1 March 2017

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City of Karratha
PO Box 219
Karratha WA 6714

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File:

re: DAMPIER DRAINAGE – SUB-CATCHMENT C1 – C4 GHD MODEL AUDIT

Arqum,

Thank you for the ongoing works regarding design review of Dampier drainage system. Please find herein reporting of the model audit for sub-catchments C1 – C4 based on site visit and workshop with City of Karratha personnel on 29 November 2016.

BACKGROUND

WISE was contracted in 2016 to complete site survey, preliminary design and cost estimates for culvert upgrades, open drain remediation and crossover reinstatements based on the GHD's Dampier Stormwater Management Study, 2015.

The feedback received from the City of Karratha suggests that the GHD model and design results do not reflect the observed historical drainage performances and that the recommended open drain cross sectional areas and culvert designs are considered overly conservative, and therefore over-capitalised.

Subsequently WISE was requested to submit a fee proposal to undertake a hydraulic modelling of a discrete sub-catchment. A site visit was conducted on the 29 November 2016 between representatives of the City of Karratha and WISE. The outcome of that meeting was an agreement to undertake hydraulic modelling of sub-catchment C.

HYDRAULIC MODELLING

1. Model Structure

A hydrologic model was built in XP Storm software based on the concept design in the WISE Dampier Drainage Design Report, 2016.

In creating the model, it was noted that run-offs from sub-catchment C routes through B1 and A1 before discharging into the natural channel downstream of culverts 334 and 335. As such those additional sub-catchments were incorporated into the model to obtain a more realistic backwater condition (refer to Attachment 1). This model therefore comprises of 6 channels (A1, B1, C1, C2, C3, & C4) with particular focus on C1 to C4.

2. *Basis of Design – Sub-catchment Area & Land Use*

Table below summarises the sub-catchment characteristics contained in the XP model:

Catchment	Areas				
	Total	Residential Lots		Others	
		m²	ha	m²	ha
A1	32,008	14,305	1.43	17,703	1.77
A2+	161,144	65,743	6.57	95,385	9.54
B1	22,566	11,424	1.14	11,142	1.11
C1	22,961	10,635	1.06	12,326	1.23
C2	21,992	13,920	1.39	8,072	0.81
C3	18,845	9,860	0.99	8,985	0.90
C4	23,368	1,834	0.18	21,534	2.15
TOTAL	302,884	47,673	4.77	62,059	6.21

3. *Basis of Design – Loss Model*

No geotechnical investigations were undertaken as part of this scope of work. However, advised from CofK is that the site generally consisted of a shallow layer of alluvial sand overlaying rock. This together with the steep terrain where runoff is expected to flow at a higher velocity would therefore produce minimal losses.

Without the geotechnical data, the following losses were assumed:

- Roof runoffs from each residential property is directed into two 1500mm diameter soakwells. The storage provided from these soakwells are considered as initial loss.

  This is then translated into mm in the Laurenson Loss Model. No further losses thereafter due to the presence of shallow rock and steep terrain.

- Road runoffs provide 1mm of depression storage, as per common practice. Thereafter no further losses have been accounted for.

Land Use Type	Initial Loss (mm)	Proportional Loss (% of Rainfall)
Residential	5.8	-
Others	1.0	-

4. *Basis of Design – Rainfall*

Hydrologic modelling was undertaken using the 100 year Intensity Frequency Duration (IFD) data for Dampier from the Bureau of Meteorology website:

ARI (Years)	Initial Loss (mm)						
	Durations (hrs)						
	1hr	3hr	6hr	12hr	24hr	48hr	72hr
100	122.0	187.8	240.6	307.2	391.2	484.8	532.1

5. *Basis of Design – Assumptions*

Sub-catchment hydrographs calculated in the runoff module of XP Storm were routed through the channel and basin network. The conceptual arterial drainage model was developed based on the following key assumptions:

- The terrain is generally steep with varying longitudinally slope between 2% to 5%. Based on this, Culverts 334 and 335 are likely to be inlet control; that is, runoff discharges through these culverts into a free outfall condition.
- All sub-catchments upstream of A1 are combined into a single sub-catchment. This approach aims to simplify the model but at the same time will account for all sub-catchments within A. Though this is expected to generate a higher peak flow at A1 and hence a higher backwater condition, it will produce a more conservative outcome for C. Similar approach for B1 was also adopted.
- Each open drain is further divided into smaller segments to account for changes in longitudinal grades (eg. C1 comprises of 3 segments). Hydraulically this will create a more accurate model.
- As each drainage corridor varies in width, the model has adopted the smallest as the default for the entire section. For example, C1 varies between a base width of 6m downstream to a base width of 2m upstream, as such a 2m base width was adopted for the entire C1.
- Open channels are expected to be lined with rocks to manage the maximum velocities. These rocks can be sourced locally from the excavations.
- All culvert sizes and invert levels are consistent with those outlined in WISE's Dampier Drainage Design Report.

