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Project: Proposed Sand and Gravel Extraction Facility

Hydraulic and Water Quality Assessment

Reference: 228155

Prepared for: Hardcore Performance Ltd

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ROCKHAMPTON REGIONAL COUNCIL
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1 Introduction

Aurecon was commissioned by Hardcore Performance Ltd to undertake a hydraulic and water quality assessment of the proposed sand and gravel extraction works on Lots 428, 431 and 432 on LIV401245 and Lot 257 on LN882. This assessment was required to assist the Development Application process and address the flooding and water quality items in Rockhampton Regional Council's information request.

Key items raised by Council which were investigated as part of this study are as follows:

> *"Please provide a detailed hydrology and hydraulics report prepared by a suitably qualified* ***Registered Professional Engineer of Queensland****, which addresses, but is not limited to;*
>
> *a) Proposed excavation, filling will not adversely affect flood levels, flood storage areas or flows on the site, upstream, and downstream;*
>
> *b) The proposed raising of Fogarty Road by 600 millimetres does not block, alter, divert existing stormwater runoff patterns or flood storage areas, or cause damage to other infrastructures; and*
>
> *c) Stormwater quality maintenance of the receiving water body in accordance with Environmental Protection (Water) Policy (as amended)."*

The first two items are addressed in Section 2 and the third item is addressed in Section 3 of this report. The figures presented in Appendix A show the development layout as provided to Aurecon.

1.1 Existing site description and characteristics

The site is situated at Fogarty Road and Old Nine Mile Road, Fairy Bower, approximately 9 km from the Rockhampton CBD and 6 km from Gracemere and lies approximately 5 km west of the Fitzroy River. Key features of the site include:

- The site is well grassed with scattered trees and shrubs
- The site is "flat" with a gentle fall (approximately 0.2%) towards a low point at the southern boundary
- Access to the site is via Fogarty Road which has recently been expanded to a six metre wide gravel pavement from Nine Mile Road
- The section of the site to be used for sand extraction is currently used for cattle grazing, with adjoining land also being used for cattle grazing as well as cropping
- An existing "farm" dam is located near the northwest of the project area, adjacent to Fogarty Road
- The site is subject to flooding in a Fitzroy River flood event. Based on flood mapping undertaken for Rockhampton Regional Council, it is estimated the site becomes flooded by an event of between 10 and 20 year average recurrence interval (ARI)

2 Flooding assessment

The site is located on the Fitzroy River floodplain and as a result can be inundated during a Fitzroy River flood event. It is also located within smaller, local drainage catchments which can contribute runoff to the site location. Whilst the proposed development has the potential to impact on the flooding/drainage characteristics associated with both regional and local flooding mechanisms, the impacts on regional flooding have the potential to impact on a significantly larger area than the local flooding impacts. For this reason, the flooding assessment has addressed both of these mechanisms, with a greater focus on the regional flood impacts.

2.1 Regional (Fitzroy River) flooding assessment

A flood assessment of this floodplain was recently completed by Aurecon on behalf of Rockhampton Regional Council (RRC); including development of a hydraulic model of the floodplain. The model was calibrated to the 1988 and 1991 historical flood events and was used to assess the flood characteristics of a range of design floods. The flood mapping prepared for Council shows that the site is subject to inundation in an event between the 10 and 20 year ARI.

The flood model developed for Council was based upon LiDAR data captured for RRC and the Department of Environment and Resource Management (DERM). This LiDAR was flown in June 2009, with a vertical accuracy of ± 0.15 m and a horizontal accuracy of ± 0.30 m. The model also included bathymetric information of the Fitzroy River channel captured in the 1950s, the accuracy of which is unknown. The calibration of this model to historical events provides a high level of confidence in its predictions.

The model was developed on a 50 m grid spacing. This spacing is sufficient to assess flooding characteristics on a regional scale but not those on a local scale. It is therefore adequate to assess the impacts of a proposed development on regional flooding. This is done by modelling the Developed Case (ie the model which represents the proposed development) and comparing the model results to those of the Existing Case (ie the model which represents the floodplain as it was developed in June 2009, including the Nine Mile Road raising).

2.1.1 Methodology

Council's TUFLOW model of the Fitzroy River was used as the basis for assessing the impacts of the proposed development on regional flooding. The proposed development layout (as provided to Aurecon and included in Appendix A) was incorporated into the TUFLOW model. Figure 1 shows the elements which were modelled in TUFLOW, including:

- A bund alongside Fogarty Road raised to an elevation of 1 m above the existing surface (this element was more likely to impact upon flooding than the 0.6 m raising of Fogarty Road so this was the element which was modelled). Information provided to Aurecon indicates that the bund is currently constructed and runs along the eastern side of Fogarty Road from Nine Mile Road to the southern boundary of Sand Extraction Pit 1 (refer to Appendix A). There is a break in the bund where the property entrance road intersects Fogarty Road. The bund also runs along the southern side of Nine Mile Road for 50 m east of its intersection with Fogarty Road
- Internal roads raised to an elevation of 0.5 m above the existing surface
- A bund around the extraction pits raised to an elevation of RL 10.2 m AHD
- Filling of the pads for the processing plant (to RL 10.2 m AHD) and the raw and processed material stockpiles (to RL 9.2 m AHD)
- Excavation of the pits to RL -1.8 m AHD

Note that no information was available regarding rehabilitation of the site/bunds as each pit is developed; therefore the modelled Developed Case included excavation of all pits and a bund around the entire pit extents, with a small opening between Pit 1 and 2, as shown in Appendix A.

The site is not shown as being inundated under the 2, 5 or 10 year ARI events; therefore the model was only run for the 20, 50 and 100 year ARI design events. The results for the Developed Case were compared to Council's Existing Case 20, 50 and 100 year flood levels to determine the impacts caused by the development.

2.1.2 Results

The model results, presented as differences in peak water levels, are shown on Figure 2 to Figure 4 for the 100, 50 and 20 year ARI events. The impact categories used in this mapping are consistent with those that have been used for previous impact assessments for Council. In these previous assessments, a change in peak water levels of up to ±20 mm has been considered a negligible impact.

Peak water levels and impacts are also reported (Table 1) at a number of locations, as shown on Figure 2 to Figure 4. These locations were selected where buildings were evident on the aerial image (c/o Microsoft Bing 2011) and where afflux is shown in Figure 2 to Figure 4.

