Rockhampton Ring Road

Water Quality Modelling Report

1167108-DJV-0SW00-RPT-000002 | 04

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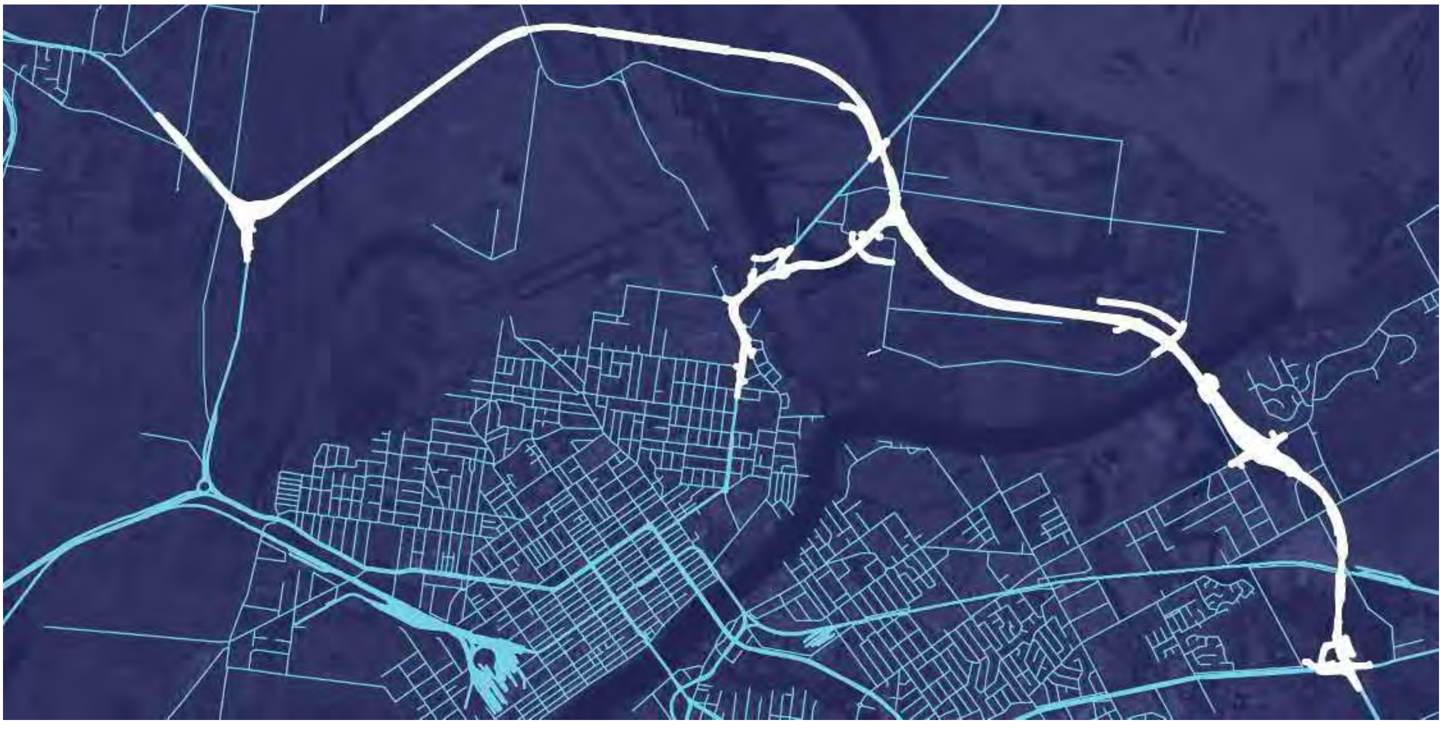
Department of Transport and Main Roads



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Document history and status

Revision	Date	Description	Author	Reviewed	Approved
01	21/05/2021	Preliminary Design	BM	JD	EVD
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03	15/07/2021	Updated PD Internal Review	BM	JD	EVD
04	22/07/2021	Updated PD	BM	JD	EVD

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Glossary

Reference	Definition
The Client or the Principal	Department of Transport and Main Roads
Project or RRR	Rockhampton Ring Road
AEP	Annual Exceedance Probability
AHD	Australian Height Datum
ANZG	Australian and New Zealand Guidelines for Fresh and Marine Water Quality
ARR	Australian Rainfall and Runoff
BIM	Building Infrastructure Management
BoDR	Basis of Design Report
BoM	Bureau of Meteorology
CAD	Computer Aided Design
CC	Climate Change
Ch	Chainage
Datum	GDA94/MGA 56, all coordinates herein refer this datum
DAF	Department of Agriculture and Fisheries
DBC	Detailed Business Case
DD	Detailed Design
Design Criteria	Design criteria, standards and guidelines used to develop the design and agreed with DTMR
Design Package	Collation of Design Documents for submission for an element or aspect of the Works at a particular design Stage.
Design Package Number	Number assigned to the Item Codes, to assist with the delivery of items in the Functional Specification. Relates to document numbering and delivery workflows.
DJV / JSDJV	Jacobs SMEC Design Join Venture
DTMR	Department of Transport and Main Roads
ESCP	Erosion and Sediment Control Plan
EHP	Department of Environment and Heritage Protection
EPP	Environmental Protection Policy
EVs	Environmental Values
EY	Exceedances per Year
GIS	Geographic Information System
GP	Gross Pollutant
HES	High Ecological Significance
IDR	Inter-Disciplinary Review
IR	Internal Reviewer (from with JSDJV Parent Companies)
IS	Infrastructure Sustainability
ISCA	Infrastructure Sustainability Council of Australia

Reference	Definition
ISMP	Infrastructure Sustainability Management Plan
ITR	Independent Technical Review
LHS	Left Hand Side
LRUD	Landscape, Revegetation and Urban Design
MHWS	Mean High Water Spring tide
MUSIC	Water Quality Modelling Software
PD	Preliminary Design
Project Works	New works, upgrade works, property works, local road works, utility works and temporary works.
PUP	Public Utility Plant
QUDM	Queensland Urban Drainage Manual
QWQG	Queensland Water Quality Guidelines
RCBC	Reinforced Concrete Box Culvert
RCP	Reinforced Concrete Pipe
RCR	Rockhampton Connector Road
RFI	Request for Information
RHS	Right Hand Side
RPEQ	Registered Professional Engineer, Queensland
RRC	Rockhampton Regional Council
RL	Reduced Level
SID	Safety in Design
State	State of Queensland
SPP	State Planning Policy
TMR	Department of Transport & Main Roads
TN	Total Nitrogen
TP	Total Phosphorous
TSS	Total Suspended Solids
WOL	Whole of Life
WPA	Wetland Protection Area
WSUD	Water Sensitive Urban Design
WQIP	Water Quality Improvement Plan
WQO	Water Quality Objectives
WUC	Works Under Contract

1. Introduction

1.1 Project Description

The RRR is the key piece of road infrastructure recommended in the Fitzroy River Floodplain and Road Planning Study, which investigated long-term solutions for flooding impacts on freight, road and rail transport in and around the city of Rockhampton.

The RRR Project will provide a western road link of the Bruce Highway to the west of Rockhampton, with key linkages into the city at the Capricorn Highway, West Rockhampton, Alexandra Street and Yaamba Road (Rockhampton – Yeppoon Road).

The RRR alignment will integrate with major infrastructure already completed, including Yeppen North and Yeppen South, as well as current works in development including the Rockhampton Northern Access Upgrade and Capricorn Highway Duplication (Rockhampton – Gracemere).

The RRR project commences on the Capricorn Highway approximately 2 km west of the intersection of the Bruce and Capricorn Highways at the Yeppen Roundabout and its alignment traverses north through the Western Yeppen Floodplain, sweeping around the Rockhampton Airport at Pink Lily and connecting to West Rockhampton near 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.

The total combined length of the Project is 17 km (including the West Rockhampton Connector Road). The length of the Project from the Capricorn Highway intersection to the Yeppoon Road intersection is 14.7 km (excluding the West Rockhampton Connector Road). Refer to Figure 1 for the project layout.

Figure 1: Project Layout

The project is a joint initiative of the Australian and State governments and intends to:

- Improve road safety and provide strength to the region's economy by improving freight efficiency and flood resilience
- Strengthen connectivity between key employment, leisure, tourism and residential growth areas of Rockhampton and the wider region
- Provide job opportunities for residents of Central Queensland and surrounding regions, along with providing opportunities for local businesses to help deliver the Project.

1.2 Purpose of this Document

This document presents the results of water quality modelling undertaken for HES (High Ecological Significance) water bodies located along the RRR alignment and the RCR alignment. The purpose of this document is to:

- Present the water quality design criteria and objectives
- Describe the proposed water quality controls for the project
- Outline the water modelling parameters used on this project
- Present results of water quality modelling for the project
- Summarise the outcomes for water quality regarding compliance with the Water Quality Objectives (WQO).

1.3 Design Criteria

1.3.1 State Planning Policy 2017

The stormwater quality assessment for the project works has been based on the requirements listed in the State Planning Policy 2017 (SPP 2017). The SPP identifies water quality as a State interest (*State Planning Policy State Interest: Water Quality 2017)* and supports the protection of the EVs of Queensland's waters as defined in the Environmental Protection (Water and Wetland Biodiversity) Policy 2019.

Post-construction phase stormwater management design objectives for Central Queensland (South) are provided in Table 1-1.

Table 1-1: State Planning Policy post-construction stormwater management design objectives

Climatic Region	Design Objectives				
	Reductions in mean annual load from unmitigated development (%)				
	Total Suspended Solids	Total Phosphorus	Total Nitrogen	Gross Pollutants >5 mm	Waterway Stability Management
Central Queensland (south)	85	60	45	90	Limit the peak 1-year ARI event discharge within the receiving waterway to the pre-development peak 1-year ARI discharge

1.4 Water Quality Objectives

The adoption of and compliance with concentration based WQO, such as those defined in the Environmental Protection (Water and Wetland Biodiversity) Policy 2019, is difficult when modelling stormwater runoff from a site. Applying these as baseline WQO for stormwater runoff is conservative and may result in oversized water quality infrastructure, which could lead to a larger impact footprint. The SPP defines pollutant reduction targets for stormwater management, while the Reef 2050 WQIP identifies end of catchment load reduction targets The ANZG and QWQG also note that load-based guidelines are more appropriate for stormwater discharges following rainfall/high flow events due to high variability in water quality. As such, the design team has adopted load-based pollutant reduction targets as defined in the SPP, instead of concentration based WQO as listed in Schedule 1 of the Environmental Protection (Water and Wetland Biodiversity) Policy 2019. The adopted approach is consistent with the Australian and New Zealand Guidelines for Fresh and Marine Water Quality and Queensland Water Quality Guidelines which both note that that load-based guidelines are more appropriate for stormwater discharges following rainfall/high flow events due to high variability in water quality.

The load-based pollutant reduction targets (WQO) adopted on this project are provided in Table 1-2. These treatment objectives for stormwater are expressed in mean annual reductions of pollutant loads from typical urban areas with no urban stormwater treatments installed.

Table 1-2: Water Quality Objectives (WQO)

Pollutant	Load-based Pollutant Reduction Targets (WQO)
Total Suspend Solids (TSS)	85%
Total Phosphorus (TP)	60%
Total Nitrogen (TN)	45%
Gross Pollutant (GP)	90%

It is expected that some results will marginally achieve the above water quality objectives without fully achieving the pollutant reduction targets. We would consider "marginally achieved" to be within 10% for TSS, 10% for TP, 15% for TN and 10% for GP. Results within this margin would demonstrate that the infrastructure in place is providing the desired benefit to the downstream receiving environment and within the margin of accuracy for the MUSIC model results.

1.5 Site and drainage characteristics

The proposed road alignment lies in the floodplain area of Fitzroy River and its tributaries. The terrain around the alignment is low-lying and flat. The natural surface below the RRR main alignment varies from RL 6.3 m AHD to RL 27 m AHD and is affected by local and regional flooding. Floodwaters from a regional event break out onto the floodplain during the 10% AEP flood event.

The proposed road alignment intersects the following wetlands:

1) Pink Lily Lagoon
2) Lotus Lagoons
3) Dunganweate Lagoon
4) Nelson Lagoon
5) Black Duck Lagoon
6) Unnamed Lagoons referred to as Capricorn Highway Wetland.

Refer to Appendix E for the water quality strategy maps which show the location of the wetlands.

All wetlands intersected by the proposed road alignments are mapped as High Ecological Significance (HES) wetlands under the *Environment Protection Act 1994*. The Environmental Protection (Water and Wetland Biodiversity) Policy 2019 identifies the management intent of HES wetlands is to achieve an effectively unmodified waterway condition. Waterways in the Project Area are identified as a moderately disturbed water type where the management intent is to improve and maintain water quality (i.e. achieve WQO detailed in Section 1.4).

The natural wetlands provide habitat for migratory bird species. The Environment Protection and Biodiversity Conservation Act 1999 considers that an action is likely to have a significant impact if there is a real chance or possibility that it will substantially modify, destroy or isolate an area of important habitat for a migratory species. The presence of the RRR has potential to modify the water quality of the wetland habitat. It is important that these changes to the water quality do not negatively impact the wetland and undermine ecosystem health.

The proposed road alignment intersects the following waterways:

1) Fitzroy River
2) Limestone Creek
3) Lion Creek
4) Two unnamed tributaries of the Fitzroy River

Within the Project Area the Fitzroy River is a large permanently inundated ninth order river with a wetted width of approximately 250 m. At this location, above the barrage, there is no tidal influence. The bedform features at this section of the river include backwaters and a very large, structurally diverse pool, which runs after flow. The riparian zone on both northern and southern banks are well developed with large native trees present that provide shading to the edges of the channel where undercut banks, root tangles, woody debris and macrophytes are present. On the southern bank the macrophyte community was dominated by the exotic species.

Limestone Creek is an ephemeral, third order waterway which is characterised by a series of large shallow pools separated in the dry season by dry cobbled reaches of varying width. Downstream of the Bruce Highway crossing, the bankfull width was up to 50 m and bank height between 2 m and 5 m.

Where the RRR alignment crosses Lion Creek at Ridgelands Road permanent water is present providing fish passage. The water column was highly turbid, and some areas were clogged with exotic macrophytes. Microhabitat features such as submerged logs, instream cover, trailing bank vegetation and macrophytes provide suitable habitat for several native and exotic fish species.

Where the RRR alignment crosses Lion Creek at Nine Mile Road the waterway is a highly ephemeral system in a landscape which has been severely degraded by historical clearing, thinning, and grazing. The riparian habitat consisted of open woodland dominated by Eucalyptus Coolabah with no defined shrub layer and a grassy understorey.

2. Stormwater Quality Management

Managing stormwater to protect aquatic ecosystem is a key objective of WSUD (Water Sensitive Urban Design). To ensure the protection of the receiving aquatic ecosystems, stormwater quality objectives (Table 1-2) have been adopted for the operational phase. The operational phase refers to the time period following completion of project works including landscaping.

The water quality management for the RRR project considers a risk-based approach which will ultimately determine the proposed water quality controls for each discharge location. Certain locations along the road corridor with sensitive receiving environments will require more stringent assessment for WQO's, and all reasonable effort should be made during the design process to ensure that WQO's and other environmental objectives are achieved. Locations that discharge to lower risk areas such as existing developments but are highly constrained could potentially aim for lower WQO if all reasonable design efforts demonstrate that effective control measures cannot be installed. Constrained areas may require relaxations to WQO, provided that the downstream impacts to the receiving environment have been assessed. Similarly, the provision of in-line tertiary treatment devices should consider maintenance provisions and whole-of-life costs.

Technical Note on Water Quality Strategy for Rockhampton Ring Road (1167108-DJV-0EN00-TNE-000001) provide further details on risk-based approach for water quality treatment. Refer to Appendix E for the Water Quality Strategy Maps which have been originally developed as part of the Technical Note on Water Quality Strategy. The maps have been updated to reflect the most up-to-date design issue and have been provided in this report for reference.

2.1 Water Quality Controls

Water quality basins with combined inlet sediment basin and bioretention basin, along with vegetated swales have been adopted as the primary treatment train measure where space is available. Due to the limited space within the road corridor as a result of flood inundation extents it was not possible to provide water quality treatment at the downstream end of all longitudinal drainage outlets discharging into a low risk water receptor.

Maintenance requirements for water quality controls are shown in Section 6. The proposed locations and details of the water quality control devices listed below are shown on the design drawings which are provided in Appendix C for reference.

2.1.1 Inlet Sediment Basin

Inlet sediment basins can form an integral component of a stormwater treatment train for bio-retention basins and are specially employed to remove coarse to medium sized sediments by settling them from the water. An inlet pond to bioretention basin system is designed to remove coarse sediment, allow for high flow to bypass the bioretention filter media, provides appropriate storage for coarse sediment, regulate flows entering filter media and also capture any spill on road. Inlet sediment basins are stormwater detention systems that promote settling of sediments through the reduction of flow velocities and temporary detention. Key elements include inlet and outlet structures, settling pond, and high flow structure. As a pre-treatment facility, the sediment basins are sized according to the design discharge and the target particle size (generally 0.125 mm).

Combined inlet sediment and bioretention basins feature a sediment basin forebay at the basin inlet to target gross pollutants and TSS. The inlet sediment basin will contain additional volume for spill containment. Low flows from the inlet sediment basin discharge through to the bioretention basin.

2.1.2 Bioretention basins

Bioretention systems operate by filtering stormwater runoff through densely planted surface vegetation and further infiltration through a filter media. During infiltration, pollutants are retained through fine filtration, adsorption and some biological uptake.

Bioretention basins are effective at removing litter, fine sediment, phosphorus, nitrogen, metal and hydrocarbons from stormwater. Bioretention basins also help in managing urban hydrology, particularly frequent stormwater flow.

Bioretention basins have the advantage of additional storage capacity and therefore are less likely to be exposed to high velocities that can occur in a bioretention swale. Lining the filter area encourages additional storage in the filtration zone and further aids the filtration process.

Bioretention basins are provided at the bridge drainage outlet locations. Bioretention basin systems are small (typically <3% of the catchment area) allowing them to be used in small and constrained spaces such as road corridor. Bioretention basin requires sufficient elevation above the outlet or receiving drainage system for the functioning of the bioretention system. The spillway of the basins will have a 20% AEP flood immunity from the surrounding floodplain. Bioretention basins have been sized to capture target pollutants in accordance with the WQO for the project where feasible.

Bioretention systems require ongoing maintenance at regular intervals and also major rehabilitation as the system reaches its design life. If maintenance is not undertaken, the performance of the system will not reach design requirements. Most maintenance requirements will be on an as needs basis. Anticipated maintenance work will are described in Section 6.

- Clearing of infiltration area and outlets as needed - whenever debris and litter have accumulated on screens to an unacceptable level or excessive coarse sediments have accumulated in the filter area;
- Removal of debris and plant litter - required based on accumulation to unacceptable levels;
- Desilting of infiltration areas and replacement of filter media - this will be driven by monitoring of silt depth and infiltration rate. It is expected that desilting will be achieved through removal by bobcat or small excavator/backhoe and may be necessary every 5-10 years;
- Treatment/removal of diseased trees and shrubs – to be performed as required;
- Inspection after rainfall events to repair eroded areas – as required after storm events; and
- Mowing of turfed areas and pruning of trees and shrubs to maintain the appearance of the treatment system.

2.1.3 Grassed-lined Swales

Grass-lined or vegetated swales are provided where possible to convey stormwater and to provide removal of coarse and medium sediments. They provide a means of disconnecting impervious areas from downstream waterways and assist in protection of waterways from damage by frequent storm events by reducing flow velocity compared with pipes. The interaction between stormwater flow and vegetation within the swales facilitate pollutant settlement and retention.

Swale treatment relies upon good vegetation establishment and therefore ensuring adequate vegetation growth is the key maintenance objective. In addition, they have a flood conveyance role that needs to be maintained to ensure adequate flood protection for local properties. The most intensive period of maintenance is during the plant establishment period (first two years) when weed removal and replanting may be required. It is also the time when large loads of sediments may impact on plant growth, particularly in developing catchments with an inadequate level of erosion and sediment control.

The potential for riling and erosion along a swale needs to be carefully monitored, particularly during establishment stages of the system. Other components of the system that will require careful consideration are the inlet points (if the system does not have distributed inflows). The inlets can be prone to scour and build-up of litter and occasional litter removal and potential replanting may be required. Swale field inlet pits also require routine inspections to ensure structural integrity and that they are free of blockages.

Grass-lined swales are provided at roundabouts or in the road corridor to convey longitudinal flow along the road where sufficient grade is available. The swales provide both a flow conveyance function and water quality treatment through sedimentation and contact of runoff with swale vegetation. However, as the project includes sections that traverse flat topography there are significant extents that are unsuitable for swale drains as free draining conditions cannot be achieved. If flow velocities are too low (e.g. due to flat gradients), there is potential for water logging and stagnant ponding.

2.1.4 Buffer strips

Buffer strips are vegetated strips adjacent to the road which provide a buffer zone between the road surface and the downstream receiving environment. These are typically used in “over-the-edge” drainage situations where runoff is not captured in a kerb and channel and instead runs directly off the carriageway over the buffer strip. They are intended to provide discontinuity between impervious road surface and the drainage system. Buffer strips take flow from impervious road surfaces in a distributed manner, promote even flows and filter sediments and coarse pollutants entrained in the runoff. The key to their operation is an even shallow flow over a wide vegetated area. They are suitable where even inflow and throughflow distribution can be maintained such as along embankments. Buffer strips are effective in the removal of coarse to medium sized suspended solids.

Buffer strips are provided along embankments and consist of the embankment verge and batter slopes. They are typically used as a pre-treatment device for small catchment (e.g. sheet flow from immediately surrounding road).

Maintenance for buffer strips is similar to open landscaped area, with vegetation growth the main objective due to the vegetation in buffer strips provides most of the pollutant removal.

2.1.5 Bridge scupper and longitudinal drainage

In locations where a bridge passes over a high risk area, runoff will be collected in scuppers and along longitudinal drainage pipes connected to the bridge deck. Where possible, these pipes will outlet directly to a water quality control device for treatment. Where this is not be feasible due to the extents of flood inundation along the road corridor, the pipes will outlet outside of the high risk area. For lengths of bridges that do not cross a high risk area or road, runoff will be captured by scuppers and outlet directly to the ground.

3. Proposed Water Treatment Devices

The RRR water quality treatment devices consider the project in separate zones which require varying approaches due to the sensitivity of the receiving environment and the constraints associated with each zone. The water quality treatment devices adopted for each zone aims to mitigate adverse environmental impacts caused by increased pollutants from the new road surface.

The water quality treatment devices for each zone is outlined in the following sections.

3.1 South Zone

The south zone runs from the Capricorn Highway to the Fitzroy River and is predominantly located in the Fitzroy River floodplain. As a result, the road gazettal boundary is subject to regular flood inundation which provides limited space for offline water quality treatment devices such as bioretention basins. Therefore, the design has adopted a risk-based approach which provides treatment devices (bioretention basins or bioretention swales) where the alignment is near high ecological significant areas.

The south zone includes extensive lengths of bridges. In locations where a bridge passes over a HES (High Ecological Significance) water receptor or high-risk area, runoff will be collected in scuppers and along longitudinal drainage pipes connected to the bridge deck. Where possible, these pipes will outlet directly to water quality basins. Kerb or shoulder dyke is used next to the bridge to convey flow to bioretention basins or swales to maximise the treated area. Where this is not feasible due to the extents of flood inundation along the road corridor, the pipes will outlet directly to ground outside of the high-risk area. For lengths of bridges that don’t cross a high-risk area or road, runoff will be captured by scuppers and outlet directly to the ground.

It is predominantly concentrated stormwater flow from bridge runoff that will be captured and treated through bioretention basins or bioretention swales. The proposed basins will have 20% AEP immunity. Therefore, the bed level of most proposed basins is raised to provide flood immunity. In addition, a bioretention basin requires sufficient elevation above the outlet or receiving drainage system for the functioning of the bioretention system.

South of the Fitzroy River, the project crosses the following HES wetlands and their associated wetland protection areas (WPA):

- Pink Lily Lagoon
- Lotus Lagoon
- Dunganweate Lagoon
- Nelson Lagoon
- An unnamed lagoon referred to as Capricorn Highway wetland

Water quality control devices in the south zone will include the following:

- Bioretention basins or bioretention swales where possible
- Grassed swale where sufficient grade is available
- Buffer strips along embankments

The following section outlines water quality control devices in the south zone at each of receiving waters:

3.1.1 Fitzroy River

The Fitzroy River is a defined watercourse under the Water Act 2000 and, at the proposed crossing location, is classified as a major risk waterway for waterway barrier works under the Fisheries Act 1994. The Fitzroy River floodplain is listed in the Directory of Nationally Important Wetlands.

Bridge B09 is the designation for the proposed bridge crossing of the Fitzroy River. The proposed water quality control for the Fitzroy River Bridge is to capture bridge runoff and pipe it to the adjacent embankment for treatment in two water quality basins. Bridge scuppers capture stormwater flow on the bridge which is conveyed through a longitudinal drainage pipe to a water quality basin. Figure 2 shows the location of the proposed bioretention basins at the Fitzroy River. Table 3-1 provides details of the proposed treatment devices, their ID, location and sizes. Refer to Appendix C for the location and Appendix D for details of the treatment devices.

Table 3-1: Proposed Treatment Devices – Fitzroy River

Treatment Device	Device ID	Location	Size
Bioretention basin with inlet sediment basin	WQ-BB07	North side of Bridge B09 west abutment (See Figure 2)	Inlet sediment basin = 24 m^2 Bioretention basin = 100 m^2
Bioretention basin with inlet sediment basin	WQ-BB08	South side of Bridge B09 east abutment (See Figure 2)	Inlet sediment basin = 28 m^2 Bioretention basin = 100 m^2

The provision of grassed swales is constrained by the flat topography of the floodplain and existence of existing drains running parallel to the road alignment on the eastern side of the bridge.

The road catchments adjacent to Bridge B09 discharging to the Fitzroy River do not include any concentrated flow outlet, as stormwater drains along the road batters as sheet flow. Buffer strips on road batters are provided to treat sheet flow from the road catchment.

Figure 2: Bioretention basins location at the Fitzroy River

3.1.2 Pink Lily Lagoon

Pink Lily Lagoon (and the unnamed lagoon to the east which we consider to be the east portion of Pink Lilly Lagoon) are HES wetlands. Figure 3 shows the extent of Pink Lily Lagoon along the proposed road alignment. Table 3-2 provides details of the proposed treatment devices, their ID, location and sizes. Refer to Appendix C for the location and Appendix D for details of the treatment devices.

A bioretention basin is provided along the edge of the lagoon within the HES mapped wetlands (but within the road corridor). The disturbance area of the basin footprint provides an overall reduction in impacts to the wetlands and associated ecological benefits compared to not providing a basin in this location. Locating a basin outside the lagoon at this location was not feasible due to the flat terrain which limits flow conveyance opportunities to outside the lagoon. This area is subject to regular flood inundation and is low lying and provides limited space for offline water quality treatment devices. The proposed water quality control for the Bridge B08 over Pink Lily Lagoon is to capture bridge runoff to the adjacent embankment for treatment in two water quality basins. The base of the bioretention basins are to be raised 0.8m to 1m higher than the surrounding ground to allow for free drainage through filter media. The road catchments west of the proposed roundabout near the Pink Lily Lagoon will also be diverted to the proposed bioretention basin using the pit and pipe network. The road batters will be provided with buffer strips to treat sheet flow.

Table 3-2: Proposed Treatment Devices – Pink Lily Lagoon

Treatment Device	Device ID	Location	Size
Bioretention basin with inlet sediment basin	WQ-BB05	South side of Bridge B08 west abutment (See Figure 3)	Inlet sediment basin = 35 m^2 Bioretention basin = 225 m^2
Bioretention basin with inlet sediment basin	WQ-BB06	South side of Bridge B08 east abutment (See Figure 3)	Inlet sediment basin = 35 m^2 Bioretention basin = 200 m^2

No bioretention basin is proposed for the east portion of Pink Lilly Lagoon (the unnamed Lagoon shown on Figure 3) as the stormwater flow sheet flows over the embankment and it is not possible to convey discharge longitudinally to basins. Grassed swales are provided for the treatment of stormwater flow where sufficient longitudinal grade is available. In addition, buffer strips are proposed on the road batters.

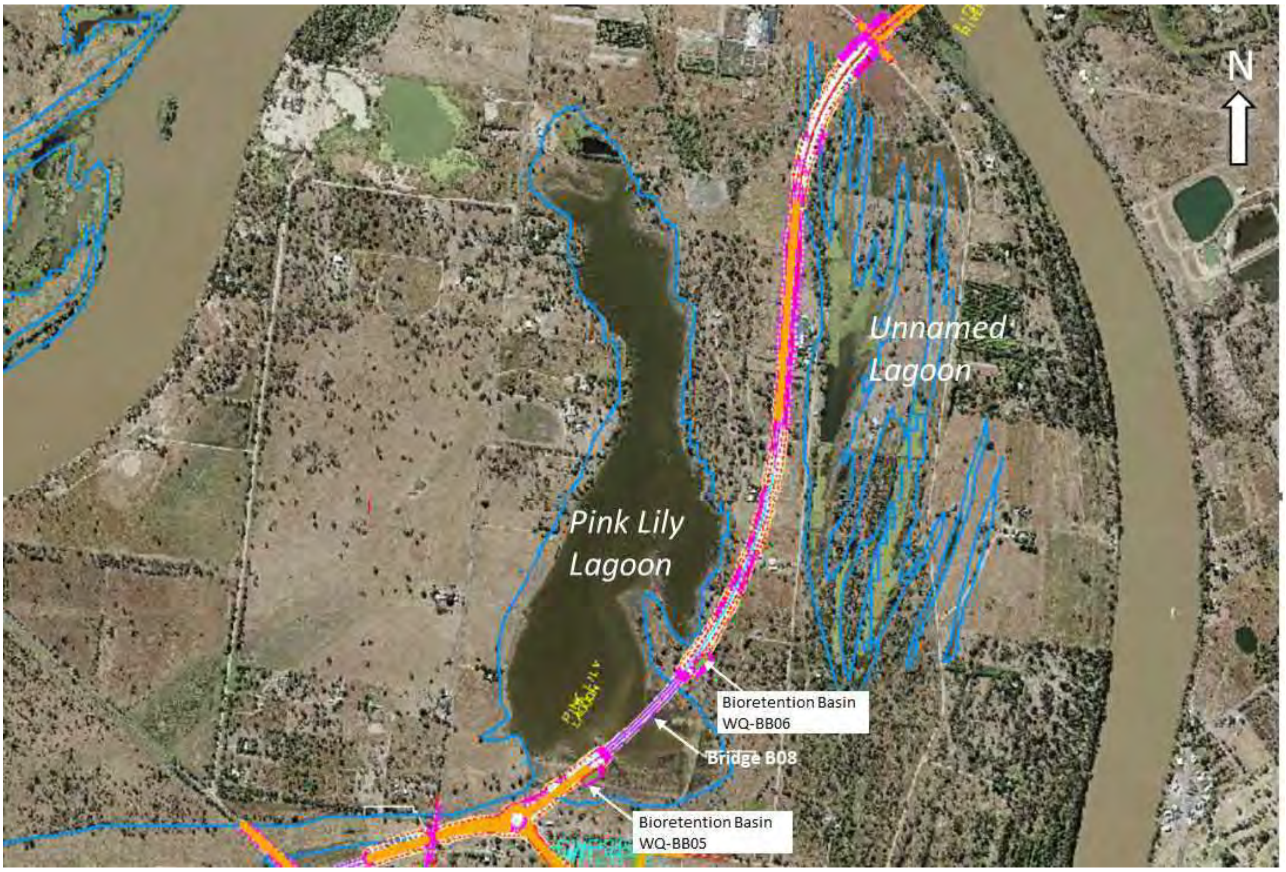

Figure 3: Extent of Pink Lily and Unnamed Lagoon in South Zone

3.1.3 Lotus Lagoon

Lotus Lagoon is a HES wetland and Figure 4 shows the extent of Lotus Lagoon along the proposed road alignment. This area is subject to regular flood inundation and is low lying and provides limited space for offline water quality treatment devices. Table 3-3 provides details of the proposed treatment devices, their ID, location and sizes. Refer to Appendix C for the location and Appendix D for details of the treatment devices.

Table 3-3: Proposed Treatment Devices – Lotus Lagoon

Treatment Device	Device ID	Location	Size
Bioretention basin with inlet sediment basin	WQ-BS03	East side of Bridge B18 south abutment (See Figure 4)	Inlet sediment basin = 20 m^2 Bioretention area = 80 m^2
Bioretention basin with inlet sediment basin	WQ-BS05	East side of Bridge B19 south abutment (See Figure 4)	Inlet sediment basin = 20 m^2 Bioretention area = 80 m^2
Bioretention basin with inlet sediment basin	WQ-BS07	West side of Bridge B20 north abutment (See Figure 4)	Inlet sediment basin = 20 m^2 Bioretention area = 120 m^2
Bioretention basin with inlet sediment basin	WQ-BS08	West side of Bridge B06 south abutment (See Figure 4)	Inlet sediment basin = 20 m^2 Bioretention area = 100 m^2
Bioretention basin with inlet sediment basin	WQ-BB04	West side of Bridge B06 north abutment (See Figure 4)	Inlet sediment basin = 20 m^2 Bioretention basin = 100 m^2

The Lotus Lagoon extent is significantly larger than other lagoons within this project corridor. It includes five bridges over Lotus Lagoon: Bridges B06, B07, B18, B19 and B20. Bioretention basins are proposed at these bridges to treat concentrated flow from the bridge areas. The area surrounding the road in this section is low lying and flat. Therefore, the bioretention basin bases are to be constructed approximately 1m above the natural ground to provide free drainage through filter media of bioretention basins to outlet. The elevated bioretention basins within the lagoon help in maintaining performance of their filter media and prevent any back flow of lagoon water in the bioretention system. The provision of the bioretention basin within the lagoon is considered to be of more ecological benefit than not providing one. Locating a basin outside the lagoon at this location was not feasible due to the flat terrain and excessive earthworks required. Excluding the bridge area, the remaining local road catchments of the Lotus Lagoon road section do not include any concentrated flow via outlets and stormwater will drain as sheet flow along the road batters. Buffer strips are provided to treat sheet flow from the road catchment.

Bioretention basins are provided to capture stormwater flow from the three small bridges (B18, B19 and B20). The bed level of bioretention basins are raised to provide free drainage and 20% AEP flood immunity. These bioretention basins will ensure that concentrated stormwater flow is treated before discharging into Lotus Lagoon. The buffer strips are proposed on the road batters to treat sheet flow from the road.

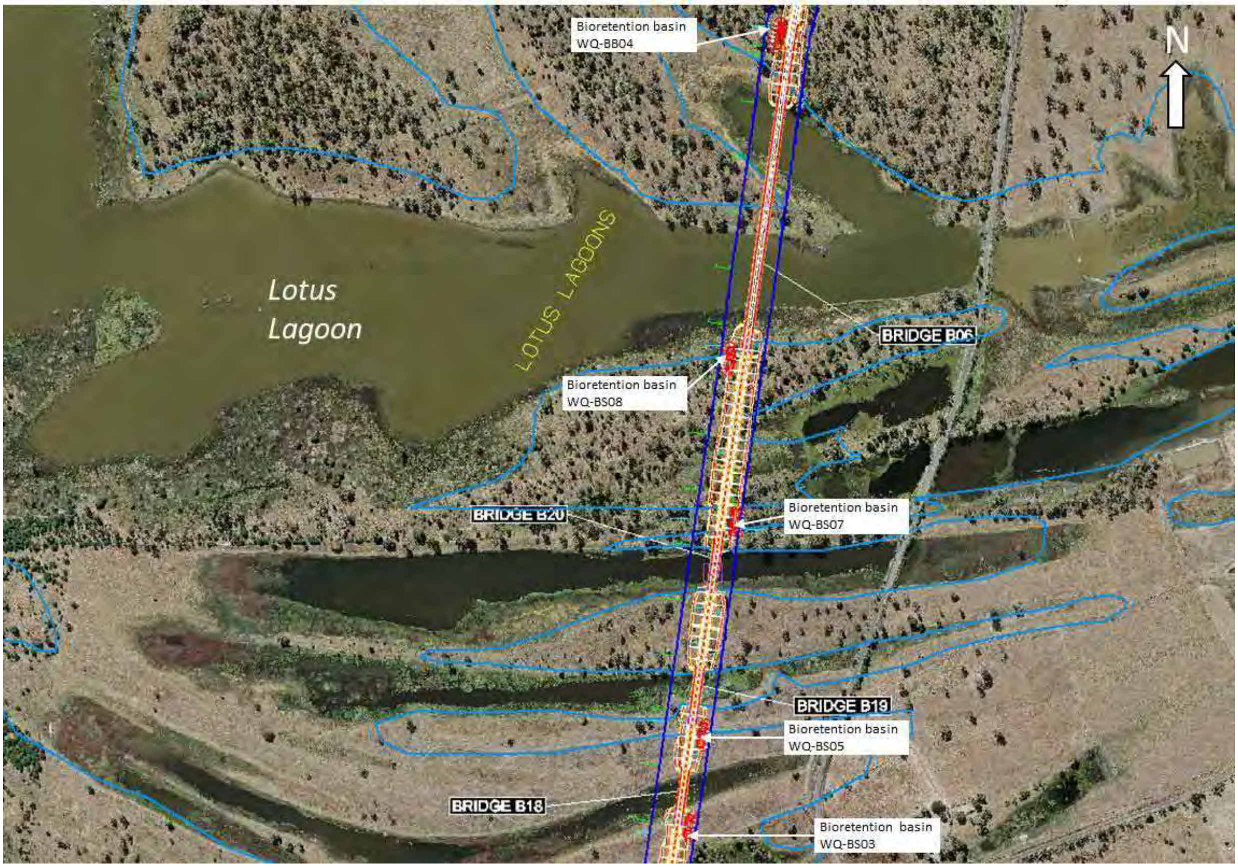

Figure 4: Location of bioretention basins at Lotus Lagoon in South Zone

3.1.4 Lion Creek

The project alignment crosses Lion Creek, which is mapped as a major risk waterway for the waterway barrier works under the Fisheries Act 1994.

Bridge B05 over Lion Creek is 670m long. Figure 5 shows two HES areas located under the bridge near the north and south bridge abutments. There is no HES area in the middle section of the bridge. Table 3-4 provides details of the proposed treatment devices, their ID, location and sizes. Refer to Appendix C for the location and Appendix D for details of the treatment devices.

The bridge has one-way crossfall and the crest on the alignment is located 120m north from the south abutment. The bridge section over Lion Creek consists of scuppers and a longitudinal drainage pipe. The bridge is too long to allow the drainage to run to the northern abutment and therefore discharges near pier 9 and not directly to any HES area. Bridge scuppers to ground discharge runoff from pier 9 to pier 18 directly to ground. Runoff from pier 18 to the northern abutment which is directly over a HES area is captured and directed to a water quality basin. Runoff from the road corridor north of the north abutment will be captured in a pit and pipe network and discharged to the water quality basin. The scuppers and a longitudinal pipe will capture and convey flow into the proposed bioretention basin on the southern side.