The hydraulic model network can be found in Attachment 1.

MODEL RESULTS

The 100 year 1 hour average recurrence interval (ARI) event was the critical design storm, resulting in the highest water level and peak flows in the open drains and culverts.

Given the steepness of the catchment and the free outfall condition at the discharge point, the critical storm duration is consistent with the GHD (2015) report.

The modelling shows that the flow depth generally varies between 1.09m downstream to 0.45m upstream resulting in flooded widths of 8.5m and 4.7m, respectively. Refer to Attachments 2 and 3.

This is significantly less than the 15m flooded width and 1.5m depth determined in the GHD report.

The peak flows range from 3.3 m^3/s for sub-catchment C1 to 0.67 m^3/s for sub-catchment C4. The maximum velocities vary between each segment of the open drains but are generally bell below the 2 m/s defined in the GHD report. However, it is common practice to consider the velocity-depth as means to provide a safe and operable environment rather than a singularly focus velocity condition.

The culvert sizes contained in the GHD report have generally found to be appropriate. Varying culvert sizes will have an impact on the backwater conditions (flow depths) and requires further analysis during detail design to consider any changes.

RECOMMENDATIONS

The WISE preliminary design cost estimate is summarised below, excluding survey, geotechnical, indirects and contingency.

Description	Capital Cost Estimate
1. Preliminaries	$611,000
2. Open drain remediation	**$2,713,000**
3. Culvert upgrade	**$1,485,000**
4. Crossover reinstatement	$696,000
5. Provisionals	$464,000
TOTAL	$5,969,000

As noted in the proposal, the greatest capital savings can be achieved by reviewing and re-designing the open drain remediation and this has been verified in the XP Model audit.

Based on the modelling outcomes, the open drain cross-sectional area can potentially be reduced by up to 50% from the GHD model (item 2 above).

The sub-catchment audit did not indicate large discrepancy in culvert sizing (item 3 above) but refinement could be achieved in full catchment modelling and detailed design.

The next phase of detail hydraulic modelling would enable the design of where and by how much each open drain can be optimised for excavation as well as the reduced velocities for safety consideration. As hydraulic modelling and detail design are inextricably linked, it is beneficial to undertake both exercise concurrently.

Should you have any queries please do not hesitate to contact either Dan Luong or myself.