Table 1 | Peak Water Levels and Afflux at Reporting Locations

Location	Lot and RP	Existing Case Peak Water Level (m AHD)			Developed Case Peak Water Level (m AHD)			Afflux (mm)		
		100yr ARI	50yr ARI	20yr ARI	100yr ARI	50yr ARI	20yr ARI	100yr ARI	50yr ARI	20yr ARI
L1	Lot 3 on LN883	10.70	10.33	9.85	10.73	10.36	9.89	+30	+35	+39
L2	Lot 2 on LN883	10.72	10.35	9.87	10.75	10.38	9.90	+25	+30	+33
L3	Lot 1 on LN883	10.74	10.37	9.88	10.76	10.39	9.91	+24	+28	+31
L4	Lot 255 on LN883	10.76	10.38	9.89	10.78	10.40	9.92	+22	+26	+30
L5	Lot 143 on LN2246	10.87	10.47	9.95	10.88	10.49	9.97	+16	+20	+24
L6	Lot 92 on SP120229	10.83	10.47	9.99	10.84	10.48	10.01	+14	+17	+19
L7	Lot 2 on RP609472	10.79	10.43	9.93	10.80	10.44	9.95	+15	+19	+25
L8	Lot 90 on PL4022	10.79	10.43	9.93	10.80	10.45	9.96	+14	+19	+24
L9	Lot 86 on LN1119	10.77	10.41	9.92	10.78	10.43	9.94	+12	+18	+25
L10	Lot 84 on PL4022	Dry	Dry	Dry	Dry	Dry	Dry	0	0	0
L11	Lot 2 on RP604078	10.80	10.44	9.93	10.81	10.45	9.95	+12	+16	+23
L12	Lot 2 on RP604082	10.79	10.43	9.91	10.81	10.45	9.94	+12	+17	+23
L13	Lot 1 on RP604077	10.80	10.43	9.91	10.81	10.45	9.93	+11	+17	+23
L14	Lot 23 on RP603312	10.03	9.59	9.01	10.03	9.59	9.03	+4	+4	+19
L15	Lot 24 on RP603312	9.81	9.35	8.77	9.81	9.35	8.77	-3	-3	+7
L16	Lot 22 on RP603312	10.03	9.60	9.03	10.04	9.61	9.05	+5	+6	+21
L17	Lot 1 on RP615160	10.01	9.59	9.02	10.02	9.59	9.04	+5	+6	+21
L18	Lot 3 on RP601912	10.91	10.50	9.97	10.92	10.52	9.99	+15	+18	+22

The impacts shown in Figure 2 to Figure 4 and results in Table 1 are summarised in the following sections.

2.1.2.1 100 year ARI event impacts

- Peak water levels are predicted to increase by up to +90 mm on the western side of Fogarty Road
- Impacts of +20 mm up to +75 mm (generally in the order of +25 to +30 mm) are predicted for up to 1.25 km to the north and west of the site and 1.6 km to the south-west of the site
- Peak water level increases of greater than +20 mm occur at four properties/buildings on the southern side of Nine Mile Road, west of Fogarty Road

2.1.2.2 50 year ARI event impacts

- Impacts up to +90 mm are predicted on the western side of Fogarty Road
- Impacts of +20 mm up to +75 mm (generally in the order of +25 to +30 mm) are predicted for up to 1.5 km to the north and 2.0 km to the west and south-west of the site
- Peak water level increases of greater than +20 mm occur at five properties/buildings on the southern side of Nine Mile Road, west of Fogarty Road

2.1.2.3 20 year ARI event impacts

- Impacts up to +170 mm are predicted on the western side of Fogarty Road
- On the upstream side of the site, impacts of +20 mm up to +75 mm (generally in the order of +25 to +30 mm) are predicted to occur for 2.5 km east along Lion Creek and 8.5 km north-west along Lion Creek
- Impacts of +20 mm up to +75 mm (generally in the order of +25 to +30 mm) are also predicted to occur for 5.5 km west of the site and 2.0 km south-west of the site
- Peak water level increases of greater than +20 mm occur at fourteen properties/buildings

2.1.2.4 Site flood levels

The peak flood levels predicted outside the extraction pits in the Developed Case are presented in Table 2. The ground elevation adjacent to the pits is approximately 8.0 – 8.3 m AHD.

Table 2 | Developed Case Peak Water Levels at the Site

Location	Peak Water Level (m AHD)		
	100yr ARI	50yr ARI	20yr ARI
North-west corner of Pit 1	10.38	9.95	9.40
South-west corner of Pit 1	10.27	9.83	9.29
North-west corner of Pit 8	10.16	9.74	9.16
North-east corner of Pit 6	10.05	9.63	9.07
South-east corner of Pit 5	9.99	9.55	8.97

2.1.3 Conclusions

The results show that impacts are predicted to occur as a result of the proposed works. These primarily occur upstream and to the west of the site and are generally in the order or +25 to +30 mm, except immediately to the west of the site where they are up to +170 mm in the 20 year ARI event and +90 mm in the 50 and 100 year ARI events. We recommend that these impacts be discussed with Council to determine what would be considered acceptable.

2.2 Local drainage assessment

In the local drainage assessment, the local catchments in the vicinity of the proposed works were identified, as shown on Figure 5. There are four separate catchments which contributé runoff towards the upstream (northern) side of the site. These catchments all join together on the downstream side of the site and flow into the lagoon located to the east of the Newman Road corridor.

The impacts of the proposed works on each of the four local catchments are summarised as follows:

- The catchment which flows around the eastern side of the site will not be impacted by the proposed works. The main flowpath in this catchment is located to the east of the pits
- There are two catchments which flow directly to the upstream side of the site. Runoff from these catchments will need to be managed within the site design and can either be diverted around the site or conveyed through the site (preference is for diversion around the site to maintain separation of clean and dirty water as per the water quality recommendations). These changes are not likely to worsen runoff conditions from the site. In the event that some impacts do occur, they will be contained within the property boundaries and will not impact on external properties
- The catchment which currently flows across Fogarty Road and around the west of the site will be impacted by the bund and the raising of Fogarty Road, however these impacts are not considered significant. The flows which will be captured on the eastern side of the bund can be directed alongside the bund to re-join with flows from the remainder of this catchment near the south-western corner, hence having little impact on the overall flows from this catchment

3 Water quality assessment

3.1 Statutory requirements

The management of stormwater quality has been assessed against the *Environmental Protection (Water) Policy 2009* (EPP Water). EPP Water is a subordinate legislation under the *Environmental Protection Act 1994*. It provides a structure for maintaining and protecting Queensland waters, through the identification of environmental values (EVs) and water quality objectives (WQOs). The EVs and WQOs are established under Schedule 1 of the EPP Water.

Released in September 2011, the Fitzroy River Sub-basin Environmental Values and Water Quality Objectives – Basin No. 130 (part), including all water of the Fitzroy River Sub-basin report outlines EVs and WQOs for the waterways associated with the project area. EVs are qualities of waterways that need to be protected, while WQOs are measures of particular indicators of water quality.

The WQOs are numerical concentration levels or narrative statements of indicators established for receiving water to support and protect the designated EVs for those waters. They are based on scientific criteria or water quality guidelines but may be modified by other (social, cultural, economic) inputs.

The project area ultimately drains into the Fitzroy River with the location area being bounded by Lion Creek to the north and Neerkol Creek to the south which forms part of the south/central tributaries of the Fitzroy River. Table 3 outlines EVs for the south/central tributaries.

