Technical Memo

AMBERFIELD

Water Balance Assessment

TO:	Caleb Clark	**HG PROJECT NO :**	9820 141842 01
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1.0 INTRODCUTION

This memo is intended to provide additional water balance analysis to support the written response by HG (17 August 2018) to the s92 request by HCC (5th July letter - Post Development Flow Assessment Items 10-12 and Item 89) and by WRC (15th June letter - Item 9).

A summary of the previous HG response so far is provided below in italics for context:

> *The base flow changes are expected to be minimal, this is because we are maintaining existing groundwater catchments directed to the freshwater streams to be retained. Plan number SK312 and SK313 show the existing catchments and stream classifications. The post development (following earthworks) catchments are also shown for comparison on SK314-315.*
>
> *For example - the post development topography on the west side of the island continues to flow towards the stream – See post development catchments (Area 5, 6, 12) in Plan SK315. Compare with the existing sub-catchments 11, 10 and 5 in Plan SK313. Sub catchment 7 is also reinstated post development to ensure base flow to the intermittent watercourse.*
>
> *As for the response under Item 10, the post development runoff hydrographs up to the 2yr LOS will be managed within road reserve soakage systems following pre-treatment and within 10yr soakage systems on each private lot.*
>
> *The intention is to mimic and retain base flow to streams as much as can be reasonably achieved, bearing in mind that the remaining streams are relatively short. The key factor is to ensure the post development catchments continue to allow groundwater to flow under gravity towards the full length of the stream. Plans SK312 and SK313 show the existing sub-catchment boundaries (1-11), the stream classification and the post development catchment boundaries (light blue dashed lines) and secondary flow arrows (dark blue arrows) are shown in Plan SK314-315.*

2.0 BACKGROUND

The water balance is relatively simple. It is based on discrete event analysis (10 min rainfall and infiltration time series) using Chicago rainfall profiles assuming uniform distribution over the catchment across a range of storm durations. We have not undertaken a continuous simulation model of rainfall runoff. It is acknowledged that this would provide some more detail in relation to seasonal and diurnal patterns taking into account the antecedent conditions. However for the purposes of understanding pre and post development hydrographs, discrete event analysis is considered reasonable.

The main assumption being that once infiltration capacity is exceeded, runoff reaches the stream. The infiltration capacity is based on the geo-technical assessment multiplied by a factor of safety of 4 for design. Reducing observed soakage rates by 4 to inform when 'runoff is triggered' is reasonable and is applied also for the existing scenario given the unknowns related to soil compaction, stocking rates and seasonal differences all of which could reduce soakage through the in situ surface soils across the farm. Also the topography is a flat river terrace with minimal depression or ponding areas.

An excel spreadsheet is attached to this memo to provide further information on the background calculations and time series. The following summary is provided for each worksheet in relation to the attached .xls file *"20181016 Water Balance - Catchment Breakdown.xlsx"*:

Worksheet 1: 'Summary Tables' of rainfall runoff volumes across a range of storm durations with summary notes provided in s1.0 below. Rainfall runoff is based on catchment area, soil type, infiltration ('reduced rates' geo-tech report/AWA ICMP) and time of concentration.

Worksheet 2: 'Sub catchment breakdown' provides the area for each soil type.

Worksheet 3: 'Infiltration-Runoff Assessment'. The rainfall volume generated for each sub catchment per 10 minute time step compared to the infiltration loss for that same 10 minute time period. A 'Runoff Volume' to the receiving environment is recorded only when rainfall intensity exceeds infiltration capacity – noting infiltration capacity for both pre and post is assumed to be reduced by a safety factor of 4 in accordance with Section 7.2 of the ICMP.

