AECOM for the Project area (AECOM, 2014). This section has been updated to reflect legislative and other changes, but no additional heritage assessments or site surveys have been undertaken.

The AECOM 2014 report was based on a framework for the identification and management of historical significance as required under the *Queensland Heritage Act 1992* (QH Act), and included the following:

- Heritage register searches, including the: National Heritage List (NHL); Commonwealth Heritage List (CHL), Australian National Shipwrecks Database; Queensland Heritage Register (QHR); and Rockhampton Regional Council Local Heritage Overlay.
- A review of historical studies, historical documents and previous historical cultural heritage assessments of the Study Area and the surrounding regions.
- An assessment of potential impacts and mitigation measures.

16.1 Historical Context

The following provides a summary of the historical context of the key locations subject to the Project area and is not intended to be an exhaustive overview. Further historical detail can be found in the AECOM 2014 report included as Appendix R.

The Rockhampton settlement had originally been established as a port to serve the large pastoral runs of the inland. Located in the hinterland along 50km of navigable river, it was an ideal location to import supplies and export wool (Bird, 1904). The purpose and extent of the settlement changed radically in 1858, however, when gold was discovered at Canoona to the north.

Rockhampton offered the closest port facilities to the field, and the then New South Wales colonial government gazetted it as a port of entry - a place where immigrants could legally enter the colonies, and duties could be collected (Figure 16-1). Rockhampton was soon swamped by an influx of more than 15,000 prospectors seeking their fortune. The Canoona field was exhausted in a matter of weeks, but the population of the district had been permanently increased (Lovell, 2000). The burgeoning township of Rockhampton was officially surveyed in 1858, with the main business area established one street back from the river, allowing Quay Street on the esplanade to be used solely for port business (Lovell, 2000).

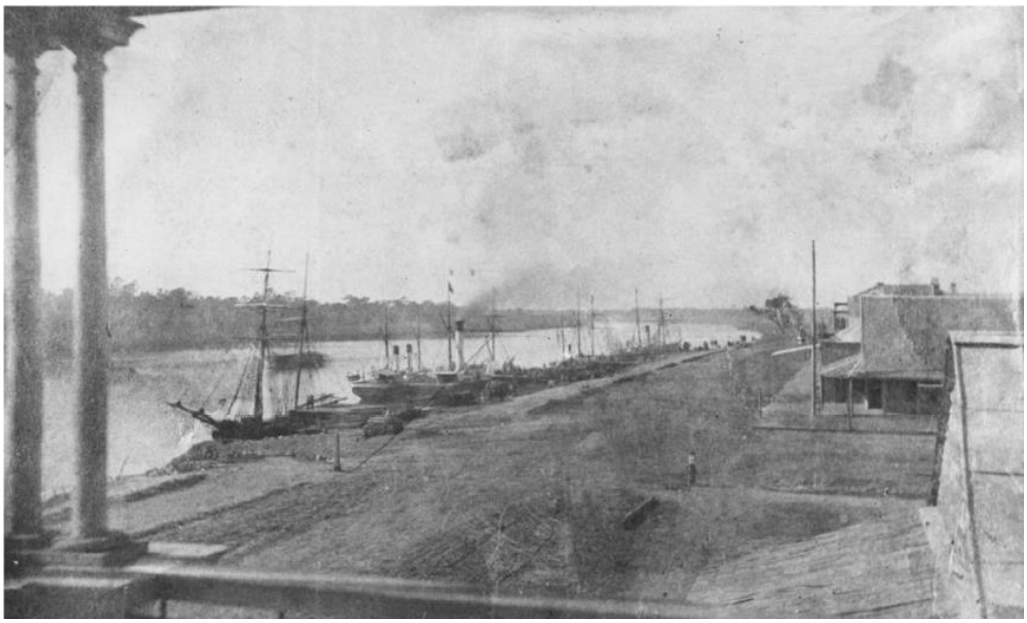


Figure 16-1 Quay Street and wharves in 1864 (State Library of Queensland (SLQ) 18000)

In 1882, Rockhampton was once again transformed by the discovery of gold, this time at Mt Morgan. The Mt Morgan deposit proved far richer than previous fields, and Rockhampton grew in wealth and consequence, becoming the second largest port in the colony with annual exports of over £1,000,000 (Lovell, 2000).

Locals began to agitate for secession from the colony of Queensland, and regarded Rockhampton as the obvious 'capital of the north'. As a reflection of this status, numerous grand public and private buildings were constructed in the town, principally along the river-side Quay Street, which was central to the port-town's identity (Figure 16-2, Figure 16-3). These included the heritage listed Custom's House, Rockhampton Club, Harbour Board and Criterion Hotel (Lovell, 2000).

Figure 16-2 Quay Street c.1890, showing the Rockhampton Club, Trustee Chambers & Cattle House

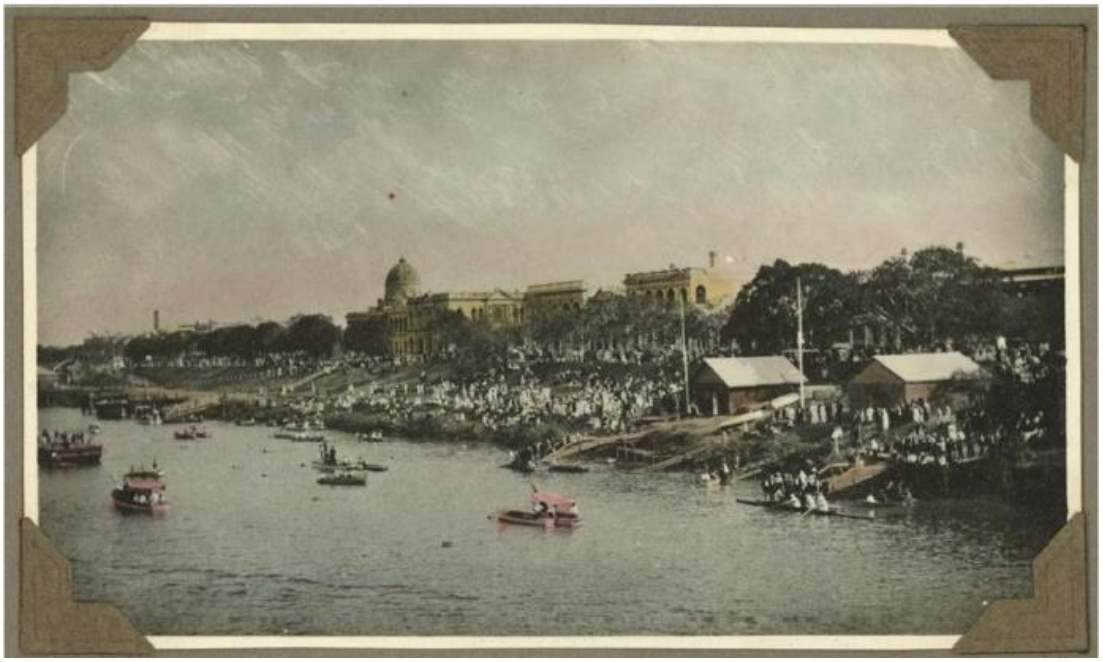


Figure 16-3 Rockhampton c.1930, Quay Street in the background & boating sheds & wharves in the foreground

16.2 Register Searches

16.2.1 Commonwealth Heritage List

The Commonwealth Heritage List is a list of Indigenous, historic and natural heritage places owned or controlled by the Australian Government. These include places connected to defence, maritime safety, communications, customs and other government activities that also reflect Australia's development as a nation (DoEE, n.s).

Lot 257R1675 is listed on the Commonwealth Heritage Register, being the former offices of the Mount Morgan Gold Mining Company, and the present ABC Radio Studios (Place ID: 105420). The site is identified on Figure 16-5. The Project area adjacent to this place is a temporary levee arrangement.

The ABC Studios is considered significant for a number or reasons, key of which include the links to the mining and economic boom in Rockhampton and the aesthetic characteristics of the building and integration with the Quay Street streetscape. The key listing criterion for the ABC studios is summarised in Table 16-1.

Table 16-1 Summary of listing values for ABC Studios (DoEE, 2019)

Criterion	Values
Criterion A – Processes.	The building, constructed in 1897 as an administration office for the Mount Morgan Gold Mining Company, has a strong link to the period when the Mount Morgan Mine was the richest gold mine in the world, and stimulated an economic boom in Rockhampton.
Criterion D – Characteristic values	Although modest in scale, the building is an example of the Federation Academic Classical style well expressed in the classical proportions of the arcaded verandah, the use of arched bays with granite columns and decorated ionic pilasters and the parapet concealing the roof. The ABC Studio Building is an integral unit of the stylistic expression of the streetscape.
Criterion E – Aesthetic characteristics	The ABC Studio is an important visual aesthetic contributor to the Quay Street streetscape (Figure 16-4). Its aesthetic characteristics are its scale, form and stylistic design that create an attractive image that is in harmony with the adjacent streetscape buildings. It is the centre piece of a group of three single storey buildings of classical style. The front façade exhibits a high degree of detail in finishes and craftsmanship that contribute to the designed aesthetic characteristics of the place and the streetscape. It is a strong contributor to image of the historic city of Rockhampton, particularly the 19th Century Quay Street streetscape.

Figure 16-4 ABC Studios – Quay Street (DoEE, 2019)

16.2.2 Register of the National Estate

The Register of the National Estate (RNE) has been suspended and is no longer a statutory list, but remains as an archive and available for educational purposes. The existence of a place on the RNE does not provide a statutory protection, however may provide relevant information to inform decision making activities at all levels of government.

Table 16-2 provides a list of the places on the RNE. The Quay Street streetscape as a whole is listed on the RNE (Place ID: 8855). The listing includes all properties on both sides of Quay Street between Fitzroy and Derby Street (including Queens Wharf). Three individual places are listed on the RNE within the Quay Street streetscape. Quay Street is described as 'outstanding group of nineteenth century buildings: public buildings, hotels, commercial buildings and residences' and 'one of the best examples of townscape of the period' (DoEE, 2019).

Table 16-2 Places listed on the RNE

Place	ID	Location
Quay Street Streetscape	8855	Quay St
Bulletin Building	17547	162 Quay St
Rockhampton Customs House (former)	8857	208 Quay St
ABC Radio Studios	8853	236 Quay Street
T and G Building	17543	8 William St
Brahman House	8859	183 East St
Harbour Board Building (former)	8856	288 Quay St
Rockhampton Railway - City Section	100565	Denison St

16.2.3 Australian National Shipwrecks Database

All known shipwrecks in Australian waters are recorded on the National Shipwrecks Database. Those that are located in Commonwealth waters are protected under the *Historic Shipwrecks Act 1976* (soon to be repealed by the *Underwater Cultural Heritage Act 2018*), while those in State waters are protected under Part 9, Division 1 of the QH Act.

A search of the National Shipwreck Database identifies a number of shipwrecks in the Fitzroy River, one of which is in the general vicinity of the Project. A shipwreck from 1905, the 'Ant' was wrecked when the Fitzroy River flooded and was carried away down river. The vessel was eventually salvaged and sent to Mount Morgan. The shipwreck database does not provide a firm identification on where the vessel was wrecked in the Fitzroy River.

16.2.4 Queensland Heritage Register

The QHR is a list of places that have cultural heritage significance to the people of Queensland. The QH Act provides the framework for assessing the significance of items and places of historical cultural heritage value in Queensland. The Act makes provision for the conservation of Queensland's cultural heritage by protecting all places and areas listed on the Queensland Heritage Register.

Table 16-3 identifies all the sites on the QHR which are adjoining the Project area. These places are shown on Figure 16-5. The places identified are listed predominately for their historical value and their aesthetic value both in their own right, and as a part of the Quay Street streetscape. In these listings, Quay Street is variously described as a premier Queensland streetscape' (QHR 601582), and as 'the symbol of Rockhampton' (QHR 600811) (AECOM, 2014).

Many of the heritage places are also listed for their rarity or representativeness, or their associations with a particular group or person. The Criterion Hotel is the only place to be listed as having research (specifically archaeological) value (AECOM, 2014).

Further detail on the listings and significance of the sites can be found in Appendix R.