Table 3 | Fitzroy south/central tributaries (fresh water) – developed areas EVs adopted from DERM (2011, p. 7)[1]

Environmental Value		Fitzroy south/central tributaries (fresh water)[2]	Environmental Value		Fitzroy south/central tributaries (fresh water)[2]
	Aquatic ecosystems	✓		Primary recreation	✓
	Irrigation	✓		Secondary recreation	✓
	Farm supply/use	✓		Visual recreation	✓
	Stock water	✓		Drinking water	✓

Environmental Value		Fitzroy south/central tributaries (fresh water)[2]	Environmental Value		Fitzroy south/central tributaries (fresh water)[2]
	Aquaculture	✓		Industrial use	✓
	Human consumer	✓		Cultural and spiritual values	✓

Note: [1] Department of Environment and Resource Management (DERM). 2011. Fitzroy River Sub-basin Environmental Values and Water Quality Objectives – Basin No. 130 (part), including all waters of the Fitzroy River Sub-basin, Department of Environment and Resource Management

[2] Fitzroy south/central tributaries, including Gogango, Moah, Scrub, Ten Mile, Station, Louisa, Middle, Deep, Lion, Neerkol, Ridgelands, Limestone, McGinley, Oakey, Poison, Swan and Tea Tree creeks

The key water quality objectives as defined in Schedule 1 of the EPP Water for the Fitzroy River Sub-basin fresh waters are summarised in Table 4.

Table 4 | Key water quality objectives to protect aquatic ecosystem environmental value (refer Plan WQ1305 for location of waters) (Schedule 1, EPP Water, 2009)

Level of protection	Water quality objectives to protect aquatic ecosystem EV
Aquatic ecosystem — Moderately disturbed	• total nitrogen: <500 µg/L • total phosphorus: <50 µg/L • turbidity: <50 NTU • suspended solids: <85 mg/L • pH: 6.5–8.5

It has been identified in the Development Application that the project area does not contain any remnant vegetation and although there are some areas of High Value Regrowth Vegetation that contains Of Concern Regional Ecosystem on the land and some areas of Wetland Protection, it has been identified that there will be no extraction in these mapped areas. The site area being used for the development does not include any of the area that is considered high value regrowth or protection area.

3.2 Proposed activities

The operation of the project is to extract sand products. The method of extraction and washing as outlined in the Development Application – Appendix C (p3) involves the following activities:

- Topsoil and vegetation will be removed by excavator and articulated dump trucks. All topsoil will be stockpiled to be used during rehabilitation of sand extraction pit
- Sand will be extracted from the pit via two different methods:
  - By excavator and loaded onto dump trucks, delivered and stockpiled behind the process plant
  - By use of a suction type pump to continue sand extraction from below the water table, which is to be pumped up and over a screening deck, sized and then fed into a cyclone to remove excess water. The product is then delivered and stockpiled behind the process plant.
- When sufficient sand is stockpiled at the wash plant, the unwashed sand will be loaded into the screening plant (Finlay 390), which will be fitted with 4 and 5 mm screens and 1st stage rinsers. The sand will then be pumped as a slurry into the Finlay 200E where it will be further washed and partially dried, then stockpiled in concrete bunkers

- Water used to wash sand in the process plant will be captured and channelled to the primary settling pond. Washed sand is allowed 24 hours to further drain in the concrete bunkers, with excess water being diverted into the settling ponds. Silt from the silt traps/drains will be removed and stockpiled for use in land rehabilitation
- Washed sand is stockpiled and loaded onto trucks for delivery as needed. The Development Application estimates up to 8 truck movements per day

As identified above, the site is subject to flooding. To help mitigate this, it is proposed that 2 m high bund walls will be constructed surrounding the sand extraction pit to prevent the ingress of flood water from the Fitzroy River into the pit. These bund walls will provide the pit with immunity to a flood of greater than 50 year ARI.

The processing plant and stockpiling areas are also to be constructed on raised platforms. The processing plant will be situated on a 2 m high platform, with both raw and finished stock piles located on 1 m high platforms. These areas will begin to become flooded during an event exceeding approximately a 10 year ARI.

Trucks will access these platforms for loading of sand via ramps to the loading area. Access/haulage roads through the site will also be raised 0.5 m from the natural ground to increase the site's accessibility during wet conditions.

3.3 Opportunities and constraints

The project site activities and operations present a number of potential opportunities and constraints regarding the management of stormwater runoff from the site.

Opportunities for stormwater management include:

- Bund wall/raised platforms allow for separation/diversion of runoff from undisturbed areas of the site away from potential contaminant sources
- Rainfall into the sand extraction pit will be contained within the pit. The bund walls will also prevent flood water from entering the sand extraction pit, except under extreme rainfall events (greater than 50 year ARI)
- There is to be no fuel or other hazardous substances stored on site
- There are no additives during the sand extraction/washing process
- All stockpile areas are raised, with drainage from these areas to settling ponds (this includes both non-dredging/dredging mining operations)
- The site is relatively large, with significant undisturbed vegetative areas surrounding all operations providing a buffer to any stormwater from the site prior to discharge to receiving waterways
- The internal gravel roads act as a continuous vibration grid therefore negating the need for a vibration grid at the site exit
- No Acid Sulphate Soils have been found in the project area

Given the nature of the site and operations a number of constraints have been identified with regard to stormwater management. These include:

- The site is subject to flooding
- There is limited existing stormwater infrastructure in the area. There is no piped drainage to connect into
- The rural location of the project area tends itself towards the need for controls requiring less maintenance and repair (ie greater self-sustained systems/vegetated systems). The systems should also fit in with the overall nature of the site, ie rural

3.4 Key pollutants

The quality of stormwater runoff from the site is affected by the presence of a number of potential contaminants. Based on the activities proposed for the site the sources of pollutants have been identified to include:

- Trucks entering and exiting the site (6 to 8 truckloads/day)
- Road runoff
- Sand stockpiles
- Process water used for sand washing

Table 5 shows the pollutants as a result of the activities identified above and a breakdown of the pollutant sources. These are the key pollutants that require water quality treatment before discharge from the site during a storm event.

Table 5 | Key pollutants and pollutant sources

Pollutant	Source
Sediment	Dust deposition on impervious areas, erosion and vehicle wear, stockpiled materials, unsealed road surfaces and sand spillage during truck loading
Hydrocarbons	Vehicles exhausts, fuels, lubricants
Heavy metals	Vehicle wear, combustion of petroleum products and maintenance materials
Nutrients	Detergents and the breakdown of vegetative matter

Limited gross pollutants are expected within the development, due to minimal human activities on site as the majority of the site will be accessed by trucks and other machinery only. It is assumed that any gross pollutants occurring as a result of human activity is collected and disposed of in an adequate manner; therefore removing the need for any gross pollutant-specific treatment systems (eg gross pollutant traps).

