CONCEPTUAL STORMWATER MANAGEMENT PLAN

Proposed Residential Subdivision
Lot 102 on RP860099 and Lot 129 on Pl402
54-102 and 263 Belmont Road, Parkhurst

Glenmore Holdings (Aust) Pty Ltd

12 September 2019

File No: K4887-003-A

ROCKHAMPTON REGIONAL COUNCIL
ADDITIONAL PLANS APPROVED
24 October 2019
DATE
These plans are approved and now incorporated into the approved suite of plans subject to the current conditions of approval associated with
Development Permit No.: D/84-2014
Dated: 15 September 2015

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Client Reference:	54-102& 263 Belmont Road, Parkhurst
Synopsis:	This Conceptual Stormwater Management Plan describes the existing site characteristics, and corresponding stormwater quantity and quality management controls to be implemented during the construction and operational phase of the development.

Reviewed by RPEQ	Reg. No.	Signed	Date
Aaron Pianta	10423		23 August 2019

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1.0 INTRODUCTION

1.1 Background

Knobel Engineers has been commissioned by Glenmore Holdings (Aust) Pty Ltd to prepare an amended *Conceptual Stormwater Management Plan* (CSWMP), to support a development application for the Material Change of Use and Reconfiguring of a Lot (2 Lots into 222 Lots) at 54-102 and 263 Belmont Road, Parkhurst.

The original CSWMP was prepared by Brown Consulting (Ref: R12394 – Stormwater Management Report) dated December 2014.

This CSWMP has been provided in response to an Information Request (IR) dated 26 March 2019 (Ref: D/84 -2014) which requests an updated “Stormwater Quality Report” and “Stormwater Management Report” to reflect the revised layout accompanying the current development permit. This report includes both the stormwater management and stormwater quality components requested from the IR.

In preparing this CSWMP Knobel Engineers has considered the management of quality and quantity of stormwater during both construction and operational phases, including sediment and erosion controls.

1.2 Objectives

This CSWMP details the planning, layout and design of the stormwater management infrastructure for both the construction and operational phases of this development.

This CSWMP aims to:

- Establish the required performance criteria for the proposed stormwater quantity and quality improvement systems;
- Provide a design of stormwater infrastructure including stormwater quality improvement devices;
- Ensure the quality of stormwater discharging from the proposed development does not adversely impact on the water quality and ecological values of downstream watercourses;
- Ensure stormwater runoff is conveyed through the site to a lawful point of discharge (LPOD) in accordance with QUDM; and
- Provide reporting and monitoring mechanisms whereby the performance of this system can be measured enabling identification of corrective actions/alterations required to ensure the above mentioned objectives are maintained.

This CSWMP has been prepared in accordance with the IEAust *Australian Runoff Quality: Guide to Water Sensitive Urban Design, Queensland State Planning Policy 2017*, IPWEA *Queensland Urban Drainage Manual Fourth Edition (2017),* Rockhampton Regional Council *SC6.18 City– Stormwater management planning scheme and* Design Guideline D5 –*Capricorn Municipal Development Guideline.*

1.3 Description of the Subject Site

1.3.1 Location

The subject site is located adjacent to Belmont Road in the suburb of Parkhurst and is situated along the Fitzroy River. The site has frontage to Belmont Road to the north east and backs onto the Fitzroy River, which runs along the site’s western boundary. The subject site comprises of Lot 102 on RP860099 and Lot 92 on SP224420 and covers a combined area of 53.5 ha, with details as summarised in Table 1 below and as located in Figure 1.

Table 1: Site Description

Developer	Lot and Property Description	Street Address
Contour Consulting	Lot 102 on RP86009 & Lot 129 on PL4021	54-102 and 263 Belmont Road, Parkhurst

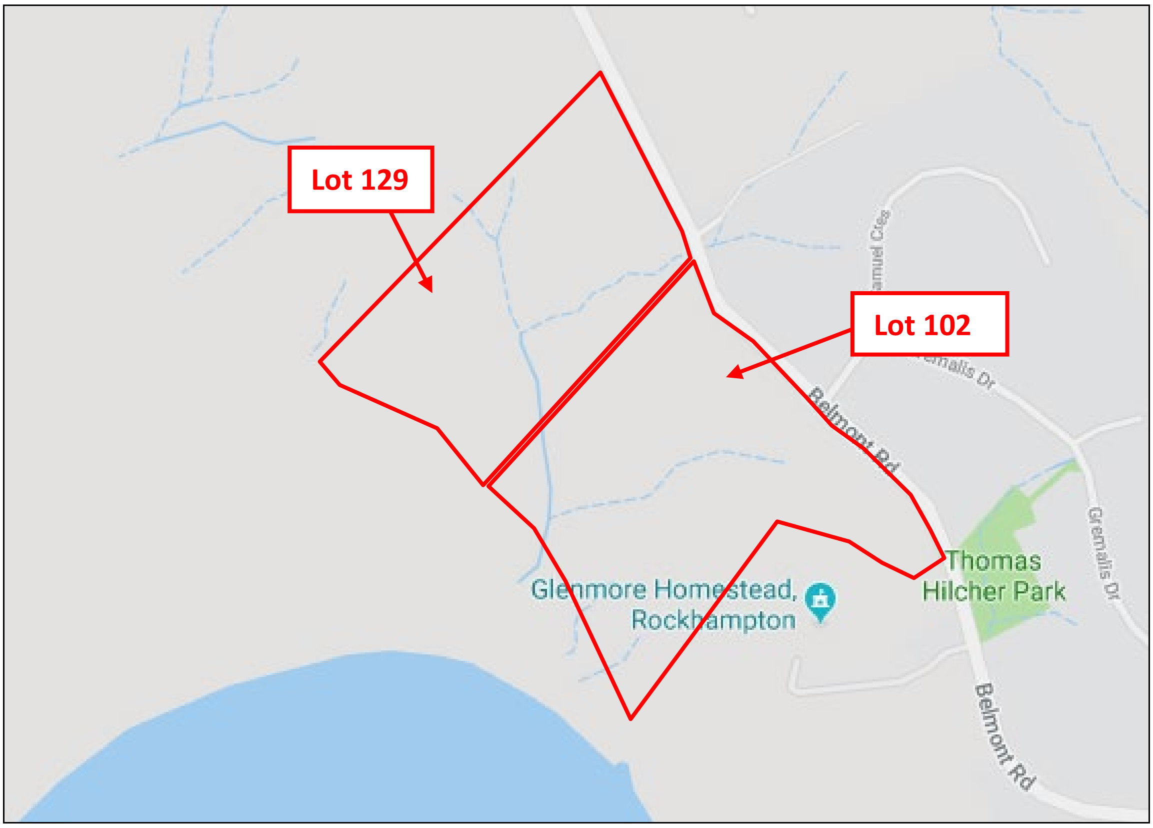

Figure 1: **Site Location Plan (sourced from nearpmaps)**

1.3.2 Site Topography

The subject site ultimately grades down to the southwest towards the junction of Ramsey Creek and the Fitzroy River. Spot heights on site range from RL 33 m AHD along the east boundary of the site to RL 4 m AHD along the banks of the Ramsey Creek/Fitzroy River junction with the grades varying throughout the site. There is an existing natural drainage path which runs through the middle of the subject site that discharges into the Ramsey Creek/Fitzroy River junction. Stormwater from the northeast and northwest of the subject site drain naturally into this channel which forms the major overland flow path for the pre development scenario.

1.3.3 Vegetation and Land Use

The Lots within the subject site are currently classified as being rural lots and mainly comprise of vacant land with average vegetation and grass coverage. A singular dwelling situated in the far eastern corner of the proposed development area is the only building within the subject development site. There are rural residential lots opposite to the subject site with the region to the south east being classified as special purpose land. Refer to Figure 2 for the aerial image of the subject site.

Figure 2: **Aerial Photograph of the Site (sourced from CoGC City Plan Interactive mapping)**

1.3.4 Description of Proposed Development

The proposed development for the site consists of a Material Change of Use for the Reconfiguration of a Lot from 2 into 222 Lots. Access to the site will be gained via Belmont Road to the north east, at the intersection of Samuel crescent and Belmont Road. There is a proposed internal road network which will connect different stages of the development. The average lot size for the proposed dwellings are greater than 1,000m^2 and as such are consistent with the surrounding land uses/zonings.

Figure 3 shows the proposed layout for the 222 Lot subdivision. For further detail refer to Contour Consulting, *Overall Landscape Concept Sketch (*Ref: 17-004/SK02) in Appendix A.

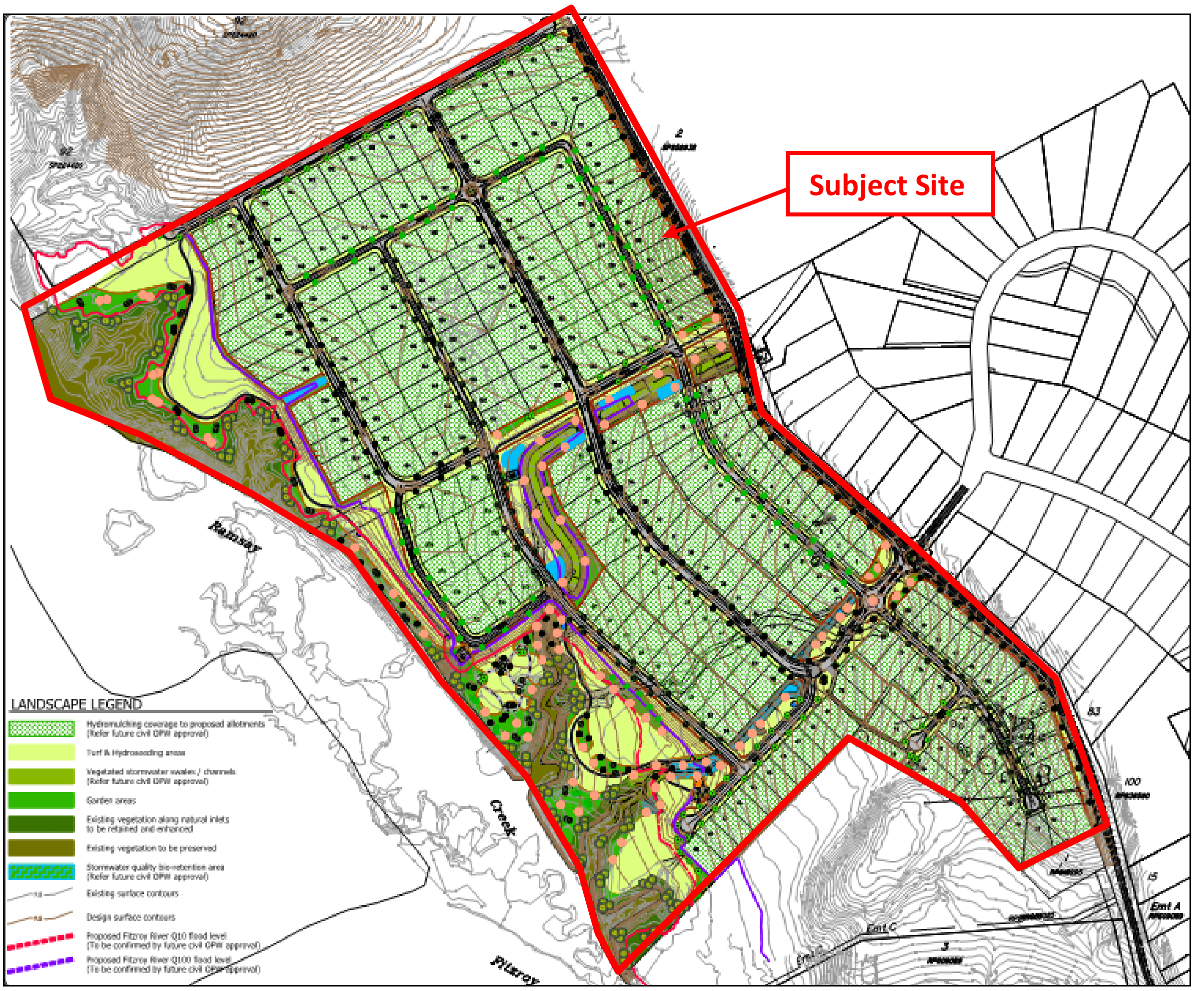

Figure 3: Proposed Layout (modified from Contour Consulting Staging Plan)

1.4 Rainfall

Rainfall intensity data has been obtained from the Australian Bureau of Meteorology's 2016 Design IFD Rainfall System. The data has been extracted for the nearest grid cell at Latitude 23.3125 (S) and Longitude 150.4875 (E). The IFD data and average rainfall intensities used in this report are in accordance with the procedures outlined in IEAust, Australian Rainfall and Runoff.

2.0 SITE HYDROLOGY AND HYDRAULICS

2.1 Background

The subject site is located along the Fitzroy River and is situated within its flood storage area. Due to the considerably large storage area of the Fitzroy River Catchment when compared to the subject site, an increase to the site runoff from the proposed development will have insignificant impact on the storage volume of the Fitzroy River Catchment. Furthermore, both its critical duration, time to peak and its peak flow rate of the subject site catchment is anticipated to be considerably less than that of the Fitzroy River Catchment and as such, the peak times of the catchments will not coincide.

As there will be no significant difference or worsening to the flood storage volume or flood levels of the Fitzroy River as a result of the increase in peak flows rates generated from the subject site, it is deemed that there is no benefit in providing a stormwater detention system for the proposed residential development.

The following section will analyse the pre and post development flow rates for the entire development and any influencing external catchments. The post development flow rates will be utilised to size the minor and major drainage infrastructure of the development.

The following sections define the parameters of the site's post development hydraulics. The Rational Method has been applied to define flow rates at and through the subject site. The Rational Method (Section 4.3 of the Queensland Urban Drainage Manual - QUDM 2017) is flexible in its data requirements and is able to produce satisfactory estimates of peak site discharges based on the following data input:

- specific intensity frequency duration (IFD) data;
- length/type of flow path;
- contributing catchment areas; and
- coefficient of discharge.

2.2 Pre Development Internal Catchments

2.2.1 Catchment Definition and Lawful Point of Discharge

In the following sections, the subject site references the combined lot area of Lot 102 and Lot 129, which covers an area of 53.5 ha.

The pre development subject site has been analysed as three (3) internal catchments for the pre development scenario based on the existing flow regime of the site. The Stormwater catchments for the pre development site have been termed Internal A, Internal B, and Internal C.

Internal Catchment A has an area of 11.73 ha and drains stormwater to the southwest into the Ramsey Creek/Fitzroy River junction. The Ramsey Creek/Fitzroy River Junction wraps around the south western site boundary and forms the Lawful Point of Discharge (LPOD) for pre development Internal Catchment A.

Internal Catchment B has an area of 40.78 ha and naturally drains towards the existing drainage channel that runs centrally through the subject site. Stormwater is conveyed from the eastern and western portions of the catchment into this channel. This channel outlets to the Ramsey Creek/Fitzroy River Junction, which represents the LPOD for pre development Internal Catchment B.

Internal Catchment C has an area of 1ha and sheds stormwater towards the south of its catchment and into a neighbouring residential lot, which represents the catchments existing point of discharge (EPOD). The ultimate LPOD for the catchment is also the Ramsey Creek/Fitzroy River Junction.

The catchment areas and LPODs for the subject site are shown on Knobel Engineers, *Pre Development Catchment Plan* (Ref: K4887/P001/A) included as Appendix B.