Table 16-3 Places listed on the Queensland Heritage Register

Place	ID	Location (adjoining Project area)	Levee Type
Criterion Hotel	600800	Lot 1 SP161850	Temporary levee
Bulletin Building	601582	Lot 283 R1675, Lot 1 RP600147	Temporary levee
Rockhampton Club	600801	Lot 285 R1675	Temporary levee
Trustee Chambers	600802	Lot 1 RP606211	Temporary levee
CJ Edwards Chambers	600803	Lot 7 RP605550	Temporary levee
Callianiotis Constructions	600804	Lot 1 RP619373	Temporary levee
Cattle House	600805	Lot 2 RP613796, Lot 1 RP618885	Temporary levee
Luck House	600806	Lot 2RP618884	Temporary levee
R Rees and Sydney Jones	600807	Lot 1RP607022	Temporary levee
Royal Bank Building (former)	600808	Lot 1 RP600163	Temporary levee
Evans and Hearn	600809	Lot 2600164	Temporary levee
Customs House Rockhampton	600817	Lot 3RP6019454	Temporary levee
Commercial Hotel and Chambers (former)	600810	Lot 225R1675	Temporary levee
Cahill's Stores (former)	600811	Lot 1 RP610641, Lot 2 RP605971	Temporary levee
Goldsborough Mort Building (former)	601489	Lot 258 R1675	Temporary levee
Avonleigh	600813	Lot 251 R1675	Temporary levee
Clewett's Building (former)	600814	Lot 1 RP600232	Temporary levee
Walter Reid Court	600815	Lot 00000 BUP60053	Temporary levee
Harbour Board (former)	600816	Lot 217R1675	Composite levee wall

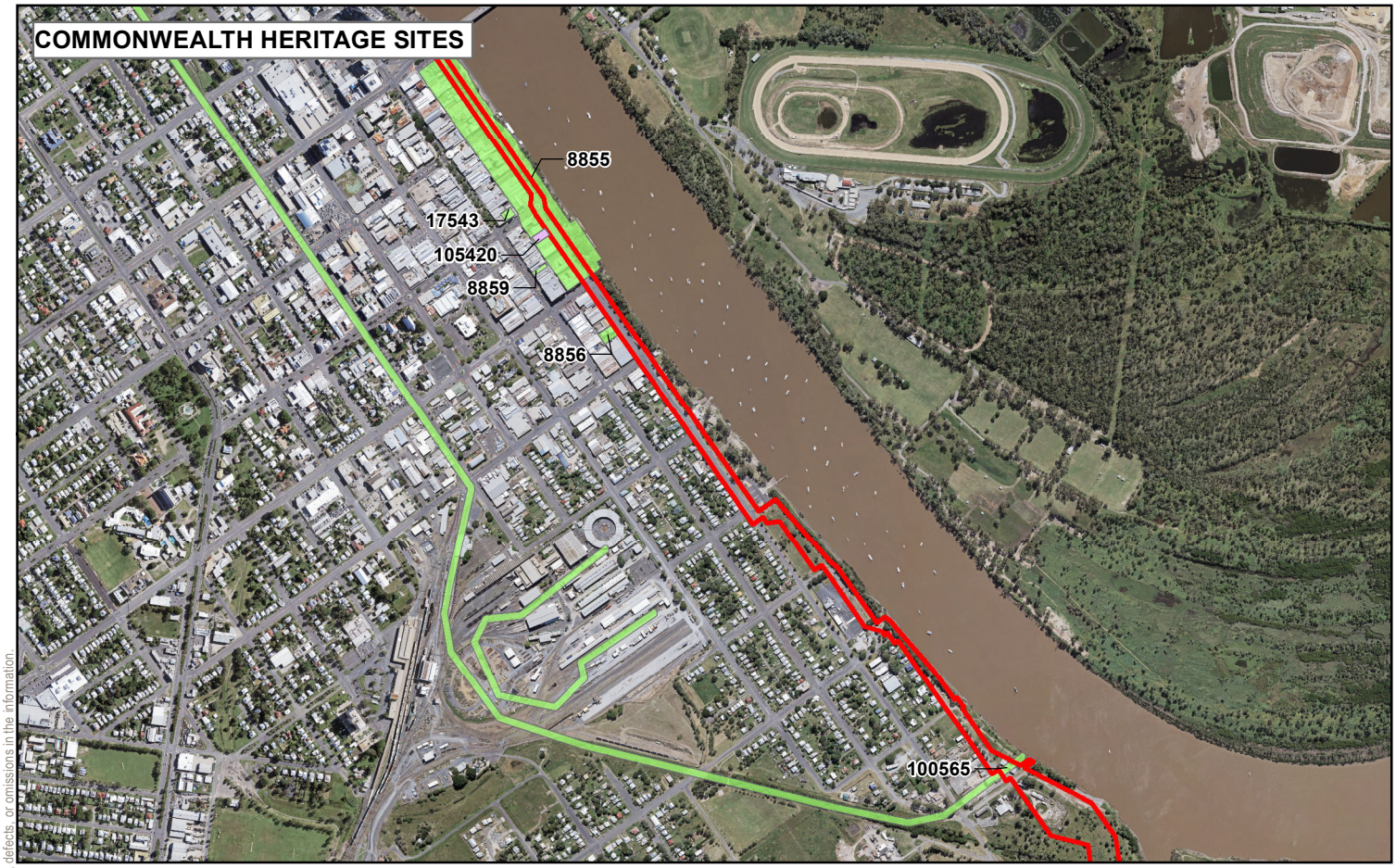
16.2.5 Local Heritage Places

The Rockhampton Regional Council Planning Scheme includes a Heritage Overlay and Code which identifies and aims to manage development in relation to 'heritage places'.

The Local Heritage Planning Scheme Policy included within the Planning Scheme (SC6.13) states that no places of local significance have been included on the local heritage place register at this stage. It is intended that over time places of local significance to Rockhampton region will be added to the register. This local heritage register will exclude sites already included on the Queensland Heritage Register and Planning Scheme Overlay and Code for heritage.

16.2.6 Other heritage values

Early maps and images of Quay Street show a number of buildings, wharves and other structures ranged along the river bank (Figure 16-2). Depending on the way these buildings were removed, and subsequent works such as land reclamation or bank stabilisation, traces of these places may remain under the current road or in the adjacent parklands. Given the importance of the Quay Street wharves to Rockhampton and to the development of Queensland as a whole, any deposits have the potential to be of state significance and, as such, would be protected under Part 9, Division 1 of the QH Act.



AECOM
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DATUM GDA 1994, PROJECTION MGA ZONE 56

0 150 300 600
metres

1:17,500 (when printed at A4)

LEGEND

- Road
- Cadastral Boundary
- Project Area
- Commonwealth Heritage List
- Register of the National Estate (non-statutory)
- State Heritage Places

Data sources:

Base Data: DCDB, Baseline Roads and Tracks, Watercourse, QLD Gov, 2018. Aecom 2018, Alignment.

SOUTH ROCKHAMPTON FLOOD LEVEE PROJECT

State and Commonwealth heritage register sites

PROJECT ID	60589157
CREATED BY	bathurstj
LAST MODIFIED	12-Apr-2019
VERSION	<version number>

Figure 16-5

Filename: G:\TSV_GIS\Projects\60589157\02_MXDs_60589157_FX_SRFL_PlanningScheme_HeritageOverlay_CURRENT_A4.mxd

A4 size

16.3 Potential Impacts

Impacts on historical heritage may be either direct or indirect in nature.

- Direct impacts are those that result from a physical connection between the development activities and the heritage place, such as the full or partial demolition of a heritage building.
- Indirect impacts are those that affect the heritage place via the surrounding environment, such as vibration from nearby construction works causing damage to a heritage building, or the alteration of the setting of the building such that its values are reduced.

The following section describes the potential direct and indirect impacts of the Project on historical heritage values in proximity of the Project area.

16.3.1 Design

The Commonwealth and State heritage places identified are wholly located within a distinct section of Quay Street, herein referred to as the 'heritage precinct' (Figure 16-5). Within this heritage precinct, there are two levee types proposed:

- Temporary levee - approximately 80% of the heritage precinct from Fitzroy Street to Derby Street.
- Composite levee – approximately 20% of the heritage precinct from Derby Street to the southern extent of the heritage precinct.

Detailed descriptions of the identified levee types can be found in Section 4.0. The Project will be within the road reserve or Council controlled park lands, and will not directly traverse any identified State or Commonwealth heritage places. A number of design and alignment options were investigated and assessed during the feasibility stage of the Project.

The final alignment, configuration and crest levels were developed and further optimised through a comprehensive design and consultation process, including workshops with Council and other key stakeholders (AECOM, 2014). The need for the Project to be located along the Fitzroy River in the proximity of Quay Street remained common for all options assessed. The Project location is required to provide the required level of immunity for the Project.

During the feasibility stage of the Project a visual amenity assessment was undertaken. The purpose of the assessment was to minimise impacts on the amenity and character of the local landscape of Rockhampton through design mitigations. This assessment recommended that where the Project is located within and adjoining the heritage precinct, the levee composition should include a temporary structure type to protect the heritage character of the area. It is also noted that the temporary levee provides freeboard mitigation only and there has only been 1 flood event in the past 130 years of records (1918) that would have necessitated the use of the temporary levee on Quay Street.

The design responded to this recommendation by including a temporary levee along the majority of the heritage precinct in order to mitigate against and minimise potential for direct impacts to the listed places of Commonwealth and State heritage significance, and the Quay Street streetscape. The temporary levee will be placed in the road reserve of Quay Street and will not have any permanent features.

A composite levee type is required for the remaining 20% of the Project area in this precinct to provide the required level of immunity and flood protection. Flood heights in this location exceed those appropriate for a temporary levee system. The composite levee arrangement will begin shortly after the intersection with Quay and Derby Street and continue until the intersection of Quay and Frances Street.

16.3.2 Construction

Construction phase impacts associated with the temporary levee are anticipated to be negligible, and are more relevant to operation. Impacts to non-Indigenous heritage during construction are limited to potential direct or indirect impacts associated with construction of the composite levee system. This will require ground disturbing activities such as driving sheet piles and excavation for footings (further detail can be found in Section 4.0). The composite levee system will be located on the eastern side of the road reserve adjacent to the Harbour Board (former) State Heritage place. Direct impacts to the Harbour Board are anticipated to be unlikely, but indirect impacts are possible.

Potential direct or indirect heritage impacts during the construction of the composite levee include the following.

- Physical interactions between built heritage and construction materials or machinery, resulting in structural damage.
- Vibration from construction activities in excess of 2mm/second, resulting in structural damage.
- Increased dust from surface construction or transport activities resulting in corrosion of fabric.
- Disturbance of archaeological deposits.
- Damage to mature plantings by disturbance of root systems.

16.3.3 Operation

During operation, the temporary levee system will be placed within the Quay Street road reserve and will be assembled in line with the relevant Council emergency management plan and levee operations plan prior to a Fitzroy River flood event. As the temporary levee will be placed within the road reserve, it will not require any invasive or ground disturbing activities.

Impacts on non-Indigenous heritage during the operational phase are likely to be minimal and indirect in nature, and relate to the disruption to the Quay Street streetscape and viewscape. As noted in the heritage listings for a number of Quay Street buildings, Quay Street is one of the most significant heritage streetscapes in Queensland. The Project has the potential to obscure the heritage setting of Quay Street during times of flood, blocking views and disrupting the relationship between heritage listed buildings and the river. This impact would be temporary, however, and would be far outweighed by the positive benefits of flood control (AECOM, 2014).

The AECOM 2014 report identified that operational phase impacts are anticipated to be largely positive. The proximity of the heritage precinct to the Fitzroy River makes the places extremely vulnerable to flooding, and this intermittent inundation has the potential to cause short and long term damage to building fabric, and to disturb any archaeological deposits. The Project will provide protection to these heritage places, and help to conserve their fabric and significant values in which they are listed for under the Commonwealth and Queensland legislation.

16.4 Mitigation and Management Measures

Prior to construction, further historical archaeological assessment should be undertaken where ground disturbing activities are proposed in the heritage precinct. This assessment would identify the potential for subsurface deposits and, if necessary, develop an archaeological management plan in accordance with DES Guidelines for Archaeological Investigations.

Potential impacts to heritage values during construction will be managed in accordance with controls outlined in the Environmental Management Plan (Planning) (Appendix T). The following measures are anticipated.

- Cultural heritage awareness training should be included in site induction processes, alerting workers to any heritage places in the vicinity, and outlining appropriate management procedures.
- Appropriate monitoring and oversight should be in place to protect heritage places and values.
- A ‘Stop Work’ procedure should be activated if any historical archaeological materials are uncovered.
- Specific measures to be included in the Construction Environmental Management Plan include following:
    - Construction materials not to be stored on or adjacent to heritage places
    - Construction site traffic to be routed away from heritage places wherever possible
    - Appropriate traffic management to be employed around heritage places if required
    - Loose loads to be appropriately covered
    - Appropriate monitoring and dust management to be implemented at the construction site

- Monitoring and structural audit to be implemented at heritage places where vibration has the potential to reach or exceed 2mm/second
- Any damage to significant fabric to be restored or reconstructed in accordance with Burra Charter principles.

17.0 Indigenous Heritage

The following section draws on the 2014 *South Rockhampton Flood Levee Cultural Heritage Desktop Review Report* (the AECOM 2014 Report) undertaken by AECOM for the Project area (AECOM, 2014). This section has been updated to reflect legislative changes and to include new search results, but no additional heritage assessments or site surveys have been undertaken.

The Indigenous (Aboriginal) heritage assessment undertaken for the AECOM 2014 included:

- A search of the Department of Aboriginal and Torres Strait Islander Partnerships (DATSIP) Cultural Heritage Database and Register to identify Aboriginal Party(s) and/or Cultural Heritage Bodies for the Project area; and any known Aboriginal cultural heritage within the Project area.
- A review of historical and archaeological research in the area to identify any additional places of cultural heritage significance, and to inform previous land use and levels of ground disturbance.
- An assessment of potential Project impacts based on the Duty of Care Guidelines gazetted under the *Aboriginal Cultural Heritage Act 2003*.

