FLANAGAN CONSULTING GROUP
Trusted Advisor to Northern Australia

Stormwater Drainage Report

Lanskey Construction Pty Ltd

Craiglie Service Station Development at 5946 Davidson Street (Lot 1 on RP739151)

Project No. 4380/01

Reference No. R-FN0373

Date: 19 October 2015

Controlled Copy no.: _____

Revisions: B

Revision Record:

Rev	Review Date	Description	Prepared	Checked	Approved
A	14/10/15	Issued as Draft	Fei Ngoo	Brett Langtree	Brett Langtree
B	19/10/15	Issued as Final	Fei Ngoo	Brett Langtree	Brett Langtree

Table of Contents

APPENDIX A – DSC Permissible Change & Extension to the Relevant Period Letter
APPENDIX B – Cardno Port Pacific Estate Stages 3 & 4 Flood Study Report
APPENDIX C – TFA Project Group Drawings
APPENDIX D – C&B Group Preliminary Site Survey
APPENDIX E – Hydrological Calculation
APPENDIX F – HECRAS Model Cross Sections (Sketch 1633-SK02)
APPENDIX G – Development Site Stormwater Extents (Sketch 4380-SK03)
APPENDIX H – HECRAS Flow Profile (Long Section), Typical Cross Sections & Detailed Outputs

1.0 INTRODUCTION

This Stormwater Drainage Report has been prepared as a response to Douglas Shire Council (DSC) comments 1 and 2 stated in the Permissible Change & Extension to the Relevant Period letter dated 16 September 2015 (attached in Appendix A) in regards to the proposed service station development at 5946 Davidson Street, Lot 1 RP739151.

The DSC comments 1 and 2 are as follows:

1) *Recent flood modelling for Craiglie associated with drainage upgrades for the Port Pacific development has established a more up-to-date understanding of the Craiglie stormwater environment. The drainage report submitted in support of the (Flanagan Consulting Engineers 2006) will need to be revised in line with this more recent modelling and the updated downstream parameters.*
2) *The revised model must also reconsider the roughness parameters adopted for this drainage path. Council officers consider the roughness values adopted in the 2006 model to be lower than would be anticipated for this drainage path. The review is required to assess the sensitivity roughness. Justification with photographs and appropriate drainage manual references is required to substantiate the roughness values selected in the modelling.*

This report includes:

- re-assessment of the catchment, determines flows from a range of rainfall events, determines the stream flow levels, velocities and extent of inundation during peak events at the development site; and
- referencing to the flood study report prepared by Cardno for Port Pacific Estate Stages 3 and 4 dated 8 November 2012. A copy of the Cardno's flood study report is included in Appendix B.

This report also considers the works required for the proposed development to prevent increased inundation above that which already exists.

This report supersedes the previous drainage report (Reference no. 1633/01/R-EK0204) submitted by Flanagan Consulting Group in 2006.

2.0 REVIEW OF CARDNO FLOOD REPORT

Below are the findings of Cardno's flood study report for Port Pacific Estate:

a) The stormwater catchment (named Northern Creek) flowing through the development site watercourse is approximately 17 hectares (ha); and

b) The assessed 100 years ARI flood level (peak at time of concentration of 52 minutes at Craiglie Creek catchment and 50 minutes at Southern Creek catchment) at the northern side of the Port Pacific Estate (which is south east to the service station development site) is approximately 4.4m AHD (refer Cardno report, Appendix B, Figures B8 and B9).

The stormwater catchment flowing through the development site watercourse assessed by Flanagan Consulting Group in 2006 is approximately 105.2 ha. There is a huge discrepancy in catchment size. The stormwater catchment through the development site has significantly reduced from 105.2 ha to 17 ha. Therefore, re-assessment of the development site watercourse catchment is required using the best available topographic data in conjunction with site inspection to verify the catchment size.

The 100 years ARI flood level of 4.4m AHD by Cardno is adopted in determining the service station building floor level to ensure the building is immune during the major rainfall events.

3.0 SITE DESCRIPTION

It is proposed to develop the site into a services station as shown on TFA Project Group Drawings 15017-03C, 15017-04C, 15017-05C, 15017-06C, 15017-07B and 15017-12A. These are attached in Appendix C.

The proposed development site is described as Lot 1 on RP739151 and is located on the Captain Cook Highway, Craiglie, Port Douglas. The site has an area of 0.573 ha and is bounded by Captain Cook Highway on the western boundary, Downing Street reserve on the eastern boundary, and commercial/industrial properties on the northern and southern boundaries.

The site has a varied profile. A raised portion of land at approximately RL 4.3m AHD exists in the south-western corner of the lot. This falls at approximately 14% to the rest of the site, which slopes from approximately RL 3.0m AHD at the western boundary to approximately RL 2.2m AHD along the eastern boundary.

The site is predominately covered in grasses, with a Melaleuca Ti-tree swamp on the eastern boundary. The "Paws and Claws Boarding Kennels" is currently established on the site, located on the raised parcel of land in the south-western corner.

An existing watercourse (along the northern boundary of the site) approximately 9m wide traverses the site from the western boundary to the eastern boundary. This watercourse is significantly vegetated and has a catchment west of the subject site. Stormwater flow from the catchment enters the watercourse from twin 2700x1800 RCBC's that run under the Captain Cook Highway.

A preliminary survey of the site was undertaken by C&B Group and is attached in Appendix D.

4.0 HYDROLOGIC ASSESSMENT

4.1 Catchment Area

As mentioned in Section 2.0, re-assessment of the development site watercourse catchment is required to verify the catchment size. The existing watercourse through the site has an upstream catchment which is located to the west of the site. The catchment extends into the Cassowary Range and includes a variety of different land uses including hill-side forest, farmland, industrial and residential development. The assessed catchment size is approximately 78.4 ha. The catchment extent is shown in Figure 1.

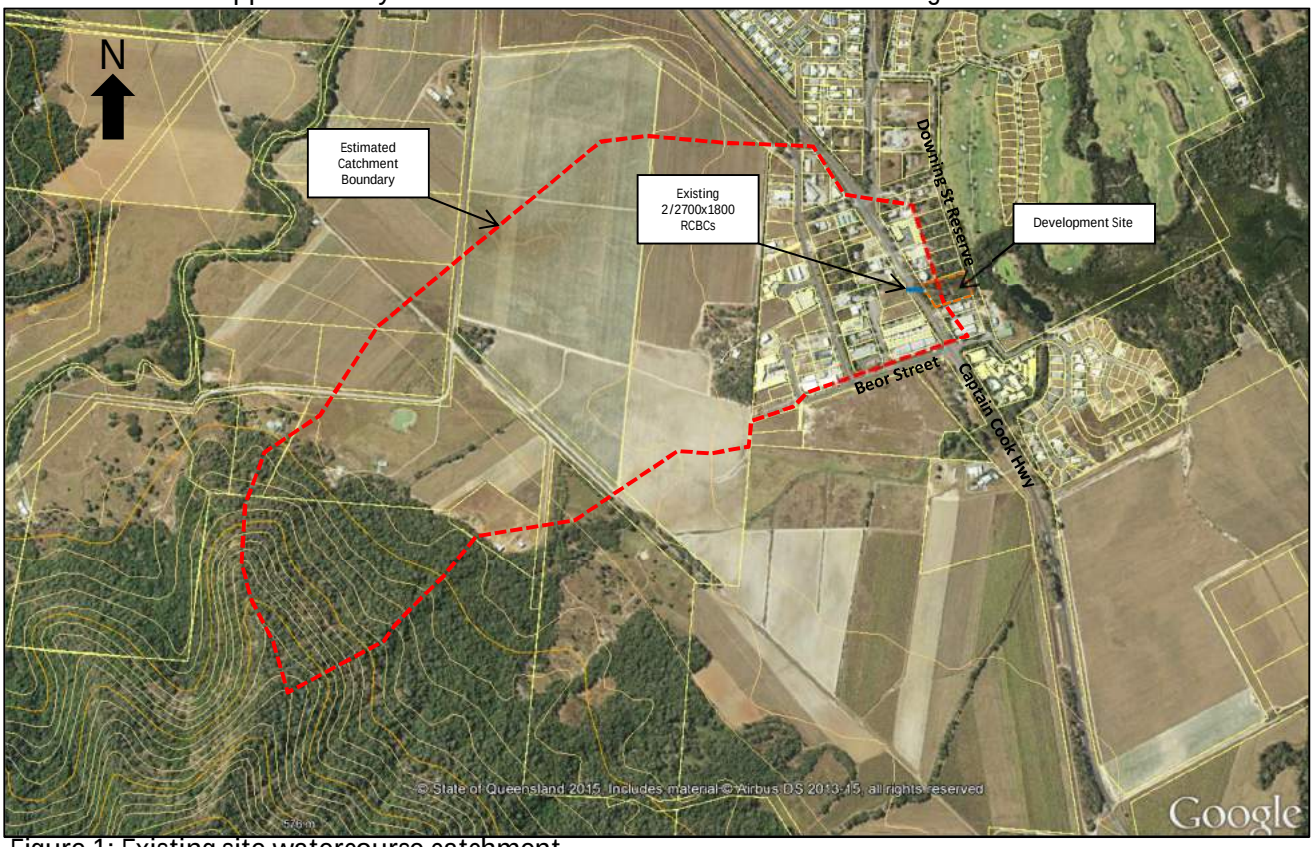


Figure 1: Existing site watercourse catchment

4.2 Methodology for Flow Calculations

The hydrology of the catchment has been analysed by the Rational Method. Use of the Rational Method and calculations for the peak flow are based on the Queensland Urban Drainage Manual (QUDM) 2013.

The Rational Method for the calculation of peak flows (refer QUDM 2013 Section 4.3) is given by the following,

$$Q_y = (C_y \,.\, {}^{t}I_y \,.\, A) / 360$$

where Q_y = peak flow rate (m3/s) for average recurrence interval (ARI) of ''y' years

C_y = coefficient of discharge (dimensionless) for ARI of 'y' years

A = area of catchment (Hectares)

${}^{t}I_y$ = average rainfall intensity (mm/h) for a design duration of 't' hours and an ARI of 'y' years

t = the nominal design storm duration as defined by the time of concentration

The design ARI events assessed in this stormwater drainage report are 5, 10, 20, 50 and 100 years.

Steps adopted for peak flows calculation can be summarised as follows:

a) Analyse possible flow paths based on available surveyed data;
b) Determine the time of concentration of each flow path;
c) Adopt the flow path with the longest time of concentration for assessment;
d) Determine the runoff coefficient; and
e) Calculate peak flow rate.

4.3 Time of Concentration

The time of concentration (t_c) of a catchment is defined as the time required from the start of a design storm, for surface runoff to collect and flow from the most remote part of the catchment to its outlet. Generally, the longest time of concentration results from the longest flow path within the catchment.

The catchment flow path is shown in Figure 2. The catchment's longest time of concentration consists of a combination of overland and channel flow paths.

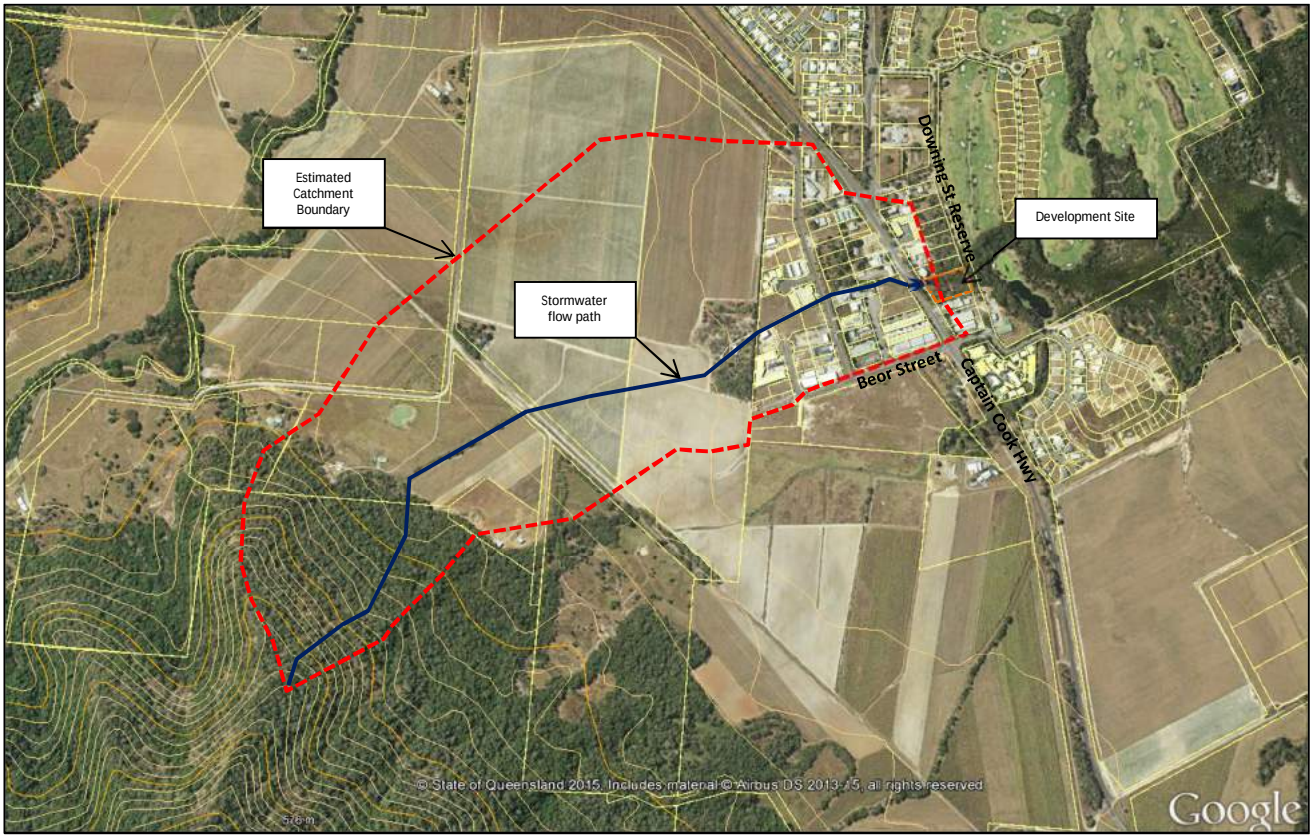


Figure 2: Catchment Flow Paths

The t_c for the overland flow path is estimated using Figure 4.6 of QUDM 2013. The t_c for the channel flow path is estimated using Table 4.6.6 of QUDM 2013.

Using Figure 4.6 and Table 4.6.6, the tabulated t_c of the catchment is approximately 49.8 minutes. Refer Appendix E for detailed hydrological calculations.

4.4 Runoff Coefficient

The runoff coefficient (C_y) for the catchment is determined in accordance with QUDM 2013 Section 4.5. The formula for the C_y is:

$$C_y = F_y \,.\, C_{10}$$

where C_y = runoff coefficient for ARI of 'y' years

F_y = frequency factor for ARI of 'y' years (refer QUDM 2013 Table 4.5.2)

C_{10} = 10 year discharge coefficient

The catchment consists of bushland (63.9 ha) and developed areas (14.5 ha). The runoff coefficient has been adjusted to account for the composite catchment.

Using Tables 4.5.1, 4.5.3 and 4.5.4, with fraction impervious (f_i) of 0.9 (developed areas) and 0.0 (bushland), and one hour rainfall intensity for a 1 in 10 year ARI ($^1I_{10}$) of 82.2mm/hr, the 10 year discharge coefficient (C_{10}) are:

- 0.88 for developed areas; and
- 0.70 for bushland.

The runoff coefficient (C_y) for different ARI rainfall events is then tabulated and is summarised in Table 1.0.

ARI (Years)	Runoff Coefficient (C_y)
5	0.70
10	0.73
20	0.77
50	0.84
100	0.87

Table 1.0: Runoff coefficient for different ARI rainfall events

Refer Appendix E for detailed hydrological calculations.

4.5 Rainfall Intensity

Intensities for the flow rate calculations have been sourced from the Australian Government Bureau of Meteorology which is referenced from Intensity-Frequency-Duration (IFD) table developed from Australian Rainfall & Runoff 2001 Book 2.

The average rainfall intensity for time of concentration of 49.8 minutes for different ARI rainfall events is interpolated from the IFD table and summarised in Table 2.0. (The IFD table is included in the detailed calculations in Appendix E)

ARI (Years)	Rainfall Intensity (mm/hr)
5	82.3
10	90.4
20	102.0
50	117.1
100	128.6

Table 2.0: Rainfall intensity for different ARI rainfall events

4.6 Peak Flow Rate

Using the tabulated time of concentration, average rainfall intensity and runoff coefficient, the peak discharge (refer Table 3.0) for different ARI rainfall event for the catchment is:

ARI (Years)	Peak Flow Rate (m^3/s)
5	12.49
10	14.45
20	17.11
50	21.46
100	24.37

Table 3.0: Peak flow rate for different ARI rainfall events

Refer Appendix E for detailed hydrological calculations.

5.0 HYDRAULIC ASSESSMENT (HECRAS)

5.1 Introduction

The purpose of the hydraulic modelling was to determine the flood extents for 5, 10, 20, 50 and 100 years ARI rainfall events.

The hydraulic modelling for the study area was undertaken utilising the mathematical HEC-RAS software which accounts for steady-state, one-dimensional and constant flow. HEC-RAS is produced and supported by the US Army Corp of Engineers, and widely accepted in Australia and internationally for this type of hydraulic analysis.

5.2 Cross-Section Data

Topographic data to define the watercourse geometry in the HEC-RAS model were based on field survey data of the study area, provided by C&B Group. Various cross sections (also named as river station in HECRAS) were produced based on the preliminary survey as per Sketch 1633-SK02 attached in Appendix F.

5.3 Roughness Values

Manning's roughness coefficients were assigned to the left overbank, right overbank and main channel for each cross section. The roughness values were estimated from field inspection and aerial photographs. The existing site watercourse and properties are shown in Photos 1 and 2.

Photo 1: Existing site watercourse (looking east)

Photo 2: Watercourse channel and bank properties

Various manual references/guidelines (for e.g. Austroad, HECRAS guidelines, DTMR Road Drainage Manual, AR&R etc) have been studied to determine the appropriate Manning's value that suits the existing watercourse properties.

The existing watercourse properties are quite similar to the photograph (see Photo 3) shown in the *Department of Transport and Main Roads (DTMR), Road Drainage Manual 2010, Chapter 8: Open Channel Design, Table 8.4.3(b).*

Photo 3: TMR Manning's n = 0.08

However, the existing watercourse has more dense shrubs/weeds along the base and bank as shown in Photo 2. Using *DTMR Table 8.4.3(b)*, the existing channel generally fall under part of category of "Heavy stand of timber, a few fallen trees, little undergrowth – flood depth below branches" (Manning's values of 0.10 to 0.12). In this case, it is believed that the watercourse Manning's falls between 0.08 to 0.10.

As the hydraulic roughness has a substantial influence in assessing the stormwater level within the site channel, it is intended to test all the Manning's values (between 0.08 to 0.10) in the HECRAS model for a sensitivity checks and adopts the worst case for conservative assessment.

5.4 Boundary Conditions

When the HEC-RAS model is used for the mixed flow (subcritical and supercritical) simulations, the user is required to specify the boundary conditions at the upstream and downstream end of the model. This provides the starting conditions for the model and for this study; the upstream and downstream boundary condition was set at normal depth for the model runs.

Peak flows from the Rational Method calculations in Section 4.0 were entered into the HEC-RAS model. Flood extents and estimated flood water surface levels were then modelled for the 5, 10, 20, 50 and 100 years ARI rainfall event.

5.5 Results

The resulting flood inundation levels (5, 10, 20, 50 and 100 ARI rainfall events) from the HEC-RAS modelling software were plotted and are attached in Appendix G, Sketch 4380-SK03.

The flow model long section, flood levels, typical cross sections and detailed HEC-RAS output (5, 10, 20, 50 and 100 ARI rainfall events) are included in Appendix H.

5.6 Discussion

5.6.1 Impacts of Roughness Coefficient (Manning's n Value)

As mentioned in Section 5.3, Manning's value of 0.08 to 0.10 is tested in the HECRAS model for a sensitivity checks.

The assessed average water level difference within the watercourse between the lowest (n = 0.08) and highest (n = 0.10) Manning's value for different ARI rainfall events are:

- 5 years ARI event – approx. 122mm
- 10 years ARI event – approx. 132mm
- 20 years ARI event – approx. 148mm
- 50 years ARI event – approx. 167mm
- 100 years ARI event – approx. 181mm

As there is a substantial different in water levels between the lowest and highest coefficients, for conservative approach, the highest Manning's value of 0.10 has been adopted for the development site stormwater drainage assessment.

The same Manning's value has been assigned to left overbank, right overbank and main channel for each cross section.

Refer Appendix E for the water levels difference summary between Manning's values of 0.08 to 0.10.

5.6.2 Existing Watercourse Water Levels & Velocities

The assessed water level and channel velocities at the watercourse during the 5, 10, 20, 50 and 100 years ARI rainfall events are summarised in Table 4.0. These are reported at various cross section (river station) locations along the existing watercourse alignment. Refer Sketch 1633-SK02 in Appendix F for cross section location.

Cross Section (River Station)	Existing Channel Ground Level (m AHD)	5 Years ARI		10 Years ARI		20 Years ARI		50 Years ARI		100 Years ARI	
		Water Level (m AHD)	Velocity (m/s)	Water Level (m AHD)	Velocity (m/s)	Water Level (m AHD)	Velocity (m/s)	Water Level (m AHD)	Velocity (m/s)	Water Level (m AHD)	Velocity (m/s)
116.64 (U/S)	1.61	3.61	1.06	3.70	1.09	3.82	1.09	3.99	1.08	4.10	1.07
100.97	1.5	3.53	0.68	3.62	0.71	3.74	0.75	3.92	0.79	4.03	0.81
89.11	1.4	3.47	0.82	3.56	0.85	3.68	0.89	3.86	0.94	3.97	0.98
78.47	1.6	3.43	0.77	3.52	0.80	3.64	0.84	3.81	0.91	3.92	0.94
67.50	1.47	3.37	0.85	3.46	0.89	3.57	0.95	3.75	1.01	3.86	1.03
54.52	1.22	3.28	0.94	3.36	1.00	3.47	1.08	3.63	1.20	3.74	1.26
44.52	1.34	3.22	0.96	3.30	1.03	3.40	1.12	3.55	1.23	3.65	1.38
34.52	1.46	3.17	0.83	3.25	0.85	3.36	0.87	3.52	0.94	3.62	0.95
24.52	1.72	3.16	0.32	3.24	0.33	3.35	0.35	3.51	0.37	3.61	0.39
17.21 (D/S)	1.94	3.15	0.32	3.24	0.34	3.34	0.36	3.50	0.39	3.60	0.40

U/S – Upstream; D/S - Downstream

Table 4.0: 5, 10, 20, 50 & 100 years ARI water levels and flow velocities for the existing watercourse

The modelling has identified that the flow is not contained entirely within the defined watercourse and that the adjacent low lying areas of the site are used for conveyance of stormwater flows. The raised parcel of land in the south-western portion of the site is the only region within the lot that has 5, 10, 20, 50 and 100 years ARI rainfall event immunity. This represents approximately 40% of the site area.

The non-uniform configuration of the existing watercourse results in varying velocities and water surface elevations at each cross section.

5.6.3 HECRAS Model Limitations

As the extent of survey does not adequately cover the entire flood plain to the north and east of the site, the model has a “glass wall” effects along the extent of survey. As a consequence of this, the flood levels to the north and east of the site cannot be accurately determined. However, saying that, the “glass wall” effect is allowing a conservative approach in assessing the flood inundation levels.

The hydraulic model does not take into consideration the impacts of the adjacent watercourse that connects further downstream of the watercourse. However, it is recommended that the Q100 water level of 4.4m AHD assessed by Cardno (as mentioned in Section 2.0) to be adopted in determining the development building floor levels.

6.0 HYDROLOGY AND HYDRAULICS FOR PROPOSED DEVELOPMENT

Hydraulic modelling indicates that any filling or reduction in area of the existing waterway through the site may increase flood levels in the surrounding areas. Therefore, filling works should not be undertaken in the hydraulic conveyance corridor without compensated flood storage earthworks.

Because of this hydraulic constraint, the proposed development has been designed with a raised concrete platform on the northwest of the development which is over the footprint of the conveyance corridor. The level of this raised platform will need to be high enough so that the under side of the slab and supporting beams are above the 100 year ARI water surface level.

This will ensure that the proposed development does not impact on the existing conveyance corridor, and does not alter the existing flood levels of the site or the surrounding area.

The proposed finish floor level of the service station building is 4.7m AHD. According to our model, the assessed Q100 level adjacent to the building site is 3.74m AHD, which indicated the service station building is approximately 1.0m above the Q100 level.

Please note that the Q100 level indicated in Cardno flood report is approximately 4.4m AHD (as mentioned in Section 2.0) however, this Q100 level is not at the location of the proposed development site. In saying that, the service station building level still 300mm above the Q100 level.

7.0 CONCLUSION

Hydrologic and hydraulic modelling for this catchment and conveyance corridor has been undertaken.

The extent of survey does not adequately cover the entire flood plain to the north and east of the site. The extent of the hydraulic model is restricted to the extent of survey. As a consequence of this, the model has a "glass wall" along the extent of survey and accurate flood levels to the north and east of the site cannot be determined. However, saying this, this allowed a conservative approach in assessing the flood inundation levels.

The modelling has shown that 5, 10, 20, 50 and 100 years ARI event flow is not contained within the channel and uses the surrounding low lying land as a flow conveyance corridor.

Hydraulic modelling indicates that any filling or reduction in area of the existing waterway through the site will increase flood levels upstream of the site, through the site and on the developments to the north and east of the site.

The proposed development has been designed with a raised concrete platform on the northwest of the development which is over the footprint of the conveyance corridor. The level of this raised platform will need to be high enough so that the under side of the slab and supporting beams are above the 100 year ARI water surface level.

The proposed finish floor level of the service station building is 4.7m AHD which is approximately 1.0m above the Q100 level of 3.74m AHD indicated in the model and 300mm above the Q100 level of 4.4m AHD indicated by Cardno.

The site is able to be developed without adversely impacting on the existing hydraulic conveyance corridor, and without altering the existing flood levels of the site or the surrounding area if the abovementioned development constraints are adhered to.

FLANAGAN CONSULTING GROUP
Trusted Advisor to Northern Australia

APPENDIX: A

DSC Permissable Change & Extension to the Relevant Period Letter

DOUGLAS
SHIRE COUNCIL

PO Box 723 Mossman Qld 4873
www.douglas.qld.gov.au
enquiries@douglas.qld.gov.au
ABN 71 241 237 800

Administration Office
64 - 66 Front St Mossman
P 07 4099 9444
F 07 4098 2902

YOUR REF:
OUR REF: MCUI 4077/2006 (461843) SC

16 September 2015

TFA Project Group
PO Box 301
ALBION QLD 4010

Email: Hayley.Edmunds@tfa.com.au

Attention: John Rowell - Principal Town Planner /Hayley Edmunds – Town Planner

Dear Sir/Madam

PERMISSIBLE CHANGE & EXTENSION TO THE RELEVANT PERIOD – SERVICE STATION AT 5946 DAVIDSON STREET, CRAIGLIE

Reference is made to our letter dated 3 August 2015 and your response letter dated 11 August 2015. We have undertaken an engineering review of the proposed development and the following comments apply:

1) Recent flood modelling for Craiglie associated with drainage upgrades for the Port Pacific development has established a more up-to-date understanding of the Craglie stormwater environment. The drainage report submitted in support of the (Flanagan Consulting Engineers 2006) will need to be revised in line with this more recent modelling and the updated downstream parameters.

2) The revised model must also reconsider the roughness parameters adopted for this drainage path. Council officers consider the roughness values adopted in the 2006 model to be lower than would be anticipated for this drainage path. The review is required to assess the sensitivity of the model (capacity and flood levels) to increased channel roughness. Justification with photographs and appropriate drainage manual references is required to substantiate the roughness values selected in the modelling.

3) As a more general comment, it appears there may be potential to optimise the site footprint further to reduce the intrusion into the drainage line and to reduce the extent of suspended slab. This may also have significant positive cost implications for the applicant.

Optimising the orientation of the building and the fuel bowsers and locating these as far south as possible appears to allow greater flexibility with the northern extent of the footprint. From the information provided it appears that turning templates can accommodate this site optimisation. From an engineering perspective it would also appear that it may offer drainage benefits through less intrusion into the drainage line.

4) The response provided in your letter to the issue of vegetation loss indicates the removal of one tree (as arrowed in Figure 1). Notwithstanding this response, it would appear that there will be a total loss of vegetation along road frontage, given ingress and egress pavements, road widening and sight-line requirements. It will also be highly likely that the Raintree that is shown in Figure 1 as being retained, will also require removal.