3.5 Stormwater management philosophy

Due to the rural location where the sand extraction works are being carried out, the implementation of a stormwater treatment system that incorporates the existing landscape and natural features of the site has been recommended where possible. The integration of vegetative treatments, as opposed to hard engineering solutions, is preferred.

3.6 Recommended treatment measures

The recommended treatment system has been developed in alignment with the stormwater management philosophy and incorporates the opportunities and constraints of the site.

As previously identified, the key systems that generate pollutants are the processing plant, stockpile areas and the roadways for processed sand collection and delivery. The processing plant is to be constructed on a raised platform and all process water used in the washing plant, as well as runoff from stockpiles, is to be captured and directed into the settling ponds.

To capture any sand spillage and treat pollutants as a result of vehicular access, a combination of treatment measures is recommended. These measures will also provide treatment to other contaminants that may be generated by the truck movements, including vehicle emissions and dust deposition. As the gravel road will perform as a continuous vibration grid, it is expected that removal of

any sand particles attached to the under body of delivery trucks will be removed almost immediately (ie close to the loading bay) which will be collected via the drainage system to the settling ponds or by the swale system (discussed further below).

It is assumed that any upstream runoff from north of the sand extraction project site will not enter the site but will be diverted via the use of a diversion bund/drain as identified in Figure 6.

The settling ponds and other recommended stormwater treatment measures are described in the sections below.

3.6.1 Settling ponds

All runoff from the processing plant area is to be captured in drains and conveyed to settling ponds. Both the raw and washed sand stockpiles are located on concrete pads that also drain to the settling ponds. These settling ponds operate in series, with water extracted from the third and final pond for reuse within the washing plant.

Settling ponds are well suited to the removal of sand from stormwater. Based on the size of the processing plant and stockpile areas (the catchment area for the settling ponds), the proposed size of the settling ponds has been determined to exceed that required for treatment of runoff from these areas. This was determined based on recommendations within the Water Sensitive Urban Design Technical Design Guidelines for South East Queensland (2006) developed by Healthy Waterways. It should be noted that this sizing check has been undertaken using the simplified sizing charts presented within the Healthy Waterways Technical Design Manual; these provide an estimate of settling area required based on the design discharge. The design storm adopted was a 1 year ARI, 10 minute storm event.

It is therefore considered that these settling ponds will provide an appropriate level of treatment for stormwater runoff from the processing plant and stockpile area.

3.6.2 Swales

Vegetated or grassed swales (natural drains) are recommended to be incorporated into the site. These should be located along designated roadway sections to provide treatment of road runoff and allow for the capture of any sand falling from trucks prior to them leaving the site area.

The use of vegetated and grassed swales would also provide conveyance of stormwater in place of underground pipes, directing runoff towards further treatment systems or overland flow paths through the site. Swales have the benefit of helping to remove coarse and medium sediment from the stormwater by utilising settlement, screening and filtration to remove sediment and nutrients. Swales are most suited to evenly graded areas with mild slopes (less than 4%) which are suitable for the "flat" project area and are often used adjacent to roadways. Swales can provide an important pre-treatment function to stormwater and also help to reduce stormwater velocities when compared to piped drainage systems.

Specific locations for the swales have not been identified as part of this study as this will ultimately be dependent on the final drainage design for the site (including exact location of culverts through the access/haul roads). However, it is considered appropriate that swales be located adjacent to access/haul roads to capture runoff, provide pre-treatment and convey the stormwater to rain gardens (discussed in the following section) for further treatment.

The overall dimensions of the swales required for water quality treatment will vary depending on the size of the catchment area being treated and how the drainage network performs. However, some typical swale dimensions are identified in Table 6.

Table 6 | Typical swale parameters

Swale parameter	Dimension
Depth (m)	300 – 500 mm
Batter slopes	1:4
Top width (m)	Varies
Base width (m)	Varies

3.6.3 Rain gardens

It is recommended that a depressed area be created and extensively planted with wetland vegetation/grasses to provide an area where stormwater runoff from access/haulage road areas can be directed to for natural filtration/treatment prior to leaving the project site. It is recommended that this system be located, as identified in Figure 6, to allow for capture/treatment of road runoff conveyed by the swale systems. This treatment should be constructed as a shallow, extensively vegetated area. The depressed area would also allow for some detention of the stormwater prior to discharge.

It is suggested this system be sized as per recommendations within the Healthy Waterways Technical Design guidelines (2006) for wetlands. Whilst the system proposed is not strictly a wetland, many of the treatment principles are the same and this sizing approach is considered appropriate given the nature of the development and surrounding areas (ie rural). Based on these guidelines the system should have an area of approximately 3 to 8% of the catchment area. Given the rural nature of the site and highly pervious catchment area, setting aside 5% of the catchment area for rain gardens is considered appropriate.

Based on the site layout and assumed drainage paths (refer Figure 6), two rain gardens are recommended with sizes as shown in Table 7 below. These areas are identified on Figure 6 and can be seen to be easily incorporated within the project site. It should be noted that the locations proposed are indicative and would be subject to change based on final flow paths through the site and locations of services.

Table 7 | Rain garden sizing

System	Approximate area required
Rain garden 1 (west side of the development)	585 m^2
Rain garden 2 (east side of the development)	708 m^2

3.7 Conclusion

The treatment system recommended for the sand extraction works consists of a treatment train involving swales and vegetated rain gardens to provide treatment for runoff from the site access/haulage road areas, with settling ponds used for treatment of wash-waters and runoff from the processing plant/stockpiling areas.

It is considered that the above stormwater treatment strategy would provide an appropriate level of treatment of stormwater runoff to maintain existing water quality in receiving waters.

It is important to note that the treatment measures discussed are targeted at managing stormwater runoff during smaller storm events. They will not provide control of water quality when larger flood events inundate the site.

4 Conclusions

This report has been prepared to address the following three issues:

> *a) Proposed excavation, filling will not adversely affect flood levels, flood storage areas or flows on the site, upstream, and downstream;*
>
> *b) The proposed raising of Fogarty Road by 600 millimetres does not block, alter, divert existing stormwater runoff patterns or flood storage areas, or cause damage to other infrastructures; and*
>
> *c) Stormwater quality maintenance of the receiving water body in accordance with Environmental Protection (Water) Policy (as amended)."*

In regards to issue a), the proposed works will impact upon flood characteristics on the upstream side and to the west and south-west of the site. These impacts need to be discussed further with Council to understand what will be considered acceptable.