17.1 Historical Context

The following summary of historical context is not intended to be exhaustive, but rather aims to provide a contextual overview of the areas surrounding the Project area. Further historical detail can be found in the AECOM 2014 report included as Appendix R.

There has been no detailed exploration of pre-contact Aboriginal life in the Study Area, but research in surrounding regions provides some insights. Cania Gorge, approximately 150 km to the south of the Project, is home to a series of excavations of rock shelters and other living sites that suggest Aboriginal occupation by at least 18,000 Before Present (Westcott, Lilley, & Ulm, 1999). The excavations at Cania Gorge also points to an increase in occupation in the last few thousand years, with dates from nine rock shelter sites indicating that they were first used between 8,500 BP and 3,500BP (Westcott et al., 1999). Many of these extensive living sites feature rock art, suggesting a period of complex socio-cultural change over the last 10,000 years, perhaps coupled with a growth in population and a more intensive use of the types of food and other resources available in the gorge (Lilley, Brian, & Ulm, 1999; Westcott et al., 1999)

The first settlers to enter the Rockhampton region were the Archer brothers, who travelled north from the Burnett in 1853 to establish the large pastoral run of 'Gracemere' (approximately 10km south west of the Study Area). By the time the Archers left the Burnett region, Aboriginal people were actively resisting colonial expansion, and the Archers came to Gracemere expecting similar conflict, bringing with them four Native Mounted Police (Bird, 1904). The following two decades were typified by intense conflict as more and more settlers moved into the region.

Aboriginal groups attacked homesteads and isolated outstations, and settlers retaliated in far greater magnitude. The Archers reputedly mounted a swivel gun to protect their Gracemere homestead, while other colonists depended on the Native Mounted Police to 'disperse' (by killing or otherwise driving off) 'troublesome' Aborigines, and a Native Mounted Police Camp was established in Rockhampton in 1860 (Bird, 1904; Richards, 2005).

By 1870, violence coupled with introduced diseases had radically reduced the Aboriginal population and, by 1900, government policy towards Aboriginal people had shifted from one of dispersal to one of protection. Many Aboriginal people who had remained on their land thus far were forcibly removed to missions and government reserves. In the Rockhampton area, this removal was generally to the Taroom Reserve approximately 260km south west of the Project area, and subsequently Woorabinda, approximately 150km south west of the Study Area (Donovan, 2002).

17.2 Register Searches

A search of the DATSIP database in November 2018 (Reference# 46029) provided the following details for the Aboriginal Party, Cultural Heritage Body and reported cultural heritage sites in the Study Area.

17.2.1 Aboriginal Party and Cultural Heritage Body

Cultural Heritage Body for the Study Area is:

Darumbal Enterprises Pty Ltd
Mr Doug Hatfield
133 Dee Street, North Rockhampton QLD 4701
Phone: (07) 4926 0026 Fax: (07) 4926 7457
Email: Darumbal.enterprises@bigpond.com

The Aboriginal Party for the Study Area is:

QC12/8 and QCD16/6 DET (QUD6131/98)
Darumbal People
Queensland South Native Title Services Limited Level 10, 307 Queen St Brisbane QLD 4000
Phone: (07) 3224 1200 Fax: (07) 3229 9880

17.2.2 Registered Sites

The DATSIP database indicates that there are no reported Aboriginal places within the Project area. It should be noted, however, that areas around waterways and wetlands are generally of high significance to Aboriginal people, and it is likely that the wider area contains previously unrecorded cultural heritage values, whether tangible or intangible (Department of Aboriginal and Torres Strait Islander Partnerships, 2004).

17.3 Potential Impacts

Historical photographs of Quay Street (Section 16.0) show that the area has undergone substantial changes since colonial settlement. Changes in more rural areas through Depot Hill and Port Curtis have been less dramatic, but vegetation clearing and other activities have caused some level of ground disturbance.

The planned works may be classified as Category 4 activities under the Duty of Care Guidelines. Category 4 activities are those that occur in areas that have already been subject to significant ground disturbance. As such, they are unlikely to harm Aboriginal cultural heritage, but care should be taken in case residual Aboriginal cultural heritage values are disturbed. The possibility of residual Aboriginal cultural heritage values existing in the Study Area is high, given the proximity to the river and wetlands. Even if all tangible cultural heritage places (such as archaeological places and scarred trees) have been previously removed, there is strong potential that intangible Aboriginal cultural values will exist within the Study Area.

17.4 Mitigation and Management Measures

In 2014, Council consulted with representatives of the Aboriginal Party, the Darumbal, to discuss the Project background, the Project area, potential construction works and future survey and mitigation works. Council are currently in the process of developing a Cultural Heritage Management Agreement for the Project with the Darumbal People. The Cultural Heritage Management Agreement will guide pre-construction surveys and management of Aboriginal cultural heritage during construction of the Project.

18.0 Visual Amenity

A visual amenity assessment was undertaken in 2014 as part of the feasibility and initial concept design process. The purpose of the visual amenity assessment was to minimise impacts on the visual amenity and character of the local landscape of Rockhampton through the development of project and context responsive landscaping proposals.

The Fitzroy River is an important element of Rockhampton's character and identity making a significant contribution to the amenity of the Rockhampton town centre. The original heart of Rockhampton located along Quay Street, parallel to the Fitzroy River, has a number of heritage buildings including the Criterion Hotel and Old Customs House that create a strong heritage character related to the presence of the river.

The zone between the town and the Fitzroy River between the Fitzroy Street Bridge and Arthur Street is characterised by both informal open space and formal 'designed' parklands with pedestrian paths and walkways. The zone includes occasional buildings and parking areas related to river uses such as boat launch ramps. The parklands include (from north to south) CBD Riverside Park, Toonooba Park and Littler-Cum-Ingham Park. This space includes a mixture of native riverside vegetation (including fringing mangroves) and parkland trees. The trees are of a variety of ages, sizes and conditions including mature native trees such as gums and *Peltophorum pterocarpum*, and parkland ornamentals including coconut palms (*Cocos nucifera*) and figs (including *Ficus lyrata*).

To the south of Arthur Street to Gavial Creek, the amenity of the landscape decreases, being characterised by former gasworks, derelict areas and a sewage treatment plant. Tree cover through this zone relates to the river and creekside zone and a heavily weed-infested and choked drainage ditch.

Between Gavial Creek and the Bruce Highway, the landscape has a more natural character, dominated by the expansive floodplain of the Fitzroy River. This area includes large wetland lagoons, fringed with macrophytes and scattered trees. Some of the trees are large, mature gums including *eucalyptus tereticornis* and *e. tessellaris*. The landscape is open in character defined within the backdrop context of the distant Berserker (Mount Archer) ranges. Through this zone, the town edge is defined by residential houses, set within mature gardens. There is a significant double avenue of mature eucalyptus trees located along Jellicoe Street. The Hastings Deering building and compound is a key element in the south of the zone.

The area is widely accessible so views can be readily obtained throughout the area, with the exception of the area around the sewage treatment plant in the east. Key views can be summarised as the following.

- Views over the Fitzroy River and riverside parkland.
- Views over the Fitzroy River floodplain and associated lagoons, including expansive views to the horizon and Berserker (Mount Archer) ranges.

These views, and viewer audiences, are illustrated with reference to the following representative viewpoints provided in Section 18.0.

18.1 Key Viewpoints

Viewpoint: 1	Quay Street in Rockhampton Central Business District
Levee Type Proposed:	Temporary levee

Source: 2014 Visual Amenity Assessment

This view is obtained from the pedestrian path on Quay Street, close to the Fitzroy Bridge in the Rockhampton Central Business District. It illustrates the heritage character of the streetscape including key buildings such as the Criterion Hotel and the high visual amenity of landscaped parkland and mature trees adjoining the Fitzroy River. This viewpoint is representative of the view obtained from Quay Street and its flanking buildings by pedestrians, cyclists, drivers, workers and visitors. Note that this section of Quay Street has undergone reconstruction in the period since 2014.

Viewpoint: 2	Quay Street (Derby Street onward)
Levee Type Proposed:	Composite levee system

Source: Google Earth Image (2019)

This view is obtained from Quay Street as the street transitions to light industrial and residential areas. The view illustrates wide streets, open space parklands (not of high amenity value) and riparian fringing vegetation on the Fitzroy River side, and light industrial and residential on the road side. These views would be primarily from Quay Street and its adjoining low density houses by pedestrians, cyclists, drivers, and residents.

Viewpoint: 3	Littler-cum-Ingham Park on Quay Street
Levee Type Proposed:	Earth embankment

Source: 2014 Visual Amenity Assessment

This view is obtained from the landscaped area on Quay Street, overlooking Littler-Cum-Ingham Park. It illustrates the contribution to streetscape character of the existing parkland with its mature and semi-mature native and exotic trees. The Fitzroy River is not directly visible from much of the parkland but its presence is denoted by the mature fringing vegetation along its banks. This viewpoint is representative of the view obtained from this part of Quay Street and its adjoining low density houses by pedestrians, cyclists, drivers, and residents. It demonstrates that while the parkland is not of the highest amenity, it is a pleasant space, overlooked by the existing houses which provide passive surveillance.

Viewpoint: 4	Wharf Street (Residential Area)
Levee Type Proposed:	Composite levee

Source: Google Earth Image (2019)

This view is obtained from the residential receptors on Wharf Street. The houses in this location are separated only by the road to the banks and fringing riparian vegetation associated with the Fitzroy River. The riparian vegetation is a mixture of dense and spare mature vegetation with disturbed ground cover and weed infestation. The river can be seen at places through the riparian vegetation and provides a level of shade and amenity to the adjoining residential receptors.

Viewpoint: 5	Lucius Street
Levee Type Proposed:	Earth Embankment

This view is obtained from the industrial area on Lucius Street, overlooking the existing Boatyard. It illustrates the poor quality of the existing landscape. However, the River and distant mountains are visible from this area and there are numerous mature native trees indicating the high potential of this area for enhanced amenity. This viewpoint is experienced by relatively few viewers – principally workers of the adjoining sites.

Viewpoint: 6	Fiddes Street across Fitzroy River floodplain
Levee Type Proposed:	Earth embankment

This view is obtained from the Fiddes Street, overlooking the Fitzroy River floodplain. It is a panoramic view providing sweeping open views with a strong sense of place across the naturalistic rural landscape and wetlands of the Fitzroy River and Gavial Creek to the distant Mount Archer ranges. This viewpoint is representative of the view obtained from this part of South Rockhampton by motorists and other users of Fiddes Street and Dunlop Street and its adjoining rural properties.

Viewpoint: 7	Jellicoe Street
Levee Type Proposed:	Earth embankment

This view is obtained from Jellicoe Street, overlooking the Fitzroy River floodplain. Similar to Viewpoint 4, sweeping views can be obtained across the naturalistic rural landscape and wetlands of the Fitzroy River. However, mature trees and tree belts provide some sense of enclosure. A significant avenue of trees is located on the southern side of Jellicoe Street. This viewpoint is representative of the view obtained by motorists and the existing residential properties on Dunlop Street.

18.3 Potential Impacts, Management and Mitigation Measures

The levee will become a key feature in the landscape for South Rockhampton. The visual amenity assessment identified a number of key landscape sensitivities, including the following.

- Perception of connectivity between the town and the Fitzroy River.
- Importance of heritage buildings.
- Maintenance of parkland accessibility and quality.
- Presence of important wetland areas.
- Presence of significant mature trees including large gums.

Mitigation measures have been included in early design stages to influence the levee types and alignment location. Whilst the levee would unavoidably change the landscape and visual amenity of parts of South Rockhampton it is considered that there are numerous opportunities for landscape proposals that would enhance the character of the proposed levee structure to minimise adverse impacts and enhance recreation and amenity outcomes. Such proposals will be investigated in further design and operational stages of the Project.

The following sections provide a summary of the potential visual and landscape impacts and the mitigations incorporated through design to minimise potential impacts of the Project. A description of the various levee arrangements is provided in Section 4.0.

18.3.1 Temporary Levee

The temporary levee system is located on part of Quay Street (associated with Viewpoint 1). During a Fitzroy River flood event concerns related to landscape and visual amenity will be superseded by the need to provide flood defence. The remainder of the time, when the temporary barrier is not erected, no visual impacts will occur. There would be temporary construction impacts when the scheme is implemented.

The use of a demountable structure is inherently a mitigation measure since it provides immunity while avoiding the landscape and visual impacts (divorcing the town from the river) that would be associated with a permanent structure. No direct mitigation is therefore proposed. The temporary levee system also helps to maintain visual values associated with the heritage precinct on Quay Street.

18.3.2 Composite Levee Wall

The composite levee wall is located on part of Quay Street (Viewpoint 2) and Wharf Street (Viewpoint 4). The construction of a continuous wall structure would have the following potential impacts.