Table 3-4: Proposed Treatment Devices – Lion Creek

Treatment Device	Device ID	Location	Size
Bioretention basin with inlet sediment basin	WQ-BS01	East side of Bridge B05 south abutment (See Figure 5)	Inlet sediment basin = 20 m^2 Bioretention area = 80 m^2
Bioretention basin with inlet sediment basin	WQ-BB03	West side of Bridge B05 north abutment (See Figure 5)	Inlet sediment basin = 20 m^2 Bioretention basin = 100 m^2

There are no concentrated flow outlets in this section of the road for the Lion Creek area as stormwater drains along the road batters as sheet flow. No grass swales are proposed in this area as the terrain is flat. Buffer strips are provided on the side slopes of the road embankment to treat sheet flow.

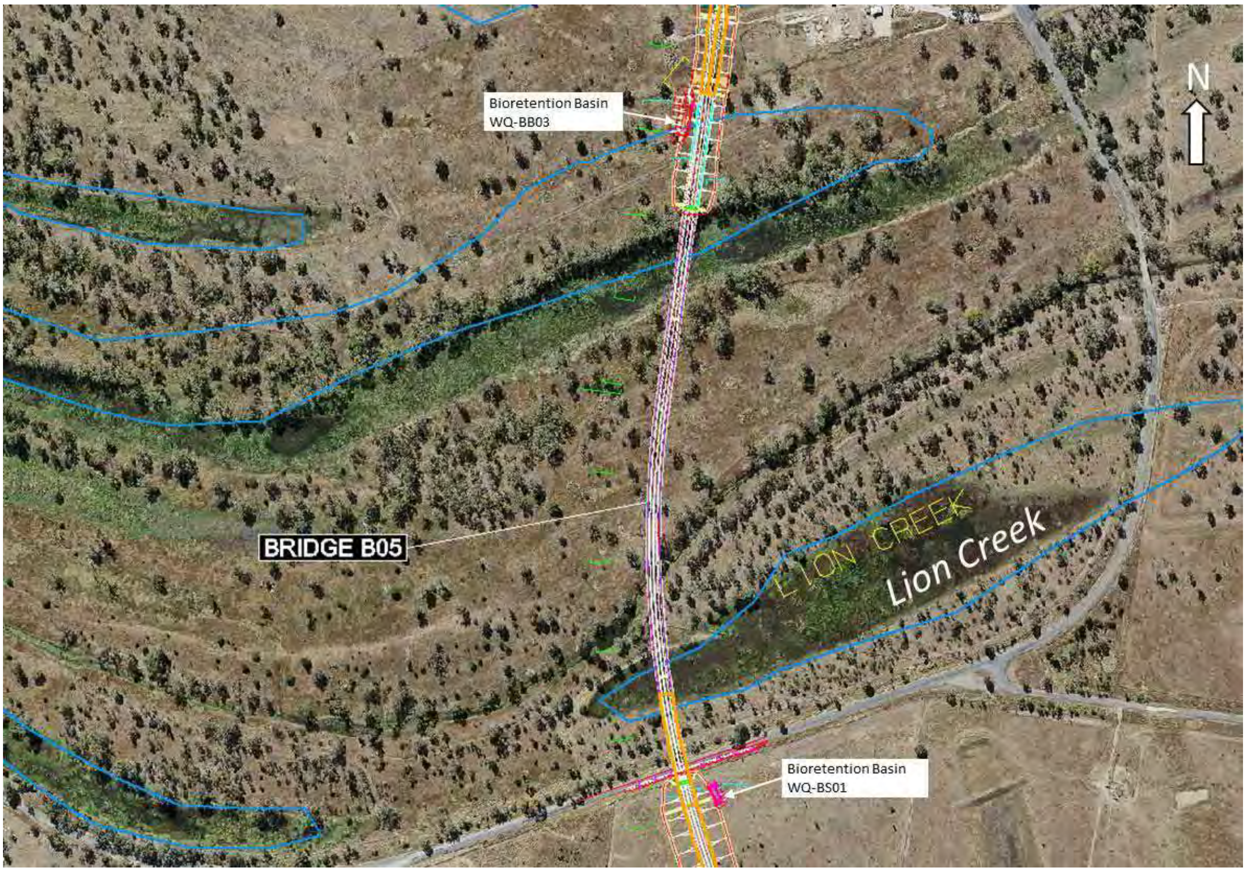

Figure 5: Location of bioretention Basins at Lion Creek in South Zone

3.1.5 Nelson Lagoon and Dunganweate Lagoon

Dunganweate Lagoon and Nelson Lagoon are HES wetlands and Figure 6 shows the extent of HES lagoons along the proposed road alignment. This area is subject to regular flood inundation and is low lying and provides limited space for offline water quality treatment devices. Bridge B04 is located over Nelson Lagoons and Dunganweate Lagoons. Table 3-5 provides details of the proposed treatment devices, their ID, location and sizes. Refer to Appendix C for the location and Appendix D for details of the treatment devices.

Table 3-5: Proposed Treatment Devices – Dunganweate Lagoon and Nelson Lagoon

Treatment Device	Device ID	Location	Size
Bioretention basin with inlet sediment basin	WQ-BB01	East side of Bridge B04 south abutment (See Figure 6)	Inlet sediment basin = 24 m^2 Bioretention area = 60 m^2
Bioretention basin with inlet sediment basin	WQ-BB02	West side of Bridge B04 north abutment (See Figure 6)	Inlet sediment basin = 20 m^2 Bioretention basin = 80 m^2

The proposed water quality controls for Bridge B04 are two bioretention basins located either end of the bridge. The bridge is approximately 970m long. The bridge has two-way crossfall and flat or zero longitudinal slope. The scuppers and a longitudinal pipe will capture and convey flow from 130m-200m bridge sections from either ends into the proposed bioretention basins. However, the remaining approximately 600m of the bridge section will drain towards downpipes at specific bridge piers located outside of the HES wetland area as the longitudinal pipe cannot be graded towards the bridge abutment due to the flat bridge grades and long pipe. Furthermore, intermediate basins between areas of mapped wetlands are not able to be accessed for maintenance purposes and have therefore not been included in the design. The bed level of bioretention basins and bioretention swales is raised to provide free drainage and 20% AEP flood immunity.

There are no concentrated flow outlets in this section of the road for the Nelson- Dunganweate area as stormwater from the road drains as sheet flow along the road embankments. No grass swales are proposed in this area as the area is flat. Buffer strips are provided on the side slopes of road embankment to treat sheet flow.

Figure 6: Proposed bioretention basins at Dunganweate Lagoon and Nelson Lagoon

3.1.6 Unnamed Lagoons (Capricorn Highway Wetland)

Two HES unnamed lagoons are located in southern most section of the project near Capricorn Highway. Figure 7 shows the extent of HES lagoons along the proposed road alignment. No HES wetlands or low risk water bodies located near Bridge B03.

Most of the stormwater flow from the proposed road is diverted using grassed swales towards the north which is a low risk area. Only 0.19 ha road catchment will flow towards the unnamed HES lagoon, which under the existing condition also flow towards the unnamed HES lagoon.

Figure 7: Unnamed Lagoons along the proposed alignment near Capricorn Highway

3.2 North zone

Flood inundation of the road gazettal boundary in the north zone is not as extensive as the south zone, which will provide less constraints when locating water quality basins and treatment measures. Water quality control devices in the north zone for the receiving waters are outlined in the following sub-sections.

3.2.1 Limestone Creek

Limestone Creek, which is not classified under the Water Act 2000, but is mapped as a high-risk waterway for waterway barrier works under the Fisheries Act 1994. Water quality treatment devices include two bioretention basins for the treatment of the bridge drainage and buffer strips on the road embankments for the treatment of sheet flows from the road.

The proposed bridge (BR11) over Limestone Creek has two-way crossfall and it is sloping longitudinally from the west to the east. The stormwater flow from the bridge will be directed into two bioretention basins for water quality treatment (Figure 8). Road kerbs (Type 4) will be provided at the end of the bridge on either side to guide flow to batter chutes which discharge into the bioretention basins. The basins will treat stormwater flow from the bridge surface and part of road area before discharging into Limestone Creek. Table 3-6 provides details of the proposed treatment devices, their ID, location and sizes. Refer to Appendix C for the location and Appendix D for details of the treatment devices.

Table 3-6: Proposed Treatment Devices – Limestone Creek

Treatment Device	Device ID	Location	Size
Bioretention basin with inlet sediment basin	WQ-BB09	North side of Bridge B11 east abutment (See Figure 8)	Inlet sediment basin = 20 m^2 Bioretention area = 60 m^2
Bioretention basin with inlet sediment basin	WQ-BB10	South side of Bridge B11 east abutment (See Figure 8)	Inlet sediment basin = 20 m^2 Bioretention basin = 40 m^2

Buffer strips will be provided along embankment side slopes, which receive sheet flow from the immediate surrounding road, which will help in the removal of coarse to medium sized suspended solids.

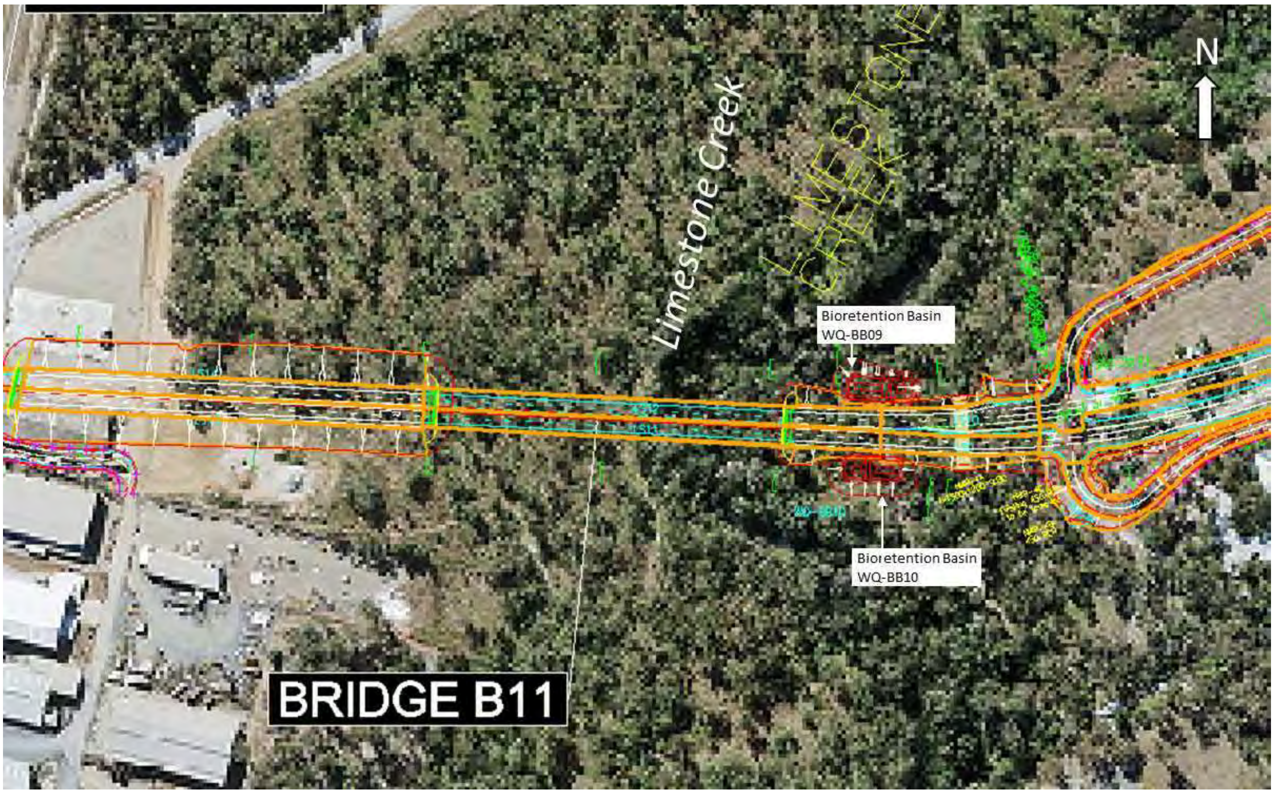

Figure 8: Location of bioretention basins at Limestone Creek Bridge

3.3 RCR Zone

Flood inundation of the road gazettal boundary in the RCR zone is not as extensive as the south zone, which will provide less constraints when locating water quality basins and treatment measures. In addition, there are more water treatment opportunities using grassed swales as natural ground has some slope.

The design has adopted a risk-based approach in providing treatment devices (bioretention basins or bioretention swales) where the alignment is near high ecological significant areas. In locations where a bridge passes over a HES (High Ecological Significance) water receptor or high-risk area, runoff will be collected in scuppers and along longitudinal drainage pipes connected to the bridge deck. Where possible, these pipes will outlet directly to water quality basins.

It is predominantly bridge runoff that creates concentrated stormwater flow and this flow is able to be captured and treated through bioretention basins or bioswales. The proposed basins will be provided where 20% AEP immunity can be achieved.

The project crosses or located near the following HES wetlands and their associated wetland protection areas (WPA):

- Black Duck Lagoon
- Lotus Lagoon
- Lion Creek

Water quality control devices in the RCR zone for the receiving waters are outlined in the following sub-sections.

3.3.1 Lotus Lagoon and Black Duck Lagoon

Lotus Lagoon and Black Duck Lagoon are HES wetlands and

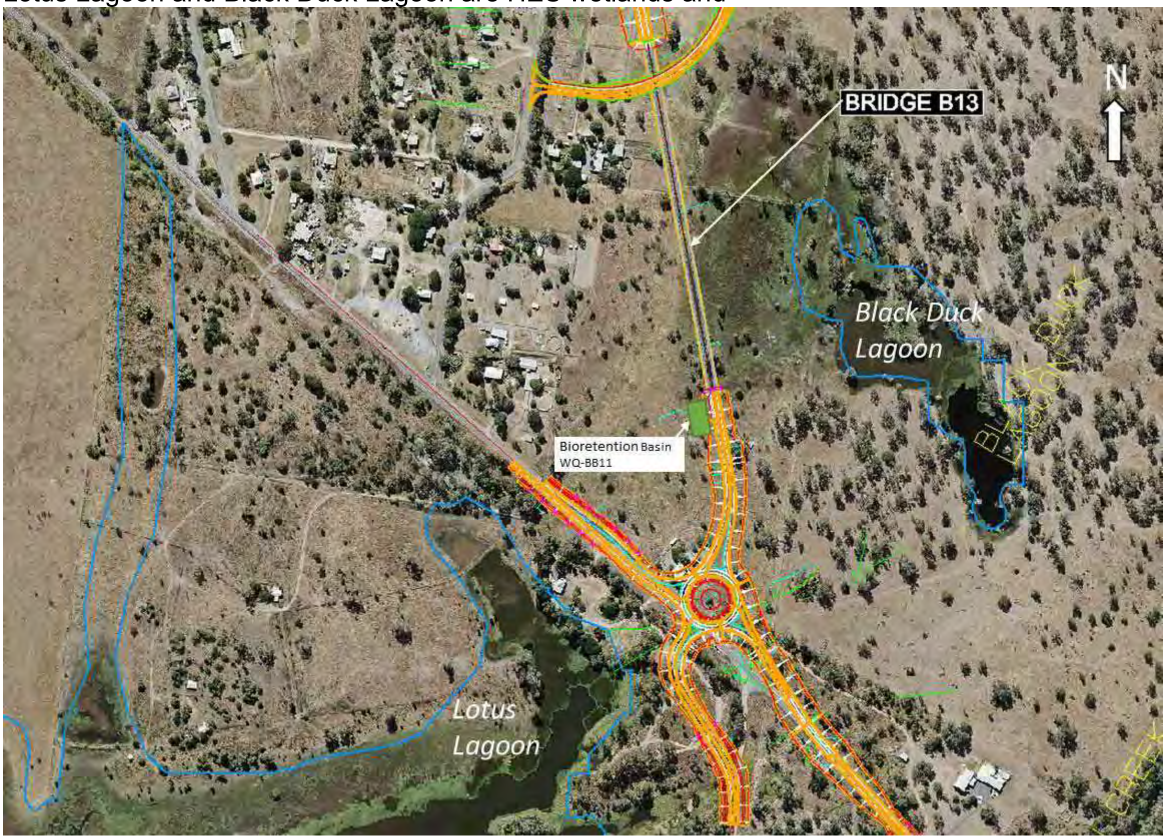

Figure **9** shows the HES areas of Lotus Lagoon and Black Duck Lagoon near the proposed road alignment. This area is subject to regular flood inundation and is low lying which provides limited space for offline water quality treatment devices. Table 3-7 provides details of the proposed treatment devices, their ID, location and sizes. Refer to Appendix C for the location and Appendix D for details of the treatment devices.

Table 3-7: Proposed Treatment Devices – Black Duck Lagoon

Treatment Device	Device ID	Location	Size
Bioretention basin with inlet sediment basin	WQ-BB11	West side of Bridge B13 south abutment (See Figure 9)	Inlet sediment basin = 32 m^2 Bioretention area = 60 m^2

The western connector roads and part of roundabout drain into Lotus Lagoon. This section does not include any concentrated flow outlet as stormwater drains along the road batters as sheet flow. Therefore, grass swales and buffer strips are provided for water quality treatment and bioretention basin or bioretention swale is not provided in this section. There is no direct drainage outflow from the proposed road catchment into Lotus Lagoon.

Black Duck Lagoon is located southeast of Bridge B13. The proposed water quality control for the Bridge B13 is scuppers and a longitudinal pipe to capture and convey stormwater flow from the bridge to a bioretention basin at the southwest side the bridge. The remaining road section does not include any concentrated flow outlets as stormwater drains along the road batters as sheet flow. Therefore, buffer strips are provided for water quality treatment.

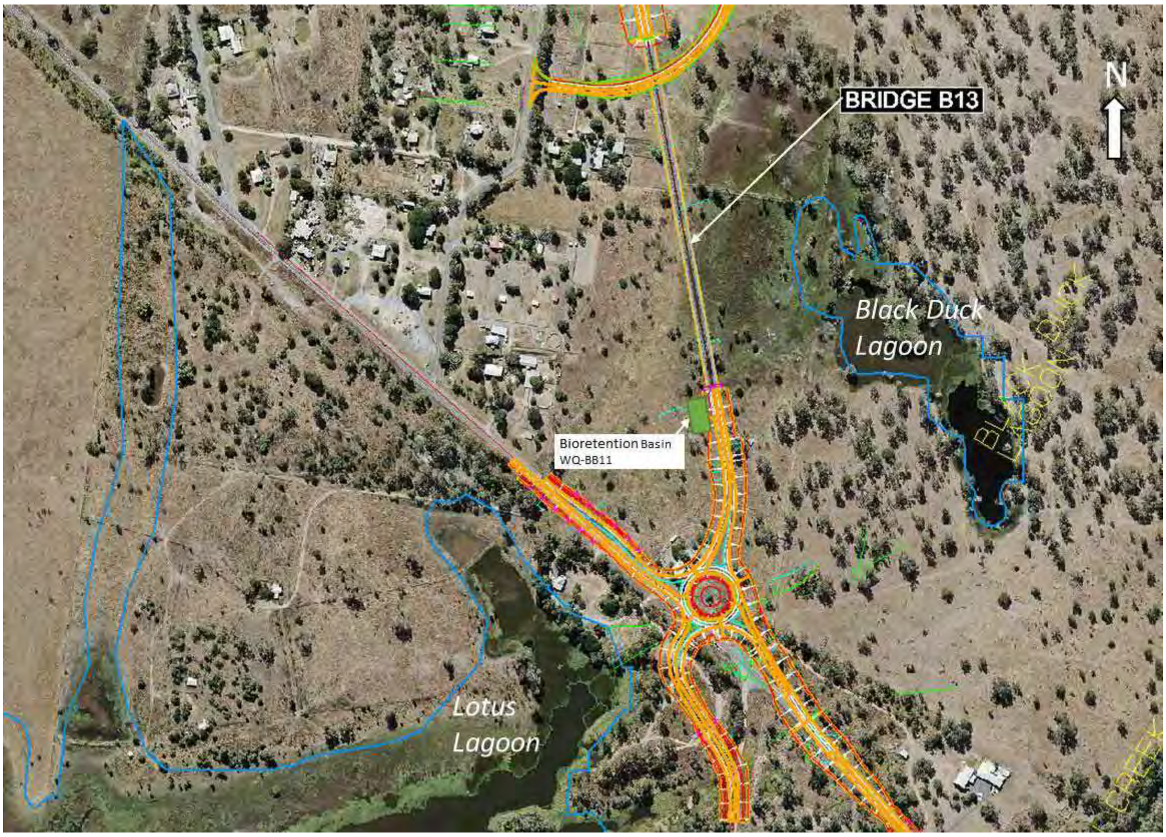

Figure 9 Proposed bioretention basin near Lotus Lagoon and Black Duck Lagoon in RCR Zone

3.3.2 Lion Creek

The project's alignment crosses Lion Creek, which is mapped as a major risk waterway for waterway barrier works under the Fisheries Act 1994.

Bridge B14 is located over Lion Creek. The proposed water quality control for Bridge B14 is to convey stormwater flow from the bridge area to two bioretention basins proposed for treatment at either end of the bridge. Figure 10 shows the proposed two bioretention basins on each end of the bridge. Table 3-8 provides details of the proposed treatment devices, their ID, location and sizes. Refer to Appendix C for the location and Appendix D for details of the treatment devices.

Table 3-8: Proposed Treatment Devices – Lion Creek (RCR)

Treatment Device	Device ID	Location	Size
Bioretention basin with inlet sediment basin	WQ-BB12	Northeast side of Bridge B14 north abutment (See Figure 10)	Inlet sediment basin = 20 m^2 Bioretention area = 40 m^2
Bioretention basin with inlet sediment basin	WQ-BB13	Northeast side of Bridge B14 south abutment (See Figure 10)	Inlet sediment basin = 20 m^2 Bioretention basin = 40 m^2

Buffer strips are proposed on the road batters, which will provide pre-treatment where located along the bioretention basins.

Figure 10 Proposed bioretention swales at Lion Creek in RCR Zone

4. MUSIC Modelling Methodology

The Model for Urban Stormwater Improvement Conceptualisation (MUSIC Version 6.3) developed by the CRC for Catchment Hydrology was used to estimate the design pollutant reduction targets for the project. The MUSIC model parameters for the project are detailed in the following sections.

4.1 Meteorological data

The Rockhampton Aero rainfall station was selected due to its proximity to the project area and it has 6 minutes time step rainfall records from 1939 to 2010. Urban stormwater - Queensland best practice environment management guideline 2009 for EPA recommends 10 years period from 1/1/1980 to 31/12/1989 for Rockhampton Rainfall Station for MUSIC Modelling. This period is long enough to allow the rainfall runoff model to reach equilibrium, in terms of soil stores and to simulate a reasonable range of climate conditions. A time step of 6 minutes was selected for simulation.

The key statistics from the rainfall and evapotranspiration data are provided in Table A-8-1 (Appendix A).

4.2 Runoff Generation Parameters

The Healthy Land and Water MUSIC Modelling Guidelines (2018) have been adopted for the water quality assessment. The guidelines provide advice on modelling various land uses in the MUSIC model and include relative percent imperviousness, runoff parameters and pollutant generation parameters.

In MUSIC, source nodes represent sub-catchments characterised by their land use. As specific information for a high-speed arterial road is not available, the 'industrial' land use runoff parameters will be adopted as they would behave similarly as a high-speed arterial road with a high percentage of total impervious area. The 'ground level' land use will be used where the most or all stormwater flow is from the road batters.

The adopted runoff generation parameters associated with 'industrial' land use are provided in Table A-8-2 (Appendix A).

4.3 Pollutant generation Parameters

MUSIC generates stormwater pollutants for both stormflow and base flow conditions. While the MUSIC Modelling Guidelines don't specify parameters for a Road land use, they do provide specific pollutant export parameters for Roads under Table 3.9 for Industrial land use. Storm flow pollutant concentration parameters for industrial source nodes as a split catchment land use have been obtained from the guideline. The pollutant generation parameters are presented in Table A-8-3 (Appendix A).

4.4 Catchment inclusion for treatment

The road sub-catchments have been divided based on the layout of drains and location of treatment system. The MUSIC catchment plans are provided in Appendix C. The catchments are shown as magenta which are located near HES areas and included for the treatment of stormwater flow from these catchments. The red catchments are excluded from the MUSIC modelling as stormwater flow from these catchments is unlikely to reach the sensitive wetlands. However, buffer strips are provided for the treatment of stormwater flow from these catchments. The percentage impervious is calculated based on the pavement area within each sub-catchment, defined from the design plans. A summary of the catchment area and percentage impervious area are provided in Table A-8-4 to Table A-8-14 in Appendix A.

4.5 MUSIC Model Configuration

MUSIC model configuration for each receiving water body was developed based on the road catchments (Appendix C) and the proposed water quality treatment devices as discussed in Section 2. Total ten (10) MUSIC models were developed, and the model configuration is shown in Figure B-5-1 to Figure B5-10 in Appendix B.

4.6 Parameters for Water Treatment Devices

Dimensions of proposed grassed swales are provided in Table A-5-15 to A-5-20 (Appendix A). The parameters include channel base width, top width, length, longitudinal slope and depth.

Parameters of proposed bioretention basins and bioretention swales are provided in Table A-5-21 to A-5-23. Parameters include bioretention basin ID, surface area, filter media area, filter media depth and length of overflow weir. Typical details of bioretention basins and bioretention swales are provided in Appendix D.

5. Results of MUSIC Modelling

5.1 Rockhampton Ring Road (RRR) – South Zone

5.1.1 Fitzroy River

Table 5-1 summarises the results of MUSIC modelling and compliance to the WQO targets. Two bioretention basins are provided for treatment of stormwater from the bridge area. Results indicate that TSS, TP, TN and GP load reductions are above the required load reduction target values. This means the stormwater treatment complied with the WQO targets.

Table 5-1: Treatment Effectiveness – Fitzroy River

Parameter	Load Sources (kg/yr)	Residual Load (kg/yr)	% Load Reduction Targets (WQO)	% Load Reduction	Compliance with WQO Target
Total Suspended Solid (TSS)	5450	776	85	86	Load reduction target achieved
Total Phosphorus (TP)	8.62	2.62	60	70	Load reduction target achieved
Total Nitrogen (TN)	30.3	15.8	45	48	Load reduction target achieved
Gross Pollutant (GP)	293	0	90	100	Load reduction target achieved

5.1.2 Pink Lily Lagoon & Unnamed Lagoon

Table 5-2 summarises the results of MUSIC modelling and compliance to the WQO targets for Pink Lily Lagoon. Results indicate that TP and GP load reductions have achieved the load reduction target values. However, TSS and TN load reduction targets are marginally achieved as they are 96% and 88% of the target value, respectively. Significant length of road is located very near Pink Lily Lagoon where it is not possible to provide any grassed swale or water treatment for stormwater flow from the road batters due to availability of space within the corridor. In addition, there also is constraint in diverting flow from these areas to the proposed basins due to flat topography. This area also has flood immunity constraints which limit the provision of any treatment device. Buffer strips are provided to treat sheet flow, which is not effective in treating TN. This constraint was the main reason of marginally achieving TN target.

Table 5-2: Treatment Effectiveness – Pink Lily Lagoon

Parameter	Load Sources (kg/yr)	Residual Load (kg/yr)	% Load Reduction Targets (WQO)	% Load Reduction	Compliance with WQO Target
Total Suspended Solid (TSS)	9200	1650	85	82	Load reduction target marginally achieved
Total Phosphorus (TP)	15.7	5.83	60	63	Load reduction target achieved
Total Nitrogen (TN)	60.3	36.5	45	40	Load reduction target marginally achieved
Gross Pollutant (GP)	466	19.1	90	96	Load reduction target achieved

Table 5-3 summarises the results of MUSIC modelling and compliance to the WQO targets for unnamed lagoon. Results indicate that TSS and TP load reductions are above 65% of the load reduction target values and these load reduction targets are not fully or marginally achieved due to drainage and flooding constraint in this area. However, TN and GP load reduction targets are not achieved. The terrain is flat and low lying and there is unavailability of suitable space for providing additional swales. The proposed grass-swale and buffer strips are not sufficient and effective in achieving pollutant load reduction targets. These constraints preclude the design from fully complying with the WQO targets.

Table 5-3: Treatment Effectiveness – Unnamed Lagoon near Pink Lily Lagoon

Parameter	Load Sources (kg/yr)	Residual Load (kg/yr)	% Load Reduction Targets (WQO)	% Load Reduction	Compliance with WQO Target
Total Suspended Solid (TSS)	7060	3010	85	57	Load reduction target not achieved
Total Phosphorus (TP)	11.8	6.82	60	43	Load reduction target not achieved
Total Nitrogen (TN)	42.0	35.2	45	16	Load reduction target not achieved
Gross Pollutant (GP)	387	240	90	38	Load reduction target not achieved

5.1.3 Lotus Lagoon

Table 5-4 summarises the results of MUSIC modelling and compliance to the WQO targets for Lotus Lagoon area. Results indicate that TSS and TP load reductions are fully achieved. However, TN load reduction targets are marginally achieved and GP target is not achieved. Although eight bioretention basins/bioretention swales are provided for the water quality treatment for the stormwater from the bridges, Lotus Lagoon has significant extent on either side of the proposed road between bridges which is not suitable for grassed swales or other treatment devices due to flat gradients. These constraints preclude the design from fully complying with the TN and GP WQO targets.

Table 5-4: Treatment Effectiveness – Lotus Lagoon

Parameter	Load Sources (kg/yr)	Residual Load (kg/yr)	% Load Reduction Targets (WQO)	% Load Reduction	Compliance with WQO Target
Total Suspended Solid (TSS)	6530	974	85	85	Load reduction target achieved
Total Phosphorus (TP)	12.6	4.84	60	62	Load reduction target achieved
Total Nitrogen (TN)	58.3	36.2	45	38	Load reduction target marginally achieved
Gross Pollutant (GP)	564	296	90	48	Load reduction target not achieved

5.1.4 Lion Creek

Table 5-5 summarises the results of MUSIC modelling and compliance to the WQO targets for the Lion Creek. Results indicate that TSS, TP, TN and GP load reductions are above the required load reduction target values and therefore comply with the WQO targets. Two bioretention basins are provided for treatment of stormwater from the bridge area, which will drain into HES areas of the Lion Creek. The middle section of the bridge will be drained away from the HES area and is excluded from the modelling.

Table 5-5: Treatment Effectiveness – Lion Creek (South Area)

Parameter	Load Sources (kg/yr)	Residual Load (kg/yr)	% Load Reduction Targets (WQO)	% Load Reduction	Compliance with WQO Target
Total Suspended Solid (TSS)	2160	252	85	88	Load reduction target achieved
Total Phosphorus (TP)	3.65	1.07	60	71	Load reduction target achieved
Total Nitrogen (TN)	13.3	7.14	45	46	Load reduction target achieved
Gross Pollutant (GP)	113	0	90	100	Load reduction target achieved

5.1.5 Nelson Lagoon and Dunganweate Lagoons

Table 5-6 summarises the results of MUSIC modelling and compliance to the WQO targets for Nelson Lagoon. Results indicate that TSS, TP, TN and GP load reductions are above the load reduction target values and therefore comply with the WQO targets.

Table 5-6: Treatment Effectiveness – Nelson Lagoons

Parameter	Load Sources (kg/yr)	Residual Load (kg/yr)	% Load Reduction Targets (WQO)	% Load Reduction	Compliance with WQO Target
Total Suspended Solid (TSS)	1380	96	85	93	Load reduction target achieved
Total Phosphorus (TP)	2.25	0.512	60	77	Load reduction target achieved
Total Nitrogen (TN)	7.53	3.59	45	52	Load reduction target achieved
Gross Pollutant (GP)	81.8	0	90	100	Load reduction target achieved

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Table 5-7 summarises the results of MUSIC modelling and compliance to the WQO targets for Dunganweate Lagoons. Results indicate that TSS, TP, TN and GP load reductions are above the load reduction target values, which means that load reduction targets complied with the WQO targets. A bioretention basin is provided for treatment of stormwater from the bridge area, which will drain into HES areas of the Nelson. However, the middle section of the bridge will be drained away from the HES area and is excluded from the modelling.

Table 5-7: Treatment Effectiveness – Dunganweate Lagoons

Parameter	Load Sources (kg/yr)	Residual Load (kg/yr)	% Load Reduction Targets (WQO)	% Load Reduction	Compliance with WQO Target
Total Suspended Solid (TSS)	1770	217	85	88	Load reduction target achieved
Total Phosphorus (TP)	2.99	0.909	60	70	Load reduction target achieved
Total Nitrogen (TN)	10.8	5.53	45	49	Load reduction target achieved
Gross Pollutant (GP)	92.3	0	90	100	Load reduction target achieved

5.2 Rockhampton Ring Road (RRR) – North Zone

5.2.1 Limestone Creek

Table 5-8 summarises the results of MUSIC modelling and compliance to the WQO targets for Limestone Creek. Results indicate that TSS, TP and TN load reductions have achieved the load reduction target values. However, GP load reduction targets are above 90% of the target value, which can be considered marginally achieved. Some part of the road has only buffer strips for the treatment of stormwater sheet flow due to the terrain constraint which is not effective in treating GP.

Table 5-8: Treatment Effectiveness – Limestone Creek

Parameter	Load Sources (kg/yr)	Residual Load (kg/yr)	% Load Reduction Targets (WQO)	% Load Reduction	Compliance with WQO Target
Total Suspended Solid (TSS)	2360	225	85	90	Load reduction target achieved
Total Phosphorus (TP)	3.77	1.0	60	73	Load reduction target achieved
Total Nitrogen (TN)	12.3	5.85	45	52	Load reduction target achieved
Gross Pollutant (GP)	135	24.3	90	82	Load reduction target marginally achieved

5.3 Rockhampton Connector Road (RCR) Zone

5.3.1 Black Duck Lagoon

Table 5-9 summarises the results of MUSIC modelling including annual pollutant loads, load reductions and compliance to the WQO targets. Results indicate that all pollution load reduction targets are achieved and comply with WQO targets.

Table 5-9: Treatment Effectiveness – Black Duck Lagoon

Parameter	Load Sources (kg/yr)	Residual Load (kg/yr)	% Load Reduction Targets (WQO)	% Load Reduction	Compliance with WQO Target
Total Suspended Solid (TSS)	1760	194	85	89	Load reduction target achieved
Total Phosphorus (TP)	2.79	0.75	60	73	Load reduction target achieved
Total Nitrogen (TN)	9.29	4.37	45	53	Load reduction target achieved
Gross Pollutant (GP)	100.0	0	90	100	Load reduction target achieved

5.3.2 Lotus Lagoon

Table 5-10 summarises the results of MUSIC modelling and compliance to the WQO targets for Lotus Lagoon. Results indicate that TSS, TP and GP load reduction targets are achieved and complies with WQO targets. TN load reduction targets are marginally achieved as the only grassed swales and buffer strips are adopted due to sheet flow of stormwater for the water quality treatment which is not effective in treating TN.

Table 5-10: Treatment Effectiveness – Lotus Lagoon

Parameter	Load Sources (kg/yr)	Residual Load (kg/yr)	% Load Reduction Targets (WQO)	% Load Reduction	Compliance with WQO Target
Total Suspended Solid (TSS)	3240	110	85	97	Load reduction target achieved
Total Phosphorus (TP)	5.15	0.97	60	81	Load reduction target achieved
Total Nitrogen (TN)	16.9	11.5	45	32	Load reduction target not achieved
Gross Pollutant (GP)	157	0	90	100	Load reduction target achieved

5.3.3 Lion Creek

Table 5-11 summarises the results of MUSIC modelling and compliance to the WQO targets for Lion Creek. Results indicate that TSS, TP, TN and GP load reduction targets are achieved and complies with WQO targets.

Table 5-11: Treatment Effectiveness – RCR Lion Creek

Parameter	Load Sources (kg/yr)	Residual Load (kg/yr)	% Load Reduction Targets (WQO)	% Load Reduction	Compliance with WQO Target
Total Suspended Solid (TSS)	583	3.75	85	99	Load reduction achieved
Total Phosphorus (TP)	0.899	0.129	60	86	Load reduction achieved
Total Nitrogen (TN)	3.05	0.926	45	70	Load reduction achieved
Gross Pollutant (GP)	33.4	0	90	100	Load reduction achieved

6. Maintenance

Treatment devices require ongoing maintenance at regular intervals and also major rehabilitation as the system reaches its design life. If maintenance is not undertaken, the performance of the system will not reach design requirements. Most maintenance requirements will be on an as needs basis. Anticipated maintenance work for the treatment devices are listed in Table 6-1.

Table 6-1: Maintenance Requirements

Treatment Device	Maintenance Item	Frequency
Inlet Sediment Basin	Sediment removal	▪ 5 years or trigger when sediment accumulates to half the basin depth
Bioretention basin	Clearing of infiltration area and outlets	▪ Whenever debris and litter have accumulated on screens to an unacceptable level or excessive coarse
	Removal of debris and plant litter	▪ Required based on accumulation to unacceptable levels
	Desilting of infiltration areas and replacement of top 50mm (100mm max) filter media	▪ every 5-10 years
	Inspection after rainfall events to repair eroded areas	▪ after heavy rainfall or major storm events
	Mowing of turfed areas and pruning of trees and shrubs to maintain the appearance of the treatment system.	▪ As required

Treatment Device	Maintenance Item	Frequency
Grassed swale	Routine inspection of the swale profile to identify any areas of obvious increased sediment deposition, scouring of the swale invert from storm flows, rill erosion of the swale batters from lateral inflows or damage to the swale profile from vehicles;	▪ After heavy rainfall or major storm events
	Removal of sediment where it is impeding the conveyance of the swale and/or smothering the swale vegetation and if necessary, re-profiling of the swale and revegetating to original design specification;	▪ As needed
	Repairing damage to the swale profile resulting from scour, rill erosion or vehicle damage;	▪ As needed
	Watering/ irrigation of vegetation until plants are established and actively growing;	▪ As needed
	Mowing of turf or slashing of vegetation (if required) to preserve the optimal design height for the vegetation;	▪ As needed
	Removal and management of invasive weeds; Removal of plants that have died (from any cause) and replacement with plants of equivalent size and species as detailed in the plant schedule;	▪ Every three months
	Litter and debris removal;	▪ Six monthly
Buffer	Weed removal and plant-re-establishment	▪ Every three months
	Monitoring for scour and erosion, and sediment or litter build-up	▪ After heavy rainfall or major storm events
	Regular watering/ irrigation of vegetation until plants are established and actively growing	▪ As needed

7. Sustainability

TMR has mandated Infrastructure Sustainability (IS) Ratings for Projects with a value of more than $100 million. The JSDJV has incorporated sustainability into the RRR design development and is targeting IS Rating credits to achieve a score of 'Excellent'.

The overall progress towards achieving IS credits is documented in the IS Management Plan (ISMP). The relevant credits to civil design are outlined in the following sections. This Design Report and attachments will form part of the evidence for the IS Rating.

Sustainability initiatives and innovation incorporated into the Design have been outlined in Table 7-1.