Regards,

Giselle Degebrodt
Lead Engineer
Water Infrastructure Science & Engineering P/L

Figure 1 – XP Model Layout

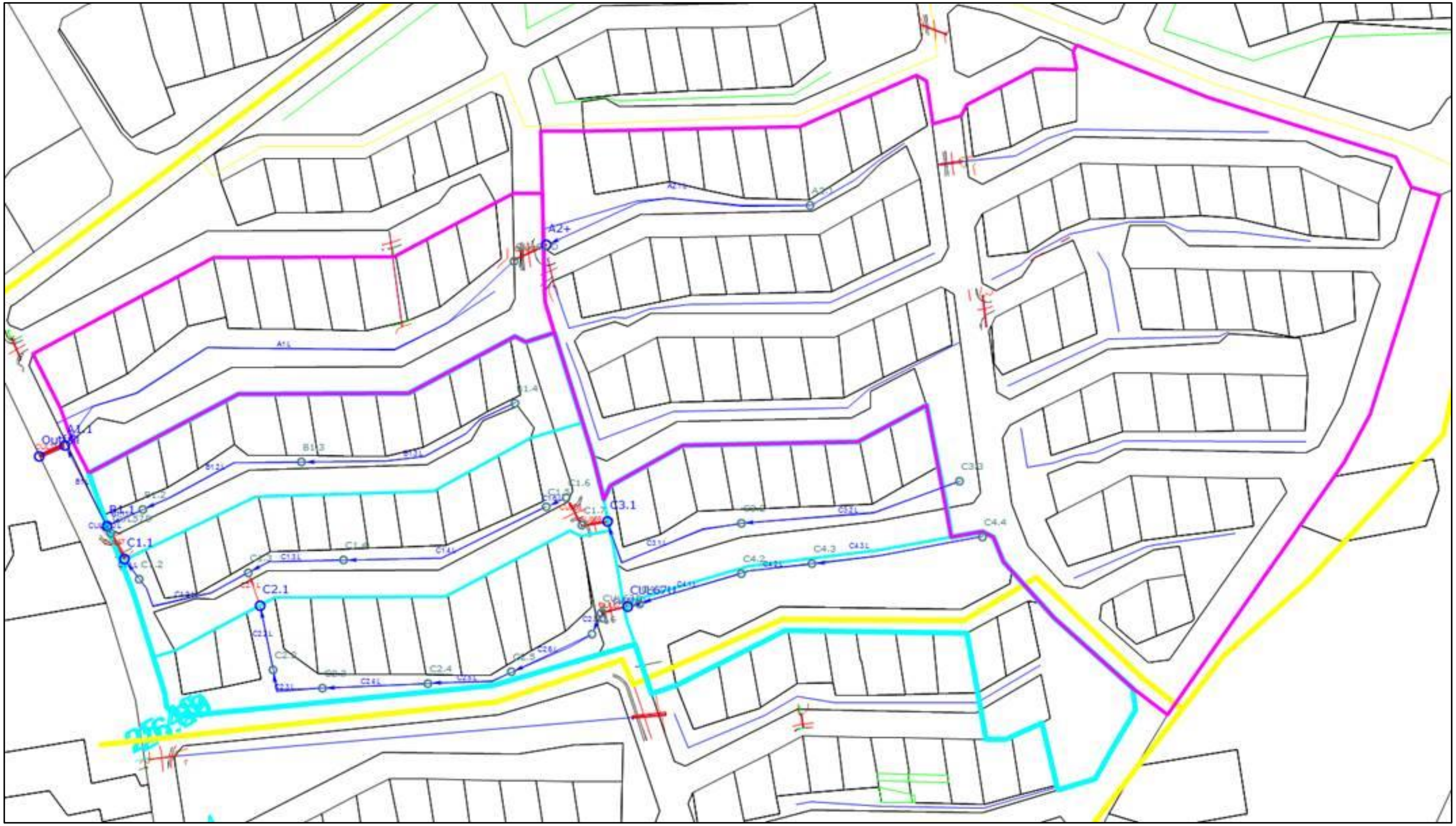
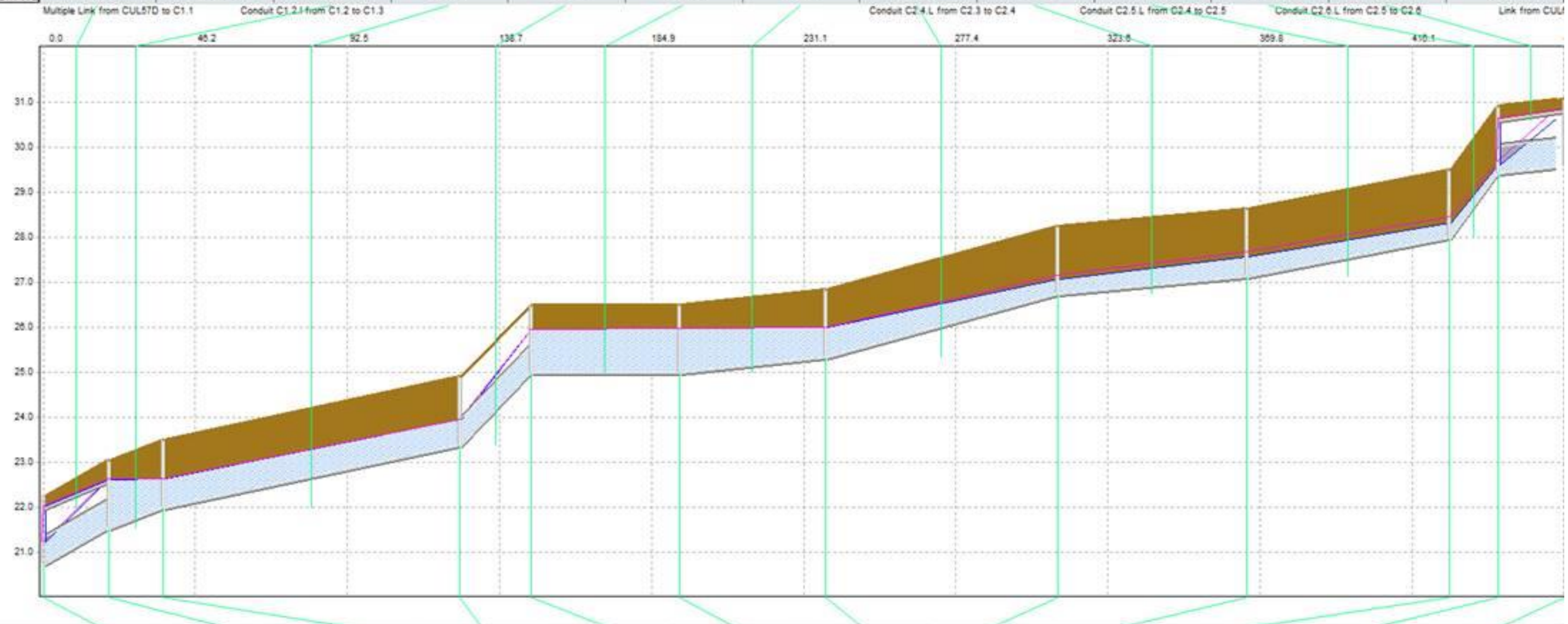


