

22 September 2017

Ref: WE1769-01

Kotare Properties Ltd
C/- Bloxam Burnett and Oliver
PO Box 9041
Hamilton 3240

Attn: Kathryn Drew

PROPOSED RESIDENTIAL SUBDIVISION – KOTARE PROPERTIES - 100 SWAYNE ROAD, CAMBRIDGE – STORMWATER MANAGEMENT PLAN

1 INTRODUCTION

Wainui Environmental have been engaged by Kotare Properties Ltd to prepare a stormwater management plan for the proposed 56 Lot residential subdivision located at 100 Swayne Road, Cambridge.

1.1 Background Reports

A memo prepared by Opus titled '86 Swayne Road -Stormwater Design Guidance' and dated June 2014 provided recommendations for stormwater management for the subject site and wider development area to ensure the design is consistent with the preliminary design requirements in the Cambridge North Residential Area (CNRA) stormwater model (refer memo attached).

Further requirements for the CNRA are presented in a report titled 'Phase 2 Preliminary Stormwater Design' prepared by Opus, dated May 2014.

The stormwater management methodology for the Kotare Properties Ltd development is consistent with requirements of the above documents.

1.2 Existing Site Description

The site is located at the northern extents of the Cambridge North Residential Zone.

Street Address -	100 Swayne Road, Cambridge
Legal Descriptions -	LOT 1 DPS 58005, LOT 2 DP350390 & LOT 1 DP 487104
Site Area -	4.11Ha
Local Authority -	Waipa District Council (WDC)

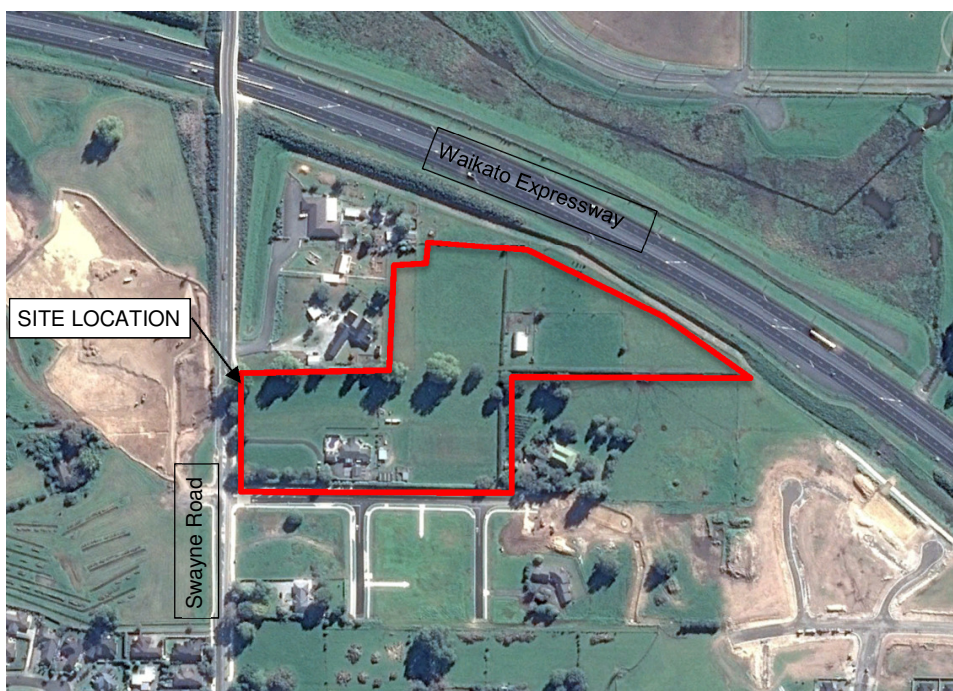


Figure 1: Site Location (Source Google maps)

The topography of the site is generally characterised by predominantly flat, undulating terrain. There is a wide and shallow basin approximately 1.0m deep located in the middle of the site, with the surrounding land generally falling toward this low point. Levels across the site typically range from RL66.6 to RL68.4m.

There is an existing dwelling with a garage, two farm sheds and several other small buildings on the site. The remainder of the site is in pasture, with the main land use being grazing. All structures, and associated hardstand areas will be removed as part of the proposed subdivision works.

The subject site is generally surrounded by a mixture of new residential subdivisions, rural/lifestyle residential properties, and farmland. The Cambridge Section of the Waikato expressway borders the site to the north-east.

An existing constructed swale borders the northern boundary of the site and discharges under the Expressway via a culvert to a constructed stormwater wetland. The wetland ultimately discharges to the Mangaone Stream to the north.

Refer to the topographic survey information on drawing WE1769-01-100 for further details.

1.3 Proposed Development

It is proposed to subdivide the site into 56 residential allotments ranging in size from 500m² to 600m². Refer Nicklin CE Scheme Plan attached for further details. Access to the subdivision will be provided from Rose Leigh Drive.

2 STORMWATER MANAGEMENT METHODOLOGY

2.1 Stormwater Management Requirements

In accordance with the Waipa Subdivision and Development Manual and the Cambridge North Residential Area Phase 2 Preliminary Stormwater Design¹ the following stormwater management is required for the development;

Table 1. CNRA Stormwater Design Philosophy

Parameter	Design LOS
Minimum design capacity for public primary reticulation	Primary piped reticulation designed to 20% AEP.
Minimum design capacity for secondary stormwater system	2% AEP for secondary overland flow paths.
Minimum building floor levels	2% AEP for industrial, commercial and habitable floors.
Minimum freeboard allowance	500mm for all cases.
On-site soakage	On-site soakage designed for 10% AEP at all sites where testing indicates at least 80mm/hr infiltration and suitable groundwater levels. Consideration of alternative solutions where on-site soakage is unsuitable.
Overland flow paths	Overland flow path provided within the road corridor with unrestricted connectivity to swales.

¹ Cambridge North Residential Area Phase 2 Preliminary Stormwater Design-OPUS Ltd 2013

2.2 CNRZ Soakage Zones

The CNRZ On-site stormwater soakage guidelines provides a map showing soakage potential across the CNRZ area (refer Figure 6.2 below). The map shows the south-west corner within Zone B (Average Permeability, intermediate to deep ground water levels) with the remaining area within Zone C (Poor permeability, shallow groundwater).

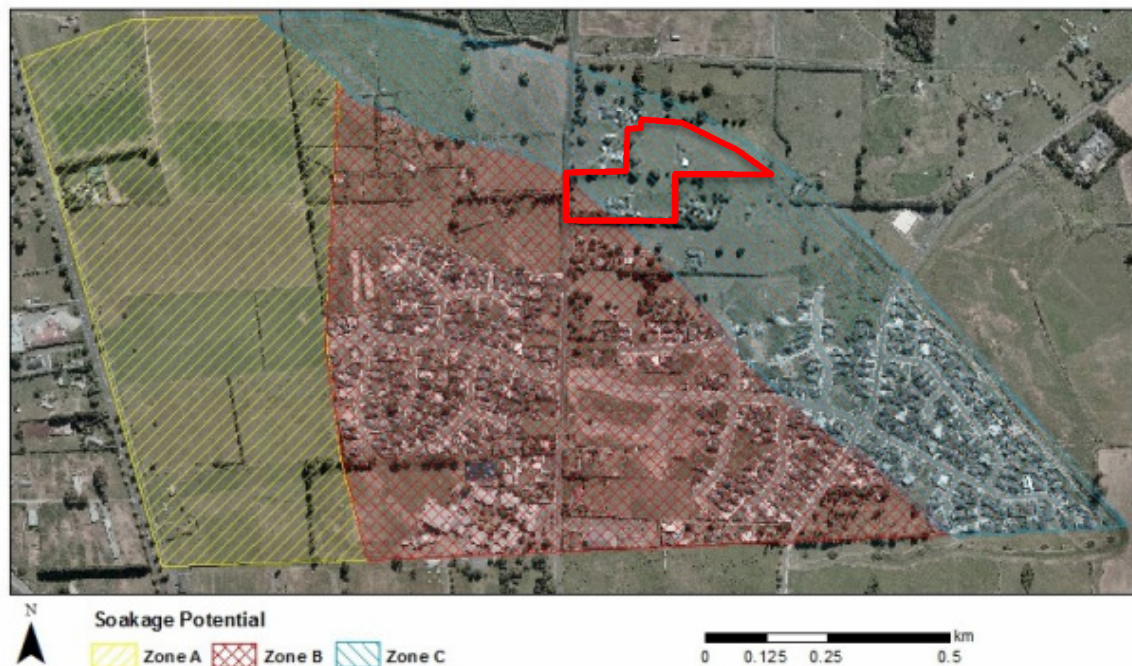


Figure 2: Preliminary assessment of the soakage potential across the CNRZ based on both soil permeability and depth to groundwater.