- Create a barrier that physically and visually divorces Quay Street from the Fitzroy River.
- Potentially obstruct views from residents, workers, drivers and pedestrians on Quay Street, Wharf Street and other adjoining streets.
- Remove passive surveillance leading to accessibility and CPTED issues in the adjoining parklands.
- Provide a wall along Quay Street that has potential to attract graffiti leading to poor visual quality.
- Construction impacts including removal of existing riparian vegetation on Wharf Street.

A number of physical openings in the permanent wall have been included in strategic locations to provide opportunities for visual permeability and physical access. These would need to be filled with a demountable structure in times of flood. In these locations they will maintain the open connection to the river in views down these streets as well as break up the façade for viewers from Quay Street.

Removal of riparian vegetation will be most prevalent from the Wharf Street viewpoint, where a direct loss in vegetation and shade will occur. No direct mitigation is proposed to the Wharf Street section in relation to this impact. Revegetation is not possible as roots may impact the integrity of the flood protection structure leading to risk of failure.

18.3.3 Crib Wall

Crib walls are utilised when there is not sufficient room for an earth embankment - e.g. at the South Rockhampton Sewage Treatment Plant where there is only a small corridor between existing infrastructure and Gavial Creek. These locations also have limited, or restricted, formal public access to the Fitzroy River. In the section of the Sewage Treatment Plant there is low visual amenity and few sensitive receptors through this section.

Impacts associated with the crib wall structure may include a less attractive finish from an urban design perspective, compared to a natural riverine view shed. The key mitigation for the crib wall is selective usage. The crib wall has been used in places where there is insufficient space, and industrial areas with limited public access and usage.

18.3.4 Earth Embankment Levee

The earth embankment is likely to have the following impacts.

- The embankment will impede open views across the Fitzroy floodplain to the horizon.
- Potential fencing proposed to limit access will diminish the natural quality and visual amenity of the landscape.
- Removal of trees during the construction period and presence of construction plant within the current open views.
- Impact on views from residential homes on Jellicoe Street during construction and operation.

Mitigation to minimise visual impacts associated with the earth embankment levee structures include the following.

- Wherever possible existing mature trees will be maintained.
- Smoothing of angular levee sections to integrate the structure into the natural curves of the landform.
- Grass species for vegetation of the berm are proposed that mirror the surrounding landscape.

19.0 Social and Economic

The historical impacts of flooding events in Rockhampton are well documented, with flood records dating back to 1859. Flooding history and extent are discussed in detail throughout this EAR.

A large area of the Rockhampton Local Government Area is impacted during these large flood events. The inundation of the floodplain can result in the closure of Rockhampton Airport, the Bruce and Capricorn Highways and the North Coast Rail Line. The Bruce Highway and North Coast Rail Line can also be cut by floodwaters at the Alligator Creek Crossing near Yaamba. As major floods can last for several weeks there is often an extensive disruption to road, rail and air traffic that results in extensive indirect losses.

Extensive property damage can also occur within Rockhampton during flood events which can result in significant direct losses and pose a safety risk to the population. The suburbs of South Rockhampton, including Depot Hill, Allenstown, Port Curtis, and parts of Rockhampton Central Business District are typically inundated during these events. These suburbs are referred to collectively as South Rockhampton.

The Queensland Government Statisticians Office (QGSO) identifies the South Rockhampton area as the Rockhampton City Statistical Area Level 2 (SA2). The following information for South Rockhampton area is based on the SA2 data from Regional Profiles provided by QGSO (QGSO, 2019).

19.1 Community Characteristics

19.1.1 Population

The South Rockhampton area has an estimated resident population of 3,253 persons as at 30 June 2018, contributing approximately 4% of the wider Rockhampton LGA residential population of 81,067 persons (QGSO, 2019).

The estimated residential population by age group is identified in Table 19-1, and indicates that the majority of the South Rockhampton population sits across the 24-64 age group. This is also reflected as a wider trend across the Rockhampton LGA. The median age across the South Rockhampton area is 42.9 years. The populations of age groups 0-14 and 65+ collectively make up 32.5% of the South Rockhampton region.

Table 19-1 Estimated residential population by age (QGSO, 2019)

Location	Age Group									
	0-14		15-24		25-44		45-64		65+	
	#	%	#	%	#	%	#	%	#	%
South Rockhampton	500	15	399	12	854	25.7	990	29.8	583	17.5
Rockhampton LGA	17,124	21.1	11,322	13.9	21224	26.1	19,614	24.2	11,922	14.7

Population projections are generated by applying assumptions regarding future trends in components of population change, including fertility, mortality and migration, and the latest planning and development intelligence available (QGSO, 2019). The population projection for South Rockhampton over a 25 year period is a 0.7% increase. The projection for Rockhampton LGA over the same timescale is identified as 1% increase.

The percentage of Aboriginal and Torres Strait Islander peoples in the South Rockhampton area based on 2016 census information on usual place of residence was 9.1%, making up approximately 5% of the wider Rockhampton LGA Aboriginal and Torres Strait Islander peoples population.

The number of residents of the South Rockhampton area born in Australia was 2,542, with 270 people born overseas. Of the percentage born overseas, slightly more than 50% were from English speaking countries.

19.1.2 Dwellings and Buildings

The 2016 Census Population information provides a representative data set for dwelling structures and is presented in Table 19-2. Both the South Rockhampton and the Rockhampton LGA mainly include separate house dwellings.

Table 19-2 Occupied private dwellings by dwelling structure (QGSO, 2019)

Location	Separate House		Semi-Detached		Apartment		Caravan		Other	
	#	%	#	%	#	%	#	%	#	%
South Rockhampton	945	76.3	73	5.9	181	14.6	3	0.2	4	0.3
Rockhampton LGA	24,867	87.6	1968	6.9	1177	4.1	151	0.5	72	0.3

Tenure type describes whether a house hold rents or owns (or another arrangement) the dwelling being occupies. Table 19-3 identifies the tenure type for occupied private dwellings.

Table 19-3 Occupied private dwellings by tenure type (QGSO, 2019)

Location	Fully Owned		Being Purchased		Rented		Other	
	#	%	#	%	#	%	#	%
South Rockhampton	322	26.0	305	24.6	544	43.9	8	0.6
Rockhampton LGA	8,168	28.8	9,551	33.7	9,614	33.9	208	0.7

Homelessness is a lack of one or more elements that represent 'home'. South Rockhampton has a homeless rate of 430.7 per 10,000 persons, compared to that of the wider Rockhampton LGA which has a rate of 46.8 persons per 10,000 persons, indicating that the South Rockhampton area has a high percentage of homeless people, making up approximately 5% of the population.

There is low levels of building approvals within the South Rockhampton area, with only 1 approval identified within the 12 months leading up to February 2019 (QGSO, 2019). This is likely due to the already developed nature of the area, alongside the restrictions on further intensification through local planning instruments due to the severity of flooding impacts.

In the 12 months ending in September 2018 there were 80 residential dwelling sales, with a median sale price of $260,000. The median house price is only slighter less than the Rockhampton LGA median sale price of $265,000.

19.1.3 Income and Employment

Table 19-4 provides the selected median averages for economic information based the 2016 census data. The median household income for South Rockhampton was $892/week, compared to the wider Rockhampton Local Government Area of $1,255/week.

Table 19-4 Selected medians and averages (QGSO, 2019)

Location	Median Mortgage Repayment	Median Total Family Income	Median Total House Hold Income	Median Total personal Income	Average Household Size	Average Number of Persons per Bedroom
	$/month	$/week	$/week	$/week	persons	number
South Rockhampton	1,127	1,185	892	486	2.1	0.8
Rockhampton LGA	1,517	1,539	1,255	626	2.5	0.8

In the December quarter of 2018 South Rockhampton had an unemployment rate of 22.4%, compared to that of Rockhampton LGA which had a rate of 7.8%.

The top 5 industries of employment for South Rockhampton were identified as:

- Food and beverage services (7.9%)
- Other Store-Based Retailing (5.8%)
- Social Assistance Services (5.0%)
- Accommodation (5.0%)
- Hospitals (4.6%).

It is noted, that agriculture, forestry and fishing made up 1.2% of the employment industries.

The number of businesses in South Rockhampton in 2017 – 2018 was 888 businesses. Of these businesses approximately 50% were non-employing, and 30% were employed 1 – 4 employees.

19.1.4 Services

The following emergency services, school and hospitals are identified within the South Rockhampton area as at June 2018.

- Police Station - 1
- Ambulance Station - 1
- Fire Station - 1
- Schools - 3
- Hospitals – 1.

The schools present within the South Rockhampton area include:

- Depot Hill State School
- Port Curtis State School
- Rockhampton Special School.

The South Rockhampton area also includes a number of recreational facilities, including Rosel Park, Bartlem Park and Littler Cum-Ingham Park.

19.1.5 Disadvantage

Socio-Economic Indexes for Areas (SEIFA) is a summary measure of the social and economic conditions of geographic areas across Australia. In 2016 an Index of Relative Socio-Economic Disadvantage was produced, ranking geographical areas in terms of their relative socio-economic disadvantage. The index focuses on low-income earners, relatively lower education attainment, high unemployment and dwellings without motor vehicles.

Table 19-5 provides the SEIFA for both South Rockhampton and Rockhampton LGA. Low index values represent areas of most disadvantage and high values represent areas of least disadvantage. Table 19-5 identifies that the South Rockhampton area has an extremely high SEIFA score compared to that of the wider Rockhampton LGA.

Table 19-5 Population by index of relative socio-economic disadvantage quintiles

Location	Quintile 1 (most disadvantaged)	Quintile 2	Quintile 3	Quintile 4	Quintile 5 (least disadvantaged)
South Rockhampton	96.5 %	3.5 %	0.0 %	0.0 %	0.0 %
Rockhampton LGA	39.1 %	29.8 %	13.4 %	7.3%	10.4 %

19.2 Community Views

Council undertook an extensive community engagement program on the Project in July 2013 (further information can be found in Section 6.0). This involved discussing the Project with various community members including landholders within the levee, landholders outside the levee and the broader community (RRC, 2014).

To understand if there was community support for the levee, Council undertook two significant surveys which both indicate that there is support for the levee. From the survey process there were numerous benefits that the community believed would be created through the construction of the Project. The top 5 included the following (RRC, 2014).

- Reduction in damage to the city.
- Help protect roads and infrastructure.
- Reduce disruptions to the community.
- Highway traffic won't need to be diverted during floods.
- Help protect community members.

Concerns about the Project were raised, and were focused on both cost and increasing flood waters outside of the levee area. One in five persons was concerned with increased flood waters outside of the levee.

19.3 Potential Impacts

19.3.1 Benefits of the Project

A study of the social and economic impacts of the Project was undertaken in 2014 (Rolfe, Windle, & Small, 2014). The study aimed to identify the benefits that flood protection may generate. The study concluded that the Project would result in the following benefits to the South Rockhampton area.

- Protection of properties in South Rockhampton area from flood events.
- Reduced public health and safety risks associated with direct (actual harm to people) and indirect (impacts of pest and disease) impacts of a flood event.

- Improved social well-being through reduction in social, psychological and economic costs of evacuation, interruption to services, employment related impacts and community wellbeing and resilience.
- Reduced insurance premiums through protection of dwellings from flooding.
- Reduced business interruptions and business losses through minimising losses on property and stock, the loss of staff wages during downtime, inability to trade and impacts on the supply chain.
- Improved property values within the dry side of the levee generated by the protection of private property as well as the other amenity benefits of the proposed levee.
- Provision of urban renewal opportunities, albeit tempted by the inability to remove all flood risks, but opportunities for upgrading private residential areas and public infrastructure will exist (however no intensification).

In addition, wider benefits across the Rockhampton region included the following.

- Reduced disaster management costs associated with coordination and investment of local, State and volunteer services.
- Reduced maintenance costs on public infrastructure.
- Avoided road construction costs associated with the lower Dawson Road upgrade.
- Improvements to reputation through reduce effects on tourism and business markets.

19.3.1.1 Protection of Community Infrastructure

There are a range of existing services located within the South Rockhampton area as identified in Section 19.1.4. The Project will provide a higher level of protection to these services, in particular 3 schools, and other emergency services and hospitals.

19.3.1.2 Job Opportunities

The Project is predicted to generate a number of construction related jobs. It is expected that construction work forces would preferentially be sourced from the regional area, however some of the workforce would also be sourced further afield.

19.3.2 Disbenefits of the Project

19.3.2.1 Increases in Floodwater Outside of Levee

Section 19.2 identified that during community consultation concerns about increasing flood waters outside of the levee area were raised. The hydraulic assessment included an assessment of buildings at risk of increased inundation as a result of the Project. There is a number of impacted building which are identified as subject to additional above floor flooding or an increase of flood height above floor in certain modelled events. Further detail on this is provided in Section 7.0 of the EAR.

Whether an impact on people or buildings is acceptable or not or the change in hydraulic effects are acceptable or not is dependent on a number of factors. The DNRME Levee Guidelines notes that the acceptability of a hydraulic change will typically rely on a negotiation between the applicant, the Assessment Manager and any impacted parties. In this case, the final decision on the acceptability of the impacts is to be made by DSDMIP.

Whether the Project represents an acceptable impact on people and buildings has not been assessed in this EAR. However, the Cost Benefit Analysis (discussed further in Section 19.4) shows the economic benefits of the Project and considers the negative impacts of the Project.