2.2.2 Coefficient of Runoff

The pre development coefficient of runoff (C year) for each catchment was determined based on the fraction impervious method specified in QUDM. The pre developed site is currently vacant land and as such has no impervious surfaces. In accordance with QUDM Table 4.5.4, the C_{10} value was determined by the catchment land description and the one hour ten year rainfall intensity (${}^{1}I_{10}$) of 65.8 mm/hr for the site. Assuming good grass coverage and medium soil permeability, a C_{10} value of 0.66 has been adopted for all pre development catchments. With reference to QUDM Table 4.5.2, applying the frequency factors for the standard storms of 2, 10, 20 and 100 years results in the following post development coefficients of runoff as shown in Table 2:

Table 2: Pre Development Coefficient of Runoff

Catchment	C_2	C_{10}	C_{20}	C_{100}
Internal A/B/C	0.56	0.66	0.69	0.79

2.2.3 Time of Concentration

The time of concentration for each pre development catchment has been calculated in accordance with QUDM section 4.6.6 – Overland Flow. Friend's Equation ($t = (107n\ L^{0.333})/S^{0.2}$) has been used to calculate the initial travel time using sheet flow with the remaining travel time being concentrated natural flows through small rills and channels. Please refer to Table 3 below for the calculated time of concentration for each pre developed catchment.

Table 3: Pre Development Time of Concentration

Catchment	Catchment Area (ha)	Catchment Properties	Time of concentration		
			Overland flow Friend's Equation	Concentrated Overland Flow Figure 4.8	Total t_c
Internal A	11.73	Average grassed surface	Horton's (n) = 0.045 L = 100 m Slope = 1% t = 22.3 mins	L = 270m Fall = 9 m Δ = 3 t = 9 mins	31.3 mins
Internal B	40.78	Average grassed surface	Horton's (n) = 0.045 L = 100m Slope = 7% t = 15.2 mins	L = 700m Fall = 19.5 m Δ = 5 t = 15 mins	30.2 mins
Internal C	1.00	Average grassed surface	Horton's (n) = 0.045 L = 120 m Slope = 8.3% t = 15.5 mins	NA	15.5 mins

2.2.4 Design Flow Rates

Design storm flow rates have been calculated for standard storms with an ARI of 2, 10, 20 and 100 years for the pre development case using design rainfall intensities from the Bureau of Meteorology. The Rational Method (Q = 2.78 x 10^{-3} CIA) has been used to calculate the required design flow rates for the subject site. The pre development peak flows for the subject site are presented in Table 4.

Table 4: Pre Development Flow Rate

Internal A					
Average Recurrence Interval	**ARI**	2	10	20	100
Coefficient of Runoff	**C**	0.56	0.66	0.69	0.79
Area of Catchment (ha)	**A**	11.73	11.73	11.73	11.73
Average Rainfall Intensity (mm/h)	**I**	62.90	98.41	113.39	150.45
Peak Flow Rate (m^3/s)	**Q**	**1.15**	**2.12**	**2.56**	**3.89**
Internal B					
Average Recurrence Interval	**ARI**	2	10	20	100
Coefficient of Runoff	**C**	0.56	0.66	0.69	0.79
Area of Catchment (ha)	**A**	40.78	40.78	40.78	40.78
Average Rainfall Intensity (mm/h)	**I**	64.3	100.63	115.94	153.81
Peak Flow Rate (m^3/s)	**Q**	**4.09**	**7.53**	**9.11**	**13.81**
Internal C					
Average Recurrence Interval	**ARI**	2	10	20	100
Coefficient of Runoff	**C**	0.56	0.66	0.69	0.79
Area of Catchment (ha)	**A**	1.00	1.00	1.00	1.00

Average Rainfall Intensity (mm/h)	**I**	90.50	141.13	162.52	215.18
Peak Flow Rate (m^3/s)	**Q**	**0.142**	**0.260**	**0.314**	**0.475**
TOTAL Peak Flow Rate (m^3/s)	**Q_t**	**5.38**	**9.91**	**11.99**	**18.17**

2.3 Pre Development External Catchments

2.3.1 Catchment Definition and Lawful Point of Discharge

The subject site and the surrounding area were examined to determine if any external catchments will contribute flows into the subject site.

Based on the existing infrastructure, contours and levels of the regions surrounding the subject site, there have been five (5) external catchments identified which discharge stormwater into the subject site. The external catchments have been termed External Catchment A-E.

External Catchment A comprises of vacant land and is situated to the west of Internal Catchment A/B and has an area of 6.15 ha. Stormwater from this catchment discharges across the western site boundary of Internal Catchment A/B, which represents the existing point of discharge for the external catchment.

External Catchment B comprises of vacant land and is situated to the north of Internal Catchment B and has an area of 6.89 ha. Stormwater from this catchment drains towards Belmont Road, where there is a sag point in the road. At present, flows from External Catchment B discharge into the subject site (internal pre development Catchment B) underneath Belmont Road, through a headwall with (1200 x 450) twin box culverts.

External Catchment C consists of rural residential lots to the northeast of the subject site and comprises of both vacant land and rural residential lots. The external catchment is situated to the east of Internal Catchment B and has an area of 12.31 ha. Stormwater from this catchment drains towards another sag point along Belmont Road where it then enters and existing stormwater pipe and drainage channel running through the subject site. The existing drainage channel represents the existing point of discharge for External Catchment C.

External Catchment D is situated to the east of Internal Catchment B and consists primarily of rural residential lots with a contributing catchment area of 12.47 ha. Stormwater collected in this catchment drains towards Samuel Crescent, which connects into Belmont Road. Major and minor flows from External Catchment D are conveyed along Belmont Road, along the natural grade of the road to the northwest and discharges into the existing central drainage channel running through the subject site.

External Catchment E is situated to the south east of Internal Catchment B and has a catchment area of 3.93ha. The catchment consists primarily of vacant land, with the exception of two (2) existing residential lots situated in the north east corner of the catchment. Stormwater collected in External Catchment E drains along the southern boundary of Internal Catchment B, where it eventually outlets into the Ramsey Creek/Fitzroy River Junction.

Refer to Knobel Engineers, Pre Development Catchment Plan (Ref: K4887/P001/A) for further information on the pre development catchment layout.

2.3.2 Coefficient of Runoff

The external catchment coefficient of runoff (C year) was determined based on fraction impervious (f_i) method as specified in QUDM and Capricorn Municipal Development Guideline - Stormwater Drainage Design D5 - Table D05.06.1 – Fraction Impervious for Development Categories.

External Catchments A, B and E consist of vacant land and as such have no impervious surfaces. In accordance with QUDM Table 4.5.4, the C_{10} value was determined by the catchment land description and the one hour ten year rainfall intensity (${}^{1}I_{10}$) of 65.8 mm/hr for the site. Assuming good grass coverage and medium soil permeability, a C_{10} value of 0.66 has been adopted for all pre development catchments.
External Catchment C has been classified as a rural residential zone under the Rockhampton Rock-e-plan interactive mapping system. The coefficient of runoff has been determined using the Stormwater Drainage Design D5 - Table D05.06.1 – Fraction Impervious for Development Categories.

Based on rural lots of (2-5 dwelling per ha) a fraction impervious of 0.20 has been assumed for the pre development catchment. Using a one hour, ten year rainfall intensity ($^{1}I_{10}$) of 65.8 mm/hr, a C_{10} value of 0.71 has been adopted for each post development catchment.

External Catchment D has been classified as low residential zone under the Rockhampton Rock-e-plan interactive mapping system. The coefficient of runoff has been determined using the Stormwater Drainage Design D5 - Table D05.06.1 – Fraction Impervious for Development Categories based on a lot size of 750 m^{2}. Using a fraction impervious of 0.55, a one hour ten year rainfall intensity ($^{1}I_{10}$) of 65.8 mm/hr, a C_{10} value of 0.79 has been adopted for each post development catchment.

With reference to QUDM Table 4.5.2, applying the frequency factors for the standard storms of 2, 10, 20 and 100 years results in the following pre development coefficients of runoff as shown in Table 5.

Table 5: Pre Development External Catchment Coefficient of Runoff

Catchment	C_2	C_{10}	C_{20}	C_{100}
EXT A, B, E	0.56	0.66	0.69	0.79
EXT C	0.60	0.71	0.75	0.85
EXT D	0.67	0.79	0.83	0.95

2.3.3 Time of Concentration

The time of concentration has been calculated in accordance with QUDM section 4.6.6 – Overland Flow. Friend's Equation ($t = (107n\ L^{0.333})/S^{0.2}$) has been used to calculate the initial travel time using sheet flow and the remaining distance being calculated as concentrated natural flows using Figure 4.8. Please refer to Table 6 for the calculated time of concentration for each external catchment.

Table 6: External Catchment Time of Concentration

Catchment	Catchment Area (ha)	Catchment Properties	Time of concentration		
			Overland flow Friend's Equation	Concentrated Overland Flow Figure 4.8	Total t_c
EXT A	6.15	Average grassed surfaces	Horton's (n) = 0.045 L = 100 m Slope = 10.0% t = 14min	L = 150m Fall = 24 m Δ = 3 t = 3 mins	17 mins
EXT B	6.89	Average grassed surfaces	Horton's (n) = 0.045 L = 100 m Slope = 15.0% t = 12.8 min	L = 250m Fall = 12 m Δ = 3 t = 6 mins	18.8 mins
EXT C	12.31	Average grassed surfaces	Horton's (n) = 0.045 L = 100 m Slope = 13.0% t = 13.36 min	L = 320m Fall = 14 m Δ = 3 t = 6 mins	19.36 mins
EXT D	12.47	Developed	Standard roof to inlet time of 5 mins	L = 682 m Fall = 41 m Δ = 1 t = 3 mins	8 mins
EXT E	3.93	Average grassed surfaces	Horton's (n) = 0.045 L = 100 m Slope = 3.0% t = 17.91 min	L = 300m Fall = 12 m Δ = 3 t = 6 mins	23.91 mins

2.3.4 Design Flow Rates

Design storm flow rates have been calculated for standard storms with an ARI of 2, 10, 20 and 100 years for the external catchment case using design rainfall intensities from the Bureau of Meteorology. The Rational Method ($Q = 2.78 \times 10^{-3}$ CIA) has been used to calculate the required design flow rates for the subject site.

The calculated pre and post development peak flows for the external catchment are presented in Table 7.

Table 7: External Catchments – Pre Development Peak Flow Rates

External Catchment A					
Average Recurrence Interval	**ARI**	2	10	20	100
Coefficient of Runoff	**C**	0.56	0.66	0.69	0.79
Area of Catchment (ha)	**A**	6.15	6.15	6.15	6.15
Average Rainfall Intensity (mm/h)	**I**	86.65	135.14	155.64	206.14
Peak Flow Rate (m^3/s)	**Q**	**0.832**	**1.526**	**1.845**	**2.793**
External Catchment B					
Average Recurrence Interval	**ARI**	2	10	20	100
Coefficient of Runoff	**C**	0.56	0.66	0.69	0.79
Area of Catchment (ha)	**A**	6.89	6.89	6.89	6.89
Average Rainfall Intensity (mm/h)	**I**	82.40	128.55	148.06	196.16
Peak Flow Rate (m^3/s)	**Q**	**0.886**	**1.626**	**1.966**	**2.977**
External Catchment C					
Average Recurrence Interval	**ARI**	2	10	20	100
Coefficient of Runoff	**C**	0.60	0.71	0.75	0.85
Area of Catchment (ha)	**A**	12.31	12.31	12.31	12.31
Average Rainfall Intensity (mm/h)	**I**	81.60	127.31	146.64	194.29
Peak Flow Rate (m^3/s)	**Q**	**1.686**	**3.094**	**3.742**	**5.666**
External Catchment D					
Average Recurrence Interval	**ARI**	2	10	20	100
Coefficient of Runoff	**C**	0.67	0.79	0.83	0.95
Area of Catchment (ha)	**A**	12.47	12.47	12.47	12.47
Average Rainfall Intensity (mm/h)	**I**	115.25	179.79	206.75	272.80
Peak Flow Rate (m^3/s)	**Q**	**2.684**	**4.926**	**5.948**	**8.969**
External Catchment E					
Average Recurrence Interval	**ARI**	2	10	20	100
Coefficient of Runoff	**C**	0.56	0.66	0.69	0.79
Area of Catchment (ha)	**A**	3.93	3.93	3.93	3.93
Average Rainfall Intensity (mm/h)	**I**	73.19	144.30	131.67	174.56
Peak Flow Rate (m^3/s)	**Q**	**0.449**	**0.825**	**0.997**	**1.511**

2.4 Post Development Internal Catchments

2.4.1 Catchment Definition and Lawful Point of Discharge

The post development scenario has been analysed as six (6) internal catchments and are described as Post Development Catchments A-F. The delineation of the post development catchments have been based on the design earthworks contours, (supplied by Contour Consulting) for the site, existing overland flow paths running through the subject site and the location of the proposed bio-retention basins.

Post Development Catchment A consists of lots 60-100 to the east of the subject site and has a contributing area of 8.69 ha. This catchment will discharge stormwater towards the southwest through overland and piped flow. The overland flow will be collected and conveyed along the proposed road and discharge to the south of the lot. The minor flows will be collected in a series of pits and pipes and discharged to the proposed bio-retention basins running along the western boundary of the catchment for treatment.

Post Development Catchment B consists of lots 1-51 in the central portion of the subject site and has a contributing area of 9.845 ha. The overland flow will be collected and conveyed along the proposed road network and discharge into the existing drainage channel running through the subject site. The minor flows will be collected in a series of pits and pipes and discharged to the proposed bio-retention basins running along the west of the catchment for treatment.

Post Development Catchment C consists of lots 101-160 and 185-187 to the west of the subject site and has a contributing area of 12.3 ha. The overland flow will be collected and conveyed along the proposed road network towards the existing drainage channel running through the subject site. The minor flows will be collected in a series of pits and pipes and discharged to the proposed bio-retention basins to the east of the catchment for treatment.

Post Development Catchment D consists of lots 161,179, 181 -184, 188-196 and 201-210 to the southwest of the subject site and has a contributing area of 10.4 ha. This catchment will discharge stormwater towards the southwest through overland and piped flow. The overland flow will be collected and conveyed along the proposed road towards a drainage channel at the south of the subject site. The minor flows will be collected in a series of pits and pipes and discharged to the proposed bio-retention basins to the south of the catchment for treatment.

Post development Catchment E consists of the southern portion of the site (remaining portion thus totalling up the site area) that remains undeveloped and has a catchment area of 12.35 ha. Stormwater collected in this catchment will drain naturally as sheet flow into the junction of Ramsey Creek and the Fitzroy River. Note that Catchment E collects the stormwater from Catchments A-D.

Post Development Catchment F consists of lots 197-199 to the southwest of the subject site and has a contributing area of 0.56 ha. The major overland flow will drain naturally as sheet flow into the undeveloped land in Catchment E. The minor flows will be collected in a series of pits and pipes and discharged to the proposed bio-retention basins to the west of the catchment for treatment.

Note that the total site area has slightly increased in the post development scenario due to the acquisition of land to the west of the subject site for the development of a new access driveway.

The ultimate LPOD for all post development catchments is the junction of Ramsey Creek and the Fitzroy River. The catchment areas and LPODs for the subject site are shown on Knobel Engineers, *Post Development Catchment Plan* (Ref: K4887/P002/A) included as Appendix C.

2.4.2 Coefficient of Runoff

The coefficient of runoff (C year) for the post development catchments was determined based on the fraction impervious method specified in QUDM and the Capricorn Municipal Development Guideline - Stormwater Drainage Design D5 - Table D05.06.1 – Fraction Impervious for Development Categories.

Post Development Catchments A-D and F have been classified as low residential zones under the Rockhampton Rock-e-plan interactive mapping system. The coefficient of runoff has been determined using the Stormwater Drainage Design D5 - Table D05.06.1 – Fraction Impervious for Development Categories based on a lot size of 750 m^2. Using a fraction impervious of 0.55 and a one hour, ten year rainfall intensity ($^1I_{10}$) of 65.8 mm/hr, a C_{10} value of 0.79 has been adopted for each post development catchment.