Results from the site specific testing (as outlined below) however show better than anticipated soakage potential across the subject site.

2.3 Soil investigations and Soakage Suitability

Soil investigations and soakage testing on the site was undertaken by Wainui Environmental Ltd in September 2017 in accordance with the Cambridge North Residential Zone Method outlined in the Cambridge North Residential Zone On-site Stormwater Guidelines.

The weather leading up to the site testing can be characterised as notably wet, with rainfall totals in July and August above historic averages and 2016 records. As such, groundwater elevations were considered to be generally be high winter levels.

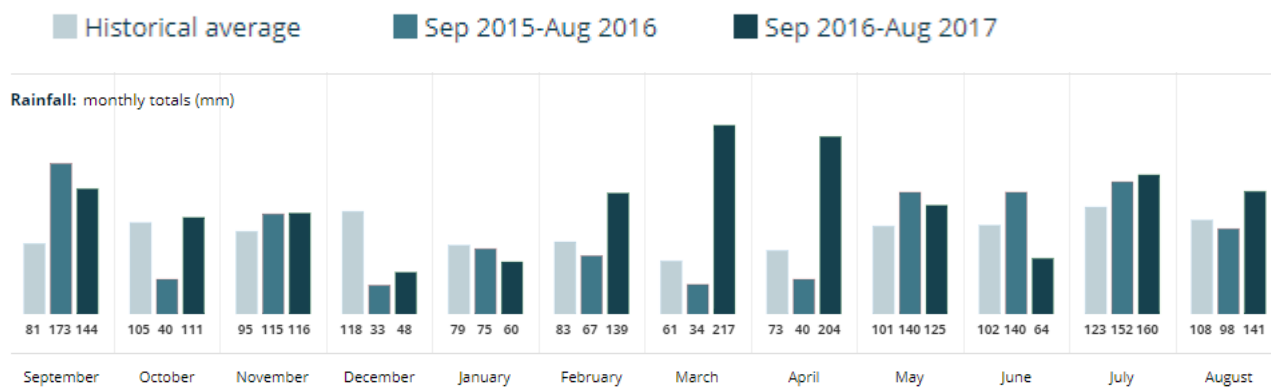


Figure 3: Monthly Rainfall Totals: Hamilton Airport (Source: www.metservice.com)

Fourteen (14) hand augers were drilled to a maximum depth of 2.0 meters. Soils found within the boreholes generally consisted of generally 200-300mm of topsoil overlying silts and gravelly sands. The water table was encountered within five of the boreholes at depths ranging from 1.50-1.80m below ground level.

Falling Head Permeability tests were undertaken within all the drilled boreholes to determine the capacity of the soils to receive concentrated stormwater flows over time. Table 1 below presents the results of the soakage testing. Refer to the attached borehole logs and soakage plots for further details.

Table 1: Soakage Testing and Groundwater Assessment

Soakage Test	Proposed Lot no.	Hole Depth (m)	Water Table Depth (m)	Collapsed borehole depth(m)	Depth soakage test drained (m)	Soakage Rate (l/m ² /min)	Soakage Suitability Category G = Good M=Moderate
ST-01	1	2.0	-	-	1.80	6.45	G
ST-02	12	2.0	-	-	1.65	0.53	M
ST-03	27	2.0	1.80	-	1.65	0.55	M
ST-04	29	2.0	1.50	-	1.50	0.80	M
ST-05	32	2.0	-	-	2.00	2.14	G
ST-06	54	2.0	-	1.90	1.90	22.22	G
ST-07	51	2.0	1.50	1.60	1.20	0.56	M
ST-08	11	2.0	1.75	-	1.65	1.0	M
ST-09	47	2.0	1.80	1.80	1.80	5.74	G
ST-10	37	2.0	-	1.80	1.80	1.63	G
ST-11	40	2.0	-	1.75	1.75	1.88	G
ST-12	16	1.5	-	1.40	1.40	2.78	G
ST-13	21	2.0	-	1.95	1.95	4.55	G
ST-14	24	2.0	-	1.90	1.90	3.91	G

The test results indicate that the soils found across the site have varying soakage rates between 0.53 l/m²/min and 22.22 l/m²/min. The results from the falling head tests are all above the minimum soakage threshold of 0.5 litres/m²/min mm/hr specified in the WDC On-Site Stormwater Soakage Guidelines; 7. Design Standards CNRZ.

The testing revealed two distinct areas of soakage:

- Good Soakage Areas – Generally located on the higher land at the north, east and western extents of the development. Soils characterised by a layer of silt to 0.9-1.1m depth, overlaying medium-course sands with some gravels (>=1.0m deep). Water table depths >2.0m below existing ground levels. Soakage rates were generally between 1.0-6.0l/m²/min.
- Moderate Soakage Areas - Located within the lower central part of the site. Soils were characterised by thicker layers of silts and higher groundwater levels (1.5-1.8m below ground level). Soakage rates were generally between 0.5-1.0l/m²/min.

Refer to the attached Site Plan for soakage test locations and delineated soakage zones.

2.3.1 Groundwater Depth

Based on an assessment of the borehole locations and relative RL's, it is anticipated that the winter high ground water table is at RL65.30-65.60m across the subject site.

2.4 Stormwater Management Philosophy

Stormwater disposal by soakage is the preferred primary stormwater disposal option throughout the CNRZ. Based on the results of the soakage testing, and in accordance with the Stormwater Design Guidance² the following stormwater management system is proposed for the development;

1. Onsite soakage shall be utilised on each individual lot as a primary method of stormwater disposal. Recommended design requirements for lots in each zone are presented below:
 - Good Soakage Areas (proposed Lots 1-6, 13-25, 31-47, 56) - On-lot soakage systems designed for the **10% AEP (10 Year ARI) event** with no reticulated lot connection.
 - Moderate Soakage Areas (proposed Lots 7-12, 27-30, 48-55) - **Reduced** on-lot soakage systems designed for the **50% AEP (2 year ARI) event** with a high level overflow provided to the reticulated SW system in the road.
2. Piped reticulation within the road network designed for the 20% AEP (5 year ARI) event, discharging to the constructed swale at the north boundary.
3. Secondary overland flows to be conveyed by the road network, directing flows to the constructed swale at the northern boundary.

2.5 On-Lot soakage system design recommendations

Design of on-site soakage system shall be undertaken in accordance with the Waipa District Council 'On-site Stormwater Soakage Guidelines' for CNRZ.

The soakage systems will need to be designed at Building Consent stage. Additional percolation testing will be required to confirm soakage rates for design purposes.

2.5.1 Good Soakage Areas

Each lot in the "Good Soakage" area delineated on the attached plan shall have a soakage system designed for the 10% AEP (10 year ARI) event for all impervious areas on the site (both roof and hardstand).

All lots will be required to have a strip drain on the driveway at the site boundary to collect surface water flows. The system will need to be configured to ensure that flows exceeding the capacity of the soakage system can bubble up and discharge to the road network in a controlled manner.

2.5.2 Moderate Soakage Areas

Although there is a reduced soakage potential across this area, soakage is still considered a viable method of stormwater disposal, subject to the following recommendations:

- Reduced design storm - soakage system shall be designed to receive roof water and hardstand runoff from each lot for the 50% AEP event.
- The soakage systems shall be kept as shallow as possible, ideally no deeper than 1.5m below natural ground levels.
- A high level overflow is provided to allow for periods when the water table is elevated and soakage rates are reduced. The overflow shall be connected to the site SW connection and discharged to the reticulation within the Road corridors.

To quantify the likely soakage system required within the moderate soakage zone, a generic design has been undertaken for a 500m² lot area with an assumed 70% impervious area. The system has been designed based on an average soakage rate of 60mm/hr (1.0L/m²/min) and 2 year ARI design event. A summary of required dimensions for a gravel filled soakage trench is presented below.