Table 7-1: IS Rating Credits Initiatives

IS Rating Credit and Aim	Target Level	Benchmark Requirements	Design Response and Evidence
Dis-1 Receiving Water Quality	2	▪ Measures to minimise adverse impacts to receiving water environmental values during construction and operation have been identified and implemented. ▪ Monitoring of water discharges and receiving waters is undertaken at appropriate intervals and at times of discharge during construction ▪ Monitoring and modelling of water discharges and receiving waters demonstrates no adverse impact on receiving water environmental values. ▪ The infrastructure does not increase peak stormwater flows for rainfall events of up to a 1.5 year ARI event discharge.	▪ A risk-based approach is adopted where we provide treatment devices bioretention basins where the alignment is near high ecological significant areas. ▪ The water quality treatment devices adopted for each sensitive water receptor aims to mitigate adverse environmental impacts caused by increased pollutants from the new road surface. ▪ MUSIC water quality modelling has been undertaken for the assessing the performance of the proposed treatment design for each sensitive receptor. ▪ Results of MUSIC modelling showed that the proposed stormwater treatment design helps in reducing pollutant load reduction of TSS, TP, TN, and GP and complying WQO load reduction targets. ▪ The proposed basins and swales also help in maintaining the peak stormwater flows to sensitive receptors during frequent rainfall events.

8. Conclusion

The RRR alignment is predominantly located in the Fitzroy River floodplain, which is flat and subject to regular flood inundation and suitable for limited water quality treatment devices. Therefore, the design has adopted a risk-based approach in providing treatment devices (bioretention basins) where the alignment is near high ecological significant areas. The water quality treatment devices consider the project in separate sensitive water receptors which require varying approaches due to the sensitivity of the receiving environment and the constraints associated with each sensitive water receptor. The water quality treatment devices adopted for each sensitive water receptor aims to mitigate adverse environmental impacts caused by increased pollutants from the new road surface.

MUSIC water quality modelling has been undertaken for the assessing the performance of the proposed treatment design for each sensitive receptor.

Results of MUSIC modelling showed that the proposed stormwater treatment design helps in reducing pollutant load reduction of TSS, TP, TN, and GP. The proposed stormwater treatment fully complies with the WQO load reduction target for Fitzroy River, Lion Creek, Nelson Lagoon, Dunganweate Lagoon and Black Duck Lagoon. WQO targets of TSS, TP and GP are fully achieved for Pink Lily Lagoon, Lotus Lagoon (RCR) and Limestone Creek.

At Unnamed Lagoon, pollution load reduction target for TN and GP are not achieved. At Lotus Lagoon, pollution reduction targets for GP are not achieved. Unnamed Lagoon and Lotus Lagoon have significant flat gradients and difficulties achieving positive drainage flow along RRR making it unfeasible to use grass swales and bioretention as a treatment option. Any swales constructed would be flat and it would not be possible to daylight them. It would not be possible to positively drain any bioretention subsoil drainage at these locations. The floodplain location and flat gradients limit other alternative treatment options that treat concentrated flow (in-line treatment devices) as most road runoff here is sheet flow making it difficult to capture and treat base flow runoff. The floodplain is subject to regular inundation and restricts the placement of water quality devices.

Appendix A. MUSIC Modelling Parameters

MUSIC model parameters were adopted according to the Music Modelling Guidelines (2018). The parameters adopted for the MUSIC model are outlined in the tables below.

A.1 Rainfall and Evapotranspiration Data

MUSIC model parameters were adopted according to the Music Modelling Guidelines (2018). The parameters adopted for the MUSIC model are outlined in the tables below.

Table A-8-1: Meteorological and Rainfall Runoff Data

Parameter	Data used in modelling
Rainfall station	*Rockhampton Aero*
Time step	*6 minute*
Modelling period	*1980 to 1989 (10 years)*
Mean annual rainfall (mm)	*779 mm*
Evapotranspiration	*1703 mm*
Soil Properties (Runoff Generation Parameters)	*Industrial (*Music Modelling Guidelines Version 1.0*).*
Pollutant Concentration (Base & Storm Flow Concentration Parameters)	*Industrial (*Music Modelling Guidelines Version 1.0*, see table below)*

A.2 Runoff Generation Parameters

In MUSIC, source nodes represent sub-catchments characterised by their land use. As specific information for a high-speed arterial road is not available, the 'industrial' land use runoff parameters was adopted as they would behave similarly as a high-speed arterial road with a high percentage of total impervious area.

Table A-8-2 outlines the adopted runoff generation parameters associated with 'industrial' land use in this design.

Table A-8-2: Runoff Generation Parameters

Characteristics	Adopted parameter
Impervious Area	
Rainfall threshold (mm/day)	1
Pervious Area	
Soil Storage Capacity (mm)	18
Initial storage (%)	10
Field Capacity (mm)	80
Infiltration Capacity Coefficient	243
Infiltration Capacity Exponent	0.6
Groundwater	
Initial Depth (mm)	50
Daily recharge Rate (%)	0
Daily Base Flow Rate (%)	31
Daily Deep Seepage Rate (%)	0

A.3 Pollutant generation Parameters

MUSIC generates stormwater pollutants for both stormflow and base flow conditions. The MUSIC Modelling Guidelines do not specifically include parameters for roads. Storm flow pollutant concentration parameters for industrial source nodes as a split catchment land use have been obtained from the guideline. The pollutant generation parameters for roads source nodes are presented in Table A-8-3.

Table A-8-3: MUSIC Pollutant Parameters for Industrial Urban Roads Source Nodes

Land use	Parameter	Total Suspended Solids (Log_{10}mg/L)		Total Phosphorus (Log_{10}mg/L)		Total Nitrogen (Log_{10}mg/L)	
		Mean	Std dev.	Mean	Std dev.	Mean	Std dev.
Road	Baseflow	0.78	0.45	-1.11	0.48	0.14	0.20
	Stormflow	2.43	0.44	-0.30	0.36	0.25	0.32
Ground Level	Baseflow	0.78	0.45	-1.11	0.48	0.14	0.20
	Stormflow	1.92	0.44	-0.59	0.36	0.25	0.32
Industrial Lump	Baseflow	0.78	0.45	-1.11	0.48	0.14	0.20
	Stormflow	1.92	0.44	-0.59	0.36	0.25	0.32

A.4 Catchment Data

The road sub-catchments have been divided based on the layout of drains and location of treatment system. The MUSIC catchment plans are provided in Appendix C. The percentage impervious is calculated based on the pavement area within each sub-catchment, defined from the design plans.

The following sections provide tables summarising catchment ID, catchment area and percentage impervious area of each sub-catchment.

A.4.1 South Area

Table A-8-4: Catchments for Fitzroy River

Catchment ID	Catchment Area (Ha)	Road		Ground Level	
		Impervious	Pervious	Impervious	Pervious
		(%)	(%)	(%)	(%)
FZ-01	0.3255	45	55		
FZ-02	0.2441	62	38		
FZ-03	0.9896	93	7		
FZ-04	0.256			0	100
FZ-05	0.1973			0	100
FZ-06	0.7729	87	13		
FZ-07	0.088			0	100

Table A-8-5: Catchments for Pink Lily Lagoon

Catchment ID	Catchment Area (Ha)	Road		Ground Level	
		Impervious	Pervious	Impervious	Pervious
		(%)	(%)	(%)	(%)
PLL-01	0.124	100	0		
PLL-02	0.662	48	52		
PLL-03	0.584			0	100
PLL-04	0.052	100	0		
PLL-05	0.644	58	42		
PLL-06	0.232			0	100
PLL-07	0.160	87	13		
PLL-08	0.191	34	66		
PLL-10	0.130	100	0		
PLL-11	0.143			0	100
PLL-12	0.133			0	100
PLL-13	0.082	100	0		
PLL-14	0.072			0	100
PLL-15	0.179	45	55		
PLL-16	0.190	35	65		
PLL-17	0.060	100	0		
PLL-18A	0.250			0	100
PLL-18B	0.361	100	0		
PLL-19	0.334			0	100
PLL-19A	0.408	100	0		
PLL-20	0.627	100	0		
PLL-20A	0.091			0	100
PLL-21	0.140			0	100
PLL-22	0.592	100	0		
PLL-22A	0.256			0	100
PLL-23	1.131	72	28		
PLL-23A	0.309	100	0		
PLL-24	0.462			0	100
PLL-25	1.082	70	30		
PLL-26	0.217	75	25		
PLL-27	1.460	49	51		
PLL-28	0.337	56	44		
PLL-29	1.138	53	47		
PLL-30	0.121	58	42		
PLL-31	0.603	72	28		
PLL-32	0.678			0	100
PLL-33	0.440	56	44		
PLL-34	0.963	61	39		
PLL-35	0.684	65	35		
PLL-36	0.257			0	100

Catchment ID	Catchment Area (Ha)	Road		Ground Level	
		Impervious	Pervious	Impervious	Pervious
		(%)	(%)	(%)	(%)
PLL-37	0.091	85	15		
PLL-38	0.096	72	28		
PLL-40	0.062			0	100
PLL-41	0.101			0	100
PLL-42	0.519			0	100

Table A-8-6: Catchments for Lotus Lagoon

Catchment ID	Catchment Area (Ha)	Road		Ground Level	
		Impervious	Pervious	Impervious	Pervious
		(%)	(%)	(%)	(%)
LL-01	0.630	100	0		
LL-02	0.876			0	100
LL-03	2.836	55	45		
LL-04	0.159			0	100
LL-05	0.500	100	0		
LL-06	0.186			0	100
LL-07	0.443	74	26		
LL-08	0.080			0	100
LL-09	0.815	29	71		
LL-10A	0.118	30	70		
LL-10	0.748	30	70		
LL-11	0.074	100	0		
LL-12	0.129	56	44		
LL-13	0.182	31	69		
LL-14	0.176	30	70		
LL-15	0.183	31	69		
LL-16	0.179	31	69		
LL-17	0.171	48	52		
LL-18	0.171	49	51		
LL-19	0.198	19	81		
LL-20	0.125	32	68		
LL-21	0.082	100	0		
LL-21A	0.361	32	68		
LL-22	0.152	58	42		
LL-22A	0.302	35	65		
LL-23	0.029	48	52		
LL-24	0.276	70	30		
LL-25	0.207	53	47		

Catchment ID	Catchment Area (Ha)	Road		Ground Level	
		Impervious	Pervious	Impervious	Pervious
		(%)	(%)	(%)	(%)
LL-26	0.043	49	51		
LL-27	0.071	62	38		
LL-28	0.012	71	29		
LL-30	0.046	49	51		
LL-31	0.254	54	46		
LL-32	0.280	55	45		
LL-33	0.255	50	50		
LL-34	0.290	48	52		
LL-35	0.288			0	100
LL-36	0.590	61	39		
LL-37	0.069	65	35		
LL-38	0.021			0	100
LL-39	0.049	54	46		
LL-40	0.059	45	55		

Table A-8-7: Catchments for Nelson Lagoon

Catchment ID	Catchment Area (Ha)	Road		Ground Level	
		Impervious	Pervious	Impervious	Pervious
		(%)	(%)	(%)	(%)
NL-01	0.865			0	100
NL-02	1.465	48	52		
NL-03	2.026	42	58		
NL-04	2.056	40	60		
NL-05	0.164			0	100
NL-06	0.149			0	100
NL-07	0.530	100	0		
NL-08	0.977	100	0		
NL-09	0.522	71	29		
NL-10	0.150			0	100

Table A-8-8: Catchments for Lion Creek (South Area)

Catchment ID	Catchment Area (Ha)	Road		Ground Level	
		Impervious	Pervious	Impervious	Pervious
		(%)	(%)	(%)	(%)
LC-01	0.496	41	59		
LC-02	0.493	39	61		
LC-03	0.151			0	100
LC-04	0.397	90	10		
LC-05	0.191			0	100
LC-06	0.600	100	0		
LC-07	0.077			0	100
LC-08	0.288	27	73		

Table A-8-9: Catchments for Unnamed Lagoons

Catchment ID	Catchment Area (Ha)	Road		Ground Level	
		Impervious	Pervious	Impervious	Pervious
		(%)	(%)	(%)	(%)
UT-01	0.886	37	63		
UT-02	0.178			0	100
UT-03	0.991	41	59		
UT-04A	0.207	48	52		
UT-04B	0.323	28	72		
UT-05	0.191	61	39		
UT-06	0.241	59	41		
UT-07	0.396	38	62		
UT-08	0.234	48	52		
UT-08A	0.022			0	100
UT-09	0.488	47	53		
UT-10	0.190	63	37		
UT-11	0.251			0	100
UT-12	0.067	81	19		
UT-13	0.057	52	48		
UT-14	0.029			0	100
UT-15	0.056			0	100
UT-16	0.136	73	27		
UT-17	0.079	24	76		
UT-18	0.693			0	100
UT-19	0.532	67	33		
UT-20	0.344	60	40		
UT-21	0.035			0	100
UT-22	0.151	90	10		
UT-23	0.238	43	57		

Catchment ID	Catchment Area (Ha)	Road		Ground Level	
		Impervious	Pervious	Impervious	Pervious
		(%)	(%)	(%)	(%)
UT-24	0.099			0	100
UT-25	0.636	64	36		
UT-26	0.083			0	100

A.4.2 North Area

Table A-8-10: Catchments for Limestone Creek

Catchment ID	Catchment Area (Ha)	Road		Ground Level	
		Impervious	Pervious	Impervious	Pervious
		(%)	(%)	(%)	(%)
LS1	0.034			0	100
LS2	1.021	95	5		
LS3	0.532	100	0		
LS3A	0.061			0	100
LS4	0.439	100	0		
LS5	0.157			0	100
LS6	0.139	60	40		
LS7	0.217	90	10		
LS8	0.078			0	100
LS9	0.185	55	45		
LS10	0.189	84	16		
LS11	0.320	96	4		
LS12	0.341	89	11		
LS13	0.675	41	59		
LS14	0.684	40	60		

Table A-8-11: Catchments for Unnamed Tributary 1

Catchment ID	Catchment Area (Ha)	Road		Ground Level	
		Impervious	Pervious	Impervious	Pervious
		(%)	(%)	(%)	(%)
UNT1	0.084	100	0		
UNT2	0.081	100	0		
UNT3	0.647	74	26		
UNT4	0.389	41	59		
UNT5	1.961	69	31		
UNT6	0.236			0	100
UNT7	0.221	81	19		
UNT8	0.181	100	0		
UNT9	0.067			0	100
UNT10	0.014			0	100
UNT11	0.774	78	22		

Catchment ID	Catchment Area (Ha)	Road		Ground Level	
		Impervious	Pervious	Impervious	Pervious
		(%)	(%)	(%)	(%)
UNT12	0.084	0	100		
UNT13	0.441	0	100		
UNT14	0.229	87	13		
UNT15	0.286	83	17		
UNT16	0.133	90	10		
UNT17	0.105	84	16		
UNT18	0.160	90	10		
UNT19	0.650	73	27		
UNT20a	0.064			0	100
UNT20B	0.102			0	100

Table A-8-12: Catchments for Unnamed Tributary 2

Catchment ID	Catchment Area (Ha)	Road		Ground Level	
		Impervious	Pervious	Impervious	Pervious
		(%)	(%)	(%)	(%)
UNT2-1	0.175	77	23		
UNT2-2	0.399	90	10		
UNT2-2A	0.042			0	100
UNT2-3	0.046			0	100
UNT2-4	0.256	84	16		
UNT2-5	0.173	81	19		
UNT2-6	1.046	66	34		
UNT2-7	0.461	100	0		
UNT2-8	1.357	78	22		
UNT2-9	0.099			0	100
UNT2-10	0.119	82	18		
UNT2-11	0.130	76	24		
UNT2-12	0.067	75	25		
UNT2-13	0.106	66	34		
UNT2-14	0.195	87	13		
UNT2-15	0.079	66	34		
UNT2-16	0.224	87	13		
UNT2-17	0.051	66	34		
UNT2-18	0.498	73	27		
UNT2-19	0.502	78	22		
UNT2-20	0.092	87	13		
UNT2-21	0.606	87	13		
UNT2-21A	0.163			0	100
UNT2-22	0.255			0	100
UNT2-23	0.318	72	28	72	28

Catchment ID	Catchment Area (Ha)	Road		Ground Level	
		Impervious	Pervious	Impervious	Pervious
		(%)	(%)	(%)	(%)
UNT2-24	0.070	100	0		
UNT2-25	0.784	73	27	73	27
UNT2-26	0.411	85	15	85	15

A.4.3 RCR Area

Table A-8-13: Catchments for Lotus Lagoon & Black Duck Lagoon

Catchment ID	Catchment Area (Ha)	Road		Ground Level	
		Impervious	Pervious	Impervious	Pervious
		(%)	(%)	(%)	(%)
BL-01	0.267	25	75		
BL-02	0.268	27	73		
BL-03	0.601	48	52		
BL-04	0.357			0	100
BL-05	0.115	46	54		
BL-06	0.070			0	100
BL-07	0.121	27	73		
BL-08	0.117	27	73		
BL-09A	0.287	100	0		
BL-09B	0.304	89	11		
BL-10	0.497	40	60		
BL-11	0.349	38	62		
BL-12	0.253			0	100
BL-13	0.421	30	70		
BL-14	0.323	39	61		
BL-15	0.289	53	47		
BL-16	0.217	34	66		
BL-17	0.188	41	59		
BL-18	0.231	42	58		
BL-19	0.196	53	47		
BL-20	0.162	68	32		
BL-21	0.264	56	44		
BL-22	0.194	44	56		
BL-23	0.557	72	28		
BL-24	0.553	72	28		

Table A-8-14: Catchments for Lion Creek (RCR Area)

Catchment ID	Catchment Area (Ha)	Road		Ground Level	
		Impervious (%)	Pervious (%)	Impervious (%)	Pervious (%)
LCR-01	0.289	37	63		
LCR-02	0.273	23	77		
LCR-03	0.190	39	61		
LCR-04	0.078	44	56		
LCR-05	0.164	43	57		
LCR-06	0.060	34	66		
LCR-07	0.127	81	19		
LCR-08	0.083	82	18		
LCR-09	0.060			0	100
LCR-10	0.060	100	0		
LCR-11	0.379	74	26		
LCR-12	0.149	23	77		
LCR-13	0.060			0	100
LCR-14	0.205	66	34		

A.5 Proposed Grassed Swales

Dimensions of proposed grassed swales in each zone are provided in the following tables. Default vegetation height of 0.25m is adopted. In addition, default values of k and C are adopted, which are shown in below table.

	k (m/yr)	C* (mg/L)	C** (mg/L)
Total Suspended Solids	8000	20.000	14.000
Total Phosphorus	6000	0.130	0.130
Total Nitrogen	500	1.400	1.400
Threshold Hydraulic Loading for C** (m/yr)			3500

A.5.1 South Zone

Table A-8-15: Proposed Grassed Swales for Pink Lily Lagoon MUSIC Model

Swale ID	Length (m)	Base Width (m)	Top Width (m)	Slope (%)	Depth (m)
PLL-S1	128	1.0	5.0	0.50	0.50
PLL-S2	87	2.0	5.0	0.50	1.00
PLL-S3	690	1.8	5.0	0.50	1.00
PLL-S4	114	1.0	5.0	0.50	0.50
PLL-S5	531	1.8	5.0	0.50	0.25
PLL-S6A	74.5	1.8	7.8	0.50	0.50
PLL-S6B	75.0	1.8	7.8	0.50	0.50

Table A-8-16: Proposed Grassed Swales for Lotus Lagoon

Swale ID	Length (m)	Base Width (m)	Top Width (m)	Slope (%)	Depth (m)
LL-S1	26	1.8	2.8	0.10	0.10
LL-S2	28	1.8	6.8	0.30	0.50
LL-S3	46	1.8	3.8	0.10	0.20
LL-S4	178	1.8	5.8	0.30	0.40
LL-S5	45	1.8	2.8	1.20	0.10
LL-S6	203	1.8	5.8	0.30	0.40
LL-S7	165	1.8	6.3	0.20	0.45
LL-S8	226	1.8	5.8	0.10	0.40

Table A-8-17: Proposed Grassed Swales for Unnamed Lagoons

Swale ID	Length (m)	Base Width (m)	Top Width (m)	Slope (%)	Depth (m)
UT S1	198	1.8	6.8	0.27	0.5
UT S2	113	0.0	6.0	0.50	0.5
UT S3	70	0.0	4.7	0.50	0.5
UT S4	142	1.8	7.8	0.80	0.5
UT S5	57	1.8	9.8	0.30	0.8
UT S6	166	0.0	6.0	2.30	0.5
UT S7	28	1.8	3.8	0.50	0.2
UT S8	89	1.8	2	0.5	0.2

A.5.2 North Zone

Table A-8-18: Proposed Grassed Swales for Limestone Creek

Swale ID	Length (m)	Base Width (m)	Top Width (m)	Slope (%)	Depth (m)
LS-S1	50	1	5	1.0	0.5
LS-S2	210	1	5	0.5	0.5

A.5.3 RCR Zone

Table A-8-19: Proposed Grassed Swales for Lotus Lagoon & Black Duck Lagoon

Swale ID	Length (m)	Base Width (m)	Top Width (m)	Slope (%)	Depth (m)
BL S1	138	2	7.0	1.3	0.5
BL S2	131	2	8.4	1.5	0.8
BL S3	118	2	8.4	1.5	0.8
BL S4	140	2	6.0	0.7	0.5
BL S5	135	2	6.0	1.0	0.5

A.6 Proposed bioretention basins

Table A-8-20, Table A-8-21 and Table A-8-22 provides details of the proposed bioretention basins in South Area, North Area and RCR Area, respectively.

Default values of Ksat (200 mm/hr), TN 800 (mg/kg) and Orthophosphate content of filter media 55 mg/kg, k and C (provided in below table) have been adopted. In addition, exfiltration rate of 0.0 mm/hr is adopted. Orthophosphate content of filter media 30 mg/kg show minor increase in phosphorus reduction. TN content of filter media 400 mg/kg also show minor increase in load reduction of TN. TN K=200 m/y and C* = 0.75 provides similar results. Due to these reasons, software default values are adopted.

	k (m/yr)	C* (mg/L)
Total Suspended Solids	8000	20.000
Total Phosphorus	6000	0.130
Total Nitrogen	500	1.400

A.6.1 South Area

Table A-8-20: Proposed bioretention basins with inlet sediment basin in South Area

Model	Bioretention basin	Inlet Sediment Basin (m^2)	Extended Detention Depth (m)	Surface Area (m^2)	Filter Area (m2)	Filter Depth (m)	Overflow Weir Width (m)
Fitzroy River	WQ-BB07	24	0.3	155.4	100	0.6	4
	WQ-BB08	28	0.3	155.4	100	0.6	5
Pink Lily	WQ-BB05	35	0.3	318.2	225	0.6	5
	WQ-BB06	35	0.3	284.2	200	0.6	4
Lotus Lagoon	WQ-BS03	20	0.0	126.4	80	0.6	2
	WQ-BS05	20	0.0	126.4	80	0.6	2
	WQ-BS07	20	0.0	184.4	120	0.6	2
	WQ-BS08	20	0.0	155.4	100	0.6	2
	WQ-BB04	20	0.3	155.4	100	0.6	3
Lion Creek	WQ-BS01	20	0.0	126.4	80	0.5	2
	WQ-BB03	20	0.3	155.4	100	0.6	3
Nelson Creek	WQ-BB01	24	0.3	97.4	60	0.6	4
	WQ-BB02	20	0.3	126.4	80	0.6	3

A.6.2 North Area

Table A-8-21: Proposed bioretention basins in North Area

Model	Bioretent ion basin	Inlet Sediment Basin (m^2)	Extended Detention Depth (m)	Surface Area (m^2)	Filter Area (m2)	Filter Depth (m)	Overflow Weir Width (m)
Limestone Creek	WQ-BB09	20	0.3	97.4	60	0.6	2
Limestone Creek	WQ-BB10	20	0.3	97.4	60	0.6	2

A.6.3 RCR Area

Table A-8-22: Proposed bioretention basins in RCR Area

Model	Bioretent ion basin	Inlet Sediment Basin (m^2)	Extended Detention Depth (m)	Surface Area (m^2)	Filter Area (m2)	Filter Depth (m)	Overflow Weir Width (m)
Black Duck Lagoon	WQ-BB11	32	0.3	97.4	60	0.6	4
Lion Creek	WQ-BB12	20	0.3	111	80	0.6	2
	WQ-BB13	20	0.3	111	80	0.6	2

Appendix B. MUSIC Model Network Configuration

Default drainage links are adopted to connect source node to treatment devices or junction nodes. Secondary links are used for high flow bypass or weir overflow for inlet sediment basin.