   As previously advised, this part of Craiglie is an important gateway into Port Douglas as a premium tourism destination of international renown. It was anticipated that a response referencing a survey plan would provide better clarification to this issue rather than photographs provided in the response.

Please advise of how you wish to proceed with the request to extend and the permissible change application in light of the abovementioned issues. Should you require any further information or assistance, please contact either Neil Beck of Development and Environment on telephone number 07 4099 9451 or Simon Clarke on telephone number 07 4099 9480.

Yours faithfully

Donna Graham
Manager Development & Environment

FLANAGAN CONSULTING GROUP
Trusted Advisor to Northern Australia

APPENDIX: B

Cardno Port Pacific Estate Stages 3 & 4 Flood Study Report

Port Pacific Estate
Stages 3 & 4

Flood Study

Q074061

Prepared for
Port Pacific Estates Pty Ltd

8 November 2012

Cardno®
Shaping the Future

Cardno (Qld) Pty Ltd
ABN 57 051 074 992
Level 11 Green Square North Tower
515 St Paul's Terrace
Fortitude Valley Qld 4006
Locked Bag 4006 Fortitude Valley
Queensland 4006 Australia
Telephone: 07 3369 9822
Facsimile: 07 3369 9722
International: +61 7 3369 9822
cardno@cardno.com.au
www.cardno.com.au

Document Information

Prepared for	Port Pacific Estates Pty Ltd
Project Name	Port Pacific Estate - Stages 3 & 4
File Reference	O:\Q074061\wp\Stage 3-4\Stage34 Development.docx
Job Reference	Q074061
Date	8 November 2012

Document Control

Version	Date	Author	Author Initials	Reviewer	Reviewer Initials
1	8 November 2012	M. Della	MD	H. Doherty	HD

Table of Contents

Tables

Appendices

1 Introduction

The Port Pacific Estate is located at Craiglie, just south of Port Douglas. Entry to the subject site is obtained from Beor Street.

The site is generally bounded by the Captain Cook Highway and the existing Plantation Resort to the west, the Beor Street road reserve to the north, and farming land to the south.

Stages 1 and 2 of the development have been constructed. It is now proposed to construct Stages 3 and 4 of the Estate. The layout of the development is shown in Appendix A.

A flood study of the area around the Port Pacific Estate was carried out, to determine:

- the flood levels in the area, for a range of Average Recurrence Interval (ARI) events, assuming existing climate conditions; and
- the 100 year flood levels in the area assuming the predicted impacts of Climate Change to the year 2100, as these levels will be used to set the allotment levels within Stages 3 and 4.

This report presents the results of the investigation.

2 Catchment Hydrology

2.1 Catchment Area

Two main catchments discharge stormwater runoff to the Port Pacific Estate. A third smaller catchment discharges runoff into Craiglie Creek downstream of the subject site. The size of these catchments was determined from topographic data of the area. The catchment boundaries are shown in Appendix C (Figure C1). The total catchment areas upstream of the Captain Cook Highway were calculated to be approximately:

- Craiglie Creek 196 hectares;
- Southern Creek 90 hectares; and
- Northern Creek 17 hectares.

2.2 Time of Concentration

The time of concentration for the two main catchments was calculated using two different methodologies, as described in the Queensland Urban Drainage Manual (QUDM), Section 4.06.11: the Bransby-Williams' Equation and the Modified Friend's Equation.

The formula for the Bransby-Williams' Equation is:

$$t_c = \frac{58L}{A^{0.1}S^{0.2}}$$

where: t_c = time of concentration of the catchment (min)
L = length of flowpath from the outlet to the catchment divide (km)
A = catchment area (ha)
S = equal area slope (%)

The formula for the Modified Friend's Equation is:

$$t_c = \frac{800L}{ChA^{0.1}S^{0.4}}$$

where: t_c = time of concentration of the catchment (min)
L = length of flowpath from the outlet to the catchment divide (km)
Ch = Chezy's coefficient at the site = $R^{1/6}/n$
R = hydraulic radius = $0.65R_s$ (where the slope varies along the stream)
R_s = hydraulic radius at the site (m)
n = average Manning's n roughness along the stream
A = catchment area (ha)
S = equal area slope (%)

Using these equations, the time of concentration of each catchment to the subject site was calculated, as shown in Table 2-1.

Table 2-1 Time of Concentration

Parameter	Craiglie Creek	Southern Creek
Stream Length (m)	2117	1908
Catchment Area (ha)	196.1	90.3
Equal Area Slope (%)	5.4	6.0
Hydraulic Radius at Outlet (m)	1.0	0.75
Average Manning's n	0.10	0.10
Time of Concentration – Bransby Williams (min)	52	50
Time of Concentration – Modified Friends (min)	55	54

These results show that the calculated times of concentration are consistent using both methodologies. Thus, the following times of concentration were adopted for each catchment:

- Craiglie Creek 52 minutes; and
- Southern Creek 50 minutes.

2.3 Coefficient of Runoff

The coefficient of runoff for the catchment was determined in accordance with the FNQROC Development Manual (Version No. 11/06) and the Queensland Urban Drainage Manual (2007), as shown below.

The catchments are generally undeveloped, thus a 10 year coefficient of runoff of 0.70 was adopted.

The coefficient of runoff for the 100 year ARI event is therefore 0.84.

2.4 Rational Method

Using the times of concentration shown above, the Rational Method was used to calculate the 100 year discharge from each catchment.

Design rainfall intensities for Port Douglas were obtained using the Intensity-Frequency-Duration data contained in FNQROC Development Manual (Version No. 11/06).

The resultant peak discharges for the 100 year event using the Rational Method are:

- Craiglie Creek 56 m^3/s; and
- Southern Creek 27 m^3/s.

2.5 WBNM Model

A WBNM hydrologic model of the catchments was established. The layout of the model is shown in Appendix C (Figure C2).

The design rainfall data for the catchment was determined in accordance with Australian Rainfall & Runoff. The information used is as follows:

2 Year ARI, 1 hour Intensity	60 mm/h
2 Year ARI, 12 hour Intensity	13 mm/h
2 Year ARI, 72 hour Intensity	5.0 mm/h
50 Year ARI, 1 hour Intensity	100 mm/h
50 Year ARI, 12 hour Intensity	27.5 mm/h
50 Year ARI, 72 hour Intensity	9.5 mm/h
Regional Skewness	0.15
Geographical Factor F2	3.86
Geographical Factor F50	17.1

The design rainfall losses adopted for the analysis were:

Pervious Area	Initial Loss = 0 mm
	Continuing Loss = 2.5 mm/h
Impervious Area	Initial Loss = 0 mm
	Continuing Loss = 0 mm/h

A Lag Parameter of 1.50 was used in the WBNM model. Studies carried out using WBNM have found that the average value of the Lag Parameter across a wide range of catchments is between 1.30 and 1.80 (ref. WBNM User Manual). Thus, the adopted value of 1.50 is within the accepted bounds.

The WBNM model was run for a range of storm durations, from 10 minutes to 72 hours, with the 1.5 hour event producing the peak discharge from each catchment. The peak discharges calculated by the WBNM model are:

- Craiglie Creek 61 m^3/s; and
- Southern Creek 28 m^3/s.

This result shows that the peak flows calculated by the WBNM model agree well with those from the Rational Method (refer Section 5.4). Thus, it was considered that the WBNM model could be used to calculate the discharge hydrographs from the catchment.

3 Hydraulic Analysis

3.1 Topographic Information

The flood flow within the study area was modelled using the 2 dimensional unsteady flow software TUFLOW (Build 2012-05-AA-iSP-w64).

A digital terrain model (DTM) of the study area was set up using:

- Lidar data of the floodplain and surrounds in the vicinity of the subject site;
- field survey of key areas around the subject site;
- as-constructed survey of Stages 1 and 2 of Port Pacific Estate; and
- design DTM of Stages 3 and 4 of Port Pacific Estate.

Council recently approved flood mitigation works for Stages 1 and 2 of the Port Pacific Estate. These works included:

- a 20 metre wide grass-lined open channel along the southern boundary of the Port Pacific site (known as the Southern Drain);
- a stormwater drainage line, running from the sag in Dulku Close to the Southern Drain;
- additional filling for the existing vacant lots in Stage 2; and
- upgrading the existing overland flow path from the Stage 2 sag to a 10 metre wide concrete path.

Some details of the flood mitigation works are shown in Appendix A. Thus, these works were also incorporated into the DTM for the TUFLOW model.

This DTM was used to define the existing ground levels within the flood model study area.

Based on this DTM, a TUFLOW model with a fine 5 metre grid was established. The extent of the TUFLOW model is shown in Figure B1 in Appendix B.

It is noted that a formal open channel (known as the Northern Drain) may be constructed along the northern boundary of the site. In addition, there may be changes to:

- the elevation of the Entry Road; and
- the size and number of culverts underneath the Entry Road.

Various flood mitigation options have been modelled, however a final design has not yet been approved. Thus, this report does not include any possible changes to the topography and drainage design at the northern end of the site.

3.2 1-D Links

Culverts were input into the TUFLOW model as 1-dimensional flow links. Inlet and outlet loss coefficients of 0.5 and 1.0 respectively were used for all structures. The TUFLOW model checks the operation of culverts under both inlet and outlet flow control, for Class 1 (free water surface) and Class 2 (submerged entrance) conditions.

The existing open channel along the western boundary of the site was also modelled as a series of 1-dimensional flow links. Cross sections of the open channel were extracted from field survey, and used in the TUFLOW model to define the flow area.

3.3 Floodplain Roughness

The Manning's n roughness values applicable to the study area were determined from site inspections and aerial photography. The values used are summarised in Table 3-1.

Table 3-1 Manning's n Values

Location	Manning's n
Road Reserves	0.02
Golf Course	0.035
Heavily Grassed or Vegetated Areas	0.08
Densely Treed/Mangrove Areas	0.15
Commercial Precincts	0.20

3.4 Tailwater Level

The downstream boundary of the TUFLOW model is located at the outfall of Craiglie Creek to the Pacific Ocean, near Port Douglas. Relevant ocean levels are as follows.

- The Highest Astronomical Tide (HAT) level at Port Douglas is 1.78 mAHD (ref. *Queensland Tide Tables 2012*, Queensland Government).
- The 100 year storm tide level in the vicinity of Port Douglas (i.e. at Oak Beach) is 1.9 mAHD (ref. *Queensland Climate Change and Community Vulnerability to Tropical Cyclones – Ocean Hazards Assessment Stage 3*, Queensland Government, July 2004). An allowance of 300 mm was added to this level, to account for wave setup at the coastline.

Based on these levels, a 100 year storm tide level of 2.2 mAHD was adopted for the existing 100 year event, and a Highest Astronomical Tide level of 1.78 mAHD was adopted for the smaller events.

3.5 Catchment Inflows

Subcatchment hydrographs calculated by the WBNM model were input into the TUFLOW model. As discussed in Section 2.5, the 1.5 hour storm event produced the peak discharges in the vicinity of the subject site.

Direct rainfall-on-grid was applied to the TUFLOW model for all parts of catchment area east of the Captain Cook Highway. This included the subject site, the Coral Gardens site to the south, and the Juniper development to the north.

Overland flow from Stages 3 and 4 of the subject site discharges along Wabul Street to the Southern Drain, or along Jiwal Jiwal Street into the floodplain to the east of the site.

3.6 Model Results

The TUFLOW model was used to calculate the flood levels in the vicinity of the Port Pacific Estate for a range of average recurrence interval (ARI) flood events.

The calculated flood levels and extent of inundation for each event are shown in Appendix B. A summary of the results is presented in Table 3-2. The location of the reporting points is shown in Figure B2 in Appendix B.

Table 3-2 Peak Flood Levels

Location	Peak Flood Level (mAHD)					
	2 year ARI	5 year ARI	10 year ARI	20 year ARI	50 year ARI	100 year ARI
Southern Drain Upstream End of Stage 3	3.29	3.33	3.37	3.44	3.52	3.60
Southern Drain Midway Along Boundary	3.07	3.10	3.13	3.17	3.23	3.29
Southern Drain Downstream End	2.66	2.72	2.75	2.81	2.88	2.97
Port Pacific Site Eastern Boundary	2.49	2.59	2.64	2.71	2.79	2.90

3.7 Climate Change

The allotment fill levels in Stages 3 and 4 will be designed to account for the impacts of Climate Change on the Craiglie Creek flood levels.

Recent climate change investigations (ref. *Increasing Queensland's resilience to inland flooding in a changing climate: Final Scientific Advisory Group report – Derivation of a rainfall intensity figure to inform an effective interim policy approach to managing inland flooding risks in a changing climate*, Department of Environment and Resource Management, 2010) recommend that an allowance for a 20% increase in design rainfall intensities should be adopted for climate change.

The current projection for sea level rise by the International Panel on Climate Change (IPCC, 2007) is 800 mm by the Year 2100.

An analysis was therefore carried out for the 100 year ARI event, incorporating the following elements of climate change:

- increase in rainfall intensity of 20%; and
- sea level rise of 800 mm (i.e. giving a tailwater level = 3.0 mAHD).

The impact of climate change on the calculated 100 year ARI flood levels is shown in Table 3-3. The extent of inundation and flood levels associated with this event are shown in Figure B9 in Appendix B. As discussed above, these flood levels will be used to determine the minimum allotment levels in Stages 3 and 4 of the Port Pacific Estate.

Table 3-3 Impact of Climate Change on Flood Levels

Location	Peak Flood Level (mAHD)	
	100 year ARI	100 year ARI + Climate Change
Southern Drain – Upstream End of Stage 3	3.60	3.77
Southern Drain – Midway Along Boundary	3.29	3.44
Southern Drain – Downstream End	2.97	3.22
Port Pacific Site – Eastern Boundary	2.90	3.20

4 Conclusions

It is proposed to develop Stages 3 and 4 of the Port Pacific Estate at Craiglie.

A flood study was carried out to determine the flood levels applicable to the proposed development.

A WBNM hydrologic model of the catchment discharging to the Port Pacific Estate site was setup. The model achieved similar results to the peak flows calculated using the Rational Method.

A TUFLOW hydraulic model of the study area was set up to determine the flood levels applicable to the site.

The allotment fill levels in Stages 3 and 4 will be designed to account for the following impacts of Climate Change on the Craiglie Creek flood levels:

- increase in rainfall intensity of 20%; and
- sea level rise of 800 mm (i.e. tailwater level = 3.0 mAHD).

The peak flood levels and extent of inundation at the site are shown in Appendix B.

Port Pacific Estate - Stages 3 & 4

APPENDIX A

Development Layout

Cardno
Shaping the Future

EXISTING BUND

MILMAN DRIVE

NORTHERN DIVERSION DRAIN (FUTURE)
16m WIDE GRASS OPEN CHANNEL

NORTH

LOTS 1 TO 10 RETAINING WALL
800mm RETAINING WALL TO REAR OF LOTS 1 TO 10

EXISTING STORMWATER OUTLET

STAGE 2 LOT FILLING
FILLING OF STAGE 2 LOTS AND UPGRADE OF EXISTING STORMWATER OUTLET

STAGE 1
EXISTING

STAGE 2
EXISTING

MILMAN DRIVE

WANDI CLOSE

DULKU CLOSE

DULKU CLOSE DRAINAGE
Q100 STORMWATER PIPE THROUGH STAGE 3 TO SOUTHERN DRAIN

STAGE 3

STAGE 4

JIWAL JIWAL STREET

FUTURE SECONDARY VEHICLE ACCESS

WABUL STREET

SOUTHERN DIVERSION DRAIN
20m WIDE EASMENT GRASSED DRAIN

15 0 30 60m
SCALE 1:1500 AT ORIGINAL SHEET SIZE

CAD FILE: H:\2007\074061-001\Design\Acad\Flood Mitigation Concept\SW 01-01.dwg Nov 06, 2012 - 11:51am XREF's: x_base 074061 FMC Overall; x_Base Dulku Drain 074061-001; x_base 074061 Northern Drain

ISSUE	DATE	DESCRIPTION / APPROVED USE	REV'D	APP'D
01	06.11.12	FLOOD STUDY ISSUE	-	-

APPROVED USE
The information contained in this document is provided for a specific use only as noted in the adjacent box. This document is only suitable for the intended purpose and shall not be applied to any other use without the written approval of Cardno. Unless the approved use of this drawing as stated in the issue box is 'FOR CONSTRUCTION', this drawing was not approved for construction purposes at time of issue.

DOCUMENT CONTROL STATUS
Unless stamped 'CONTROLLED COPY No.___' in red, this copy is 'UNCONTROLLED'.

VERIFICATION OF CURRENCY
Verify this drawing against a current controlled copy held by Cardno prior to use to ensure that it is the current issue.

DRAWN	KJE 06.11.12
DESIGNED	- 06.11.12
CHECKED / PROJECT MGR	BNC 06.11.12
APPROVED PROJECT DIRECTOR	- -

Cardno (Qld) Pty Ltd
Level 1, 280 Sheridan Street, Cairns North
P.O. BOX 1619 CAIRNS QLD. 4870
Email: cairns@cardno.com.au
ABN 57 051 874 992
PH. 07 40510 288
FAX 07 40510 133

OFFICES	TELEPHONE	FAX
Sunshine Coast	(07) 5443 2555	(07) 5443 5642
Brisbane	(07) 3369 9822	(07) 3369 9722
Sydney	(02) 9416 8233	(02) 9416 6529
Gold Coast	(07) 5539 9333	(07) 5538 4647
Townsville	(07) 4772 1166	(07) 4721 2508
Hervey Bay	(07) 4124 5455	(07) 4124 5155
Cairns	**(07) 4051 0288**	**(07) 4051 0133**
Rockhampton	(07) 4924 7500	(07) 4926 4375
Darling Downs	(07) 4637 8122	(07) 4637 8155
Toowoomba	(07) 4633 9333	(07) 4634 9355
Darwin	(08) 8981 3613	(08) 8941 1768

CLIENT: PORT PACIFIC ESTATES Pty Ltd

PROJECT: SUBDIVISIONAL WORKS
AT PORT PACIFIC ESTATE
DOWNING STREET/CAPTAIN COOK HIGHWAY
CRAIGLIE

TITLE: STAGING PLAN

ORIGINAL SHEET SIZE	JOB_No.	DRAWING NO.	ISSUE
A3	Q074061-003	SP 01	01

FLOOD MITIGATION WORKS
AT PORT PACIFIC ESTATE
DOWNING STREET/CAPTAIN COOK HIGHWAY, CRAIGLIE

SOUTHERN DIVERSION DRAIN AND DULKU CLOSE DRAINAGE

DRAWING SCHEDULE

CARDNO

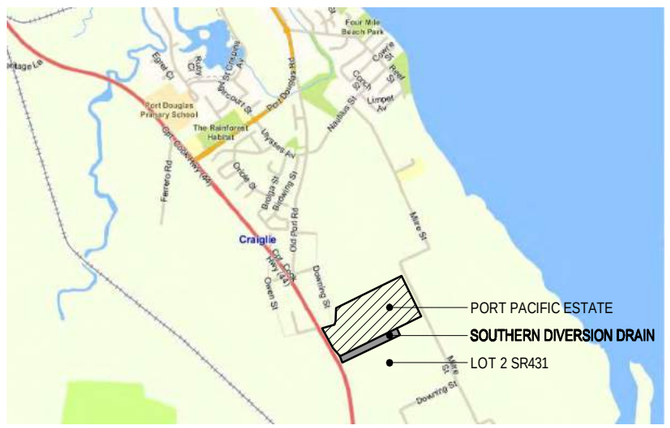
SD C00-1	DRAWING SCHEDULE AND LOCALITY PLAN
SD C01	NOTES
SD C02	SITE WORKS PLAN AND DETAILS
SD C03	LONGITUDINAL SECTION AND DETAILS
SD C04	CROSS SECTIONS - SHEET 1 OF 2
SD C05	CROSS SECTIONS - SHEET 2 OF 2
ND DC08	DULKU CLOSE DRAINAGE - Q100 RELIEF PIPE PLAN
ND DC09	DULKU CLOSE DRAINAGE - STORMWATER DETAILS
ND DC10	DULKU CLOSE DRAINAGE - STORMWATER LONGITUDINAL SECTIONS - Q100
ND DC11	DULKU CLOSE DRAINAGE - STORMWATER CALCULATION TABLE - Q100

IMEAQ

D-0041 SEDIMENT CONTROL DEVICES

FNQROC

S1000 CONCRETE KERB AND CHANNEL



LOCALITY PLAN
NTS

DISCLAIMER

The proposed Southern Diversion Drain as shown on these drawings is proposed to form a part of proposed flood mitigation works for Port Pacific Estate.

The concept shown on these drawings is subject to approval by Cairns Regional Council of an overall proposal for provision of flood mitigation works for Port Pacific Estate, approval by Cairns Regional Council of the report prepared by Cardno (Qld) Pty Ltd titled Port Pacific Estate Port Douglas Flood Study and agreement by other stakeholders including affected landowners to the overall proposal for provision of flood mitigation works for Port Pacific Estate.

The design intent of the proposed Southern Diversion Drain is to convey from the east side of the road reserve of the Captain Cook Highway to outfall east of proposed Stage 4 of Port Pacific Estate the part of the estimated discharge corresponding to a flood event of average recurrence interval (ARI) 100 years in the waterway described in the Port Pacific Estate Port Douglas Flood Study as the Southern Creek which would cross the Captain Cook Highway in existing culverts.

It is proposed that eventually the outfall of the Southern Diversion Drain will be diverted through culverts between proposed Stages 4 and 5 of Port Pacific Estate to outfall to the north of proposed Stage 5 of Port Pacific Estate.

Hydrological investigation performed by Cardno (Qld) Pty Ltd (refer Flood Study report) has estimated that the discharge approaching the west side of the Captain Cook Highway in the Southern Creek catchment for a flood event with an average recurrence interval of 100 years is approximatley 28 m^3/s. Further hydraulic investigation by Cardno (Qld) Pty Ltd has estimated that a peak discharge approximately 19 m^3/s would cross the Highway via the existing culverts, no flow would overtop the Highway and the balance of the discharge from the southern Creek catchment would be diverted towards the north along the west side of the Highway or be attenuated by the flood storage available in this area.

A detailed hydraulic investigation by Cardno (Qld) Pty Ltd has estimated that the capacity of the proposed drain dimensioned and surfaced as shown on these drawings will be adequate to convey the estimated discharge of 19 m^3/s corresponding to a flood event with an average recurrence interval of 100 years with 300mm freeboard.

The proposed Southern Diversion Drain as shown on these Cardno (Qld) Pty Ltd drawings relies on the findings of the Cardno (Qld) Pty Ltd Flood Study and associated investigations.

Other flood mitigation works proposed to be implemented in conjunction with the proposed Southern Diversion Drain include the following.

- Flood mitigation works within Stage 1 of Port Pacific Estate as described in the Port Pacific Estate Port Douglas Flood Study.
- Construction of a Northern Diversion Drain generally in the unformed road reserve of Downing Street along the northern boundary of Port Pacific Estate.

The proposed flood mitigation works will not achieve compliance with the requirements of the FNQROC Development Manual or the Queensland Urban Drainage Manual for stormwater drainage design, particularly with respect to the depth of inundation of the Port Pacific Estate entrance road.

The extent of flood mitigation in Port Pacific Estate expected to be achieved by the proposed Southern Diversion Drain is described in the Port Pacific Estate Port Douglas Flood Study.

It is expected that construction of the proposed Southern Diversion Drain would increase the extent of the 100 years ARI flood inundation and corresponding flood water levels at the downstream end of the proposed Southern Diversion Drain including in property other than the Port Pacific Estate property, as discussed in the Port Pacific Estate Port Douglas Flood Study. The largest increases in the 100 years ARI flood levels near the eastern end of the Southern Diversion Drain have been estimated as part of the Flood Study to be approximately 330mm for all flood mitigation options considered by the Flood Study. Increases in the 100 years ARI flood levels within the heavily vegetated area downstream of the Port Pacific site have been estimated as part of the Flood Study to be up to 100mm for all flood mitigation options considered by the Flood Study.

FOR CONSTRUCTION

ISSUE	DATE	DESCRIPTION / APPROVED USE	REV'D	APP'D
01	09.10.12	ISSUED FOR CONSTRUCTION	ACA	ACA
E	08.07.12	ISSUED FOR TENDER	MAP	MAP
D	18.11.10	RE-ISSUED FOR AMENDED APPROVAL	MAP	MAP
C	27.10.10	RE-ISSUED FOR AMENDED APPROVAL	MAP	MAP
B	23.09.10	RE-ISSUED FOR APPROVAL	PVS	PVS
A	24.08.09	ISSUED FOR APPROVAL	PVS	PVS

APPROVED USE
The information contained in this document is provided for a specific use only as noted in the adjacent box. This document is only suitable for the intended purpose and shall not be applied to any other use without the written approval of Cardno. Unless the approved use of this drawing as stated in the issue box is 'FOR CONSTRUCTION', this drawing was not approved for construction purposes at time of issue.

DOCUMENT CONTROL STATUS
Unless stamped 'CONTROLLED COPY No.___' in red, this copy is 'UNCONTROLLED'.

VERIFICATION OF CURRENCY
Verify this drawing against a current controlled copy held by Cardno prior to use to ensure that it is the current issue.