² Opus Memo titled '86 Swayne Rd – Stormwater Design Guidance', dated 11 June 2017.

- 2.0m wide x 1.3m deep x 7.5 m long trench (total volume of gravel = 19.5m³)

2.5.3 Piped Drainage Network

Runoff from the road surfaces and any runoff not collected by the on-lot systems shall be collected via catchpits within the road corridor and conveyed via underground SW reticulation discharging to the existing swale located over the north-eastern boundary of the site.

Lot SW connections shall be provided for all lots within the moderate soakage zone (Lots 7-12, 27-30, 48-55) discharging to the SW reticulation within the road. Due to the reduced soakage potential, it is recommended that the SW reticulation is sized assuming the on lot soakage systems within the moderate soakage areas are at capacity.

The pipe network shall be designed for the 20% AEP event in accordance with the Cambridge North Design Guidelines.

Preliminary sizing of the network has been undertaken based on the contributing catchment of 1.89 Ha (Roads and lots within the moderate soakage areas) for the 20% AEP, 10 minute event. Calculations show a 525mm diameter pipe is required with a minimum grade of 0.67% to convey these flows to the north-eastern swale.

Detailed pipe design shall be undertaken as part of engineering design. Design will need to consider the effect of water levels in the receiving swale and associated backwater effects.

3 Secondary Overland Flow

Secondary overland flows within the subdivision shall be conveyed to the Road carriageway where they will be conveyed to the north eastern end of the site discharging to the swale. The Road network will need to be designed to accommodate the 2% AEP event.

A suitable overland flow path will need to be constructed through the reserve area to discharge flows to the swale.

Design of the secondary overland flow network will also need to allow for external flows conveyed through the site from surrounding properties and roads.

4 Minimum Floor Levels and Freeboard

The OPUS Stormwater report states that the 500mm freeboard shall be applied from the top of the kerb **OR** the maximum model flood level, whichever is higher, as shown below.

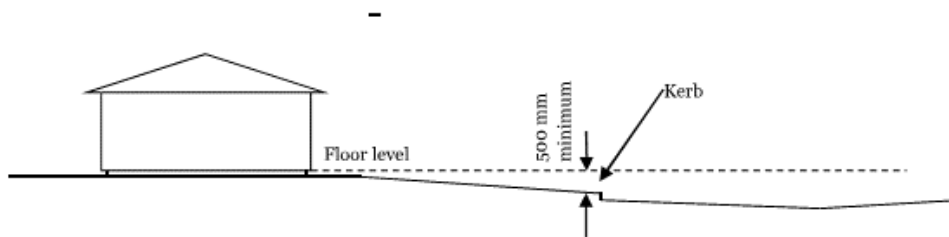


Figure 2: Minimum Floor Level set from Top of Kerb (NTS)

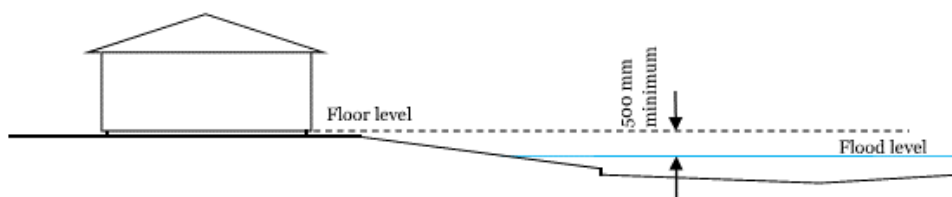


Figure 4: Minimum Floor Level set from Flood Level (NTS)

Figure 4: Freeboard requirements (Source: Opus Memo '86 Swayne Rd – Stormwater Design Guidance')

Confirmation of regional flood levels across the subject site will need to be obtained from Waipa District Council prior to setting minimum FFL's. If regional flooding does not affect the subject site, the 'flood level' will need to be set based on the depth of overland flow within the Road corridor. When the overland flow is contained below the top of kerb, the 500mm freeboard will need to be applied from the top of the kerb.

We trust the above is to your satisfaction. Should you require any further information please do not hesitate to contact the undersigned.

Yours faithfully

WAINUI ENVIRONMENTAL LTD

A handwritten signature in black ink, appearing to read 'H Vink', written in a cursive style.

Hayden Vink

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SWAYNE ROAD
Legal Road Sealed and In Use

RIPRAP
STORMWATER
OUTLET INV OUT
RL=66.27

Ex. SWMH
LL=68.37
LL=66.35

OVERHEAD POWER

ROSE LEIGH DRIVE

Legal Road Sealed and In Use

LEGEND:



20% AEP PIPED STORMWATER NETWORK CATCHMENT



OVERLAND FLOW

This drawing is confidential and shall only be used for the purposes of this project.

SCALE (AT ORIGINAL SHEET SIZE)

SHEET
SIZE

A1

NOTES

SCALE 10 0 10 20 1500

No.	BY	DATE	DESCRIPTION	APPD
A	H.V	22/09/2017	ORIGINAL ISSUE	

DESIGNED	HV	CHECKED	
DRAWN	JO	CHECKED	
APPROVED	HV	DATE	22/09/2017



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www.wainuienvironmental.co.nz

CLIENT
KOTARE PROPERTIES LTD

PROJECT
100 SWAYNE ROAD,
CAMBRIDGE

STORMWATER MANAGEMENT PLAN

Status
PRELIMINARY

DRAWING NUMBER
WE1769-01-100

Rev.
A

PERCOLATION TEST RESULTS



Client:	Kotare Properties Ltd	Tested bY:	AM/CB
Project:	100 Swayne Road, Cambridge North	Date Tested:	4 September, 2017
Job No.	WE1769	Revision:	A

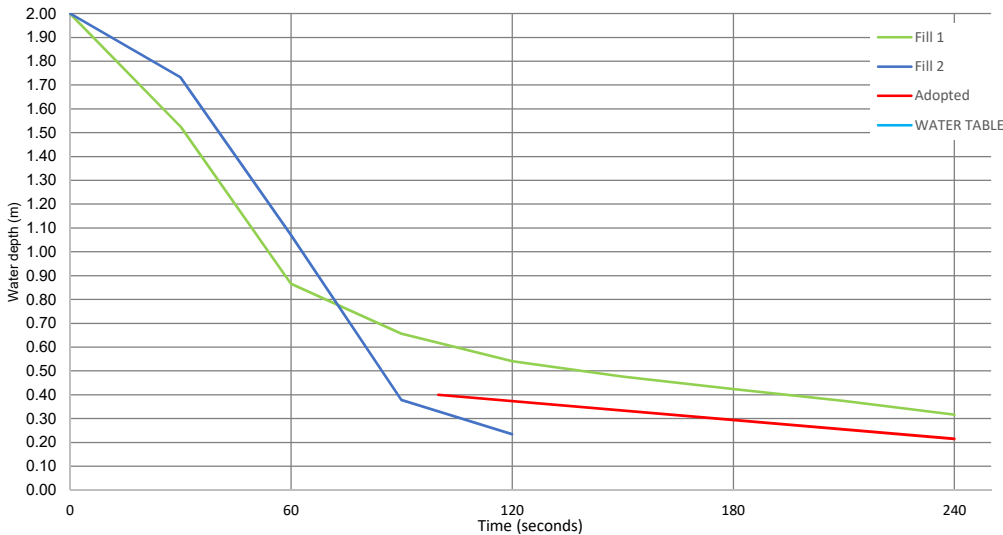
Test No. **ST-01** **Lot 18**

Test carried out in accordance with On-site Stormwater soakage Guidelines - Cambridge North Residential Zone

Falling head test	
y	Hole is pre-soaked for at least 4 hours in winter and 17 hours in summer, and then for 10 minutes immediately prior to the test
y	Drop in water level is recorded at intervals of 30 minutes or less
y	Test is continued for 4 hours or until holes is empty
y	Stop test or refill hole when water level is 0.35m above the base of the bore
y	Test is repeated at least 3 times or until a constant drainage curve is obtained
y	Soakage rate is determined from the minimum slope of the curve

Field Notes:
Hole drained extremely quickly.
No water table observed.