19.3.2.2 Changes to Demographics

As outlined above and as per the Cost Benefit Analysis derived for the Project, a number of indirect benefits that would impact the demographics of South Rockhampton have been identified as follows.

- Reduced insurance premiums through protection of dwellings from flooding.
- Improved property values within the dry side of the levee generated by the protection of private property as well as the other amenity benefits of the proposed levee.

On this basis, it is possible that gentrification may occur i.e. more affluent residents will move into the area altering the demographics of the area. Considering that there are only minor differences in median house prices in South Rockhampton compared to the wider Rockhampton LGA, it is unlikely that the Project would have any significant impacts on housing affordability, and that lower income housing stock would remain available across the LGA.

19.3.2.3 Disruptions to Business

The purpose of the Project is to protect residential and commercial properties from flood inundation from the Fitzroy River. Generally, the sections of permanent levee (including the composite flood wall) are located so as not to impact the operations of businesses adjacent to the levee.

There are three businesses/organisations located on the "Wet Side' of the levee on Quay Street as follows:

- Boat House Restaurant
- Rockhampton Coast Guard
- Fitzroy Motor Boat Club.

The operation of these organisations/businesses will be affected during nominated flood events as sewerage mains that service each of these will need to be isolated so that backflow from the river does not enter the dry side of the levee. It is noted that during the nominated flood events the businesses/organisations may not be accessible due to the river level.

The provision of the temporary levee along Quay St will require the closure of Quay Street. Street closure is required for safety reason as there should not be vehicles in close proximity to the temporary levee.

The temporary levee provides freeboard mitigation only and there has only been 1 flood event in the past 130 years of records (1918) that would have necessitated the use of the temporary levee on Quay Street i.e. without the temporary levee in this area the businesses would already be affected by the flood event. On this basis, the provision of the temporary levee along Quay Street protects businesses and therefore would not have an adverse impact to the business operation during times which they would not already be impacted if a flooding event was to occur.

19.3.3 Lifestyle and amenity

There is the potential for the following temporary impacts during construction:

- noise emissions from the operation of machinery
- dust emissions associated with earthworks
- traffic disruptions.

These impacts are discussed further in respective sections of this EAR, and are anticipated to be managed through a Construction Environmental Management Plan to avoid, minimise and manage construction impacts where possible.

In some locations the Project will introduce a new permanent item into the visual landscape. Visual impacts and potential mitigation measures are addressed in Section 18.0.

19.4 Cost Benefit Analysis

AECOM has updated the 2014 cost-benefit analysis (CBA) for the Project. This report outlines the methodology and results of the CBA and can be found in Appendix S. The CBA results have been presented for 'direct' benefits only, and a combination of the 'direct' and 'indirect' benefits.

Two cost streams were included in the economic analysis, including the following.

- Capital Expenditure: The 2018 cost estimate update was used in the economic analysis. The total capital cost of $80.36m estimated in 2018 was found to decline to $72.70m in present value terms.

- Operational Maintenance Expenditure: Operational expenditure relating to maintaining the levee has been included in the CBA. It has been assumed that the levee increases maintenance by approximately $450,000 per annum.

Eight benefit streams were included in the economic analysis, including the following.

19.4.1 Direct benefits

- Reduced Flood Damages: Average annual flood damages were updated by AECOM and documented in the Flood Damage Assessment Report for the base case and project case. The analysis found that the levee is expected to avoid $1.74m in damages each year.
- Reduced Social Impacts: In addition to the damages to existing infrastructure and asset damage which results from a flood, there is a significant social burden associated with a major flood event.

  An analysis of the 2010 Queensland floods found that social impacts accounted for slightly more than the direct flood damages. The ratio of social costs to flood damage costs is 52:48.
- Disaster Management Costs: A study conducted by Rolf et al (2014) for the SRFL estimated that the project will reduce disaster management costs in a major flood between $2.03m - $2.38m.
- Avoiding the upgrade of Lower Dawson Road: The Fitzroy River Floodplain and Road Planning Study (AECOM, 2011) presented an Implementation Programme for upgrades to the Bruce Highway and North Coast Rail line to meet the transport needs of the Rockhampton region to 2031 and beyond. Stage 6 – Lower Dawson Road Flood Immunity Upgrade is scheduled for 2021 and is expected to cost approximately $70m (2019 dollars). The SRFL will protect Lower Dawson Road from flooding up to a 1% AEP magnitude and therefore makes the investment redundant and the ensuing savings are treated as a benefit.
- Residual Value: The residual value captures the benefit associated with the useful life of the project extending beyond the evaluation period. AECOM estimate a useful life of 50 years, resulting in 25 years of life remaining at the end of the evaluation.

19.4.2 Indirect benefits

- Reduced Insurance Premiums: As the probability of a property flooding declines, the insurance premium paid is also expected to fall. A study undertaken by Rolf et al (2014) suggests an insurance premium saving of $0.2m to $0.94m per annum is achievable.
- Improved Property Values: A study by Rolf et al (2014) estimated that the SRFL would improve property values within the protected area over time by lowering the probability of flood damages. It is estimated that there might be an improvement in property values between $16m and $32m in total. However this would be a once-off improvement in values, and would take some years to be recognised fully. It is assumed this will be a gradual process over 12 years, with equal amounts per year.
- Reduced Business Interruptions and Losses: Interruptions to business operations are a major cost of flood events. There are currently three locations where businesses are impacted by local flooding and where the benefits of the levee would be most relevant: Depot Hill; Port Curtis and at Allenstown, along the Lower Dawson Road and Gladstone Rd. The loss of business production within the area to be protected by the proposed levee has been estimated in a study by Rolf et al (2014) using estimates of the labour force in the area. Estimated losses in GRP are $9.49m (low), $11.39m (medium) and $13.29m (high).

19.4.3 CBA Results

Costs and benefits quantified in the analysis are summarised in Table 19-6.

Table 19-6 Headline Cost and Benefit Inputs - 7% discount rate, 25 years of benefits

Item	Direct Only Benefits	Direct and Indirect Benefits
COSTS		
Capital Expenditure	$72.7m	
Operational Expenditure	$4.6m	
Residual Value	-$6.5m	
Total Costs	**$70.8m**	
BENEFITS		
Reduced Flood Damages	$17.7m	$17.7m
Reduced Social Impacts	$19.5m	$19.5m
Reduced Disaster Management	$1.1m	$1.1m
Avoiding Lower Dawson Road Upgrade	$57.1m	$57.1m
Direct Benefits Subtotal	**$95.4m**	**$95.4m**
Reduced Insurance Premiums	N/A	$5.2m
Improved Property Values	N/A	$13.9m
Reduced Business Interruptions	N/A	$5.8m
Indirect Benefits Subtotal	**$0.0m**	**$24.9m**
Total Benefits	**$95.4m**	**$120.3m**

Based on the inputs, the Project delivers a positive net economic benefit at the 7% discount rate for both the 'direct' and 'direct plus indirect' benefits included as presented below.

The Project is expected to produce a positive economic return mainly driven by the direct cost of flood damage and the avoidance of the Lower Dawson Road Upgrade with a BCR of 1.70 and a net present value (NPV) of $49.5m. The BCR with 'direct' only benefits is 1.35 and the NPV is $24.6m.

Table 19-7 Headline CBA Results - 7% discount rate, 25 years of benefits

Item	Direct Only Benefits	Direct and Indirect Benefits
BCR	1.35	1.70
NPV	$24.6m	$49.5m
FYRR	82.3%	85.8%
NPV/I	0.37:1	0.75:1

The FYRR is a useful way to optimise the timing of projects. If the FYRR is greater than the discount rate, the project should proceed immediately. If the FYRR is less than the discount rate, but still viable, then the project should be deferred until the FYRR equals the discount rate. Based on the range of discount rates tested, the Project should commence immediately.

19.4.4 Sensitivity Analysis

The headline results have been tested for variations to the underlying assumptions in the CBA, including changes to capital costs, operating costs, benefits and discount rate. A summary of sensitivity tests are provided below:

- Low Scenario for Benefits
- High Scenario for Benefits
- Capital Cost + 20%
- Capital Cost - 20%
- Annual Maintenance $1m per annum
- Social Impacts Reduced to 30%
- Lower Dawson Road Benefit Removed

Under all tests, the NPV and BCR remained well above the usual hurdle rates, noting that the removal of the Lower Dawson Road avoidance benefit brings the BCR below 1.0.

19.4.5 Discount Rate Testing

The results of the CBA have been presented at different discount rates in accordance with guidance from Infrastructure Australia. While the 7% discount rate was used as the main assumption, given the current rates of interest in Australia (e.g. government bonds) there is an argument that a discount rate lower than 7% may be more appropriate.

These results show that the Project is viable for both the 'direct' and 'direct plus indirect' benefit scenarios across the range of discount rates assessed in Table 19-8.

Table 19-8 BCR at Various Discount Rates

BCR	4%	6%	7%	10%
Direct Only Benefits	1.70	1.44	1.35	1.15
Direct and Indirect Benefits	2.19	1.83	1.70	1.43

19.4.6 Summary

The results of the CBA have been aggregated into 'direct' and 'indirect' benefits. The BCR is then calculated using "direct" only benefit and also using both 'direct' and 'indirect.' This is to ensure that there is transparency in the results and that any views on double counting of benefits can be addressed. Given these inherent limitations, readers of this report should consider the results of the sensitivity and scenario testing and also whether the BCR should include 'direct' only benefits or both the 'direct' and 'indirect' benefits.

The assessment shows the Project is viable for both the 'direct' and 'direct plus indirect' benefit scenarios. The Project is considered to be low risk at most discount rates and sensitivities and therefore is worthy of consideration.

20.0 Infrastructure

The following section provides an overview of the existing infrastructure located within and adjacent to the Project area, and the design solutions provided to mitigate the potential impacts associated with the construction and operation of levee.

The design development process has considered a number of options for alignment and levee type. The options analysis and alignment selection process undertaken throughout the life of the Project has considered the potential impacts associated with infrastructure providers. Consultation with infrastructure providers has been ongoing throughout the design development process.

A Concept Design Report is provided in Appendix E and provides a detailed description on design solutions. A summary is provided below.

20.1 Local Government

There are a number of local government infrastructure assets located within and adjoining the Project area. These include roads; water supply networks; sewage networks; stormwater drainage; and the South Rockhampton Sewage Treatment Plant (SRSTP).

20.1.1 Roads

The Project crosses a number of Council roads with the potential to impact traffic conditions. Access will be maintained through the construction of levee crossings and gates where required. Where possible, road ramps have been incorporated to reduce risk (to levee structure compared with gates) and maximise functional time leading up to and after a flood event. Road closures resulting from levee gate closures / erection during a flood event provide no net impact as these roads are currently inundated during a flood event. These have been summarised in Table 20-1.

Table 20-1 Local roads within Project area

Road Name	Description	Design Solution
Unnamed Road Reserve	Unformed road reserve off Jellicoe Street	Road gate - removable flood barrier (road ramp not feasible)
Old Bruce Highway	Sealed road	Road gate - removable flood barrier (road ramp not feasible)
Unnamed Road Reserve	Unformed road reserve off Port Curtis Road	Nil. Alternative access available to surrounding properties as agreed with DNRME.
Port Curtis Road	Sealed road	Road ramp levee crossing
Jellicoe Street	Unsealed road to unformed road reserve at eastern end	Road ramp levee crossing
Prospect Street	Unformed road reserve	Nil at crossing of Prospect Street. Upgrades to Bowlin Road, including turn-around areas to provide access to adjoining lot.
Quay Street (southern end)	Sealed road	Road ramp levee crossing.
Unnamed Road Reserves	Unformed road reserves along Main Drain / Gavial Creek	Nil. Alternative access available to surrounding properties as agreed with DNRME.
Broadway Street	Unformed road reserve	Nil. Alternative access available to surrounding properties as agreed with DNRME. Ramp levee crossing provided for access to Powerlink assets.

Road Name	Description	Design Solution
The Bend	Unformed road reserve / unsealed road	Nil. Alternative access available to surrounding properties as agreed with DNRME. Ramp levee crossing provided for access to Powerlink assets.
Lucius Street	Unsealed road	Nil. Alternative access available to surrounding properties as agreed with DNRME. Ramp levee crossing provided for access to Powerlink assets.
Wharf Street	Sealed road / Unsealed road	Lucius Street to Wood Street - Levee alignment parallel to road. Access maintained. Wood Street to Arthur Street - Nil. Alternative access available to surrounding properties as agreed with DNRME.
Quay Street (Francis Street to Stanley Street)	Sealed road	Composite levee wall (I-Wall) with combination permanent and temporary wall components. Access gates (removable barrier) to be provided to maintenance property access through wall.
Quay Street (Stanley to Fitzroy Street	Sealed road / sandstone paved Riverbank Precinct	Temporary (fully removable barrier). No permanent impacts to road.

20.1.2 Water and Sewer

There are multiple water and sewer services that are impacted by the levee. The design has considered these services and provided solutions for either removal and or relocation where required to provide the same level of service. These works generally include the following.