DRAWN NLL 09.10.12
DESIGNED NLL 09.10.12
CHECKED / PROJECT MGR ACA 09.10.12
APPROVED PROJECT DIRECTOR A.C.ALCOCK RPEQ No. 8333 09.10.12

Cardno
Cardno (Qld) Pty Ltd
Level 1, 280 Sheridan Street, Cairns North
P.O. BOX 1619 CAIRNS QLD. 4870
Email: cairns@cardno.com.au
ABN 57 051 074 992
PH. 07 40510 288
FAX 07 40510 133

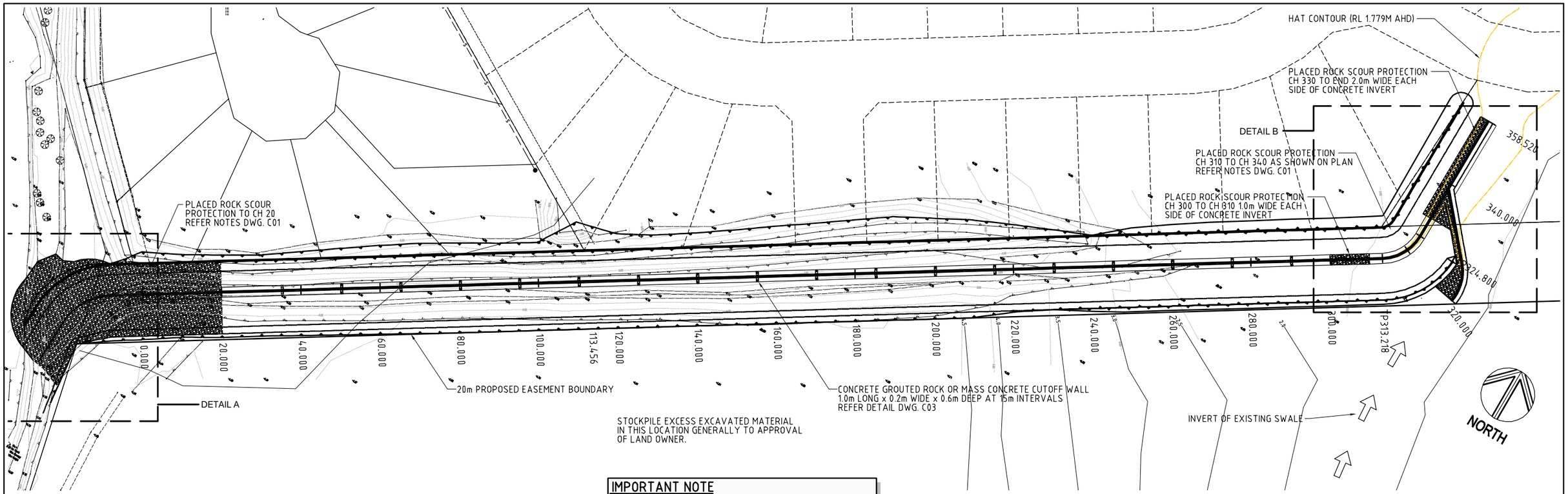
OFFICES	TELEPHONE	FAX
Sunshine Coast	(07) 5443 2555	(07) 5443 5642
Brisbane	(07) 3369 9822	(07) 3369 9722
Sydney	(02) 9416 8233	(02) 9416 6529
Gold Coast	(07) 5539 9333	(07) 5538 4647
Townsville	(07) 4772 1166	(07) 4721 2508
Hervey Bay	(07) 4124 5455	(07) 4124 5155
Cairns	**(07) 4051 0288**	**(07) 4051 0133**
Rockhampton	(07) 4924 7500	(07) 4926 4375
Darling Downs	(07) 4637 8122	(07) 4637 8155
Toowoomba	(07) 4633 9333	(07) 4634 9355
Darwin	(08) 8942 8200	(08) 8942 8211

CLIENT: PORT PACIFIC ESTATES Pty Ltd
PROJECT: FLOOD MITIGATION WORKS AT PORT PACIFIC ESTATE
DOWNING STREET/CAPTAIN COOK HIGHWAY, CRAIGLIE
SOUTHERN DIVERSION DRAIN

TITLE: DRAWING SCHEDULE AND LOCALITY PLAN

ORIGINAL SHEET SIZE	PROJECT No.	DRAWING No.	ISSUE
A1	Q074061-001	SD C00-1	01

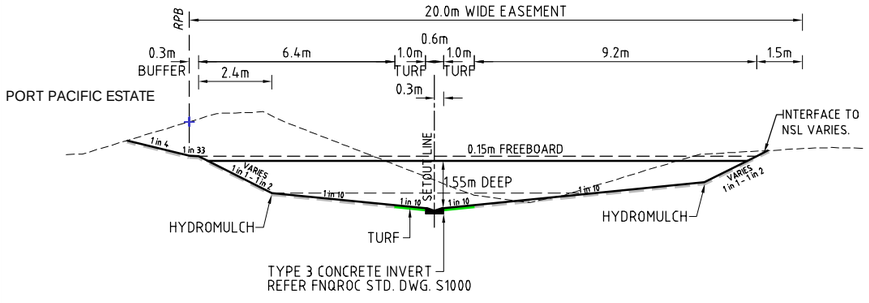
CAD FILE: H:\2007\Q74061-001\Design\Acad\Southern Drain\Amended Approval\For Construction\SD C00-1_01.dwg Oct 09, 2012 - 9:54am XREF's:



SOUTHERN DRAIN HORIZONTAL SETOUT DATA

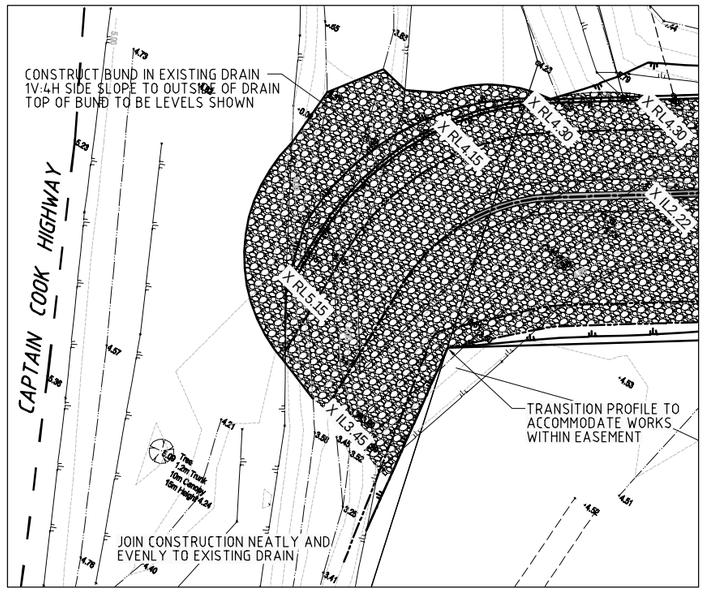
PT	CHAINAGE	EASTING	NORTHING	LEVEL	BEARING	RADIUS	A.LENGTH	D.ANGLE
IP	-32.600	365.767	823.912	3.453				
TC	-25.279	366.724	831.170	3.416	7°30'44"			
IP	-12.640	368.494	844.593			28.500	25.279	50°49'16"
IP	0.000	380.018	851.701	3.290	58°20'0"			
TC	313.218	646.603	1016.133	1.724	58°20'0"			
IP	319.009	651.995	1019.459			-11.500	-11.581	57°42'2"
CT	324.800	652.065	1025.794	1.685	0°37'58"			
IP	358.520	652.438	1059.512	1.501				

NOTE: SETOUT DATA IS TO A SITE BASED DATUM

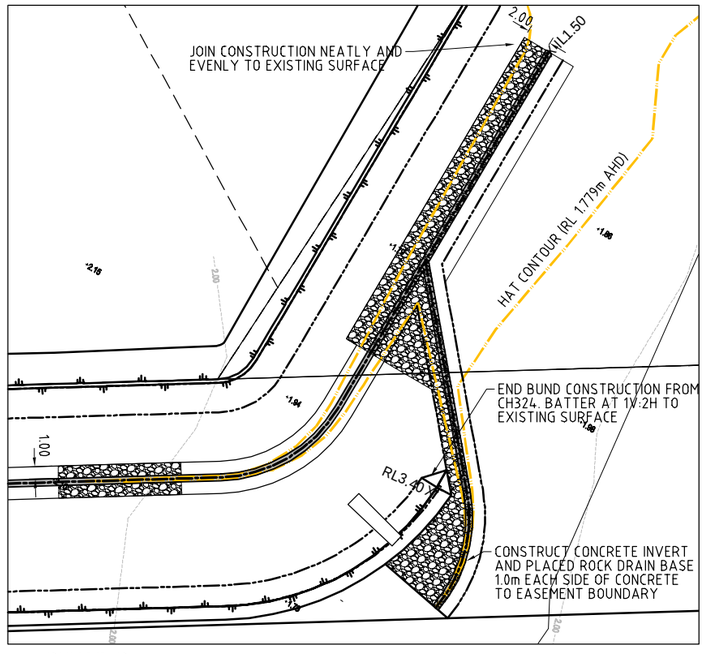


TYPICAL SECTION
1:100

IMPORTANT NOTE
GRASSED LINED DRAIN TO BE REGULARLY MAINTAINED SO THAT THE GRASS HEIGHT REMAINS 150mm OR LOWER.



DETAIL A
1:250



DETAIL B
1:250

2 1 0 2 4 6 8m
SCALE 1:100 AT ORIGINAL SHEET SIZE

10 5 0 10m 20m
SCALE 1:250 AT ORIGINAL SHEET SIZE

NOTE: CONTOURS ARE AT 0.5m INTERVALS

10 5 0 10 20 30 40m
SCALE 1:500 AT ORIGINAL SHEET SIZE

FOR CONSTRUCTION

ISSUE	DATE	DESCRIPTION / APPROVED USE	REV'D	APP'D
01	09.10.12	ISSUED FOR CONSTRUCTION	ACA	ACA
H	21.09.12	GEOWEB LOAD SUPPORT REMOVED	ACA	ACA
G	29.05.12	ISSUED FOR CONSTRUCTION	MAP	MAP
F	17.02.12	AMENDED AS CLOUDED	MAP	MAP
E	09.09.11	AMENDED AS CLOUDED	MAP	MAP
D	18.11.10	RE-ISSUED FOR AMENDED APPROVAL	MAP	MAP
C	27.10.10	RE-ISSUED FOR AMENDED APPROVAL	MAP	MAP
B	23.09.10	RE-ISSUED FOR APPROVAL	PVS	PVS
A	24.08.09	ISSUED FOR APPROVAL	PVS	PVS

APPROVED USE
The information contained in this document is provided for a specific use only as noted in the adjacent box. This document is only suitable for the intended purpose and shall not be applied to any other use without the written approval of Cardno. Unless the approved use of this drawing as stated in the issue box is 'FOR CONSTRUCTION', this drawing was not approved for construction purposes at time of issue.

DOCUMENT CONTROL STATUS
Unless stamped 'CONTROLLED COPY No.___' in red, this copy is 'UNCONTROLLED'.

VERIFICATION OF CURRENCY
Verify this drawing against a current controlled copy held by Cardno prior to use to ensure that it is the current issue.

DRAWN NLL 09.10.12
DESIGNED KJE 09.10.12
CHECKED / PROJECT MGR ACA 09.10.12
APPROVED PROJECT DIRECTOR A.C.ALCOCK RPEQ No. 8333 09.10.12

Cardno
Cardno (Qld) Pty Ltd
Level 1, 280 Sheridan Street, Cairns North
P.O. BOX 1619 CAIRNS QLD. 4870
Email: cairns@cardno.com.au
ABN 57 051 074 992
PH. 07 40510 288
FAX 07 40510 133

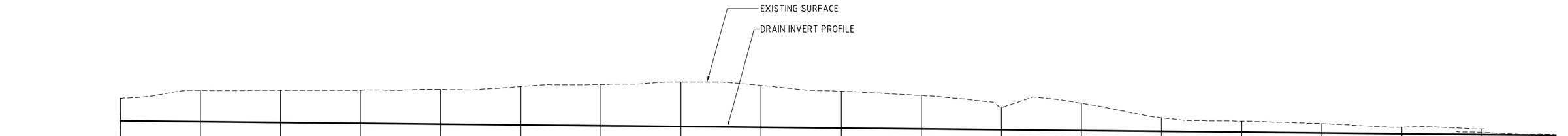
OFFICES	TELEPHONE	FAX
Sunshine Coast	(07) 5443 2555	(07) 5443 5642
Brisbane	(07) 3369 9822	(07) 3369 9722
Sydney	(02) 9416 8233	(02) 9416 6529
Gold Coast	(07) 5539 9333	(07) 5538 4647
Townsville	(07) 4772 1166	(07) 4721 2508
Hervey Bay	(07) 4124 5455	(07) 4124 5155
Cairns	**(07) 4051 0288**	**(07) 4051 0133**
Rockhampton	(07) 4924 7500	(07) 4926 4375
Darling Downs	(07) 4637 8122	(07) 4637 8155
Toowoomba	(07) 4633 9333	(07) 4634 9355
Darwin	(08) 8942 8200	(08) 8942 8211

CLIENT: PORT PACIFIC ESTATES Pty Ltd
PROJECT: FLOOD MITIGATION WORKS AT PORT PACIFIC ESTATE DOWNING STREET/CAPTAIN COOK HIGHWAY, CRAIGLIE
SOUTHERN DIVERSION DRAIN

TITLE: SITE WORKS PLAN AND DETAILS

ORIGINAL SHEET SIZE	PROJECT No.	DRAWING No.	ISSUE
A1	Q074061-001	SD C02	01

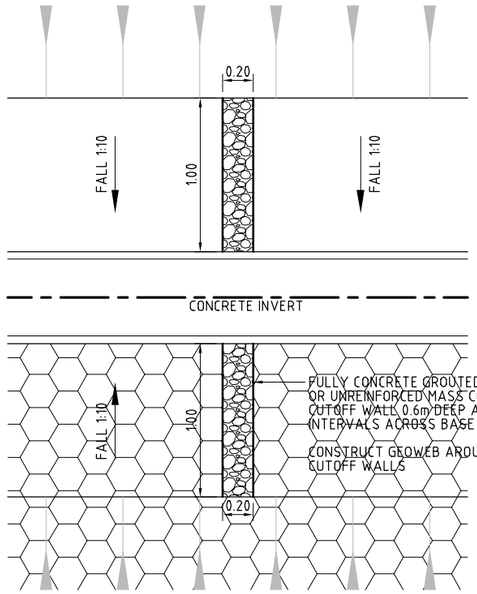
CAD FILE: H:\2007\Q74061-001\Design\Acad\Southern Drain\Amended Approval\For Construction\SD C02_01.dwg Oct 09, 2012 - 9:56am XREF's: x_Base Southern Drain 074061-001



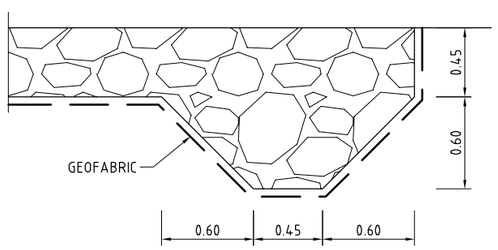
DATUM -3.000

DESIGN LEVELS ON DRAIN INVERT	2.215	2.175	2.135	2.095	2.055	2.015	1.975	1.935	1.895	1.855	1.815	1.775	1.735	1.695	1.655	1.615	1.575	1.535	1.534	
EXISTING SURFACE ON DRAIN INVERT	3.346	3.741	3.748	3.750	3.791	3.933	4.036	4.155	3.988	3.694	3.481	2.879	3.094	2.377	2.210	2.092	1.900	1.811		
CHAINAGE	0	20	40	60	80	100	120	140	160	180	200	220	240	260	280	300	320	340	358.52	

LONGITUDINAL SECTION
HOR. 1:500
VERT. 1:100

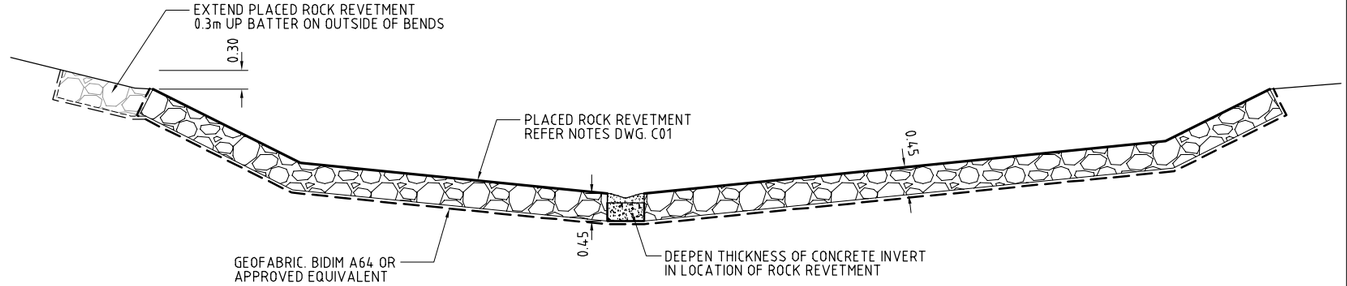


CUTOFF WALL TYPICAL DETAIL
1:20



PLACED ROCK END TREATMENT TYPICAL DETAIL
1:20

THIS TREATMENT IS REQUIRED AT THE UPSTREAM AND DOWNSTREAM ENDS OF BOTH REVETMENT ZONES.



PLACED ROCK TYPICAL DETAIL
1:50

0.5 0 0.5 1 1.5m
SCALE 1:20 AT ORIGINAL SHEET SIZE

1 0.5 0 1 2 3 4m
SCALE 1:50 AT ORIGINAL SHEET SIZE

HOR. 10 5 0 10 20 30 40m 1 : 500
VERT. 2 1 0 2 4 6 8m 1 : 100
SCALE AT ORIGINAL SHEET SIZE

FOR CONSTRUCTION

01	09.10.12	ISSUED FOR CONSTRUCTION	ACA	ACA
D	09.09.11	AMENDED AS CLOUDED	MAP	MAP
C	27.10.10	RE-ISSUED FOR AMENDED APPROVAL	MAP	MAP
B	23.09.10	RE-ISSUED FOR APPROVAL	PVS	PVS
A	24.08.09	ISSUED FOR APPROVAL	PVS	PVS
ISSUE	DATE	DESCRIPTION / APPROVED USE	REV'D	APP'D

APPROVED USE
The information contained in this document is provided for a specific use only as noted in the adjacent box. This document is only suitable for the intended purpose and shall not be applied to any other use without the written approval of Cardno. Unless the approved use of this drawing as stated in the issue box is 'FOR CONSTRUCTION', this drawing was not approved for construction purposes at time of issue.

DOCUMENT CONTROL STATUS
Unless stamped 'CONTROLLED COPY No.___' in red, this copy is 'UNCONTROLLED'.

VERIFICATION OF CURRENCY
Verify this drawing against a current controlled copy held by Cardno prior to use to ensure that it is the current issue.

DRAWN KJE 09.10.12
DESIGNED KJE 09.10.12
CHECKED / PROJECT MGR ACA 09.10.12
APPROVED PROJECT DIRECTOR A.C.ALCOCK RPEQ No. 8333 09.10.12

Cardno (Qld) Pty Ltd
Level 1, 280 Sheridan Street, Cairns North
P.O. BOX 1619 CAIRNS QLD. 4870
Email: cairns@cardno.com.au
ABN 57 051 074 992
PH. 07 40510 288
FAX 07 40510 133

OFFICES	TELEPHONE	FAX
Sunshine Coast	(07) 5443 2555	(07) 5443 5642
Brisbane	(07) 3369 9822	(07) 3369 9722
Sydney	(02) 9416 8233	(02) 9416 6529
Gold Coast	(07) 5539 9333	(07) 5538 4647
Townsville	(07) 4772 1166	(07) 4721 2508
Hervey Bay	(07) 4124 5455	(07) 4124 5155
Cairns	**(07) 4051 0288**	**(07) 4051 0133**
Rockhampton	(07) 4924 7500	(07) 4926 4375
Darling Downs	(07) 4637 8122	(07) 4637 8155
Toowoomba	(07) 4633 9333	(07) 4634 9355
Darwin	(08) 8942 8200	(08) 8942 8211

CLIENT: PORT PACIFIC ESTATES Pty Ltd
PROJECT: FLOOD MITIGATION WORKS AT PORT PACIFIC ESTATE
DOWNING STREET/CAPTAIN COOK HIGHWAY, CRAIGLIE
SOUTHERN DIVERSION DRAIN

TITLE: LONGITUDINAL SECTION AND DETAILS

ORIGINAL SHEET SIZE	PROJECT No.	DRAWING No.	ISSUE
A1	Q074061-001	SD C03	01

CAD FILE: H:\2007\Q74061-001\Design\Acad\Southern Drain\Amended Approval\For Construction\SD C03_01.dwg Oct 09, 2012 - 9:56am XREF's:

NORTH

SP 192596

MILMAN DRIVE

LOT 11

LOT 12

LOT 26

LOT 25

EXISTING 525ø RCP TO BE CAPPED OFF & MADE REDUNDANT.

Q100 STORMWATER CULVERT (0.1%)

ADDITIONAL KERB INLET PITS TO ALLOW FOR Q100 FLOW INLET CAPACITY

EXISTING SEWER MAIN TO BE CONCRETE ENCASED AT CULVERT CROSSING. REFER TO WSAA STD DWG SEW-1207 FOR DETAILS.

REINSTATE ROAD PAVEMENT AND KERB AND CHANNEL AS REQUIRED.

EXISTING 100ø WATER MAIN

DULKU CLOSE

FUTURE STAGE 3 (LOT 120 on SP 192596)

DULKU CLOSE DRAINAGE DRAINAGE WORKS BOUNDARY

EXISTING 150ø SEWER MAIN

1000 STORMWATER PIPE (0.1%)

'SOUTHERN DIVERSON DRAIN' DOCUMENTED SEPERATELY

NEW HEADWALL OUTLET INCLUDING TIDE FLAP FOR DULKU CLOSE MINOR AND MAJOR FLOWS & ROCK SCOUR PROTECTION. OUTLET IL 2.00

- REFER TO ND.DC 09 FOR 2/9, 3/9 & 4/9 PIT DETAILS -

NORTH

EXISTING 450ø RCP

EXISTING 525ø RCP TO BE CAPPED OFF & MADE REDUNDANT.

1/750x375 RCBC

1/750x525 RCBC

DULKU CLOSE

EXISTING 100ø PVC WATER MAIN

PROPOSED 3.0m WIDE EASEMENT FOR STORMWATER PURPOSES

1/1200x375 RCBC

1/1500x600 RCBC

1/2100x750 RCBC

3.0m

CUT BACK EXISTING 525ø RCP AS SHOWN AND CONNECT INTO NEW PIT (IL 2.341).

EXISTING 525ø RCP

EXISTING 100ø PVC WATER MAIN TO BE LOWER IN LOCATION AS SHOWN UNDER CULVERT GENERALLY IN ACCORDANCE WITH WSAA STD DWG WAT-1211 . THE WATER MAIN MUST BE FLANGED DICL (PN45) INCLUDING THE VERTICAL SECTIONS OF PIPE. REFER TO DETAIL ON DWG ND.DC 10.

DULKU CLOSE GULLY DETAIL

1:50

ROAD WORKS NOTES:

1. ALL KERB AND CHANNEL, PAVEMENT ETC TO BE REINSTATED. EXTENT OF RECONSTRUCTION AS REQUIRED TO CONSTRUCT THE WORKS.

NOTE: CONTOURS ARE AT 0.5m INTERVALS

1 0.5 0 1 2 3 4m
SCALE 1:50 AT ORIGINAL SHEET SIZE

10 5 0 10 20 30 40m
SCALE 1:500 AT ORIGINAL SHEET SIZE

FOR CONSTRUCTION

CAD FILE: H:\2007\Q74061-001\Design\Acad\Southern Drain\Amended Approval\For Construction\ND.DC 08 _01.dwg Oct 09, 2012 - 10:11am XREF's: x _Base Southern Drain 074061-001

ISSUE	DATE	DESCRIPTION / APPROVED USE	REV'D	APP'D
01	09.10.12	ISSUED FOR CONSTRUCTION	ACA	ACA
A	7.12.10	ISSUED FOR APPROVAL	MAP	MAP

APPROVED USE
The information contained in this document is provided for a specific use only as noted in the adjacent box. This document is only suitable for the intended purpose and shall not be applied to any other use without the written approval of Cardno. Unless the approved use of this drawing as stated in the issue box is 'FOR CONSTRUCTION', this drawing was not approved for construction purposes at time of issue.

DOCUMENT CONTROL STATUS
Unless stamped 'CONTROLLED COPY No.___' in red, this copy is 'UNCONTROLLED'.

VERIFICATION OF CURRENCY
Verify this drawing against a current controlled copy held by Cardno prior to use to ensure that it is the current issue.

DRAWN KJE 09.10.12
DESIGNED KJE 09.10.12
CHECKED / PROJECT MGR ACA 09.10.12
APPROVED PROJECT DIRECTOR A.C.CLOCK RPEQ No. 8333 09.10.12

Cardno
Cardno (Qld) Pty Ltd
Level 1, 280 Sheridan Street, Cairns North
P.O. BOX 1619 CAIRNS QLD 4870
Email: cairns@cardno.com.au
ABN 57 051 074 992
PH. 07 40510 288
FAX 07 40510 133

OFFICES	TELEPHONE	FAX
Sunshine Coast	(07) 5443 2555	(07) 5443 5642
Brisbane	(07) 3369 9822	(07) 3369 9722
Sydney	(02) 9416 8233	(02) 9416 6529
Gold Coast	(07) 5539 9333	(07) 5538 4647
Townsville	(07) 4772 1166	(07) 4721 2508
Hervey Bay	(07) 4124 5455	(07) 4124 5155
Cairns	**(07) 4051 0288**	**(07) 4051 0133**
Rockhampton	(07) 4924 7500	(07) 4926 4375
Darling Downs	(07) 4637 8122	(07) 4637 8155
Toowoomba	(07) 4633 9333	(07) 4634 9355
Darwin	(08) 8942 8200	(08) 8942 8211

CLIENT PORT PACIFIC ESTATES Pty Ltd

PROJECT FLOOD MITIGATION WORKS AT PORT PACIFIC ESTATE
DOWNING STREET/CAPTAIN COOK HIGHWAY, CRAIGLIE
SOUTHERN DIVERSION DRAIN AND DULKU CLOSE DRAINAGE