Depth of hole: 2.00 m
Water table depth: m



Soil Log		WT
Depth (m)	Soil Description	
0.0m	0.0 TOPSOIL, Brown, Dry, Soft	
	0.250 SILT, Orangey Brown, Dry, Friable, Traces of sand	
0.5m		
1.0m	0.800 Med-Coarse SAND, Creamy Brown/Grey, Moist Traces of gravel up to 30mm	
1.5m	Moisture Increasing With Depth	
2.0m	End of log 2.0m	

Percolation Rate Calculation:

Time (s)	Water Depth (m)
100	0.400
240	0.215

Minimum Slope - Lower
Minimum Slope - Upper

Bore Hole Diameter: 0.100 m
Minimum Gradient: 1.3E-03 m/s = 0.08 m/min
Soakage Rate =

$$k = \frac{D \times \text{gradient} \times 1000}{4 \times d \quad **}$$

k	=	6.45 l/m ² /min
	=	386.76 mm/hr



PERCOLATION TEST RESULTS



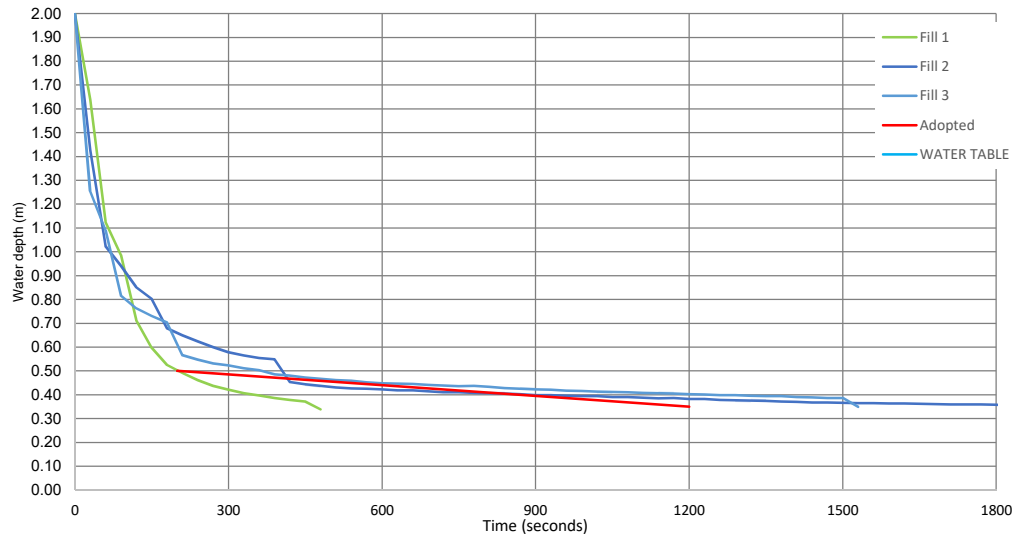
Client: Kotare Properties Ltd
Project: 100 Swayne Road, Cambridge North
Job No. WE1769

Tested bY: AM/CB
Date Tested: 4 September, 2017
Revision: A

Test No. **ST-02** **Lot 12**

Test carried out in accordance with On-site Stormwater soakage Guidelines - Cambridge North Residential Zone

Falling head test	
y	Hole is pre-soaked for at least 4 hours in winter and 17 hours in summer, and then for 10 minutes immediately prior to the test
y	Drop in water level is recorded at intervals of 30 minutes or less
y	Test is continued for 4 hours or until holes is empty
y	Stop test or refill hole when water level is 0.35m above the base of the bore
y	Test is repeated at least 3 times or until a constant drainage curve is obtained
y	Soakage rate is determined from the minimum slope of the curve



Percolation Rate Calculation:

Time (s)	Water Depth (m)
200	0.500
1200	0.350

Minimum Slope - Lower
Minimum Slope - Upper

Bore Hole Diameter: 0.100 m
Minimum Gradient: 1.5E-04 m/s =

0.01 m/min

Soakage Rate =

$$k = \frac{D \times gradient \times 1000}{4 \times d} \quad **$$

k	=	0.53 l/m ² /min
	=	31.76 mm/hr

Field Notes:

Hole drained freely

Signs of water present from approximately 1.5m

Depth of hole: 2.00 m
Water table depth: m

Soil Log

Depth (m)	Soil Description	WT
0.0m	0.0 TOPSOIL, Brown, Dry, Soft	
0.5m	0.350 SILT, Light Brown, Friable, Moist Moisture increasing with depth	
1.0m	1.000 sandy SILT Loam, Moist, Grey Moisture increasing with Depth	
1.5m	Saturated Soils at 1.500m	
2.0m	End of log 2.0m	



PERCOLATION TEST RESULTS



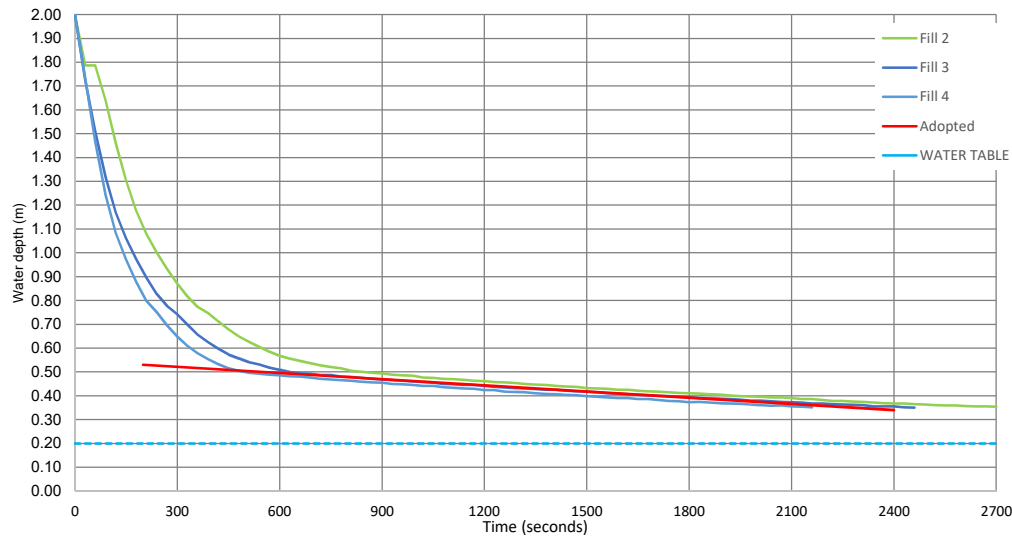
Client: Kotare Properties Ltd
Project: 100 Swayne Road, Cambridge North
Job No. WE1769

Tested by: AM/CB
Date Tested: 4 September, 2017
Revision: A

Test No. **ST-03** **Lot 27**

Test carried out in accordance with On-site Stormwater soakage Guidelines - Cambridge North Residential Zone

Falling head test	
y	Hole is pre-soaked for at least 4 hours in winter and 17 hours in summer, and then for 10 minutes immediately prior to the test
y	Drop in water level is recorded at intervals of 30 minutes or less
y	Test is continued for 4 hours or until holes is empty
y	Stop test or refill hole when water level is 0.35m above the base of the bore
y	Test is repeated at least 3 times or until a constant drainage curve is obtained
y	Soakage rate is determined from the minimum slope of the curve



Field Notes:
Hole observed to drain slowly

Depth of hole: 2.00 m
Water table depth: 1.80 m

Soil Log		WT
Depth (m)	Soil Description	
0.0m	0.0 TOPSOIL, Brown, Dry, Soft	
0.5m	0.250 clayey SILT, Orange/Creamy Brown, Dry, Friable Less clay content with depth Colour changing to Grey with depth Chaning to a Grey sandy SILT, loamy	
1.0m	Moisture increasing with depth	
1.5m		
2.0m	1.800 silty Med-Coarse SAND, Grey, Wet GW Encountered at 1.800m	
End of log 2.0m		

Percolation Rate Calculation:

Time (s)	Water Depth (m)
200	0.530
2400	0.340

Bore Hole Diameter:
Minimum Gradient:
Soakage Rate =

0.100 m

8.6E-05 m/s =

0.01 m/min

$$k = \frac{D \times \text{gradient} \times 1000}{4 \times d} \quad **$$

k	=	0.55 l/m ² /min
	=	33.08 mm/hr

Note: d=distance between mid point of last two readings and WT



PERCOLATION TEST RESULTS

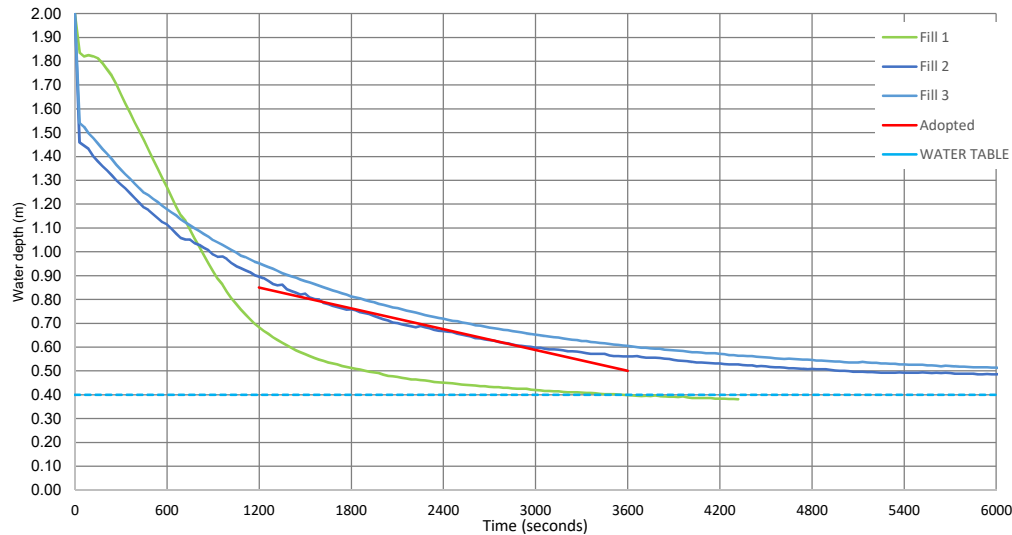


Client:	Kotare Properties Ltd	Tested bY:	AM/CB
Project:	100 Swayne Road, Cambridge North	Date Tested:	4 September, 2017
Job No.	WE1769	Revision:	A

Test No. **ST-04** **Lot 29**

Test carried out in accordance with On-site Stormwater soakage Guidelines - Cambridge North Residential Zone

Falling head test	
y	Hole is pre-soaked for at least 4 hours in winter and 17 hours in summer, and then for 10 minutes immediately prior to the test
y	Drop in water level is recorded at intervals of 30 minutes or less
y	Test is continued for 4 hours or until holes is empty
y	Stop test or refill hole when water level is 0.35m above the base of the bore
y	Test is repeated at least 3 times or until a constant drainage curve is obtained
y	Soakage rate is determined from the minimum slope of the curve



Field Notes:
Water table encountered.
Water dispersed quickly though sandy layers above water table.

Depth of hole: 2.00 m
Water table depth: 1.60 m

Soil Log		WT
Depth (m)	Soil Description	
0.0m	0.0 TOPSOIL, Brown, Dry, Soft	
0.5m	0.400 Clayey SILT, Light Brown, Moist, traces of Sand Mottled Light Brown/Orangey Brown at 0.600-1.100	
1.0m	1.100 silty Med-Coarse SAND, Light Brown, Very Moist	
1.5m	1.500 SILT loam, Grey, Wet, Fine	
2.0m	End of log 2.0m	GW Encountered @ 1.6m

Percolation Rate Calculation:

Time (s)	Water Depth (m)
1200	0.850
3600	0.500

Bore Hole Diameter: 0.100 m
Minimum Gradient: 1.5E-04 m/s = 0.0088 m/min
Soakage Rate =

$$k = \frac{D \times \text{gradient} \times 1000}{4 \times d} \quad **$$

Note: d=distance between mid point of last two readings and WT

k	=	0.80 l/m ² /min
	=	47.73 mm/hr



PERCOLATION TEST RESULTS



Client:	Kotare Properties Ltd	Tested bY:	AM/CB
Project:	100 Swayne Road, Cambridge North	Date Tested:	4 September, 2017
Job No.	WE1769	Revision:	A

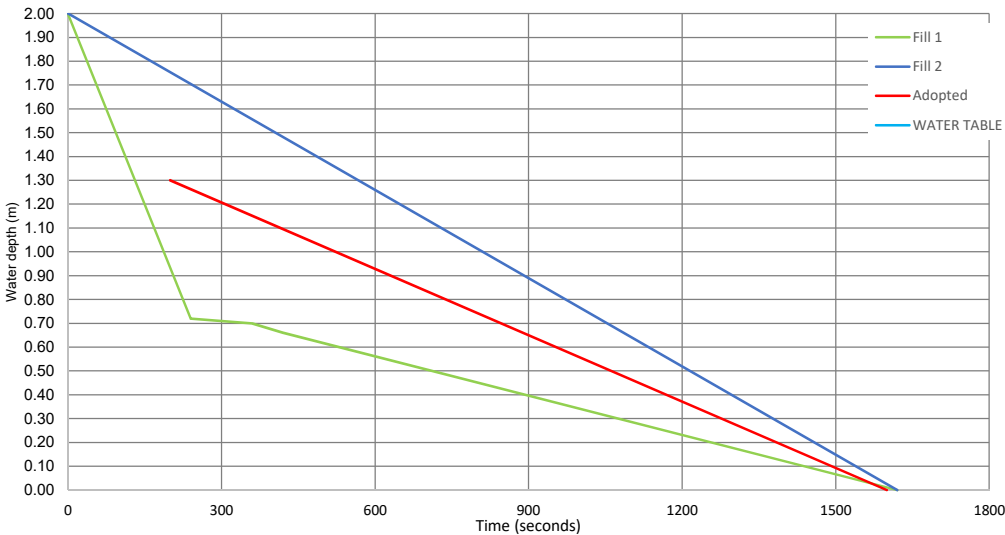
Test No. **ST-05** **Lot 14**

Test carried out in accordance with On-site Stormwater soakage Guidelines - Cambridge North Residential Zone

Falling head test	
y	Hole is pre-soaked for at least 4 hours in winter and 17 hours in summer, and then for 10 minutes immediately prior to the test
y	Drop in water level is recorded at intervals of 30 minutes or less
y	Test is continued for 4 hours or until holes is empty
y	Stop test or refill hole when water level is 0.35m above the base of the bore
y	Test is repeated at least 3 times or until a constant drainage curve is obtained
y	Soakage rate is determined from the minimum slope of the curve

Field Notes:
Soak hole observed to drain very quickly. 3 consecutive fills drained within 25 minutes.
Base of hole consisting of coarse sand collapsed on logger when filling with water.
Data logger did not return depths.
No Water Table observed

Depth of hole: 2.00 m
Water table depth: m



Depth (m)	Soil Description	WT
0.0m	0.0 TOPSOIL, Brown, Dry, Soft	
0.5m	0.200 SILT, Orangey Brown, Dry, Friable, Traces of Sand	
1.0m	0.700 silty SAND, Orangey Brown, Moist, Contains gravel up to 35mm Moisture increasing with depth	
1.5m	1.650 Med-Coarse SAND, Light Brown/Grey, Moist	
2.0m	End of log 2.0m	

Percolation Rate Calculation:

Time (s)	Water Depth (m)
200	1.300
1600	0.000

Minimum Slope - Lower
Minimum Slope - Upper

Bore Hole Diameter: 0.100 m
Minimum Gradient: 9.3E-04 m/s =

0.06 m/min

Soakage Rate =

$$k = \frac{D \times gradient \times 1000}{4 \times d} \quad **$$

k	=	2.14	l/m ² /min
	=	128.57	mm/hr



PERCOLATION TEST RESULTS

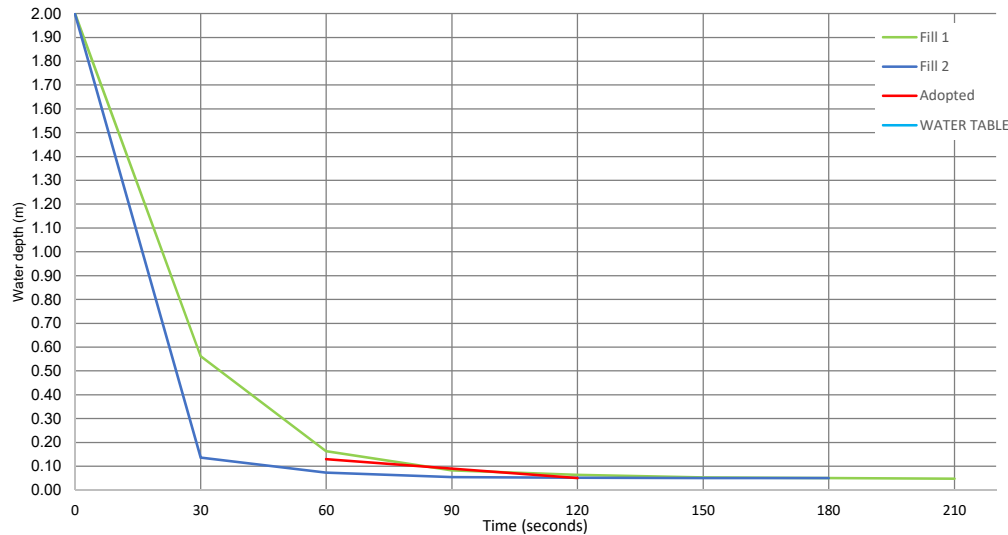


Client:	Kotare Properties Ltd	Tested bY:	AM/CB
Project:	100 Swayne Road, Cambridge North	Date Tested:	4 September, 2017
Job No.	WE1769	Revision:	A