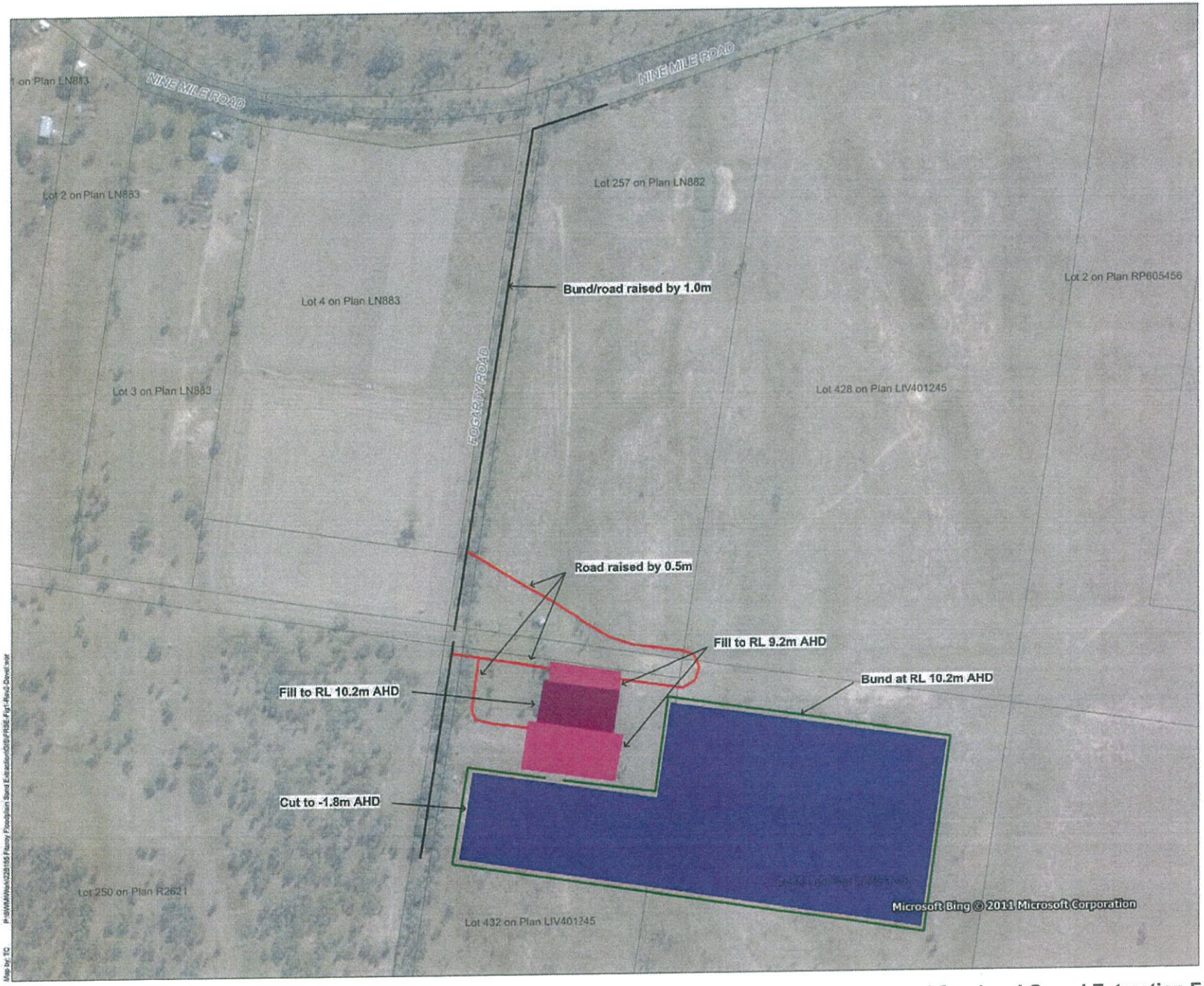
In regards to issue b), the proposed raising of Fogarty Road and inclusion of a bund on the eastern side of the road will have little impact upon local drainage. The impacts of these works are greatest in a Fitzroy River flood event, as discussed above for item a).

In regards to issue c), it is considered that the proposed stormwater treatment strategy (including the additional measures outlined within this report) would provide an appropriate level of treatment of stormwater runoff to maintain the existing water quality in receiving waters.

Appendices

Figures

aurecon



Legend

- Cadastre
- Bund (RL 10.2m AHD)
- Road Raised 0.5m
- Road/Bund Raised 1.0m
- Fill (RL10.2m AHD)
- Fill (RL 9.2m AHD)
- Cut (RL-1.8m AHD)