3.0 SOAKAGE & GROUNDWATER REPORTS – INFLUENCE ON RAINFALL-RUNOFF

- Perched and transitory water levels do occur across the site.
- Groundwater levels need to be managed to allow free soakage with each device.
- Allophanic interbedded clays creating perched water tables.
- Sandy soils are commonly found in greater thicknesses and frequency in the eastern portion of the site, and cohesive (silt and clay) soils are more prominent in the western portions of the site.
- Soakage testing (as used in this analysis) undertaken near the end of a particularly wet year, i.e. soakage potential may be underestimated and a factor safety of 4 was used for the rainfall infiltration versus runoff assessment. This means the pre-development infiltration is conservative – higher chance of runoff being generated and the post development will also be conservative because larger soakage devices will be sized using safety factor.
- Pumice quantities in the soil are low and adverse effects on soakage should be negligible.
- The intermittent to permanent Stream 2 does not generate the volumes required (small porous sub catchments) to create a typically shaped bank full channel.
- Once infiltration capacity is exceeded for any 10minute interval, the assumption is runoff volume reaches the stream by way of overland flow. This could be an over estimate considering ponding is likely to occur on the flatter terrace slopes. This could be balanced somewhat however by assuming constant infiltration across steeper areas also.

VARYING INFILTRATION DUE TO MIX OF SOIL TYPES (AWA ICMP):

SK04 & SK07 silt loam and clay loam (146 / 205 mm/hr)

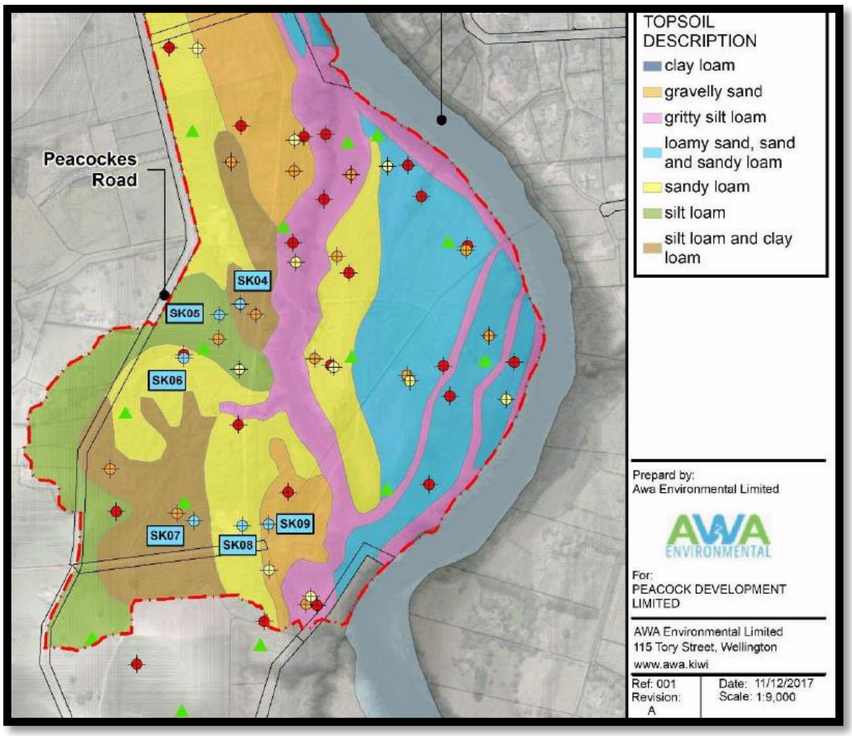
SK05 silt loam (102 mm/hr)

SK06 & SK08 sandy loam (234 / 372 mm/hr)

SK09 gravelly sand (537 mm/hr)

Test Site	Test mm/hr	Reduction Factor @ 25% mm/hr	Comments
SKT 1	2320	500	Loamy Sand
SKT 2	330	83	Sandy Loam
SKT 3	533	133	Silt Loam & Clay Loam
SKT 4	146	37	Silt Loam & Clay Loam
SKT 5	102	26	Silt Loam
SKT 6	234	60	Sandy Loam
SKT 7	205	50	Silt Loam & Clay Loam
SKT 8	372	93	Sandy Loam
SKT 9	537	134	Gravelly Sands

Table 5 Soakage testing results



Looking North along Stream 2 'Intermittent Section' showing seepage pool and no defined low flow channel.