TITLE DULKU CLOSE DRAINAGE
Q100 RELIEF PIPE PLAN

ORIGINAL SHEET SIZE	PROJECT No.	DRAWING No.	ISSUE
A1	Q074061-001	ND.DC 08	01

Port Pacific Estate - Stages 3 & 4

APPENDIX B

TUFLOW Model Results

Cardno
Shaping the Future

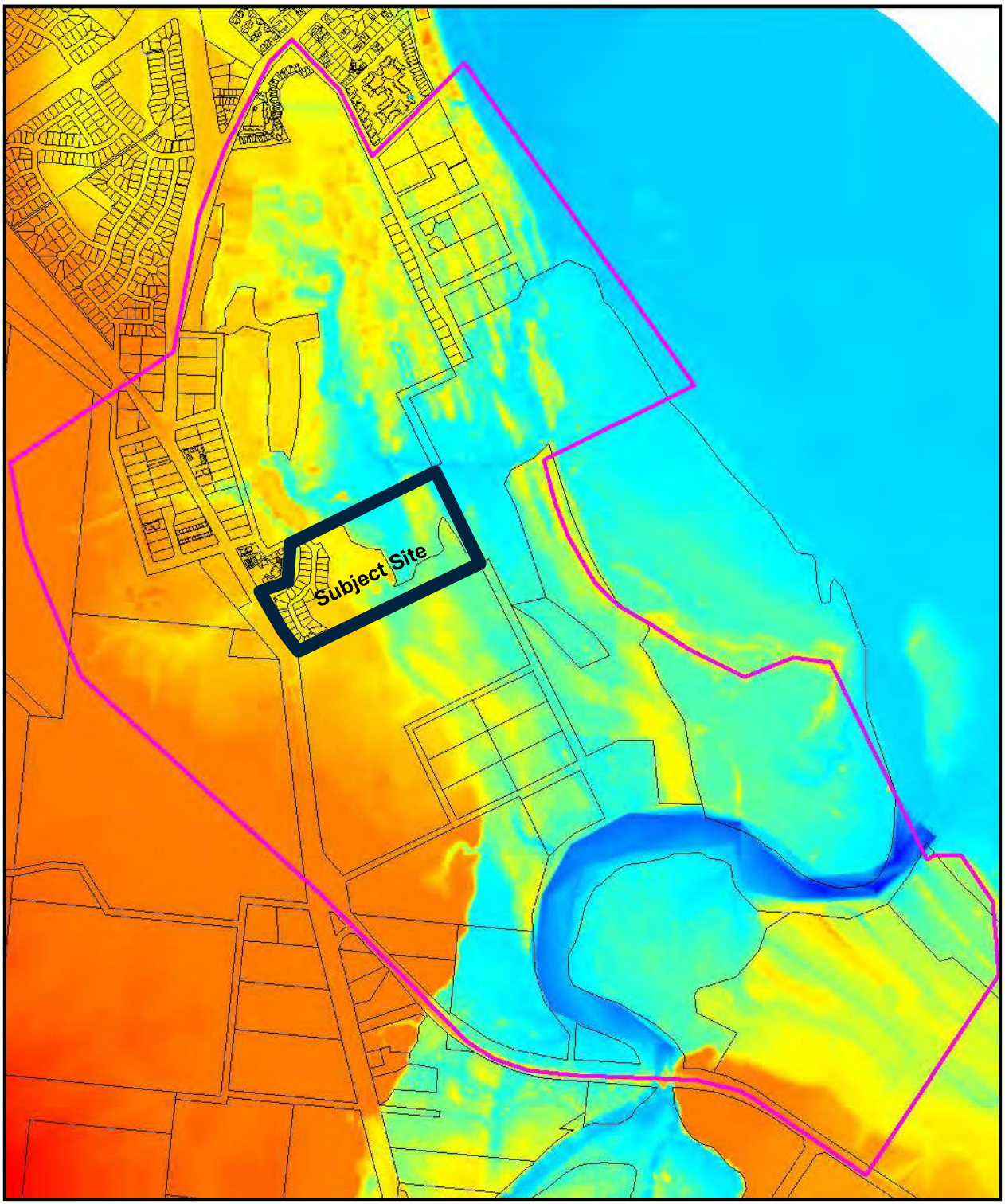


Figure B1. TUFLOW Model Extent

Figure B2 – Location of Reporting Points

Figure B3 – 2 Year ARI Flood Levels

Figure B4 – 5 Year ARI Flood Levels

Figure B5 – 10 Year ARI Flood Levels

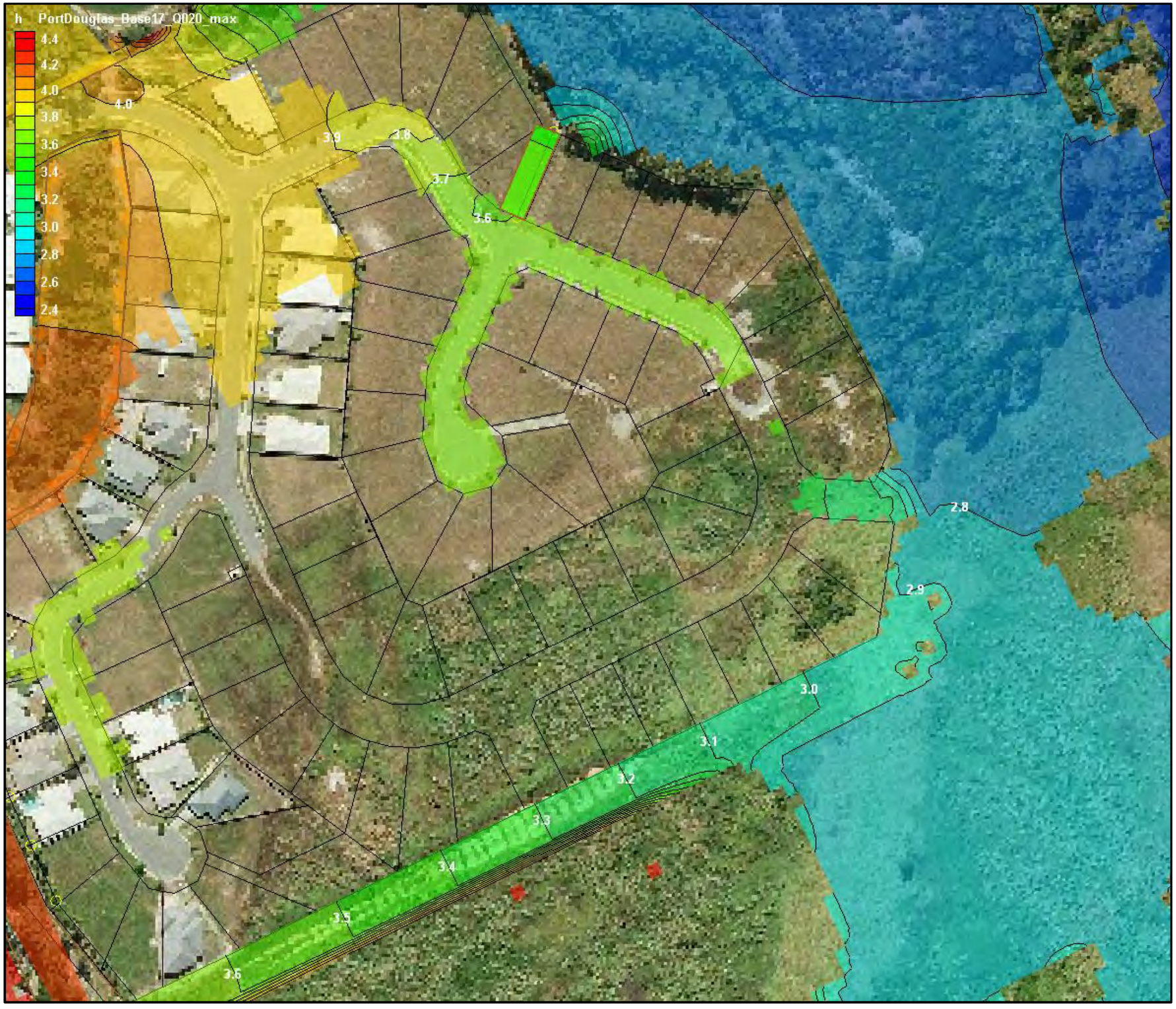


Figure B6 – 20 Year ARI Flood Levels

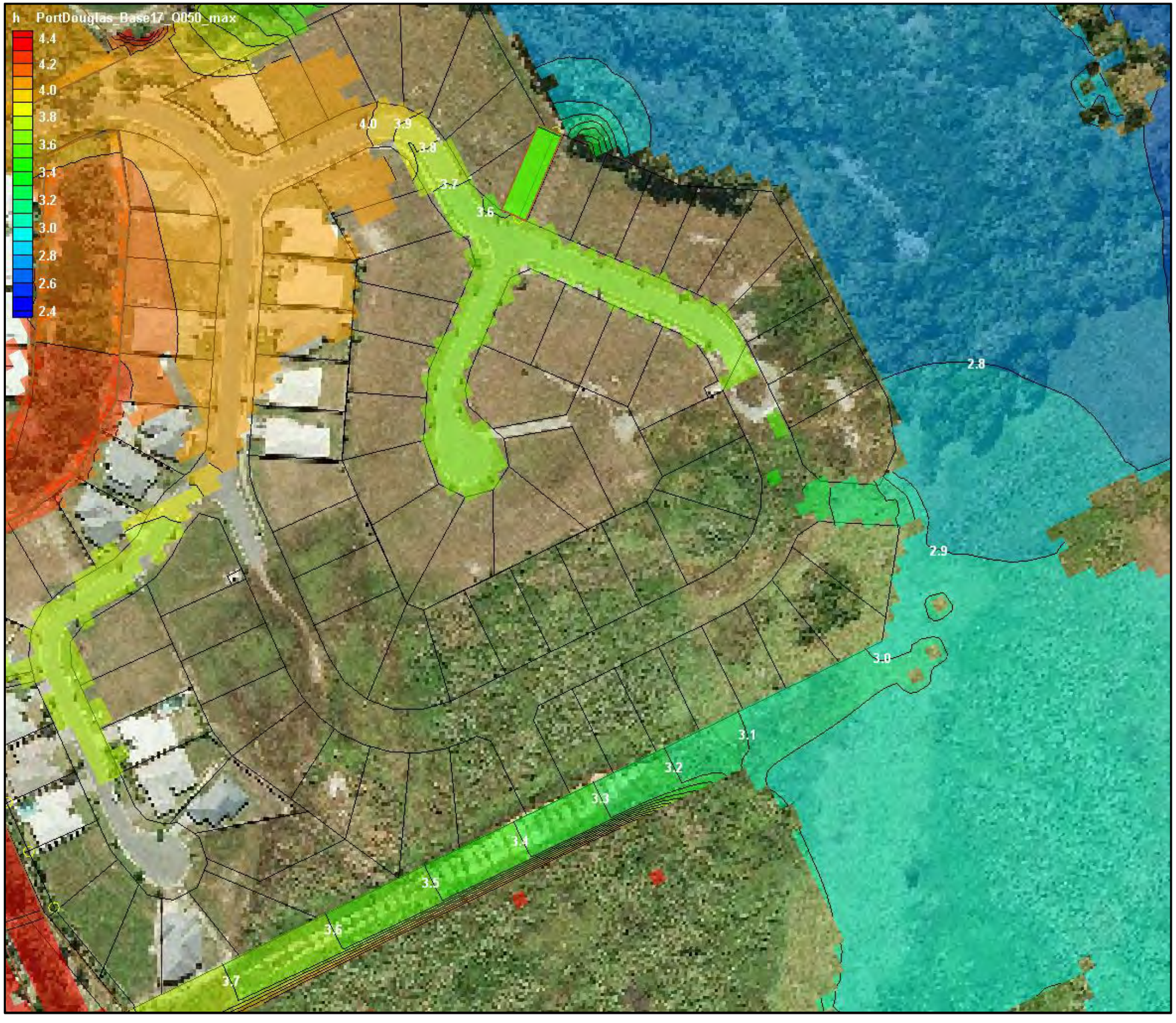


Figure B7 – 50 Year ARI Flood Levels

Figure B8 – 100 Year ARI Flood Levels

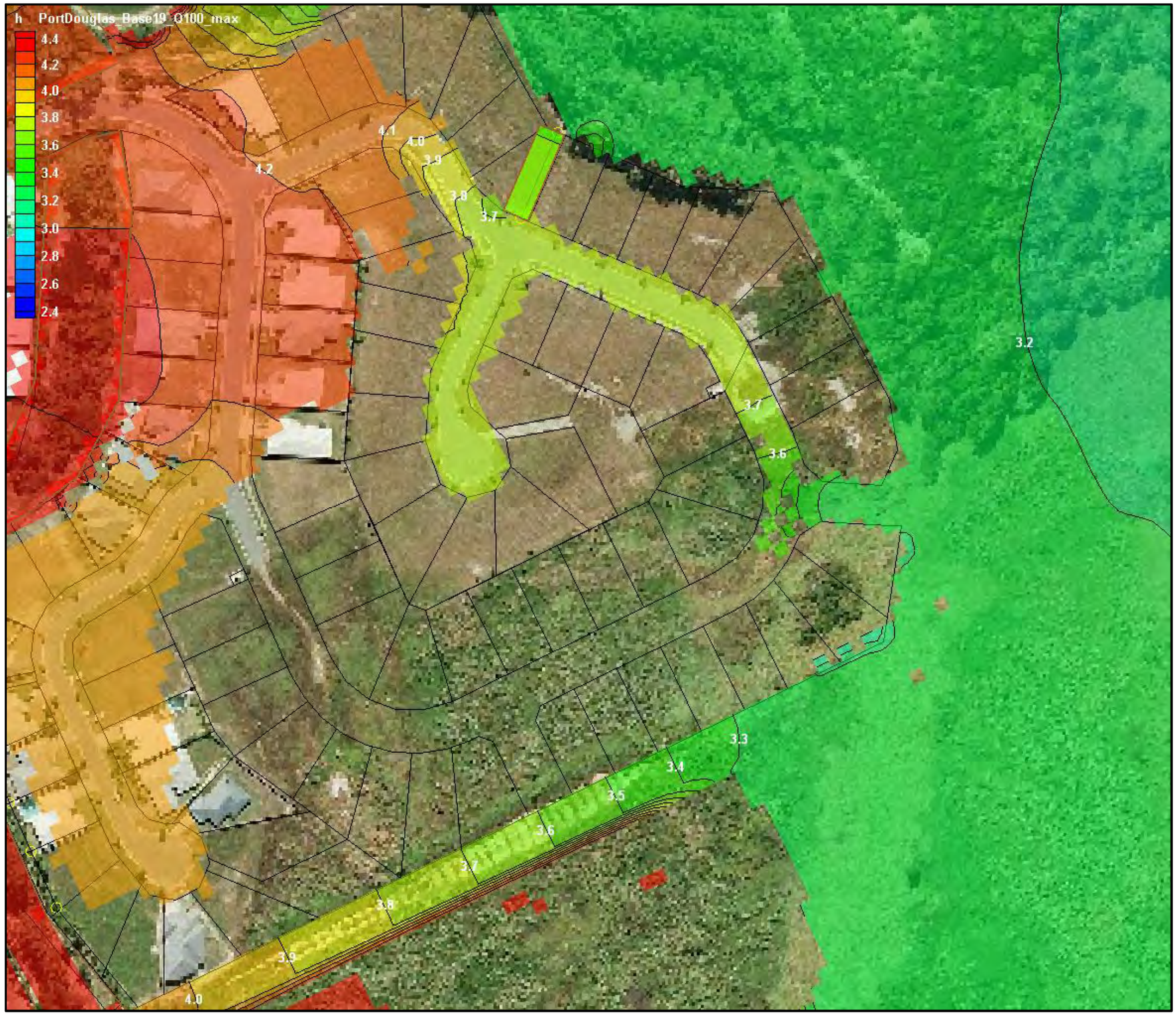


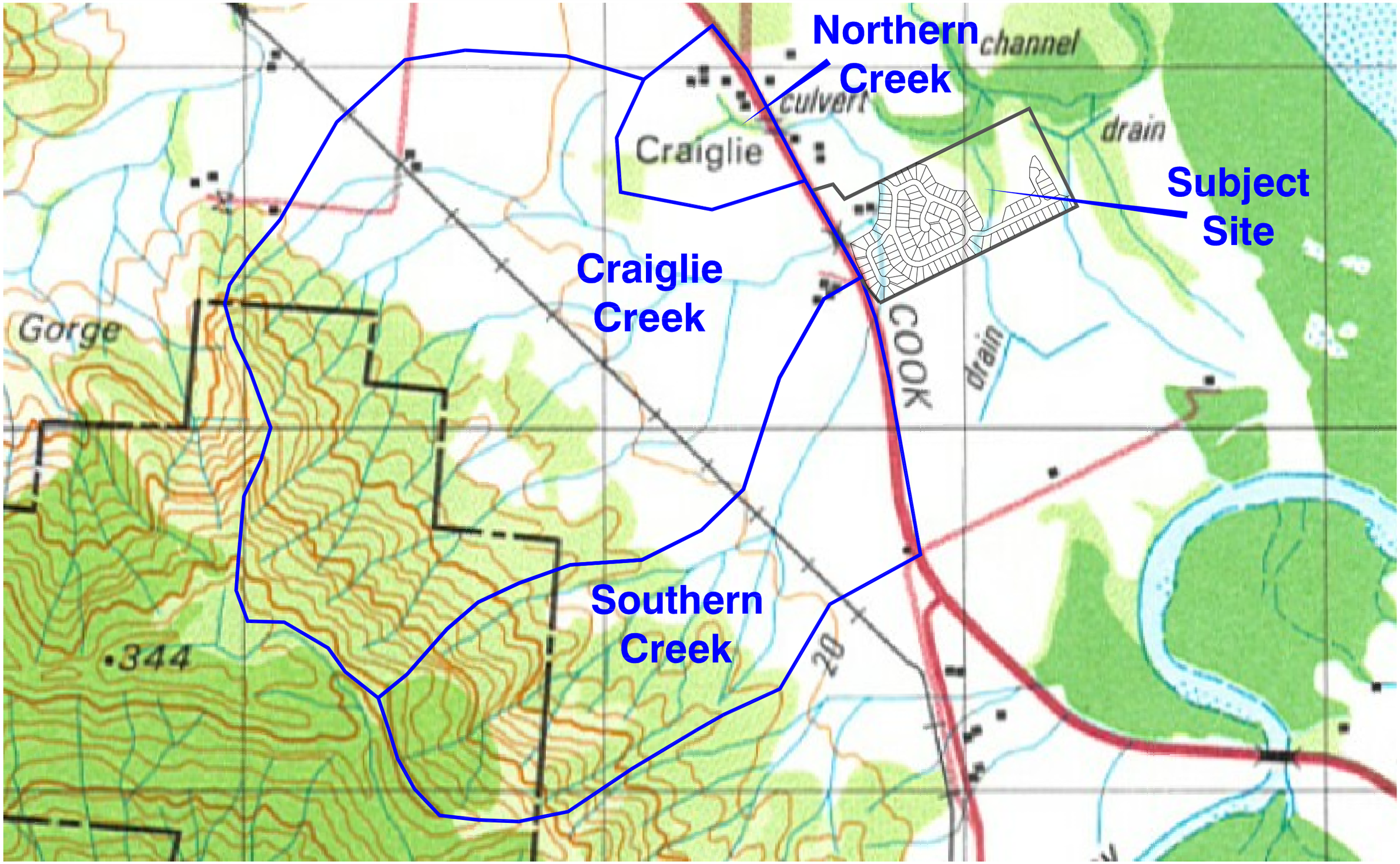
Figure B9 – 100 Year ARI + Climate Change Flood Levels

Port Pacific Estate - Stages 3 & 4

APPENDIX C

Catchment Boundaries

Cardno
Shaping the Future



Scale 1:10,000 (A3)

FIGURE C1
CATCHMENT BOUNDARIES

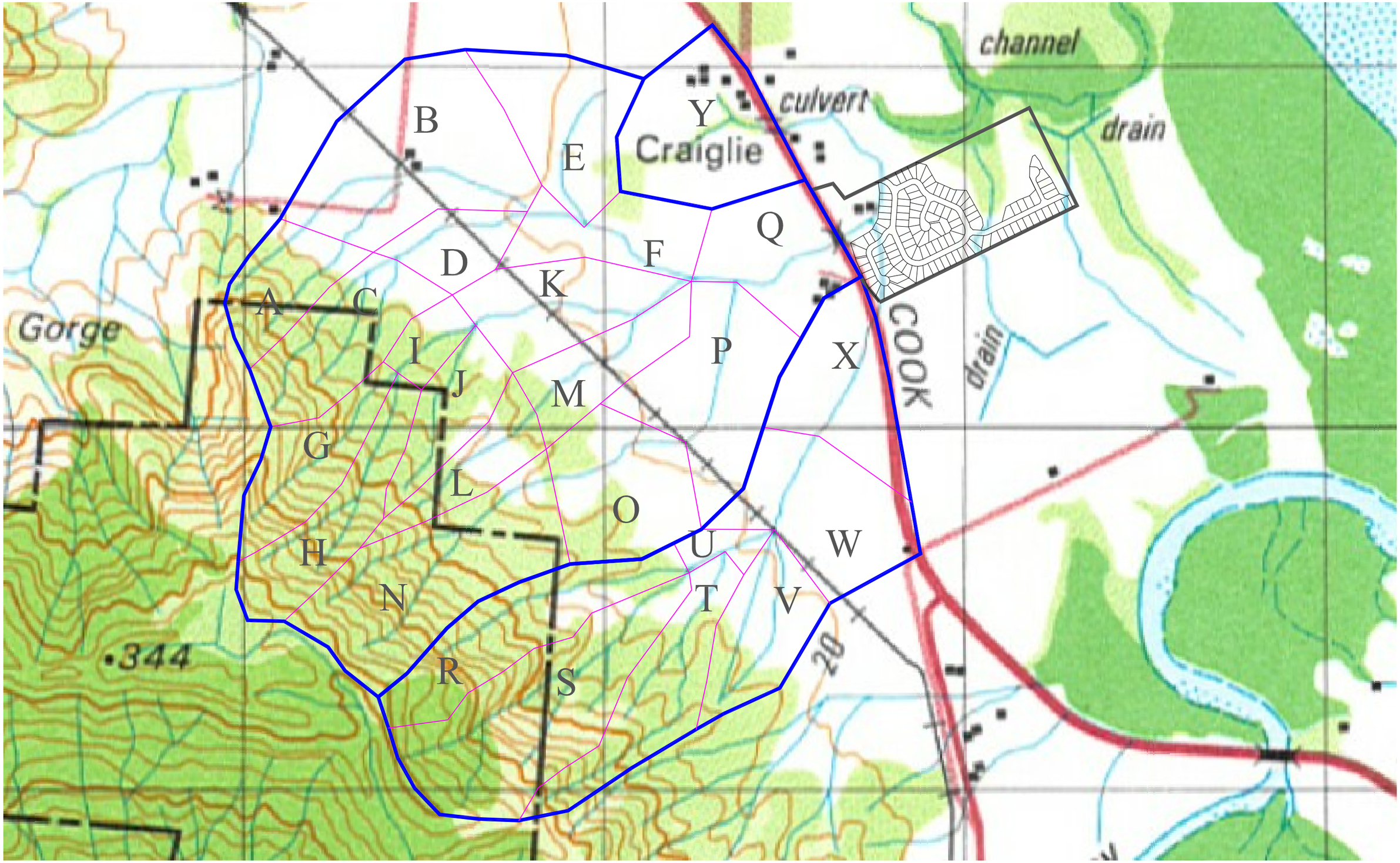
Rev: Orig. Date: 14 May 2008

Project No.: Q074061

United Pacific Properties

CAD FILE: J:\Q074061\Acad\Figure C1.dwg
XREF's:

PRINT DATE: 09 June, 2009 - 10:36am



Scale 1:10,000 (A3)

FIGURE C2
WBNM MODEL SUBAREAS

Rev: Orig. Date: 14 May 2008

Project No.: Q074061

United Pacific Properties

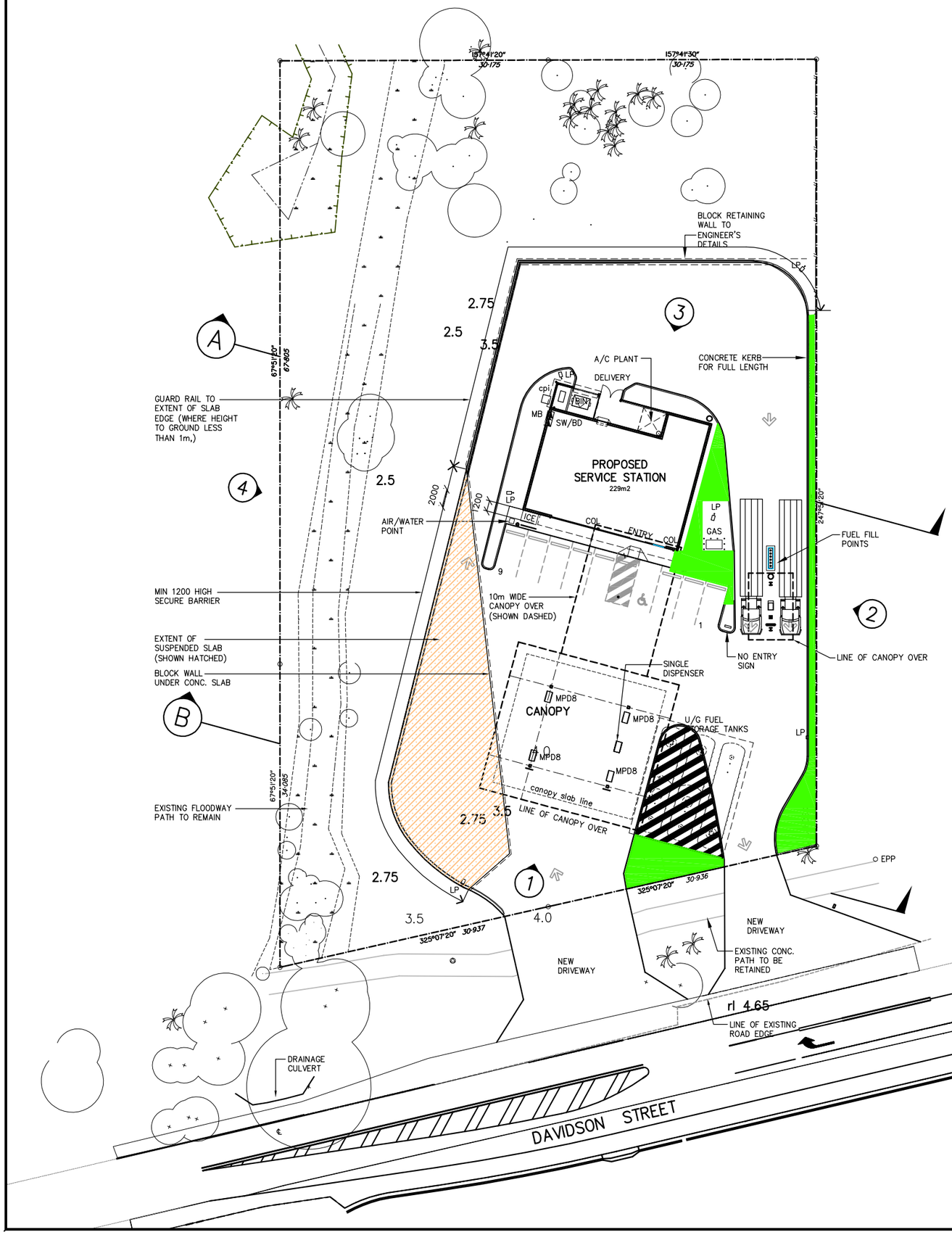
CAD FILE: J:\Q074061\Acad\Figure C2.dwg
XREF's:

PRINT DATE: 27 May, 2009 - 10:24am

FLANAGAN CONSULTING GROUP
Trusted Advisor to Northern Australia

APPENDIX: C

TFA Project Group Drawings



RPD
LOT 1
RP 739151
PARISH OF SALISBURY
COUNTY OF SOLANDER

DEVELOPMENT AREA TO CONTAIN: –

- SERVICE STATION
- REFUELING CANOPY
- HEIGHT NOT EXCEEDING ONE STOREY
- PARKING & MANOEUVRING AREAS FOR CAR MOVEMENT
- CAR PARKING SPACES PROVIDED AT APPROPRIATE RATE FOR DEVELOPMENT TYPE
- SITE SIGNAGE TO FRONT BOUNDARY IN ACCORD. WITH STD REGULATIONS MAIN POLE SIGN TO BE 8m HIGH
- NOISE LEVELS NOT TO EXCEED APPROVED LEVELS AT BOUNDARY
- LIGHTING NOT TO EXCEED APPROVED LEVELS AT BOUNDARY
- 3m LANDSCAPE ZONE TO STREET BOUNDARY FRONTAGE
- ALL LEVELS/RETAINING WALLS TO BE DETERMINED AT B.A. STAGE

BUILDING TO COMPRISE:

- SERVICE STATION – 229m2 (INCLUDING CONVENIENCE STORE)
- CAR PARKING PROVIDED = 9
  CAR PARKING REQUIRED = 5 (SERVICE STATION)

NOTE:

- CAR PARKING & ROAD AILES TO BE IN ACCORDANCE WITH AS2890.1 –2004
- CAR PARKING AREAS TO BE 5.5 LONG BY 2.6 WIDE &
- DISABLED TO BE 5.5 LONG x 3.2 WIDE

5 0 5 10 15 20 25m
Metres

revision	date	by	description	approved
C	17.07.15	DMR	MINOR REVISION	RO'B
B	13.07.15	DMR	MINOR AMENDMENTS	RO'B
A	6.07,15	DMR	CLIENT'S APPROVAL	RO'B

Figured dimensions to be taken in preference to scale readings.

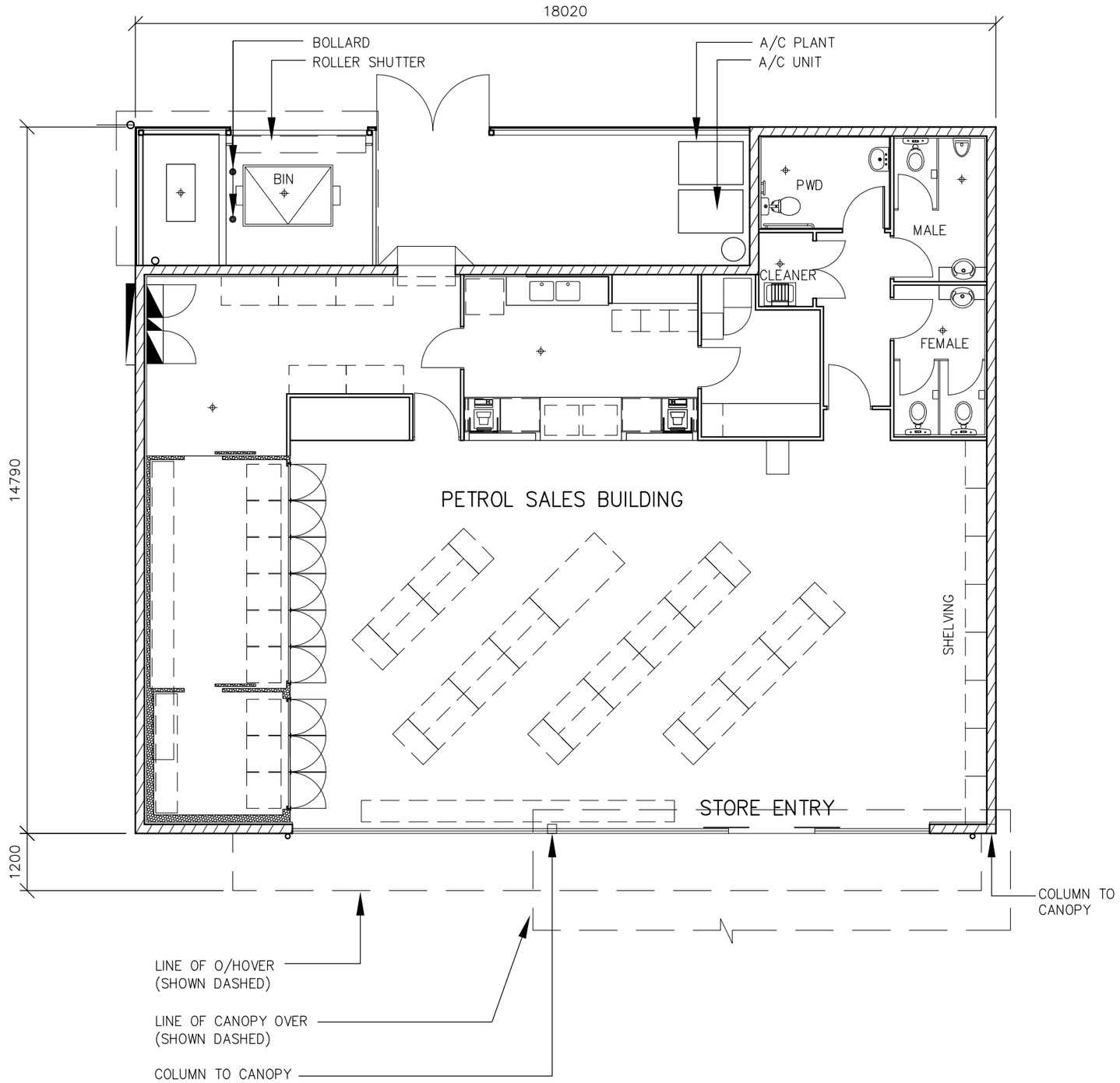
TFA Project Group
Email: enquiry@tfa.com.au
17 Dover Street, Albion QLD 4010 Australia
Ph. 61 7 3854 2900 Fax. 61 7 3854 2999
PROJECT MANAGERS | DESIGNERS | PLANNERS | ENGINEERS

project
PROPOSED SERVICE STATION
5946 DAVIDSON STREET
CRAIGLIE PORT DOUGLAS
QLD

title
PROPOSED SITE LAYOUT

drawn	approved	date created	A1 scale	A3 scale
DMR		02.07.15	1:250	1:500

status	drawing no.	rev.
PRELIMINARY	15017–03	C



RPD
LOT 1
RP 739151
PARISH OF SALISBURY
COUNTY OF SOLANDER

1 0 1 2 3 4 5m
Metres

revision	date	by	description	approved
C	17.07.15	DMR	MINOR REVISION	RO'B
B	13.07.15	DMR	MINOR AMENDMENTS	RO'B
A	6.07.15	DMR	CLIENT'S APPROVAL	RO'B

Figured dimensions to be taken in preference to scale readings.