B.1 South Area

B.1.1 Fitzroy River

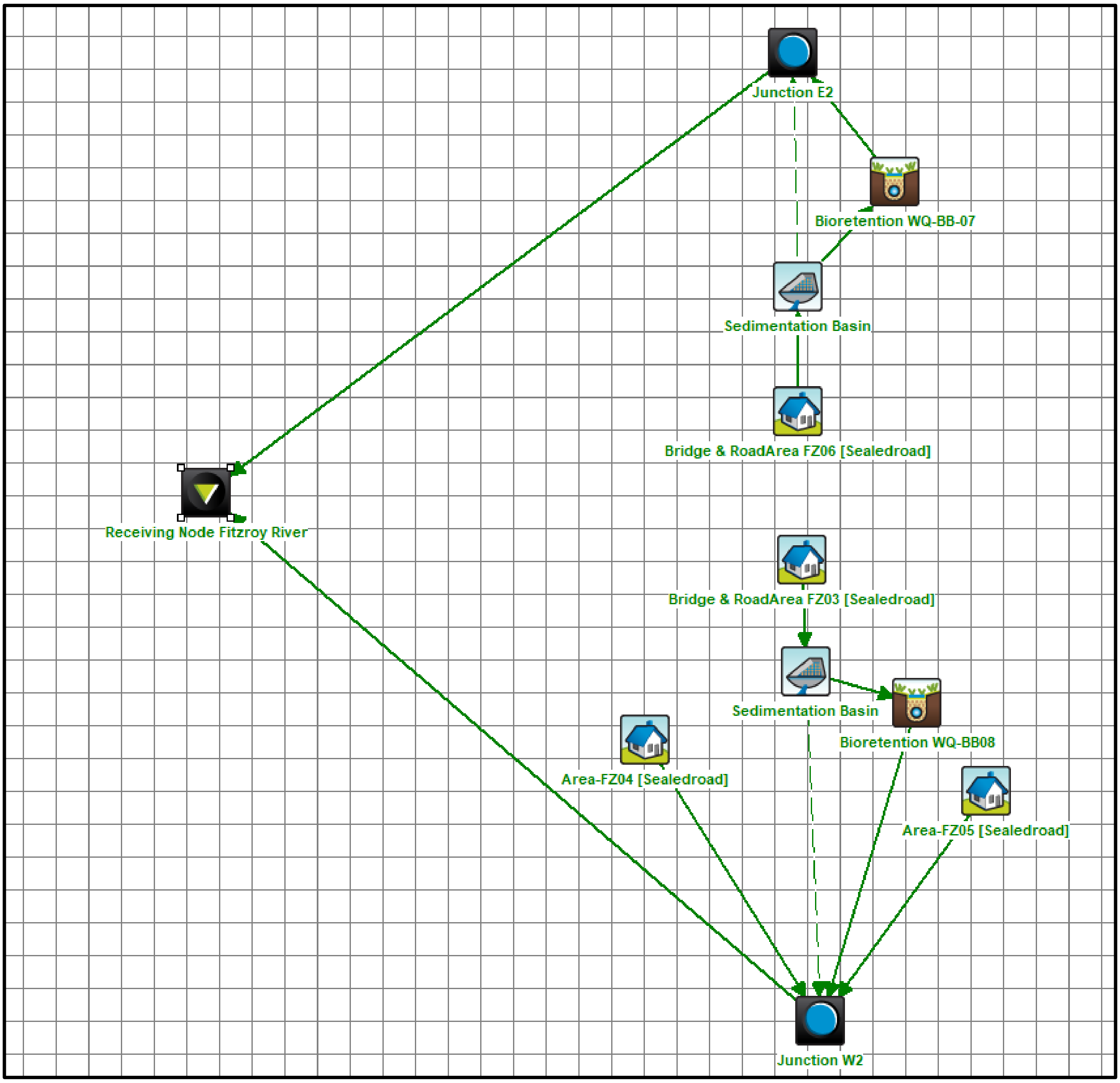


Figure B.11: Fitzroy River MUSIC Model

B.1.2 Pink Lily Lagoon & Unnamed Lagoon

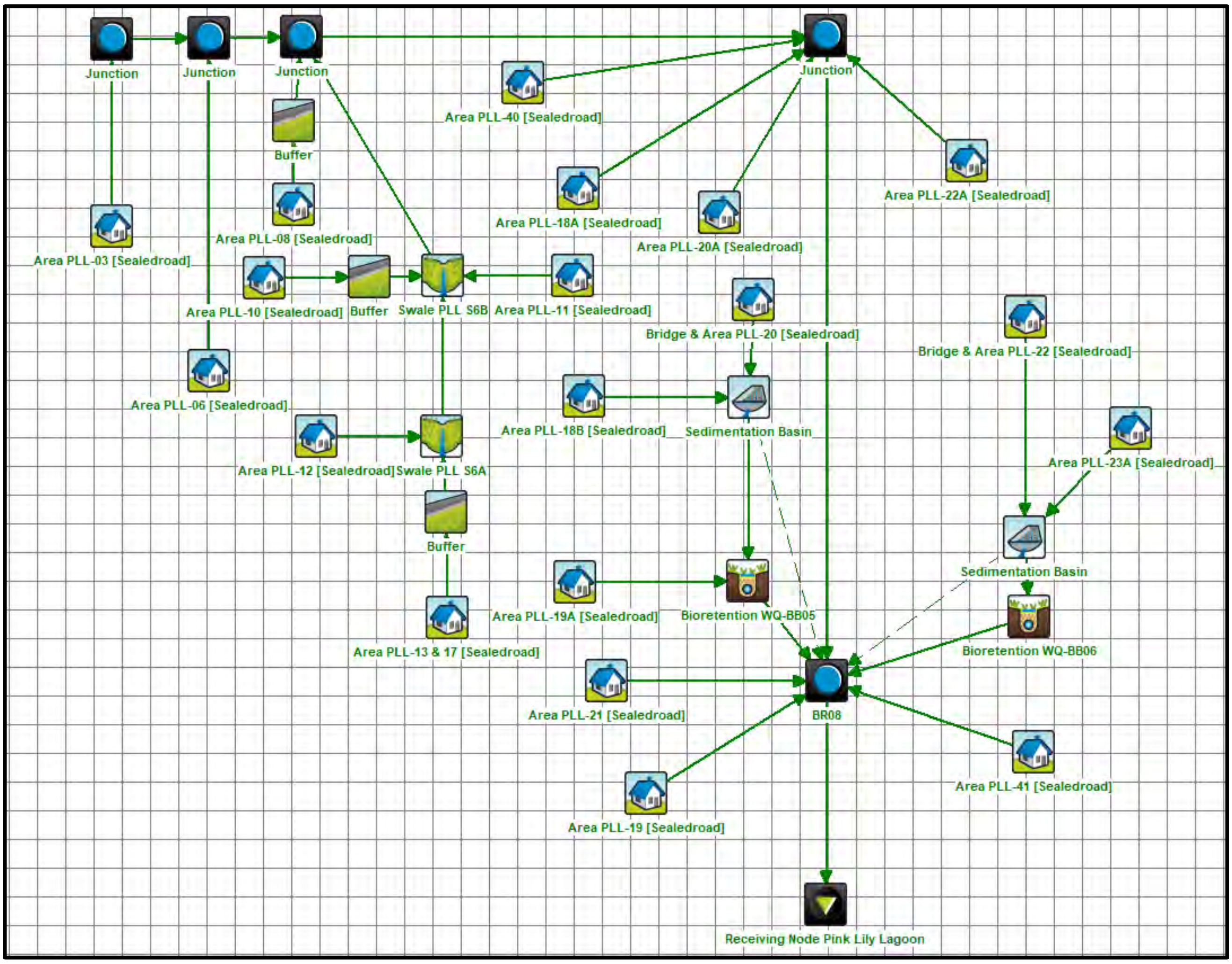


Figure B.12: Pink Lily Lagoon MUSIC Model

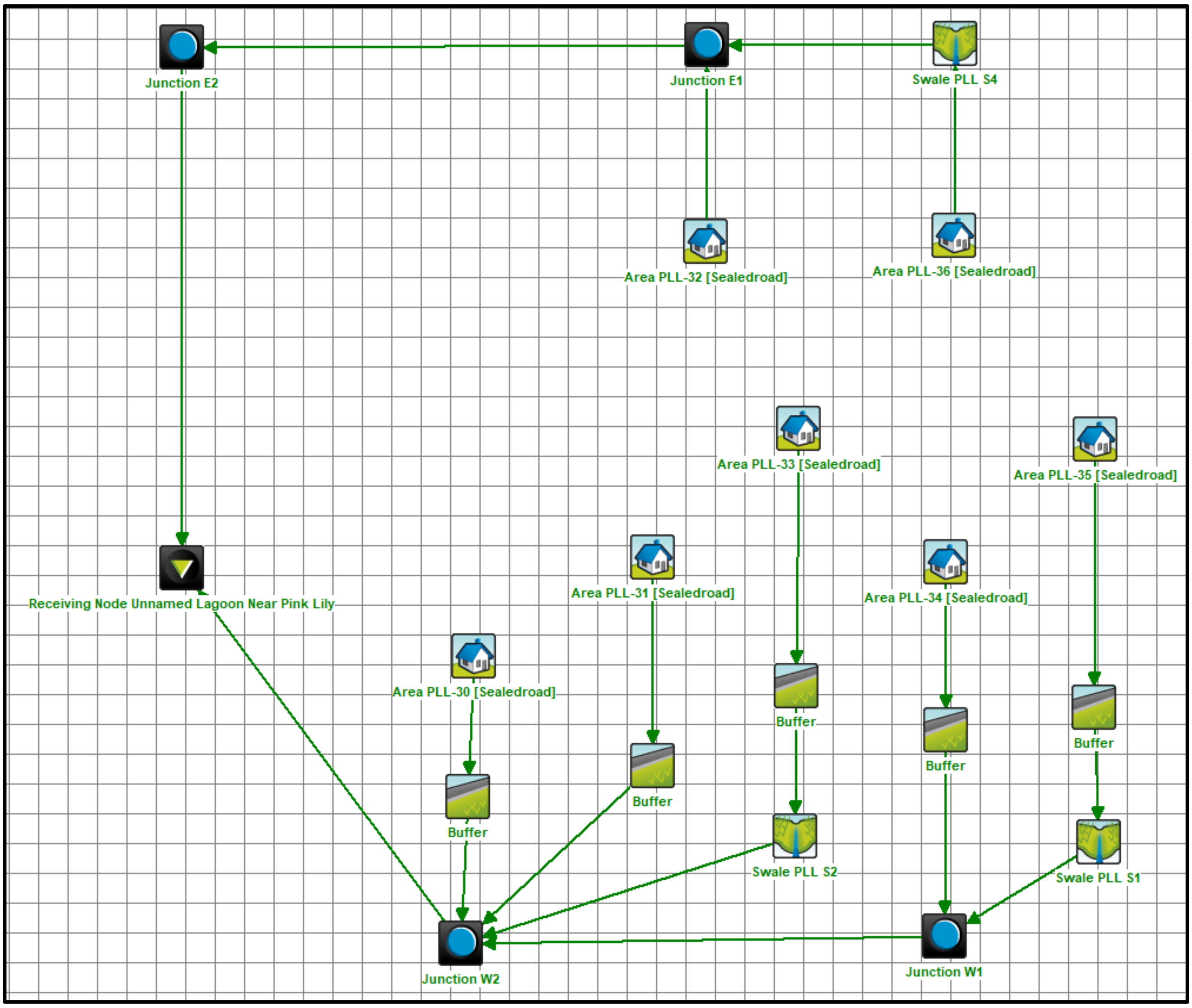


Figure B.13: Unnamed Lagoon Near Pink Lily Lagoon MUSIC Model

B.1.3 Lotus Lagoon

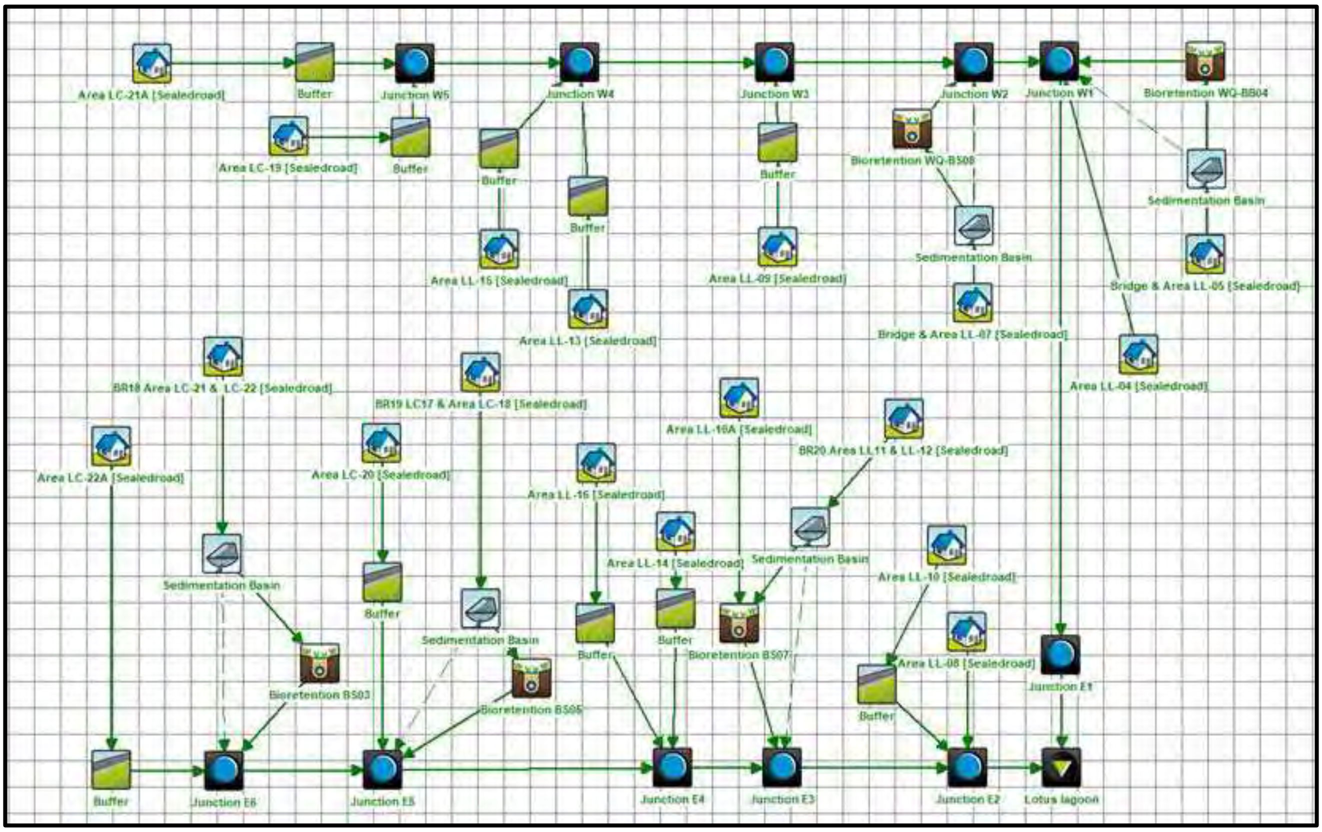


Figure B.14: Lotus Lagoon MUSIC Model

B.1.4 Lion Creek

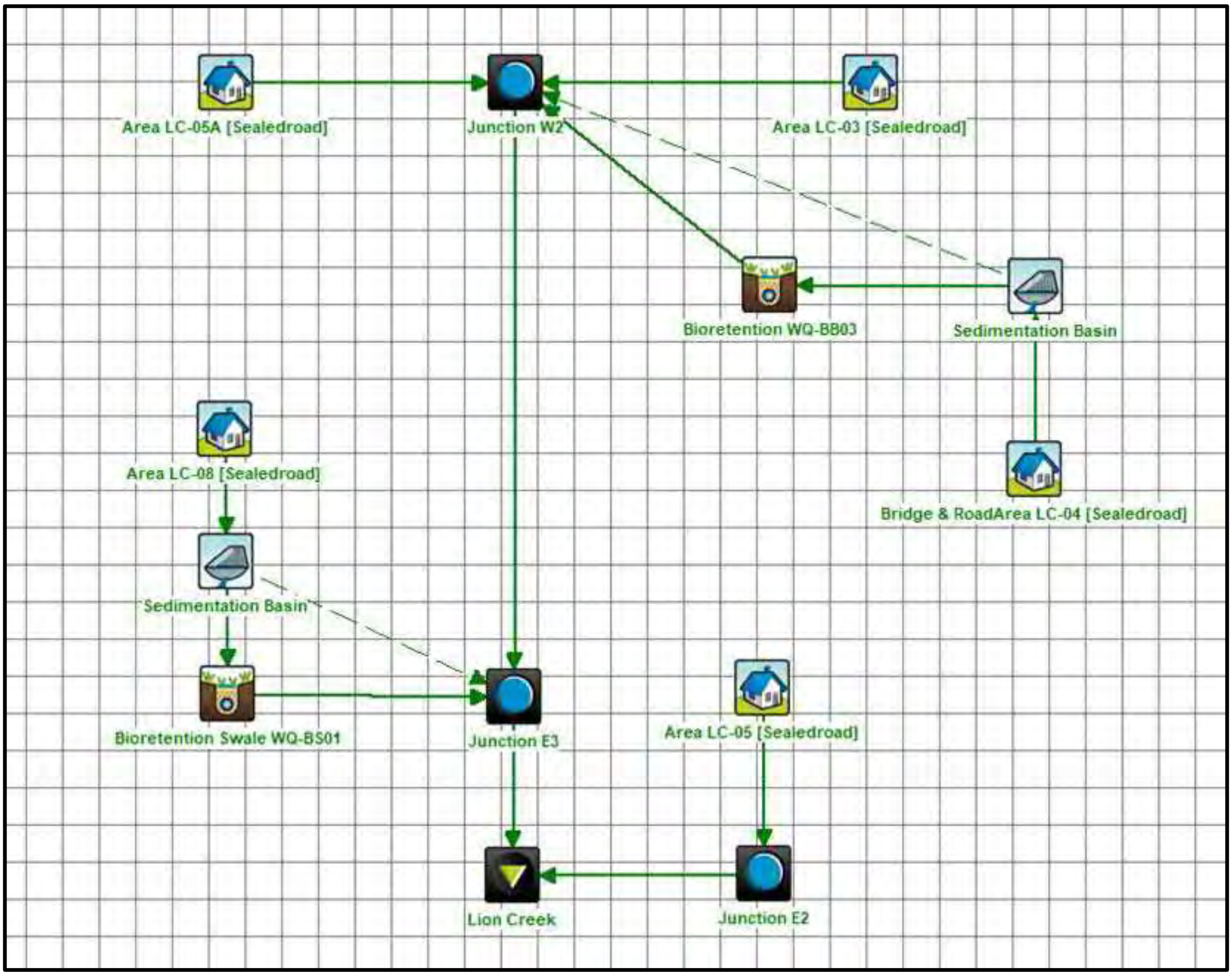


Figure B.15: Lion Creek (South Area) MUSIC Model

B.1.5 Nelson Lagoon

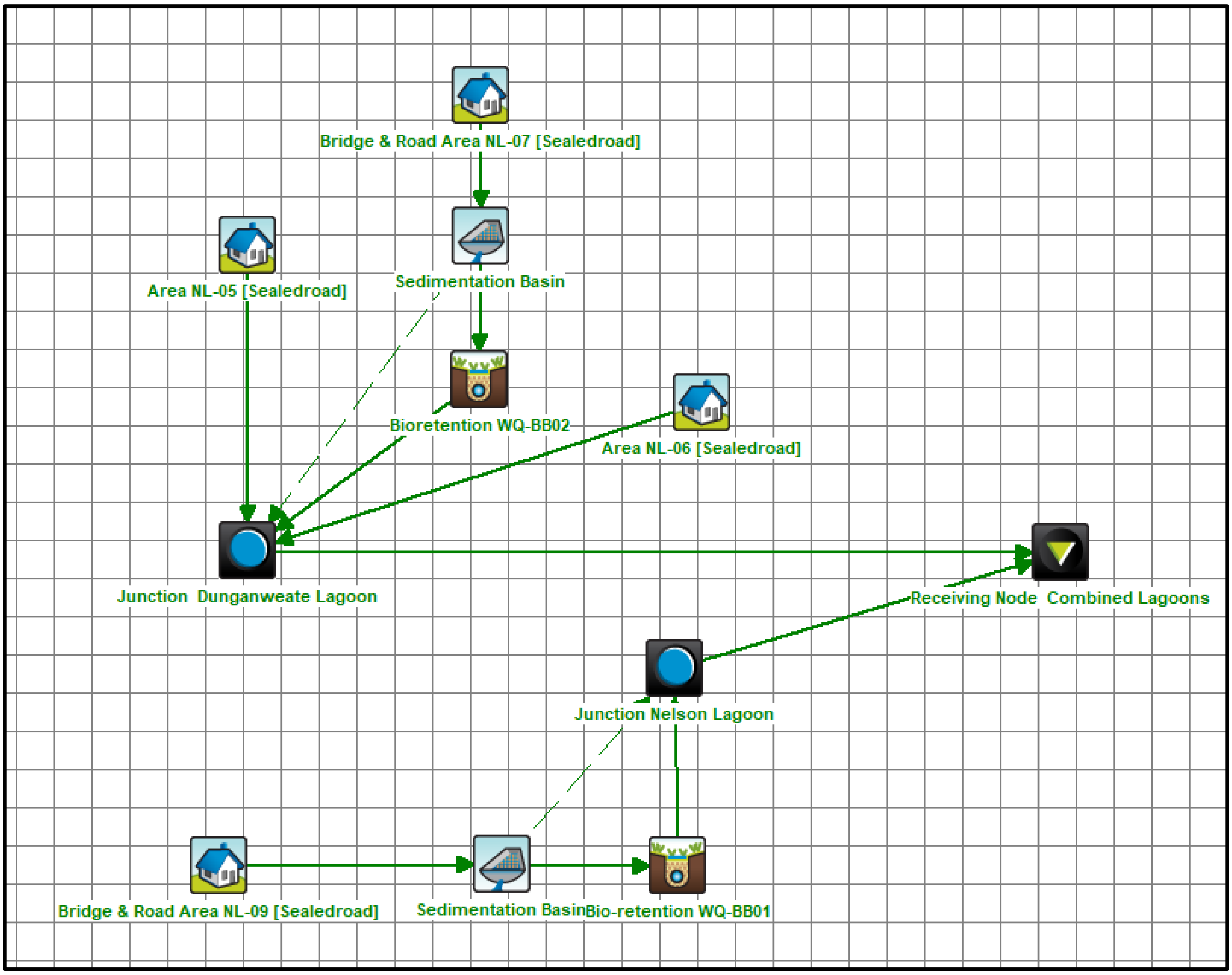


Figure B.16: Nelson Lagoon and Dunganweate Lagoon MUSIC Model

B.2 North Area

B.2.1 Limestone Creek

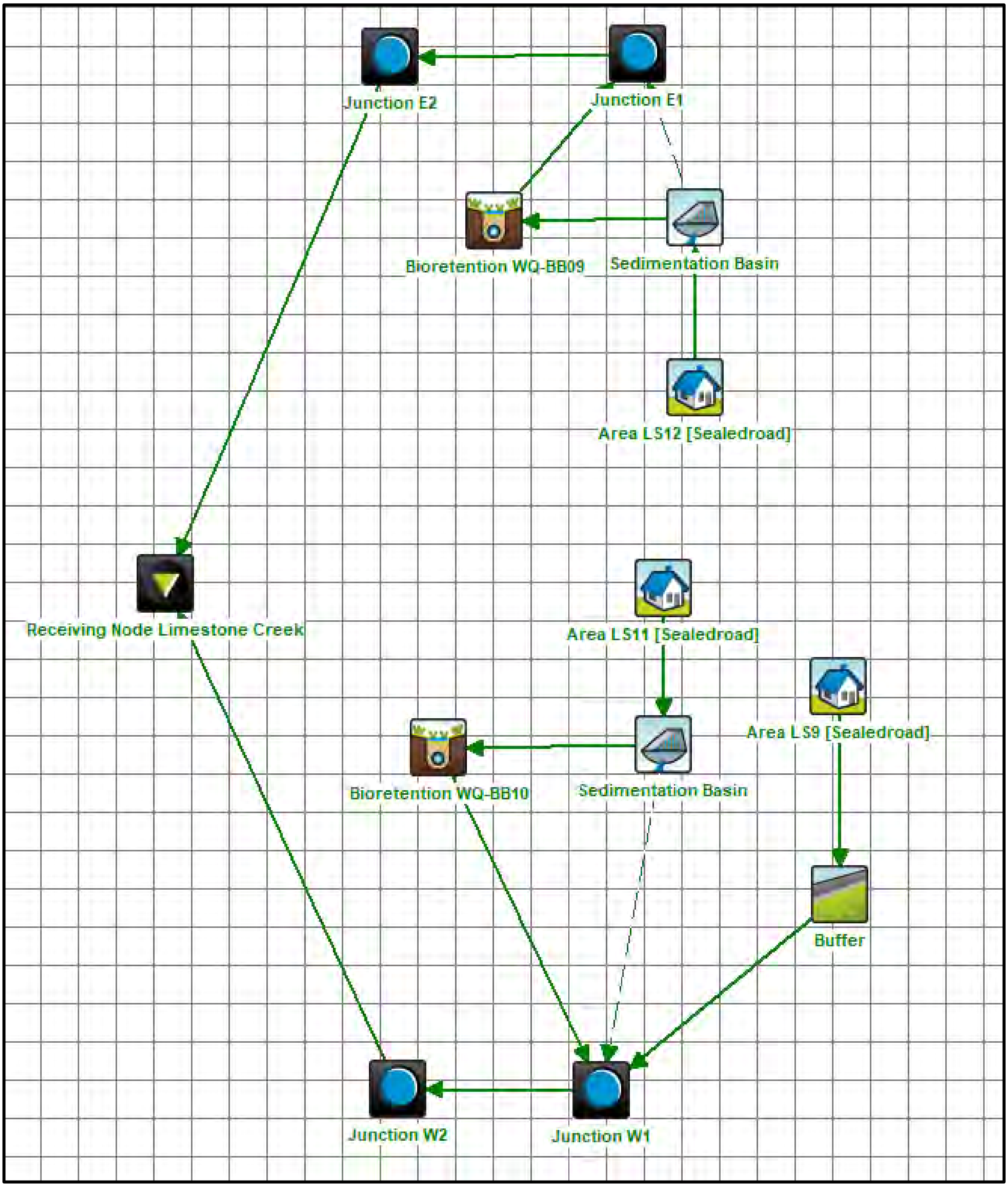


Figure B.17: Limestone Creek MUSIC Model

B.3 RCR Area

B.3.1 Lotus Lagoon and Black Duck Lagoon

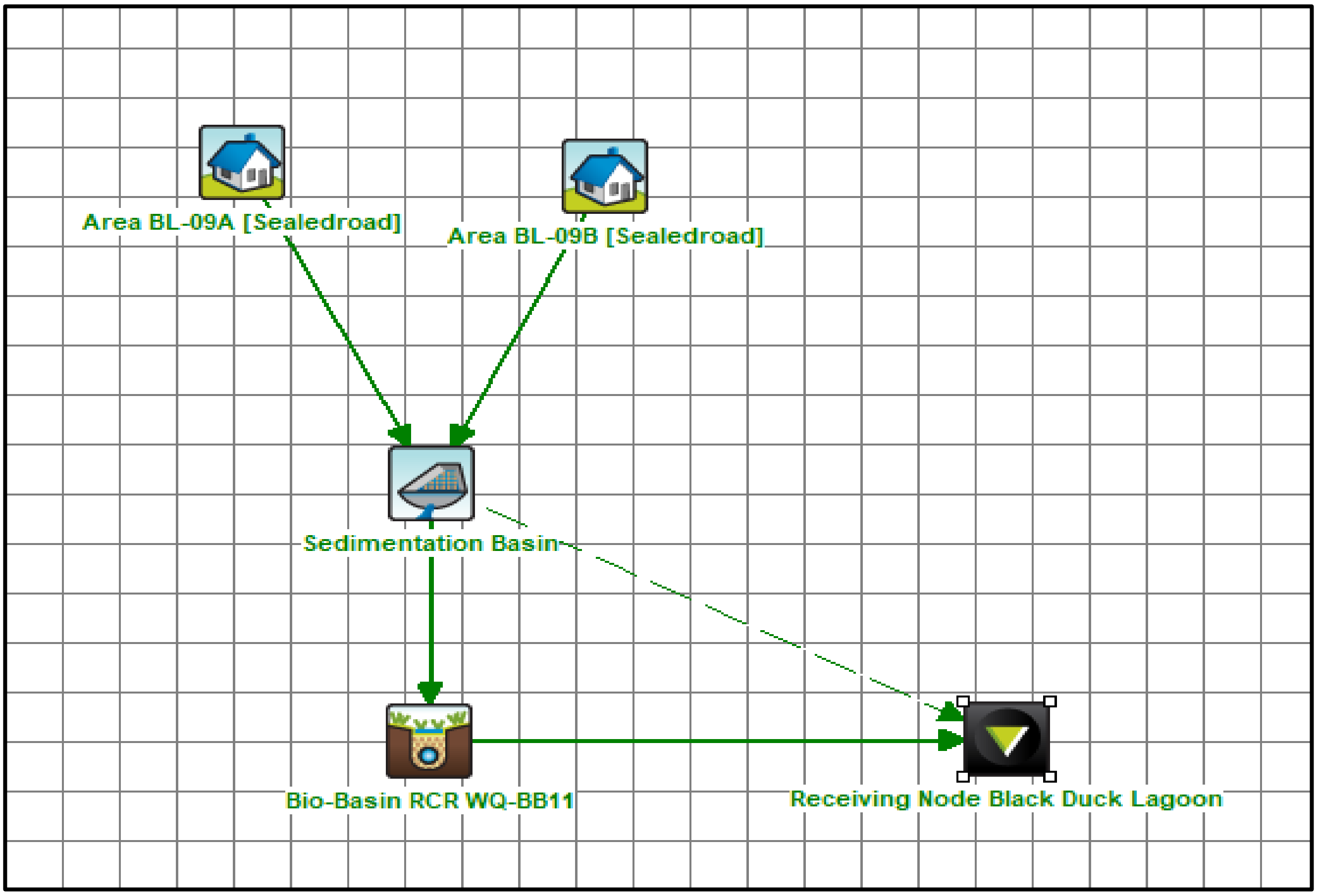


Figure B.18: Black Duck Lagoon MUSIC Model

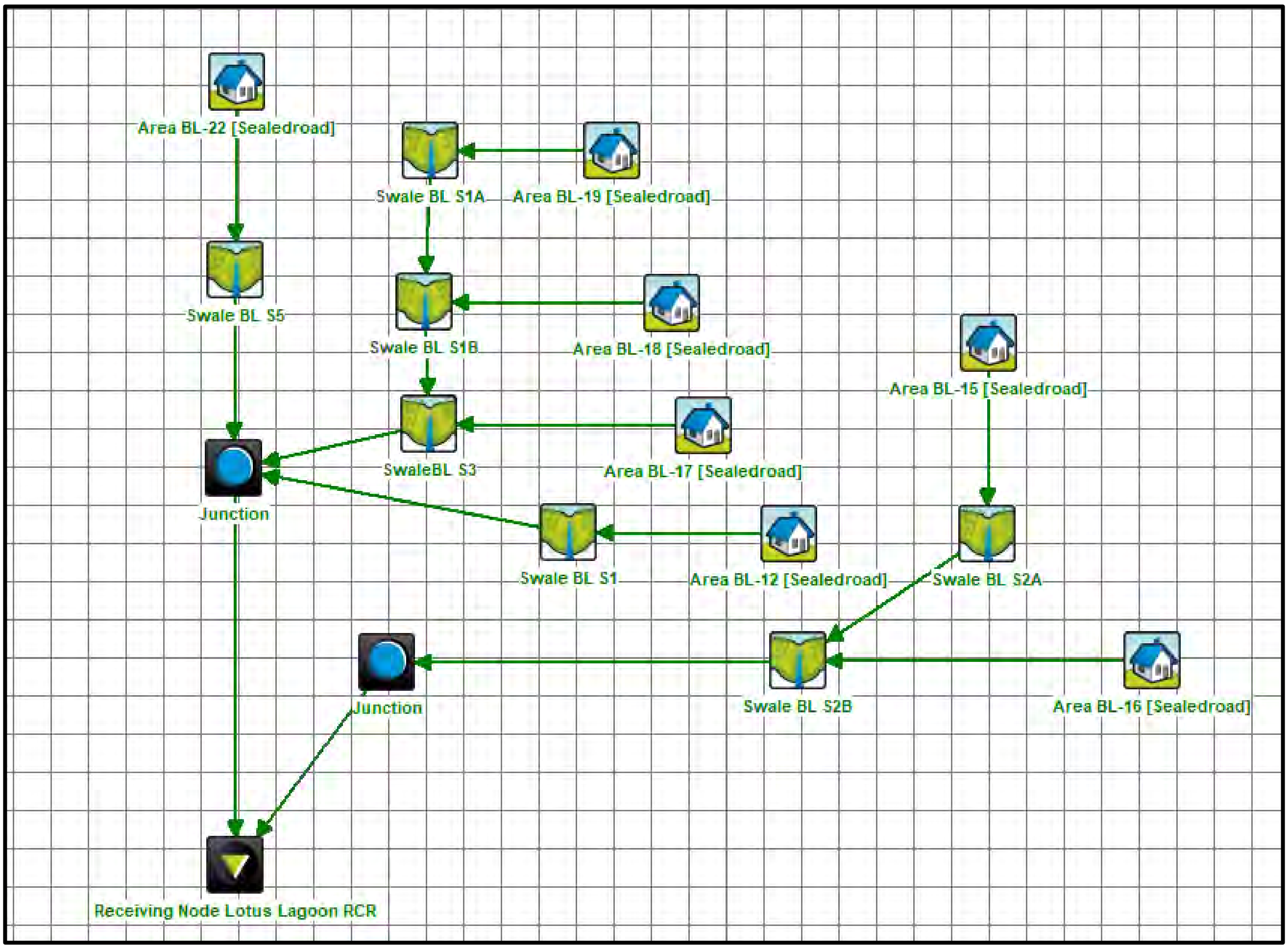


Figure B.19: Lotus Lagoon MUSIC Model

B.3.2 Lion Creek

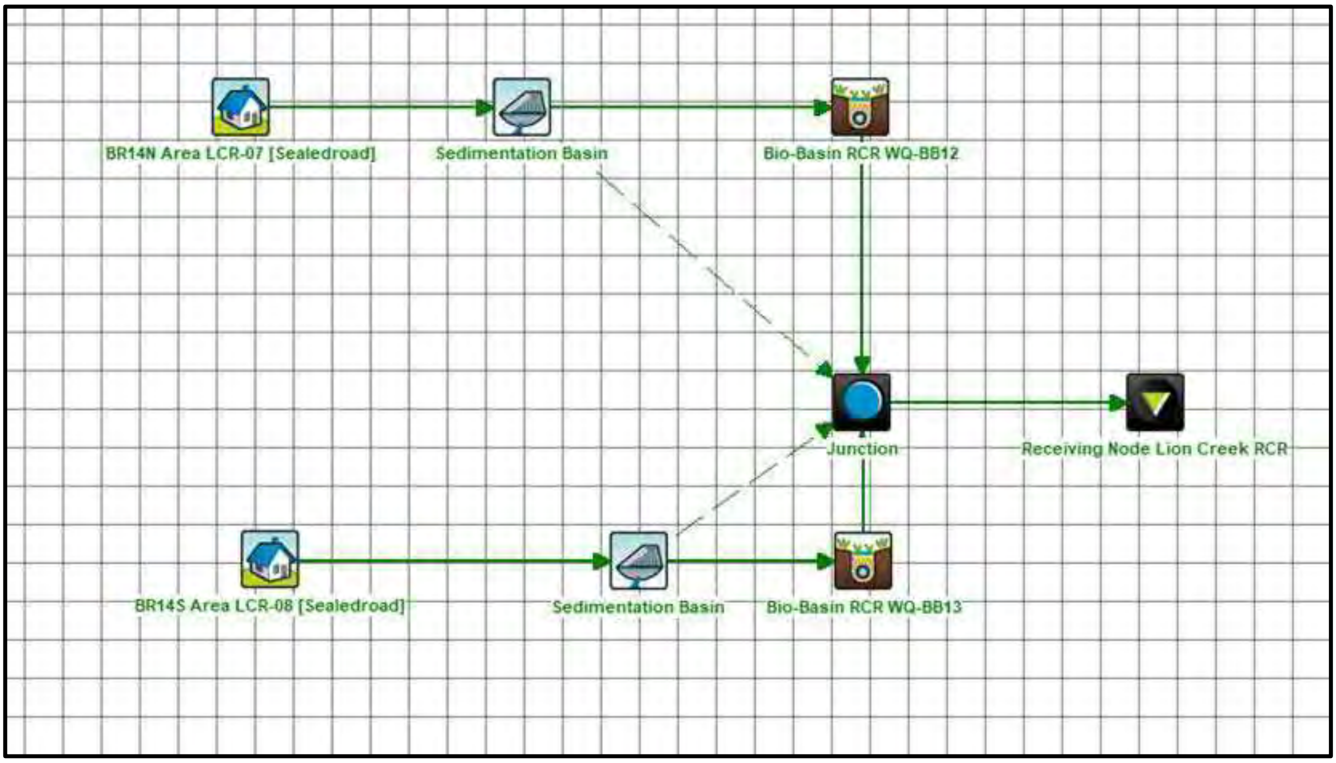
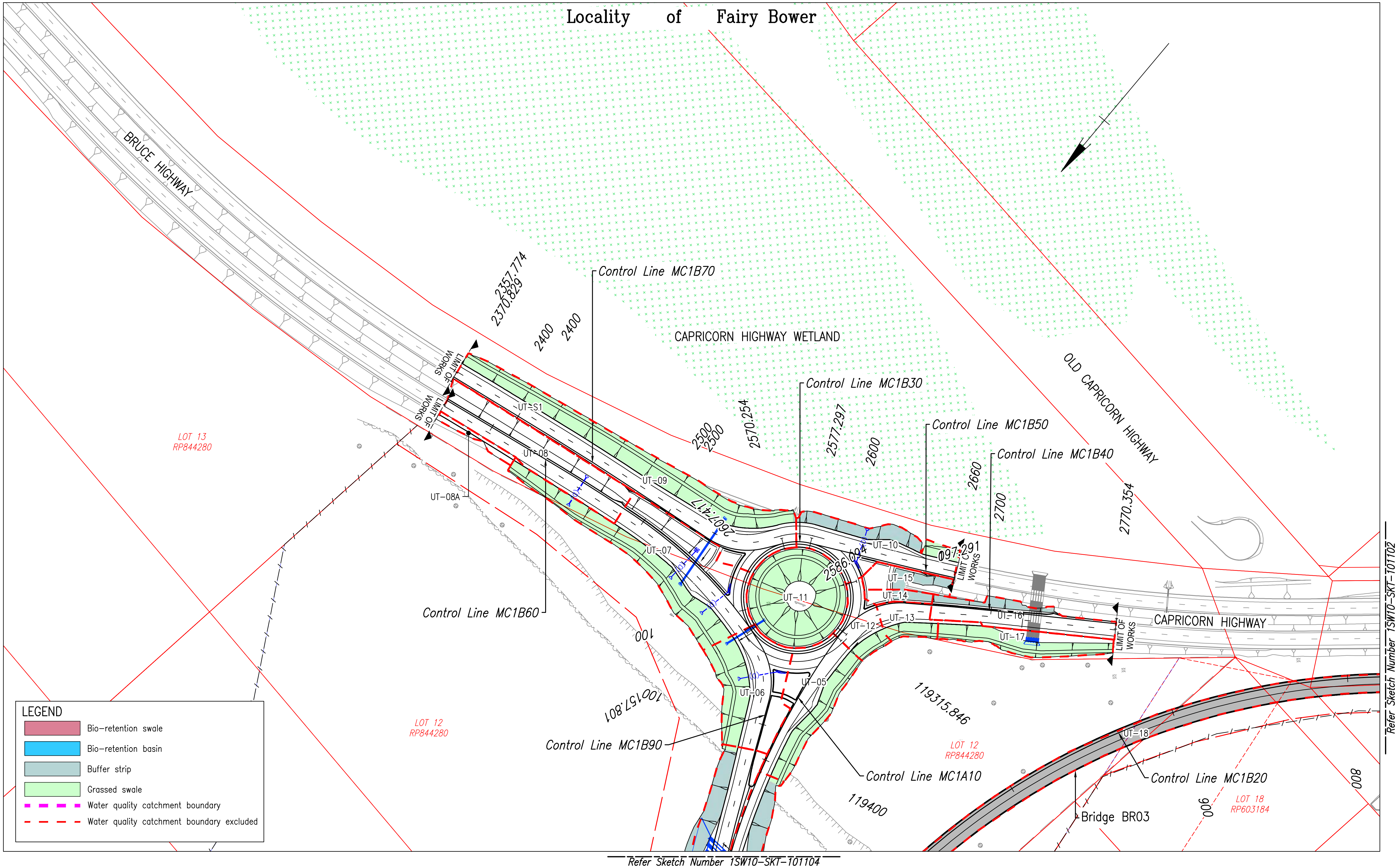


Figure B.20: Lion Creek (RCR Area) MUSIC Model

Appendix C. Water Quality Catchment Maps



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ROCKHAMPTON RING ROAD
WATER QUALITY CATCHMENT PLAN - SHEET 1

INFORMATION DOCUMENT

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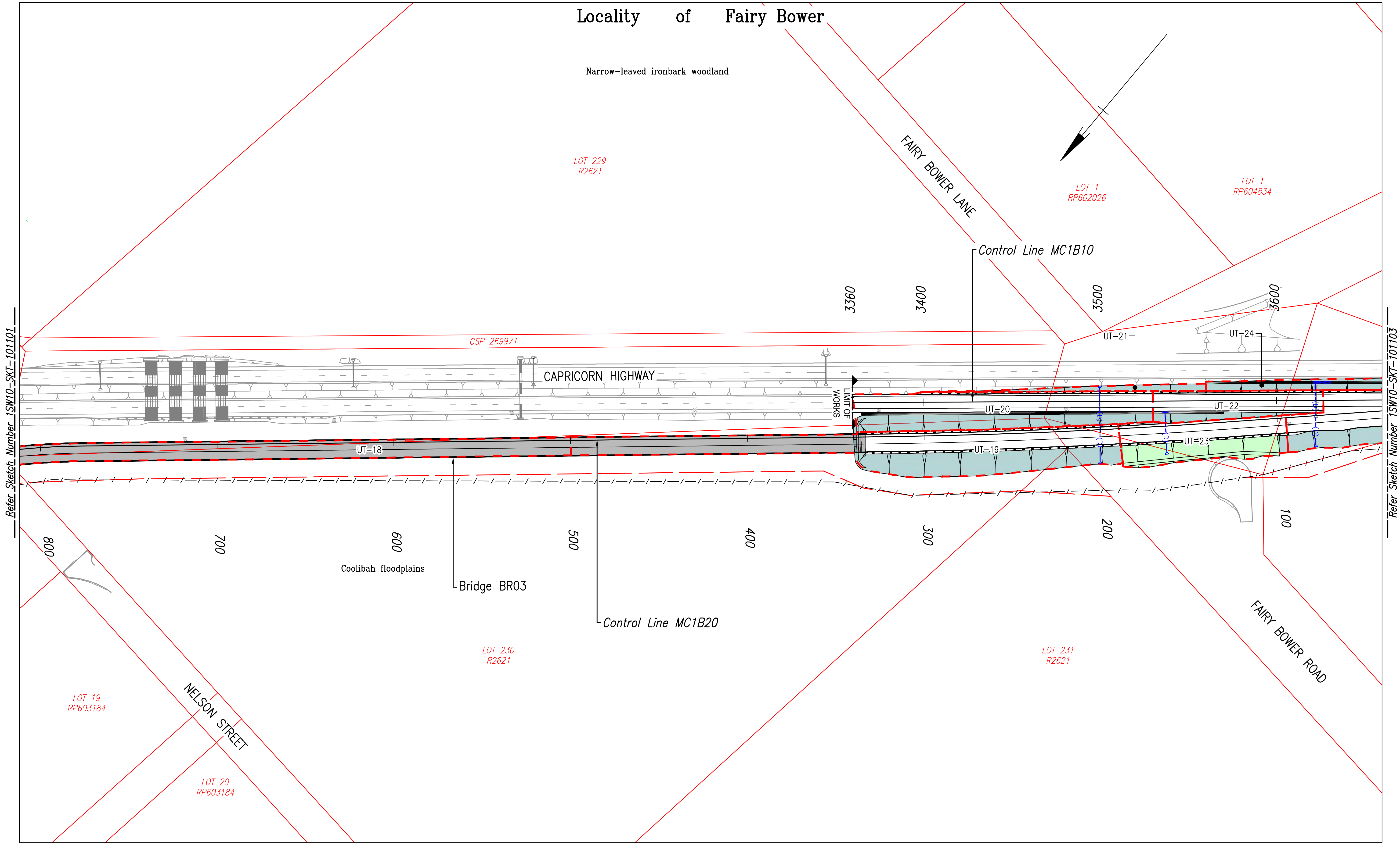

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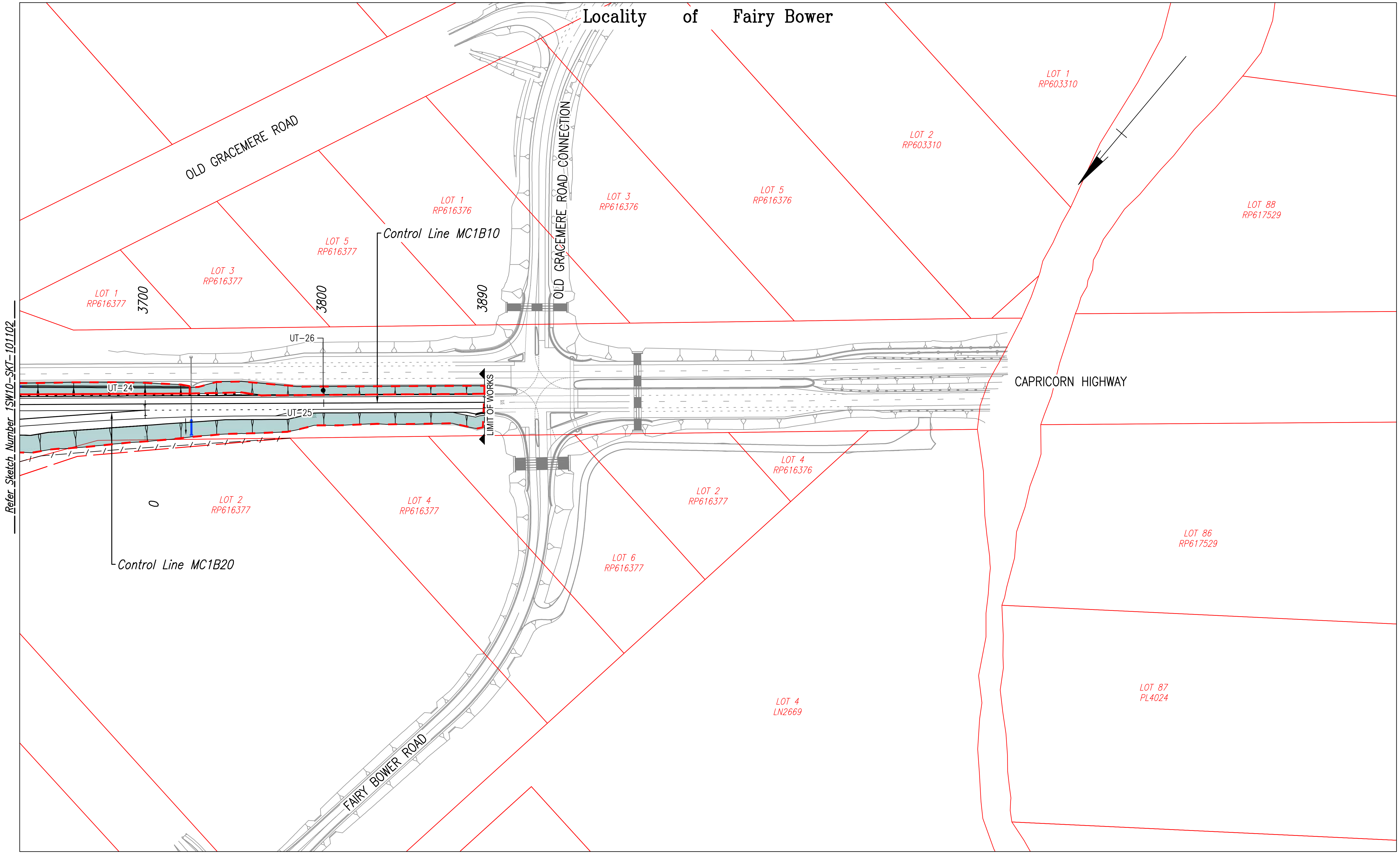

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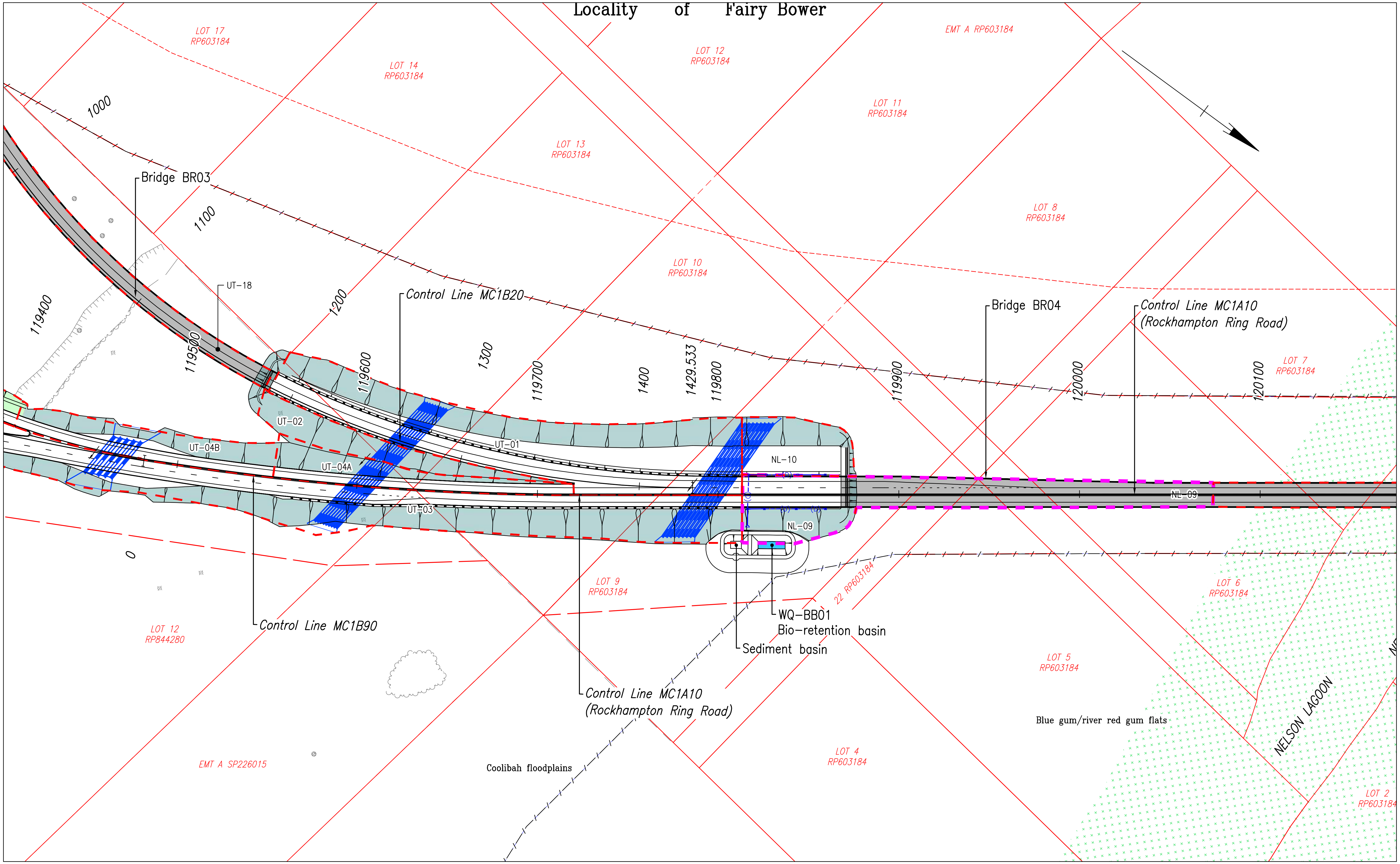