- Any services no longer required shall be isolated and removed prior to levee construction.
- Construction of a new DN100 water main within Quay Street to minimise the number of water services crossing the levee.
- Construction of a new DN150 and DN100 water main within Quay Street / Bowlin Road to increase the level of service to an existing property in this area and allow installation of a water main crossing over the levee at the Quay Street road ramp.
- Any services required to remain shall be relocated over the levee (through the freeboard section of the embankment or over/through the concrete permanent portion vertical flood walls).
- Gravity services shall be “treated” through the levee wall to reduce the likelihood and consequence of seepage affecting the levee. Isolation valves to prevent backflow during a flood event shall be provided.

Disruption of services to customers will be minimised through staged construction (to reduce required network shutdown times) and liaison with impacted property owners at the time of construction.

20.1.3 Stormwater

A number of subsurface stormwater drainage lines are impacted by the Project. The following works are proposed to mitigate these impacts.

- Installation of backflow prevention devices on existing subsurface drainage, both within the extents of the levee and directly upriver, where potential surcharge within the levee protection area is anticipated. Backflow prevention devices will be open during normal (no flood) conditions to ensure the area is free draining.
- Diversion of existing stormwater pipes to minimise the number of levee alignment crossings.

- Treatment of existing or proposed new subsurface drainage infrastructure where it crosses the levee / penetrates levee wall footings to protect the stormwater asset and minimise risk of levee failure at that location.

20.1.4 South Rockhampton Sewage Treatment Plant

The SRSTP is operated by Fitzroy River Water, a commercial business unit of Council, and is currently inundated during Fitzroy River flood events. The Project bisects the SRSTP south of the sludge lagoons providing 1% AEP flood immunity and continued operation of the plant. This alignment was preferred by FRW / Council and impacts to the plant operation, including access to the 'sludge storage' areas to the south of the Project, has been acknowledged and accepted.

Adequate clearance has been maintained from the levee to existing infrastructure within the SRSTP site to enable ongoing access for plant operations as well as maintenance and monitoring of the levee during normal and emergency conditions.

The existing outfall pipeline from SRSTP currently discharges into the Fitzroy River slightly upstream of the mouth of Gavial Creek. A backflow prevention device will be installed and a diversion outfall pipeline will be provided into the inlet of the Main Drain pump station to allow continued discharge of SRSTP flows during a flooding event.

Operation of the plant will continue through the construction of the levee. Ongoing liaison with FRW will be required during the design development and construction to minimise impacts and ensure operational requirements of the plant are met.

20.1.5 Littler-Cum-Ingham Park

The Project area traverses the eastern edge of Littler-Cum-Ingham Park. This alignment was chosen in consultation with community users of the park to maximise usable space and allow continued use for markets and other community activities.

Earth embankment type levee will be incorporated into the park landform and will include shared pathways, landscaping, terrace seating and a sheltered barbeque area. Use of the park will be impacted during construction however the proposed works will ultimately improve park access, usability and amenity.

20.2 Electrical Infrastructure

Ergon's infrastructure consists of overhead lines supported by poles, with some stay poles (bollards) and wires within the extents of the levee alignment. Where possible, poles will be relocated away from the levee to reduce impacts on the levee structure. Wires will be raised by installation or relocation of one or two higher poles adjacent, so that construction works can be completed without interference, or operation activities can be undertaken once construction is complete.

There are a few minor house connections that cross the levee or extend into the "clear zone". There are also redundant overhead services that were installed by Ergon in the past but not connected to properties. These connections can be removed once the affected property has been resumed and authorisation to proceed is given to Ergon.

Powerlink's infrastructure consists of the Powerlink Egan Hill – Rockhampton 132kv transmission line over the SRSTP. Adequate vertical and horizontal clearance from the towers and lines is provided from the levee and as such, no relocations were required of the Powerlink infrastructure. An access ramp is proposed over the earth embankment levee to provide access to an existing tower on the northern side of Main Drain.

20.3 Gas Reticulation Infrastructure

There is a single APA gas service that crosses the levee along Quay Street and services the Boathouse restaurant. The levee is of a demountable (fully removable) type in this area resulting in no impact on the gas service. Seepage risks are deemed low however further assessment will be undertaken in detailed design stage and seepage management will be incorporated into the Emergency Response Plan.

20.4 Telecommunications Infrastructure

Telstra, NBN and Optus telecommunication assets are impacted by the Project area. The design approach to maintain these services with reduced impact on customers is as follows.

- Any services no longer required shall be isolated and removed prior to levee construction.
- Any services required to remain shall be relocated over the levee (through the freeboard section of the embankment or over/through the concrete permanent portion vertical flood walls) or in new envelopers under the earth embankment levee.

Disruption of services to customers will be minimised through staged construction (to reduce required network shutdown times) and liaison with impacted property owners at the time of construction.

Preliminary discussions with Optus (Visionstream) have indicated potential issues with relocating of the optic fibre line that traverses the North Coast Rail Line flood gate (refer Section 20.5.3). Further consultation will be required to determine a suitable arrangement.

20.5 State Transport Infrastructure

Inundation of the floodplain in Fitzroy River flood events currently results in impacts on State Transport Infrastructure in the area including closure of the Bruce and Capricorn Highways and the North Coast Rail Line. The Bruce Highway and North Coast Rail Line can also be cut by floodwaters at the Alligator Creek Crossing near Yaamba (30 kilometres north of Rockhampton). As major floods can last for several weeks there is often an extensive disruption to road, rail and air traffic that results in extensive indirect losses. Construction of the Project will result increased flood levels over a number of these State Controlled assets as summarised in Table 20-2 below. Additional information is provided within the Hydraulic Assessment Report (refer to Appendix J).

Consideration of the impacts of these increased flood levels and corresponding velocities and required mitigation measures (i.e. additional scour protection will be addressed in the detailed design phase.

Table 20-2 Difference in WSE and TOS at key receptors (1% AEP Event))

Key Receptor	Baseline WSE (mAHD)	Dev Case WSE (mAHD)	Increase (m)	Baseline TOS (days)	Increase (hrs)
Existing Low Level Bruce Highway	9.13	9.29	**+0.16**	12.2	**+4**
Bruce Highway (Yeppen North)	9.24	9.41	**+0.17**	0.0	-
Blackwater Rail Line	9.31	9.46	**+0.15**	12.2	**+4**
North Coast Rail Line	8.96	9.30	**+0.35**	13.7	**+4**
Rockhampton Airport	9.91	9.99	**+0.08**	12.3	**+2**

The Project will physically interact with the following State Controlled Road and rail infrastructure.

- Fitzroy Street – Connection of temporary (fully removable barrier) to Fitzroy Bridge abutment.
- Bruce Highway – Connection of earth embankment levee to Yeppen North embankment adjacent to Jellicoe Street intersection.
- North Coast Rail Line – Installation of flood gates across rail line on the Southern side of Jellicoe Street.

The impact of the Projects construction, maintenance and operation on this infrastructure has been further detailed below.

20.5.1 Fitzroy Street

The Project will terminate at southern side of the Fitzroy Bridge. Temporary (fully removable) type barrier is proposed in this location and will connect to the bridge abutment. The connection design arrangement will be confirmed by the supplier / manufacturer during detailed design and its construction / erection prior to a flood event is not expected to impact the bridge structure or its operation (including Fitzroy Street traffic).

20.5.2 Bruce Highway

The Project will commence at the eastern side of the Yeppen North bridge embankment adjacent to the Jellicoe Street intersection. Connection of the earth embankment type levee to the road embankment is shown on the Concept Design drawings in Attachment E (drawing no. 60589157-SHT-20-1200-C-0001) and will be constructed generally in accordance with Department of Transport and Main Roads (DTMR) standards. Detailed design of this component will be confirmed and will be designed to mitigate risk of failure at this location.

No impact is expected on the operation of the Bruce Highway during construction, maintenance or operation of the levee in this location. Further liaison with will be carried out throughout the design development process.

20.5.3 North Coast Rail Line

The Project will intersect the North Coast Rail Line adjacent to the Yeppen North embankment on Jellicoe Street. The North Coast Rail line is an electrified system with overhead power lines at this location and is owned and operated by Queensland Rail (QR). A fixed flood gate system (swing or slide gate) is proposed at this location consistent with current industry practice.

The proposed concept design incorporates track slab modifications and consideration of staged construction to minimise impacts to operations. The rail gate represents a high risk component of the levee and is located within the Yeppen North high flow zone. Consideration of potential failure mechanisms has been made through key design components including wall to gate transitions, sheet pile cut of walls and scour protection works.

The configuration and structural design of the gate arrangement will be confirmed during detailed design following further consultation with QR to ensure design and operational criteria is met. Key considerations raised by QR during preliminary consultation for consideration as part of these future design and consultation works include the following.

- Construction methodologies and impacts including clearances from and isolation of electrical infrastructure.
- Impacts on the Jellicoe Street level crossing.
- Sighting distance impacts (road and rail traffic at level crossing).
- Collision risk mitigation measure.
- Acceptance of gate opening width with consideration of access / clearance requirements vs gate size / operation impacts.
- Ownership, control and maintenance of the gate structure within the rail corridor including interface agreement between Council and QR.

Operation of the gate i.e. closure prior an anticipated flood event will be detailed in the Emergency Response Plan (ERP) and will be the responsibility of QR in co-ordination with the RRC Local Disaster Management Group (LDMG). Timing for closure and subsequent opening of the gate, including understanding and acceptance of impacts on rail operations will be agreed with QR and will be reflected in the ERP.

20.6 Landholder Infrastructure

A range of private infrastructure associated with rural properties will be impacted in portions of the alignment. These include items such as informal access tracks, fencing, irrigation, livestock yards and ancillary structures (i.e. sheds). The design approach to minimise impacts on this infrastructure is as follows.

- Existing infrastructure has been avoided where possible through refinements to the levee alignment.
- Fencing will be reinstated as part of the levee works and new fencing will be provided for public and livestock safety.
- Property owner and livestock access (both in normal and emergency flood conditions) has been reviewed for each individual property and reinstated or diverted through the installation of new ramps, gate and / or access tracks where required.
- Negotiation with property owners regarding acquisition of properties where access is not able to be feasibly maintained.

Ongoing liaison with property owners will continue as part of the design development process to ensure impacts on landholder infrastructure is minimised and access maintained.

21.0 Construction Traffic

During the construction phase the road network will be used for transportation of construction materials and personnel. A large volume of imported levee embankment material is expected to be required for the construction of the Project. At this stage the source of the material is not yet known. It is anticipated that the Construction Contractor will source the material from either a licenced facility or a new quarry site. Where a new site is proposed, it will be the responsibility of the Construction Contractor to obtain all necessary approvals and licencing under local, State and Commonwealth legislation.

Given the location of the Project area, use of the local and State road network to transport the material from the source site to the Project area is unavoidable. Transportation of this material will result in increased traffic volumes on the road networks throughout the duration of the project construction phase. This increase in traffic has the potential to result in the following impacts.

- Impact the safety and efficiency of the local and state road network.
- Result in damage to the road pavements.
- Impact the safe operation of rail level crossings.

The following mitigation and management measures have been proposed for the Project.

- Once a material source is identified a Traffic Impact Assessment will be undertaken by the Construction Contractor to determine the potential impacts of the Project on the road network.
- A detailed Traffic Management Plan for the Project to be developed and implemented by the Construction Contractor prior to construction works commencing.

22.0 Air Quality

Air quality monitoring data is not readily available for the Rockhampton region. Meteorology data indicates that the prevailing wind direction is south easterly, with an average wind speed of 11.6 km/h in the mornings and 15 km/h in the afternoons (Bureau of Meteorology, 2019).

The Project area and surrounds include a range of different rural and urban land uses (refer Section 10.0). Adjoining sensitive receptors include rural and residential dwellings, commercial and industrial places, as well as environmentally sensitive areas, being waterways and wetlands. No formal air quality impact assessment has been undertaken for the Project as the potential impacts are anticipated to be localised and short term, and limited to the construction phase of the Project.

Impacts to local air quality, through the release of emissions, are anticipated to be associated with the following construction activities.

- Site preparation including vegetation clearing, topsoil stripping etc.
- Stockpiling of excavated soil.
- Wind erosion from stockpiles.
- Vehicle and equipment movements over access tracks and work sites where ground is exposed.
- Exhaust emissions from vehicle and machinery operations.

The prevailing wind direction presents a potential risk of air quality impacts during construction to the adjoining urban areas of South Rockhampton if not managed appropriately.

Construction phase mitigation and management measures proposed to reduce the potential impacts to air quality are included in the Environmental Management Plan (Planning) provided in Appendix T. These measures include the following.