TFA Project Group
Email: enquiry@tfa.com.au
17 Dover Street, Albion QLD 4010 Australia
Ph. 61 7 3854 2900 Fax. 61 7 3854 2999
PROJECT MANAGERS | DESIGNERS | PLANNERS | ENGINEERS

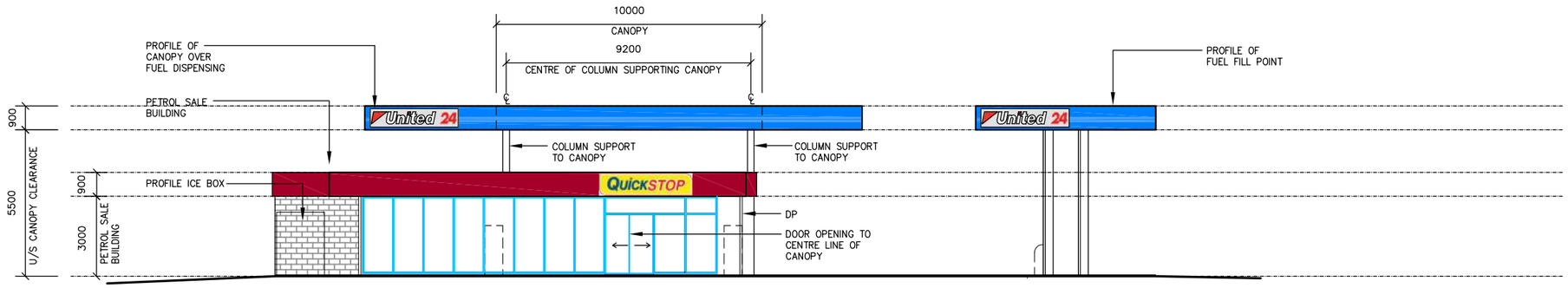
project
PROPOSED SERVICE STATION
5946 DAVIDSON STREET
CRAIGLIE PORT DOUGLAS
QLD

title
PROPOSED BUILDING FLOOR PLAN

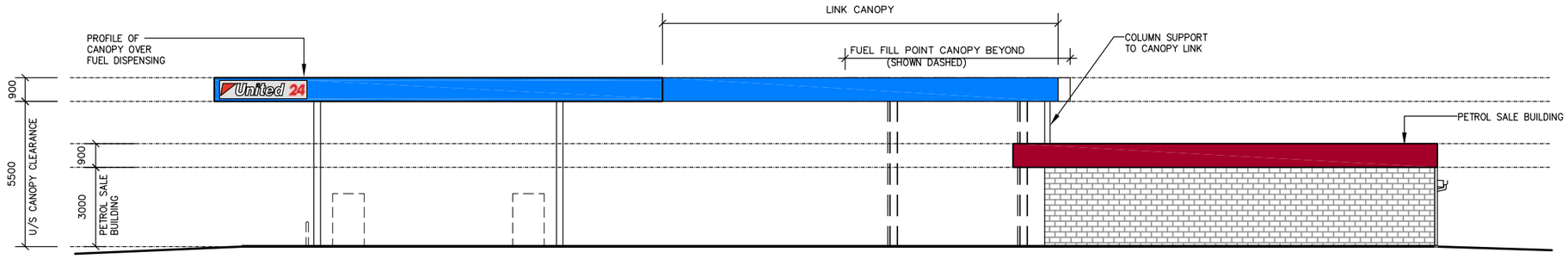
drawn	approved	date created	A1 scale	A3 scale
DMR		02.07.15	1:50	1:100

status	drawing no.	rev.
PRELIMINARY	15017–04	C

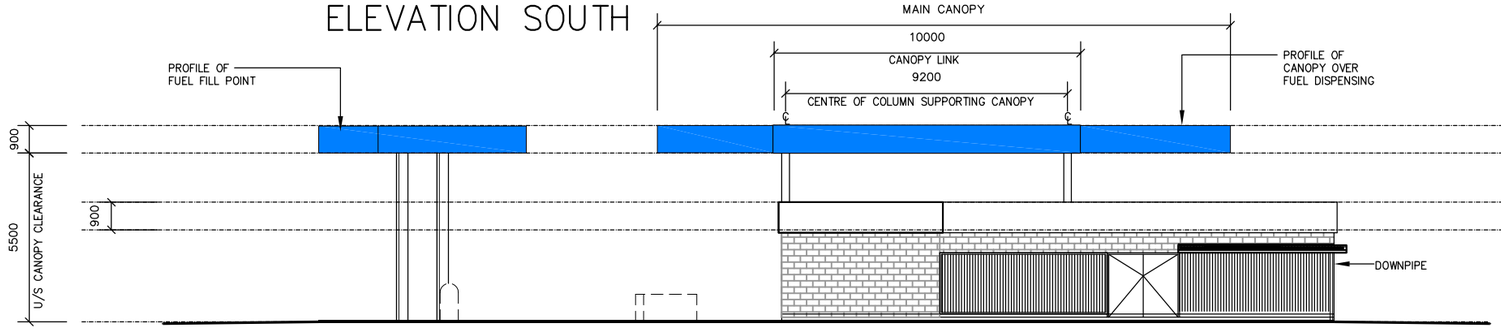
RPD
LOT 1
RP 739151
PARISH OF SALISBURY
COUNTY OF SOLANDER



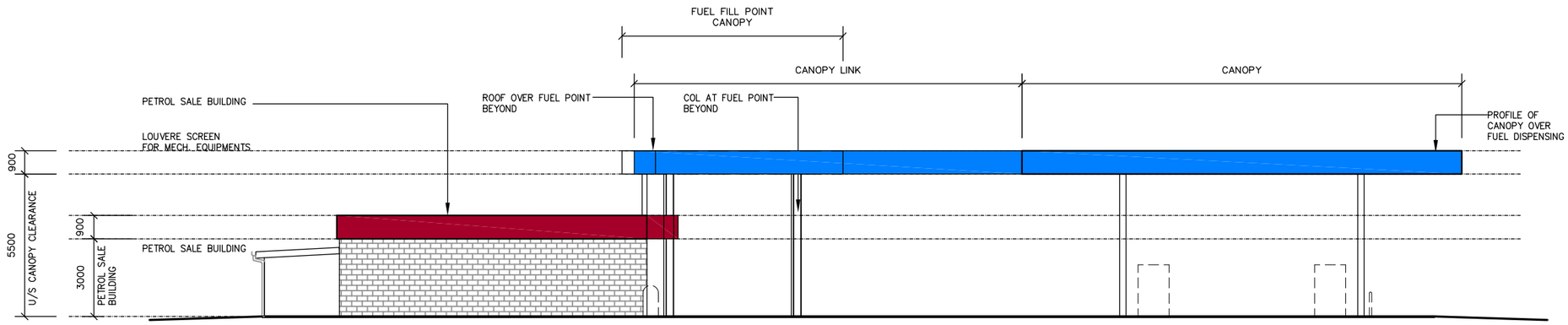
ELEVATION WEST



ELEVATION SOUTH



ELEVATION EAST



ELEVATION NORTH

2 0 5 10m

Metres

revision	date	by	description	approved
C	17.07.15	DMR	MINOR REVISION	RO'B
B	13.07.15	DMR	MINOR AMENDMENTS	RO'B
A	6.07.15	DMR	CLIENT'S APPROVAL	RO'B

Figured dimensions to be taken in preference to scale readings.

TFA Project Group
Email: enquiry@tfa.com.au
17 Dover Street, Albion QLD 4010 Australia
Ph. 61 7 3854 2900 Fax. 61 7 3854 2999
PROJECT MANAGERS | DESIGNERS | PLANNERS | ENGINEERS

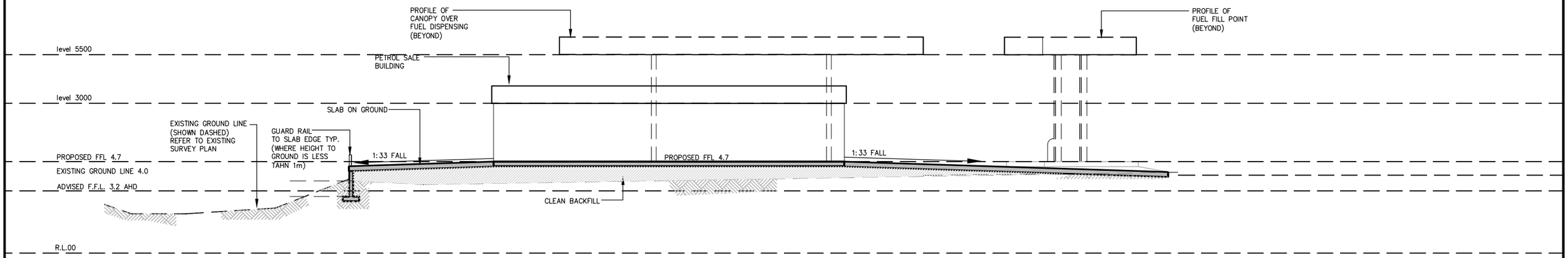
project
PROPOSED SERVICE STATION
5946 DAVIDSON STREET
CRAIGLIE PORT DOUGLAS
QLD

title
PROPOSED BUILDING ELEVATIONS

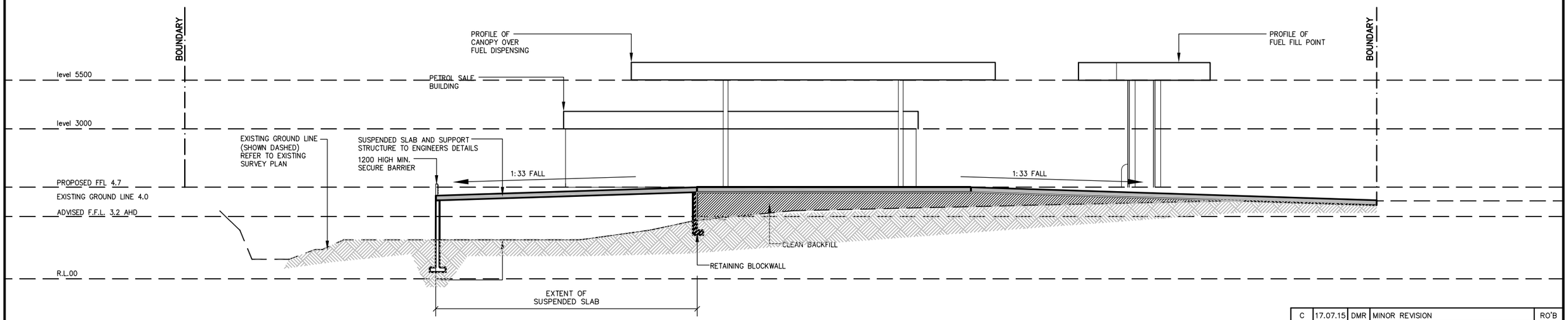
drawn	approved	date created	A1 scale	A3 scale
DMR		02.07.15	1:100	1:200

status	drawing no.	rev.
PRELIMINARY	15017–05	C

RPD
LOT 1
RP 739151
PARISH OF SALISBURY
COUNTY OF SOLANDER



SECTION A



SECTION B

revision	date	by	description	approved
C	17.07.15	DMR	MINOR REVISION	RO'B
B	13.07.15	DMR	MINOR AMENDMENTS	RO'B
A	6.07.15	DMR	CLIENT'S APPROVAL	RO'B

Figured dimensions to be taken in preference to scale readings.

TFA Project Group
Email: enquiry@tfa.com.au
17 Dover Street, Albion QLD 4010 Australia
Ph. 61 7 3854 2900 Fax. 61 7 3854 2999
PROJECT MANAGERS | DESIGNERS | PLANNERS | ENGINEERS

project
PROPOSED SERVICE STATION
5946 DAVIDSON STREET
CRAIGLIE PORT DOUGLAS
QLD

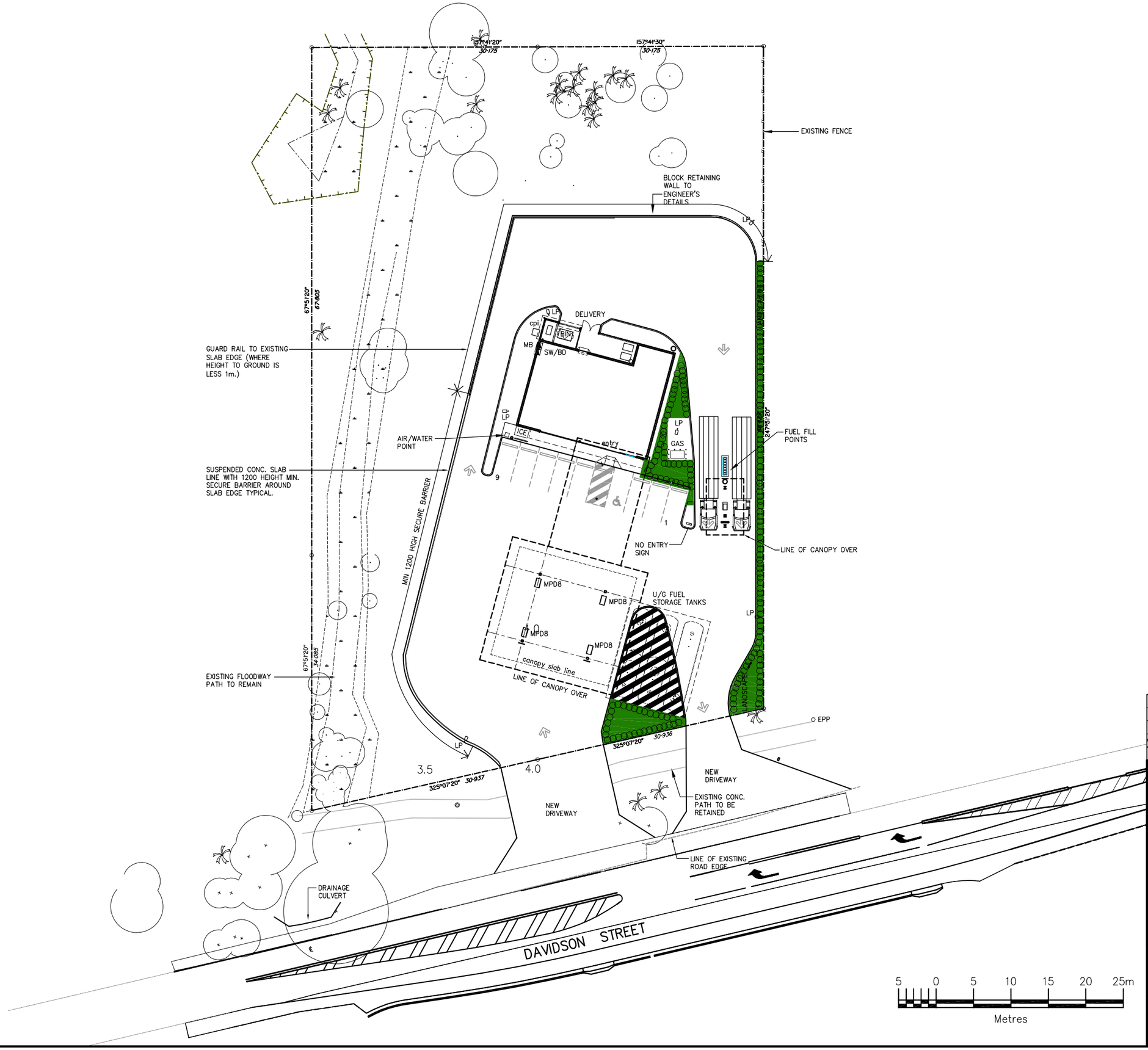
title
PROPOSED SITE SECTION

2 0 5 10m
Metres

drawn	approved	date created	A1 scale	A3 scale
DMR		02.07.15	1:100	1:200

status	drawing no.	rev.
PRELIMINARY	15017–06	C

LOT 1
RP 739151
PARISH OF SALISBURY
COUNTY OF SOLANDER



revision	date	by	description	approved
B	13.07.15	DMR	MINOR AMENDMENTS	RO'B
A	6.07.15	DMR	CLIENT'S APPROVAL	RO'B

Figured dimensions to be taken in preference to scale readings.

TFA Project Group
Email: enquiry@tfa.com.au
17 Dover Street, Albion QLD 4010 Australia
Ph. 61 7 3854 2900 Fax. 61 7 3854 2999
PROJECT MANAGERS | DESIGNERS | PLANNERS | ENGINEERS

project
PROPOSED SERVICE STATION
5946 DAVIDSON STREET
CRAIGLIE PORT DOUGLAS
QLD

title
PROPOSED LANDSCAPING CONCEPT

drawn	approved	date created	A1 scale	A3 scale
DMR		02.07.15	1:250	1:500

status	drawing no.	rev.
PRELIMINARY	15017-07	B

RPD
LOT 1
RP 739151
PARISH OF SALISBURY
COUNTY OF SOLANDER

NOTE:

CAR PARKING TO BE IN ACCORDANCE WITH AS2890.1

CAR PARKING AREAS TO BE 5.5m LONG X 2.6m WIDE.
DISABLED TO BE 5.5m LONG X 2.6m WIDE.

RAMPS TO BE IN ACCORDANCE WITH AS 1428.1 & AS 1428.2.

SITE AREA – 5743m²
BUILDING TOTAL FLOOR AREA – 229m²

LEGEND

LP LIGHT POLE (LOCATION TO BE CONFIRMED ON ELECTRICAL DRG'S)
EPP EXISTING POWER POLE
FW FIRE WOOD (SUPPLIED BY RELIANCE)

5 0 5 10 15 20 25m
Metres

revision	date	by	description	approved
A	6.07.15	DMR	CLIENT'S APPROVAL	RO'B

Figured dimensions to be taken in preference to scale readings.

TFA Project Group
Email: enquiry@tfa.com.au
17 Dover Street, Albion QLD 4010 Australia
Ph. 61 7 3854 2900 Fax. 61 7 3854 2999
PROJECT MANAGERS | DESIGNERS | PLANNERS | ENGINEERS

project
PROPOSED SERVICE STATION
5946 DAVIDSON STREET
CRAIGLIE PORT DOUGLAS
QLD

title
VEHICLE TURNING PATHS

ALL PERSONS PERFORMING THESE WORKS SHALL COMPLY WITH THE CURRENT QLD. WORKPLACE HEALTH & SAFETY REGULATIONS CODE OF PRACTICE.

drawn	approved	date created	A1 scale	A3 scale
DMR		02.07.15	1:250	1:500

status	drawing no.	rev.
PRELIMINARY	15017–12	A

FLANAGAN CONSULTING GROUP
Trusted Advisor to Northern Australia

APPENDIX: D

C&B Group Preliminary Site Survey

PRELIMINARY ONLY

TREE TABLE

Tree No.	Species	Height (m)	Dia (m)	Canopy (m)
1	Melaleuca	13	0.4	7
2	Palm	8	0.2	3
3	Melaleuca	14	0.4	9
4	Melaleuca	15	0.4	10
5	Melaleuca	13	0.3	7
6	Melaleuca	15	0.5	10
7	Melaleuca	15	0.4	10
8	Rain Tree	10	1.0	8
9	Melaleuca	12	0.3	7
10	Melaleuca	16	0.7	10
11	Melaleuca	16	0.7	10
12	Rain Tree	12	1.0	11
13	Eucalyptus	14	0.3	6
14	Evergreen	15	0.4	7
15	Rain Tree	10	1.0	15
16	Eucalyptus	16	0.4	7
17	Melaleuca	14	0.5	7
18	Eucalyptus	8	0.2	4
19	Palm	6	0.2	3
20	Eucalyptus	9	0.2	4
21	Eucalyptus	9	0.3	5
22	Palm	6	0.4	5
23	Melaleuca	14	0.3	4
24	Melaleuca	14	0.3	4
25	Melaleuca	14	0.4	4
26	Melaleuca	14	0.3	4
27	Melaleuca	14	0.4	5
28	Melaleuca	14	0.4	6
29	Eucalyptus	15	0.3	5
30	Eucalyptus	16	0.5	8

IMPORTANT NOTE

1. This plan was prepared for the sole purposes of the client for the specific purpose of producing a detail plan. This plan is strictly limited to the Purpose and does not apply directly or indirectly and will not be used for any other application, purpose, use or matter. The plan is presented without the assumption of a duty of care to any other person (other than the Client) ("Third Party") and may not be relied on by Third Party.
2. C&B will not be liable (in negligence or otherwise) for any direct or indirect loss, damage, liability or claim arising out of or incidental to:
   a. a Third Party publishing, using or relying on the plan;
   b. C&B relying on information provided to it by the Client or a Third Party where the information is Incorrect, Incomplete, Inaccurate, out-of-date or unreasonable;
   c. any inaccuracies or other faults with information or data sourced from a Third Party;
   d. C&B relying on surface indicators that are incorrect or inaccurate;
   e. the Client or any Third Party not verifying information in this plan where recommended by C&B;
   f. lodgement of this plan with any local authority against the recommendation of C&B;
   g. the accuracy, reliability, suitability or completeness of any approximations or estimates made or referred to by C&B in this plan.
3. Without limiting paragraph 1 or 2 above, this plan may not be copied, distributed, or reproduced by any process unless this note is clearly displayed on the plan.
4. The title boundaries as shown hereon were not marked at the time of survey and have been determined by plan dimensions only and not by field survey. If not able to be so located, services have been plotted from the records of relevant authorities where available and have been noted accordingly on this plan. Where such records either do not exist or are inadequate a notation has been made hereon.
5. Prior to any demolition, excavation or construction on the site, the relevant authority should be contacted for possible location of further underground services and detailed locations of all services.

LEGEND

- Concrete Path
- Electricity Pole
- Sewer Manhole (S)
- Sign
- Telstra Pit
- Water Meter (W)
- Water Tap
- Crown of Bitumen
- Drainage A/G (D)
- Drainage U/G (D)
- Edge of Bitumen
- Edge of Concrete
- Edge of Garden
- Line of Rocks
- Open Lined Drain
- Sewerage A/G (S)
- Sewerage U/G (S)
- Toe of Bank
- Top of Bank
- Watercourse IL

NOTES

Level Datum: AHD Der

Origin of Levels: OPM 58820 RL4.841

Meridian: RP739151

Origin of Coordinates: OPM 58820 E 2046.388 N 4881.786

Contour Interval: 0.50 Index: 1.0

Miscellaneous:

Underground Testra & Electricity located from information obtained from Dial Before You Dig Services. (Approximate location only).

Optic Fibre in this vicinity.

Some detail shown has been compiled from previous work dated December 2002.

0 2.5 5.0 7.5 10 12.5 metres

SCALE 1:250 IS APPLICABLE ONLY TO THE ORIGINAL SHEET SIZE. (A1)

PROJECT MANAGER/SURVEYOR: Laurence GREEN	DESIGNED	C. WALKER	PROJECT MANAGEMENT PLANNING ENVIRONMENTAL SERVICES SURVEYING C&B A CONICS COMPANY
CHECKED	SURVEYED: DJL 14/02/2006	PLAN OF FEATURES & LEVELS CAPTAIN COOK HIGHWAY CRAIGLIE PARISH: SALISBURY COUNTY: SOLANDER	C&B CONSULTANTS PTY LTD ACN 055 931 096 C&B GROUP
DRAWN: SE 16-02-2006	FIELD BK.: 1125 LEVEL DATUM: AHD Der		
DRAFTING CHECKED	SHEET SIZE: A1 SHEET OF SHEETS: 1 OF 3		
CAD: 8909-2.dwg 890903.CC6	SCALE: 1:250	MOSSMAN OFFICE PO Box 355 MOSSMAN QLD 4873 Tel: (07) 4098 1148 Fax: (07) 4098 1814 mossman@cbgroup.com.au www.cbgroup.com.au	AMENDED / ISSUE / DRAWING NO. 8909-2

PRELIMINARY ONLY

3
RP740359
"Express Coaches & Limousines"

38
C2252

7
C2259
Building Under Construction

1
RP739151
"Paws & Claws Boarding Kennels"

1
RP732166
"Coates Hire"

2
RP746587
"Exotica Traders"

5
RP840923

4
RP840923
Proposed Home Hardware

3
RP840923
Industrial Buildings

DOWNING STREET

CAPTAIN COOK HIGHWAY

67°51'20" 67.805

67°51'20" 34.085

157°41'30" 60.35

88-429 247°51'20"

32°30'20" 61.873

Change Of Grade...2.51
Concrete Bridge

Melaleuca Ti-tree Swamp

Building

Septic Tank 4.71

Septic Tank 4.55

Austar Disc

Stop Cock

Elect Control Box 4.89

Valve Pit

Sewerage Vent

Sewer M/H

Retaining Wall

Fence

Wire & Fence

Woven Wire Fence

High Woven Wire Fence

RCP 600ø

RCP 400ø

RCP 300ø

OPTIC FIBRE & UNDERGROUND TELSTRA IN TY

TREE TABLE

Tree No.	Species	Height (m)	Dia (m)	Canopy (m)
15	Rain Tree	10	1.0	15
16	Eucalyptus	16	0.4	7
17	Melaleuca	14	0.5	7
18	Eucalyptus	8	0.2	4
19	Palm	6	0.2	3
20	Eucalyptus	9	0.2	4
21	Eucalyptus	9	0.3	5
22	Palm	6	0.4	5
23	Melaleuca	14	0.3	4
24	Melaleuca	14	0.3	4
25	Melaleuca	14	0.4	4
26	Melaleuca	14	0.3	4
27	Melaleuca	14	0.4	5
28	Melaleuca	14	0.4	6
29	Eucalyptus	15	0.3	5
30	Eucalyptus	16	0.5	8
31	Rain Tree	13	1.0	14
32	Eucalyptus	17	1.0	10
33	Eucalyptus	12	0.4	7
34	Melaleuca	15	0.4	7
35	Melaleuca	14	1.0	7
36	Melaleuca	14	0.5	7
37	Palm	6	0.2	4
38	Eucalyptus	14	0.4	5
39	Pine	6	0.3	11
40	Eucalyptus	13	0.3	5
41	Eucalyptus	13	0.3	5
42	Eucalyptus	12	0.2	4
43	Melaleuca	17	0.5	8
44	Palm	7	0.25	5
45	Eucalyptus	10	0.3	5
46	Palm	7	0.25	5
47	Palm	6	0.2	4
48	Palm	6	0.2	4
49	Palm	6	0.2	4
50	Palm	9	0.3	5
51	Palm	6	0.3	4
52	Palm	5	0.2	3

LEGEND

- Concrete Path
- Electricity Pole
- Sewer Manhole (S)
- Sign
- Telstra Pit (T)
- Water Meter (W)
- Water Tap
- Crown of Bitumen
- Drainage A/G (D)
- Drainage U/G (D)
- Edge of Bitumen
- Edge of Concrete
- Edge of Garden
- Line of Rocks
- Open Lined Drain
- Sewerage A/G (S)
- Sewerage U/G (S)
- Toe of Bank
- Top of Bank (T)
- Watercourse IL

IMPORTANT NOTE

1. This plan was prepared for the sole purposes of the client for the specific purpose of producing a detail plan. This plan is strictly limited to the Purpose and does not apply directly or indirectly and will not be used for any other application, purpose, use or matter. The plan is presented without the assumption of a duty of care to any other person (other than the Client) ("Third Party") and may not be relied on by Third Party.
2. C&B will not be liable (in negligence or otherwise) for any direct or indirect loss, damage, liability or claim arising out of or incidental to:
   a. a Third Party publishing, using or relying on the plan;
   b. C&B relying on information provided to it by the Client or a Third Party where the information is incorrect, incomplete, inaccurate, out-of-date or unreasonable;
   c. any inaccuracies or other faults with information or data sourced from a Third Party;
   d. C&B relying on surface indicators that are incorrect or inaccurate;
   e. the Client or any Third Party not verifying information in this plan where recommended by C&B;
   f. lodgement of this plan with any local authority against the recommendation of C&B;
   g. the accuracy, reliability, suitability or completeness of any approximations or estimates made or referred to by C&B in this plan.
3. Without limiting paragraph 1 or 2 above, this plan may not be copied, distributed, or reproduced by any process unless this note is clearly displayed on the plan.
4. The title boundaries as shown hereon were not marked at the time of survey and have been determined by plan dimensions only and not by field survey. If not able to be so located, services have been plotted from the records of relevant authorities where available and have been noted accordingly on this plan. Where such records either do not exist or are inadequate a notation has been made hereon.
5. Prior to any demolition, excavation or construction on the site, the relevant authority should be contacted for possible location of further underground services and detailed locations of all services.

NOTES

Level Datum: AHD Der

Origin of Levels: OPM 58820 RL4.841

Meridian: RP739151

Origin of Coordinates: OPM 58820 E 2046.388 N 4881.786

Contour Interval: 0.50 Index: 1.0

Miscellaneous:

Underground Testra & Electricity located from information obtained from Dial Before You Dig Services. (Approximate location only).

Optic Fibre in this vicinity.

Some detail shown has been compiled from previous work dated December 2002.