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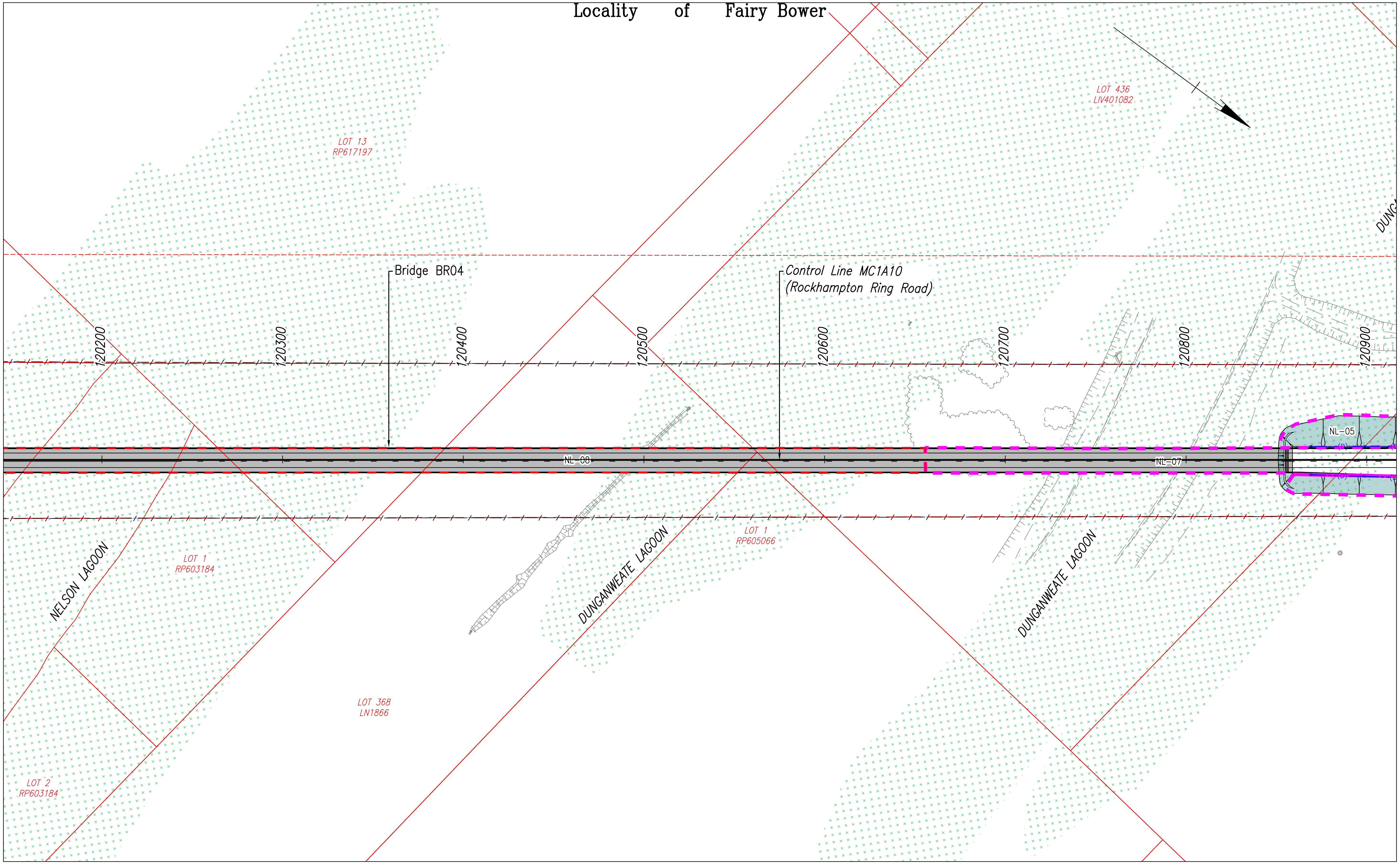

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ROCKHAMPTON RING ROAD
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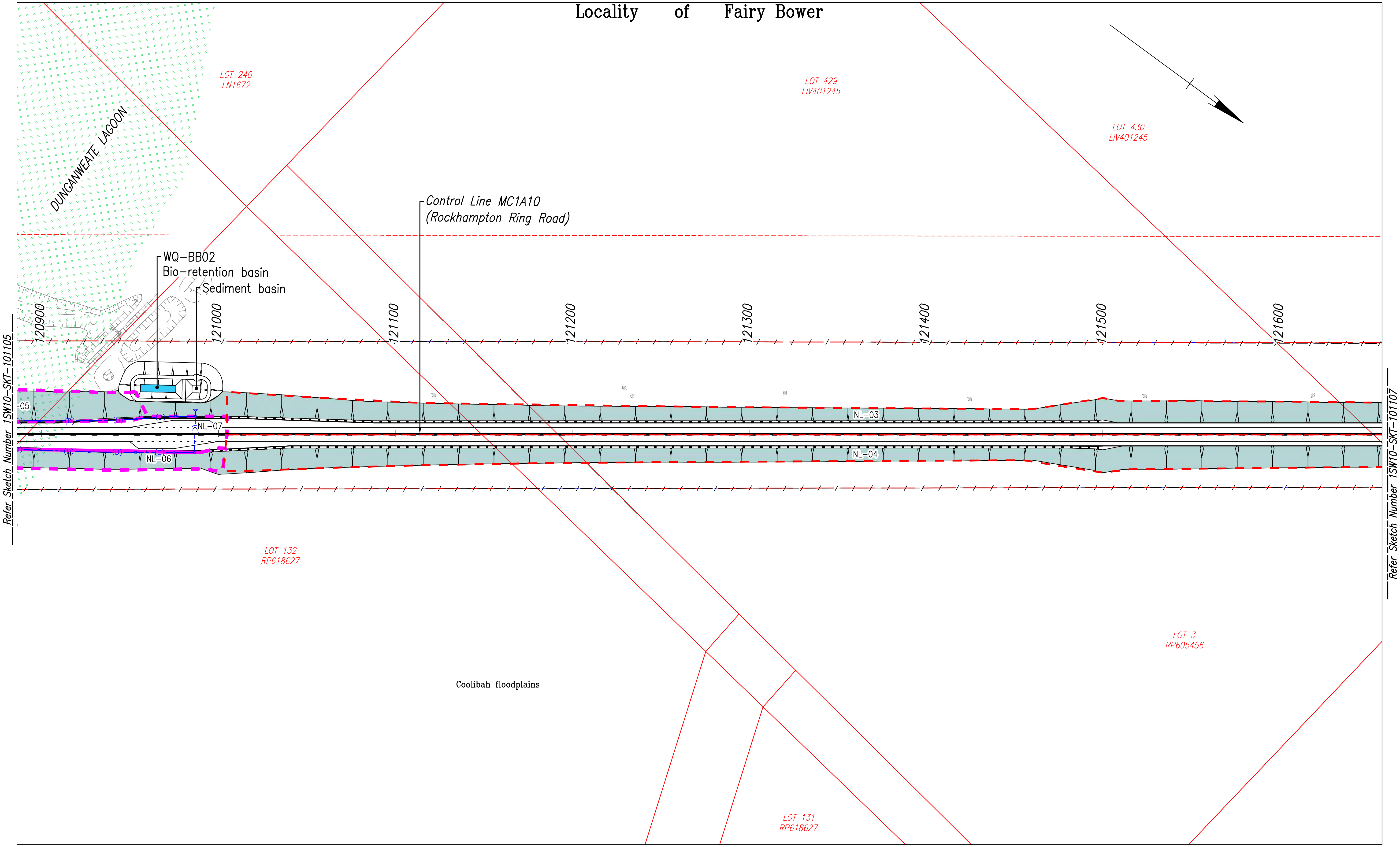

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WATER QUALITY CATCHMENT PLAN - SHEET 6

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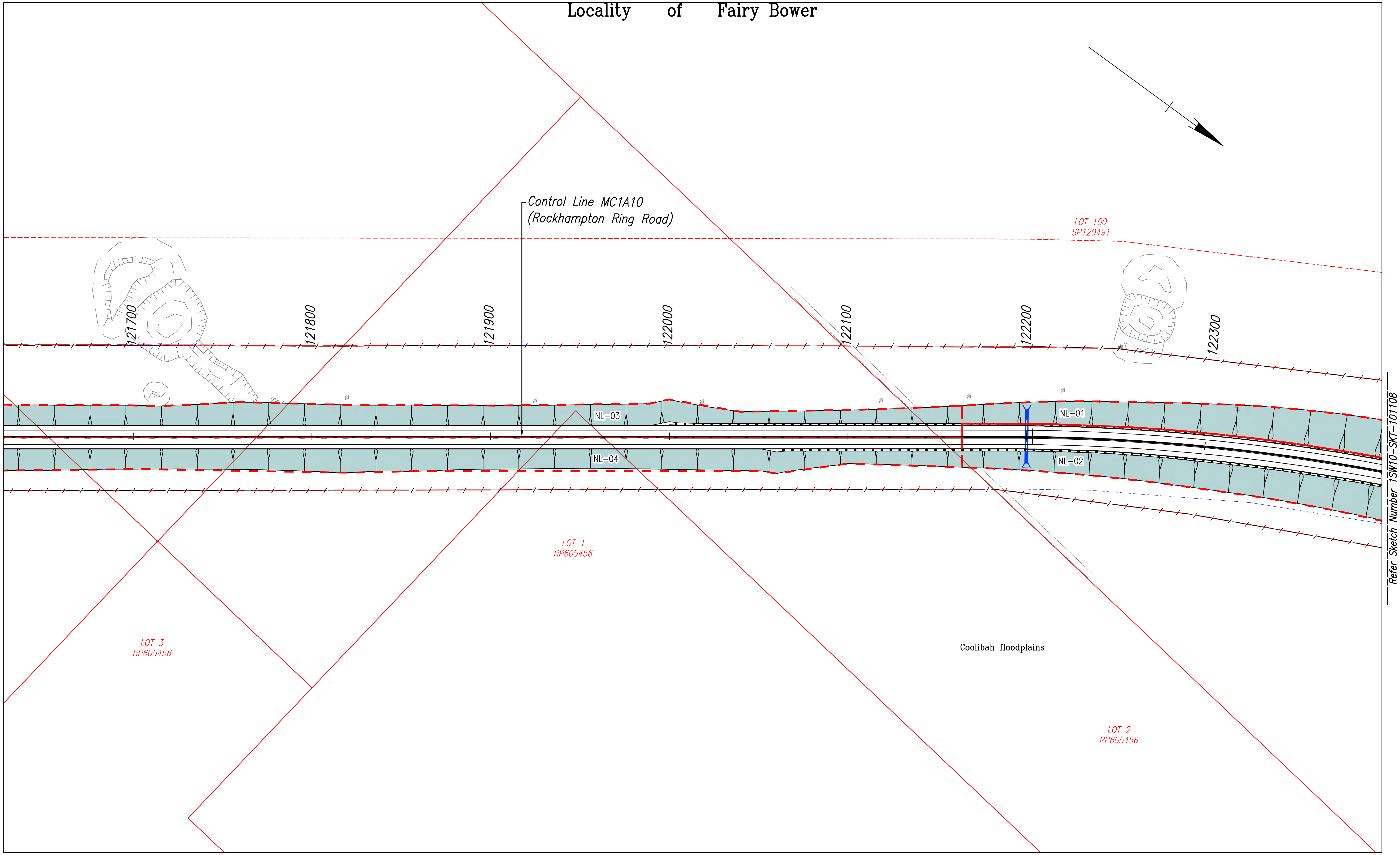

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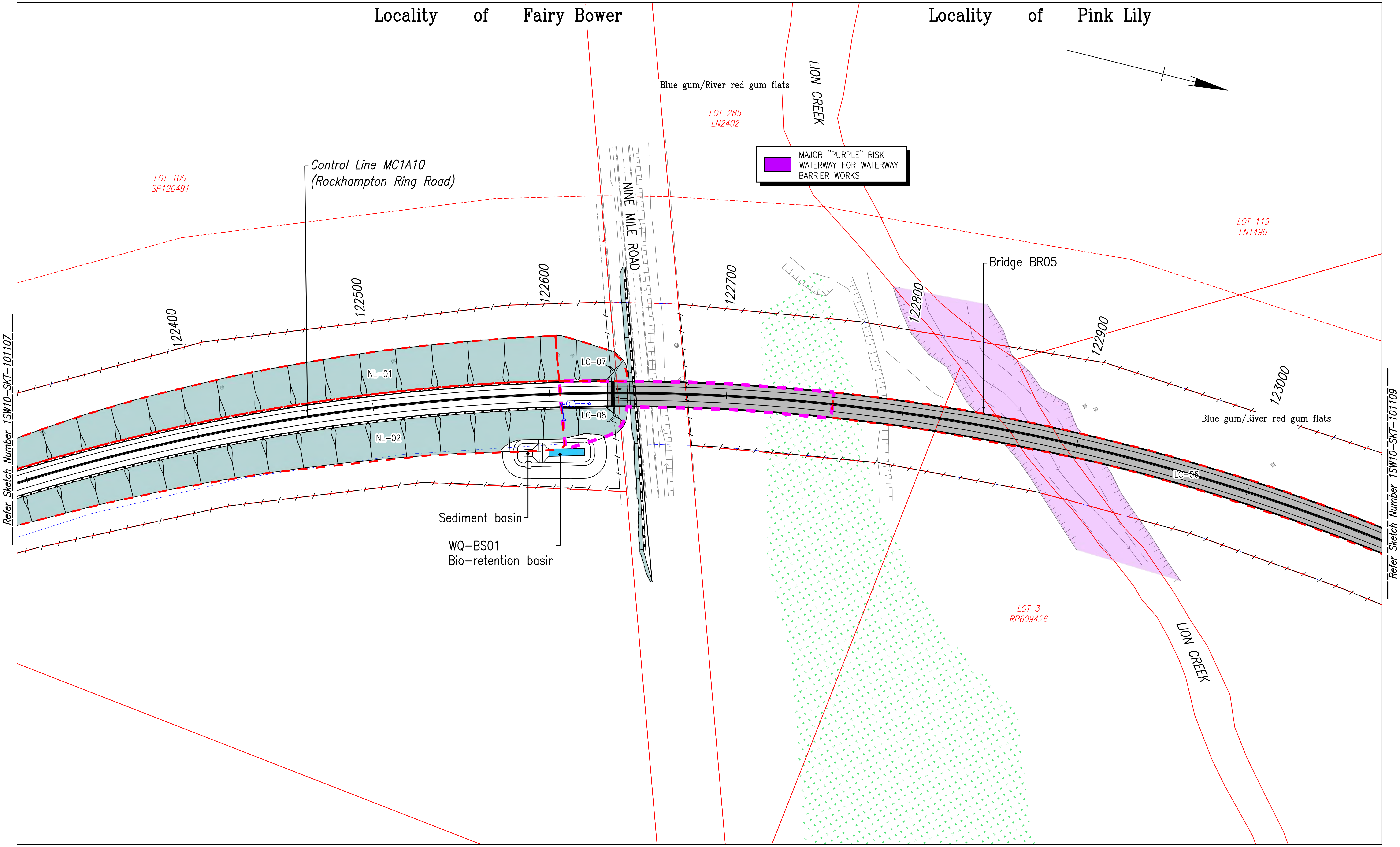

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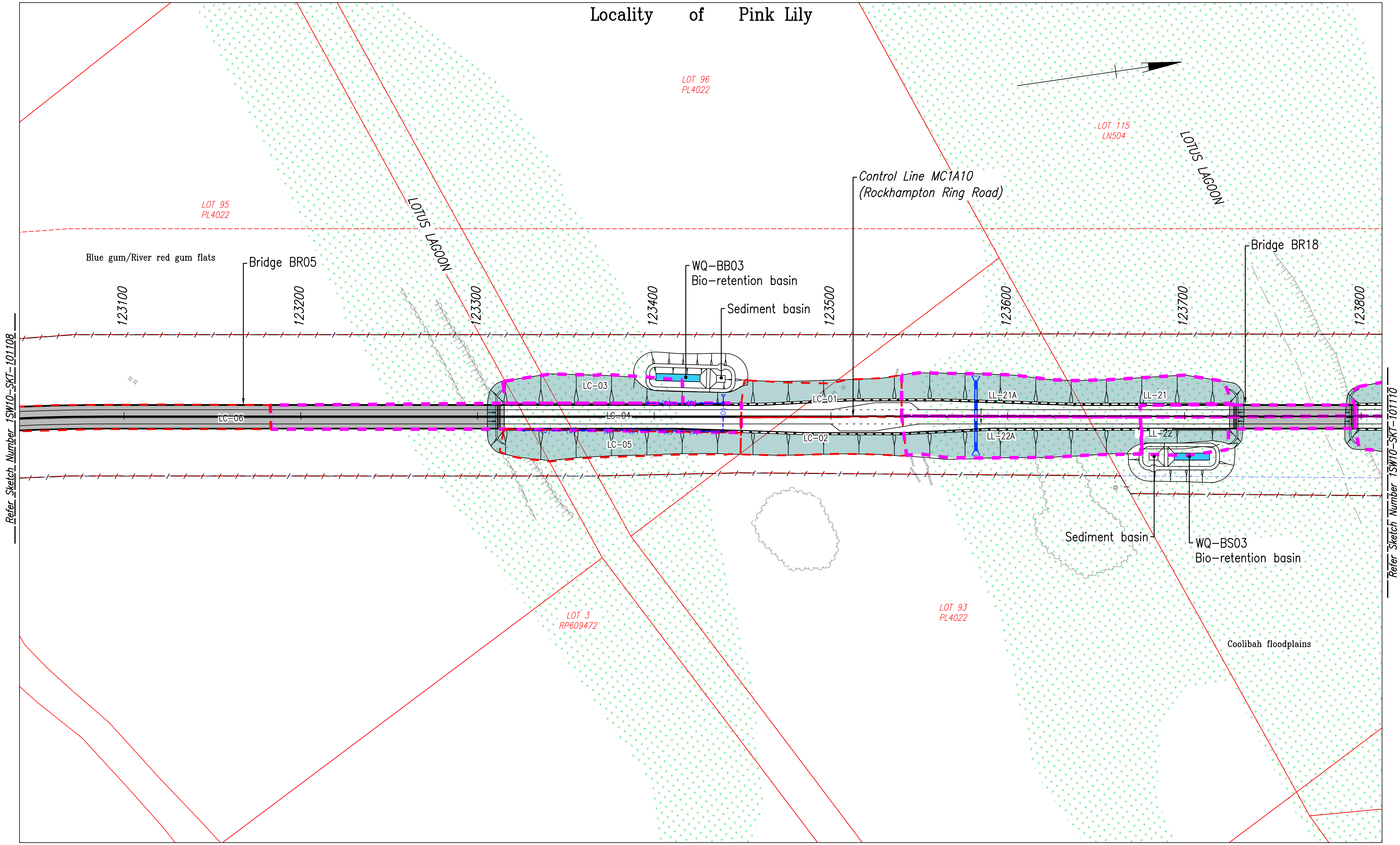

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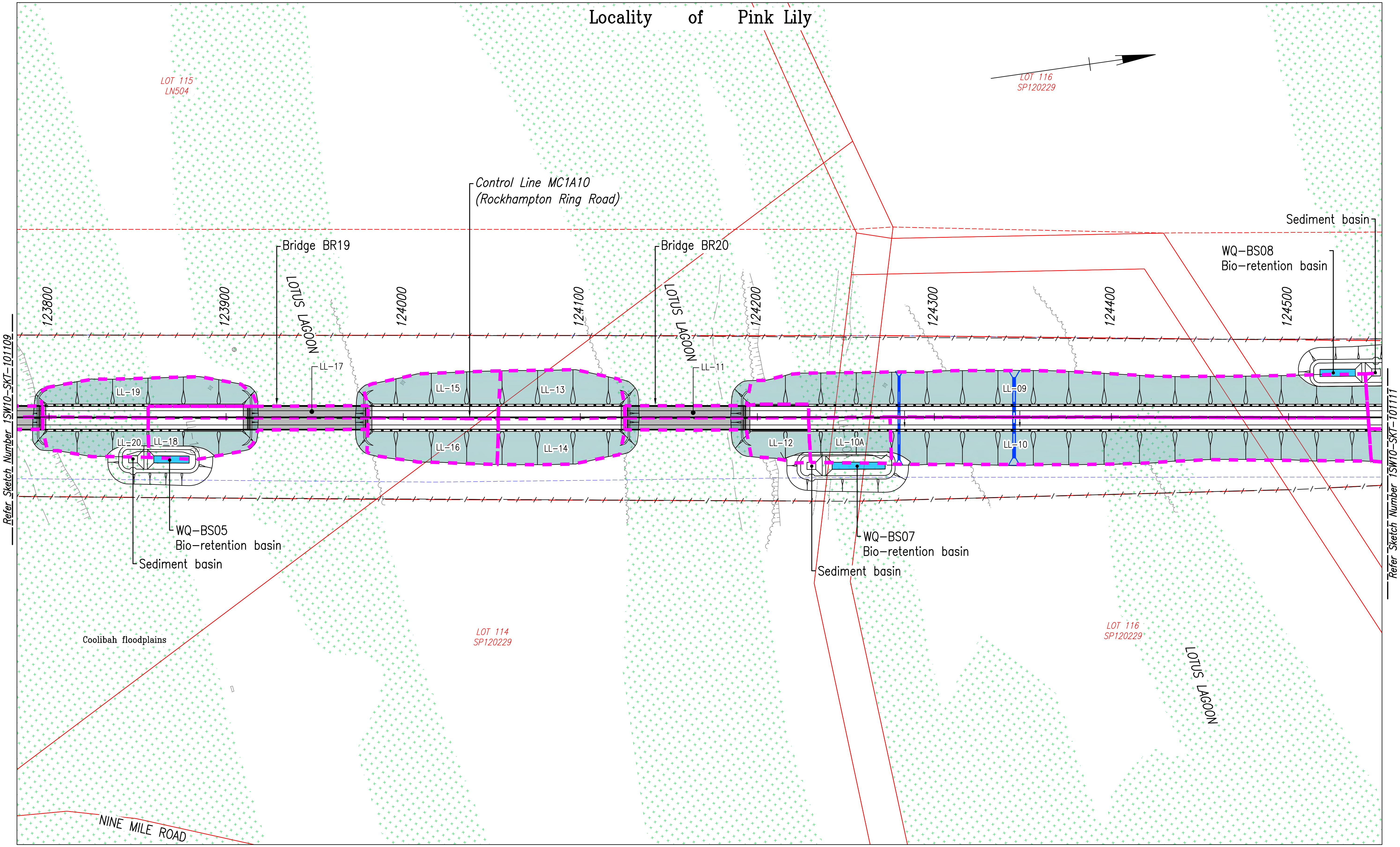

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WATER QUALITY CATCHMENT PLAN - SHEET 10

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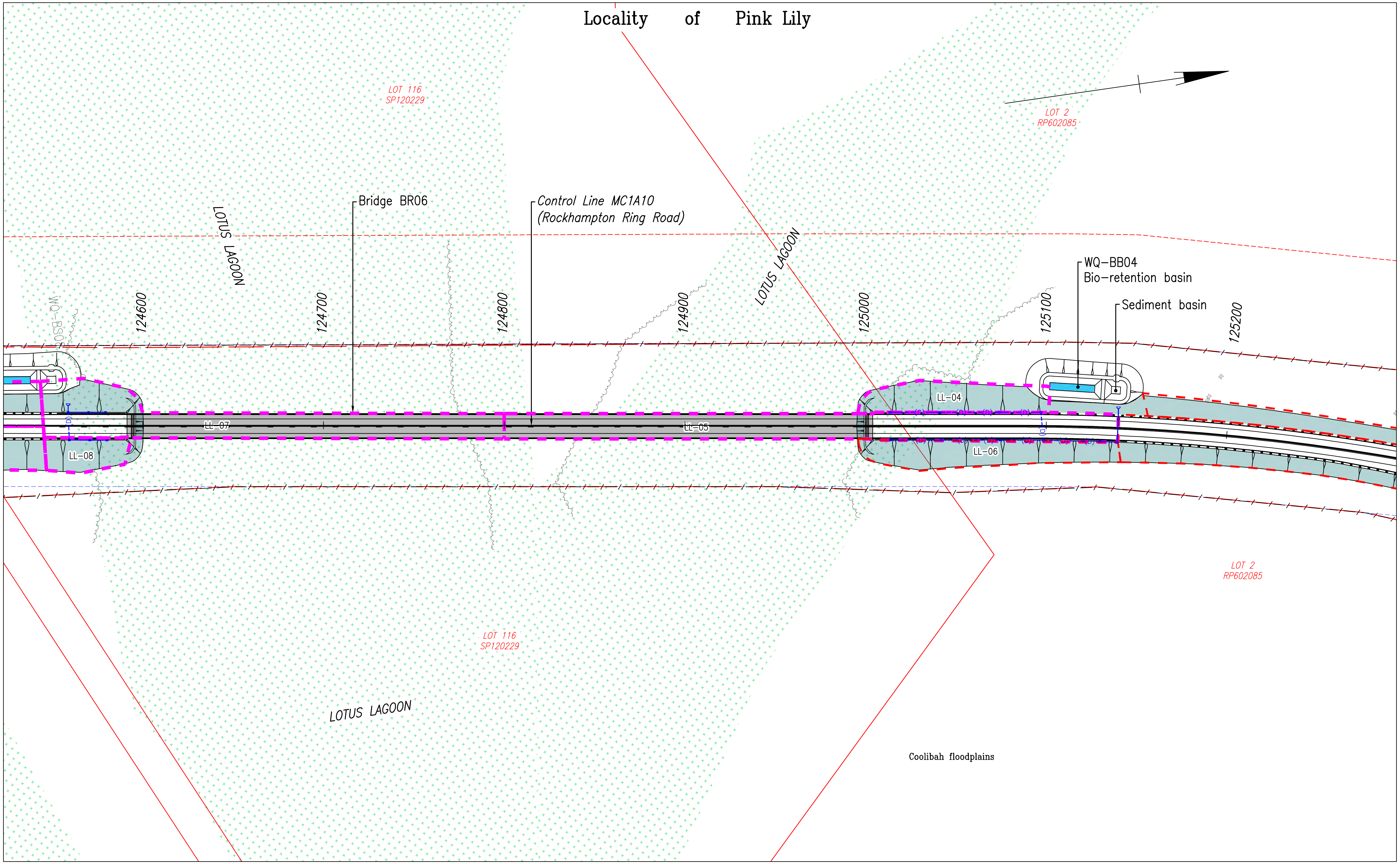

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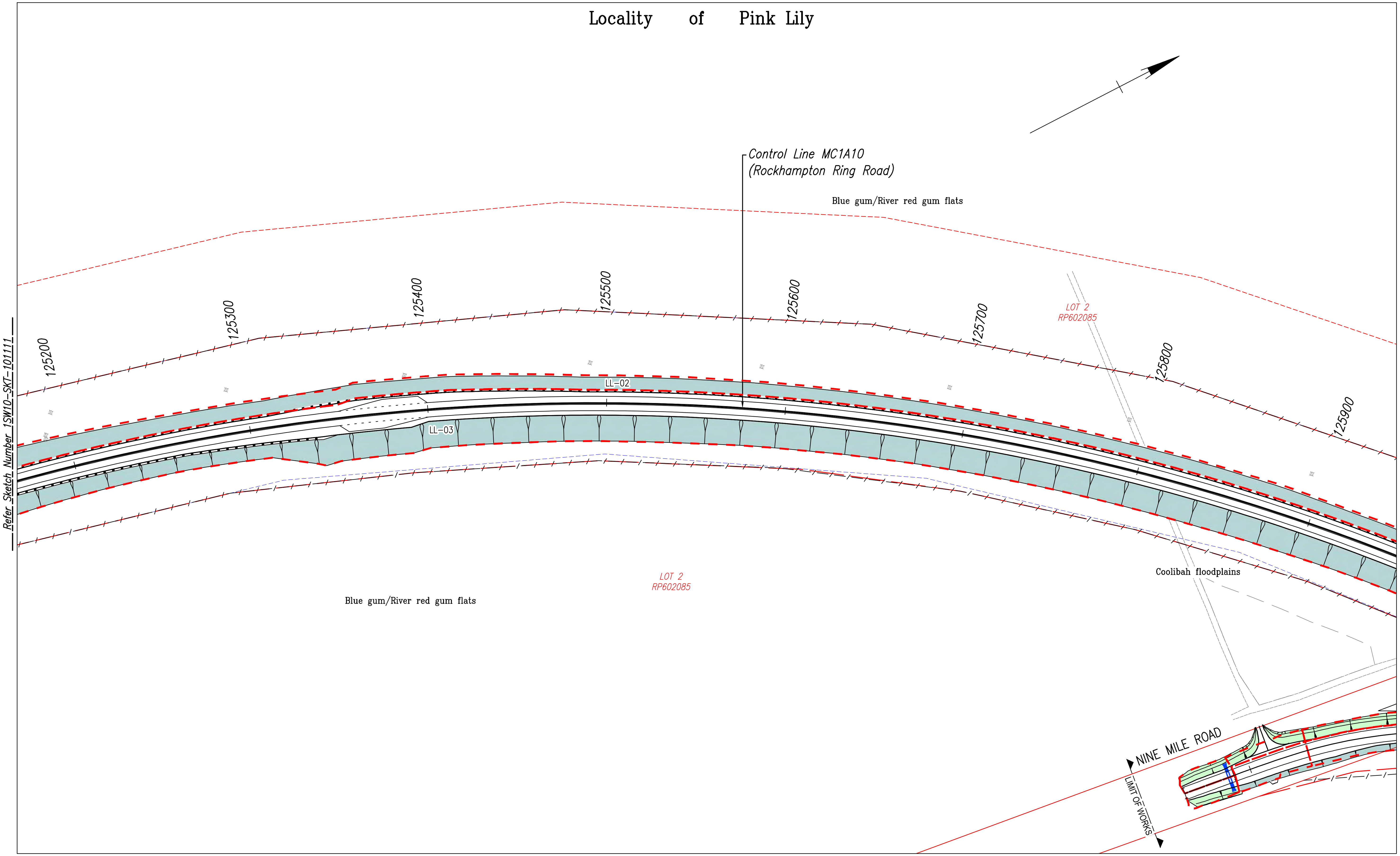

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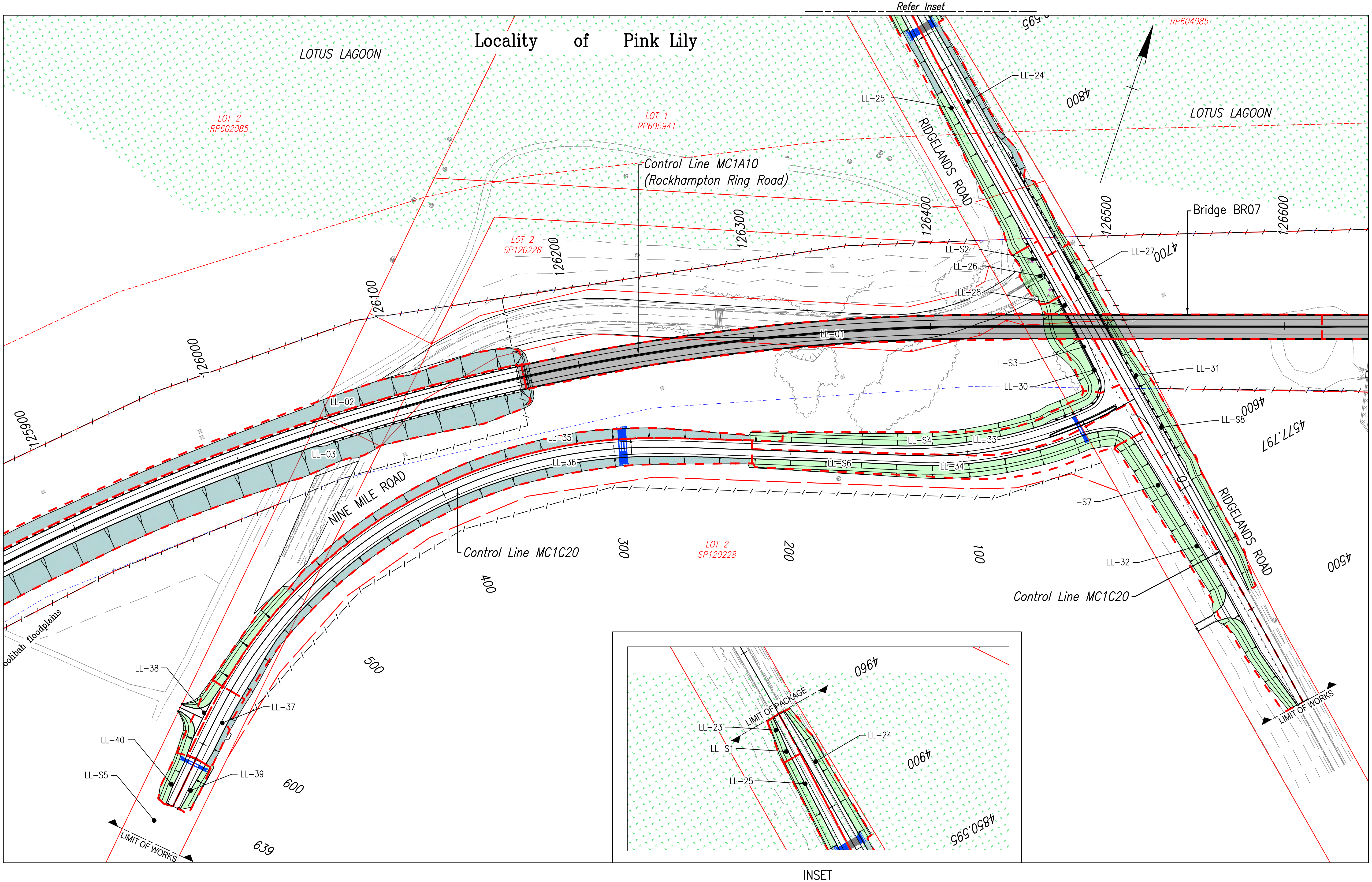

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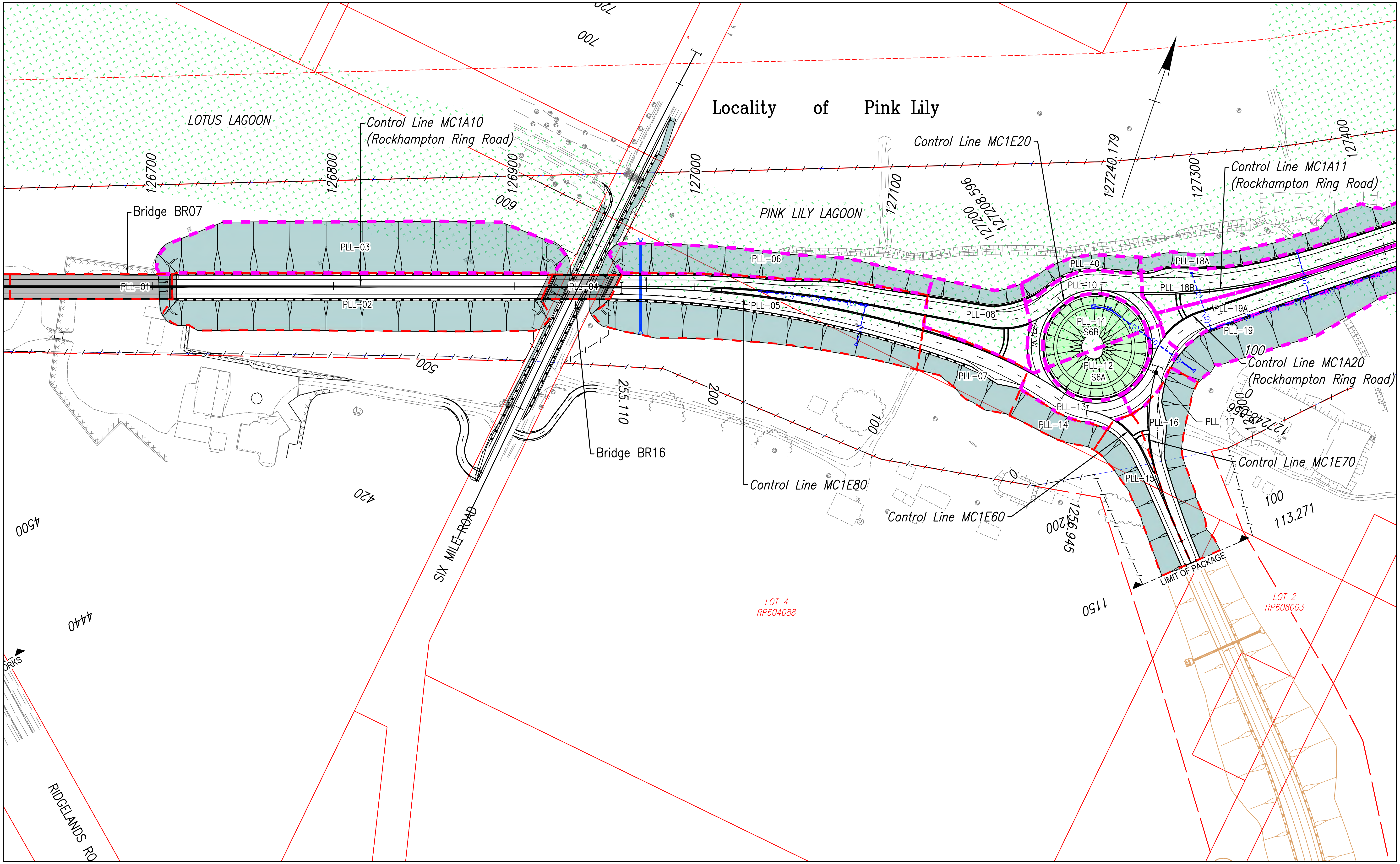

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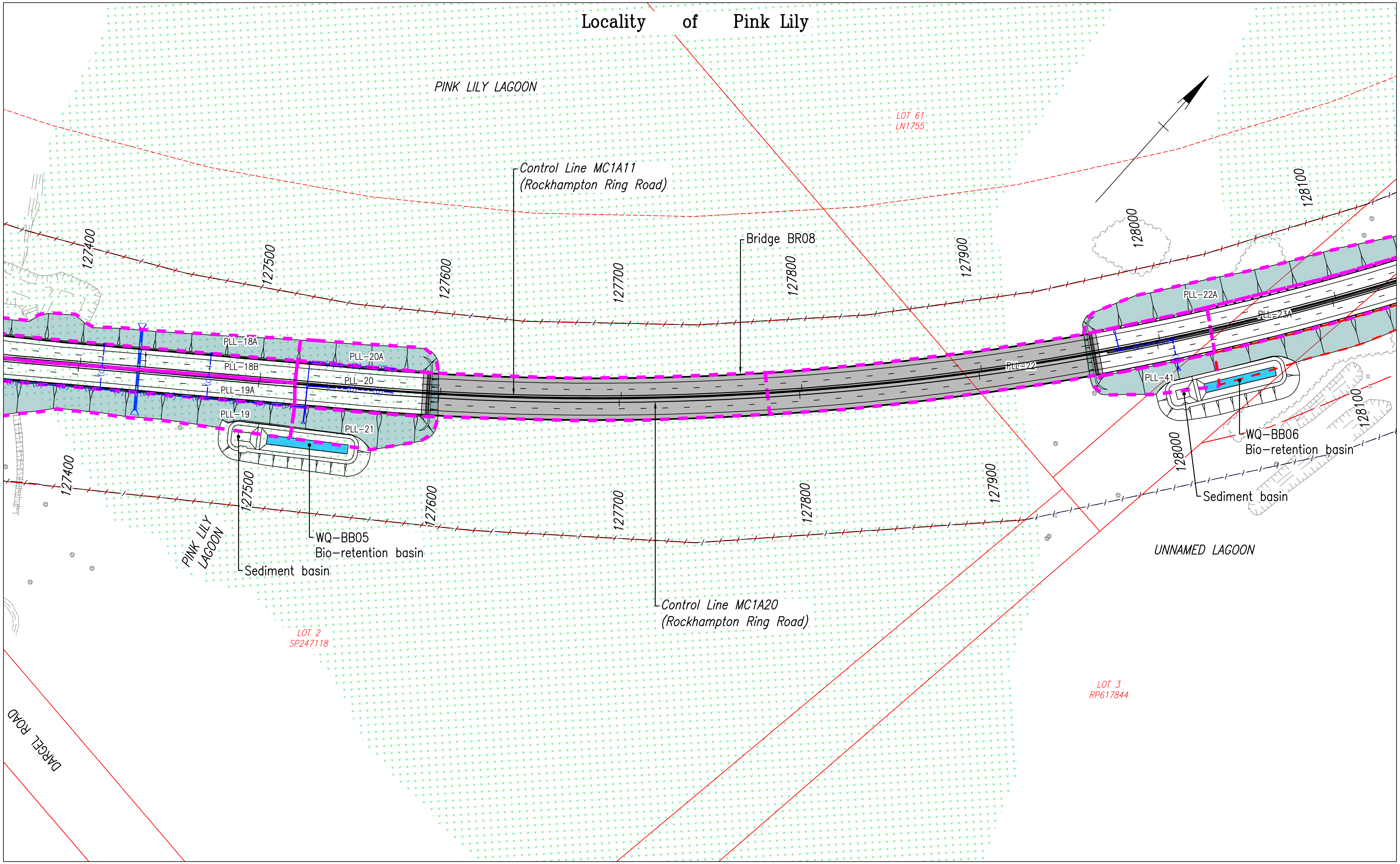