Notes

A3 scale 1:4,000

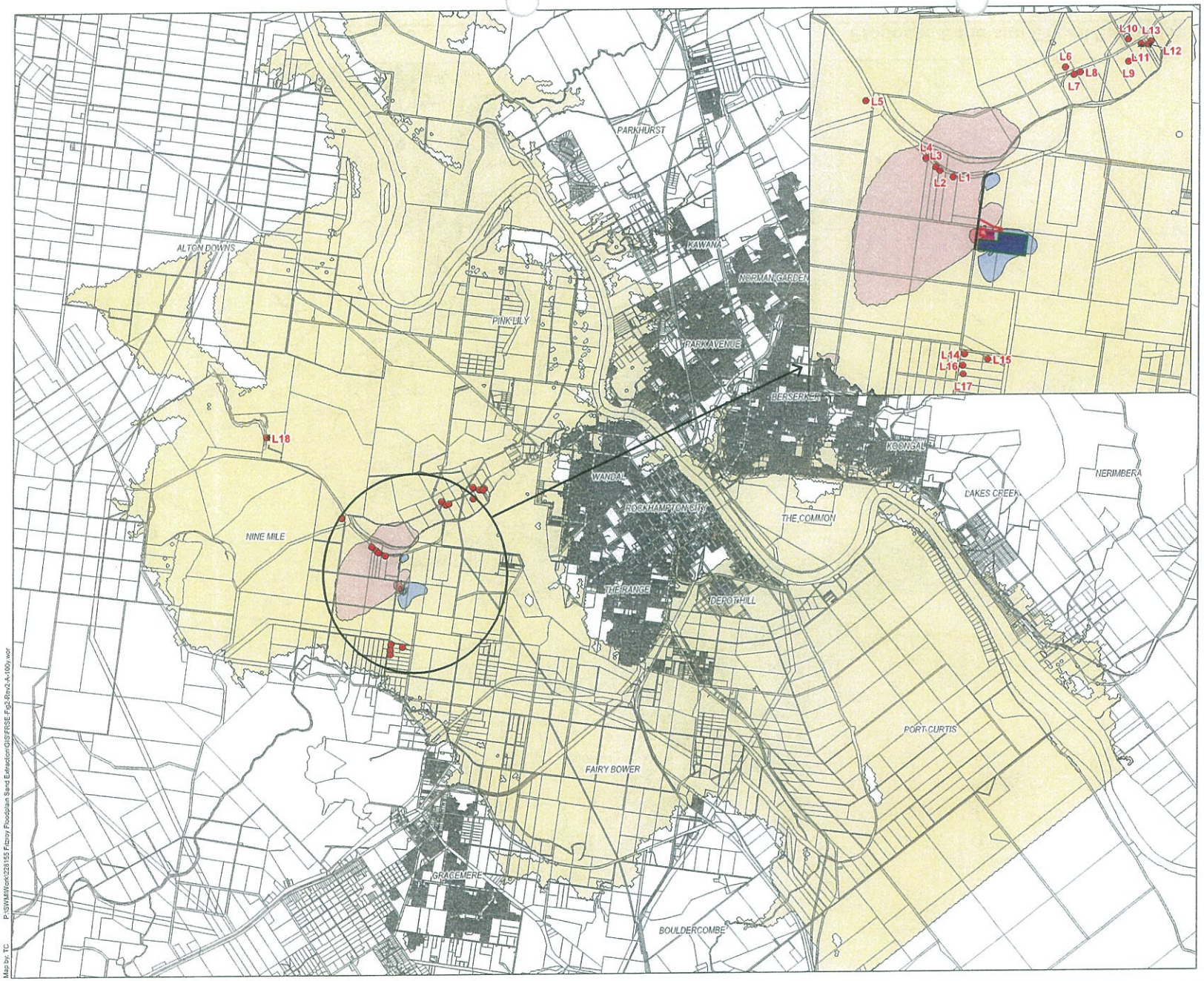
0 100 m 200 m

Date: 01/03/2012 Version: 2 Job No: 228155

Projection: MGA Zone 56

Proposed Sand and Gravel Extraction Facility Hydraulic Assessment

Figure 1: Modelled Development Extents and Details



aurecon

Legend

- Cadastre
- Bund (RL 10.2m AHD)
- Road Raised 0.6m
- Road Raised 0.5m
- Fill (RL 9.2m AHD)
- Fill (RL10.2m AHD)
- Cut (RL-1.8m AHD)
- Reporting Location

Afflux (m)

< -0.300	0.020 to 0.075
-0.300 to -0.225	0.075 to 0.150
-0.225 to -0.150	0.150 to 0.225
-0.150 to -0.075	0.225 to 0.300
-0.075 to -0.020	> 0.300
-0.020 to 0.020	

Notes:

DRAFT

Map by: TC P:\SWM\Work\228155 Fitzroy Floodplain Sand Extraction\GIS\FRSE Fig2-Rev2-A4-100y.mxd

A3 scale 1:80,000
Inset scale 1:40,000

0 2,000 m 4,000 m

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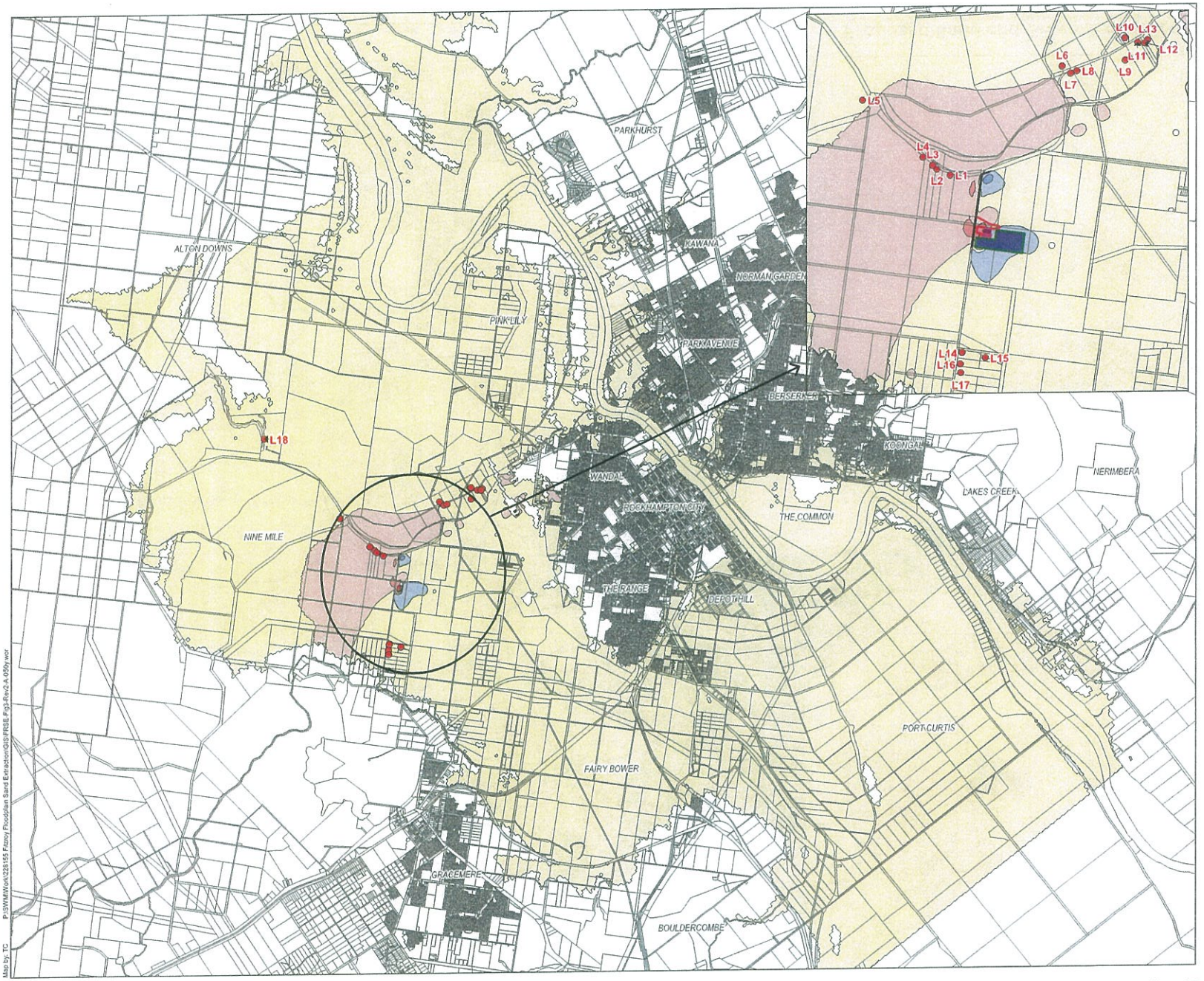
Projection: MGA Zone 56

Proposed Sand and Gravel Extraction Facility Hydraulic Assessment

Figure 2: Flood Impacts - 100 Year ARI Fitzroy River Event

aurecon



Legend

- Cadastre
- Bund (RL 10.2m AHD)
- Road Raised 0.6m
- Road Raised 0.5m
- Fill (RL 9.2m AHD)
- Fill (RL10.2m AHD)
- Cut (RL-1.8m AHD)
- Reporting Location

Afflux (m)

< -0.300	0.020 to 0.075
-0.300 to -0.225	0.075 to 0.150
-0.225 to -0.150	0.150 to 0.225
-0.150 to -0.075	0.225 to 0.300
-0.075 to -0.020	> 0.300
-0.020 to 0.020	

Notes:

DRAFT

Map by: TC P:\SWMM\Work\228155 Fitzroy Floodplain Sand Extraction\GIS\FR5E Fig3-Rev2 A 050y.wor