0 2.5 5.0 7.5 10 12.5 metres

SCALE 1:250 IS APPLICABLE ONLY TO THE ORIGINAL SHEET SIZE. (A1)

PROJECT MANAGER/SURVEYOR Laurence GREEN	DESIGNED		
CHECKED	SURVEYED DJL	14/02/2006	
DRAWN SE 16-02-2006	FIELD BK. 1125	LEVEL DATUM AHD Der	
DRAFTING CHECKED	SHEET SIZE A1	SHEET 2 OF SHEETS 3	
CAD 8909-2.dwg 890903.CC6	SCALE 1:250		

C. WALKER

PLAN OF FEATURES & LEVELS
CAPTAIN COOK HIGHWAY
CRAIGLIE
PARISH: SALISBURY COUNTY: SOLANDER

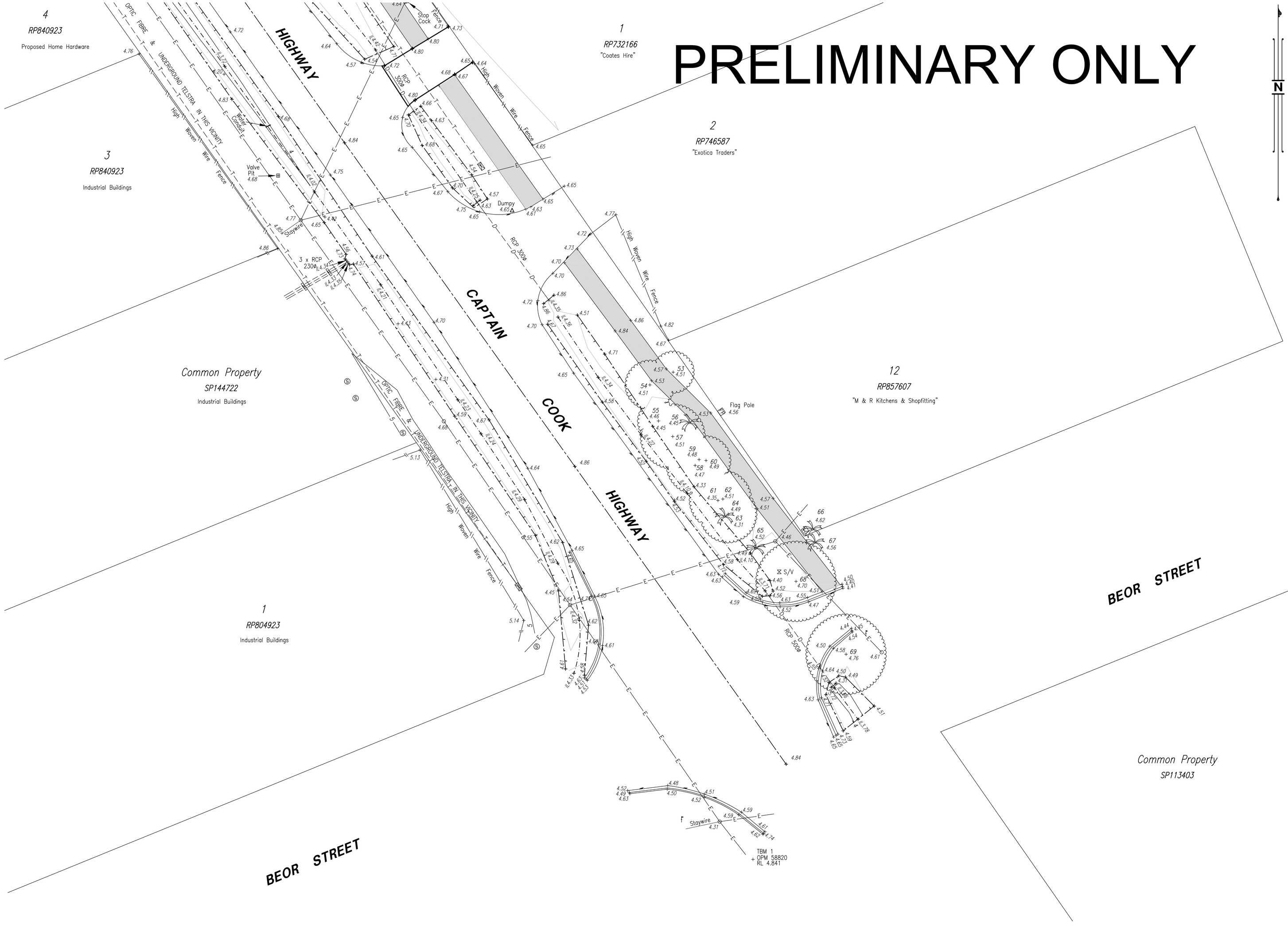
MOSSMAN OFFICE PO Box 355 MOSSMAN QLD 4873
Tel: (07) 4098 1148 Fax: (07) 4098 1814
mossman@cbgroup.com.au www.cbgroup.com.au

PROJECT MANAGEMENT
PLANNING
ENVIRONMENTAL SERVICES
SURVEYING

C&B A CONICS COMPANY
C&B CONSULTANTS PTY LTD
ACN 055 931 096
C&B GROUP

AMENDED	ISSUE	DRAWING NO.
		8909-2

PRELIMINARY ONLY



IMPORTANT NOTE

1. This plan was prepared for the sole purposes of the client for the specific purpose of producing a detail plan. This plan is strictly limited to the Purpose and does not apply directly or indirectly and will not be used for any other application, purpose, use or matter. The plan is presented without the assumption of a duty of care to any other person (other than the Client) ("Third Party") and may not be relied on by Third Party.
2. C&B will not be liable (in negligence or otherwise) for any direct or Indirect loss, damage, liability or claim arising out of or incidental to:
   a. a Third Party publishing, using or relying on the plan;
   b. C&B relying on information provided to it by the Client or a Third Party where the information is Incorrect, incomplete, inaccurate, out-of-date or unreasonable;
   c. any inaccuracies or other faults with information or data sourced from a Third Party;
   d. C&B relying on surface indicators that are incorrect or inaccurate;
   e. the Client or any Third Party not verifying information in this plan where recommended by C&B;
   f. lodgement of this plan with any local authority against the recommendation of C&B;
   g. the accuracy, reliability, suitability or completeness of any approximations or estimates made or referred to by C&B in this plan.
3. Without limiting paragraph 1 or 2 above, this plan may not be copied, distributed, or reproduced by any process unless this note is clearly displayed on the plan.
4. The title boundaries as shown hereon were not marked at the time of survey and have been determined by plan dimensions only and not by field survey. If not able to be so located, services have been plotted from the records of relevant authorities where available and have been noted accordingly on this plan. Where such records either do not exist or are inadequate a notation has been made hereon.
5. Prior to any demolition, excavation or construction on the site, the relevant authority should be contacted for possible location of further underground services and detailed locations of all services.

TREE TABLE

Tree No.	Species	Height (m)	Dia (m)	Canopy (m)
53	Eucalyptus	12	0.25	5
54	Eucalyptus	14	0.3	6
55	Melaleuca	11	0.25	5
56	Palm	5	0.2	4
57	Melaleuca	14	0.4	8
58	Eucalyptus	12	0.3	7
59	Eucalyptus	11	0.2	6
60	Eucalyptus	11	0.2	6
61	Eucalyptus	14	0.4	7
62	Eucalyptus	14	0.4	7
63	Palm	4	0.2	3
64	Eucalyptus	14	0.4	7
65	Palm	5	0.2	3
66	Palm	5	0.25	4
67	Palm	5	0.25	4
68	Eucalyptus	16	0.6	10
69	Eucalyptus	15	0.6	10

LEGEND

- Concrete Path
- Electricity Pole
- Sewer Manhole
- Sign
- Telstra Pit
- Water Meter
- Water Tap
- Crown of Bitumen
- Drainage A/G
- Drainage U/G
- Edge of Bitumen
- Edge of Concrete
- Edge of Garden
- Line of Rocks
- Open Lined Drain
- Sewerage A/G
- Sewerage U/G
- Toe of Bank
- Top of Bank
- Watercourse IL

NOTES

Level Datum: AHD Der

Origin of Levels: OPM 58820 RL4.841

Meridian: RP739151

Origin of Coordinates: OPM 58820 E 2046.388 N 4881.786

Contour Interval: 0.50 Index: 1.0

Miscellaneous:

Underground Testra & Electricity located from information obtained from Dial Before You Dig Services. (Approximate location only).

Optic Fibre in this vicinity.

Some detail shown has been compiled from previous work dated December 2002.

0 2.5 5.0 7.5 10 12.5 metres

SCALE 1:250 IS APPLICABLE ONLY TO THE ORIGINAL SHEET SIZE. (A1)

PROJECT MANAGER/SURVEYOR: Laurence GREEN	DESIGNED	C. WALKER	PROJECT MANAGEMENT, PLANNING, ENVIRONMENTAL SERVICES, SURVEYING
CHECKED	SURVEYED: DJL 14/02/2006	PLAN OF FEATURES & LEVELS CAPTAIN COOK HIGHWAY CRAIGLIE	C&B CONSULTANTS PTY LTD ACN 055 931 096
DRAWN: SE 16-02-2006	FIELD BK.: 1125	PARISH: SALISBURY COUNTY: SOLANDER	C&B GROUP
DRAFTING CHECKED	SHEET SIZE: A1	MOSSMAN OFFICE PO Box 355 MOSSMAN QLD 4873 Tel: (07) 4098 1148 Fax: (07) 4098 1814 mossman@cbgroup.com.au www.cbgroup.com.au	AMENDED / ISSUE / DRAWING NO. 8909-2
CAD: 8909-2.dwg 890903.CC6	SCALE: 1:250	SHEET OF SHEETS: 3 OF 3	

FLANAGAN CONSULTING GROUP
Trusted Advisor to Northern Australia

APPENDIX: E

Hydrological Calculation

Craiglie Service Station

Proposed site channel tc & flow tabulation (Lot 1 RP739151)

1) Time of Concentration

Overland Flow 1

- Initial overland flow time at the top of the catchment;
- Assume steep bushland at the top of the catchment;
- Based on QUDM 2013 Table 4.6.4, the recommended overland flow length is 50m;
- Using QUDM 2013 Figure 4.6, with 20% & densely grassed surface (n = 0.06), the estimated overland sheet flow times is:

t_c = 13.0 minutes

Channel Flow 1

- From the end of the overland flow component to the base of the mountain range, the slope is estimated to be approx.28%;
- QUDM Table 4.6.6 recommends a flow velocity of 3.0 m/s
- The length of flow in this section is approx. 440 m
- The estimated flow time is:

t_c = 2.4 minutes

Channel Flow 2

- From the bottom of the range to the cane rail line, the slope of the land is estimated to be approx. 7%;
- QUDM Table 4.6.6 recommends a flow velocity of 0.9 m/s
- The length of flow in this section is approx. 280 m
- The estimated flow time is:

t_c = 5.2 minutes

Channel Flow 3

- The flows are expected to remain concentrated, however the grade of the terrian redues to approx. 2%
- QUDM Table 4.6.6 recommends a flow velocity of 0.7 m/s
- The length of flow in this section is approx. 500 m
- The estimated flow time is:

t_c = 11.9 minutes

Channel Flow 4

- The flows then entered into a defined channel with a slope of approx. 1.1%
- QUDM Table 4.6.6 recommends a flow velocity of 0.3 m/s
- The length of flow in this section is approx. 140 m
- The estimated flow time is:

t_c = 7.8 minutes

Channel Flow 4

- The flows then entered into another defined channel with a slope of approx. 1.3%
- QUDM Table 4.6.6 recommends a flow velocity of 0.3 m/s
- The length of flow in this section is approx. 170 m
- The estimated flow time is:

t_c = 9.4 minutes

Total t_c = 49.8 minutes

2) Design Flow

Using Rational Method

$Q = (C \times I \times A)/360$ or $0.00278\ C.I.A$

Catchment area, A =	14.5	ha	- developed areas
Catchment area, A =	63.9	ha	- bushland
Total catchment, A =	78.4	ha	
[1] I_{10} =	82.2	mm/hr	
Fraction impervious, f_i =	0.90		- refer QUDM 2013 Table 4.5.1 - developed areas
Fraction impervious, f_i =	0.00		- refer QUDM 2013 Table 4.5.1 - bushland
C_{10} =	0.88		- refer QUDM 2013 Table 4.5.3 - developed areas
C_{10} =	0.7		- refer QUDM 2013 Table 4.5.4 - bushland

Design ARI =	**5**	**years**						
Frequency factor, F_5 =	0.95		- refer QUDM 2013 Table 4.5.2					
C_5 =	0.84		- developed areas					
C_5 =	0.67		- bushland					
C_5 =	0.70		- composite					
$^{tc}I_5$ =	82.3	mm/hr						
Q_5 =	**0.00278**	**x**	**C_5**	**x**	**$^{tc}I_5$**	**x**	**A**	
=	**0.00278**	**x**	**0.70**	**x**	**82.3**	**x**	**78.4**	
=	**12.49**	**m^3/s**						
Design ARI =	**10**	**years**						
Frequency factor, F_{10} =	1.0		- refer QUDM 2013 Table 4.5.2					
C_{10} =	0.88		- developed areas					
C_{10} =	0.70		- bushland					
C_{10} =	0.73		- composite					
$^{tc}I_{10}$ =	90.4	mm/hr						
Q_{10} =	**0.00278**	**x**	**C_{10}**	**x**	**$^{tc}I_{10}$**	**x**	**A**	
=	**0.00278**	**x**	**0.73**	**x**	**90.4**	**x**	**78.4**	
=	**14.45**	**m^3/s**						
Design ARI =	**20**	**years**						
Frequency factor, F_{20} =	1.05		- refer QUDM 2013 Table 4.5.2					
C_{20} =	0.92		- developed areas					
C_{20} =	0.74		- bushland					
C_{20} =	0.77		- composite					
$^{tc}I_{20}$ =	102.0	mm/hr						
Q_{20} =	**0.00278**	**x**	**C_{20}**	**x**	**$^{tc}I_{20}$**	**x**	**A**	
=	**0.00278**	**x**	**0.77**	**x**	**102.0**	**x**	**78.4**	
=	**17.11**	**m^3/s**						
Design ARI =	**50**	**years**						
Frequency factor, F_{50} =	1.15		- refer QUDM 2013 Table 4.5.2					
C_{50} =	1.00		- developed areas					
C_{50} =	0.81		- bushland					
C_{50} =	0.84		- composite					
$^{tc}I_{50}$ =	117.1	mm/hr						
Q_{50} =	**0.00278**	**x**	**C_{50}**	**x**	**$^{tc}I_{50}$**	**x**	**A**	
=	**0.00278**	**x**	**0.84**	**x**	**117.1**	**x**	**78.4**	
=	**21.46**	**m^3/s**						
Design ARI =	**100**	**years**						
C_{100} =	F_{100} x C_{10}							
Frequency factor, F_{100} =	1.2		- refer QUDM 2013 Table 4.5.2					
C_{100} =	1.0		- developed areas					
C_{100} =	0.84		- bushland					
C_{100} =	0.87		- composite					
$^{tc}I_{100}$ =	128.6	mm/hr						
Q_{100} =	**0.00278**	**x**	**C_{100}**	**x**	**$^{tc}I_{100}$**	**x**	**A**	
=	**0.00278**	**x**	**0.9**	**x**	**128.6**	**x**	**78.4**	
=	**24.37**	**m^3/s**						

Craiglie Service Station

HECRAS Outputs (Water Level Comparison at Site Channel with Various Roughness Coefficients)

1) Q5

	River Station (Cross Section)	Channel Elevation (m)	Water Elevation (m AHD)			Δ Water elevation (m) btw Manning's 0.08 & 0.10
			n = 0.08	n = 0.09	n = 0.10	
U/S	116.64	1.61	3.49	3.55	3.61	0.12
	100.97	1.50	3.40	3.47	3.53	0.13
	89.11	1.40	3.34	3.41	3.47	0.13
	78.47	1.50	3.30	3.37	3.43	0.13
	67.50	1.47	3.24	3.3	3.37	0.13
	54.52	1.22	3.16	3.22	3.28	0.12
	44.52	1.34	3.1	3.16	3.22	0.12
	34.52	1.46	3.05	3.12	3.17	0.12
	24.52	1.72	3.05	3.11	3.16	0.11
D/S	17.21	1.94	3.04	3.1	3.15	0.11

2) Q10

	River Station (Cross Section)	Channel Elevation (m)	Water Elevation (m AHD)			Δ Water elevation (m) btw Manning's 0.08 & 0.10
			n = 0.08	n = 0.09	n = 0.10	
U/S	116.64	1.61	3.56	3.64	3.7	0.14
	100.97	1.50	3.48	3.55	3.62	0.14
	89.11	1.40	3.43	3.50	3.56	0.13
	78.47	1.50	3.38	3.45	3.52	0.14
	67.50	1.47	3.32	3.39	3.46	0.14
	54.52	1.22	3.23	3.30	3.36	0.13
	44.52	1.34	3.17	3.23	3.30	0.13
	34.52	1.46	3.13	3.19	3.25	0.12
	24.52	1.72	3.12	3.18	3.24	0.12
D/S	17.21	1.94	3.11	3.17	3.24	0.13

3) Q20

	River Station (Cross Section)	Channel Elevation (m)	Water Elevation (m AHD)			Δ Water elevation (m) btw Manning's 0.08 & 0.10
			n = 0.08	n = 0.09	n = 0.10	
U/S	116.64	1.61	3.66	3.74	3.82	0.16
	100.97	1.50	3.59	3.67	3.74	0.15
	89.11	1.40	3.53	3.61	3.68	0.15
	78.47	1.50	3.49	3.56	3.64	0.15
	67.50	1.47	3.42	3.50	3.57	0.15
	54.52	1.22	3.32	3.40	3.47	0.15
	44.52	1.34	3.25	3.33	3.40	0.15
	34.52	1.46	3.22	3.29	3.36	0.14
	24.52	1.72	3.21	3.28	3.35	0.14
D/S	17.21	1.94	3.20	3.27	3.34	0.14

4) Q50

	River Station (Cross Section)	Channel Elevation (m)	Water Elevation (m AHD)			Δ Water elevation (m) btw Manning's 0.08 & 0.10
			n = 0.08	n = 0.09	n = 0.10	
U/S	116.64	1.61	3.82	3.90	3.99	0.17
	100.97	1.50	3.75	3.84	3.92	0.17
	89.11	1.40	3.69	3.78	3.86	0.17
	78.47	1.50	3.65	3.73	3.81	0.16
	67.50	1.47	3.57	3.66	3.75	0.18
	54.52	1.22	3.46	3.55	3.63	0.17
	44.52	1.34	3.38	3.47	3.55	0.17
	34.52	1.46	3.36	3.44	3.52	0.16
	24.52	1.72	3.35	3.43	3.51	0.16
D/S	17.21	1.94	3.34	3.42	3.50	0.16

4) Q100

	River Station (Cross Section)	Channel Elevation (m)	Water Elevation (m AHD)			Δ Water elevation (m) btw Manning's 0.08 & 0.10
			n = 0.08	n = 0.09	n = 0.10	
U/S	116.64	1.61	3.91	4.00	4.10	0.19
	100.97	1.50	3.85	3.94	4.03	0.18
	89.11	1.40	3.79	3.88	3.97	0.18
	78.47	1.50	3.74	3.83	3.92	0.18
	67.50	1.47	3.67	3.76	3.86	0.19
	54.52	1.22	3.55	3.64	3.74	0.19
	44.52	1.34	3.47	3.56	3.65	0.18
	34.52	1.46	3.44	3.53	3.62	0.18
	24.52	1.72	3.44	3.53	3.61	0.17
D/S	17.21	1.94	3.43	3.52	3.60	0.17

Craiglie Service Station

IFD

Return Period	A	B	C	D	E	F	G	
1	3.884688854	-5.54E-01	-7.26E-02	6.62E-03	4.94E-03	-1.88E-04	-1.36E-04	<--- Paste values from BOM website
2	4.118324757	-5.47E-01	-6.48E-02	6.64E-03	4.17E-03	-1.87E-04	-1.15E-04	
5	4.313015938	-5.28E-01	-4.52E-02	6.67E-03	2.23E-03	-1.85E-04	-6.31E-05	
10	4.408716679	-5.18E-01	-3.46E-02	6.80E-03	1.16E-03	-1.96E-04	-3.17E-05	
20	4.530264378	-5.09E-01	-2.56E-02	6.58E-03	3.05E-04	-1.71E-04	-1.25E-05	
50	4.669937611	-5.00E-01	-1.54E-02	6.80E-03	-7.24E-04	-1.91E-04	1.88E-05	
100	4.764779091	-4.93E-01	-8.64E-03	6.73E-03	-1.38E-03	-1.84E-04	3.52E-05	

Duration (Hours)	1 Year	2 Years	5 Years	10 Years	20 Years	50 Years	100 Years	Duration (Mins)
0.083	133	168	207	229	261	302	333	5.0
0.100	125	158	195	216	246	285	314	6.0
0.167	105.2	134	164	182	206	238	263	10.0
0.333	81.9	103.4	126	138	156	180	198	20.0
0.500	68.9	86.9	105.2	116	130	149	164	30.0
1.000	48.7	61.5	74.7	82.2	92.8	106.7	117	60.0
2.000	32.1	40.9	50.8	56.6	64.5	75.0	83.2	120.0
3.000	24.6	31.6	40.0	45.1	51.9	60.9	68.0	180.0
6.000	15.5	20.2	26.5	30.4	35.6	42.7	48.2	360.0
12.000	9.96	13.12	17.7	20.7	24.5	29.8	34.0	720.0
24.000	6.71	8.88	12.11	14.2	16.9	20.6	23.6	1440.0
48.000	4.58	6.04	8.21	9.60	11.41	13.9	15.9	2880.0
72.000	3.50	4.63	6.32	7.42	8.84	10.82	12.39	4320.0

Calculated t_c		Intensity (mm/hr)						
minutes	Hours	1 Year	2 Years	5 Years	10 Years	20 Years	50 Years	100 Years
49.8	0.83	53.8	67.9	82.3	90.4	102.0	117.1	128.6
	0.00	#NUM!	#NUM!	#NUM!	#NUM!	#NUM!	#NUM!	#NUM!
	0.00	#NUM!	#NUM!	#NUM!	#NUM!	#NUM!	#NUM!	#NUM!
	0.00	#NUM!	#NUM!	#NUM!	#NUM!	#NUM!	#NUM!	#NUM!
	0.00	#NUM!	#NUM!	#NUM!	#NUM!	#NUM!	#NUM!	#NUM!
	0.00	#NUM!	#NUM!	#NUM!	#NUM!	#NUM!	#NUM!	#NUM!
	0.00	#NUM!	#NUM!	#NUM!	#NUM!	#NUM!	#NUM!	#NUM!
	0.00	#NUM!	#NUM!	#NUM!	#NUM!	#NUM!	#NUM!	#NUM!
	0.00	#NUM!	#NUM!	#NUM!	#NUM!	#NUM!	#NUM!	#NUM!
	0.00	#NUM!	#NUM!	#NUM!	#NUM!	#NUM!	#NUM!	#NUM!
	0.00	#NUM!	#NUM!	#NUM!	#NUM!	#NUM!	#NUM!	#NUM!
	0.00	#NUM!	#NUM!	#NUM!	#NUM!	#NUM!	#NUM!	#NUM!
	0.00	#NUM!	#NUM!	#NUM!	#NUM!	#NUM!	#NUM!	#NUM!
	0.00	#NUM!	#NUM!	#NUM!	#NUM!	#NUM!	#NUM!	#NUM!
	0.00	#NUM!	#NUM!	#NUM!	#NUM!	#NUM!	#NUM!	#NUM!
	0.00	#NUM!	#NUM!	#NUM!	#NUM!	#NUM!	#NUM!	#NUM!
	0.00	#NUM!	#NUM!	#NUM!	#NUM!	#NUM!	#NUM!	#NUM!
	0.00	#NUM!	#NUM!	#NUM!	#NUM!	#NUM!	#NUM!	#NUM!

FLANAGAN CONSULTING GROUP
Trusted Advisor to Northern Australia

APPENDIX: F

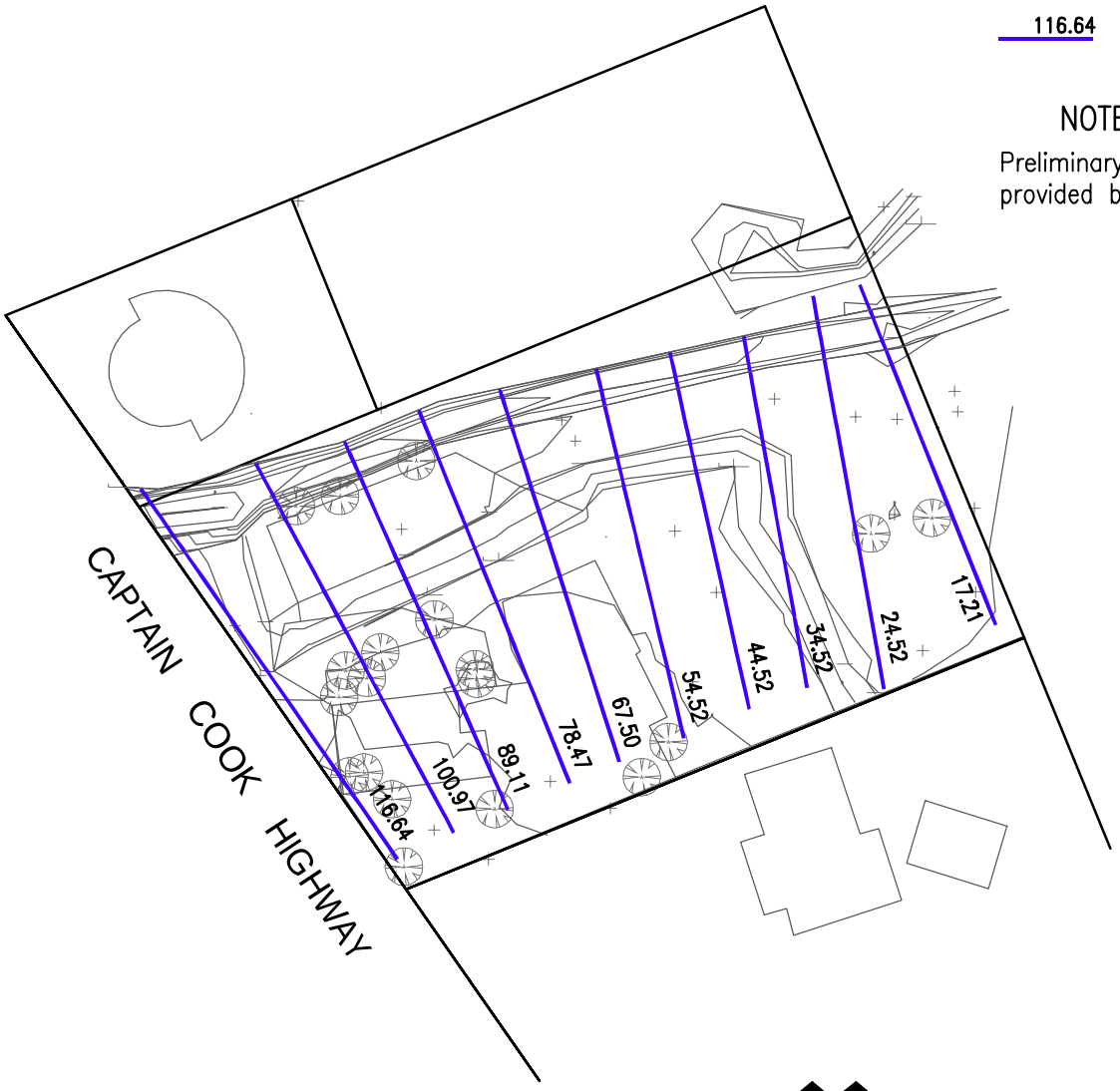
HECRAS Model Cross Sections (Sketch 1633-SK02)

LEGEND

116.64 Cross Section

NOTES

Preliminary survey detail provided by C&B Group



FLANAGAN CONSULTING GROUP

Craiglie Service Station

Lanwal Pty Ltd.