Post Development Catchment E remains undeveloped and as such has no impervious surfaces. In accordance with QUDM Table 4.5.4, the C_{10} value was determined by the catchment land description and the one hour ten year rainfall intensity ($^1I_{10}$) of 65.8 mm/hr for the site. Assuming good grass coverage and medium soil permeability, a C_{10} value of 0.66 has been adopted for this catchment.

With reference to QUDM Table 4.5.2, applying the frequency factors for the standard storms of 2, 10, 20 and 100 years results in the following post development coefficients of runoff as shown in Table 8:

Table 8: Post Development Coefficient of Runoff

Catchment	C_2	C_{10}	C_{20}	C_{100}
Post Development A-D, F	0.67	0.79	0.83	0.95
Post Development E	0.56	0.66	0.69	0.79

2.4.3 *Time of Concentration*

The time of concentration for post developed catchments A-D and F has been calculated in accordance with QUDM section 4.6.6 – Overland Flow, Table 4.6.3 – Recommended roof drainage system travel times and Figure 4.8 –Flow travel time in pipes and channels.

For Post Development Catchment E the time of concentration has been calculated in accordance with QUDM section 4.6.6 – Overland Flow. Friend's Equation ($t = (107n\ L^{0.333})/S^{0.2}$) has been used to calculate the initial travel time using sheet flow with the remaining travel time being concentrated natural flows through small rills and channels. Please refer to Table 9 for the calculated time of concentration for each post developed catchment.

Table 9: Post Development Time of Concentration

Catchment	Catchment Area (ha)	Catchment Properties	Time of concentration		
			Overland flow Friend's Equation	Concentrated Overland Flow Figure 4.8	Total t_c
A	8.693	Developed	Standard roof to inlet time of 5 mins	L = 400m Fall = 9.6 m Δ = 1 t = 5 mins	10
B	9.845	Developed	Standard roof to inlet time of 5 mins	L = 350 m Fall = 6 m Δ = 1 t = 4 mins	9
C	12.328	Developed	Standard roof to inlet time of 5 mins	L = 400 m Fall = 3 m Δ = 1 t = 7 mins	12
D	10.401	Developed	Standard roof to inlet time of 5 mins	L = 220 m Fall = 2.5 m Δ = 1 t = 4 mins	9
E	12.358	Average grassed surface	Horton's (n) = 0.045 L = 100 m Slope = 3.25% t = 17.6 mins	L = 130 m Fall = 5.3 m Δ = 3 t = 3 mins	20.6 mins
F	0.560	Developed	Standard roof to inlet time of 5 mins	L = 80 m Fall = 1 m Δ = 1 t = 2 mins	7

2.4.4 Design Flow Rates

Design storm flow rates have been calculated for standard storms with an ARI of 2, 10, 20 and 100 years for the post development catchments using design rainfall intensities from the Bureau of Meteorology. The Rational Method ($Q = 2.78 \times 10^{-3}$ CIA) has been used to calculate the required design flow rates for the subject site. The post development peak flows for the subject site are presented in Table 10.

Table 10: Post Development Flow Rate

Post Development A					
Average Recurrence Interval	**ARI**	2	10	20	100
Coefficient of Runoff	**C**	0.67	0.79	0.83	0.95
Area of Catchment (ha)	**A**	8.693	8.693	8.693	8.693
Average Rainfall Intensity (mm/h)	**I**	107.49	167.62	192.87	254.87
Peak Flow Rate (m^3/s)	**Q**	**1.744**	**3.200**	**3.867**	**5.839**
Post Development B					
Average Recurrence Interval	**ARI**	2	10	20	100
Coefficient of Runoff	**C**	0.67	0.79	0.83	0.95
Area of Catchment (ha)	**A**	9.845	9.845	9.845	9.845
Average Rainfall Intensity (mm/h)	**I**	111.25	173.51	199.60	263.58
Peak Flow Rate (m^3/s)	**Q**	**2.045**	**3.751**	**4.531**	**6.839**
Post Development C					
Average Recurrence Interval	**ARI**	2	10	20	100
Coefficient of Runoff	**C**	0.67	0.79	0.83	0.95
Area of Catchment (ha)	**A**	12.328	12.328	12.328	12.328
Average Rainfall Intensity (mm/h)	**I**	100.65	156.93	180.64	238.94
Peak Flow Rate (m^3/s)	**Q**	**2.316**	**4.249**	**5.135**	**7.763**
Post Development D					
Average Recurrence Interval	**ARI**	2	10	20	100
Coefficient of Runoff	**C**	0.67	0.79	0.83	0.95
Area of Catchment (ha)	**A**	10.401	10.401	10.401	10.401
Average Rainfall Intensity (mm/h)	**I**	111.25	173.51	199.60	263.58
Peak Flow Rate (m^3/s)	**Q**	**2.160**	**3.963**	**4.787**	**7.225**
Post Development E					
Average Recurrence Interval	**ARI**	2	10	20	100
Coefficient of Runoff	**C**	0.56	0.66	0.69	0.79
Area of Catchment (ha)	**A**	12.358	12.358	12.358	12.358

Average Rainfall Intensity (mm/h)	**I**	79.11	123.45	142.20	188.44
Peak Flow Rate (m^3/s)	**Q**	**1.525**	**2.799**	**3.386**	**5.127**
Post Development F					
Average Recurrence Interval	**ARI**	2	10	20	100
Coefficient of Runoff	**C**	0.67	0.79	0.83	0.95
Area of Catchment (ha)	**A**	0.560	0.560	0.560	0.560
Average Rainfall Intensity (mm/h)	**I**	119.50	186.47	214.34	282.53
Peak Flow Rate (m^3/s)	**Q**	**0.104**	**0.192**	**0.231**	**0.348**
TOTAL Peak Flow Rate (m^3/s)	**Qt**	**9.894**	**18.154**	**21.937**	**33.141**

Note, the total peak flow is summation of all separate post development catchments and has been undertaken as a comparison only.

2.5 Post Development External Catchments

In the post development scenario, the external catchments have been analysed to account for any future development that may occur. It has been assumed that External Catchments A, B, C and E will be developed to low density residential lots, which is consistent with surrounding land classifications. Post Development Catchment D is already developed and as such the pre-existing condition for this catchment has been maintained in the following assessment. Analysing the peak flow rates under this development conditions will ensure that the proposed stormwater infrastructure for the subject site can safely convey the flows from the external catchment in the occurrence of development.

2.5.1 Catchment Definition and Lawful Point of Discharge

The location and size of the external catchments in the post development conditions are the same as described in the pre development description in section 2.3.1.

Note there are current development applications for residential subdivisions of External Catchments A, B and C. This information has been considered throughout the report and any hydraulic analysis of external catchments flows to ensure an accurate assessment of the influencing flow rates into the subject site.

The flows from External Catchment E will not enter into any of the proposed residential allotments in the developed scenario. The earthworks along the south eastern boundary adjacent to External Catchment E indicates a bund which directs stormwater along the site boundary to discharge into Ramsey Creek/Fitzroy River Junction. This arrangement maintains the pre development flow regime and causes no impact on the subject site or neighbouring lots.

2.5.2 Coefficient of Runoff

The coefficient of runoff (C year) for the post development external catchments was determined based on the Capricorn Municipal Development Guideline - Stormwater Drainage Design D5 - Table D05.06.1 – Fraction Impervious for Development Categories.

All external catchments have been classified as low residential zones under the Rockhampton Rock-e-plan interactive mapping system. The coefficient of runoff has been determined using the Stormwater Drainage Design D5 - Table D05.06.1 – Fraction Impervious for Development Categories based on a lot size of 750 m^2. Using a fraction impervious of 0.55 and a one hour, ten year rainfall intensity ($^1I_{10}$) of 65.8 mm/hr, a C_{10} value of 0.79 has been adopted for each post development catchment.

2.5.3 *Time of Concentration*

The time of concentration for the catchment has been determined using QUDM Table 4.6.2 – Recommended standard inlet times for urban residential catchments. This method has been adopted as the developed layout of the external catchments in unknown and therefore specific inlet times cannot be calculated accurately. Assuming an average slope of 3% to 6% for the post developed external catchment, a time of concentration of 13 mins has been adopted. Note that as External Catchment D is already developed, a time of concentration of 8 mins has been maintained for this catchment.

2.5.4 *Design Flow Rates*

Design storm flow rates have been calculated for standard storms with an ARI of 2, 10, 20 and 100 years for the post development catchments using design rainfall intensities from the Bureau of Meteorology. The Rational Method (Q = 2.78 x 10^{-3} CIA) has been used to calculate the required design flow rates for the subject site. The post development (unmitigated) peak flow estimates for the external catchments are presented in Table 11.

Table 11: External Catchments – Post Development Peak Flow Rates

External Catchment A					
Average Recurrence Interval	**ARI**	2	10	20	100
Coefficient of Runoff	**C**	0.67	0.79	0.83	0.95
Area of Catchment (ha)	**A**	6.15	6.15	6.15	6.15
Average Rainfall Intensity (mm/h)	**I**	97.54	152.08	175.08	231.67
Peak Flow Rate (m^3/s)	**Q**	**1.121**	**2.055**	**2.485**	**3.757**
External Catchment B					
Average Recurrence Interval	**ARI**	2	10	20	100
Coefficient of Runoff	**C**	0.67	0.79	0.83	0.95
Area of Catchment (ha)	**A**	6.89	6.89	6.89	6.89
Average Rainfall Intensity (mm/h)	**I**	97.54	152.08	175.08	231.67
Peak Flow Rate (m^3/s)	**Q**	**1.255**	**2.302**	**2.783**	**4.208**
External Catchment C					
Average Recurrence Interval	**ARI**	2	10	20	100
Coefficient of Runoff	**C**	0.67	0.79	0.83	0.95
Area of Catchment (ha)	**A**	12.31	12.31	12.31	12.31
Average Rainfall Intensity (mm/h)	**I**	97.54	152.08	175.08	231.67
Peak Flow Rate (m^3/s)	**Q**	**2.242**	**4.112**	**4.971**	**7.517**
External Catchment D					
Average Recurrence Interval	**ARI**	2	10	20	100
Coefficient of Runoff	**C**	0.67	0.79	0.83	0.95
Area of Catchment (ha)	**A**	12.47	12.47	12.47	12.47
Average Rainfall Intensity (mm/h)	**I**	115.25	179.79	206.75	272.80
Peak Flow Rate (m^3/s)	**Q**	**2.684**	**4.926**	**5.948**	**8.969**
External Catchment E					
Average Recurrence Interval	**ARI**	2	10	20	100
Coefficient of Runoff	**C**	0.67	0.79	0.83	0.95
Area of Catchment (ha)	**A**	3.93	3.93	3.93	3.93
Average Rainfall Intensity (mm/h)	**I**	97.54	152.08	175.08	231.67
Peak Flow Rate (m^3/s)	**Q**	**0.716**	**1.313**	**1.588**	**2.401**

3.0 OVERLAND FLOW ASSESSMENT

As outlined previously, there are number of external catchments which direct flow into the subject site. These flows require appropriate management and routing through the proposed development to ensure no adverse impacts on the proposed development and surrounding properties

A combination of open conveyance channels and piped drainage has been provided in the location of major overland flows paths within the subject site to safely intercept and convey stormwater from the influencing external catchments through the development. Drainage infrastructure has been designed in accordance with Capricorn Municipal Development Guideline - *Stormwater Drainage Design D5*.

External Catchment A

A conveyance channel has been proposed to manage the flows discharging into the site from External Catchment A. The channel has been assessed for the pre development catchment scenario as there is a current development application for the sub-division and development of External Catchment. As part of this development, only pre development flow rates will be permitted to be discharged into the subject site.

In the pre development condition, the channel capacity has been designed to accommodate the Q100 flow rate from the catchment. The channel is to run from north to south along the western extent of the subject site and intercept stormwater prior to flows entering the development. Note that if the developed layout of External Catchment A directs overland flow away from the site subject, the purpose of the conveyance channel becomes redundant and the channel can be decommissioned.

External Catchment B

The overland flow from External Catchment B is to be collected in a piped drainage system and conveyed into the subject site and into the main conveyance channel running through the development. Note that there is an active development approval in place for External Catchment B which is currently under construction. As part of this development application, there is an approval condition which specifies that only pre development flows are to be discharged underneath Belmont Road into the subject site. Assuming that this development adheres to this condition, the capacity of the pipe system for External Catchment B has been sized to accommodate the pre development flows only, due to the assumption appropriate detention has been provided upstream.

At present, flows from External Catchment B discharge into the subject site (internal Catchment C) underneath Belmont Road, through a headwall with (1200 x 450) twin box culverts. These culverts are proposed to connect into the internal drainage network (designed by others) and conveyed through the development into the main conveyance channel running through the subject site. An easement is to be provided over these pipes in accordance with Capricorn Municipal Development Guideline - *Stormwater Drainage Design D5.* The easement is to provide a route for overland flows in the event of pipe blockage.

Stormwater discharging from External Catchment B has been assumed as “clean water” having undergone water quality treatment from the current development in External Catchment B. It is noted that this clean water will be mixed with the untreated runoff from internal catchments from this development and ultimately be conveyed into the bio retention basins designed for the subject site. To control this, the pipes discharging into the proposed bio-retention basins are to be sized to convey only the Q3 month flows from the internal catchments of the site. Further detail on this is provided in Section 6.0 of this report.

Internal Catchment C – D

A channel has been designed in the south west corner of the development in Internal Catchment D, to collect the Q100 flows from internal sub catchment C1 and C2. The channel is situated in between Lots 205 and 206 and will convey flows into Internal Catchment E. Refer to Knobel Engineers*, Stormwater Sub Catchment Plan* (Ref: 4887/P005/A) for further details of internal sub catchments C1 and C2.

Each channel has been designed (by Contour Consulting) with the maximum allowable batters of 1V:6H and a minimum freeboard of 300 mm. Table 12 provides details of the design parameters of conveyance channels for External Catchment A and Internal channel D. Refer to Section 4.0 for details on the proposed culverts for External Catchment B.

Table 12: Channel Parameters and Capacities

	EXTERNAL A	**CHANNEL D**
Type	Grass-lined	Grass-lined
Conveyance capacity	Q100 pre development flows External Catchment A	Q100 flows from Sub catchment C1, C2,
Slope (%)	1 %	1 %
Base Width (m)	7	8
Flow Depth (m)	0.65 (including 300mm freeboard)	0.75 (including 300mm freeboard)
Side Slope	1 in 6	1 in 6
Top Width (m)	15	14.6
Design Capacity (m^3/s)	**3.05**	**3.68**
Required Capacity (m^3/s)	2.095	3.31

As demonstrated in Table 12, the proposed infrastructure can safely convey the required flows from external catchments while maintaining the necessary 300mm of freeboard to surrounding roads and properties.

4.0 MAJOR CHANNEL FLOW ASSESSMENT

The capacity of the major conveyance channel running through the centre of the subject site has been assessed at critical sections to ensure that the proposed development can cater for the Q100 overland flows generated from both the external and internal catchments being drained into this channel.
The road sections along the main conveyance channel have also been assessed to ensure compliance with QUDM Table 7.4.5 – Flow limits for 'transverse' flow during MAJOR STORM during the Q100 event.

4.1 Hydraulic Model

A hydraulic computer model has been developed to assess the capacity of the main conveyance channel and critical road sections along this channel. The culvert and drainage easement for External Catchment B has also been assessment. The model assesses whether the channels and proposed culverts are adequately sized to accommodate the flows from internal and external catchments and that road sections have the required immunity to be compliant with local and state guidelines.