Figure 2 – Open Drain Profile for Catchment C1 to C2

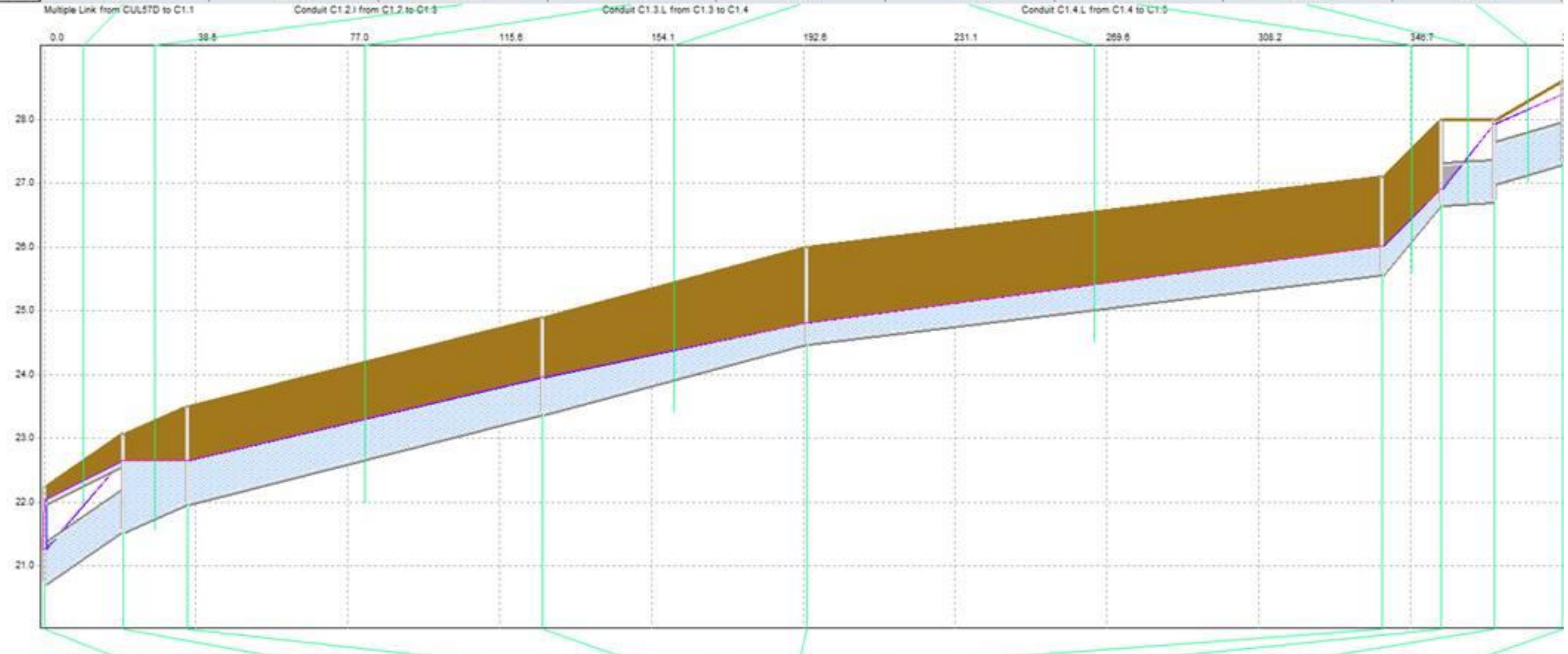
	2973.1	CUL57.w	C1.1.L	C1.2.I	C2.1.L	C2.2.L	C2.3.L	C2.4.L	C2.5.L	C2.6.L	C2.7.L	2958.1	CUL67.w
Storm	Dampier 100y1h	Dampier 100y1h	Dampier 100y1h	Dampier 100y1h	Dampier 100y1h	Dampier 100y1h	Dampier 100y1h	Dampier 100y1h	Dampier 100y1h	Dampier 100y1h	Dampier 100y1h	Dampier 100y1h	Dampier 100y1h
Link Name	CUL57	CUL57	C1.1.L	C1.2.I	C2.1.L	C2.2.L	C2.3.L	C2.4.L	C2.5.L	C2.6.L	C2.7.L	CUL67	CUL67
Max Velocity	5.150	1.590	1.590	1.570	4.020	0.590	0.860	1.430	1.040	1.310	2.430	2.510	1.050
Max Velocity *	2.702	0.076	1.009	0.951	3.033	0.327	0.537	0.722	0.494	0.648	0.868	1.966	0.063
Max Flow	3.799	0.798	3.347	3.321	2.274	1.517	1.802	1.984	2.000	2.013	2.015	1.346	0.670
Maximum Wa	22.649	22.649	22.653	23.960	25.959	25.971	26.004	27.154	27.689	28.447	29.690	30.860	30.860