Test No. **ST-06** **Lot 54**

Test carried out in accordance with On-site Stormwater soakage Guidelines - Cambridge North Residential Zone

Falling head test	
y	Hole is pre-soaked for at least 4 hours in winter and 17 hours in summer, and then for 10 minutes immediately prior to the test
y	Drop in water level is recorded at intervals of 30 minutes or less
y	Test is continued for 4 hours or until holes is empty
y	Stop test or refill hole when water level is 0.35m above the base of the bore
y	Test is repeated at least 3 times or until a constant drainage curve is obtained
y	Soakage rate is determined from the minimum slope of the curve



Percolation Rate Calculation:

Time (s)	Water Depth (m)	
60	0.130	Minimum Slope - Lower
120	0.050	Minimum Slope - Upper

Bore Hole Diameter: 0.100 m
Minimum Gradient: 1.3E-03 m/s =
Soakage Rate =

0.08 m/min

$$k = \frac{D \times \text{gradient} \times 1000}{4 \times d \times \text{**}}$$

k	=	22.22 l/m ² /min
	=	1333.33 mm/hr

Field Notes:

Water drained very quickly

Depth of hole: 2.00 m
Water table depth: m

Soil Log

Depth (m)	Soil Description	WT
0.0m	0.0 TOPSOIL, Brown, Dry, Soft	
0.5m	0.300 SILT, Orange Brown, Dry, Fine, Friable Colour Changing to Light Brown With Depth Sand content Increasing with depth Becoming Moist With Depth	
1.0m	1.100 Med-Coarse SAND, Light Brown/Grey, Moist, Contains Gravel up to 20mm Moisture Increasing With Depth	
1.5m		
2.0m	End of log 2.0m	



PERCOLATION TEST RESULTS



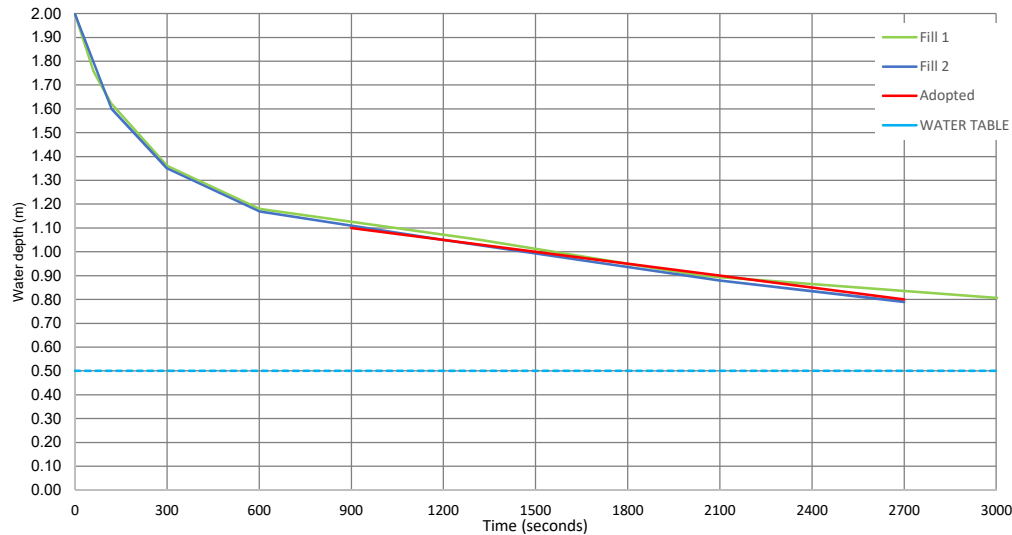
Client: Kotare Properties Ltd
Project: 100 Swayne Road, Cambridge North
Job No. WE1769

Tested by: AM/CB
Date Tested: 4 September, 2017
Revision: A

Test No. **ST-07** **Lot 51**

Test carried out in accordance with On-site Stormwater soakage Guidelines - Cambridge North Residential Zone

Falling head test	
y	Hole is pre-soaked for at least 4 hours in winter and 17 hours in summer, and then for 10 minutes immediately prior to the test
y	Drop in water level is recorded at intervals of 30 minutes or less
y	Test is continued for 4 hours or until holes is empty
y	Stop test or refill hole when water level is 0.35m above the base of the bore
y	Test is repeated at least 3 times or until a constant drainage curve is obtained
y	Soakage rate is determined from the minimum slope of the curve



Field Notes:
Water table observed at 1.5m.
Hole drained moderately

Depth of hole: 2.00 m
Water table depth: 1.50 m

Soil Log		WT
Depth (m)	Soil Description	
0.0m	0.0 TOPSOIL, Brown, Dry, Soft	
0.5m	0.250 SILT, Dry, Orange Brown, Friable Mottled Orange Brown to Light Brown/Grey from 0.600-1.100 Traces of Clay Present	
1.0m	SILT loam, Grey, Moist, Traces of Clay Increase in Moisture with Depth, Soils becoming Wet	
1.5m	Traces of Sand from 1.600 1.800 Med-Coarse SAND, Light Brown, Wet, GW Encountered @ 1.5m	
2.0m	End of log 2.0m	

Percolation Rate Calculation:

Time (s)	Water Depth (m)
900	1.100
2700	0.800

Minimum Slope - Lower
Minimum Slope - Upper

Bore Hole Diameter: 0.100 m
Minimum Gradient: 1.7E-04 m/s =
Soakage Rate =

0.010 m/min

$$k = \frac{D \times \text{gradient} \times 1000}{4 \times d \quad **}$$

Note: d=distance between mid point of last two readings and WT

k	=	0.56 l/m ² /min
	=	33.33 mm/hr



PERCOLATION TEST RESULTS

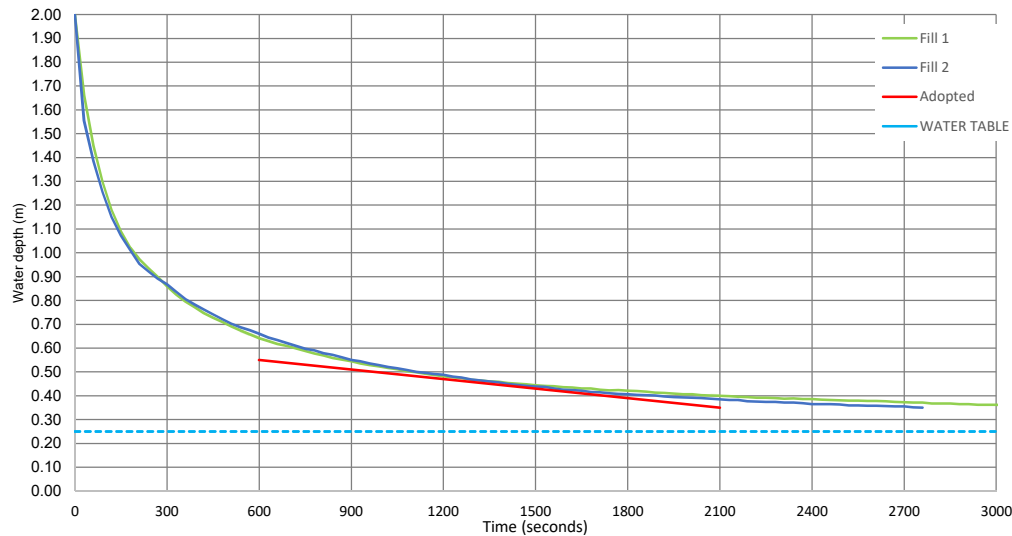


Client:	Kotare Properties Ltd	Tested bY:	AM/CB
Project:	100 Swayne Road, Cambridge North	Date Tested:	4 September, 2017
Job No.	WE1769	Revision:	A

Test No. **ST-08** **Lot 11**

Test carried out in accordance with On-site Stormwater soakage Guidelines - Cambridge North Residential Zone

Falling head test	
y	Hole is pre-soaked for at least 4 hours in winter and 17 hours in summer, and then for 10 minutes immediately prior to the test
y	Drop in water level is recorded at intervals of 30 minutes or less
y	Test is continued for 4 hours or until holes is empty
y	Stop test or refill hole when water level is 0.35m above the base of the bore
y	Test is repeated at least 3 times or until a constant drainage curve is obtained
y	Soakage rate is determined from the minimum slope of the curve



Field Notes:
Water table observed at 1.75m.