4.0 RESULTS DISCUSSION

- The result Table 1 below is also provided in Worksheet 1 in the .xls along with other data tables for soil type, infiltration rate and runoff volumes. A Chicago 'nested' hyetograph which incorporates short intense durations (10 minutes) as well as less intense longer durations out to 24 hours.
- The results are based on the existing soil and soakage conditions compared to rainfall intensity to estimate the % of runoff versus infiltration. There is no post development runoff model. The assumption being the proposed soakage design will replicate the existing soakage conditions given

the proper functioning of the soakage devices and reinstatement of top soils as per the in situ soil conditions.

- Table 1 shows that the majority of the rainfall infiltrates to ground in the existing landuse scenario. As expected for the water quality and 50% AEP events, the % of rainfall converted to overland flow runoff is minimal and certainly far less than for the 1% AEP event.
- Runoff to the stream during the WQ and 50% AEP events is very small and, given the uncertainties (antecedent conditions, topography etc) could be considered as negligible.
- For the post development scenario, runoff during the WQ and 50% AEP events will be also minimal, with all flow (minus evaporation) contributing to either through flow or base flow recharge via soakage devices for the impervious areas combined with natural soakage from the remaining porous areas ie. Gardens and roadside berms.
- For the post development scenario, private lots make up the majority of the catchment areas draining to Stream 2. These lots will manage soakage to ground up to a 10% AEP event. The road reserves soak to ground up to the 50% AEP event (via linear trenches or communal basins). During a 10% AEP event there will be a 'balance of runoff' from the road reserves which will discharge to the stream via the overflow pipe network (stormwater reticulation plans showing outlet locations within the island gully have bene previously provided).
- It is intended that this volume, along with any residual runoff from the post development porous areas (given suitably reinstated topsoil) will replicate conditions similar to existing with a limited runoff volume reaching Stream 2 during a 10% AEP event (currently this volume is approximately 1,617m3 from Table 1).
- The total road carriage area within sub catchments 5,6,10 and 11 is 2.75ha, the residual volume (2yr total rain depth minus 10yr total rain depth) is 880m^3. This runoff volume is approximately half the existing volume estimated to runoff from the entire area (Table 1) but it does not include residual from the post development porous areas. The volume from the road reserve is considered therefore to be of the right order to provide a sweetening flow to the stream.

TABLE 1: RAINFALL-RUNOFF ASSESSMENT SUMMARY (EXISTING)

	RAINFALL VOLUME (M^3)	RUNOFF VOLUME (M^3)	% CONVERTED TO RUNOFF
WQ	9,552.74	55.60	0.6%
50% AEP	28,658.23	718.50	2.5%
10% AEP	43,029.25	1,617.23	3.8%
1% AEP	71,519.89	4,523.21	6.3%

5.0 CONCLUSIONS

- Given the generally porous geology, flat topography and small catchment area – runoff to Stream 2 is negligible across a range of return periods and storm events. This is not surprising as our site visit revealed a wide gully wetland area with no defined low flow channel indicating no rapid runoff response during regular rain events to generate channel forming flows.
- Some limited runoff is expected during larger events however these flows are expected to spread out across the gully floor with low risk of bed or bank erosions due to the absence of these features.
- The focus of the stormwater network is to recharge base flow to ensure the intermittent and permanent water sources are retained for environmental flow and the life supporting capacity of the stream. This flow regime is important so that new planting and restoration of the gully can thrive into the future.
- It is interesting to note that the gully is a remnant feature which was shaped during the active channel forming 'incision' phase of the Waikato River. I understand there is some debate as to whether the gully separating the island was shaped at all by hydrological processes. An alternative theory presented by geo-technical experts is that seismic activity may have created the gully.