Modelling software XP-SWMM has been selected for the hydrologic and hydraulic analysis. Details of the model set-up, channel design and model results are summarised in the following sections for each critical section.

4.2 Model Set-up

Rainfall data for the subject site has been obtained from the Australian Bureau of Meteorology's 2016 Design IFD Rainfall System. The data has been extracted for the nearest grid cell at Latitude 23.3125 (S) and Longitude 150.4875 (E). The IFD data and average rainfall intensities used in this report are in accordance with the procedures outlined in IEAust, Australian Rainfall and Runoff. Several storm events have been included in the modelling with durations ranging from 10 min to 3hrs.

4.3 Model Validation

A single node has been designated in the hydrologic portion of the model for each catchment that contributes runoff into the main conveyance channel. The influencing catchments include, external catchments B-C and internal sub-catchments 1-3. Refer to Knobel Engineers, *Stormwater Sub catchment Plan* (Ref: K4887/P005/A) for further details on catchment details. Figure 4 details the setup for the hydraulic and hydrologic model.

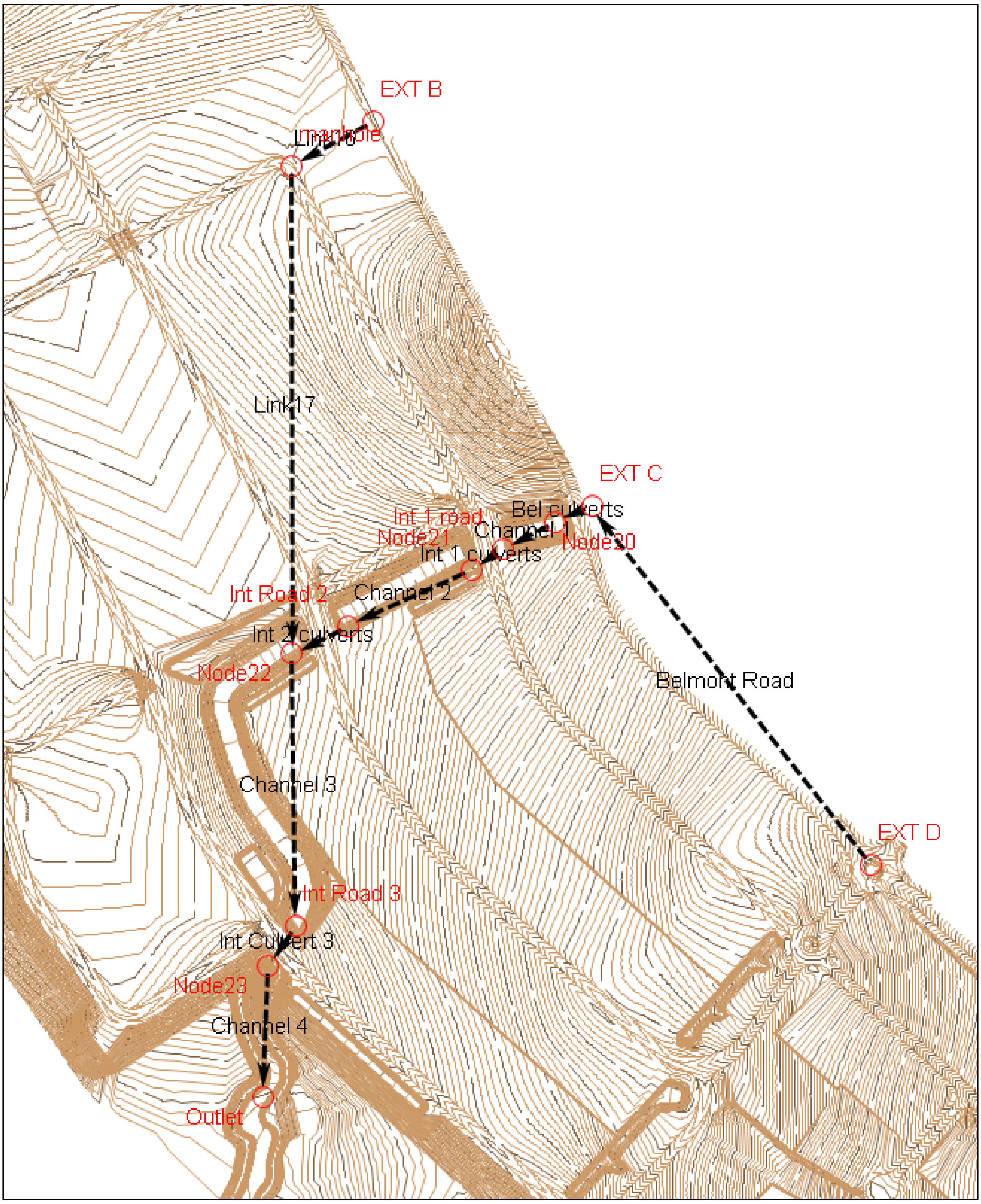

Figure 4: **XPSWMM Hydraulic Model Layout**

4.4 Assumptions of Hydraulic Model

Due to unavailable survey for Belmont Road and External Catchments contributing to the main conveyance channel, a range of assumptions have been made in determining the location and volume of runoff entering the channel.

External Catchment D has been modelled to drain into the upstream end of the central conveyance channel near Belmont Road. This has been assumed as there is road drainage infrastructure on the upstream side of Belmont Road and a crown in the road which would prevent stormwater from overtopping into the subject site. The culverts under Belmont Road at the upstream end of the conveyance channel have been modelled as twin 1050 mm culverts.

External Catchment B has been modelled as entering the conveyance channel as piped flow as per the stormwater strategy adopted to manage external flows for this catchment.

Pre development flows have been assumed for External Catchment B and C as per the existing development application for these catchments that stipulates that only pre development flows can be discharged into the subject site.

4.5 Hydraulic Parameters of Model

The proposed channels, culverts and weirs modelled at each critical section along the conveyance channel have been determined based off the extracted sections from the design contours provided from Contour Consulting.

The main conveyance channel has been modelled as four (4) separate links between each internal road section. The profile of the channel in each link has been assigned from the design contours provided by Contour Consulting. The average profile of the channel (channel 1-4, see Figure 4) has a general arrangement of a base width of 10m, batters of 1V;6H and total height of 1.8m. The channels have been designed so that the minor flows are contained within the section and that overtopping only occurs in a major storm.

At each road crossing along the main channel, culverts have been modelled to convey flows underneath the road. The size of the culverts have been determined such that the quantity of flows overtopping the road are in compliance with QUDM. The profile of the road has been modelled as a natural channel to simulate a spill over point in major events. Tables 13 – 16 detail the adopted infrastructure for each internal road crossing.

Table 13: Internal Road Crossing 1 Hydraulic Parameters

Location:	Internal Road Crossing 1
Culvert size:	2 x 1050mm
UPIL:	12.8m
DSIL:	12.5m
Length:	36m
Grade:	0.83%
Road surface level (spill over point):	14.7m

Table 14: Internal Road Crossing 2 Hydraulic Parameters

Location:	Internal Road Crossing 2
Culvert size:	2 x 1050 mm
UPIL:	11.3 m
DSIL:	11.1 m
Length:	34 m
Grade:	0.6%
Road surface level (spill over point):	13.2 m

Table 15: Internal Road Crossing 3 Hydraulic Parameters

Location:	Internal Road Crossing 3
Culvert size:	2 x 1200 mm
UPIL:	9.7 m
DSIL:	9.1 m
Length:	36 m
Grade:	1.6%
Road surface level (spill over point):	12 m

Table 16: External Catchment B Easement Crossing

Location:	External Catchment B Easement Crossing
Culvert size:	2 x 900 mm
UPIL:	14.45 m
DSIL:	13.85 m
Length:	60 m
Grade:	1%
Road surface level (spill over point):	15.5 m

Note that the above culvert parameters have been assigned from the design contours provided by Contour Consulting and are subject to change during the detailed design process.

4.6 Results of Hydraulic Model

For each internal road crossing, the water level, velocity and depth of flow on the road section have been analysed. In accordance with QUDM Table 7.4.5 – Flow limits for 'transverse' flows during MAJOR STORM , the flow over the road is to have a maximum depth of 250mm and have a depth*velocity product smaller than 0.4m^2/s. Table X-X detail the results at each internal Road crossing in the Q100 major event.

Table 17: Results Internal Road Crossing 1

Internal Road Crossing 1:		
Efficiency of culverts:	100%	50%
Peak Flow in culverts (m^3/s)	5.83	2.948
Peak Flow over road (m^3/s)	3.19	6.07
Q100 water level	14.79	14.83
Depth of flow over road (m)	0.09	0.130
Velocity of flow over road (m/s)	0.72	0.91
D*V	0.0648	0.12

Table 18: Results Internal Road Crossing 2

Internal Road Crossing 2:		
Efficiency of culverts:	100%	50%
Peak Flow in culverts (m^3/s)	5.62	2.86
Peak Flow over road (m^3/s)	5.503	8.527
Q100 water level	13.31	13.34
Depth of flow over road (m)	0.11	0.14
Velocity of flow over road (m/s)	0.80	0.9
D*V	0.088	0.13

Table 19: Results Internal Road Crossing 3

Internal Road Crossing 3:		
Efficiency of culverts:	100%	50%
Peak Flow in culverts (m^3/s)	8.77	4.55
Peak Flow over road (m^3/s)	6.32	12.40
Q100 water level	12.17	12.24
Depth of flow over road (m)	0.17	0.24
Velocity of flow over road (m/s)	1.01	1.29
D*V	0.17	0.31

Table 20: External Catchment B Easement

External Catchment B Easement Crossing		
Efficiency of culverts:	100%	50%
Peak Flow in culverts (m^3/s)	2.37	2.01
Peak Flow over road (m^3/s)	0	0.358
Q100 water level	15.07	15.69
Depth of flow over road (m)	0	0.19
Velocity of flow over road (m/s)	0	0.70
D*V	0	0.133

As demonstrated in the tables above, the depth and depth*velocity product for each internal road crossing is in accordance with the requirement of QUDM in the events of both full culvert efficiency and 50% blockage. The results indicate that the flow regime over the road sections is within an acceptable limit and that the channels and culverts are adequately sized to convey internal and external flows through the subject site.

It is to be noted that although the results in Table 20 show compliance with QUDM, it is crucial that the all lots are designed to have immunity from the Q100 water levels experienced in the conveyance channel during a major rainfall event. A minimum of 300mm of freeboard above the Q100 water level is to be provided to the finished floor level of surrounding lots.

5.0 WATER QUALITY ASSESSMENT

5.1 Background

The development of land has the potential to increase the pollutant loads within stormwater runoff and downstream watercourses. During the construction phase of the development disturbance to the vegetation on the site has the potential to significantly increase sediment loads entering downstream watercourses. The operational phase of the development will change the land use potentially increasing the amount of sediments and nutrients washing from the site.

The following sections describe the predicted increase in pollutant loads generated by the proposed development and treatment devices to mitigate the potential increases.

5.2 Construction Phase

A high risk of stormwater pollution will occur from the site during the construction phase due to erosion and sediment transportation off site to the receiving environment. The majority of this risk results from construction activities disturbing the site and exposing areas of soil to the direct erosive influence of the environment.

The following section outlines the procedures necessary to minimise erosion and control sediment during construction in accordance with the *International Erosion Control Association (IECA) Best Practice ESC Document.*

5.2.1 Key Pollutants

The key pollutants have been identified for the Construction Phase of this development.

Table 21: Key Pollutants, Construction Phase

Pollutant	Sources
Litter	Paper, construction packaging, food packaging, cement bags, material off cuts.
Sediment	Exposed soils and stockpiles during earthworks and building works.
Hydrocarbons	Fuel and oil spills, leaks from construction equipment and temporary car park areas.
Toxic Materials	Cement slurry, asphalt primer, solvents, cleaning agents, and wash waters (e.g., from tile works).
Acids or Alkaline substances	Acid sulphate soils, cement slurry and wash waters.

5.2.2 Performance Criteria

The following site discharge pollutant criteria have been adopted for water quality monitoring during the construction phase of the development.

Table 22: Construction Phase, Water Quality Performance Criteria

Pollutant	Criteria
Total Suspended Solids	80% hydrological effectiveness to 50mg/L
pH	6.5 – 8.5
Dissolved Oxygen	90th %ile >80% saturation or 6mg/L
Hydrocarbons	No visible sheen on receiving waters
Litter	No visible litter washed from site.
Cations and Anions	As recommended by Acid Sulphate Soil Management Plan (If Applicable to Development).
Contaminants	Dispose of waste containing contaminants at authorised facilities.

5.2.3 Sediment and Erosion Controls

Sediment and Erosion Control devices (S&EC) employed on the site shall be designed and constructed in accordance with the *International Erosion Control Association (IECA) Best Practice ESC Document as* shown on Knobel Engineers, *Sediment and Erosion Control Plan* (Ref: K4887/P004/A) included as Appendix F. The following devices and management measures are proposed:

Pre-Construction

- Stabilised site access/exit on Belmont Road;
- Sediment fences to be located along downstream contours;
- Sediment basins to be installed in accordance with Knobel Engineers, *Sediment Basin Plan* (Ref: SK01)
- Dust fencing to be installed if required; and
- Educate site personnel to the requirements of Erosion and Sediment Control Plan.

Initial Construction – Bulk Earthworks

- Maintain construction access/exit, sediment fencing, dust fences and all other existing controls as required;
- Construct diversion drains to convey disturbed site run-off to the temporary sediment traps;
- Construct clean water diversion drain to divert runoff from external catchment A; and
- Confine construction activities to stages to minimise areas of disturbance at any given time.

Second Stage Construction

- Maintain construction access/exit, sediment fencing, dust fences, diversion drain and all other existing controls as required;
- Progressively revegetate finished areas where applicable;
- Divert runoff from un-disturbed areas around disturbed areas; and
- Drainage structure protection around field inlets and gully pits.

During construction, all areas of exposed soils allowing dust generation are to be suitably treated. Treatments will include covering the soil and watering. Road accesses are to be regularly cleaned to prevent the transmission of soil on vehicle wheels and eliminate any build-up of typical road dirt and tyre dusts from delivery vehicles.

Adequate waste disposal facilities are to be provided and maintained on the site to cater for all waste materials such as litter, hydrocarbons, toxic materials, acids or alkaline substances.

5.2.4 Water Quality Monitoring and Inspections

To ensure that the water quality objectives are being met during the construction phase of the development water quality monitoring shall be conducted. Water quality monitoring shall use a calibrated probe or sampling and testing at a NATA registered laboratory.

Location:	Monitoring Stations MS1 shown on Knobel Engineers, *Sediment and Erosion Control Plan* (Ref: K4887/P004/A).
Parameters:	Site discharge criteria.
Frequency:	Following at least 30 mm of rainfall in a 24 hour period.

The contractor shall be responsible for the inspection and maintenance of all sediment and erosion control devices. Additional controls and review of existing controls shall be undertaken in response to the results of the above-mentioned monitoring program.

5.2.5 Reporting

An inspection report shall be written by a suitably qualified and experienced scientist/engineer following each water quality monitoring episode. The report shall include at least the following information:

- Name, address and real property description for the development site;
- Council file reference number (if known);
- Monitoring locations;
- Performance criteria;
- Results for each monitoring location, identifying any breaches of performance criteria;
- Recommended corrective actions to be taken and additional sediment and erosion controls, if required; and
- Inspection reports shall be provided to the contractor for their action and compilation in an on-site register.

If the above mentioned performance criteria are exceeded and results from the downstream monitoring stations show significant deterioration from upstream results (if applicable), the contractor shall implement all recommendation of the inspection report within one (1) working day of receipt of the report.