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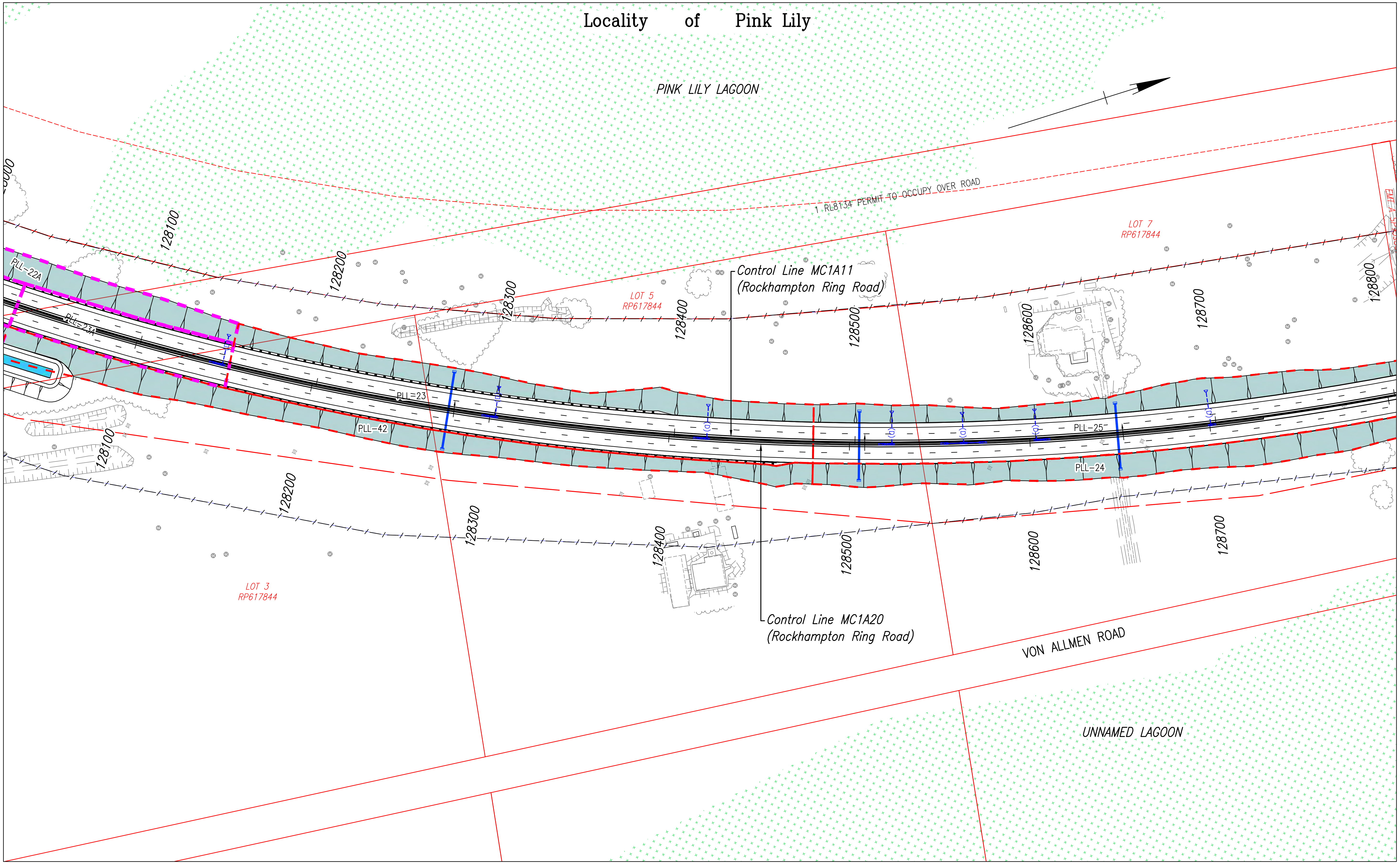

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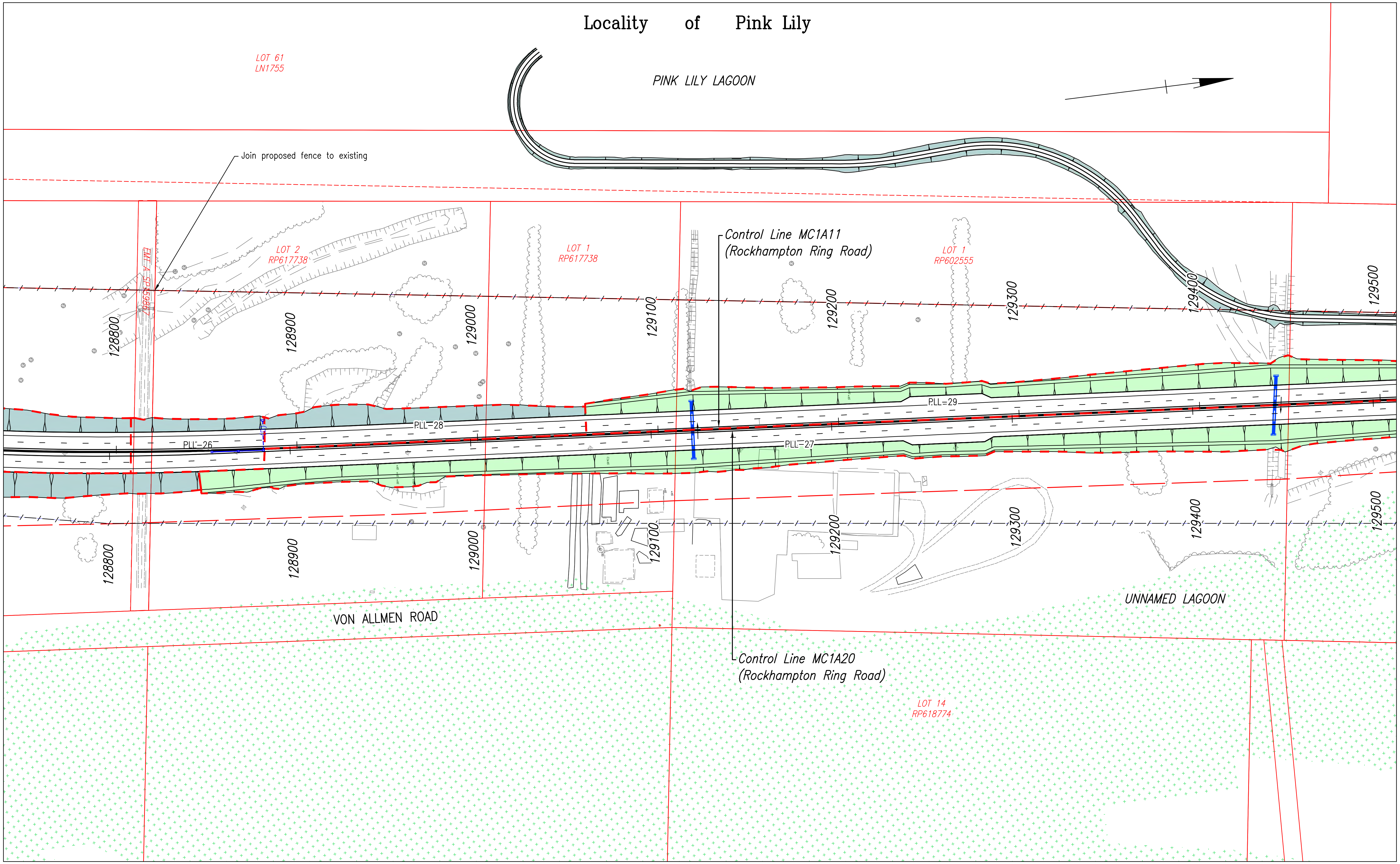

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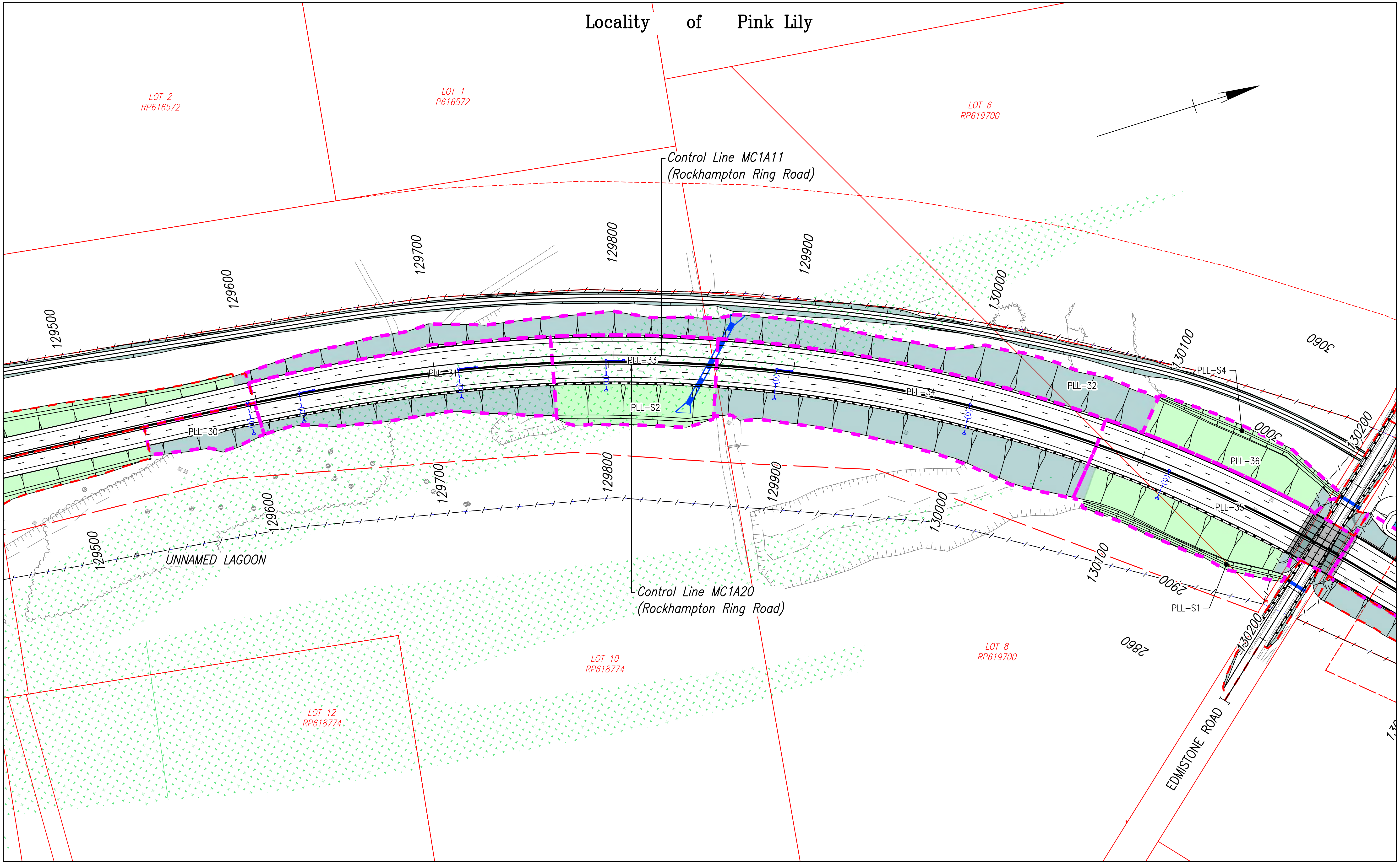

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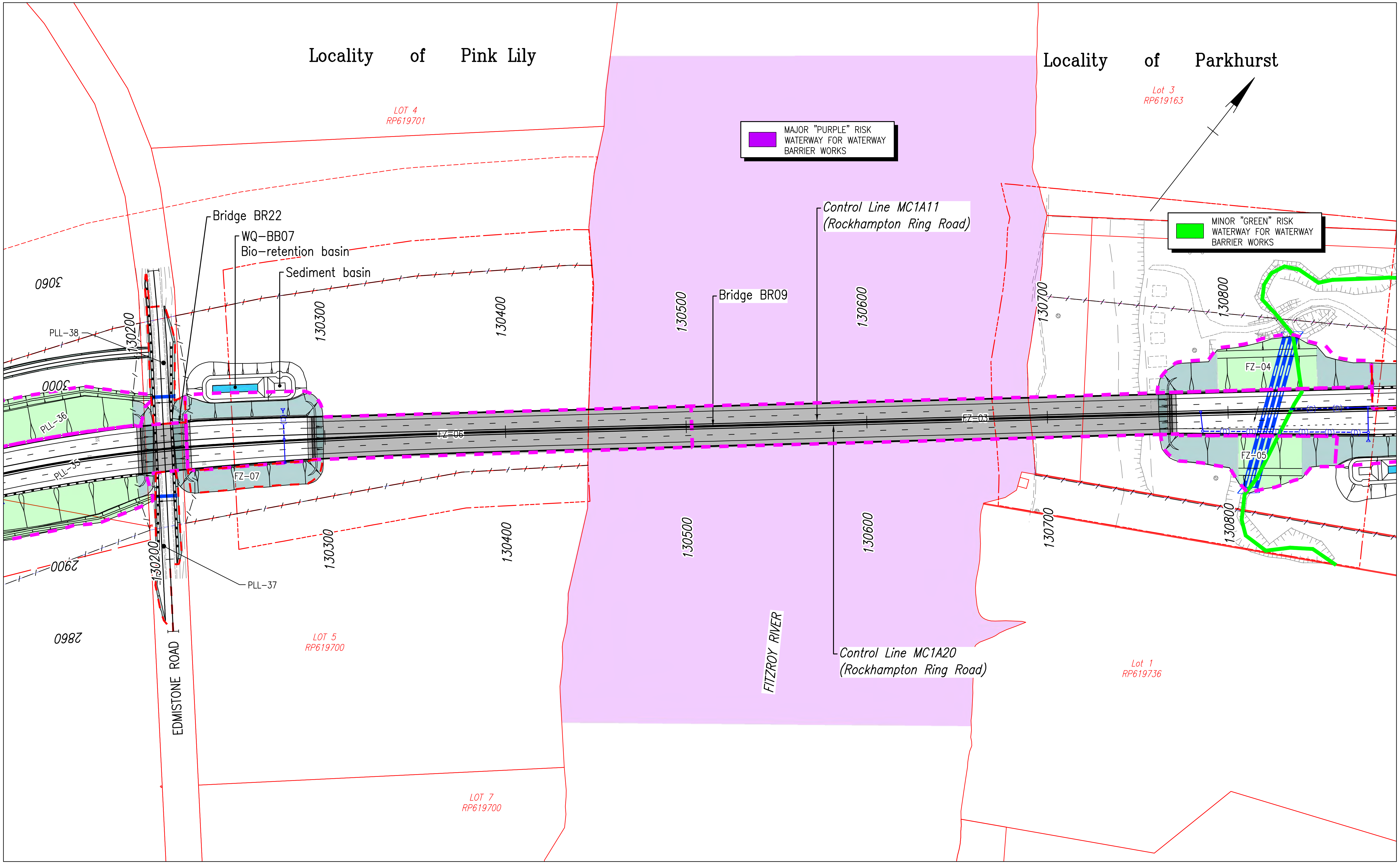

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ROCKHAMPTON RING ROAD
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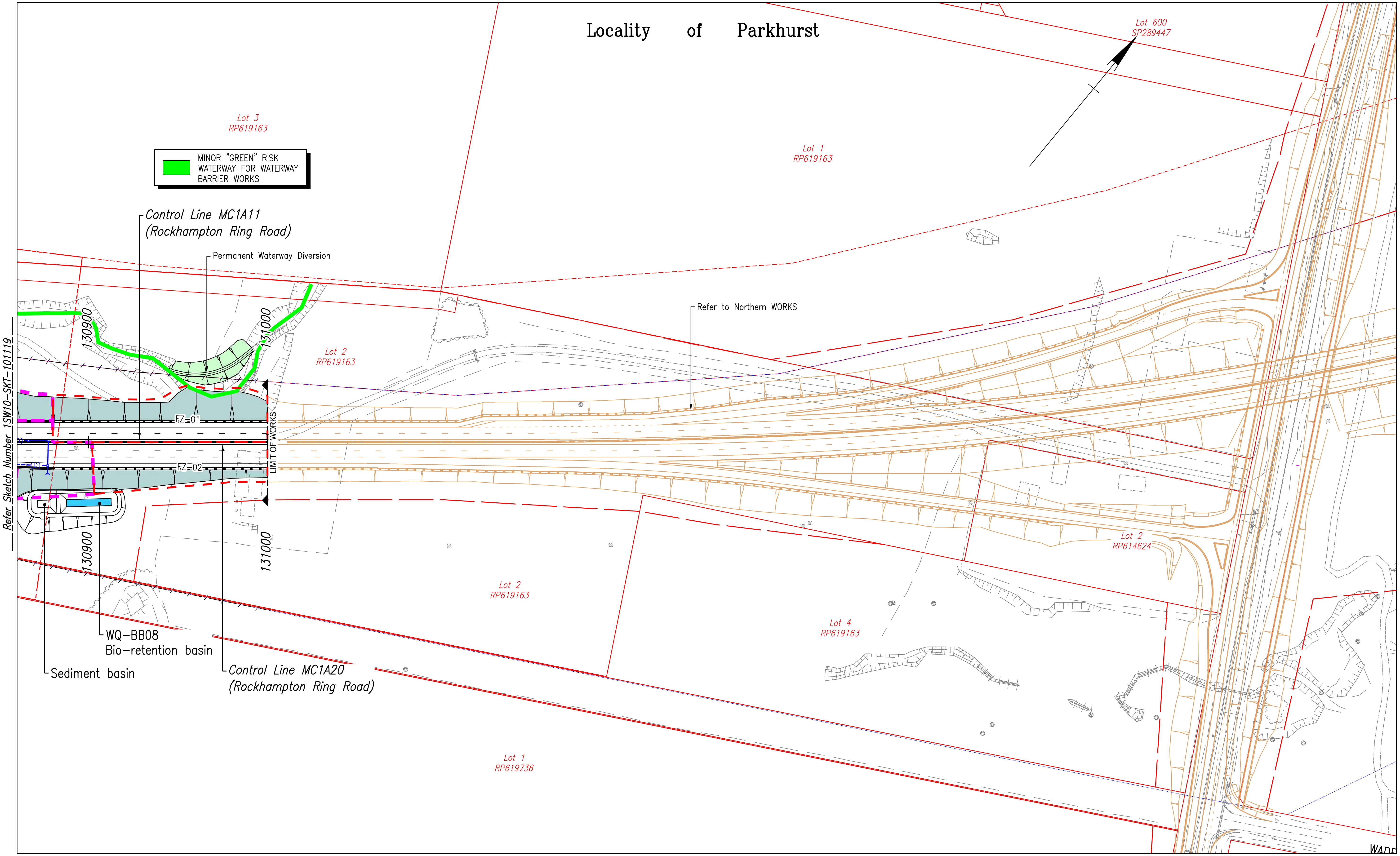

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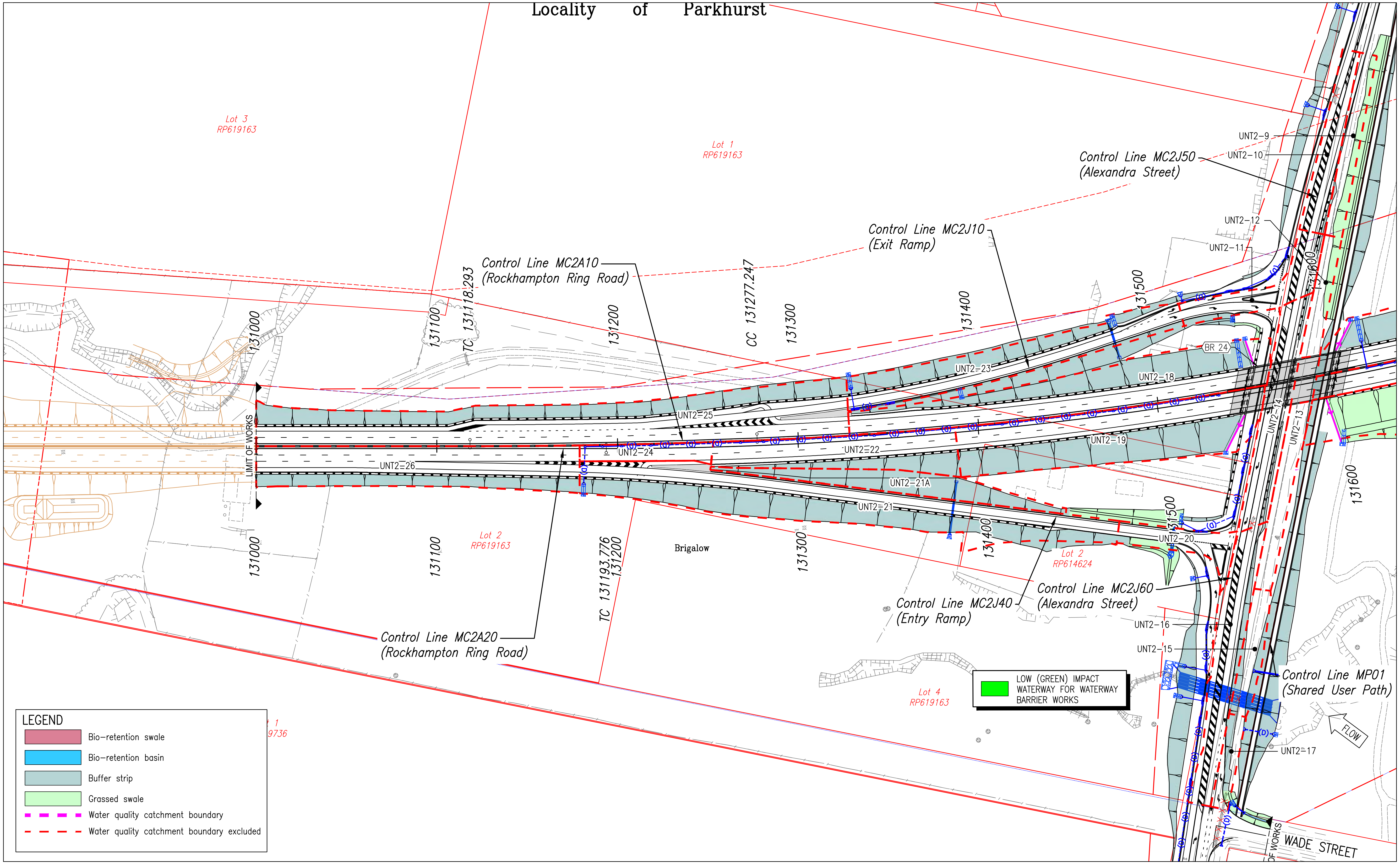

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WATER QUALITY CATCHMENT PLAN - SHEET 1

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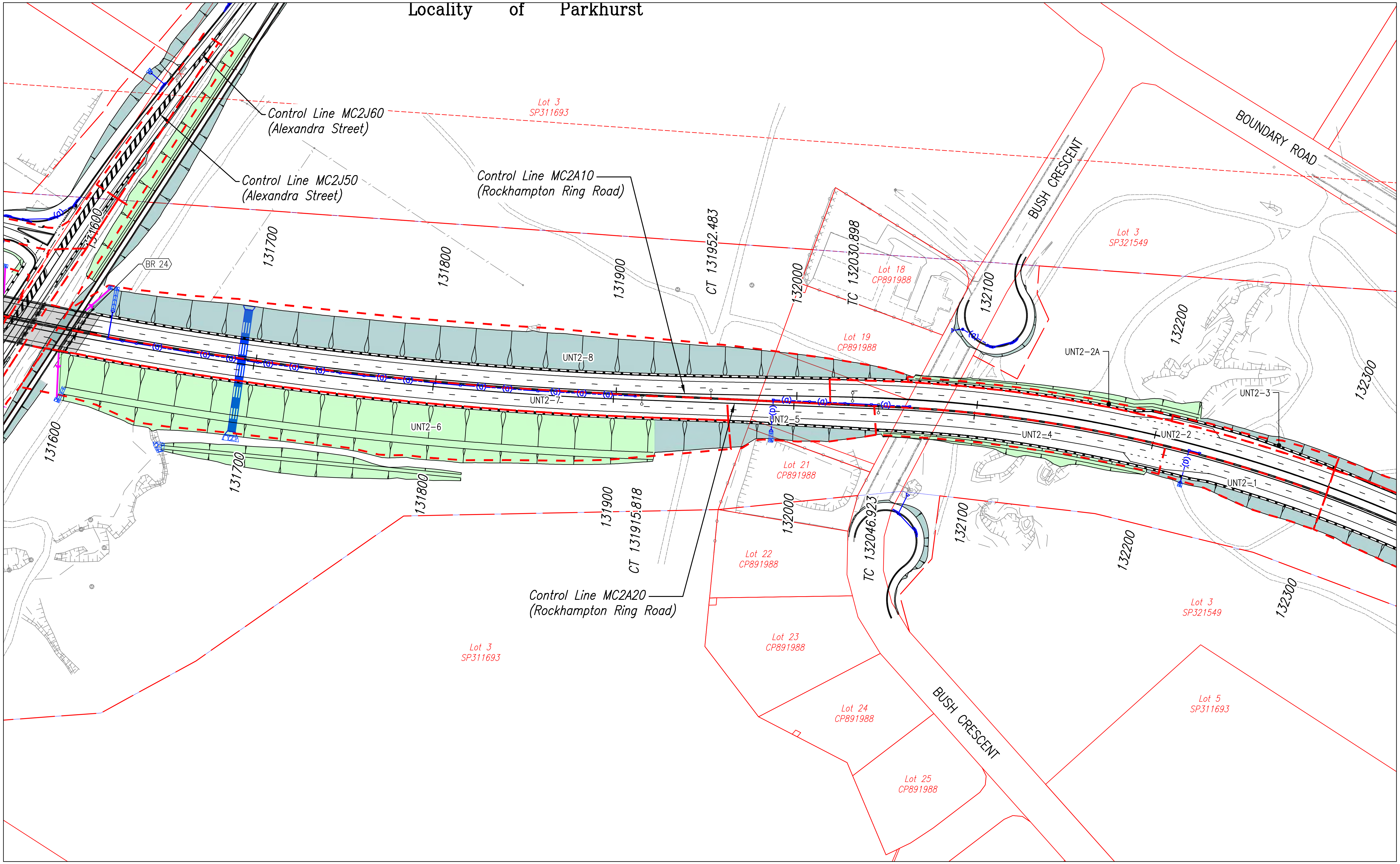

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ROCKHAMPTON RING ROAD
WATER QUALITY CATCHMENT PLAN - SHEET 2

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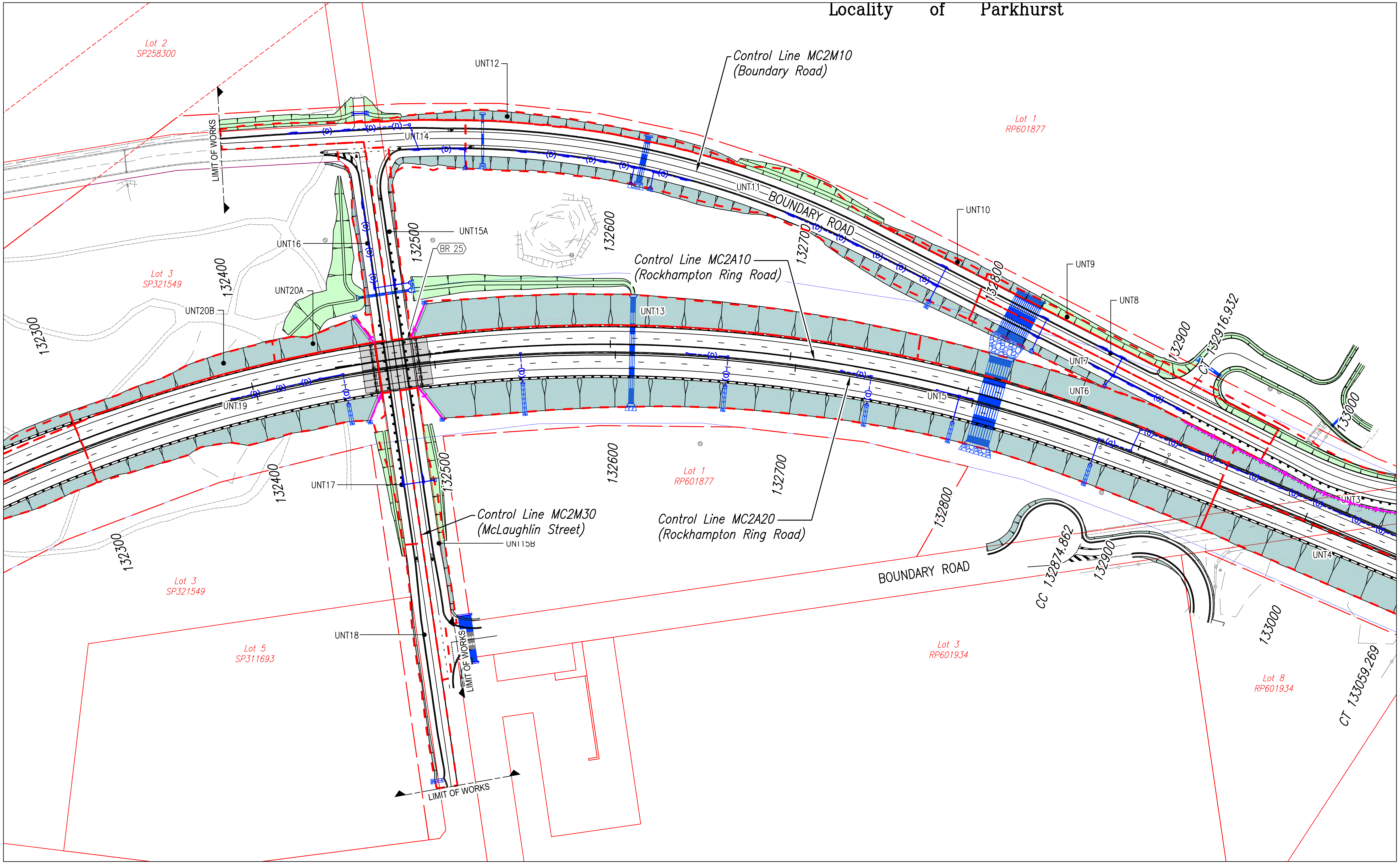

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ROCKHAMPTON RING ROAD

WATER QUALITY CATCHMENT PLAN - SHEET 3

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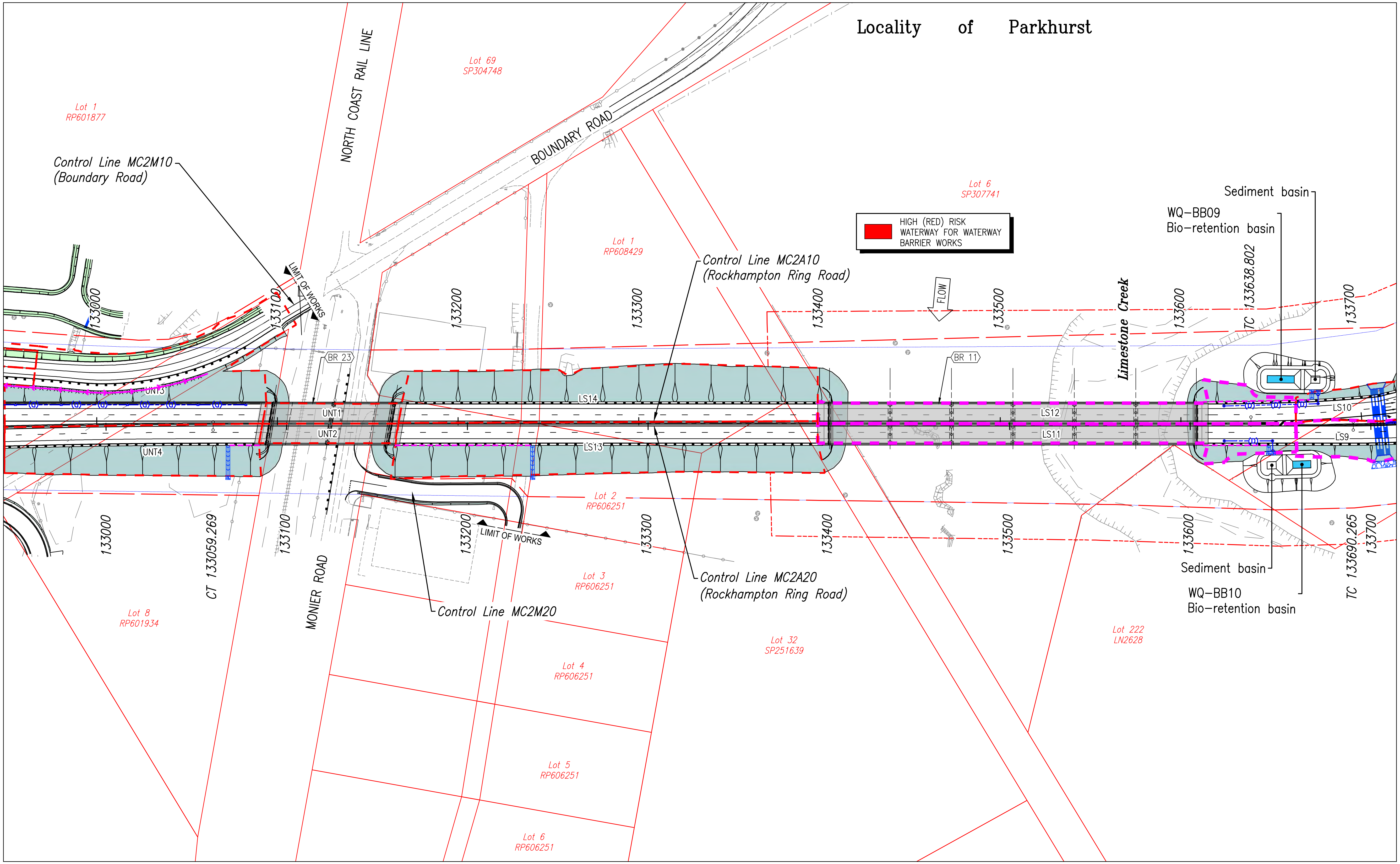

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ROCKHAMPTON RING ROAD
WATER QUALITY CATCHMENT PLAN - SHEET 4

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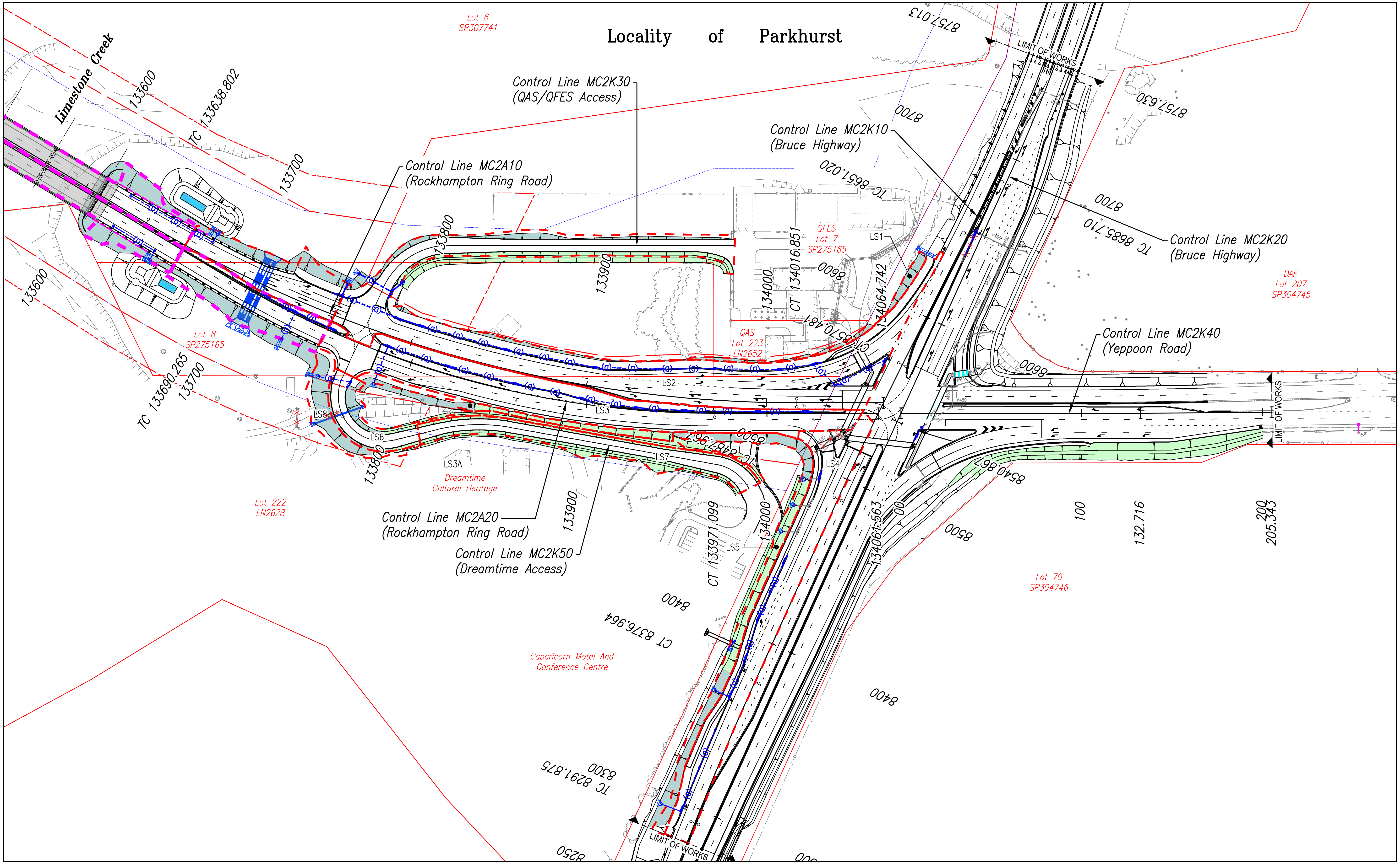