A3 scale 1:80,000
Inset scale 1:40,000

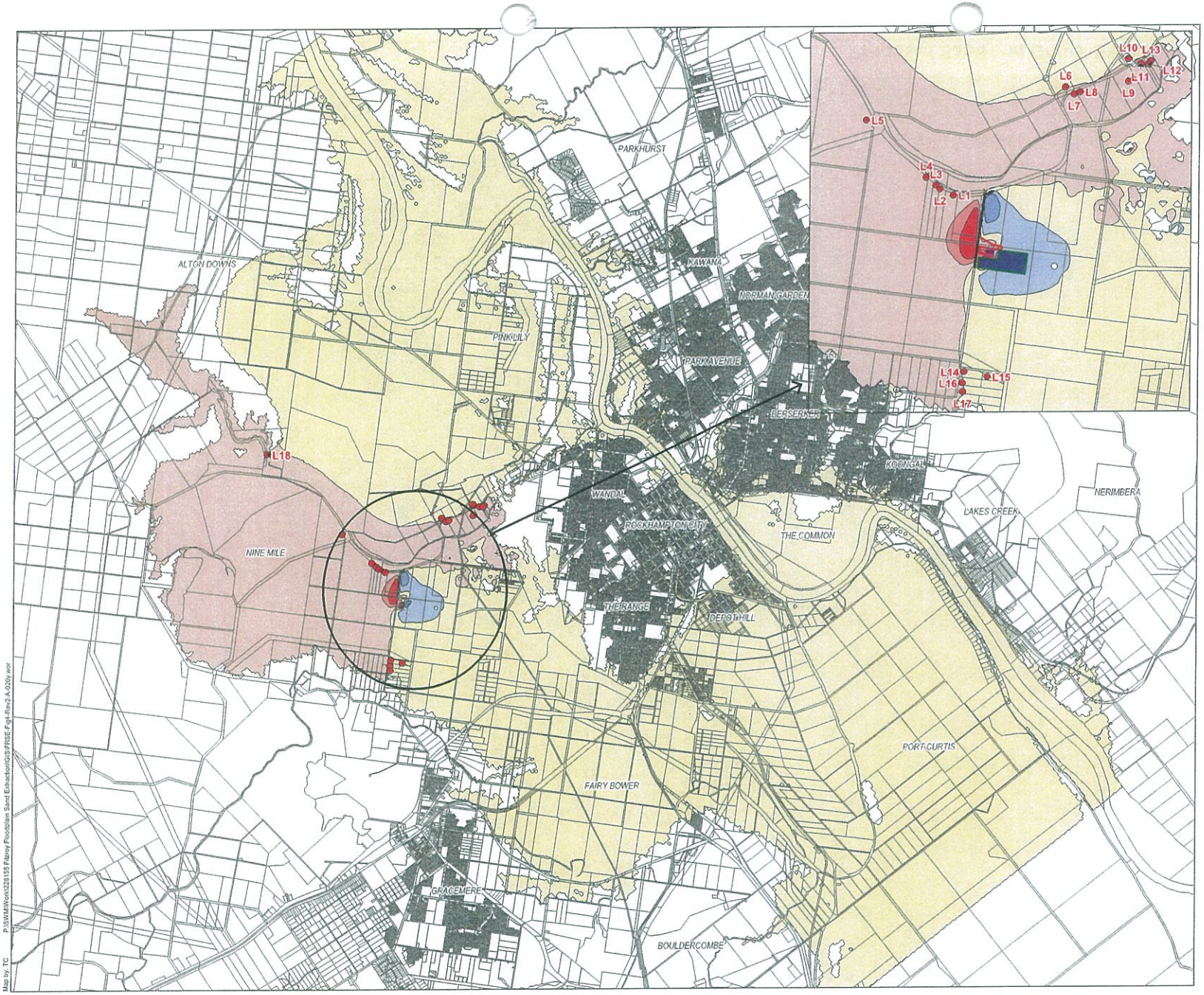
0 2,000 m 4,000 m

Date: 07/03/2012 Version: 2 Job No: 228155

Projection: MGA Zone 56

Proposed Sand and Gravel Extraction Facility Hydraulic Assessment

Figure 3: Flood Impacts - 50 Year ARI Fitzroy River Event



aurecon

Legend

- Cadastre
- Bund (RL 10.2m AHD)
- Road Raised 0.6m
- Road Raised 0.5m
- Fill (RL 9.2m AHD)
- Fill (RL10.2m AHD)
- Cut (RL-1.8m AHD)
- Reporting Location

Afflux (m)

- < -0.300
- -0.300 to -0.225
- -0.225 to -0.150
- -0.150 to -0.075
- -0.075 to -0.020
- -0.020 to 0.020
- 0.020 to 0.075
- 0.075 to 0.150
- 0.150 to 0.225
- 0.225 to 0.300
- > 0.300

Notes:

DRAFT

Map by: TC

P:\SWM\Work\228155 Fitzroy Floodplain Sand Extraction\GIS\FRSE Fig4-Rev2 A-020v.wor