5.3 Operational Phase

The following sections provide details of the stormwater quality improvement devices (SQID's) proposed for the operational phase of the development. Knobel Engineers, *Stormwater Management Plan* (Ref: K4887/P003/A) included as Appendix D illustrates the size and location of the proposed SQID's.

To assess the quantities of pollutants discharging from the site the water quality modelling package MUSIC v6.3 has been applied. MUSIC Modelling Parameters and delineated data have been sourced from Water by Design, *MUSIC Modelling Guidelines*. A MUSIC model has been set up using Rainfall Station 39083 for Rockhampton using a date range 1999 – 2010 with a 6 minute time step.

5.3.1 Stormwater Quality Objectives

To protect the water quality of the downstream watercourses the following water quality objective has been applied to stormwater runoff from the site in accordance with Capricorn Municipal Development Guidelines, *Stormwater Drainage Design D5 – D05.21.01.*

Best Management Practices (BMP) are required to be demonstrated for all development applications within Rockhampton Regional Council. The following load reduction targets must be achieved when assessing the post-development treatment train (comparison of unmitigated developed case versus developed mitigated case).

- 80% reduction in Total Suspended Sediment (TSS)
- 60% reduction in Total Phosphorus (TP)
- 45% reduction in Total Nitrogen (TN)
- 90% reduction in litter (sized 5 mm or greater)

5.3.2 Stormwater Quality Improvement Devices

Due to the site being located in a region that has environmental and ecological significance, a Water Sensitive Urban Design (WSUD) approach has been adopted for the site. Bio-retention systems have been proposed as the most suitable SQID's to treat runoff from the subject site as it can readily be integrated into the proposed landscaping and revegetation works. There are separate bio-retention basins proposed for Post Development Catchment A-D and F. Note that as Post Development Catchment E remains undeveloped, no bio-retention basin has been proposed for this catchment.

The MUSIC catchment areas have been based off the post development catchments described in Section 2.5 of this report. The road areas have been obtained from the proposed road network detailed in the post development layout. The roof areas have been calculated based on an assumed 350 m^2 roof area and the number of lots within the catchment. The ground surface is the remaining area and has been modelled as 15% impervious in accordance with Table 3.6 of Water by Design, *MUSIC Modelling Guidelines*.

Bio-retention basins are required to treat the Q3 month flow generated from their influencing catchments. The Q3 month flow rate for each catchment is provided in Table 23 for reference and to assist in sizing the drainage infrastructure (i.e., diversion structure) that discharges into each bio-retention basin.

Table 23: Q3 Month Runoff

Water Quality Catchment	Catchment Area (m^2)	Q3 Month Runoff (m^3/s)
A	8.693	0.737
B	9.845	0.864
C	12.328	0.979
D	10.401	0.913
F	0.560	0.044

The contributing roof, road and ground areas for each post development catchment are listed below.

Post Development Catchment A:

- Roof – 1.40 ha
- Road – 0.686 ha
- Ground – 6.608 ha

Post Development Catchment B:

- Roof – 2.065 ha
- Road – 0.248 ha
- Ground – 7.531 ha

Post Development Catchment C:

- Roof – 2.24 ha
- Road – 0.996 ha
- Ground – 9.093 ha

Post Development Catchment D:

- Roof – 1.925 ha
- Road – 1.091 ha
- Ground - 7.385 ha

Post Development Catchment F:

- Roof – 0.105 ha
- Road – 0.05 ha
- Ground – 0.4048 ha

For assessment purposes only, each post development catchment has been modelled to discharge into a singular bio-retention device for treatment. This has been carried out to allow the total required treatment area for each catchment to be determined. The layout of the proposed bio-retention basins for each catchment are depicted on Knobel Engineers, *Stormwater Management Plan* (Ref: K4887/P003/A) included as Appendix D.

The final location and arrangement of bio-retention basins within the catchments will be determined at detailed design stage.

A diagram of the operational treatment train can be seen in Figure 5.

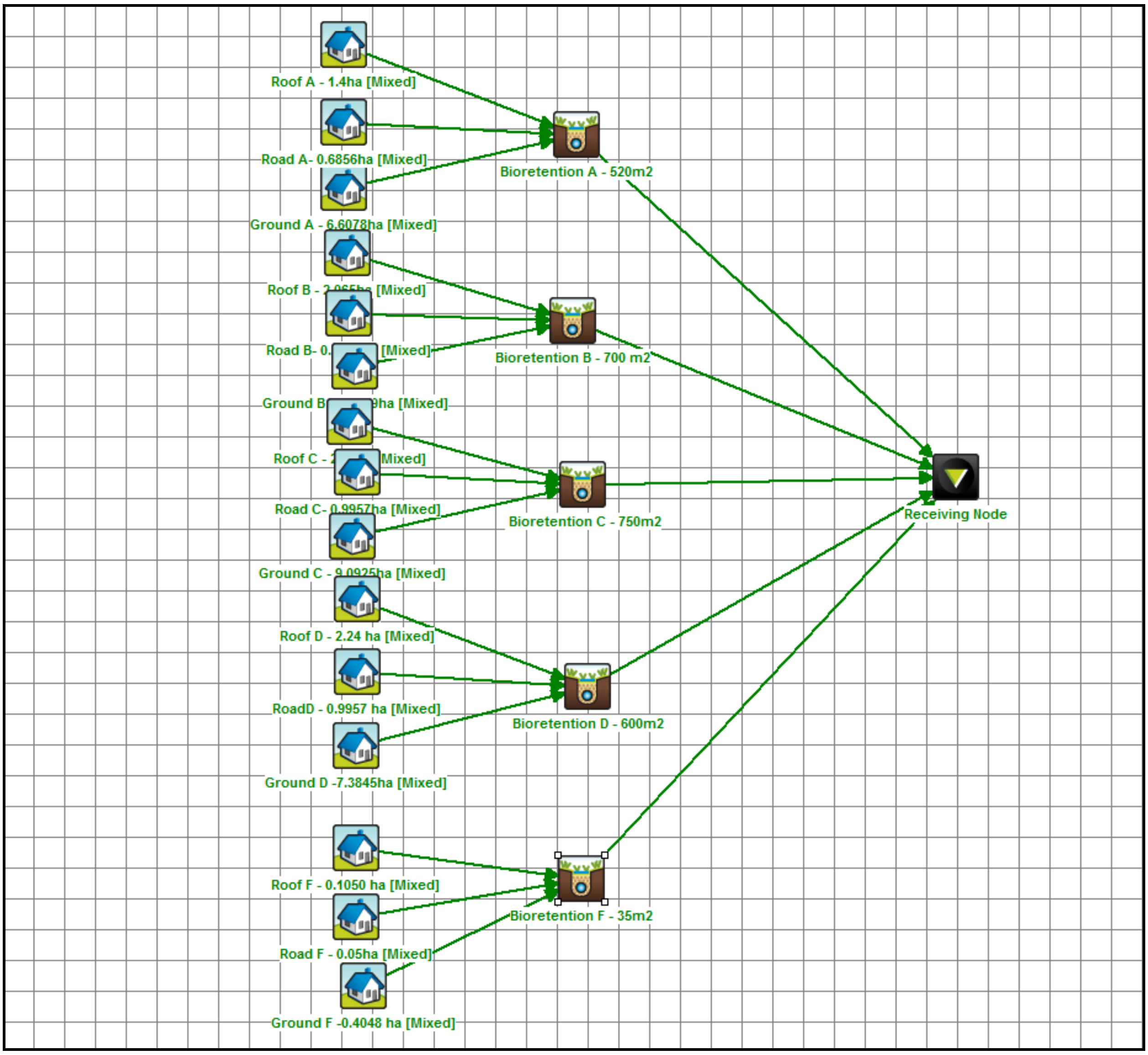

Figure 5: Operational Phase Treatment Train for Site

5.3.3 *Design Parameters of the Stormwater Quality Improvement System*

Detailed design of the stormwater treatment train shall be in accordance with the WSUD, Technical Design Guidelines for South East Queensland – Version 1 (June 2006).

BIO-RETENTION BASINS

A bio-retention basin is designed to pond stormwater allowing it to percolate through a layer of filter media, typically sandy loam. Runoff passing through the filter media is collected with a perforated pipe discharging to the downstream drainage infrastructure. The Bio-retention basins shall be located to treat all stormwater from the development area. The inlet of the bio-retention basin is to be equipped with a sediment forebay to allow a control point at the entrance to the bio for maintenance and removal of sediment accumulation. It will also dissipate flows reducing pipe exit velocity and limit the occurrence of potential scour of the sensitive downstream constructed bio-retention media surface.

All bio-retention basins have been modelled with the same parameters with the only change being the filter and surface area for each device. For each specific bio-retention basin, the filter area and surface area have been modelled as the same value to ensure a conservative design approach at the conceptual stage. The bio-retention basins have been modelled with the following properties:

ALL BASINS:

▪ Filter media	Sandy Loam; 5 – 10% Organic Content in accordance with AS1289.4.1.1; Average D50 0.45 mm; Ksat 200 mm/hr; TN Content = 400 mg/kg Orthophosphate Content = 30 mg/kg
▪ Filter media depth	0.40 m;
▪ Drainage layer	0.20 m;
▪ Extended detention depth	0.30 m;
▪ Seepage	0 mm/hr;

BASIN A

▪ Filter Area	520 m^2;
▪ Surface Area	520 m^2.

BASIN B

▪ Filter Area	700 m^2;
▪ Surface Area	700 m^2.

BASIN C

▪ Filter Area	750 m^2;
▪ Surface Area	750 m^2.

BASIN D

▪ Filter Area	600 m^2;
▪ Surface Area	600 m^2.

BASIN F

▪ Filter Area	35 m^2;
▪ Surface Area	35 m^2.

5.3.4 Post Development Modelling Results - Mitigated

The stormwater quality improvement device (SQID) will reduce the amount of sediments and nutrients discharging from the proposed residential development. Table 24 illustrate the effectiveness of the SQID's in each treatment train to each of the LPODs. Note that as all stormwater from the development outlet to the one consolidated LPOD, the treatment train effectiveness shown below is for the entire site.

Table 24: Treatment Train Effectiveness

Parameter	Post	Post Mitigated	Reduction	Water Quality Objectives
Flow (ML/yr)	106	101	4.8 %	-
TSS (kg/yr)	16800	3320	80.3 %	80 %
TP (kg/yr)	35.4	9.82	72.2 %	60 %
TN (kg/yr)	221	115	48 %	45 %
Gross Pollutants (kg/yr)	3050	0	100 %	90 %

The results demonstrate that the proposed SQID meet the intended water quality objectives for suspended solids, phosphorous and nitrogen levels for the entire development.

6.0 OPERATIONAL PHASE MAINTENANCE REQUIREMENTS

The proposed stormwater management devices will require maintenance and monitoring to ensure that they function as designed. The following section provides an outline of the necessary maintenance tasks for the proposed devices.

6.1 Bio-retention Basin Maintenance

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 could impact on plant growth particularly in developing catchments with poor building controls.

Maintenance is primarily concerned with:

- Maintenance of flow to and through the bio-retention basin;
- Maintaining vegetation;
- Preventing undesired overgrowth vegetation from taking over the bio-retention basin;
- Removal of accumulated sediments; and
- Litter and debris removal.

Vegetation maintenance will include:

- Fertilising plants;
- Removal of noxious plants or weeds; and
- Re-establishment of plants that die.

Sediments accumulated at the inlets need to be monitored. Depending on the catchment activities the deposition of sediment can tend to smother plants and reduce the ponding volume available. Should excessive sediment build-up it will impact on the plant health and require removal before it reduces the infiltration rate of the filter media. The proposed SQIDs will require regular maintenance and monitoring to ensure that they function as designed.

Table 25: Bio-retention Basin Maintenance Schedule

Bio-retention Basin Maintenance Checklist			
Inspection Frequency: 3 Monthly	**Date of Visit:**		
Location:			
Description:			
Site Visibility:			
Inspection Items	**Yes**	**No**	**Action Required (Details)**
Sediment accumulation at inflow points?			
Litter basin?			
Erosion at inlet or other key structures (e.g. crossovers)?			
Traffic damage present?			
Evidence of dumping (Building waste, oils etc)?			
Vegetation condition satisfactory (density, weeds etc)?			
Replanting required?			
Mowing required?			
Clogging of drainage points (sediment or debris)?			
Evidence of ponding?			
Damage/vandalism to structures present?			
Surface clogging visible?			
Drainage system inspected?			
Resettling of system required?			
Comments:			

7.0 FLOOD STORAGE ASSESSMENT

7.1 Flood Storage

As mentioned previously, the subject site is located alongside the Fitzroy River, with a small portion of the development being situated in the Fitzroy Rivers flood fringe area. A portion of the subject site is located within the Q100 flood event extent and must therefore be appropriately managed to ensure that any residential allotments have adequate flood immunity.

The council flood model for the subject site was obtained in order to perform a flood storage volume check for the pre and post development layout. The model contains the inundation areas and peak water surface levels from the Fitzroy River in a Q100 flood event.

The model was interrogated to extract the Q100 water level for the subject site, which was found to be 11.8 m AHD. The proposed development will maintain the existing flood storage total of 490,283 m^3 on site below the designated flood level (DFL) of 11.8 m AHD.

Flood storage compensation for the post-development case has been achieved by sculpting and increasing the volume around the southern portion of the site and within the main conveyance channel which runs through the centre of the subject site. The post development contours achieve a flood storage volume of 490,776 m^3 for the subject site, which results in a surplus of 493 m^3 below the DFL. Therefore, the proposed development will provide adequate compensatory flood storage for the site.

Refer to Knobel Engineers, *Preliminary Pre Development Flood Storage Plan* (Ref: K4887/P006/A) and Knobel Engineers, *Preliminary Post Development Flood Storage Plan* (Ref: K4887/P007/A) in Appendix H for further information.

7.2 Minimum Floor Levels

All residential allotments are to have adequate flood immunity in the Q100 event, which is to be achieved by setting finished floor levels a minimum of 300 mm above the DFL of 11.8 m AHD. In addition to this, the allotments situated along the main conveyance channel are to achieve 300 mm freeboard above the Q100 water level reached in the conveyance channel. Refer to Section 4.0 for information on the Q100 water levels reached at critical locations along the conveyance channel.

8.0 CONCLUSIONS

Knobel Engineers has been commissioned by Glenmore Holdings (Aust) Pty Ltd to prepare an amended *Conceptual Stormwater Management Plan* (CSWMP), to support a development application for the Material Change of Use and Reconfiguring of a Lot (2 Lots into 222 Lots) at 54-102 and 263 Belmont Road, Parkhurst. This CSWMP addresses the conceptual planning, layout and design of the stormwater quality and quantity management infrastructure for both the construction and operational phases of this development.

Hydraulic analysis demonstrated that the development will increase peak flow rates discharging from the site, however due to the location of the development within the Fitzroy River Catchment, stormwater detention will provide no noticeable impact to the hydraulics of the catchment and has therefore not been implemented for the development.

A hydraulic model built using the XPSWMM software program was utilised to assess the capacity of the major conveyance channel and impacted internal road sections within the developed site. Results indicated that the proposed infrastructure can safely convey the Q100 flows from contributing internal and external catchments through the subject site while adhering to QUDM transverse road flow requirements.

Knobel Engineers has adopted a water sensitive urban design (WSUD) approach to managing the stormwater runoff from the proposed development by treating stormwater runoff within separate bio-retention basins for each post development catchment. A total of 2,605 m^2 of bioretention filter area is required to treat stormwater runoff from the entire subject site and satisfy water quality objectives for Rockhampton Regional Council. A monitoring and maintenance plan for the basins has been included. A sediment and erosion control plan is provided for the construction phase of the development and shall be implemented by the contractor and developer.