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ROCKHAMPTON RING ROAD

WATER QUALITY CATCHMENT PLAN - SHEET 5

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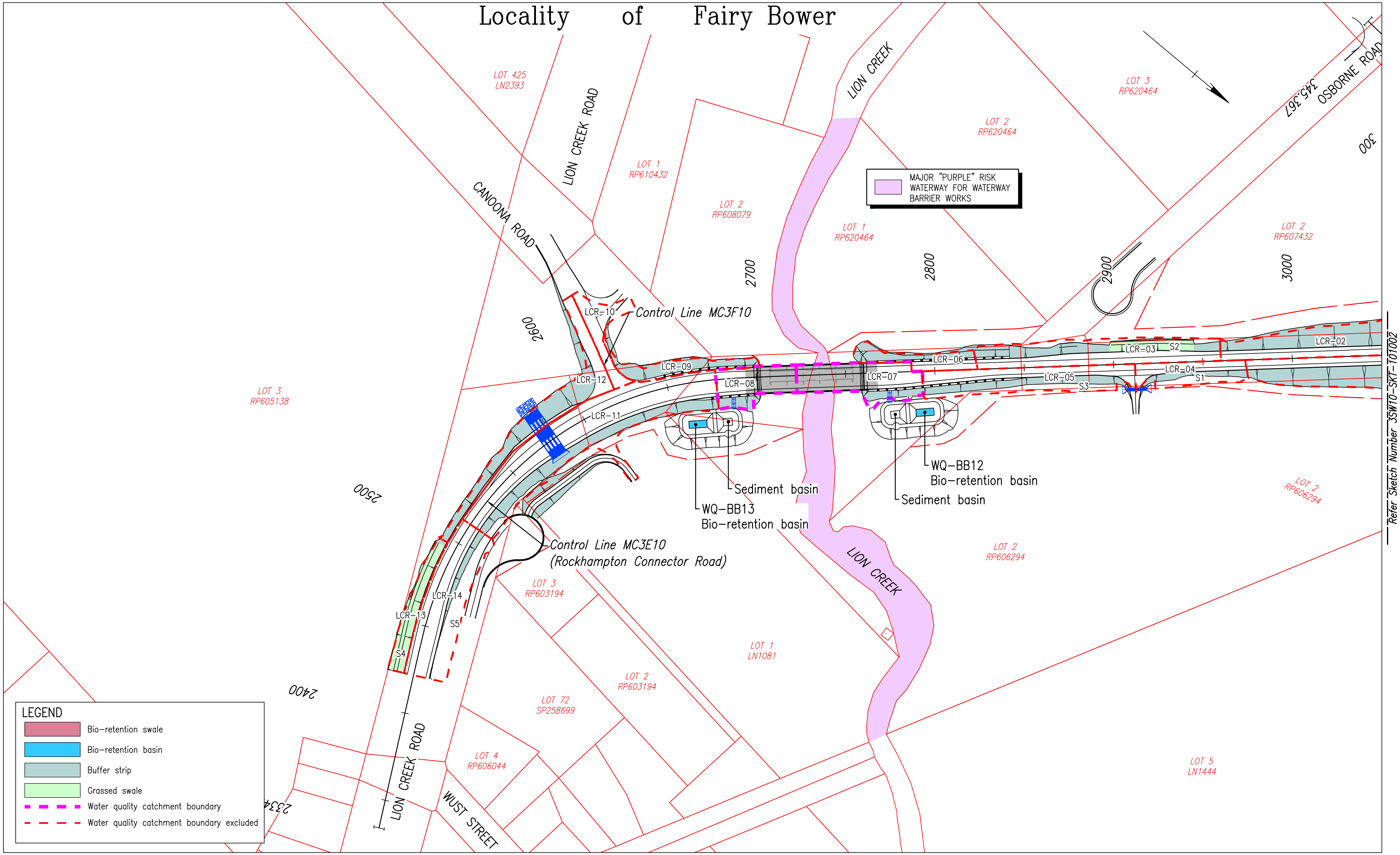
Last Modified :- Jun 21, 2021 - 10:48am



NOT FOR CONSTRUCTION

SCALE 1:1000

ROCKHAMPTON RING ROAD

RCR - WATER QUALITY CATCHMENT PLAN - SHEET 1

INFORMATION DOCUMENT

1167108-DJV-3SW10-SKT-101001

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Last Modified :- Jul 13, 2021 - 8:29am

DRAWING FILE LOCATION / NAME
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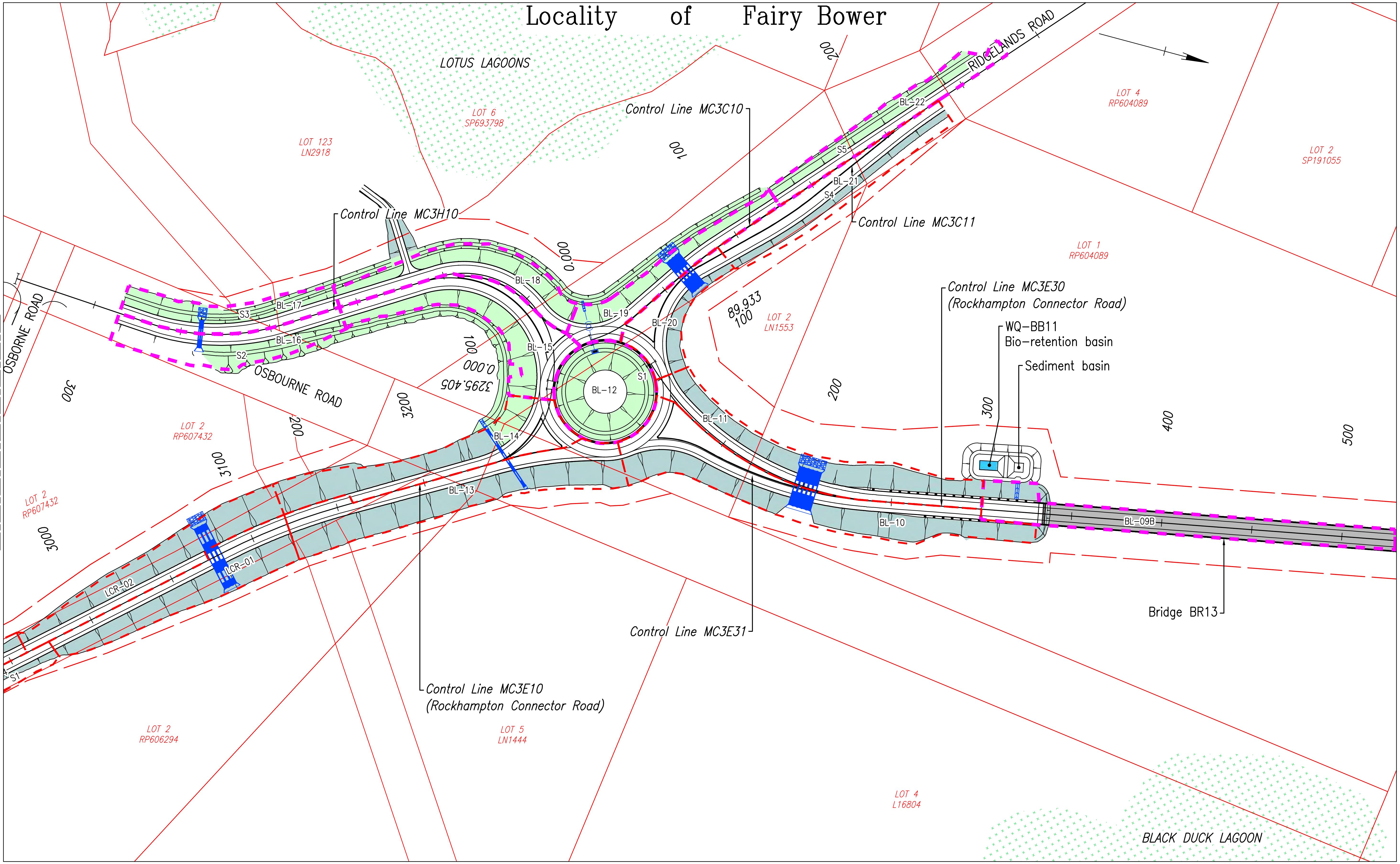

NOT FOR CONSTRUCTION

SCALE 1:1000

ROCKHAMPTON RING ROAD

RCR - WATER QUALITY CATCHMENT PLAN - SHEET 2

INFORMATION DOCUMENT

1167108-DJV-3SW10-SKT-101002

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DRAWING FILE LOCATION / NAME
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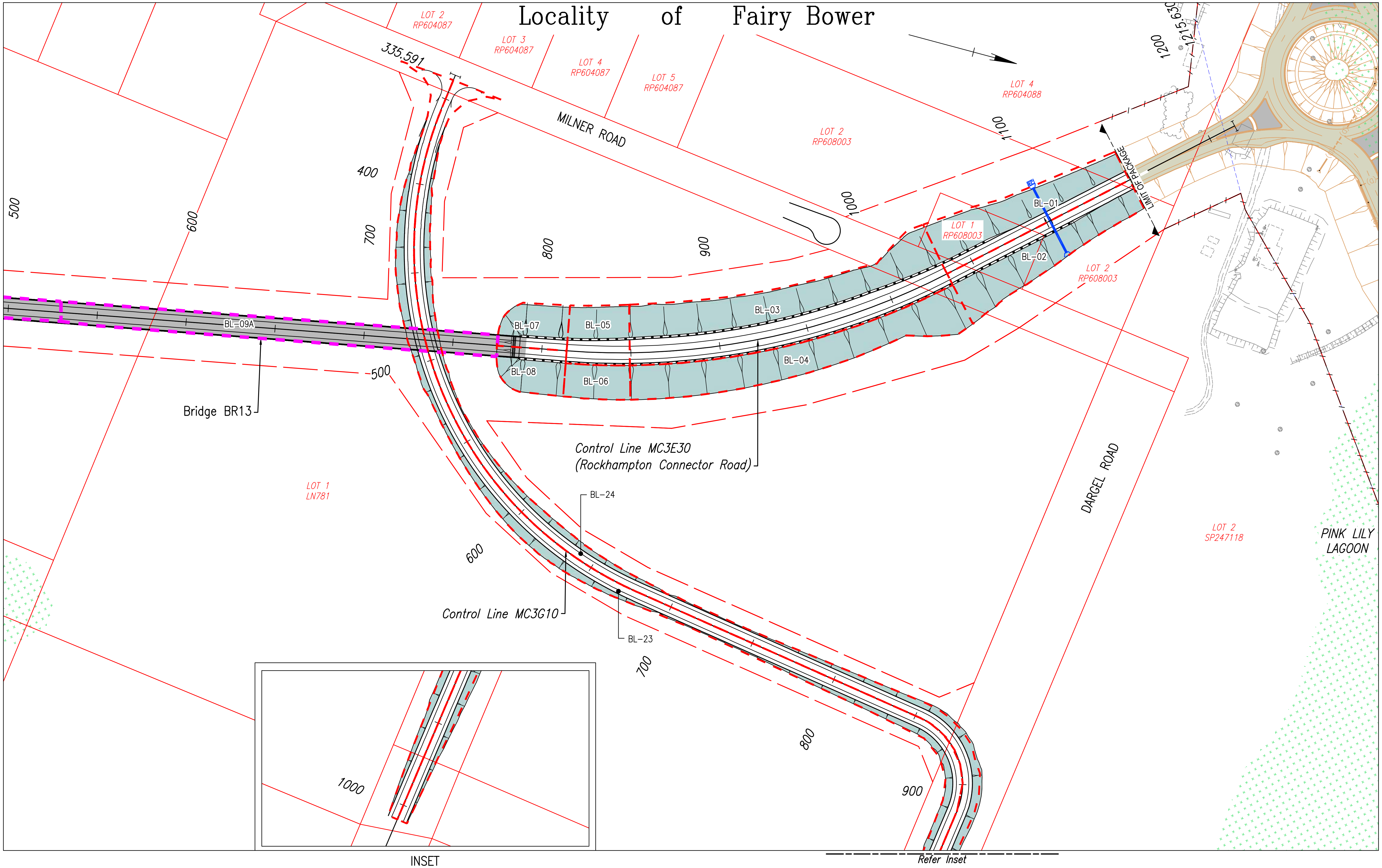
Last Modified :- Jul 13, 2021 - 9:44am



NOT FOR CONSTRUCTION

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ROCKHAMPTON RING ROAD

RCR - WATER QUALITY CATCHMENT PLAN - SHEET 3

INFORMATION DOCUMENT

1167108-DJV-3SW10-SKT-101003

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DRAWING FILE LOCATION / NAME
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Appendix D. Typical Details of bioretention basins

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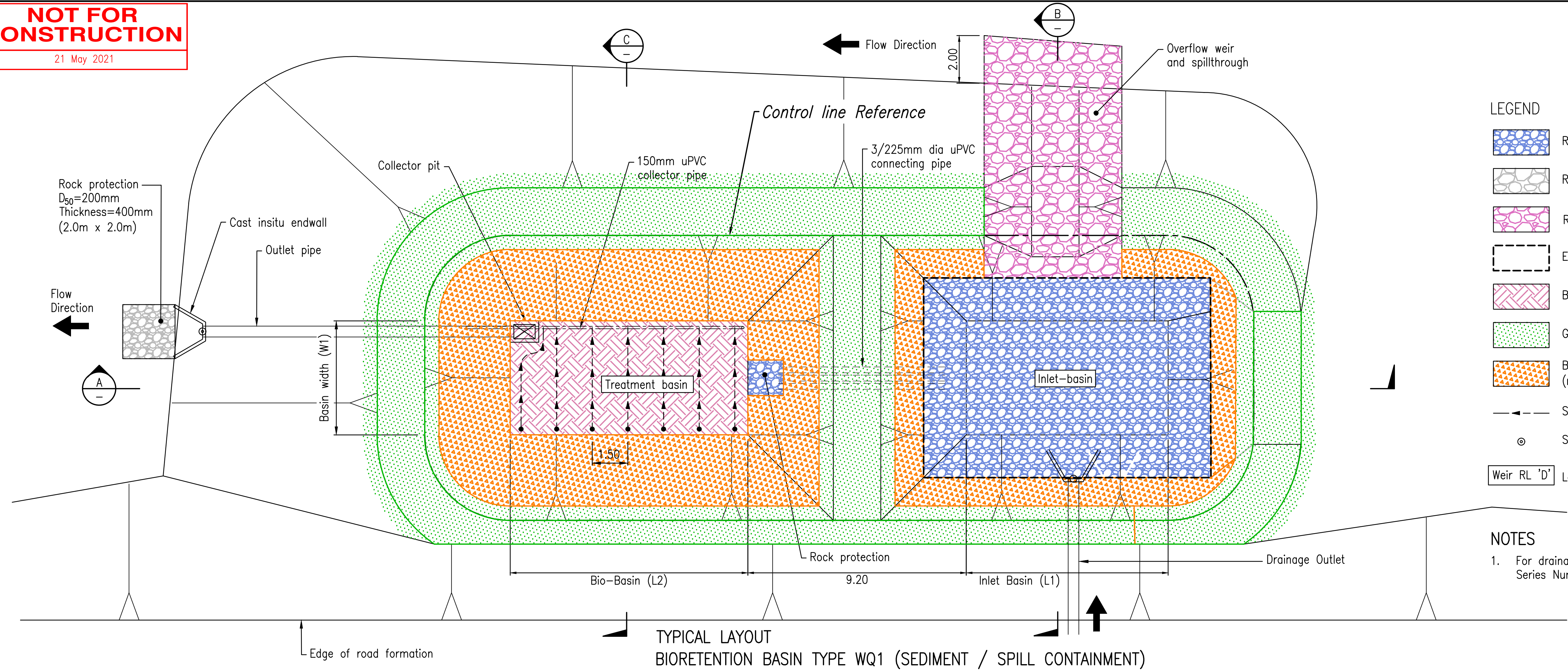
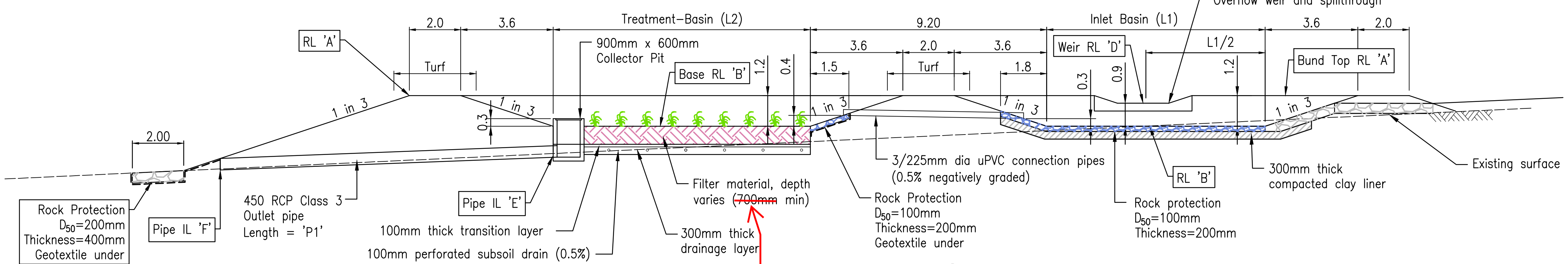
DJV Doc No 1167108-DJV-1SW10-DRG-602009



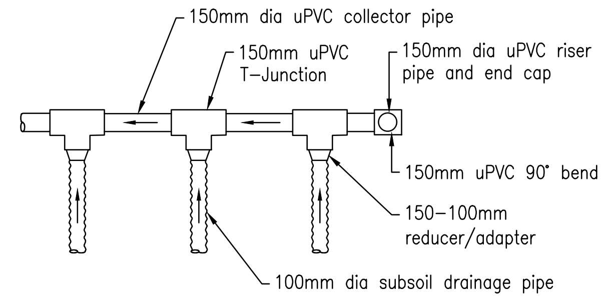
TYPICAL LAYOUT
BIORETENTION BASIN TYPE WQ1 (SEDIMENT / SPILL CONTAINMENT)
Scale A

LEGEND
- Rock protection – D_{50} = 100mm
- Rock protection – D_{50} = 200mm
- Rock filled wire mattress (230mm thick)
- Extent of Clay liner
- Bio Zone (native tube stock and rock mulch)
- Grass Turf
- Bio-Basin Batter – Coir mesh (native tube stock planting)
- Subsoil drain
- Setout reference point
- Weir RL 'D' Level Reference

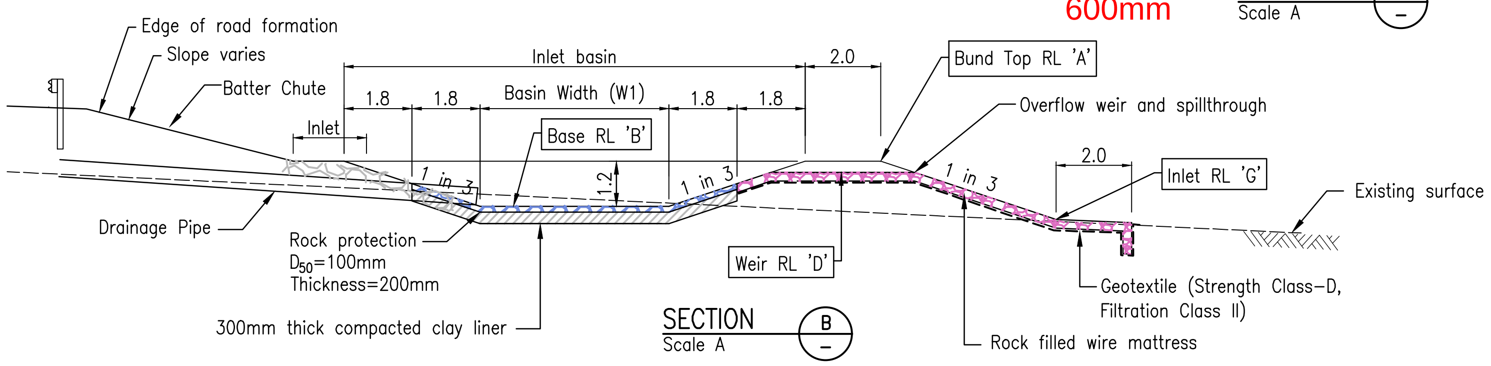
NOTES
1. For drainage legend and general notes refer to Series Numbers S-SW-01 and S-SW-02.



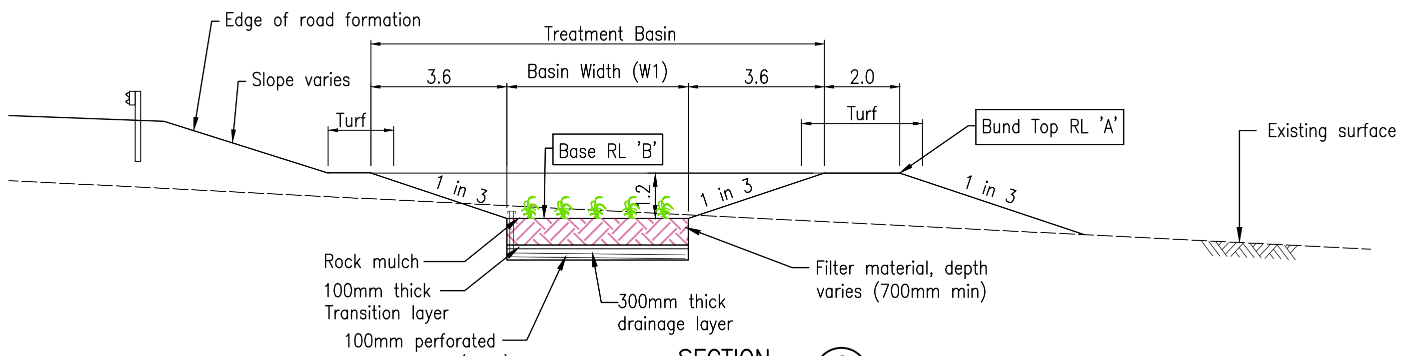
SECTION A
Scale A



TYPICAL PIPE ARRANGEMENT
Scale B



SECTION B
Scale A



SECTION C
Scale A

1	Preliminary Design Issue		21/05/21
A	~~Issued For Stage 1 Reference Design~~		
Revisions/Descriptions	Name or RPEQ No.	Signature	Date

CAD FILES C:\Users\Public\appdata\local\projectwise\jacobs_anz_ie\d0424345\1167108-DJV-1SW10-DRG-602009.dwg

Last Modified :- May 21, 2021 - 12:52pm

Associated Job Nos
Auxiliary Drg Nos

Survey Data	
Horiz. Datum	GDA94
Horiz. Grid	MGA Z56
Height Datum	AHD (Derived)
Survey Books	MR102631

Scales: A 0 1 2 3 4m; B 0 500 1000mm

Dimensions shown in millimetres except where shown otherwise

ROCKHAMPTON REGIONAL COUNCIL
ROCKHAMPTON RING ROAD
CTL CHGE 119315.846 TO 134064.742

Reference Points

Preceding RP	Dist. to start of job (km)	From start to end of job	From end to Following RP	Following RP
16A/1	2.357	14.748	0.00	10F/4

Through Chainage from 10D/10E 119.315km to 134.064km

ROCKHAMPTON RING ROAD – SOUTH
STORMWATER
TYPICAL DETAILS – SHEET 9

Drawn: A. Fourie
Designed: J. Gray

ENGINEERING CERTIFICATION (RPEQ)

ENG. AREA	NAME	SIGNATURE	No.	DATE
Civil				

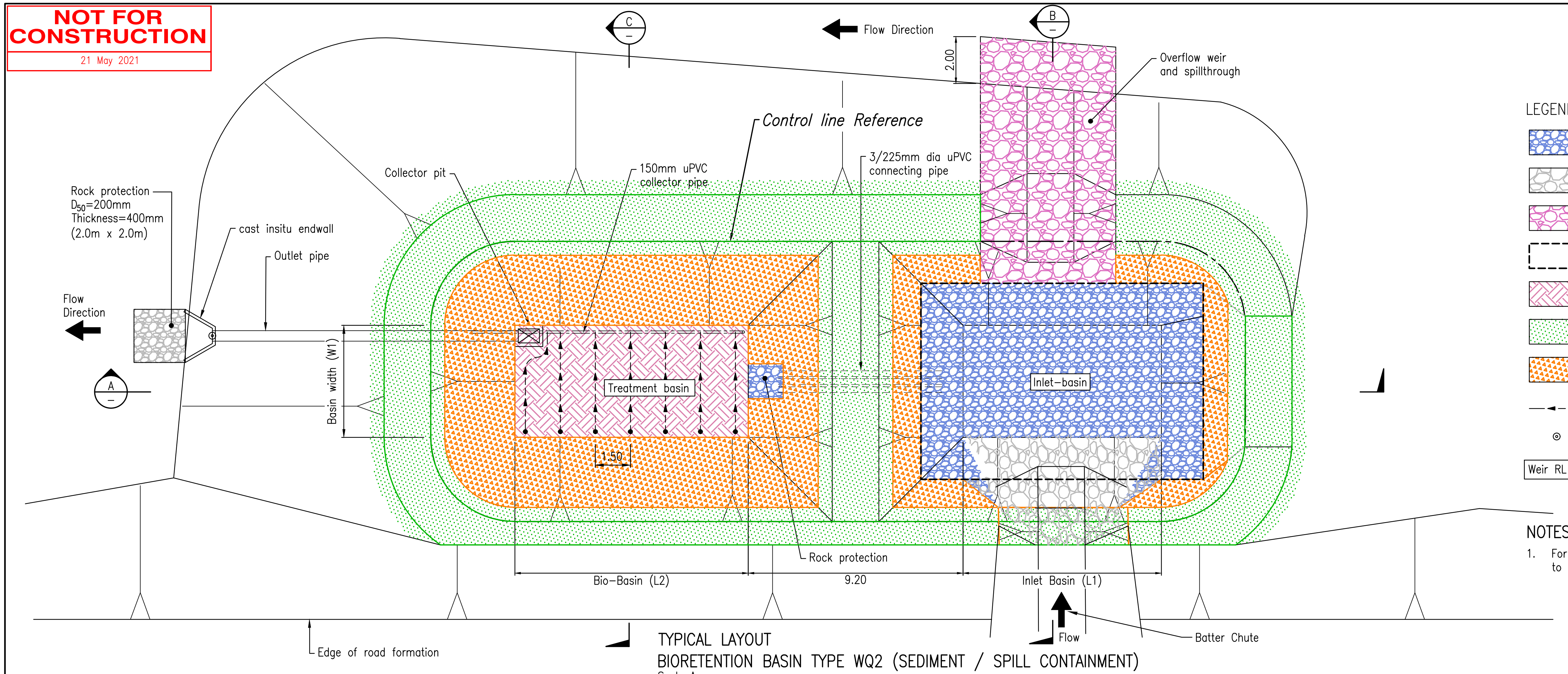
Queensland Government

Job No.
Contract No.
Drawing No. – 1
Series Number S-SW-45 of 62

NOT FOR CONSTRUCTION
21 May 2021

Jacobs | SMEC Member of the Surbana Jurong Group

DJV Doc No 1167108-DJV-1SW10-DRG-602010



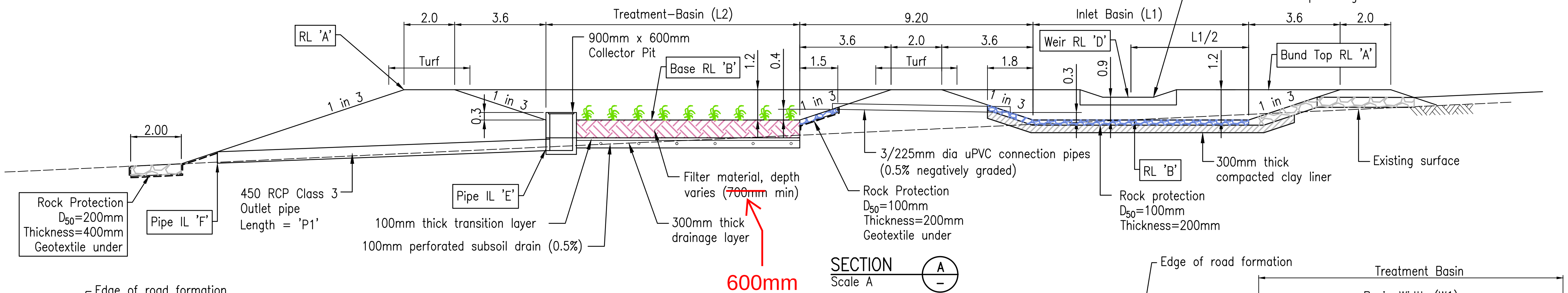
TYPICAL LAYOUT
BIORETENTION BASIN TYPE WQ2 (SEDIMENT / SPILL CONTAINMENT)
Scale A

LEGEND

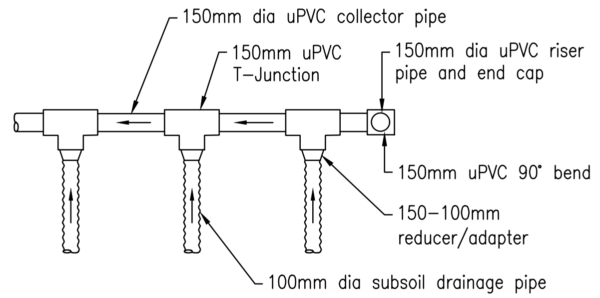
- Rock protection – D_{50} = 100mm
- Rock protection – D_{50} = 200mm
- Rock filled wire mattress (230mm thick)
- Extent of Clay liner
- Bio Zone (native tube stock and rock mulch)
- Grass Turf
- Bio-Basin Batter – Coir mesh (native tube stock planting)
- Subsoil drain
- Setout reference point
- Weir RL 'D' – Level Reference

NOTES

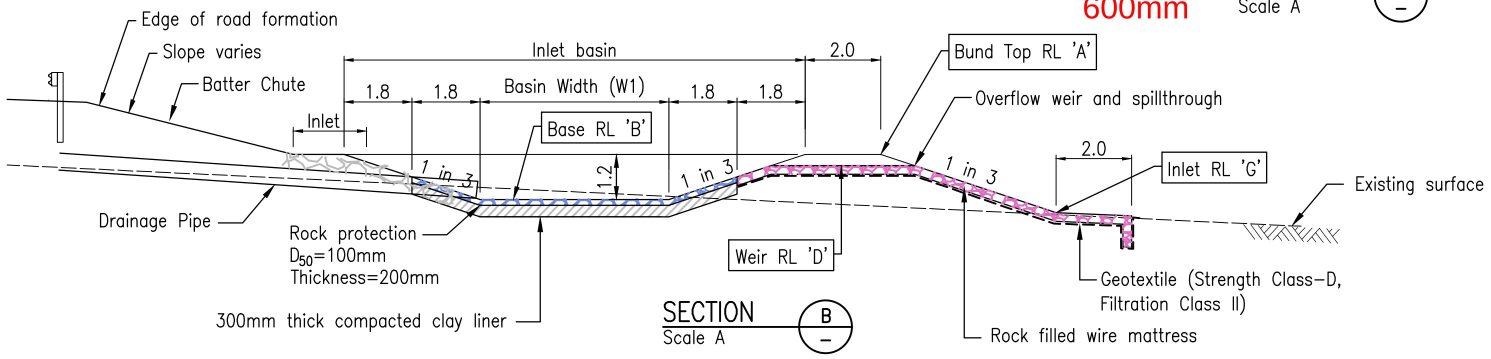
1. For drainage legend and general notes refer to Series Numbers S-SW-01 and S-SW-02.



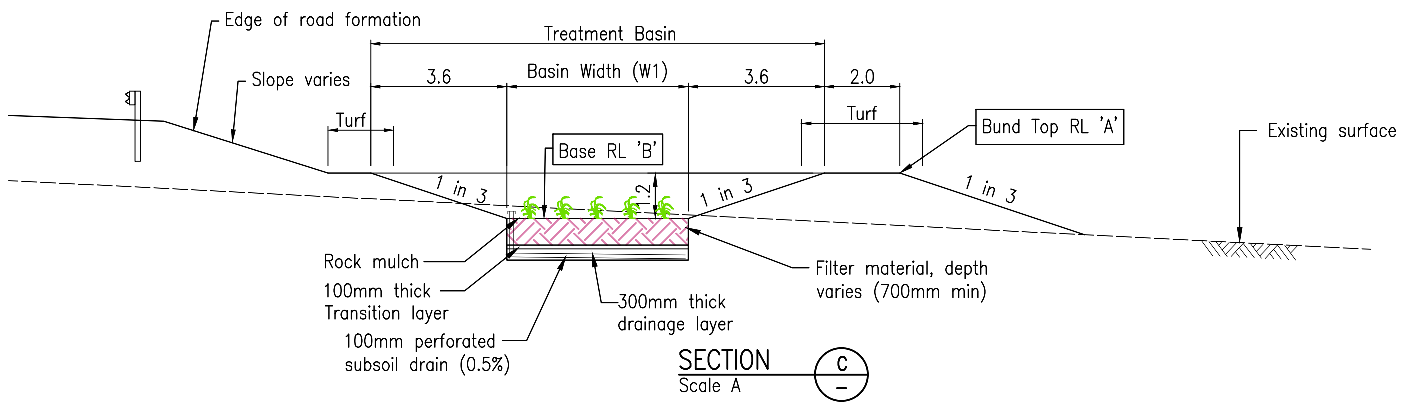
SECTION A
Scale A



TYPICAL PIPE ARRANGEMENT
Scale B



SECTION B
Scale A



SECTION C
Scale A

No.	Revisions/Descriptions	Name or RPEQ No.	Signature	Date
1	Preliminary Design Issue			21/05/21
A	Issued For Stage 1 Reference Design			

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Last Modified :- May 21, 2021 - 12:53pm

Associated Job Nos

Auxiliary Drg Nos

Survey Data	
Horiz. Datum	GDA94
Horiz. Grid	MGA Z56
Height Datum	AHD (Derived)
Survey Books	MR102631

Scales: A 0 1 2 3 4m; B 0 500 1000mm

Dimensions shown in millimetres except where shown otherwise

ROCKHAMPTON REGIONAL COUNCIL
ROCKHAMPTON RING ROAD
CTL CHGE 119315.846 TO 134064.742

Reference Points				
Preceding RP	Dist. to start of job (km)	From start to end of job	From end to Following RP	Following RP
16A/1	2.357	14.748	0.00	10F/4

Through Chainage from 10D/10E 119.315km to 134.064km

ROCKHAMPTON RING ROAD – SOUTH
STORMWATER
TYPICAL DETAILS – SHEET 10

Drawn: A. Fourie
Designed: J. Gray

ENGINEERING CERTIFICATION (RPEQ)

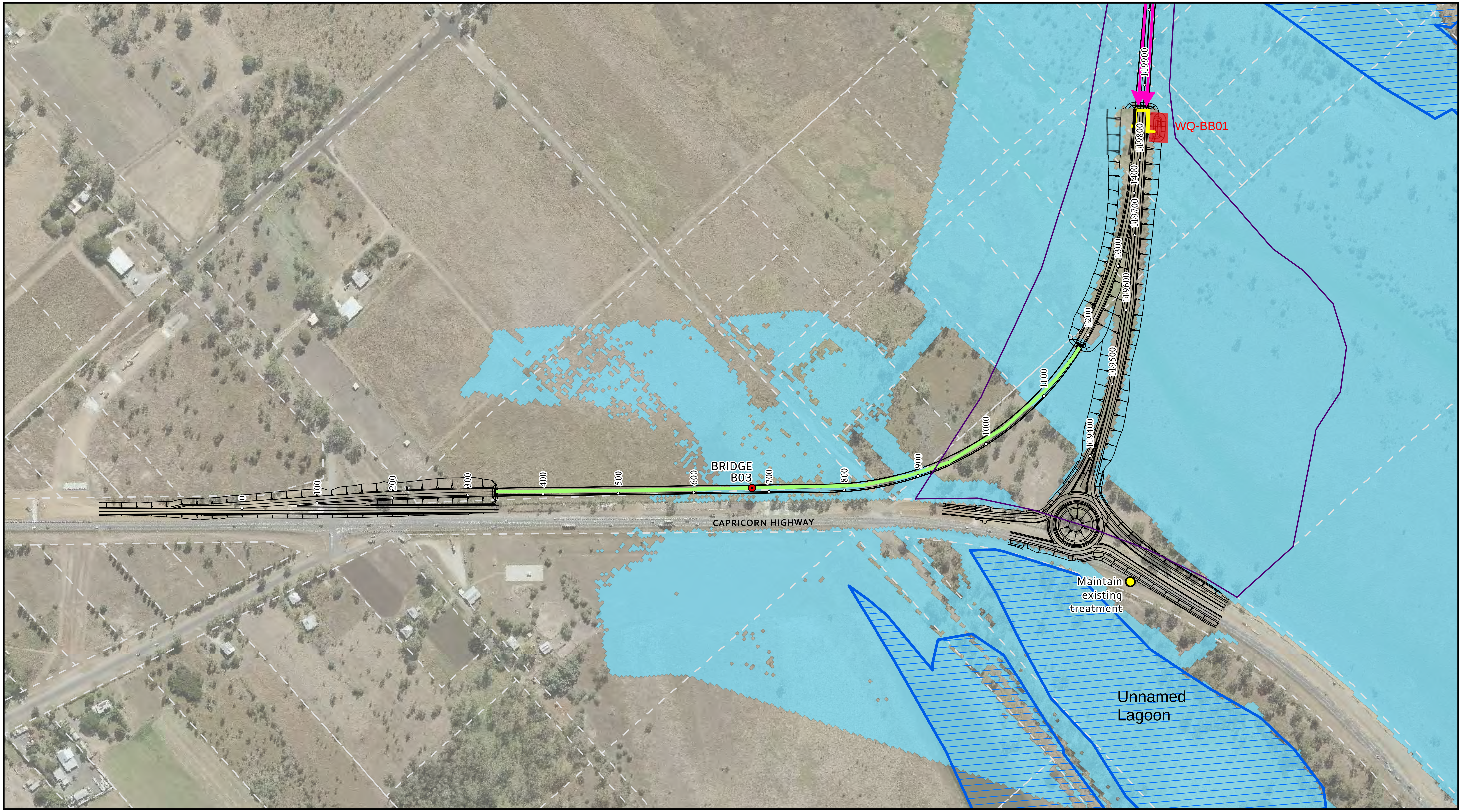
ENG. AREA	NAME	SIGNATURE	No.	DATE
Civil				

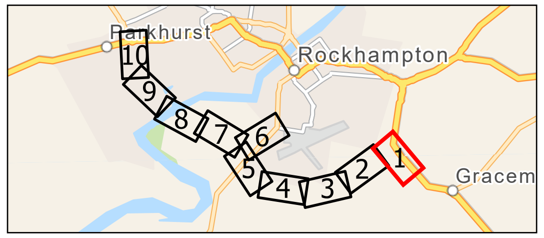
Queensland Government

Job No.
Contract No.
Drawing No. – 1
Series Number S-SW-46 of 62

Appendix E. Water Quality Strategy Maps

Figure 1: Water Quality Strategy (Sheet 1 of 10)