A3 scale 1:80,000
Inset scale 1:40,000

0 2,000 m 4,000 m

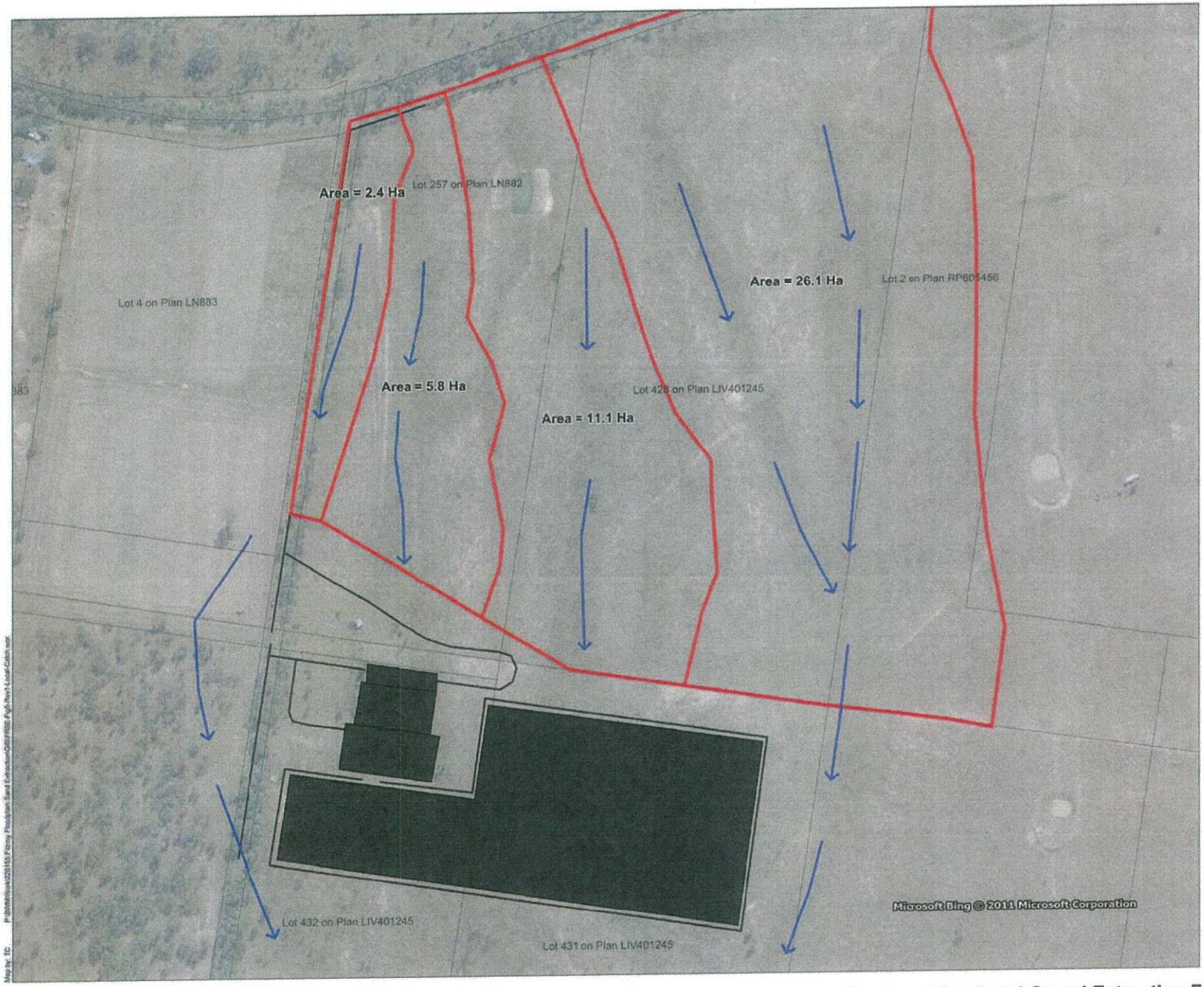
Date: 07/03/2012 Version: 2 Job No: 228155

Projection: MGA Zone 56

Proposed Sand and Gravel Extraction Facility Hydraulic Assessment

Figure 4: Flood Impacts - 20 Year ARI Fitzroy River Event

aurecon



Legend

- Cadastre
- Proposed Development
- Proposed Development

Notes:

A3 scale 1:4,000

0 100 m 200 m

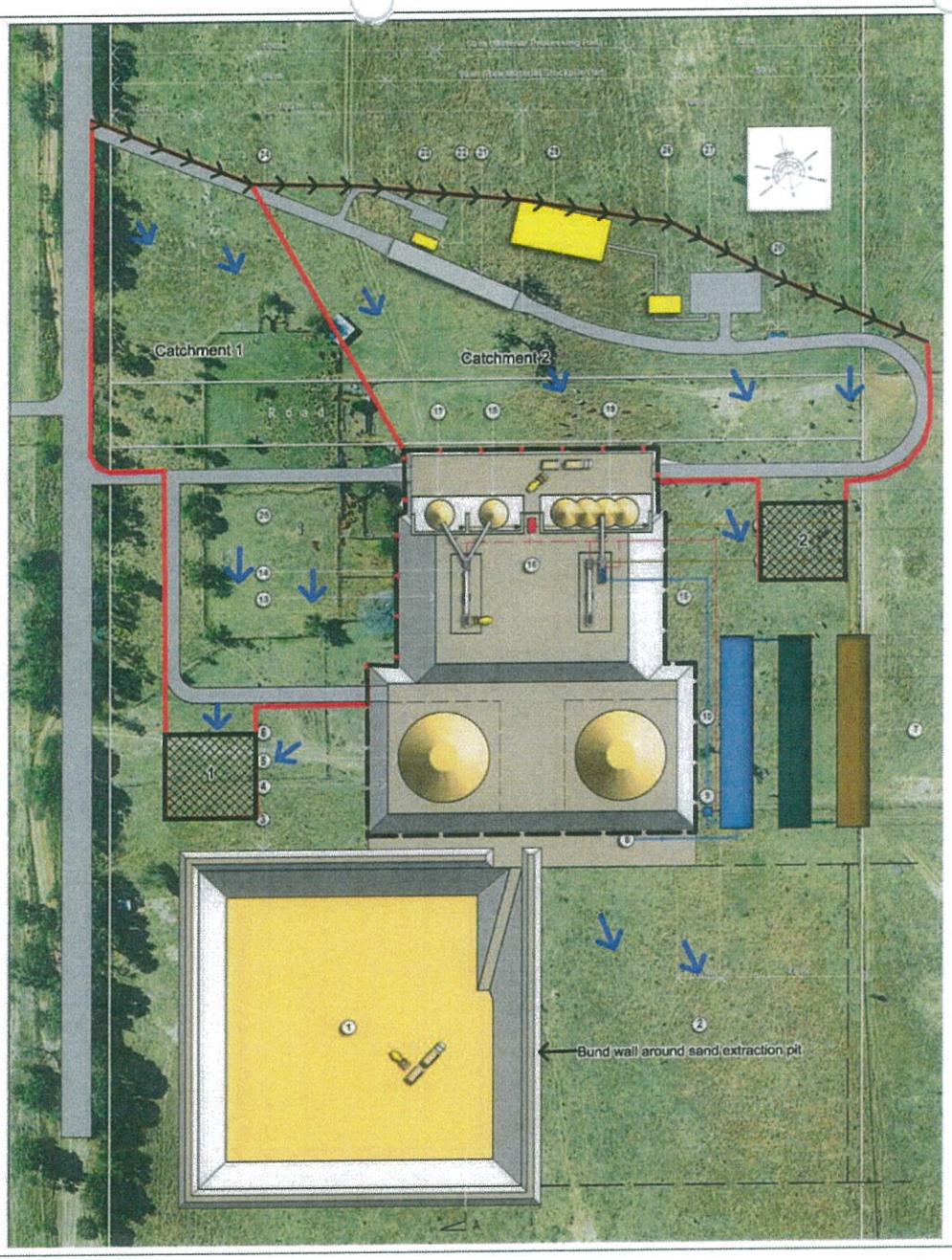
Date: 01/03/2012 Version: 1 Job No: 228155

Projection: MGA Zone 56

Proposed Sand and Gravel Extraction Facility Hydraulic Assessment

Figure 5: Local Catchment Extents

END RESPONSE TO COUNCIL'S INFORMATION REQUEST.



aurecon

Legend

- Assumed Flow Direction
- Diversion Bund
- Raised Bunded Area Draining to Settling Ponds
- Rain Gardens
- Catchments

Notes:

A3 scale 1:1500

0 37.5 m 75 m

Date: 07/03/2012 Version: 2 Job No: 228185

Projection: MGA Zone 56

Proposed Sand and Gravel Extraction Facility **Hydraulic Assessment**

Figure 6: Conceptual Stormwater Treatment Strategy