APPENDIX

A

Contour Consulting

Overall Landscape Concept Sketch

(Ref: 17-004/SK02)

APPENDIX

LANDSCAPE LEGEND

▨	Hydromulching coverage to proposed allotments (Refer future civil OPW approval)
🟨	Turf & Hydroseeding areas
🟩	Vegetated stormwater swales / channels (Refer future civil OPW approval)
🟩	Garden areas
🟩	Existing vegetation along natural inlets to be retained and enhanced
🟫	Existing vegetation to be preserved
▨	Stormwater quality bio-retention area (Refer future civil OPW approval)
9.0	Existing surface contours
9.5	Design surface contours
- - -	Proposed Fitzroy River Q10 flood level (To be confirmed by future civil OPW approval)
- - -	Proposed Fitzroy River Q100 flood level (To be confirmed by future civil OPW approval)

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N

SCALES

0 20.0 80.0m 1:4000

REVISION / ISSUE REGISTER

No.	DATE	REMARKS
A	07/19	For Review

DESIGN	DRAWN
RS	RS

GLENMORE HOLDINGS (AUST) PTY LTD

RIVERSIDE WATERS
STAGES 1 to 12
BELMONT RD, ROCKHAMPTON

OVERALL LANDSCAPE CONCEPT SKETCH

DWG No. 17-004/SK02 A

DO NOT SCALE - IF IN DOUBT ASK

B

Knobel Engineers

Pre Development Catchment Plan

(Ref: K4887/P001/A)

LEGEND

━━	SITE BOUNDARY
━ · ━ · ━	STORMWATER CATCHMENT BOUNDARY
Ⓐ	STORMWATER CATCHMENT I.D.
EXT A	EXTERNAL STORMWATER CATCHMENT I.D.
LPOD	LAWFUL POINT OF DISCHARGE
➔	PROPOSED FLOW DIRECTION

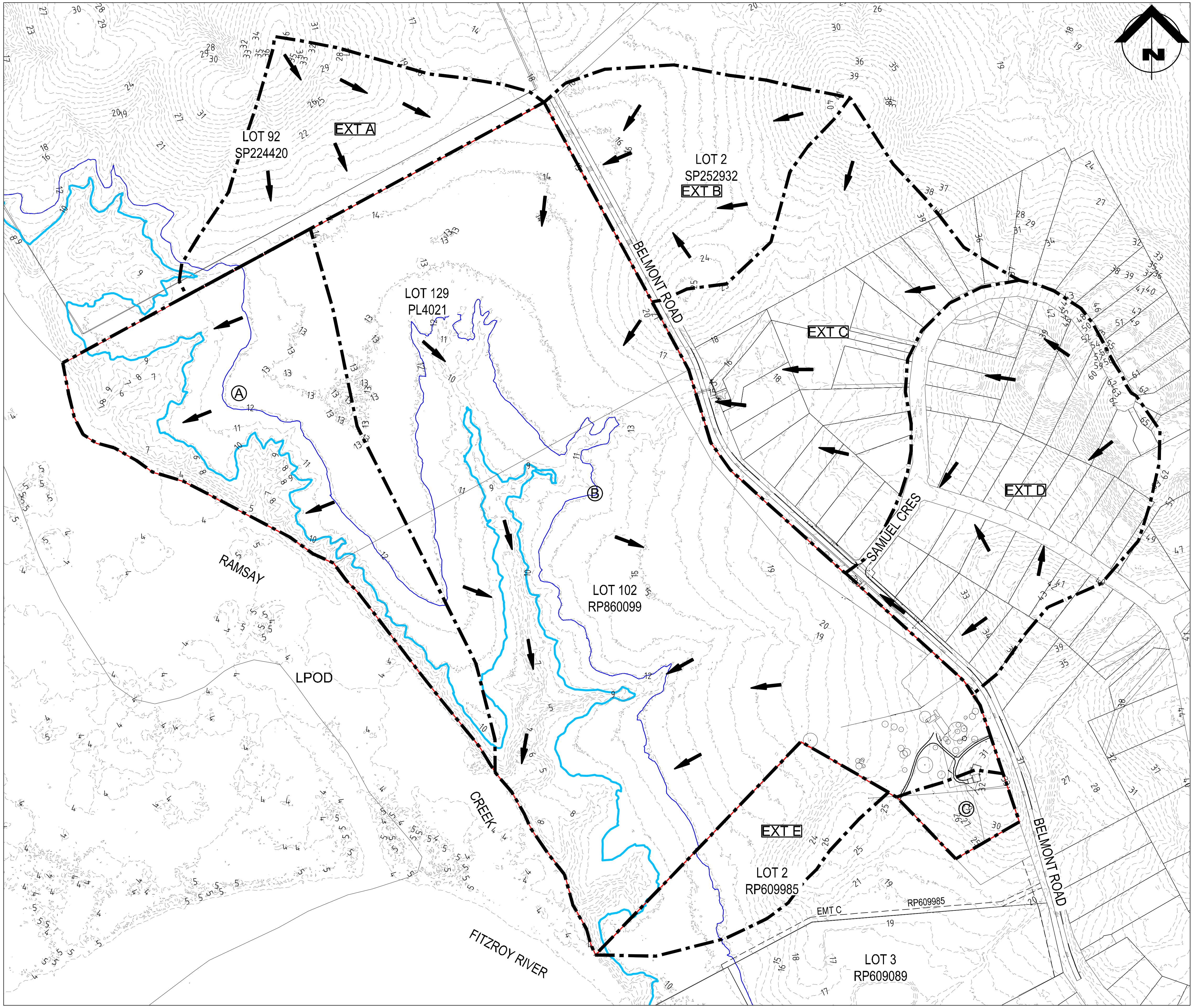
PRE DEVELOPMENT STORMWATER CATCHMENT TABLE

STORMWATER CATCHMENT I.D.	AREA (ha)
A	11.732
B	40.785
C	1.003
TOTAL	53.50

EXTERNAL STORMWATER CATCHMENT TABLE

STORMWATER CATCHMENT I.D.	AREA (ha)
EXT A	6.154
EXT B	6.892
EXT C	12.312
EXT D	12.476
EXT E	3.932
TOTAL	41.766

CONTRACTOR TO DETERMINE AND LOCATE ALL EXISTING SERVICES PRIOR TO COMMENCEMENT OF WORKS



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ISSUE No.	DATE	AMENDMENT
A	-	ISSUED FOR REPORT

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CLIENT
GLENMORE HOLDINGS (AUST) PTY LTD

PROJECT
RIVERSIDE WATERS ESTATE
54-102 AND 263 BELMONT ROAD
PARKHURST QLD 4702

DESIGN	DRAWN	APPROVED
SK	DKC	

TITLE
PRE DEVELOPMENT CATCHMENT PLAN

SCALE
1:12500 AT A1
1:25000 AT A3
0 500 1000m

PROJECT NO.
K4887

DWG NO.
P001

ISSUE
A

APPENDIX

C

Knobel Engineers

Post Development Catchment Plan

(Ref: K4887/P002/A)

LEGEND

—	SITE BOUNDARY
—·—	STORMWATER CATCHMENT BOUNDARY
Ⓐ	STORMWATER CATCHMENT I.D.
EXT A	EXTERNAL STORMWATER CATCHMENT I.D.
LPOD	LAWFUL POINT OF DISCHARGE
➡	PROPOSED FLOW DIRECTION

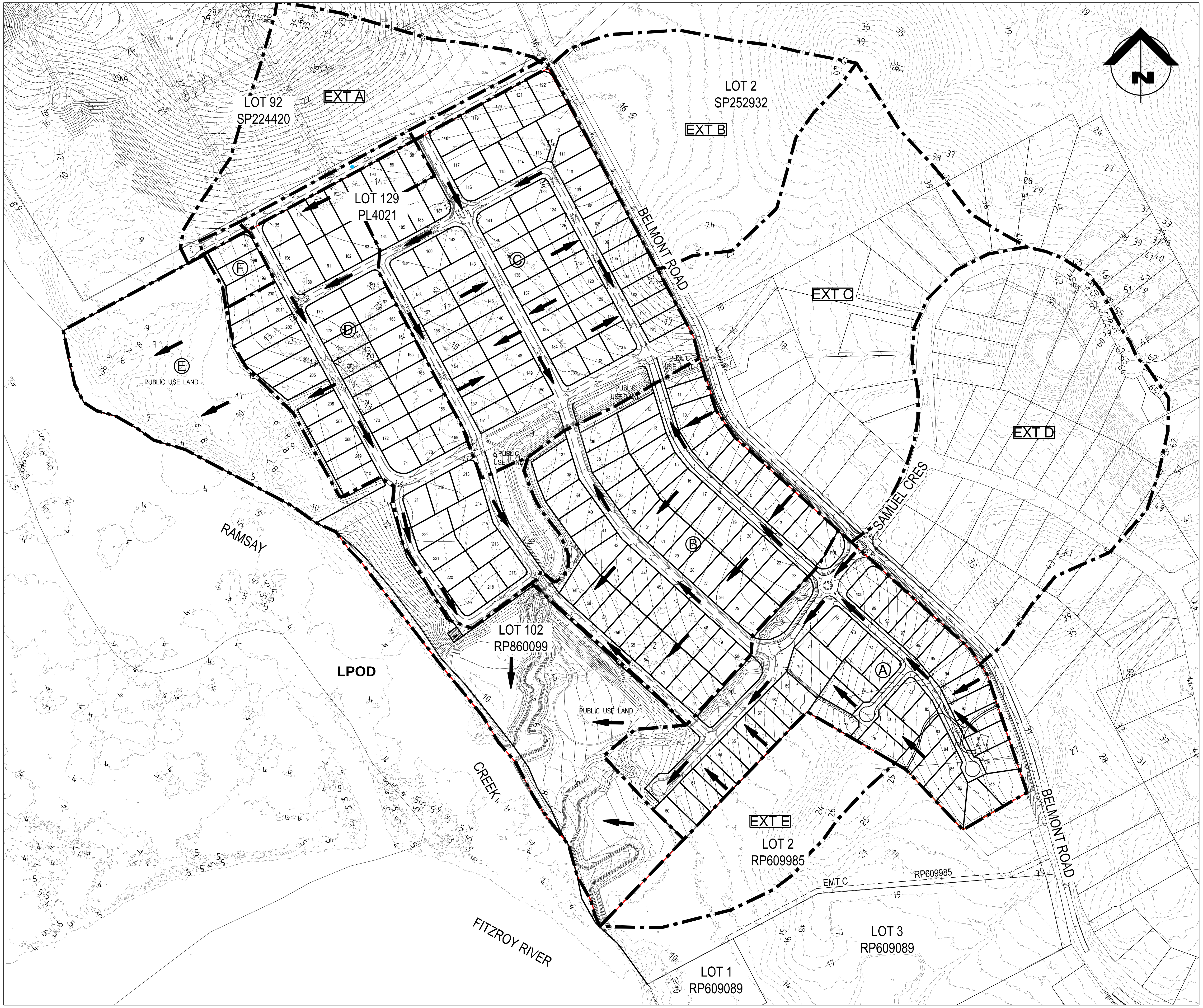
POST DEVELOPMENT STORMWATER CATCHMENT TABLE

STORMWATER CATCHMENT I.D.	AREA (ha)
A	8.693
B	9.845
C	12.328
D	10.401
E	12.358
F	0.560
TOTAL	54

EXTERNAL STORMWATER CATCHMENT TABLE

STORMWATER CATCHMENT I.D.	AREA (ha)
EXT A	6.154
EXT B	6.892
EXT C	12.312
EXT D	12.476
EXT E	3.932
TOTAL	41.766

CONTRACTOR TO DETERMINE AND LOCATE ALL EXISTING SERVICES PRIOR TO COMMENCEMENT OF WORKS



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SK	DKC	

TITLE
POST DEVELOPMENT CATCHMENT PLAN

SCALE
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1:25000 AT A3
0 500 1000m

PROJECT NO.
K4887

DWG NO.
P002

ISSUE
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APPENDIX

D

Knobel Engineers

Stormwater Sub-Catchment Plan

(Ref: K4887/P005/A)

LEGEND

🟥	SITE BOUNDARY
— · —	STORMWATER CATCHMENT BOUNDARY
Ⓐ	STORMWATER CATCHMENT I.D.
INT A	STORMWATER CATCHMENT I.D.
EXT A	EXTERNAL STORMWATER CATCHMENT I.D.
LPOD	LAWFUL POINT OF DISCHARGE
➡	PROPOSED FLOW DIRECTION

STORMWATER SUB-CATCHMENT TABLE

STORMWATER CATCHMENT I.D.	AREA (ha)
A1	0.093
A2	3.336
A3	2.516
C1	3.581
C2	1.517
INT 1	5.105
INT 2	12.01
INT 3	4.503

EXTERNAL STORMWATER CATCHMENT TABLE

STORMWATER CATCHMENT I.D.	AREA (ha)
EXT A	6.154
EXT B	6.892
EXT C	12.312
EXT D	12.476
EXT E	3.932
TOTAL	41.766

CONTRACTOR TO DETERMINE AND LOCATE ALL EXISTING SERVICES PRIOR TO COMMENCEMENT OF WORKS

STORMWATER SUB-CATCHMENT DISCHARGE TABLE

STORMWATER CATCHMENT ID	DISCHARGE LOCATION
A1, A2, A3	CATCHMENT A
INT 1, INT 2, INT 3	MAIN CONVEYANCE CHANNEL
C1, C2	CHANNEL D

REPORT ISSUE

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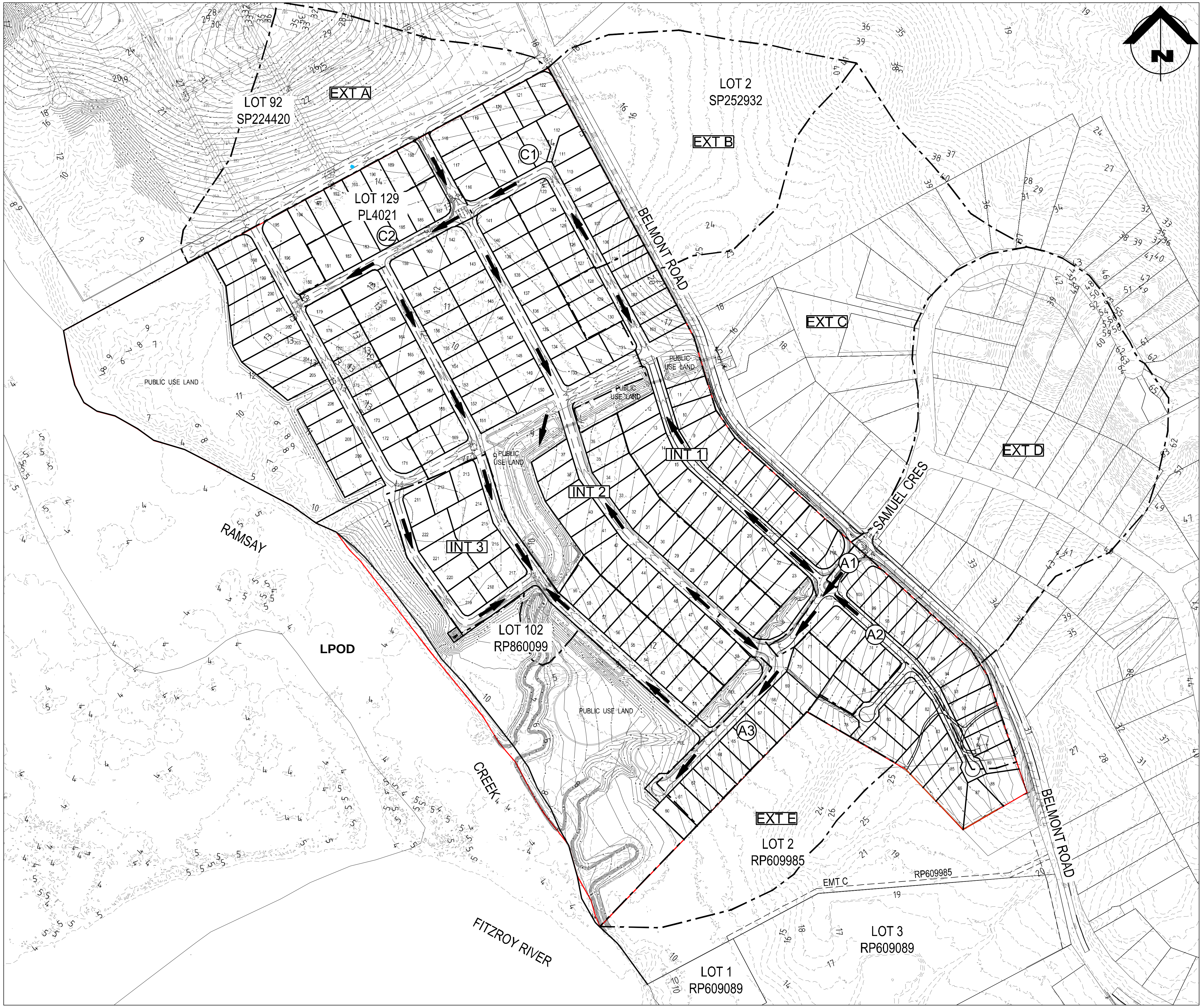

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PARKHURST QLD 4702

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SK	DKC	

TITLE
STORMWATER SUB CATCHMENT PLAN

SCALE
1:12500 AT A1
1:25000 AT A3
0 500 1000m

PROJECT NO.
K4887

DWG NO.
P005

ISSUE
A

APPENDIX

E

Knobel Engineers

Stormwater Management Plan

(Ref: K4887/P003/A)

LEGEND

STORMWATER CATCHMENT BOUNDARY

Ⓐ STORMWATER CATCHMENT I.D.