- Orientating material stockpiles in a direction that reduces exposed surfaces to prevailing winds.
- Watering of stockpiles to maintain a moisture content that minimises dust generation or alternatively temporarily cover stockpiles.
- Adequately store all bulk materials, and cover vehicles transporting materials to and from site.
- Watering unsealed haul roads.
- Restrict vehicle movements to within designated access tracks, and enforce speed limits where track is unsealed.
- Limit dust-producing work on windy days when possible or water down of dusty work sites to minimise dust generation.
- Avoid burning cleared vegetation whenever possible. If burning, obtain relevant approvals prior.
- Disturbed areas and bare earth should be stabilised or revegetated as soon as practical to minimise wind-blown dust.
- Ensure stationary plant, construction vehicles and equipment (especially those powered by diesel motors) is working correctly and maintained as per manufacturers recommendations (this will also aid in the mitigation of potential odour emissions).
- Shut down plant and equipment idling for excessive periods (i.e. longer than 5 minutes) where possible.
- Minimise queuing of construction vehicles and idling for excessive periods (e.g. more than 5 minutes).

23.0 Noise

The Project area and surrounds include a range of different rural and urban land uses (refer Section 10.0). Adjoining sensitive receptors include rural and residential dwellings, commercial and industrial places, as well as environmentally sensitive areas, being waterways and wetlands.

Noise impacts are anticipated to be associated with both construction phase activities and the operational phase. No formal noise impact assessment has been undertaken for the Project as the potential impacts are expected to be localized and short term.

Noise impacts during the construction phase of the Project are likely to be associated with the following activities.

- Construction phase traffic movements.
- Operation of machinery.
- Clearing and excavation activities.
- Sheet piling activities.

Construction phase mitigation and management measures proposed to reduce the potential noise impacts are included in the Environmental Management Plan (Planning) provided in Appendix T. These measures include the following.

- A Noise Management Plan for the Project to be developed and implemented by the construction contractor prior to construction works commencing.
- Construction activities should be undertaken in line with the limits in Environmental Protection (Noise) Policy 2008.
- Works to be carried out in general working hours. Where this is not possible, approval is obtained from council and notification to surrounding residents.
- Plant to be turned off when not in use and be regularly maintained, and repaired or replaced if it becomes noisier.
- Non-tonal reversing alarms to be used where practicable.

Potential operational noise impacts are likely to be associated with the operation of the three pump stations (further details on pump station components are included in Section 4.0). Pump station activities with potential noise impacts are anticipated to include the following:

- The pump stations will operate during a combination event of Fitzroy River flood and local catchment rainfall, where the water on the dry side of the levee needs to be removed.
- Emergency generators will be operated to power the pump stations in the event of a power outage.
- The pump stations will be operated approximately 2 times a year where they are tested for one day at a time.

The pump stations are located between 200 and 400m away from the nearest residential receptors and are housed below ground which is anticipated to reduce external noise levels. It is considered unlikely that a noise nuisance will be realised at the nearby residential receptors.

The pump stations are located directly adjacent to the two of the wetland protection areas in the Project area. The noise generated from the pump stations during maintenance activities may cause a temporary disturbance to fauna visiting the area. Impacts and mitigation associated with fauna values is discussed further in Section 13.0.

24.0 Bushfire Risks

The Rockhampton region has a diverse landscape with large areas of bushland surrounding settlements areas and within rural areas, presenting a potential risk of bushfire occurrence. Bushfire season in Rockhampton Regional Council Local Government Area is generally between July and November (RRC, 2019).

The State Planning Policy (SPP) 2017 expresses the state interests in land-use planning and development, including natural hazards, risk and resilience. The SPP identifies Bushfire Prone Areas. A Bushfire Prone Area is defined by the SPP as land that is potentially affected by significant bushfires, including vegetation likely to support a significant bushfire; adjacent land they could be subject to impacts from a significant bushfire; and land that is identified by the SPP and / or a Local Planning Instrument as a Bushfire Prone Area.

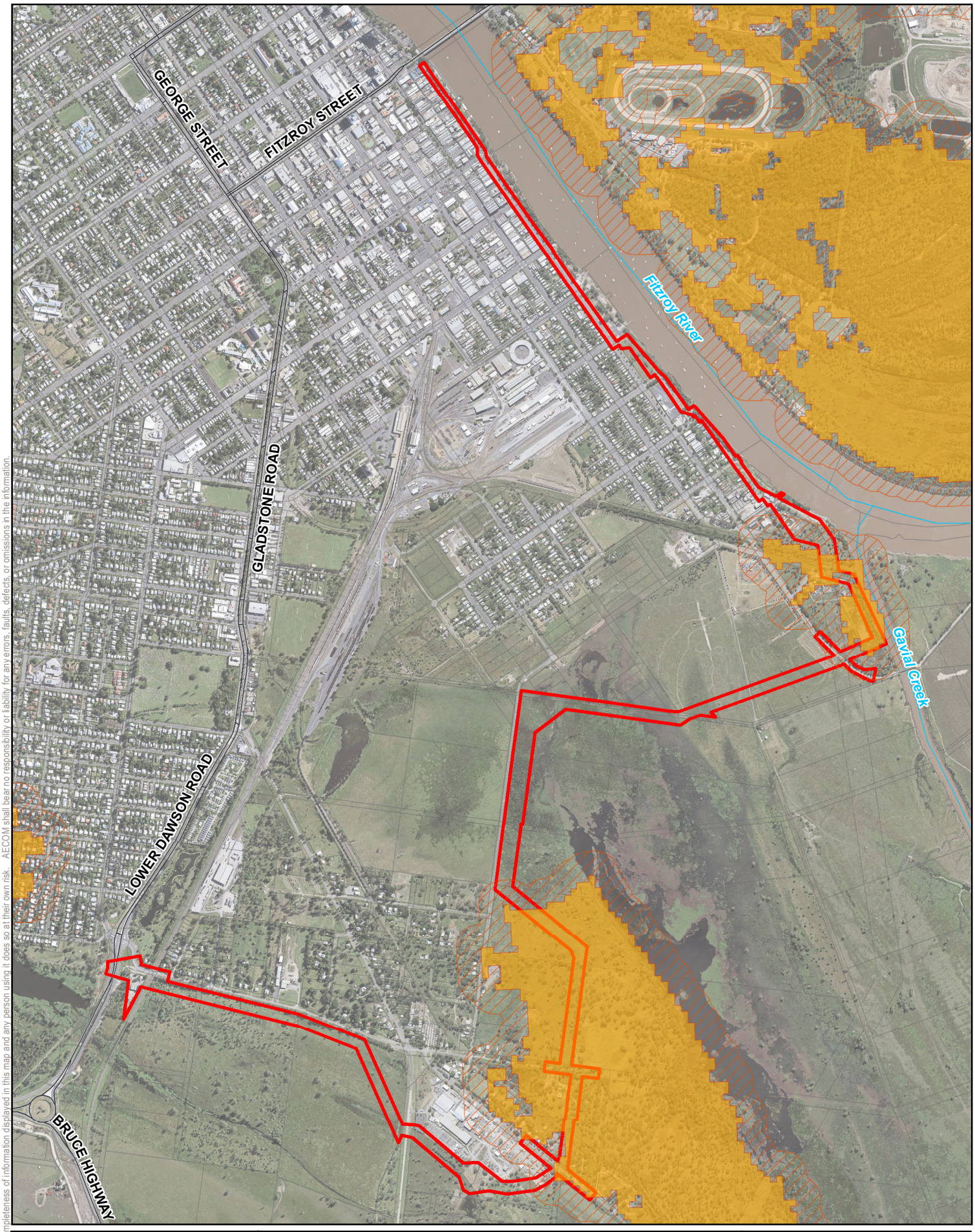
The overall intent of the natural hazards, risk and resilience State interest in the SPP is as follows.

> *The risks associated with natural hazards, including the projected impacts of climate change, are avoided or mitigated to protect people and property and enhance the community's resilience to natural hazards.*

The State interest includes a number of assessment benchmarks in relation to Bushfire Prone Areas, which are summarised below.

- Development avoids bushfire prone areas, and where avoidance is not possible, development mitigates the risk to people and property to an acceptable or tolerable level.
- Development supports and does not hinder disaster management response or recovery capacity and capabilities.
- Development avoids increasing the severity of bushfires and the potential resulting impacts.
- Risks to public safety as a result of storage and use of hazardous materials are avoided.

Two sections of the Project area are located within areas mapped as 'Medium Potential Bushfire Intensity' Bushfire Prone Area under the SPP mapping (Figure 24-1). The sections identified as bushfire prone include the rural land adjacent to Dunlop Street and the South Rockhampton Sewage Treatment Plant. The Planning Scheme reflects the Bushfire Prone Areas identified with the SPP.



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DATUM GDA 1994, PROJECTION MGA ZONE 56

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metres

1:20,000 (when printed at A4)

LEGEND

- Road
- Watercourse
- Cadastral Boundary
- Project Area

Bushfire Prone Areas

- Medium Potential Bushfire Intensity
- Potential Impact Buffer

Data sources:

Base Data: DCDB, Baseline Roads and Tracks, Watercourse, QLD Gov, 2018.
Aecom 2018, Alignment.

SOUTH ROCKHAMPTON FLOOD LEVEE PROJECT

Bushfire Prone Area

PROJECT ID	60589157
CREATED BY	bathurstj
LAST MODIFIED	11-Apr-2019
VERSION	<version number>

Figure 24-1

Filename: G:\TSV_GIS\Projects\60589157\02_MXDs_60589157_FX_SRFL_BushfireProneAreas_A4.mxd

A4 size

24.1 Potential Impacts, Mitigation and Management Measures

Bushfires are potentially harmful to people and property. Potential impacts are addressed below as either a fire hazard from the Project or fire hazard to the Project.

24.1.1 Design

Avoidance of Bushfire Prone Areas is not feasible due to the nature of the Project. Where the alignment traverses the area adjacent Dunlop Street, vegetation will be cleared to facilitate the Project, reducing the hazardous vegetation load in the area.

24.1.2 Construction

Construction equipment and vehicles have the potential to create a fire risk through the generation of sparks or heat, machinery faults which may ignite dry combustible materials. Potential spills of fuel, oil and flammable liquid may also increase the risk of bushfire, particularly in proximity to dry combustible materials. Other potential sources of ignition may arise from accidental fires from human related activities.

As a part of the overall construction management, a Bushfire Management Plan will be developed and implemented by the Construction Contractor. The Bushfire Management Plan will align with the existing Council policies and plans of bushfire management, as well as considering site specific risks and activities which may increase the risk of a bushfire event. Key management measures during construction will include the following.

- Storage of hazardous materials (i.e. fuel) away from bushfire prone areas and hazardous vegetation and in line with AS1940– 2004 'The Storage and Handling of Flammable and Combustible Liquids.'
- Fire hazard warnings associated with weather patterns and fire risk are issued by the Bureau of Meteorology and the Queensland Rural Fire Service. Regulator checking of fire hazard warnings will be undertaken and construction crews made aware of the fire warnings (e.g. through pre-starts).
- All machinery must have a tested and tagged fire extinguisher available.
- Burning of vegetation is prohibited, unless a permit is obtained by a local fire authority and Council.
- Designated smoking areas are to be identified with cigarette butt bins for safe disposal.

24.1.3 Operation

Operational fire risk is generally related to external influences, such as climate, surrounding land use, and the proximity and density of surrounding vegetation. Operational fire risk from the Project is considered be low, and unlikely to occur.

Fires burning adjacent to the Project have the potential to damage infrastructure. Fire events which may occur in the vicinity of the Project would most likely be a result of environmental conditions, such as climatic conditions or land use activities. Council will maintain access tracks and these are expected to operate a fire break to surrounding developed areas in the event of a fire.

Fuel storage will be required for the pump stations. The pump stations are located in three areas along the Project as described in Section 4.0. The pump station located near the Main Drain and the South Rockhampton Sewage Treatment Plant is located within a Bushfire Prone Area, and the associated buffer. The remaining two pumps stations are located outside the Bushfire Prone Area and buffer.

The pump station located within the Bushfire Prone Area will include suitable buffers from vegetation to reduce potential bushfire risks. In addition, the three pump stations are located in areas away from general public access and / or areas that are industrial in nature.

The Project is not anticipated to hinder disaster management response or recovery capabilities in relation to bushfire management, as existing formal access points will remain unchanged and unhindered. During the operational life of the levee it is anticipated the infrastructure will be incorporated into the Council wide emergency management plans for bushfire events.

25.0 Coastal Management

Coastal management and protection is a key component of the SPP and is reflected in the Planning Scheme. The Planning Scheme identifies that development should be planned, designed, constructed and operated to avoid the social, financial, environment costs arising from the impacts of coastal hazards. Coastal erosion and storm tide inundation are two key factors identified by both the State and local government in managing the risks associated with coastal hazards.

No formal assessment or modelling has been undertaken in relation to erosion prone areas and storm surge associated with the Project. Impacts associated with coastal management are anticipated be minimal. Throughout the life of the Project, if impacts of coastal erosion occur, maintenance activities and protective measures will be undertaken to rectify and alleviate any impacts. Coastal hazards will continue to be managed by Council through the existing Disaster Management Plans.

25.1 Coastal Erosion

Coastal erosion means the loss of land or the removal of beach or dune sediments by wave action, wind action, tidal currents or water flows or permanent inundation due to sea-level rise. The Planning Scheme defines areas at risk of erosion ('erosion prone areas') due to storm impact and long term trends of sediment loss and channel migration.