Depth of hole: 2.00 m
Water table depth: 1.75 m

Soil Log		WT
Depth (m)	Soil Description	
0.0m	0.0 TOPSOIL, Brown, Dry, Soft	
0.5m	0.200 clayey SILT, Orangey Brown, Dry	
	Colour Change to Grey at 0.450m	
	Increasing in Moistuer With Depth	
1.0m	Traces of Sand Increasing With Depth	
	0.900 Med-Coarse SAND, Grey, Moist, Traces of Silt	
1.5m	1.450 clayey SILT loam, Moist, Grey, Med-Coarse Sand	
	1.800 silty Med-Coarse SAND, Grey, Wet,	
2.0m	End of log 2.0m	GW Encountered @ 1.75m

Percolation Rate Calculation:

Time (s)	Water Depth (m)
600	0.550
2100	0.350

Minimum Slope - Lower
Minimum Slope - Upper

Bore Hole Diameter:
Minimum Gradient:
Soakage Rate =

0.100 m

1.3E-04 m/s =

0.01 m/min

$$k = \frac{D \times gradient \times 1000}{4 \times d} **$$

k	=	1.00 l/m ² /min
	=	60.00 mm/hr

Note: d=distance between mid point of last two readings and WT



PERCOLATION TEST RESULTS



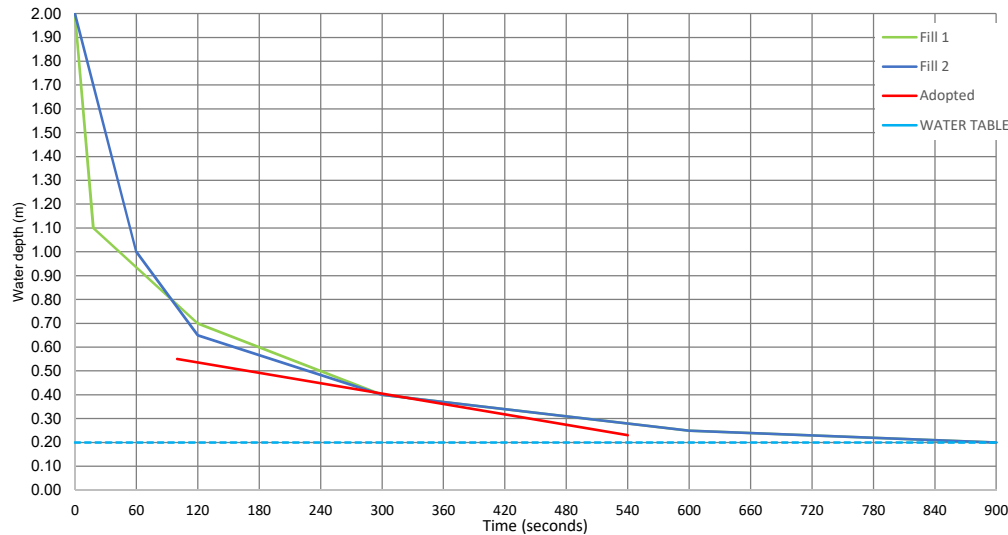
Client: Kotare Properties Ltd
Project: 100 Swayne Road, Cambridge North
Job No. WE1769

Tested bY: AM/CB
Date Tested: 5 September, 2017
Revision: A

Test No. **ST-09** **Lot 46**

Test carried out in accordance with On-site Stormwater soakage Guidelines - Cambridge North Residential Zone

Falling head test	
y	Hole is pre-soaked for at least 4 hours in winter and 17 hours in summer, and then for 10 minutes immediately prior to the test
y	Drop in water level is recorded at intervals of 30 minutes or less
y	Test is continued for 4 hours or until holes is empty
y	Stop test or refill hole when water level is 0.35m above the base of the bore
y	Test is repeated at least 3 times or until a constant drainage curve is obtained
y	Soakage rate is determined from the minimum slope of the curve



Percolation Rate Calculation:

Time (s)	Water Depth (m)
100	0.550
540	0.230

Minimum Slope - Lower
Minimum Slope - Upper

Bore Hole Diameter: 0.100 m
Minimum Gradient: 7.3E-04 m/s =
Soakage Rate =

0.04 m/min

$$k = \frac{D \times \text{gradient} \times 1000}{4 \times d} \quad **$$

Note: d=distance between mid point of last two readings and WT

k	=	5.74 l/m ² /min
	=	344.50 mm/hr

Field Notes:

Water drained very quickly.

Depth of hole: 2.00 m
Water table depth: 1.80 m

Soil Log

Depth (m)	Soil Description	WT
0.0m	0.0 TOPSOIL, Brown, Dry, Soft	
0.5m	0.400 SILT, Orangey Brown, Dry, Friable	
1.0m	1.100 silty Med-Coarse SAND, Light Brown, Dry	
1.5m	1.300 Med-Coarse SAND, Light Brown/Grey	
	Moisture increasing with depth	
2.0m	End of log 2.0m	GW Encountered @ 1.8m



PERCOLATION TEST RESULTS



Client:	Kotare Properties Ltd	Tested bY:	AM/CB
Project:	100 Swayne Road, Cambridge North	Date Tested:	5 September, 2017
Job No.	WE1769	Revision:	A

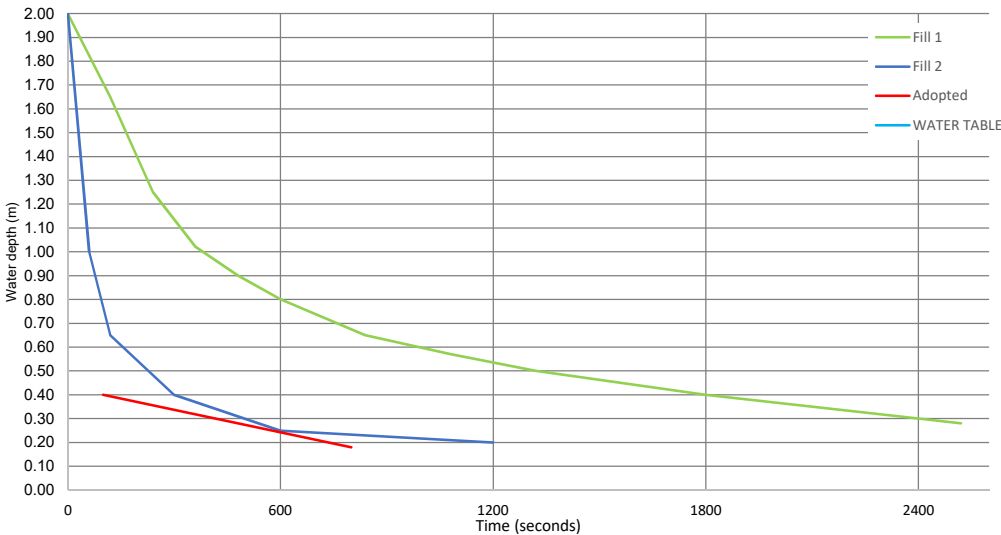
Test No. **ST-010** **Lot 37**

Test carried out in accordance with On-site Stormwater soakage Guidelines - Cambridge North Residential Zone

Falling head test	
y	Hole is pre-soaked for at least 4 hours in winter and 17 hours in summer, and then for 10 minutes immediately prior to the test
y	Drop in water level is recorded at intervals of 30 minutes or less
y	Test is continued for 4 hours or until holes is empty
y	Stop test or refill hole when water level is 0.35m above the base of the bore
y	Test is repeated at least 3 times or until a constant drainage curve is obtained
y	Soakage rate is determined from the minimum slope of the curve

Field Notes:
Water drained quickly.
No water table observed.