SITE BOUNDARY

LPOD LAWFUL POINT OF DISCHARGE

SWD PROPOSED STORMWATER PIPE

CATCHMENT FLOW DIRECTION

▨ PROPOSED BIORETENTION BASIN

> > > > > > PROPOSED CHANNEL

BIORETENTION BASIN PARAMETERS TABLE

BASIN I.D	FILTER AREA	EXTENDED DETENTION DEPTH	BATTERS
A	520 m²	0.3 m	1 in 4
B	700 m²	0.3 m	1 in 4
C	750 m²	0.3 m	1 in 4
D	600 m²	0.3 m	1 in 4
F	35 m²	0.3 m	1 in 4

BIORETENTION Q3 MONTH FLOW RATE

BASIN I.D	CATCHMENT AREA (ha)	Q3 MONTH FLOW RATE (m^3/s)
A	8.693	0.737
B	9.845	0.864
C	12.328	0.979
D	10.401	0.913
F	0.560	0.044

STORMWATER MANAGEMENT NOTES

1. INTERNAL STORMWATER DRAINAGE DESIGNED BY OTHERS.
2. Q3 MONTH FLOWS TO BE DISCHARGED INTO BIORETENTION BASIN.
3. SEDIMENT FOREBAYS AND MAINTAINENCE TRACKS TO BE IMPLEMENTED AT EACH BIORETENTION BASIN INLET.
4. SCOUR PROTECTION TO BE PROVIDED AROUND CULVERT INLETS AND OUTLETS.
5. FINISHED FLOOR LEVELS OF ALLOTMENTS TO BE 300mm ABOVE THE Q100 WATER LEVELS.

CONTRACTOR TO DETERMINE AND LOCATE ALL EXISTING SERVICES PRIOR TO COMMENCEMENT OF WORKS

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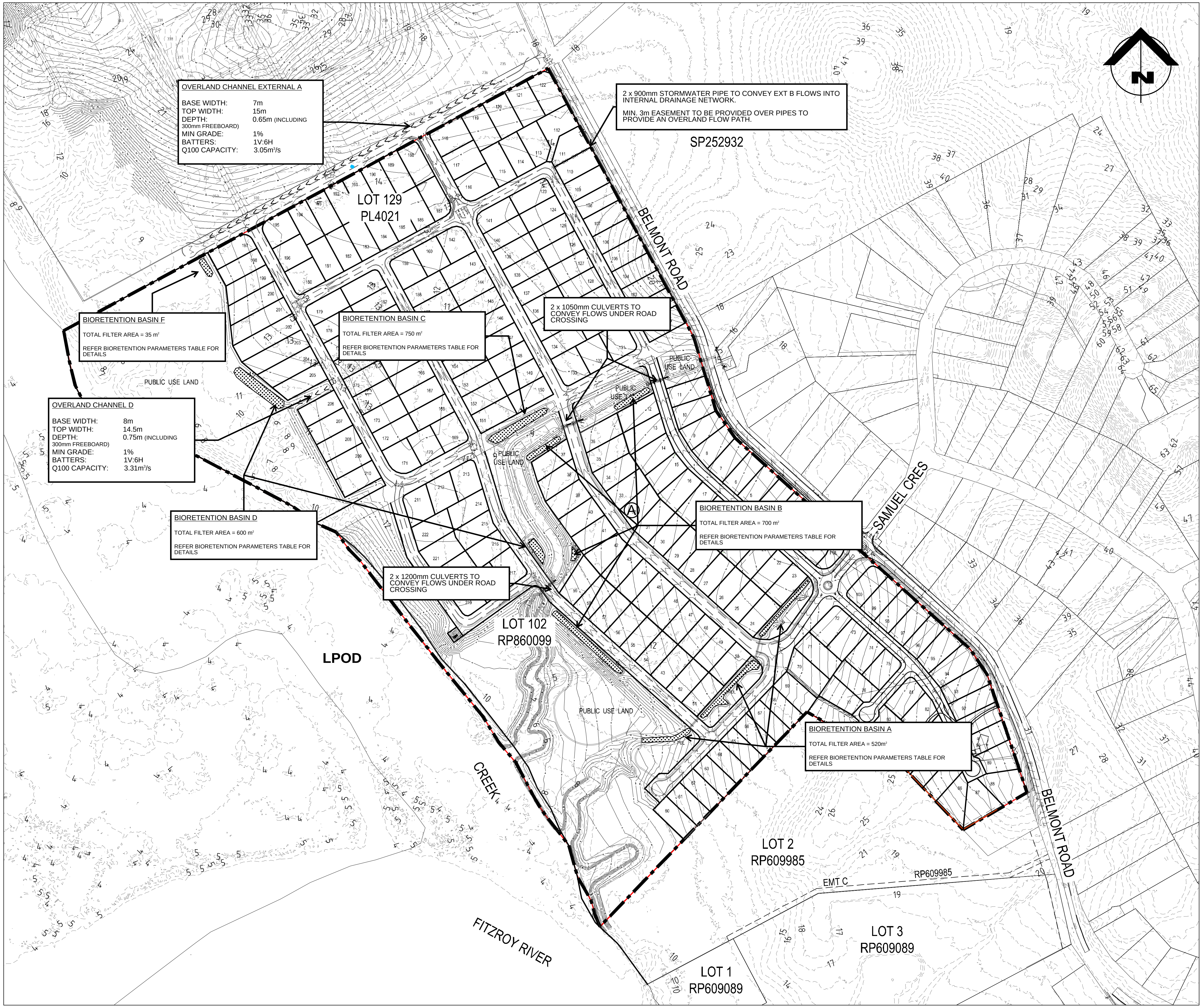

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PARKHURST QLD 4702

DESIGN SK
DRAWN DKC
APPROVED

TITLE
STORMWATER MANAGEMENT PLAN

SCALE
1:12500 AT A1
1:25000 AT A3
0 500 1000m

PROJECT NO. K4887
DWG NO. P003
ISSUE A

APPENDIX

F

Knobel Engineers

Sediment and Erosion Control Plan

(Ref: K4887/P004/A)

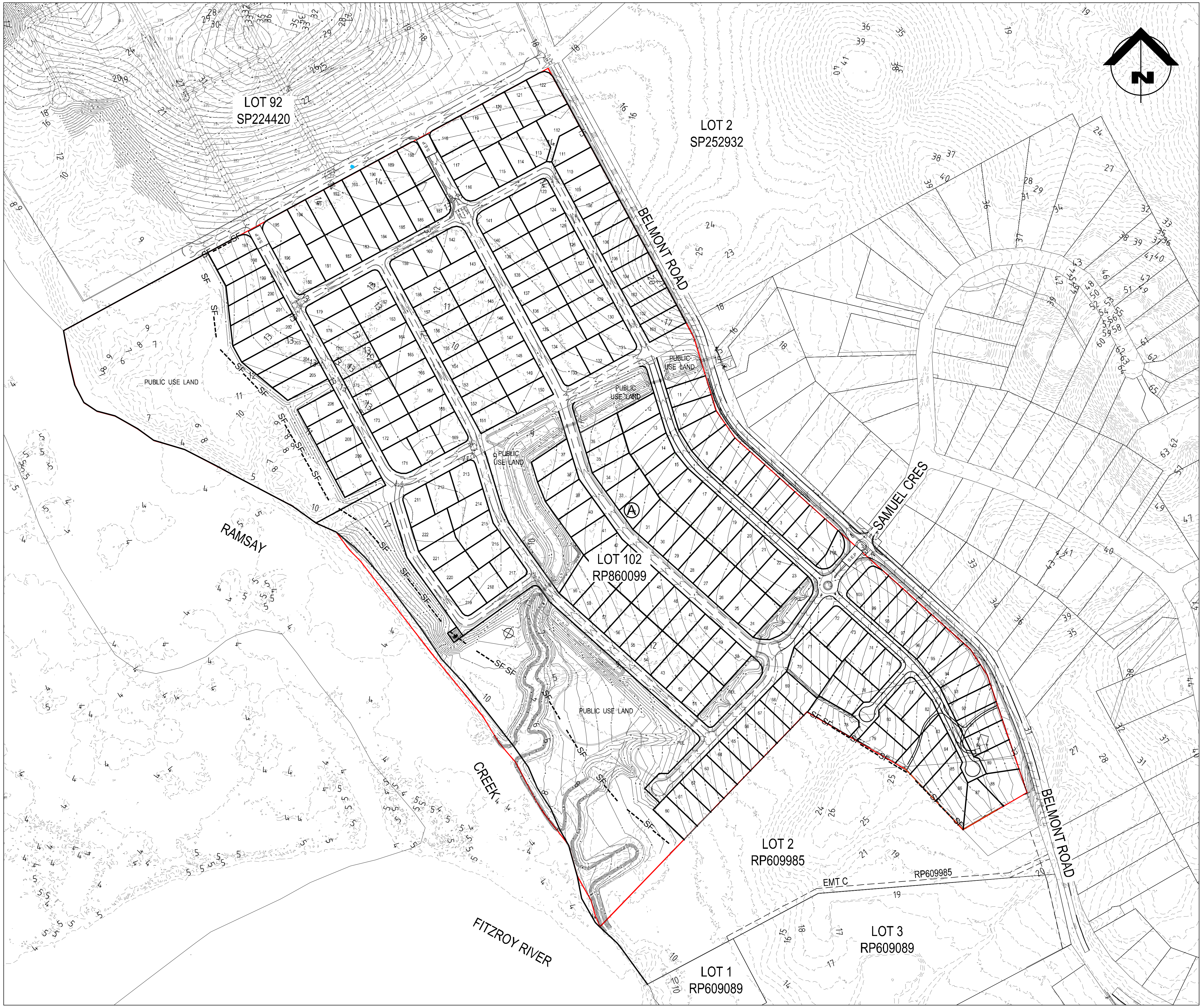
LEGEND

━━	SITE BOUNDARY
— / — SF —	SEDIMENT FENCE
SER	STABILISED ENTRY/EXIT POINT
MS1 ⊕	WATER QUALITY MONITORING STATION
⬡ DSP	DRAINAGE STRUCTURE PROTECTION

CONTRACTOR TO DETERMINE AND LOCATE ALL EXISTING SERVICES PRIOR TO COMMENCEMENT OF WORKS

SEDIMENT & EROSION CONTROL NOTES

1. REFER TO KNOBLE ENGINEERS SK01 FOR SEDIMENT BASIN LAYOUT.
2. DRAINAGE STRUCTURE PROTECTION TO BE IMPLEMENTED AROUND ALL CONSTRUCTED DRAINAGE INFRASTRUCTURE.



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PROJECT
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54-102 AND 263 BELMONT ROAD
PARKHURST QLD 4702

DESIGN	DRAWN	APPROVED
SK	DKC	

TITLE
SEDIMENT AND EROSION CONTROL PLAN

SCALE
1:12500 AT A1
1:25000 AT A3
0 500 1000m

PROJECT NO.
K4887

DWG NO. P004
ISSUE A

APPENDIX

G

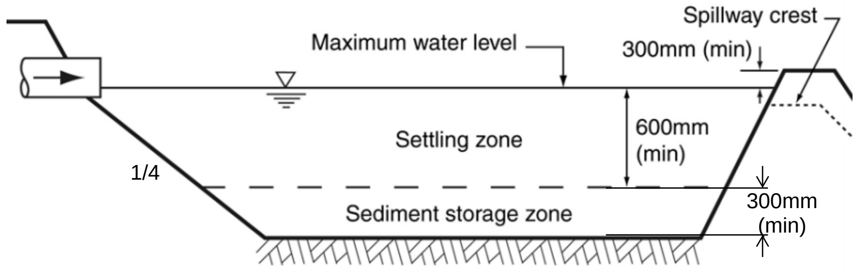
Knobel Engineers

Sediment Basin Plan

(Ref: SK01)