	CUL57D	C1.1	C1.2	C1.3	C2.1	C2.2	C2.3	C2.4	C2.5	C2.6	CUL67D	CUL67U
Storm	Dampier 100y1h	Dampier 100y1h	Dampier 100y1h	Dampier 100y1h	Dampier 100y1h	Dampier 100y1h	Dampier 100y1h	Dampier 100y1h	Dampier 100y1h	Dampier 100y1h	Dampier 100y1h	Dampier 100y1h
Invert Elevati	20.750	21.560	22.000	23.400	25.000	25.000	25.337	26.750	27.142	28.000	29.420	29.560
Ground Eleva	22.250	23.060	23.500	24.900	26.500	26.500	26.837	28.250	28.642	29.500	30.920	31.060
Max Water El	21.263	22.649	22.653	23.960	25.958	25.970	26.004	27.154	27.688	28.447	29.689	30.860
Max Volume	0.628	1.329	0.797	0.683	1.171	1.185	0.814	0.493	0.667	0.545	0.329	1.586
Max Flow	0.000	1.468	0.000	0.000	1.177	0.000	0.000	0.000	0.000	0.000	0.000	2.026

Figure 3 – Open Drain Profile for Catchment C1 to C3

	2973.1	CUL57.w	C1.1.L	C1.2.I	C1.3.L	C1.4.L	C1.6.L	CUL68	CUL69
Storm	Dampier 100y1h	Dampier 100y1h	Dampier 100y1h	Dampier 100y1h	Dampier 100y1h	Dampier 100y1h	Dampier 100y1h	Dampier 100y1h	Dampier 100y1h
Link Name	CUL57	CUL57	C1.1.L	C1.2.I	C1.3.L	C1.4.L	C1.6.L	CUL68	CUL69
Max Velocity	5.150	1.590	1.590	1.570	1.070	0.870	1.810	2.180	2.470
Max Velocity *	2.702	0.076	1.009	0.951	0.467	0.313	0.562	1.531	2.019
Max Flow	3.799	0.798	3.347	3.321	1.107	1.112	1.150	1.153	1.155
Maximum Wa	22.649	22.649	22.653	23.960	24.813	26.013	26.903	27.936	28.403



	CUL57D	C1.1	C1.2	C1.3	C1.4	C1.5	C1.6	C1.7	C3.1
Storm	Dampier 100y1h	Dampier 100y1h	Dampier 100y1h	Dampier 100y1h	Dampier 100y1h	Dampier 100y1h	Dampier 100y1h	Dampier 100y1h	Dampier 100y1h
Invert Elevati	20.750	21.560	22.000	23.400	24.500	25.600	26.690	26.740	27.320
Ground Eleva	22.250	23.060	23.500	24.900	26.000	27.100	28.000	28.000	28.600
Max Water El	21.263	22.649	22.653	23.960	24.813	26.010	26.903	27.935	28.405
Max Volume	0.628	1.329	0.797	0.683	0.381	0.503	0.260	1.459	1.322
Max Flow	0.000	1.468	0.000	0.000	0.000	0.000	0.000	0.000	1.157