Plan view of Cross Sections For HEC RAS Model

1633-SK02

1:1000
A4 Full Size

Acad No. 1633SK02

7 September 2006

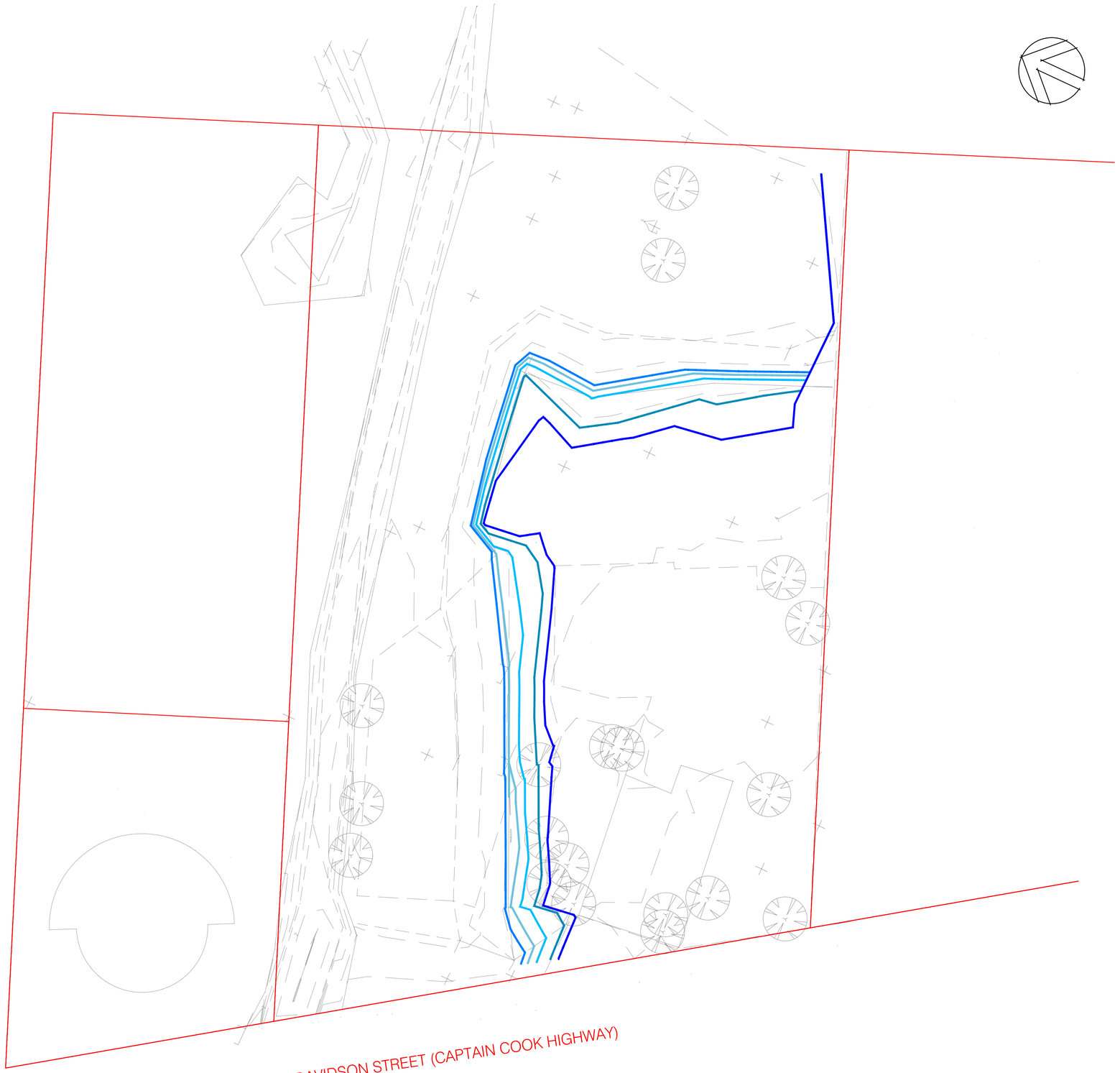
FLANAGAN CONSULTING GROUP
Trusted Advisor to Northern Australia

APPENDIX: G

Development Site Stormwater Extents (Sketch 4380-SK03)

LEGEND

- Q5 Flow Event Boundary
- Q10 Flow Event Boundary
- Q20 Flow Event Boundary
- Q50 Flow Event Boundary
- Q100 Flow Event Boundary



Notes

FLANAGAN CONSULTING GROUP
DEVELOPMENT CONSULTANTS • PROJECT MANAGERS • ENGINEERS • PLANNERS

CAIRNS	DARWIN	MACKAY	TOWNSVILLE
(07) 4031 3199	(08) 8943 0620	(07) 4944 1200	(07) 4724 5737

www.flanaganconsulting.com.au

Proposed Craiglie Service Station
5946 Davidson Road, Port Douglas

HEC RAS MODEL (n=0.10) & DEVELOPMENT SITE WATER EXTENT

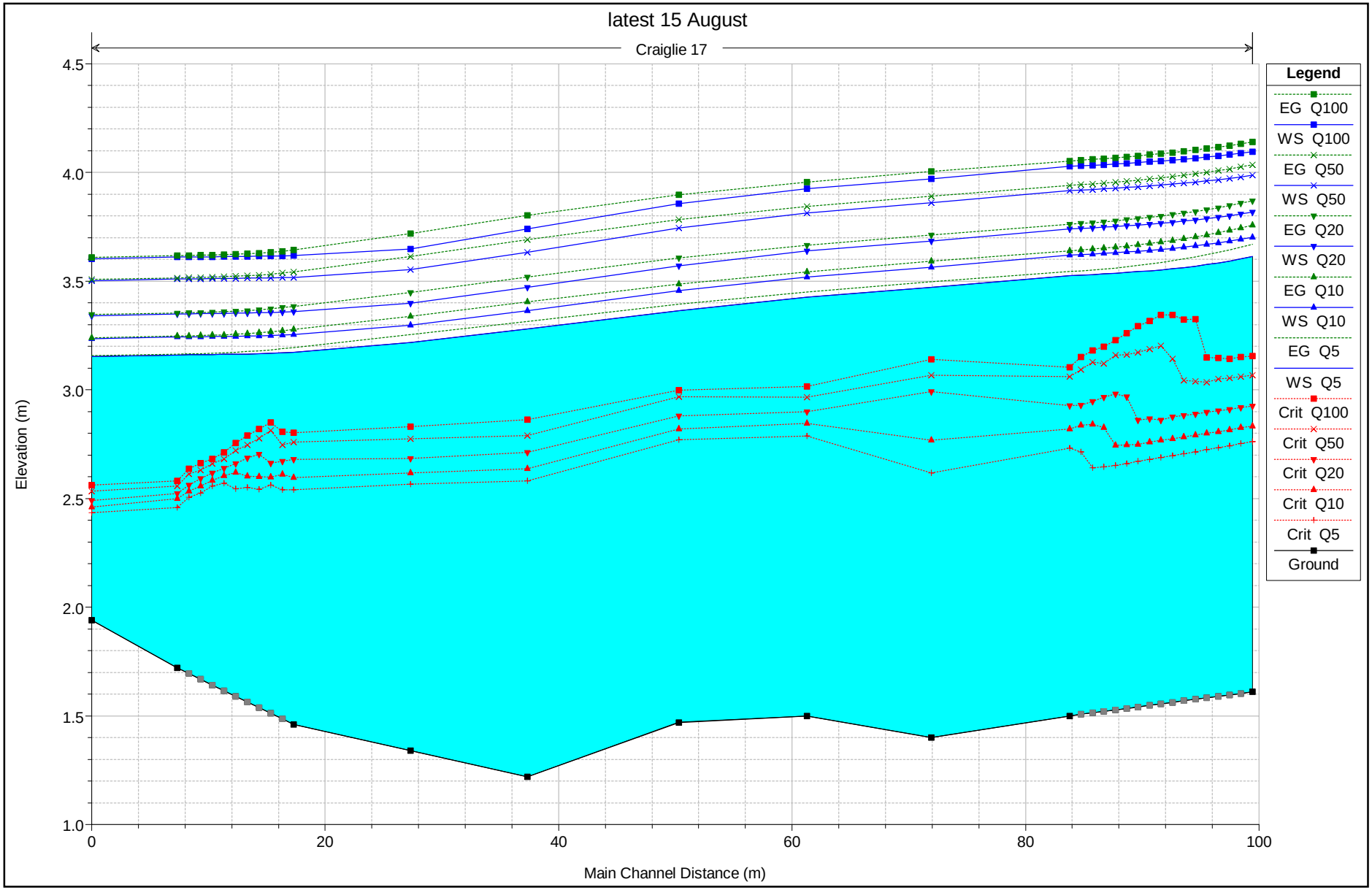
4380-SK03 — 1:250 A1 Full Size

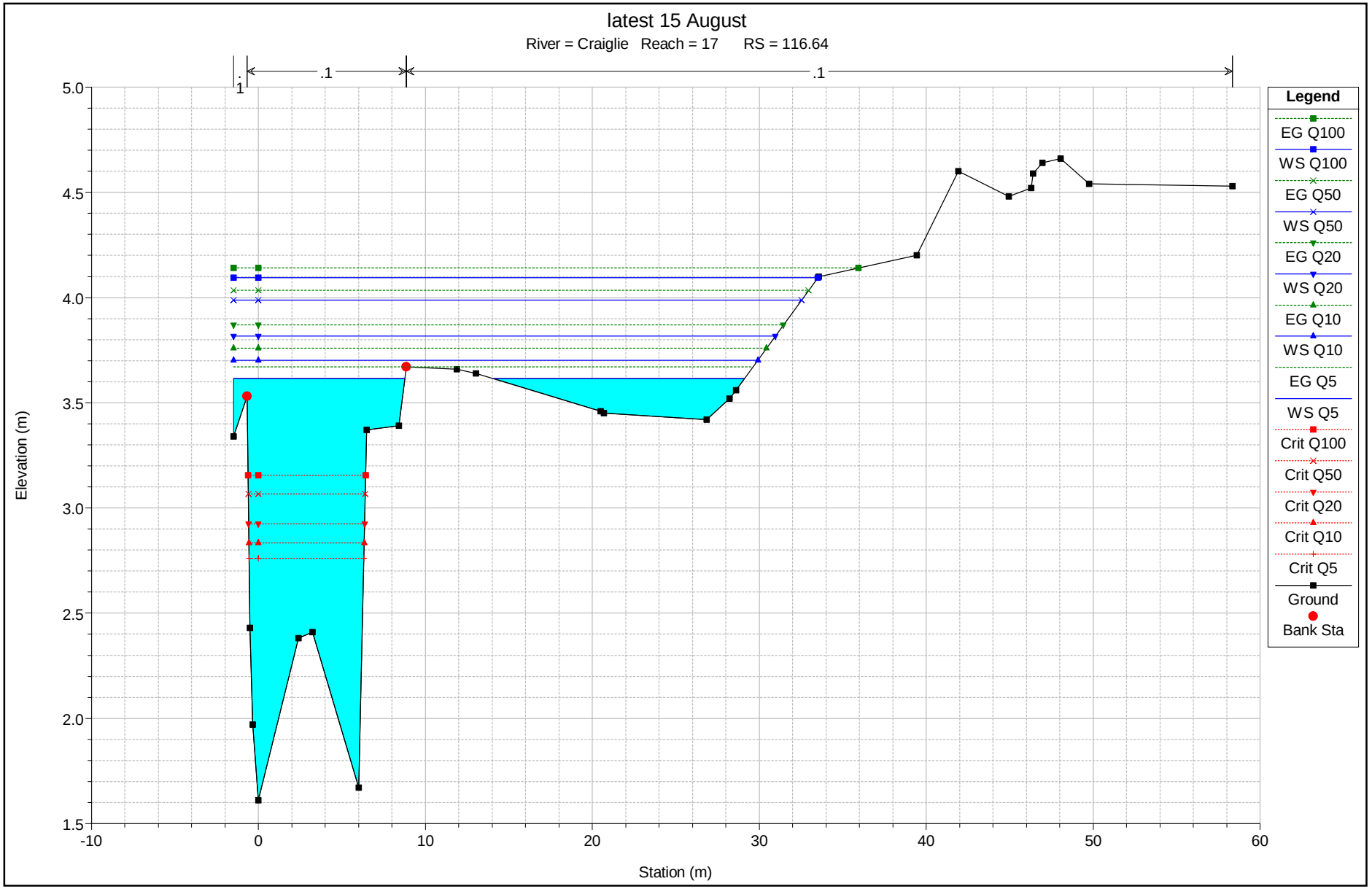
Acad No. 4380-SK03.DWG — 13 October 2015

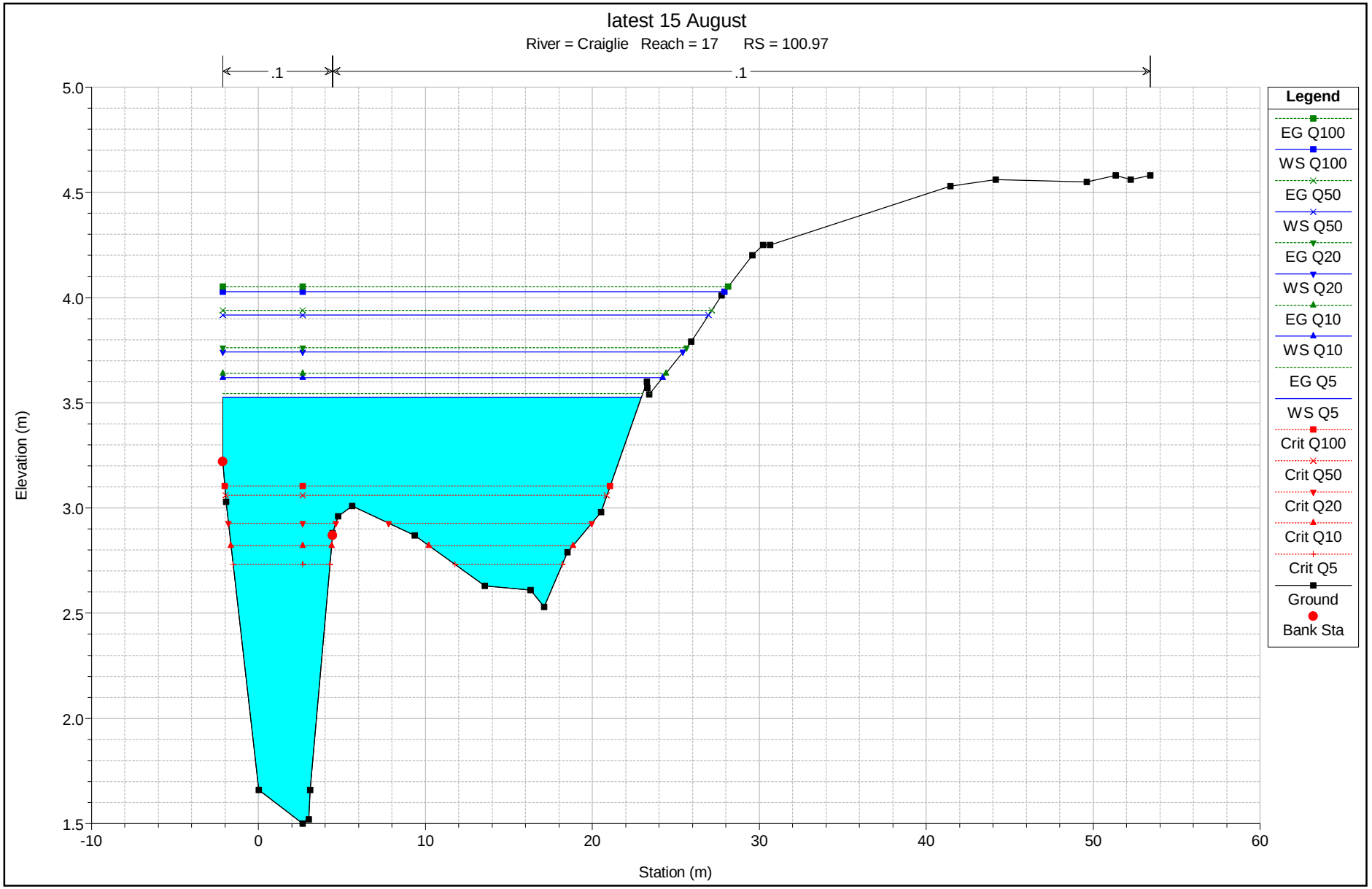
FLANAGAN CONSULTING GROUP
Trusted Advisor to Northern Australia

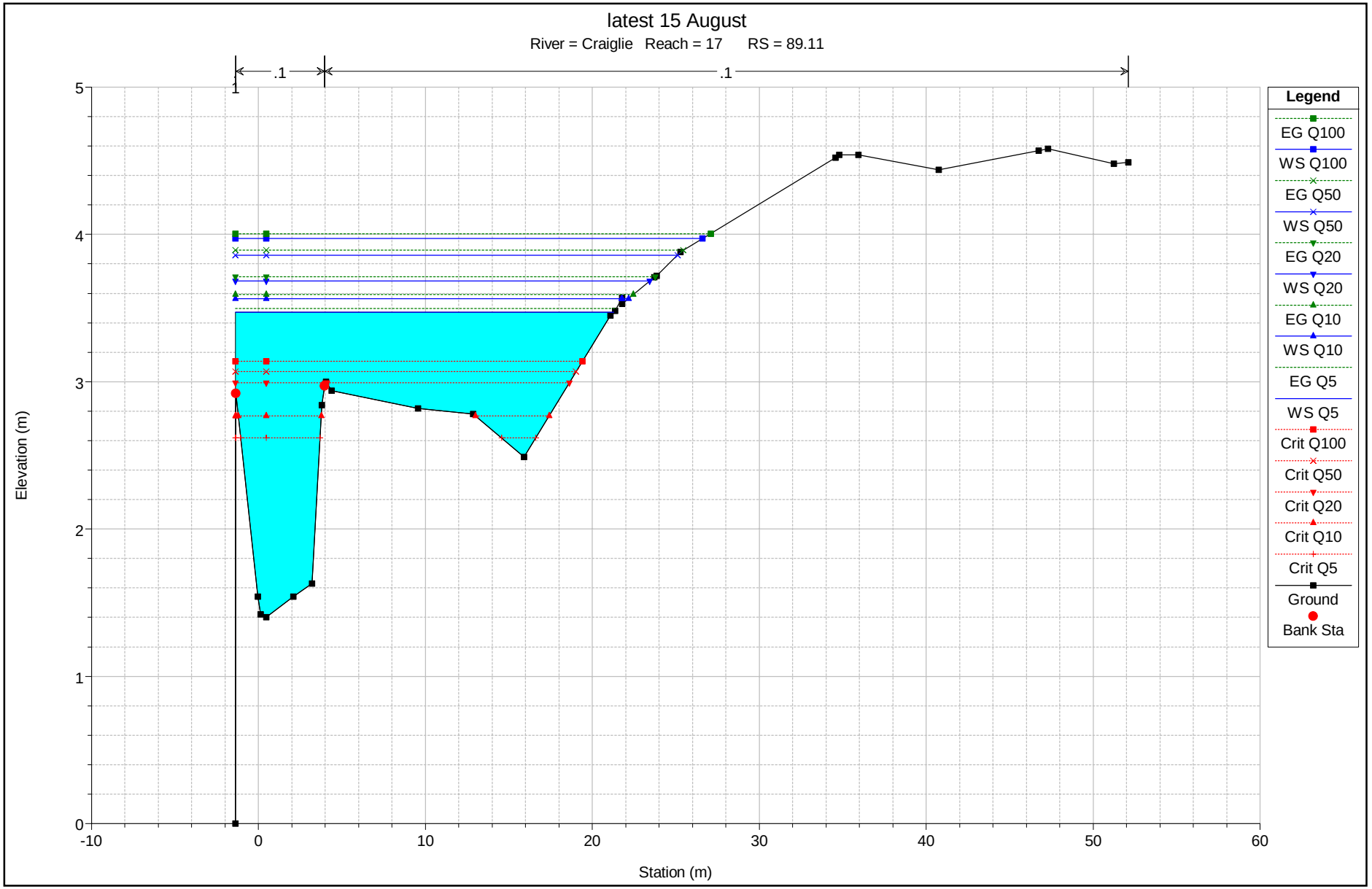
APPENDIX: H

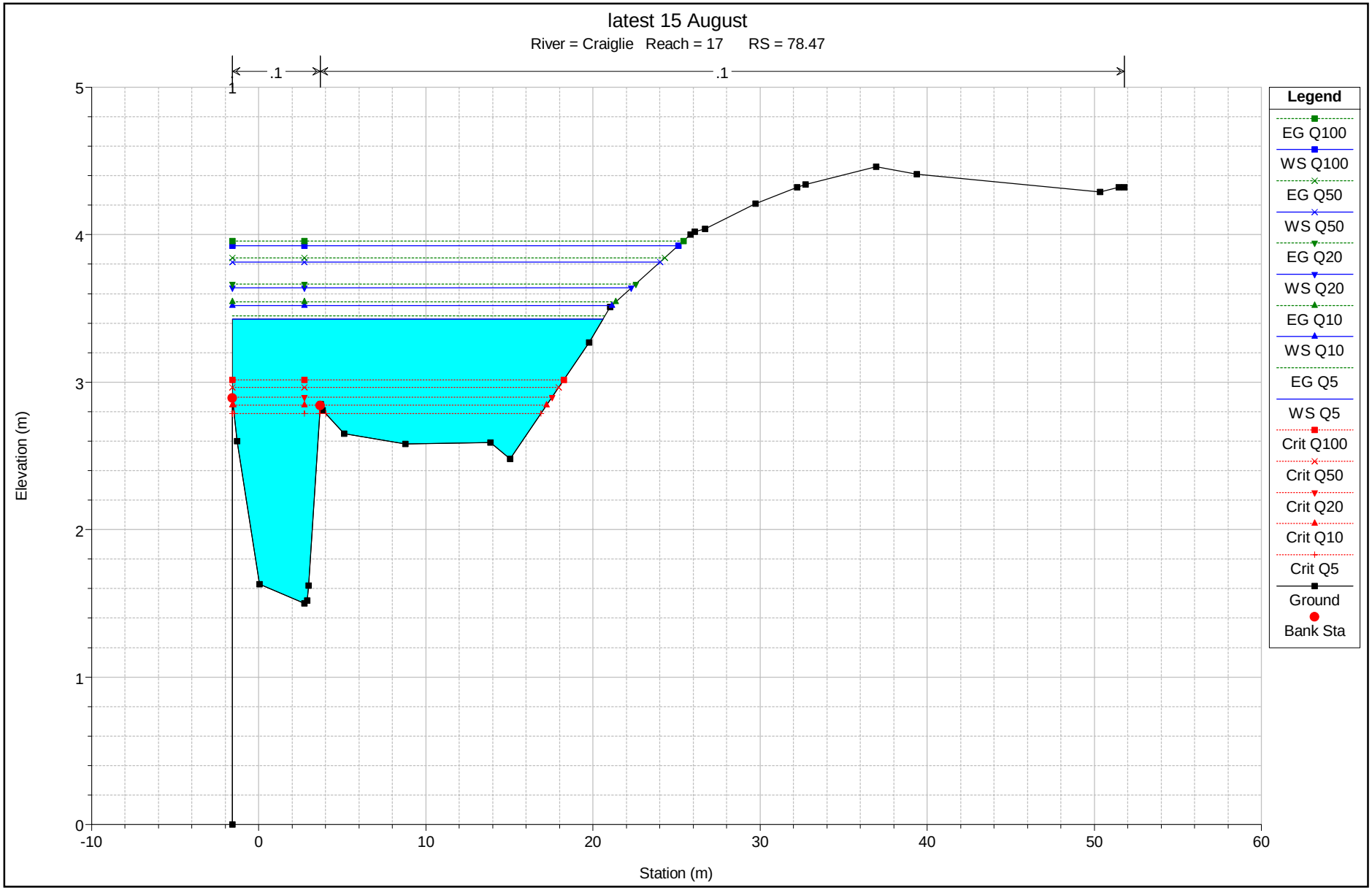
HECRAS Flow Profile (Long Section), Typical Cross Sections & Detailed Outputs

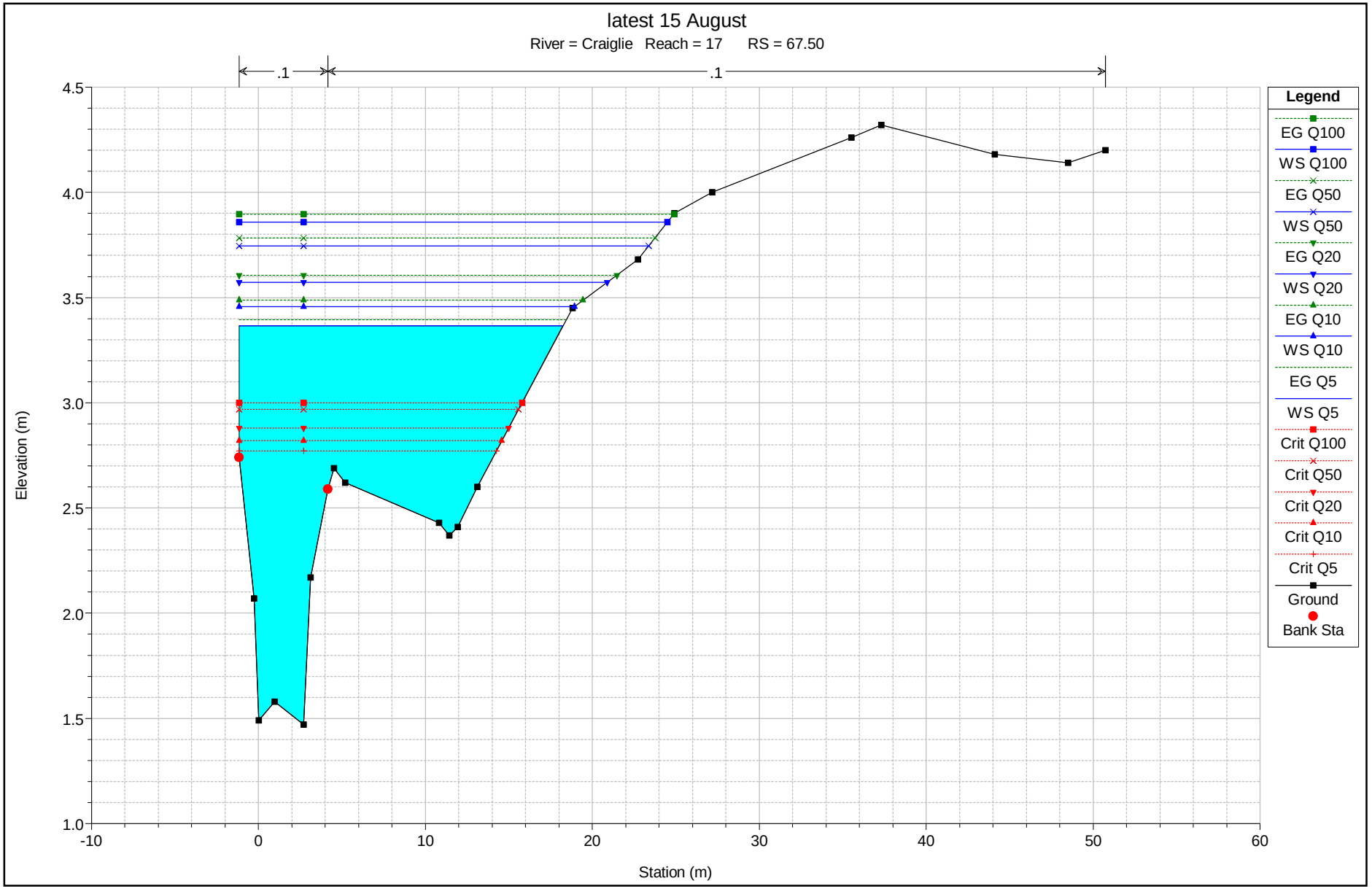

latest 15 August
Craiglie 17
Elevation (m)
Main Channel Distance (m)
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0
20
40
60
80
100
Legend
EG Q100
WS Q100
EG Q50
WS Q50
EG Q20
WS Q20
EG Q10
WS Q10
EG Q5
WS Q5
Crit Q100
Crit Q50
Crit Q20
Crit Q10
Crit Q5
Ground