KNOBEL ENGINEERS

PROJECT NUMBER:	K4887
SKECTH NO:	SK01
DESCRIPTION:	SEDIMENT BASIN PLAN
DATE:	07/05/2019

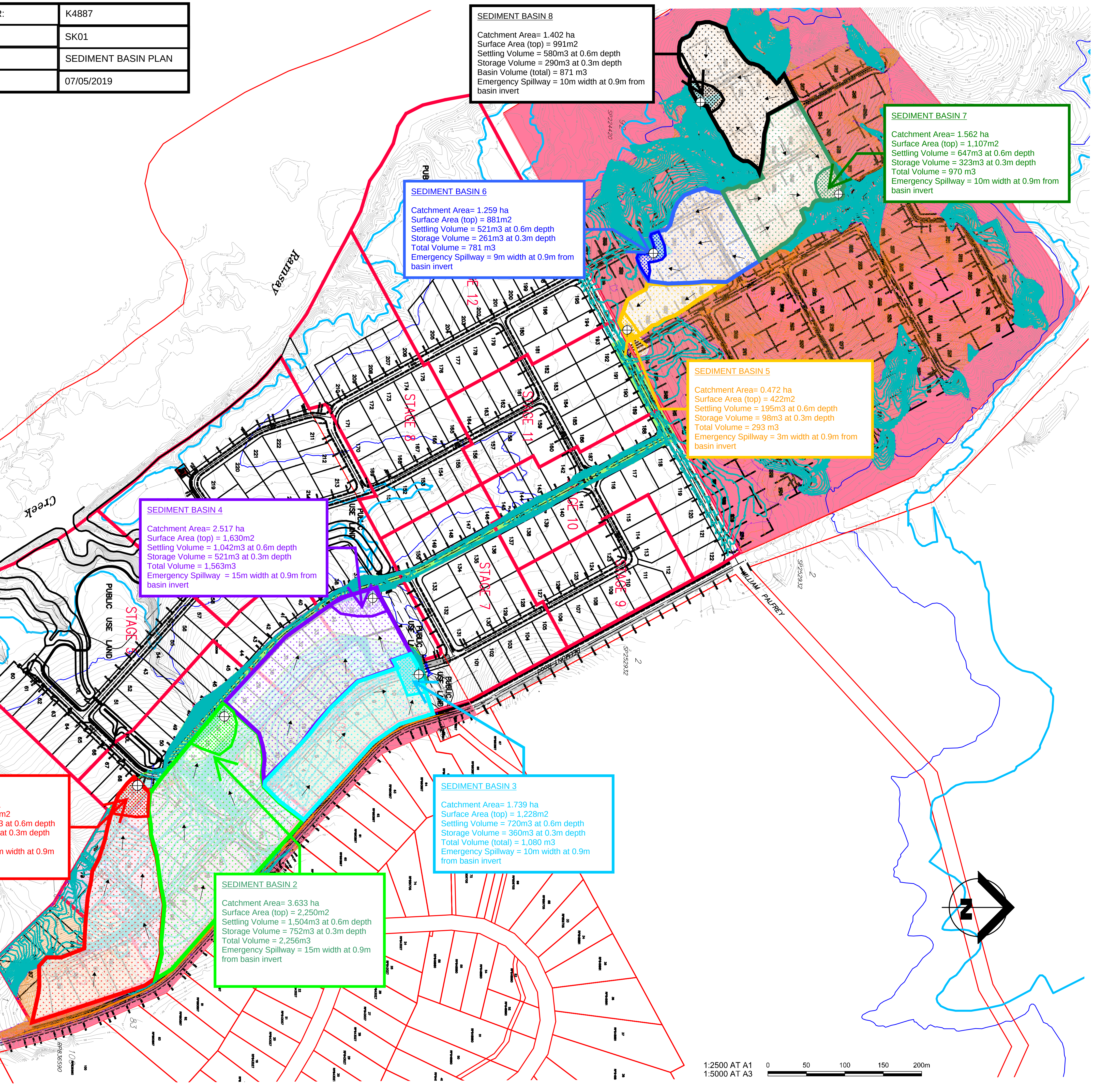


SEDIMENT BASIN D TYPICAL SECTION

LEGEND

FLOW DIRECTION →

WATER QUALITY MONITORING STATION ⊕



SEDIMENT BASIN 8

Catchment Area= 1.402 ha
Surface Area (top) = 991m2
Settling Volume = 580m3 at 0.6m depth
Storage Volume = 290m3 at 0.3m depth
Basin Volume (total) = 871 m3
Emergency Spillway = 10m width at 0.9m from basin invert

SEDIMENT BASIN 7

Catchment Area= 1.562 ha
Surface Area (top) = 1,107m2
Settling Volume = 647m3 at 0.6m depth
Storage Volume = 323m3 at 0.3m depth
Total Volume = 970 m3
Emergency Spillway = 10m width at 0.9m from basin invert

SEDIMENT BASIN 6

Catchment Area= 1.259 ha
Surface Area (top) = 881m2
Settling Volume = 521m3 at 0.6m depth
Storage Volume = 261m3 at 0.3m depth
Total Volume = 781 m3
Emergency Spillway = 9m width at 0.9m from basin invert

SEDIMENT BASIN 5

Catchment Area= 0.472 ha
Surface Area (top) = 422m2
Settling Volume = 195m3 at 0.6m depth
Storage Volume = 98m3 at 0.3m depth
Total Volume = 293 m3
Emergency Spillway = 3m width at 0.9m from basin invert

SEDIMENT BASIN 4

Catchment Area= 2.517 ha
Surface Area (top) = 1,630m2
Settling Volume = 1,042m3 at 0.6m depth
Storage Volume = 521m3 at 0.3m depth
Total Volume = 1,563m3
Emergency Spillway = 15m width at 0.9m from basin invert

SEDIMENT BASIN 1

Catchment Area= 2.601ha
Surface Area (top) = 1630m2
Settling Volume = 1,077m3 at 0.6m depth
Storage Volume = 538m3 at 0.3m depth
Total Volume = 1,615m3
Emergency Spillway = 16m width at 0.9m from basin invert

SEDIMENT BASIN 2

Catchment Area= 3.633 ha
Surface Area (top) = 2,250m2
Settling Volume = 1,504m3 at 0.6m depth
Storage Volume = 752m3 at 0.3m depth
Total Volume = 2,256m3
Emergency Spillway = 15m width at 0.9m from basin invert

SEDIMENT BASIN 3

Catchment Area= 1.739 ha
Surface Area (top) = 1,228m2
Settling Volume = 720m3 at 0.6m depth
Storage Volume = 360m3 at 0.3m depth
Total Volume (total) = 1,080 m3
Emergency Spillway = 10m width at 0.9m from basin invert

APPENDIX

H

Knobel Engineers

Preliminary Pre Development Flood Storage Plan

(Ref: K4887/P006/A)

Preliminary Post Development Flood Storage Plan

(Ref: K4887/P007/A)

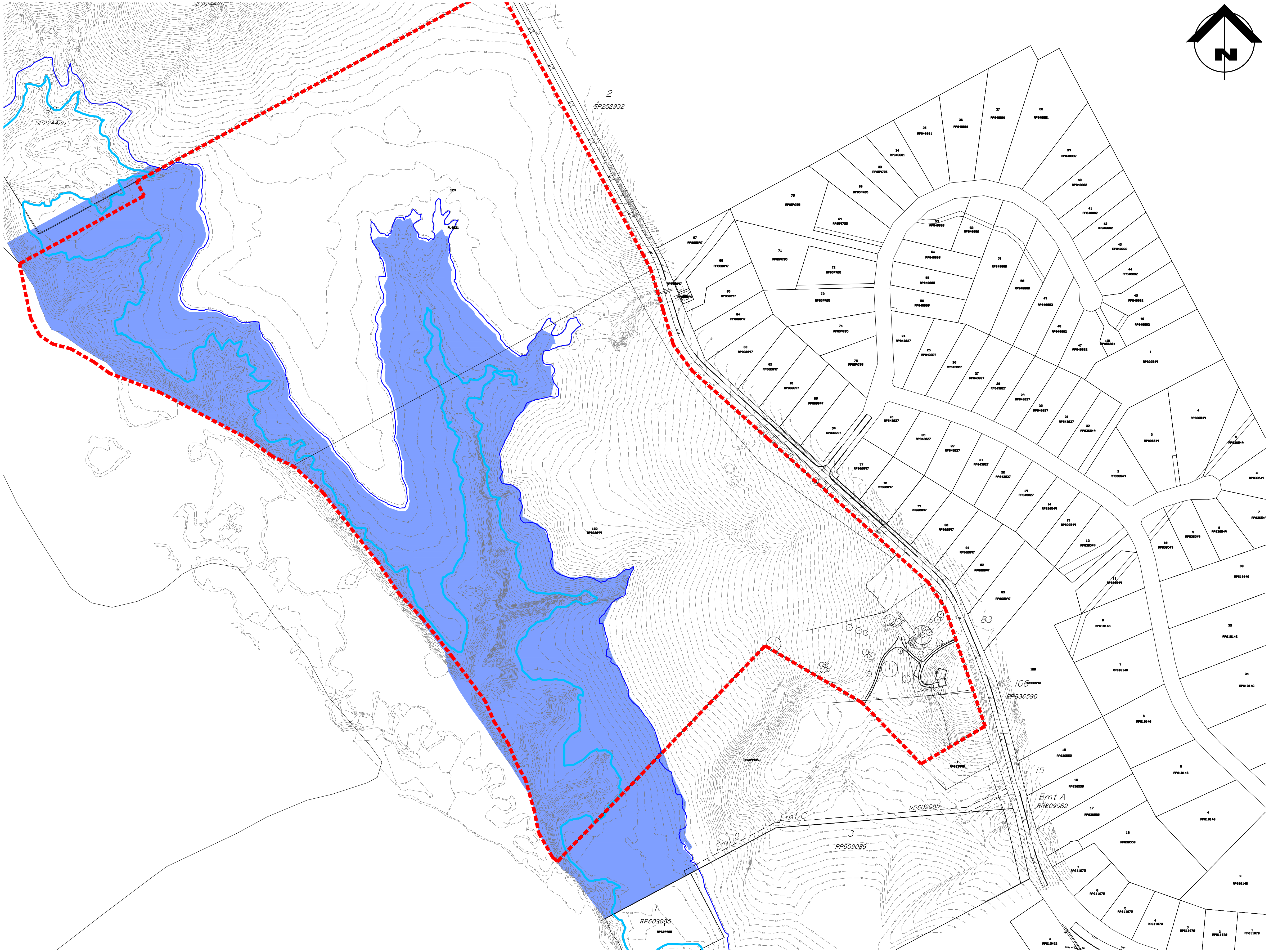
LEGEND

🟦	FLOODED AREA
━━	SITE BOUNDARY
- - - 80.0 - - -	EXISTING SURFACE CONTOURS
⇨	FLOW DIRECTION

PRELIMINARY FLOOD STORAGE VOLUME CALCULATIONS	
EXISTING CASE	
PRE DEVELOPMENT Q_{100} FLOOD STORAGE TO RL 11.80m A.H.D	490283m³

NOTES:

1. DESIGNATED Q_{100} FLOOD LEVEL (DFL) 11.80m A.H.D
2. FLOOD STORAGE CALCULATION HAS CONSIDERED THE EXTENT OF SITE SURVEY IN BOTH PRE/POST SCENARIOS.



PRE DEVELOPMENT

REPORT ISSUE
NOT FOR CONSTRUCTION

CONTRACTOR TO DETERMINE AND LOCATE ALL EXISTING SERVICES PRIOR TO COMMENCEMENT OF WORKS

ISSUE No.	DATE	AMENDMENT
A	12-09-19	ISSUED FOR REPORT

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CLIENT
GLENMORE HOLDINGS (AUST) PTY LTD

PROJECT
RIVERSIDE WATERS ESTATE
54-102 AND 263 BELMONT ROAD
PARKHURST QLD 4702

DESIGN	DRAWN	APPROVED
SK	EG	

TITLE
PRELIMINARY PRE DEVELOPMENT FLOOD STORAGE PLAN

SCALE 1:2500 AT A1
1:5000 AT A3
0 50 100 150 200m

PROJECT NO. K4887

DWG NO. P006

ISSUE A

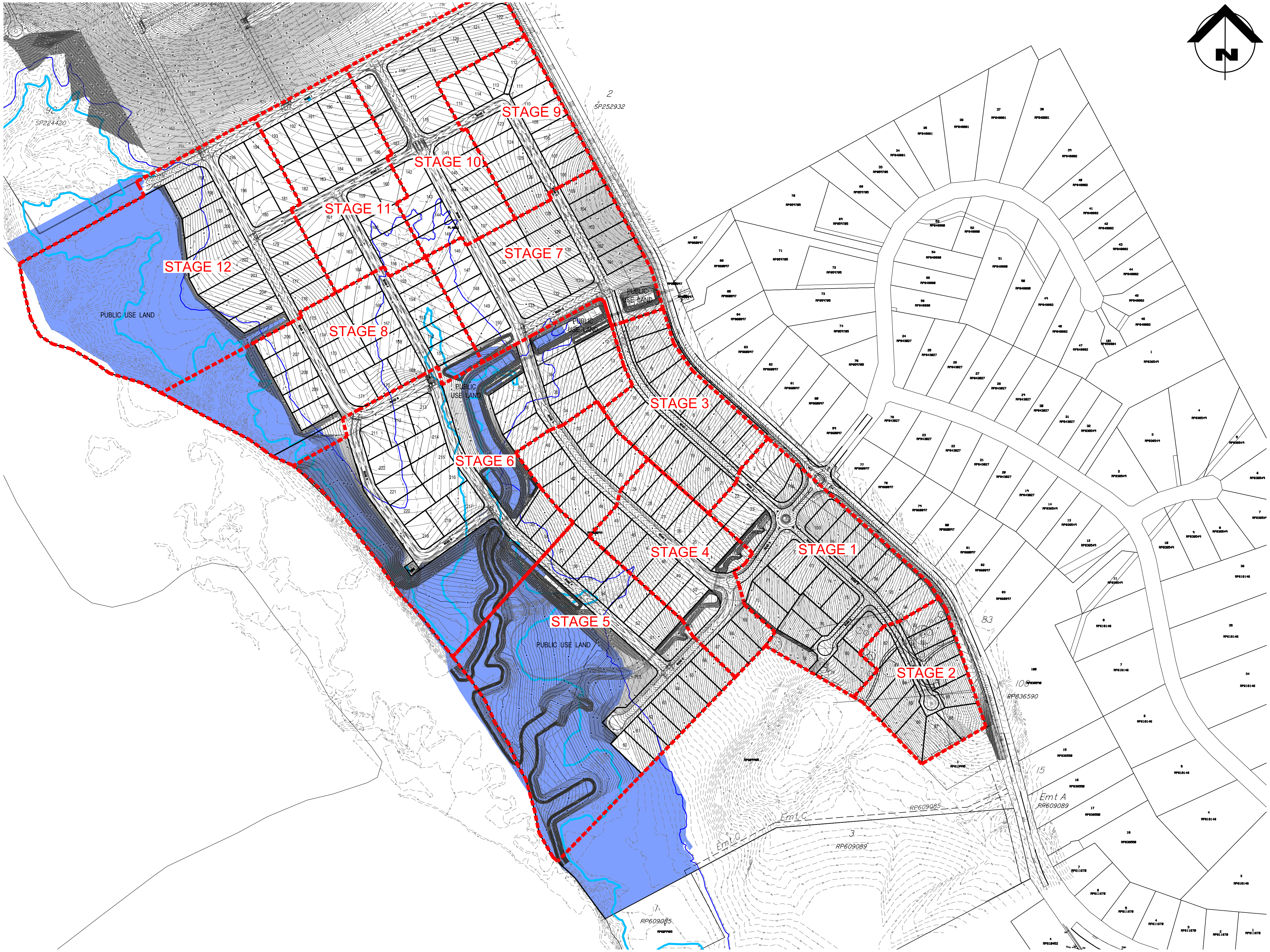
LEGEND

🟦	FLOODED AREA
───	SITE BOUNDARY
– – – 80.0 – – –	EXISTING SURFACE CONTOURS
⇨	FLOW DIRECTION

PRELIMINARY FLOOD STORAGE VOLUME CALCULATIONS	
EXISTING CASE	
PRE DEVELOPMENT Q_{100} FLOOD STORAGE TO RL 11.80m A.H.D	490283m³
DEVELOPED CASE	
POST DEVELOPMENT Q_{100} FLOOD STORAGE TO RL 11.80m A.H.D	490776m³

NOTES:

1. DESIGNATED Q_{100} FLOOD LEVEL (DFL) 11.80m A.H.D
2. FLOOD STORAGE CALCULATION HAS CONSIDERED THE EXTENT OF SITE SURVEY IN BOTH PRE/POST SCENARIOS.



POST DEVELOPMENT

REPORT ISSUE

NOT FOR CONSTRUCTION

CONTRACTOR TO DETERMINE AND LOCATE ALL EXISTING SERVICES PRIOR TO COMMENCEMENT OF WORKS

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54-102 AND 263 BELMONT ROAD
PARKHURST QLD 4702

DESIGN	DRAWN	APPROVED
SK	EG	

TITLE
PRELIMINARY POST DEVELOPMENT FLOOD STORAGE PLAN

SCALE 1:2500 AT A1 1:5000 AT A3

0 50 100 150 200m

PROJECT NO. K4887

DWG NO. P007

ISSUE A