Erosion prone areas identified from the Planning Scheme, within and surrounding the Project, are shown in Figure 25-1. Erosion prone areas are mapped as confined to the tidally influenced areas of the Fitzroy River, adjacent to the levee.

Coastal erosion may occur as a result of natural coastal processes and sediment transport in the Fitzroy River. Where sections of the Fitzroy River bed and banks have been identified as at high risk of erosion and / or failure from velocities associated with a flooding event, rock protection has been included through a separate initiative by Council (i.e. not part of the designation process).

25.2 Storm Tide Inundation

Storm tide inundation means temporary inundation of land by abnormally high ocean levels caused by cyclones and severe storms. The Planning Scheme defines storm tide inundation areas as either a high hazard area where water depth is one metre or greater, or a medium hazard area where water is less than 1m depth. Storm tide inundation areas within and surrounding the Project area are shown on .

The Project has been designed with a freeboard allowance which caters to events larger than those mapped as the highest storm surge event in the Planning Scheme coastal hazard overlay mapping. Freeboard allowances have also taken into account the potential for wave run up from Port Alma through to Rockhampton.

25.3 Coastal Resources

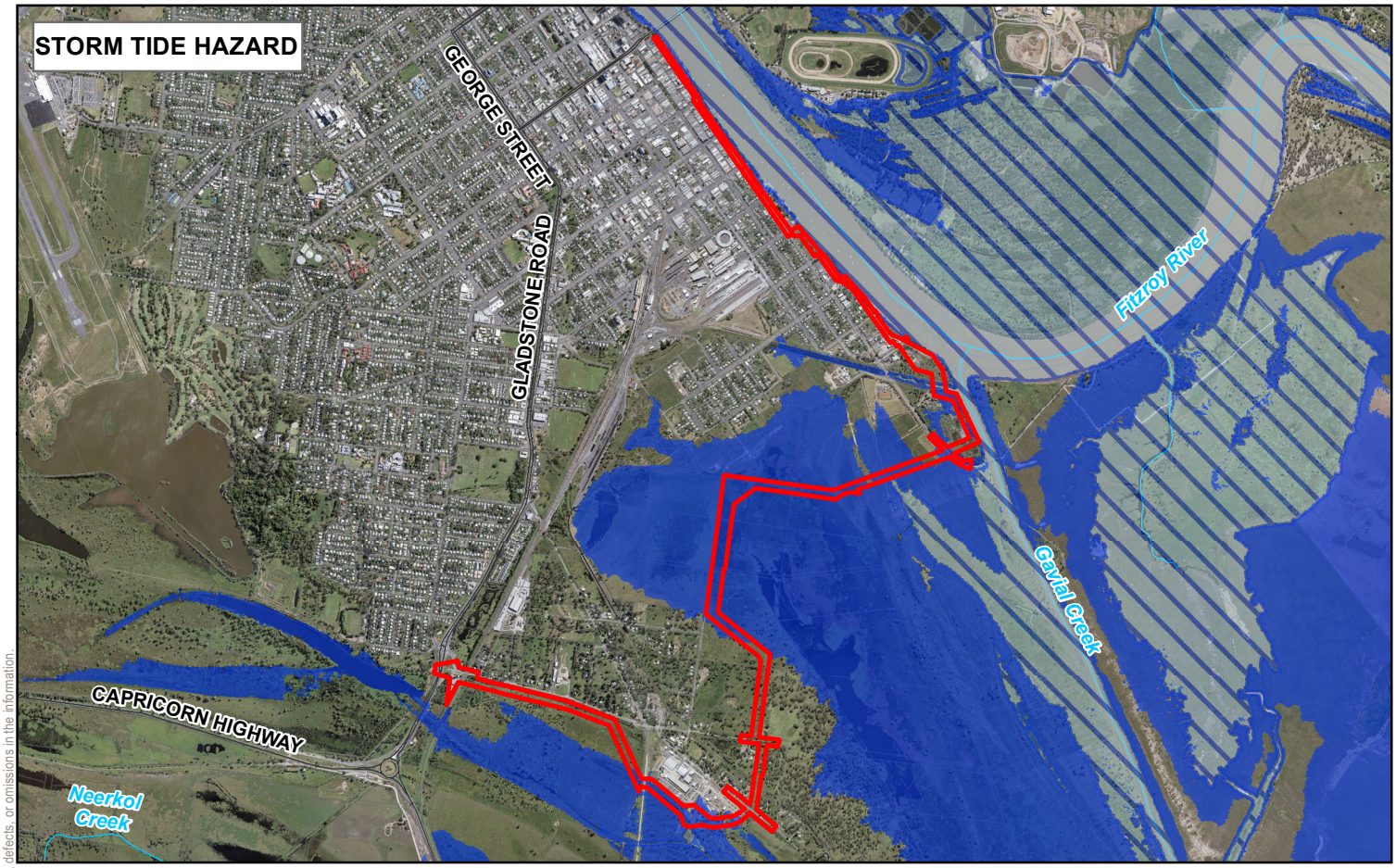
Coastal resources are defined under *Coastal Protection and Management Act 1995* as the natural and cultural resources of the coastal zone. The Matters of State Environmental Significance (as defined under the Environmental Offset Regulation 2014) associated with the natural and cultural resources of the coastal zone within the area of South Rockhampton are likely to include wetlands and watercourses; protected wildlife habitat; waterways for providing fish passage; and marine plants. Matters of State Environmental Significance are discussed in Section 15.0.

Impacts to coastal resources, including Matters of State Environmental Significance, may include the following.

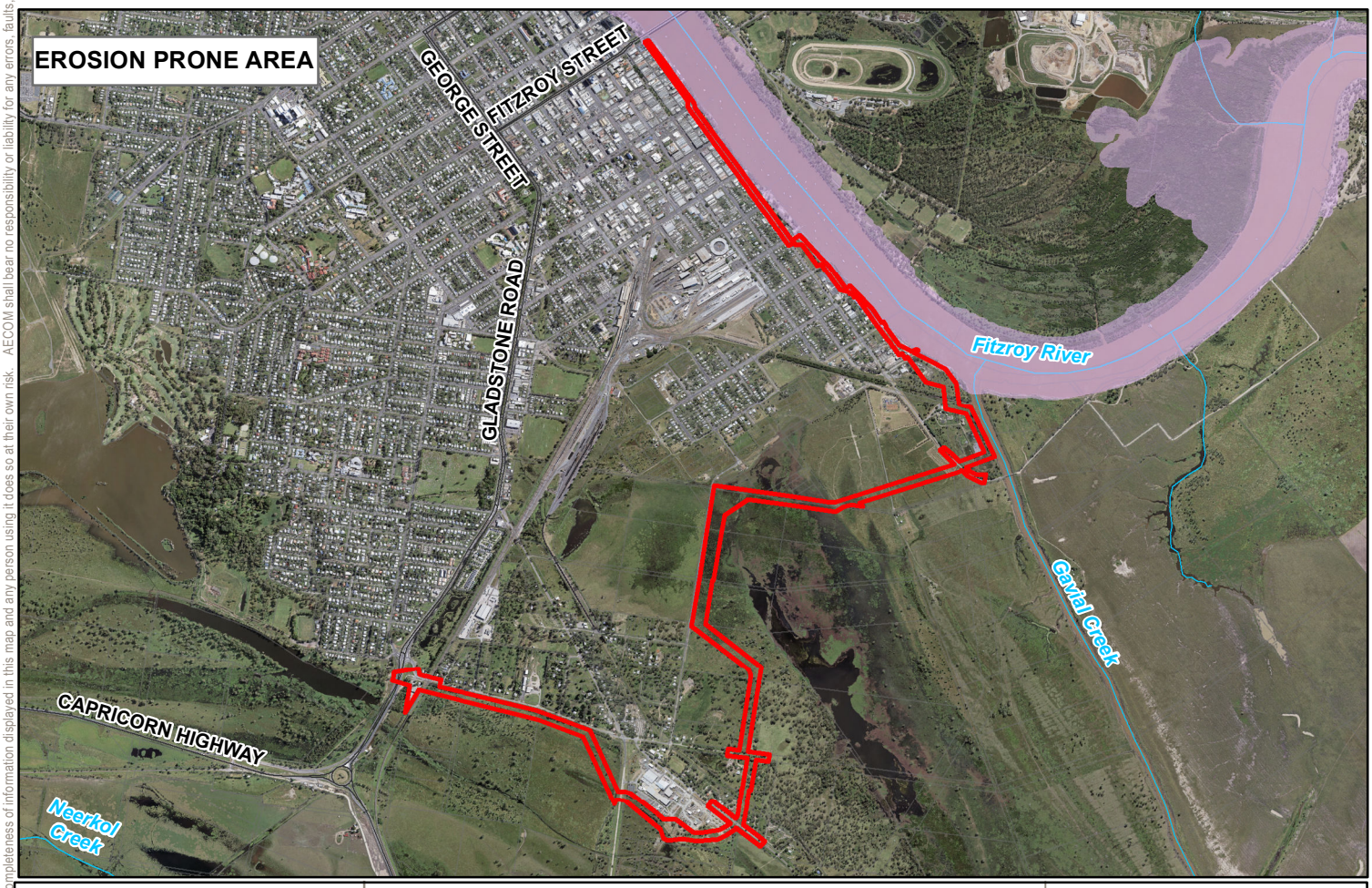
- Loss of marine plants in areas adjoining the Fitzroy River where clearing is required for the Project (further information on the presence of marine plants is provided in Section 13.0).
- Temporary disruption to the presence of protected terrestrial and migratory species associated with the construction phase of the Project (further information of species is provided in Section 13.0).

- Direct and indirect impacts to wetlands as a result of the levee infrastructure (further information on potential impacts to wetlands are provided in Section 12.0).
- The Project will directly interact with the high bank of the Fitzroy River and Gavial Creek in some locations, it is not anticipated to result in a reduction in capacity of the systems or impacts to flow or fish passage (further information of waterways are provided in Section 11.0).

STORM TIDE HAZARD



EROSION PRONE AREA



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DATUM GDA 1994, PROJECTION MGA ZONE 56

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LEGEND

- Road
- Cadastral Boundary
- Project Area
- Storm Tide Medium Hazard
- Storm Tide High Hazard
- Erosion Prone Areas

Data sources:

Base Data: DCDB, Baseline Roads and Tracks, Watercourse, QLD Gov, 2018. Aecom 2018, Alignment.

SOUTH ROCKHAMPTON FLOOD LEVEE PROJECT

Coastal Protection Overlay

(Erosion Prone Areas and Storm Tide Areas)

PROJECT ID	60589157
CREATED BY	bathurstj
LAST MODIFIED	12-Apr-2019
VERSION	<version number>

Figure 25-1

Filename: G:\TSV_GIS\Projects\60589157\02_MXDs_60589157_FX_SRFL_CoastalMap_A4.mxd

A4 size

26.0 Environmental Management

26.1 Council's Commitment to Environmental Management

Council is committed to active development and support of sustainability initiatives and practices that both benefits the Region and contributes to a wider global response to protecting the environment. Council incorporates ecologically sustainable development into its business and decision making processes to ensure the Region's environment is protected and enhanced over time.

This is achieved through managing the use, development and protection of natural and physical resources in a way, or at a rate, which enables people and communities to provide for their social, economic and cultural well-being and for their health and safety by adhering to guiding principles which can be found on their website.

26.2 Environmental Management Plans

An Environmental Management Plan (Planning) has been prepared to highlight key environmental elements relevant to the Project, and is provided in Appendix T. The Environmental Management Plan (Planning) provides guidance to Construction Contractors for the development of a Construction Environmental Management Plan for the construction phase of the Project, and includes the mitigation and management measures proposed for the Project.

27.0 Commitments

The following section provides a list of commitments from the EAR process.

- Construction phase mitigation and management measures proposed throughout the EAR have been captured within the Environmental Management Plan (Planning). The Environmental Management Plan (Planning) will be used by the Construction Contractor to guide requirements for the Construction Environmental Management Plan for the construction of the Project.
- Once a material source is identified a Traffic Impact Assessment will be undertaken by the construction contractor to determine the potential impacts of the Project on the road network.
- A detailed Traffic Management Plan for the Project to be developed and implemented by the Construction Contractor prior to construction works commencing. The Traffic Management Plan will manage construction phase traffic on Local and State roads, as well as internal access tracks.
- Council will continue to work with the Department of Natural Resources, Mines and Energy and relevant land owners to obtain appropriate tenure and access for the construction and operation of the Project.
- Council will ensure Aboriginal Cultural Heritage duty of care is undertaken prior to and during construction of the Project.
- Council will continue to investigate opportunities for landscape proposals that would enhance the character of Project to minimise adverse impacts and enhance recreation and amenity outcomes.
- Council will update the Emergency Management Plan upon completion of detailed design to include the emergency management requirements as nominated by the Minister.
- Consultation will be undertaken with the relevant emergency management authorities, including the Local Disaster Management Group, and updates will be made to the Local Disaster Management Plan.
- The Project is currently going through a peer review process. Updates, where required as a result of this process will be incorporated during detailed design.

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