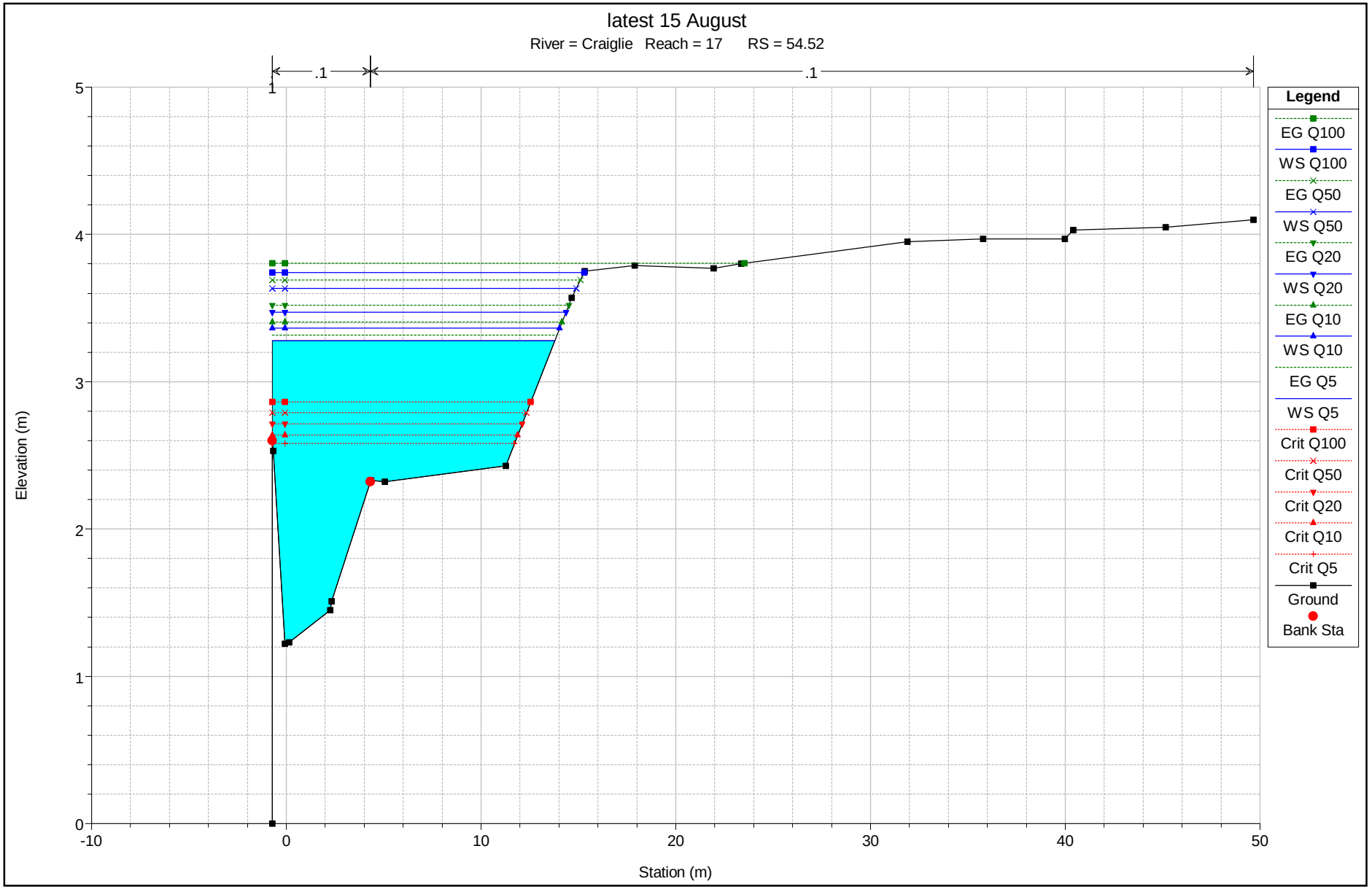

latest 15 August
River = Craiglie Reach = 17 RS = 116.64
.1
.1
.1
Elevation (m)
Station (m)
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
-10
0
10
20
30
40
50
60
Legend
EG Q100
WS Q100
EG Q50
WS Q50
EG Q20
WS Q20
EG Q10
WS Q10
EG Q5
WS Q5
Crit Q100
Crit Q50
Crit Q20
Crit Q10
Crit Q5
Ground
Bank Sta

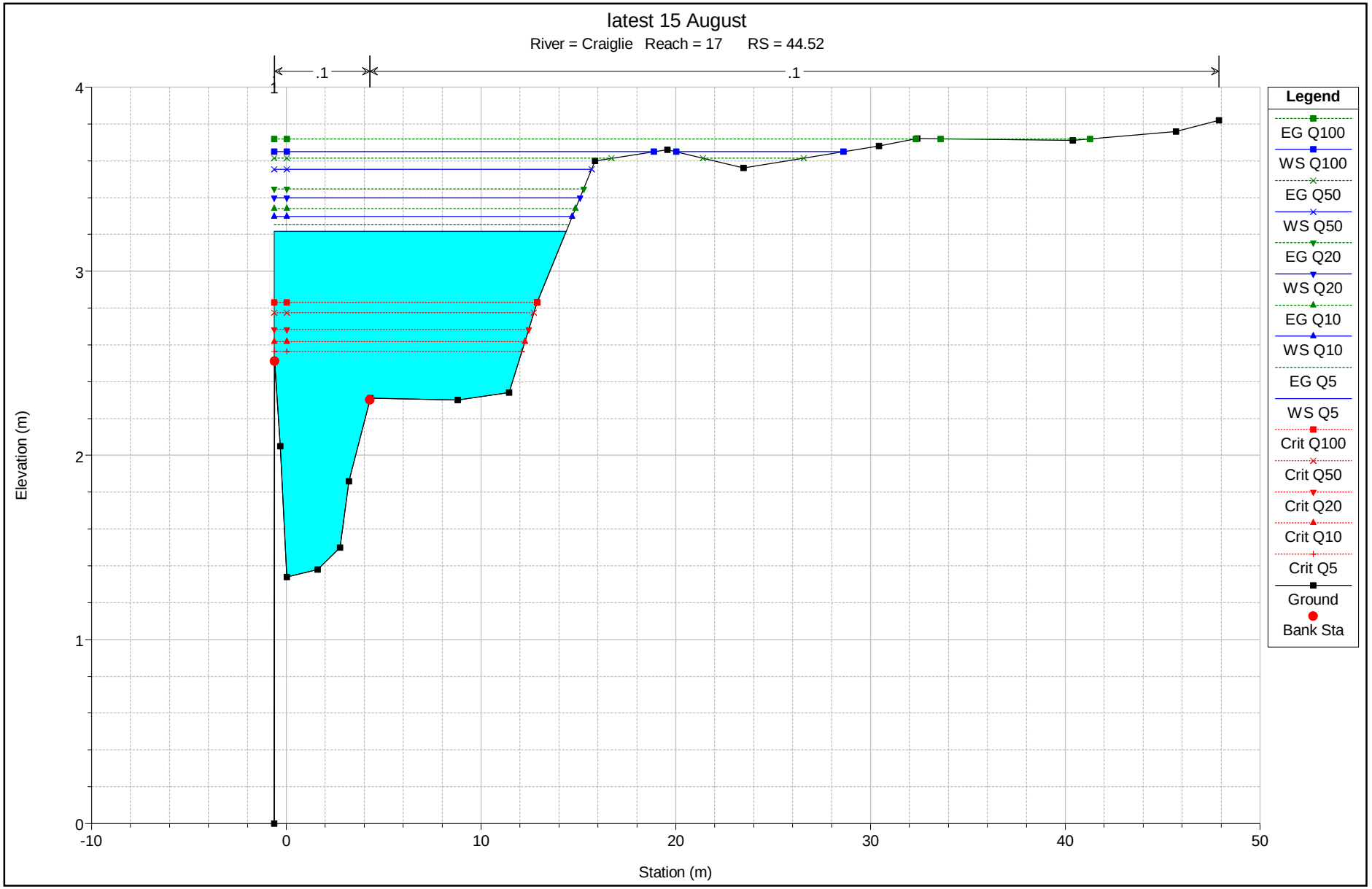

latest 15 August
River = Craiglie Reach = 17 RS = 100.97
.1
.1
Elevation (m)
Station (m)
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
-10
0
10
20
30
40
50
60
Legend
EG Q100
WS Q100
EG Q50
WS Q50
EG Q20
WS Q20
EG Q10
WS Q10
EG Q5
WS Q5
Crit Q100
Crit Q50
Crit Q20
Crit Q10
Crit Q5
Ground
Bank Sta

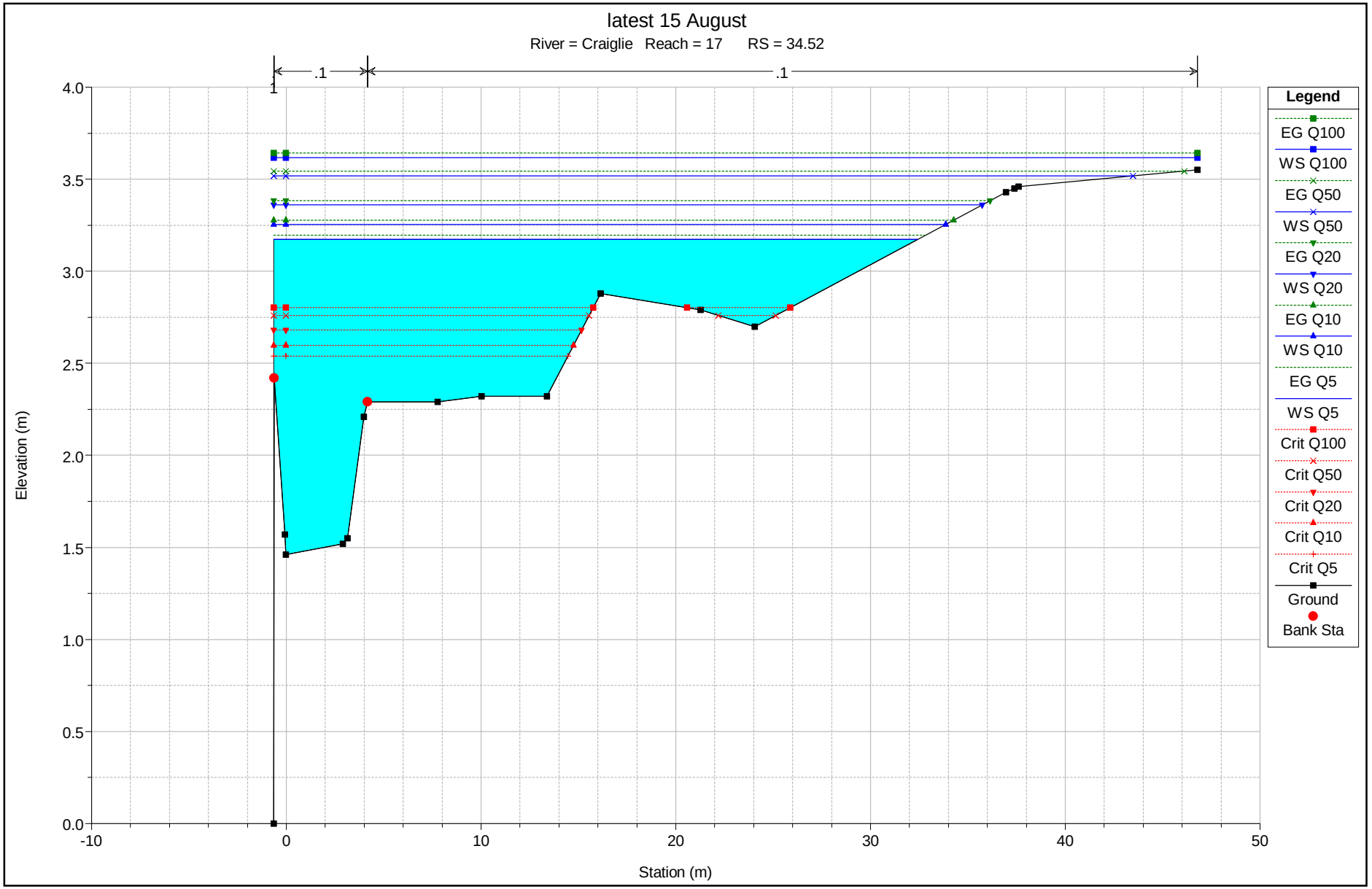

latest 15 August
River = Craiglie Reach = 17 RS = 89.11
.1
.1
1
Elevation (m)
Station (m)
0
1
2
3
4
5
-10
0
10
20
30
40
50
60
Legend
EG Q100
WS Q100
EG Q50
WS Q50
EG Q20
WS Q20
EG Q10
WS Q10
EG Q5
WS Q5
Crit Q100
Crit Q50
Crit Q20
Crit Q10
Crit Q5
Ground
Bank Sta

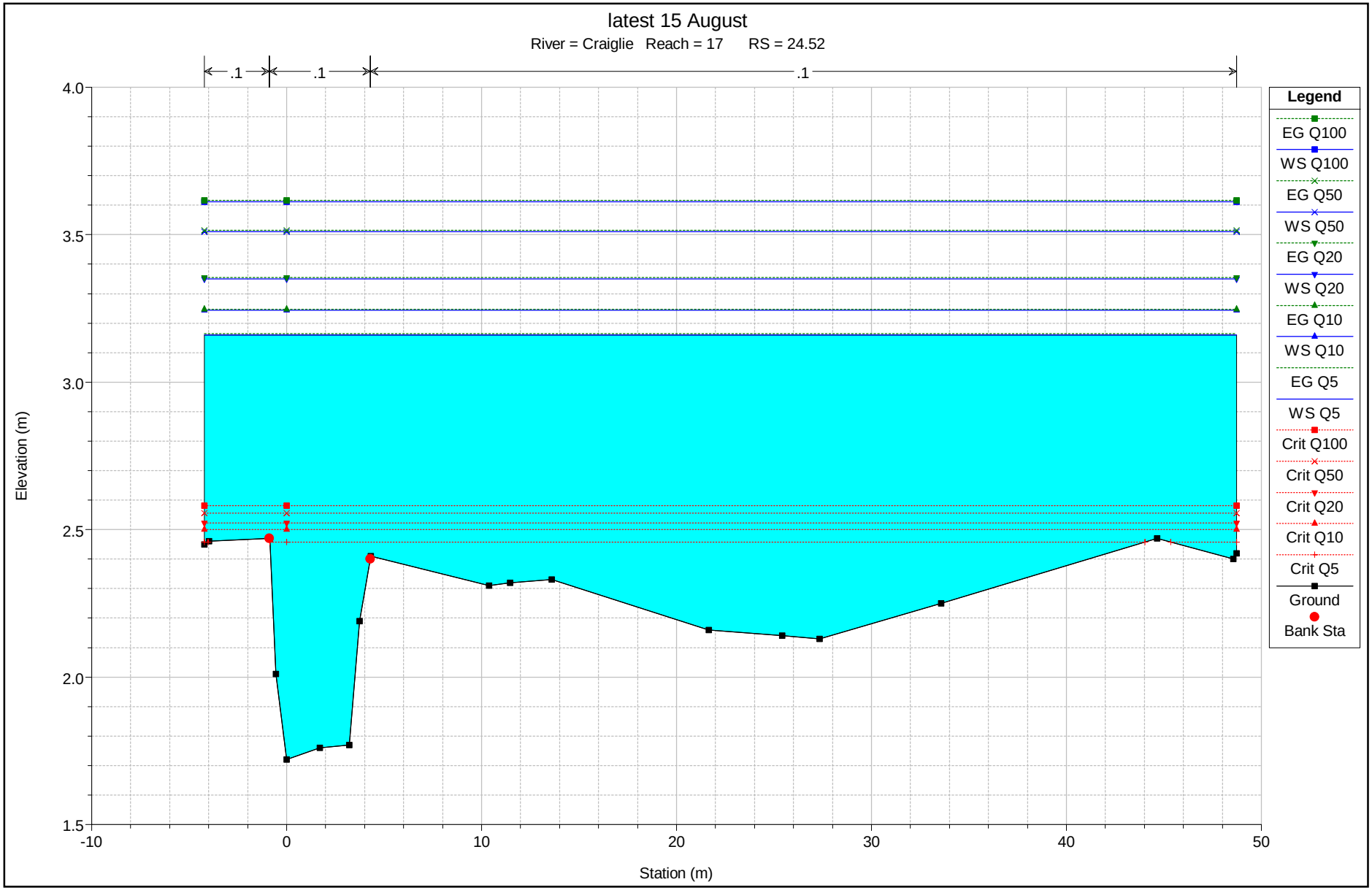

latest 15 August
River = Craiglie Reach = 17 RS = 78.47
.1
.1
1
Elevation (m)
Station (m)
0
1
2
3
4
5
-10
0
10
20
30
40
50
60
Legend
EG Q100
WS Q100
EG Q50
WS Q50
EG Q20
WS Q20
EG Q10
WS Q10
EG Q5
WS Q5
Crit Q100
Crit Q50
Crit Q20
Crit Q10
Crit Q5
Ground
Bank Sta

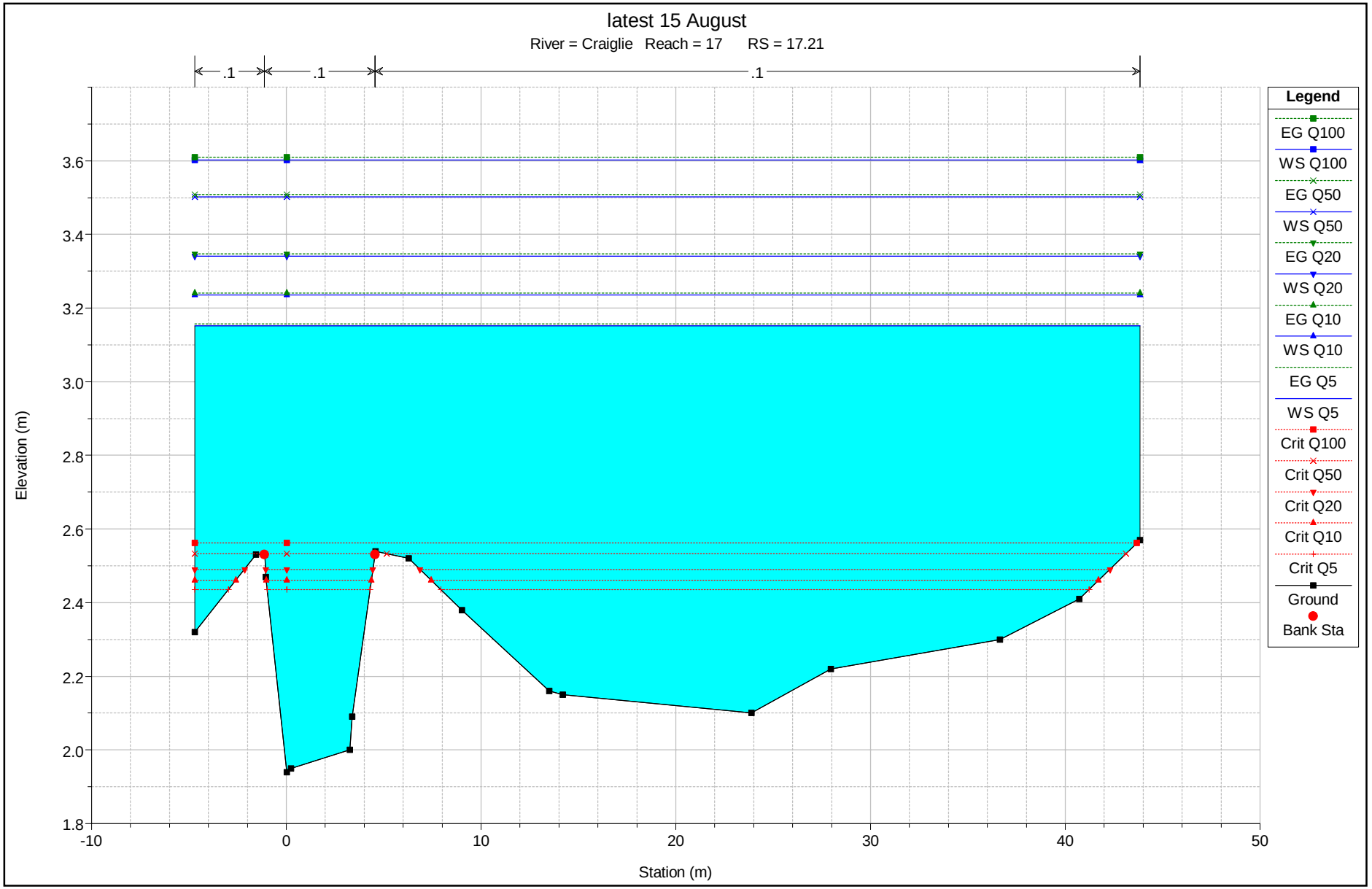

latest 15 August
River = Craiglie Reach = 17 RS = 67.50
.1
.1
Elevation (m)
Station (m)
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
-10
0
10
20
30
40
50
60
Legend
EG Q100
WS Q100
EG Q50
WS Q50
EG Q20
WS Q20
EG Q10
WS Q10
EG Q5
WS Q5
Crit Q100
Crit Q50
Crit Q20
Crit Q10
Crit Q5
Ground
Bank Sta


latest 15 August
River = Craiglie Reach = 17 RS = 54.52
.1
.1
1
Elevation (m)
Station (m)
0
1
2
3
4
5
-10
0
10
20
30
40
50
Legend
EG Q100
WS Q100
EG Q50
WS Q50
EG Q20
WS Q20
EG Q10
WS Q10
EG Q5
WS Q5
Crit Q100
Crit Q50
Crit Q20
Crit Q10
Crit Q5
Ground
Bank Sta


latest 15 August
River = Craiglie Reach = 17 RS = 44.52
.1
.1
1
Elevation (m)
Station (m)
0
1
2
3
4
-10
0
10
20
30
40
50
Legend
EG Q100
WS Q100
EG Q50
WS Q50
EG Q20
WS Q20
EG Q10
WS Q10
EG Q5
WS Q5
Crit Q100
Crit Q50
Crit Q20
Crit Q10
Crit Q5
Ground
Bank Sta


latest 15 August
River = Craiglie Reach = 17 RS = 34.52
.1
.1
1
Elevation (m)
Station (m)
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
-10
0
10
20
30
40
50
Legend
EG Q100
WS Q100
EG Q50
WS Q50
EG Q20
WS Q20
EG Q10
WS Q10
EG Q5
WS Q5
Crit Q100
Crit Q50
Crit Q20
Crit Q10
Crit Q5
Ground
Bank Sta


latest 15 August
River = Craiglie Reach = 17 RS = 24.52
.1
.1
.1
4.0
3.5
3.0
2.5
2.0
1.5
Elevation (m)
-10
0
10
20
30
40
50
Station (m)
Legend
EG Q100
WS Q100
EG Q50
WS Q50
EG Q20
WS Q20
EG Q10
WS Q10
EG Q5
WS Q5
Crit Q100
Crit Q50
Crit Q20
Crit Q10
Crit Q5
Ground
Bank Sta


latest 15 August
River = Craiglie Reach = 17 RS = 17.21
.1
.1
.1
Elevation (m)
3.6
3.4
3.2
3.0
2.8
2.6
2.4
2.2
2.0
1.8
-10
0
10
20
30
40
50
Station (m)
Legend
EG Q100
WS Q100
EG Q50
WS Q50
EG Q20
WS Q20
EG Q10
WS Q10
EG Q5
WS Q5
Crit Q100
Crit Q50
Crit Q20
Crit Q10
Crit Q5
Ground
Bank Sta

HEC-RAS Plan: Plan 01 Locations: User Defined

River	Reach	River Sta	Profile	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl
				(m3/s)	(m)	(m)	(m)	(m)	(m/m)	(m/s)	(m2)	(m)	
Craiglie	17	116.64	Q5	12.49	1.61	3.61	2.76	3.67	0.012836	1.06	13.27	25.31	0.31
Craiglie	17	116.64	Q10	14.45	1.61	3.70	2.83	3.76	0.012538	1.09	15.78	31.42	0.31
Craiglie	17	116.64	Q20	17.11	1.61	3.82	2.93	3.87	0.011123	1.09	19.45	32.47	0.30
Craiglie	17	116.64	Q50	21.46	1.61	3.99	3.07	4.04	0.009334	1.08	25.10	34.02	0.28
Craiglie	17	116.64	Q100	24.37	1.61	4.10	3.16	4.14	0.008370	1.07	28.82	35.01	0.26
Craiglie	17	100.97	Q5	12.49	1.50	3.53	2.73	3.54	0.003382	0.68	22.64	25.08	0.18
Craiglie	17	100.97	Q10	14.45	1.50	3.62	2.82	3.64	0.003484	0.71	25.05	26.36	0.18
Craiglie	17	100.97	Q20	17.11	1.50	3.74	2.93	3.76	0.003510	0.75	28.31	27.58	0.18
Craiglie	17	100.97	Q50	21.46	1.50	3.92	3.06	3.94	0.003531	0.79	33.31	29.12	0.18
Craiglie	17	100.97	Q100	24.37	1.50	4.03	3.10	4.05	0.003510	0.81	36.60	30.06	0.18
Craiglie	17	89.11	Q5	12.49	1.40	3.47	2.62	3.50	0.004680	0.82	19.52	22.66	0.20
Craiglie	17	89.11	Q10	14.45	1.40	3.56	2.77	3.59	0.004666	0.85	21.66	23.51	0.20
Craiglie	17	89.11	Q20	17.11	1.40	3.68	2.99	3.71	0.004740	0.89	24.55	24.81	0.21
Craiglie	17	89.11	Q50	21.46	1.40	3.86	3.07	3.89	0.004705	0.94	29.06	26.47	0.21
Craiglie	17	89.11	Q100	24.37	1.40	3.97	3.14	4.00	0.004695	0.98	32.08	27.97	0.21
Craiglie	17	78.47	Q5	12.49	1.50	3.43	2.79	3.45	0.004221	0.77	20.26	22.18	0.20
Craiglie	17	78.47	Q10	14.45	1.50	3.52	2.85	3.54	0.004259	0.80	22.34	22.72	0.20
Craiglie	17	78.47	Q20	17.11	1.50	3.64	2.90	3.66	0.004334	0.84	25.10	23.88	0.20
Craiglie	17	78.47	Q50	21.46	1.50	3.81	2.97	3.84	0.004409	0.91	29.43	25.59	0.21
Craiglie	17	78.47	Q100	24.37	1.50	3.92	3.02	3.96	0.004395	0.94	32.33	26.68	0.21
Craiglie	17	67.50	Q5	12.49	1.47	3.37	2.77	3.39	0.006206	0.85	17.43	19.40	0.22
Craiglie	17	67.50	Q10	14.45	1.47	3.46	2.82	3.49	0.006349	0.89	19.22	20.07	0.23
Craiglie	17	67.50	Q20	17.11	1.47	3.57	2.88	3.61	0.006716	0.95	21.65	22.04	0.23
Craiglie	17	67.50	Q50	21.46	1.47	3.75	2.97	3.78	0.006881	1.01	25.72	24.54	0.24
Craiglie	17	67.50	Q100	24.37	1.47	3.86	3.00	3.90	0.006726	1.03	28.54	25.66	0.23
Craiglie	17	54.52	Q5	12.49	1.22	3.28	2.58	3.32	0.005870	0.94	15.67	14.51	0.23
Craiglie	17	54.52	Q10	14.45	1.22	3.36	2.64	3.41	0.006285	1.00	16.90	14.76	0.24
Craiglie	17	54.52	Q20	17.11	1.22	3.47	2.71	3.52	0.006764	1.08	18.50	15.08	0.26
Craiglie	17	54.52	Q50	21.46	1.22	3.63	2.79	3.69	0.007373	1.20	20.97	15.61	0.27
Craiglie	17	54.52	Q100	24.37	1.22	3.74	2.86	3.80	0.007604	1.26	22.67	16.01	0.28
Craiglie	17	44.52	Q5	12.49	1.34	3.22	2.57	3.25	0.006385	0.96	15.40	14.99	0.25
Craiglie	17	44.52	Q10	14.45	1.34	3.30	2.62	3.34	0.006863	1.03	16.61	15.30	0.26
Craiglie	17	44.52	Q20	17.11	1.34	3.40	2.68	3.45	0.007403	1.12	18.18	15.70	0.27
Craiglie	17	44.52	Q50	21.46	1.34	3.55	2.77	3.61	0.008033	1.23	20.67	16.30	0.28
Craiglie	17	44.52	Q100	24.37	1.34	3.65	2.83	3.72	0.009437	1.38	22.68	28.09	0.31
Craiglie	17	34.52	Q5	12.49	1.46	3.17	2.54	3.20	0.004804	0.83	21.83	33.07	0.21
Craiglie	17	34.52	Q10	14.45	1.46	3.25	2.60	3.28	0.004689	0.85	24.60	34.52	0.21
Craiglie	17	34.52	Q20	17.11	1.46	3.36	2.68	3.38	0.004518	0.87	28.33	36.37	0.21
Craiglie	17	34.52	Q50	21.46	1.46	3.52	2.76	3.54	0.004704	0.94	34.42	44.11	0.22
Craiglie	17	34.52	Q100	24.37	1.46	3.62	2.80	3.64	0.004427	0.95	39.12	47.44	0.22
Craiglie	17	24.52	Q5	12.49	1.72	3.16	2.46	3.16	0.000815	0.32	47.58	52.97	0.09
Craiglie	17	24.52	Q10	14.45	1.72	3.24	2.50	3.25	0.000818	0.33	51.98	52.97	0.09
Craiglie	17	24.52	Q20	17.11	1.72	3.35	2.52	3.35	0.000821	0.35	57.60	52.97	0.09
Craiglie	17	24.52	Q50	21.46	1.72	3.51	2.56	3.52	0.000824	0.37	66.09	52.97	0.09
Craiglie	17	24.52	Q100	24.37	1.72	3.61	2.58	3.62	0.000824	0.39	71.44	52.97	0.09
Craiglie	17	17.21	Q5	12.49	1.94	3.15	2.44	3.16	0.001001	0.32	43.28	48.54	0.10
Craiglie	17	17.21	Q10	14.45	1.94	3.24	2.46	3.24	0.001001	0.34	47.31	48.54	0.10
Craiglie	17	17.21	Q20	17.11	1.94	3.34	2.49	3.35	0.001001	0.36	52.45	48.54	0.10
Craiglie	17	17.21	Q50	21.46	1.94	3.50	2.53	3.51	0.001002	0.39	60.22	48.54	0.10
Craiglie	17	17.21	Q100	24.37	1.94	3.60	2.56	3.61	0.001001	0.40	65.12	48.54	0.10