LEGEND

- Chainage (100m)
- Bridge Location
- WQ Note
- Gazetted Corridor
- Scuppers Disharging to Ground
- Scuppers to Bridge Drainage
- Pit & Pipe
- Design
- Cadastre
- WQ Basin

Local 20% AEP flood height (m)

- 5-10
- MSES High Ecological Significance (HES) Wetlands

GDA 1994 MGA Zone 56

0 50 100 200 Meters

A3 1:5,000

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Jacobs SMEC Design Joint Venture

Rockhampton Ring Road

Source: DNRME: Roads, Watercourses (2020; Metromap: Imagery (2020)

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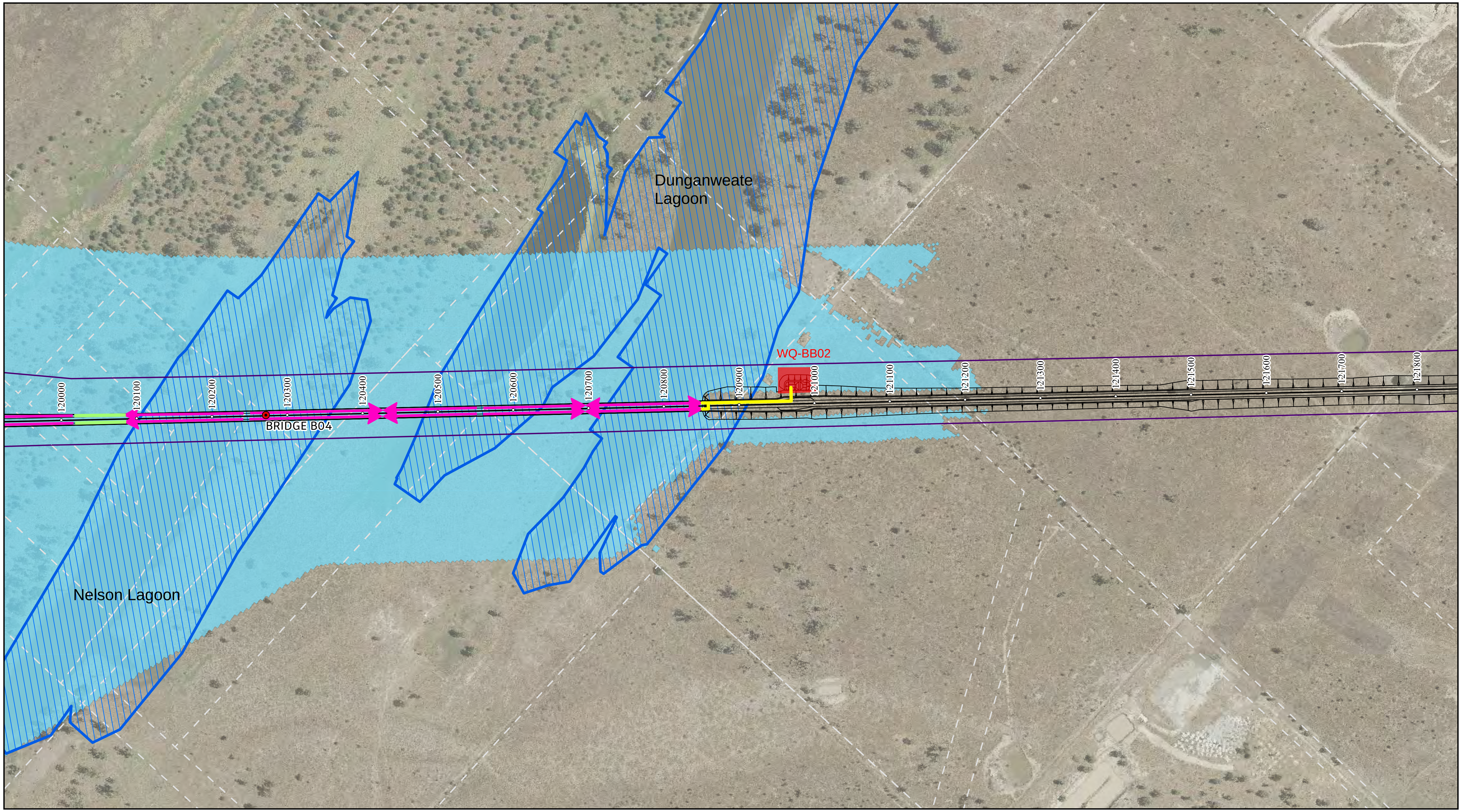
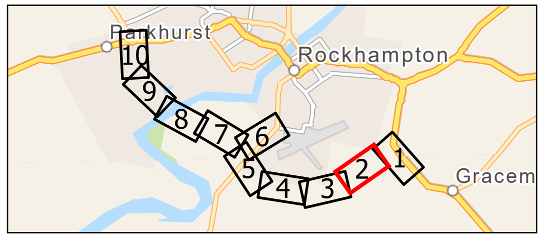
Figure 1: Water Quality Strategy (Sheet 2 of 10)





LEGEND

- Chainage (100m)
- Bridge Location
- Gazetted Corridor
- Scuppers Disharging to Ground
- Scuppers to Bridge Drainage
- Pit & Pipe
- Design
- Cadastre
- WQ Basin
- Local 20% AEP flood height (m)
- 5-10
- MSES High Ecological Significance (HES) Wetlands

GDA 1994 MGA Zone 56

0 50 100 200

Meters

A3 1:5,000

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Rockhampton Ring Road

Source: DNRME: Roads, Watercourses (2020; Metromap: Imagery (2020)

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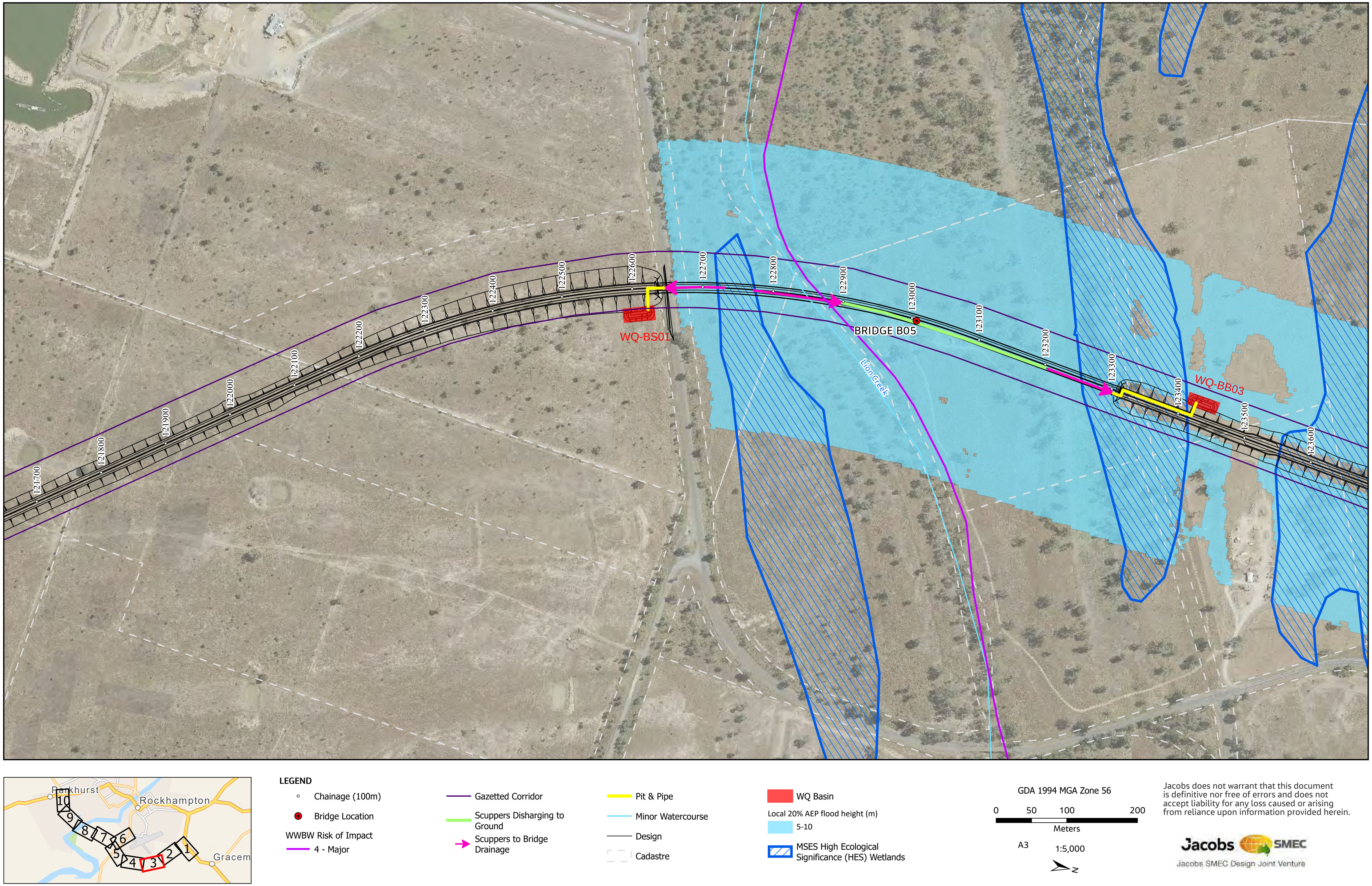
Figure 1: Water Quality Strategy (Sheet 3 of 10)



Rockhampton Ring Road

Source: DNRME: Roads, Watercourses (2020; Metromap: Imagery (2020)

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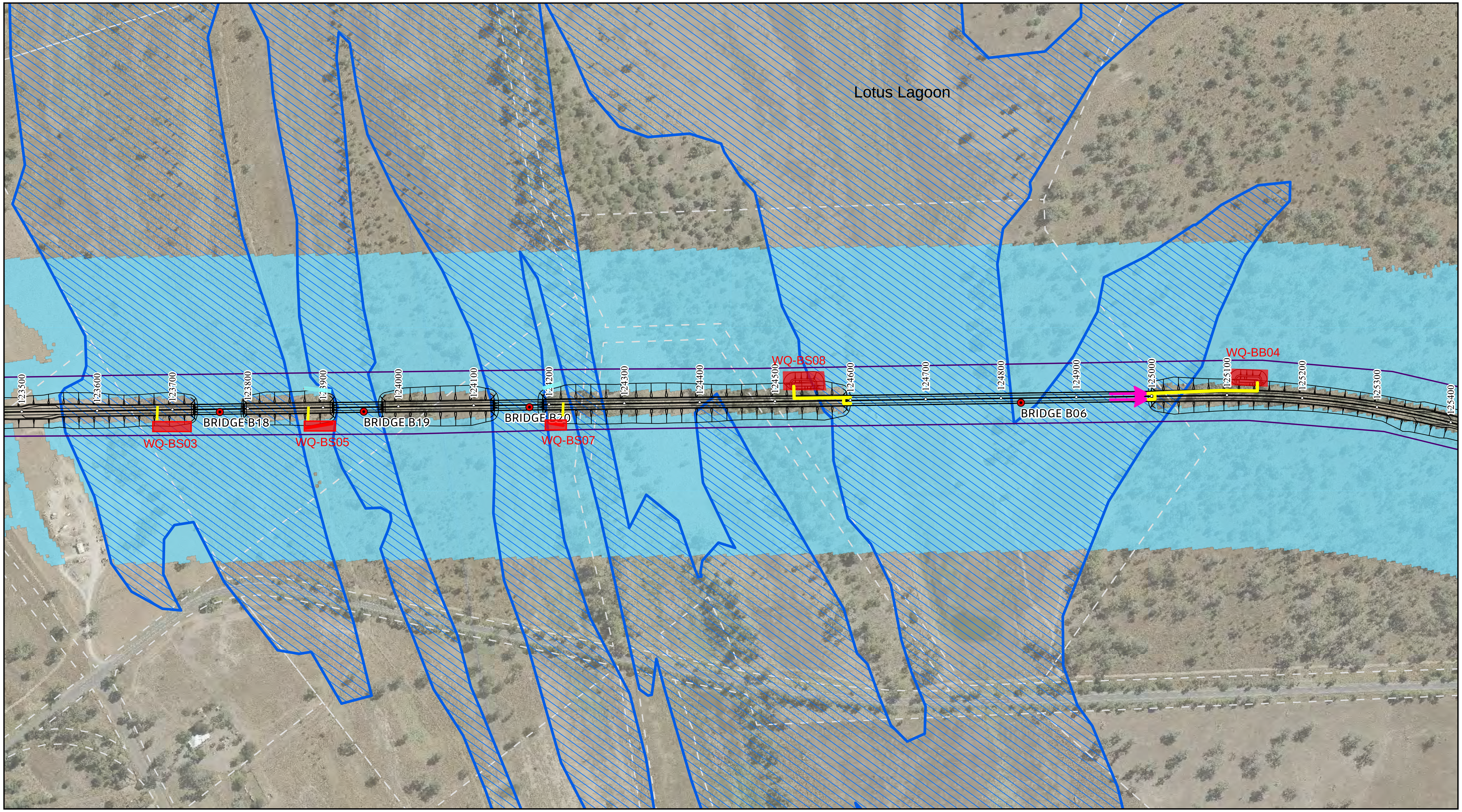
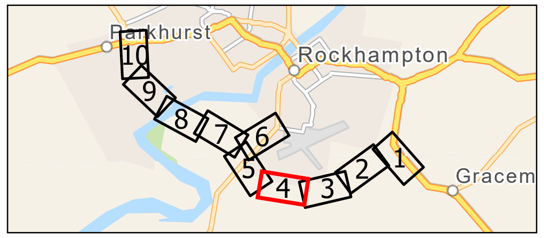
Figure 1: Water Quality Strategy (Sheet 4 of 10)





LEGEND

- Chainage (100m)
- Bridge Location
- Gazetted Corridor
- Scuppers to Bridge Drainage
- Pit & Pipe
- WQ Bioswale
- Design
- Cadastre
- WQ Basin
- Local 20% AEP flood height (m)
- 5-10
- MSES High Ecological Significance (HES) Wetlands

GDA 1994 MGA Zone 56

0 50 100 200

Meters

A3 1:5,000

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Rockhampton Ring Road

Source: DNRME: Roads, Watercourses (2020; Metromap: Imagery (2020)

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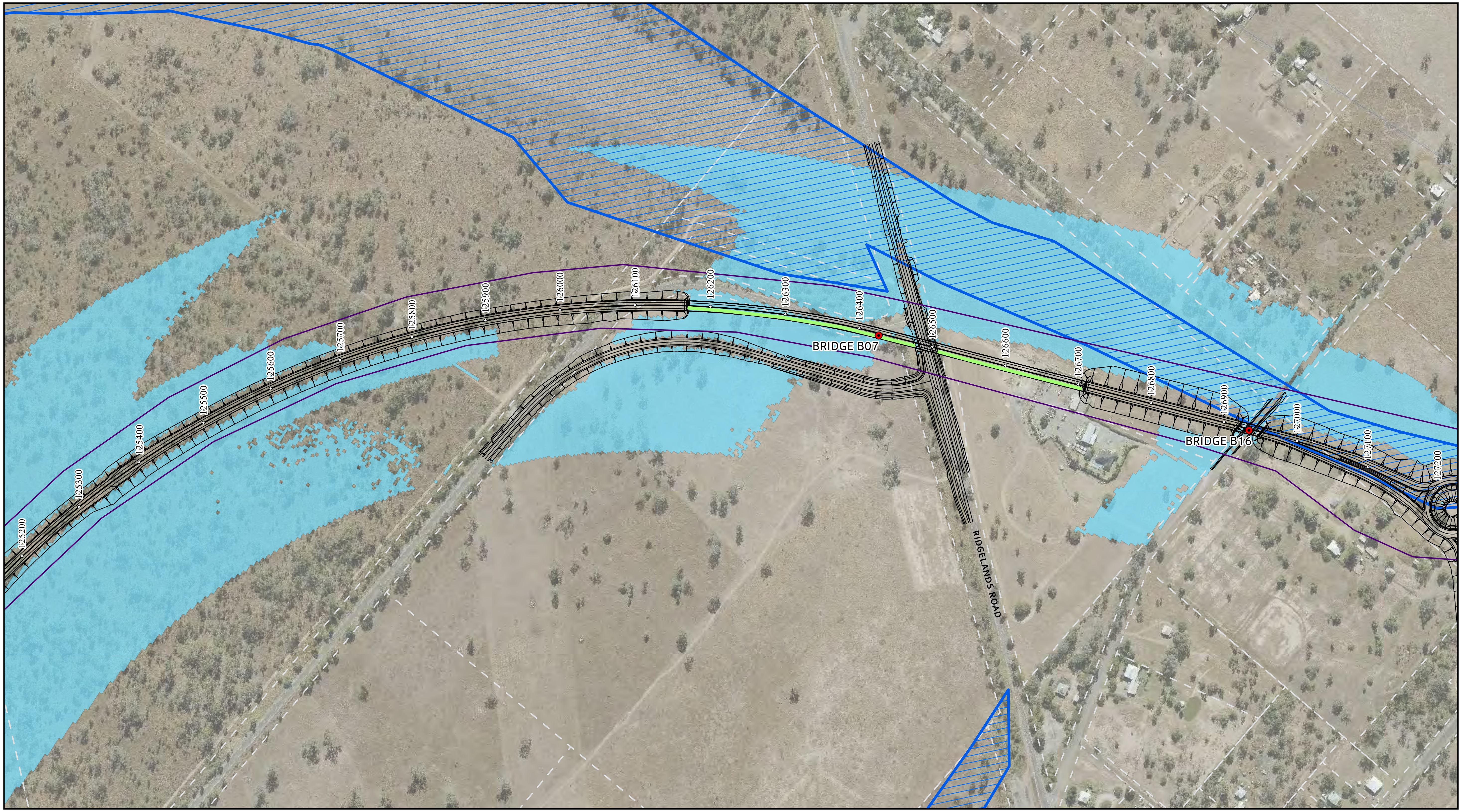
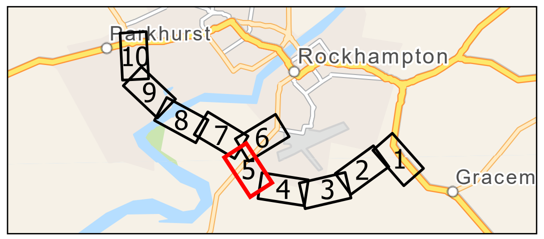
Figure 1: Water Quality Strategy (Sheet 5 of 10)





LEGEND

- Chainage (100m)
- Bridge Location
- Gazetted Corridor
- Scuppers Disharging to Ground
- Design
- Cadastre

Local 20% AEP flood height (m)

- 5-10
- MSES High Ecological Significance (HES) Wetlands

GDA 1994 MGA Zone 56

0 50 100 200
Meters

A3 1:5,000

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Rockhampton Ring Road

Source: DNRME: Roads, Watercourses (2020; Metromap: Imagery (2020)

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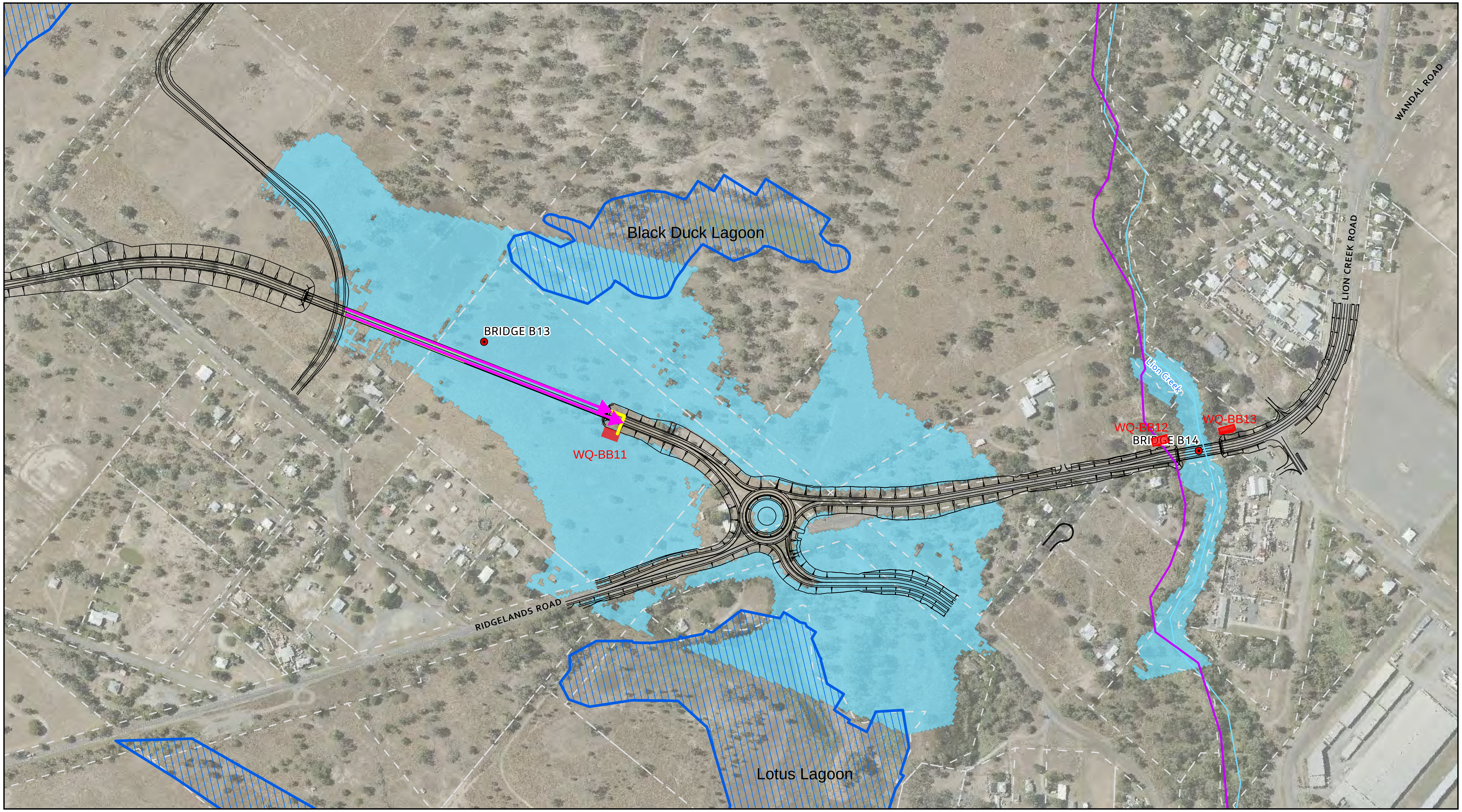
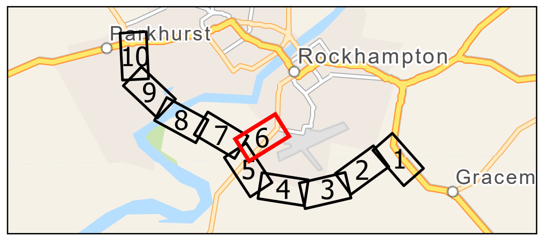
Figure 1: Water Quality Strategy (Sheet 6 of 10)





LEGEND

- Bridge Location
- WWBW Risk of Impact
  - 4 - Major
- Scuppers Disharging to Ground
- Pit & Pipe
- WQ Bioswale
- Minor Watercourse
- Design
- Cadastre
- Scuppers to Bridge Drainage
- WQ Basin
- Local 20% AEP flood height (m)
  - 5-10
- MSES High Ecological Significance (HES) Wetlands

GDA 1994 MGA Zone 56

0 50 100 200

Meters

A3 1:5,000

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Rockhampton Ring Road

Source: DNRME: Roads, Watercourses (2020; Metromap: Imagery (2020)

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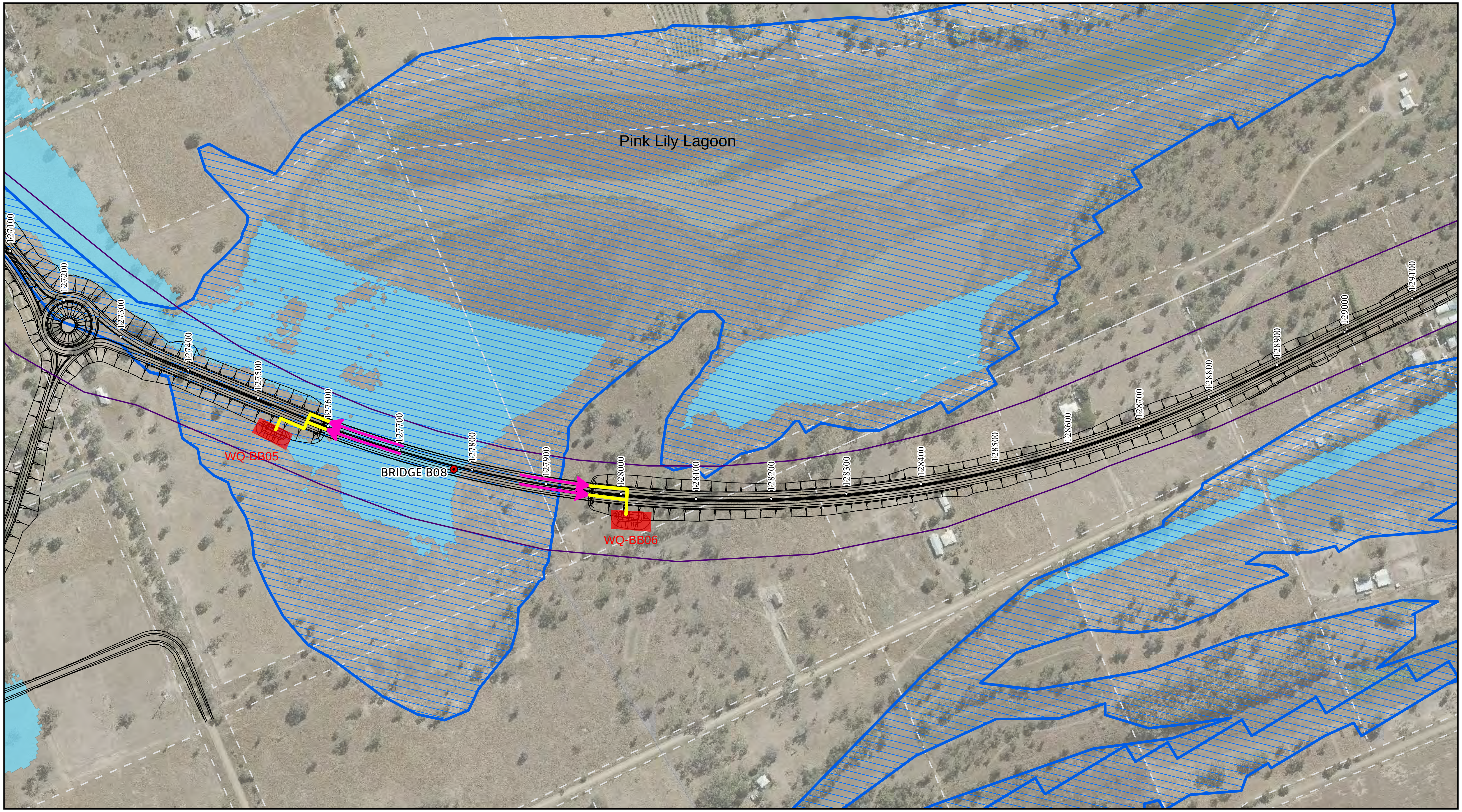
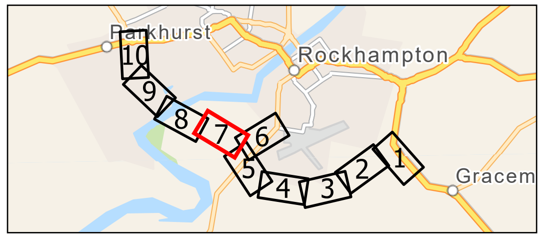
Figure 1: Water Quality Strategy (Sheet 7 of 10)





LEGEND

- Chainage (100m)
- Bridge Location
- Gazetted Corridor
- Scuppers to Bridge Drainage
- Pit & Pipe
- Design
- Cadastre
- WQ Basin
- Local 20% AEP flood height (m)
  - 5-10
- MSES High Ecological Significance (HES) Wetlands

GDA 1994 MGA Zone 56

0 50 100 200
Meters

A3 1:5,000

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Jacobs SMEC Design Joint Venture

Rockhampton Ring Road

Source: DNRME: Roads, Watercourses (2020; Metromap: Imagery (2020)

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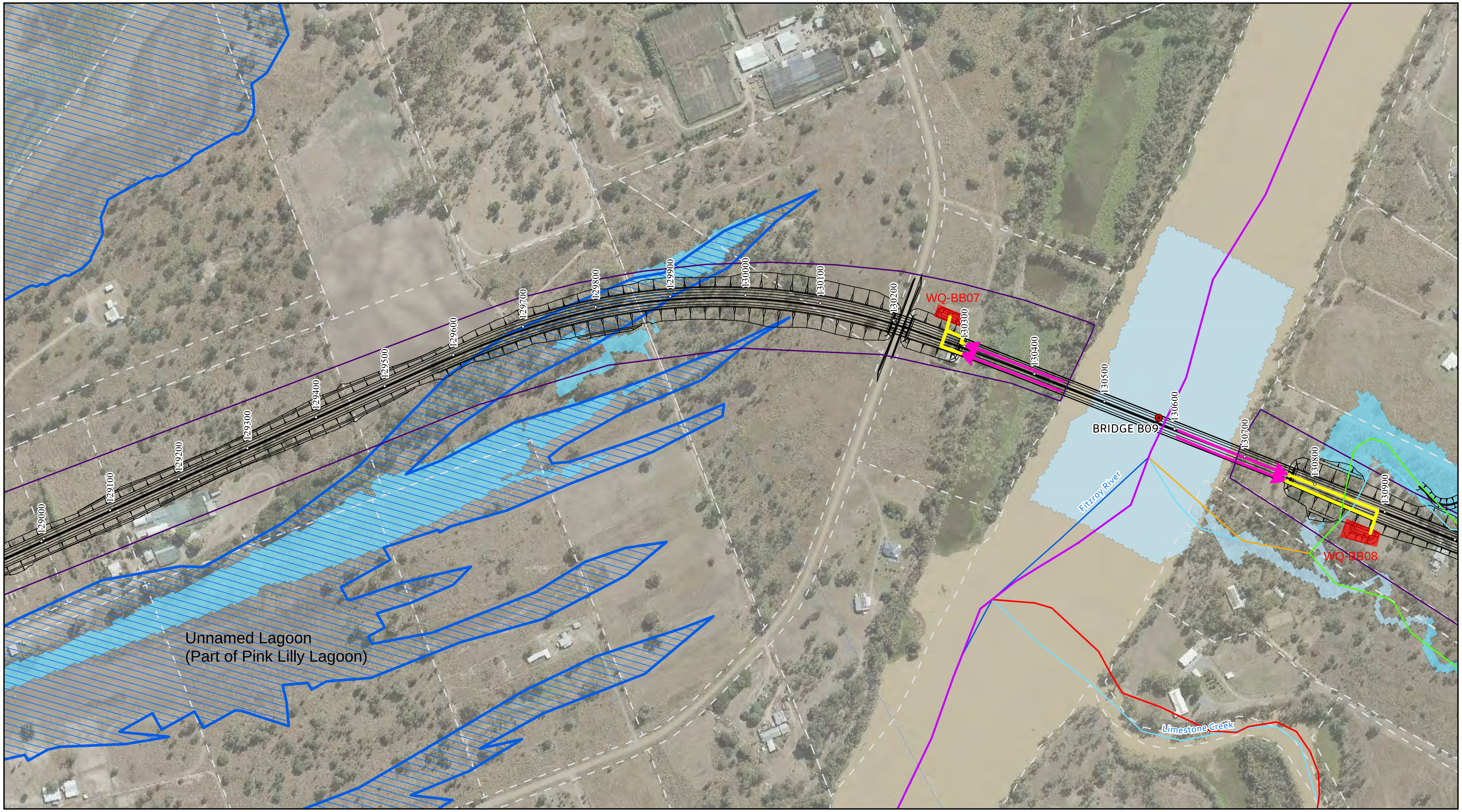
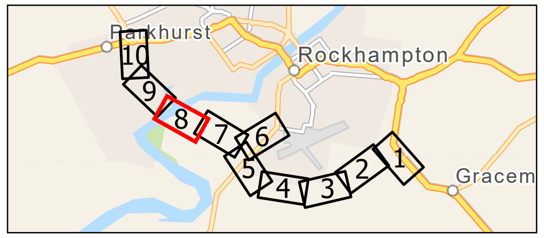
Figure 1: Water Quality Strategy (Sheet 8 of 10)





LEGEND

- Chainage (100m)
- Bridge Location

WWBW Risk of Impact
- 1 - Low
- 2 - Moderate
- 3 - High
- 4 - Major
- Gazetted Corridor
- Scuppers to Bridge Drainage
- Pit & Pipe
- Major Watercourse
- Minor Watercourse
- Design
- Cadastre
- WQ Basin

Local 20% AEP flood height (m)
- ≤5
- 5-10
- MSES High Ecological Significance (HES) Wetlands

GDA 1994 MGA Zone 56

0 50 100 200
Meters

A3 1:5,000

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Jacobs SMEC
Jacobs SMEC Design Joint Venture

Rockhampton Ring Road

Source: DNRME: Roads, Watercourses (2020; Metromap: Imagery (2020)

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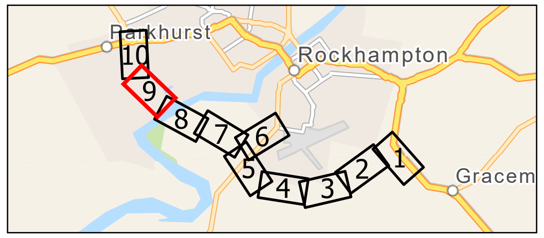
Figure 1: Water Quality Strategy (Sheet 9 of 10)



LEGEND

- Chainage (100m)
- Bridge Location

WWBW Risk of Impact

- 1 - Low
- 2 - Moderate
- 3 - High
- Gazetted Corridor
- Pit & Pipe
- Minor Watercourse
- Design
- Cadastre
- WQ Basin

Local 20% AEP flood height (m)

- ≤5
- 5-10
- 10-15
- 15-20
- 20-25

GDA 1994 MGA Zone 56

0 50 100 200

Meters

A3 1:5,000

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Rockhampton Ring Road

Source: DNRME: Roads, Watercourses (2020; Metromap: Imagery (2020)

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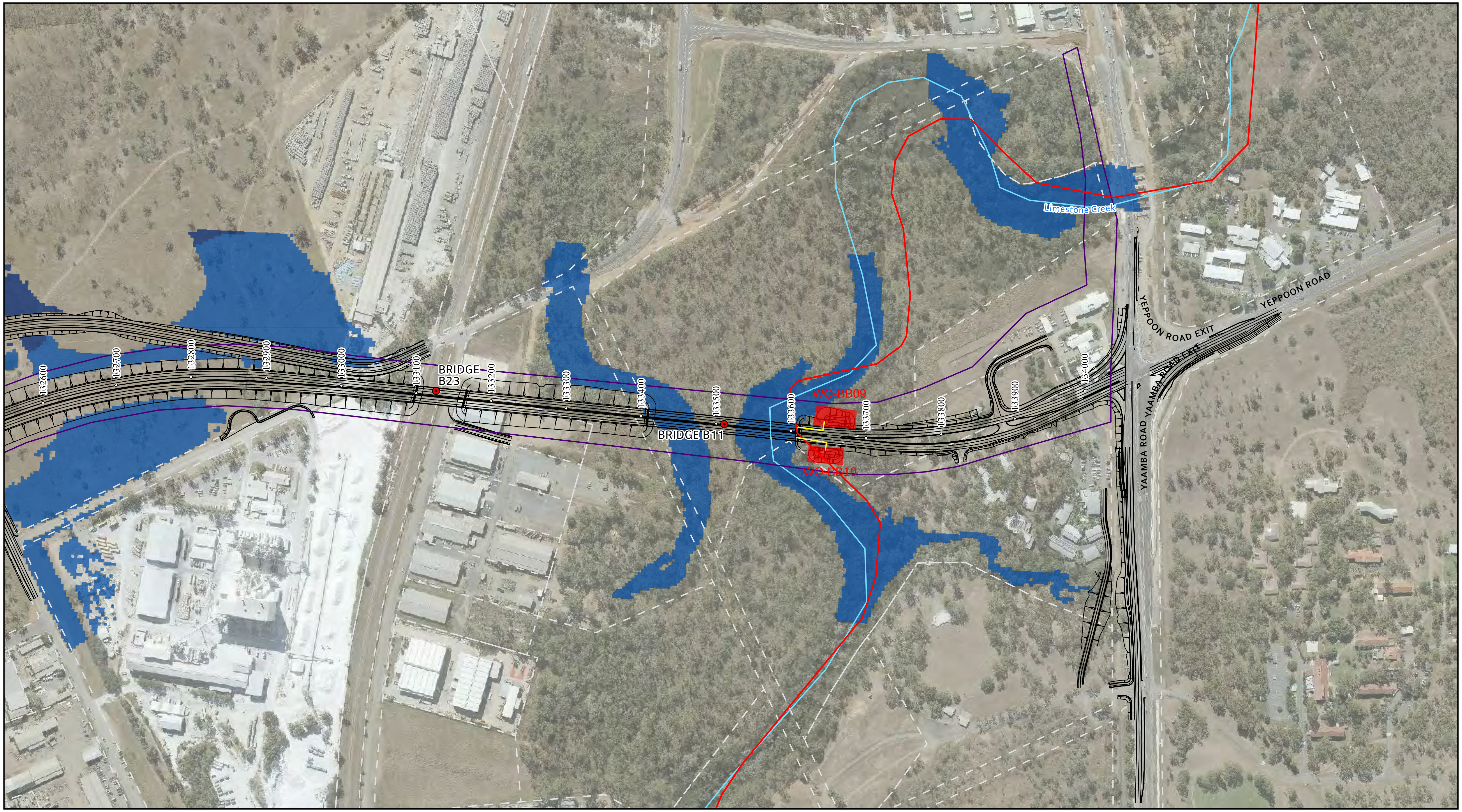
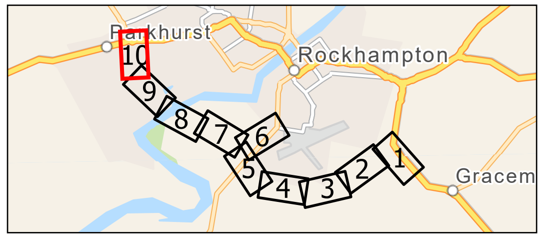
Figure 1: Water Quality Strategy (Sheet 10 of 10)





LEGEND

- Chainage (100m)
- Bridge Location
- WWBW Risk of Impact
  - 3 - High
- Pit & Pipe
- Gazetted Corridor
- Minor Watercourse
- Design
- Cadastre
- WQ Basin
- Local 20% AEP flood height (m)
  - 15-20
  - 20-25

GDA 1994 MGA Zone 56

0 50 100 200 Meters

A3 1:5,000

N

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Jacobs SMEC Design Joint Venture

Rockhampton Ring Road

Source: DNRME: Roads, Watercourses (2020; Metromap: Imagery (2020)

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