Depth of hole: 2.00 m
Water table depth: m



Soil Log		WT
Depth (m)	Soil Description	
0.0m	0.0 TOPSOIL, Brown, Dry, Soft	
0.5m	0.300 SILT, Orangey Brown, Dry, Friable	
1.0m	0.800 clayey SILT, Light Brown, Moist	
1.5m	1.100 Med-Coarse SAND, Moist, Light Brown, Moist	
2.0m	Change to a Dark brown Colour at 1.500 Change to a Grey Colour at 1.900	
End of log 2.0m		

Percolation Rate Calculation:

Time (s)	Water Depth (m)
100	0.400
800	0.180

Minimum Slope - Lower
Minimum Slope - Upper

Bore Hole Diameter: 0.100 m
Minimum Gradient: 3.1E-04 m/s =
Soakage Rate =

0.02 m/min

$$k = \frac{D \times \text{gradient} \times 1000}{4 \times d \times \text{**}}$$

k	=	1.63	l/m ² /min
	=	97.54	mm/hr



PERCOLATION TEST RESULTS

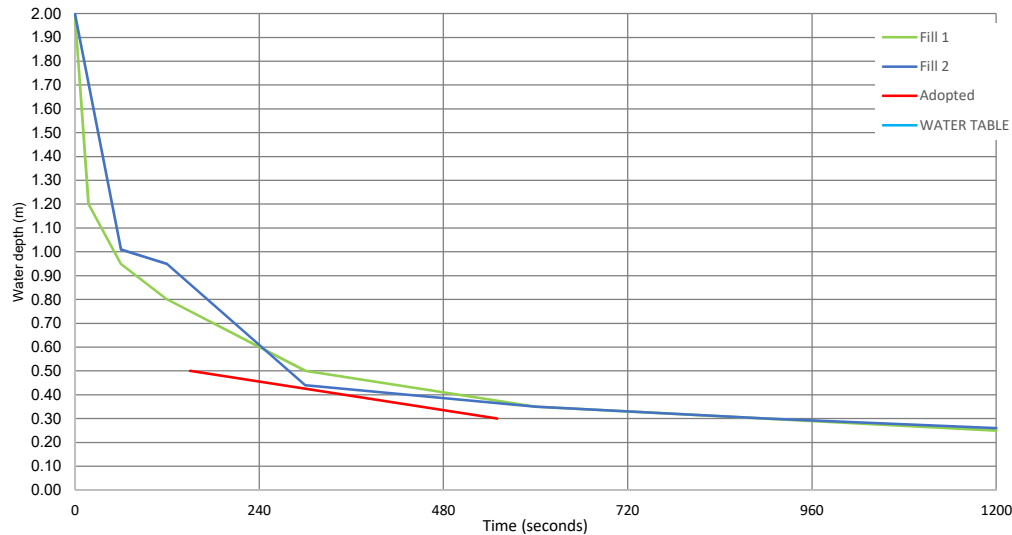


Client:	Kotare Properties Ltd	Tested by:	AM/CB
Project:	100 Swayne Road, Cambridge North	Date Tested:	5 September, 2017
Job No.	WE1769	Revision:	A

Test No. **ST-011** **Lot 40**

Test carried out in accordance with On-site Stormwater soakage Guidelines - Cambridge North Residential Zone

Falling head test	
y	Hole is pre-soaked for at least 4 hours in winter and 17 hours in summer, and then for 10 minutes immediately prior to the test
y	Drop in water level is recorded at intervals of 30 minutes or less
y	Test is continued for 4 hours or until holes is empty
y	Stop test or refill hole when water level is 0.35m above the base of the bore
y	Test is repeated at least 3 times or until a constant drainage curve is obtained
y	Soakage rate is determined from the minimum slope of the curve



Field Notes:
No water table observed.

Depth of hole: 2.00 m
Water table depth: m

Soil Log		WT
Depth (m)	Soil Description	
0.0m	0.0 TOPSOIL, Brown, Dry, Soft	
0.5m	0.300 SILT, Orangey Brown, Friable, Dry	
1.0m	0.900 Med-Coarse SAND, Brown, Moist Traces of Silt and Gravel up to 30mm in size Colour Change to Dark brown at 1.100-1.300	
1.5m	Colour Change to Grey at 1.800	
2.0m	End of log 2.0m	

Percolation Rate Calculation:

Time (s)	Water Depth (m)
150	0.500
550	0.300

Minimum Slope - Lower
Minimum Slope - Upper

Bore Hole Diameter: 0.100 m
Minimum Gradient: 5.0E-04 m/s = 0.03 m/min
Soakage Rate =

$$k = \frac{D \times \text{gradient} \times 1000}{4 \times d \quad **}$$

k	=	1.88 l/m ² /min
	=	112.50 mm/hr



PERCOLATION TEST RESULTS



Client:	Kotare Properties Ltd	Tested by:	AM/CB
Project:	100 Swayne Road, Cambridge North	Date Tested:	5 September, 2017
Job No.	WE1769	Revision:	A

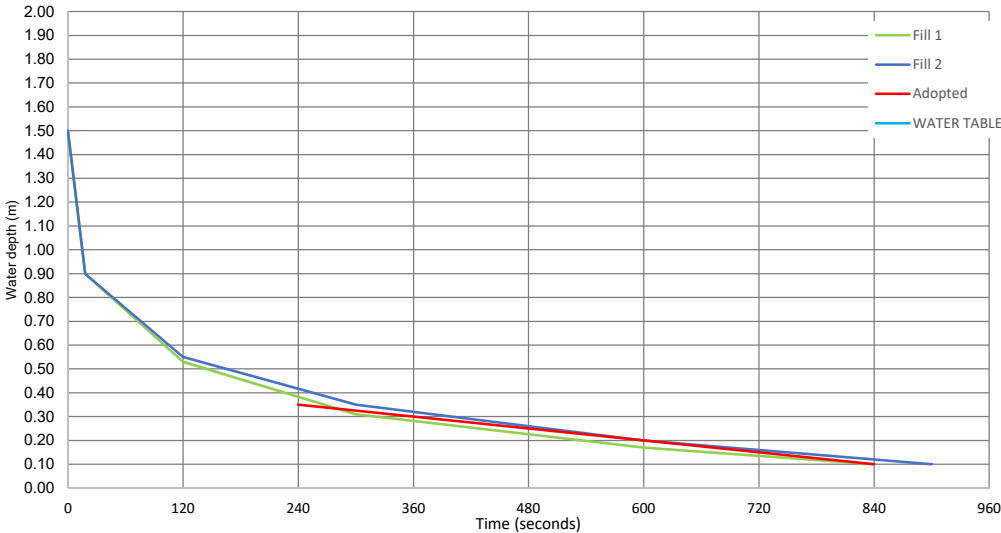
Test No. **ST-012** **Lot 16**

Test carried out in accordance with On-site Stormwater soakage Guidelines - Cambridge North Residential Zone

Falling head test	
y	Hole is pre-soaked for at least 4 hours in winter and 17 hours in summer, and then for 10 minutes immediately prior to the test
y	Drop in water level is recorded at intervals of 30 minutes or less
y	Test is continued for 4 hours or until holes is empty
y	Stop test or refill hole when water level is 0.35m above the base of the bore
y	Test is repeated at least 3 times or until a constant drainage curve is obtained
y	Soakage rate is determined from the minimum slope of the curve

Field Notes:
Effective refusal encountered at 1.5m due to stony layer.
Water drained very quickly.
No water table observed.

Depth of hole: 1.50 m
Water table depth: m



Soil Log		WT
Depth (m)	Soil Description	
0.0m	0.0 TOPSOIL, Brown, Dry, Soft	
0.5m	0.300 SILT, Orangey Brown, Friable, Dry, Traces of Sands	
1.0m	0.850 SAND, Moist, Light Brown	
1.5m	Traces of Silt but decreasing with depth Soils Contain high portion of Gravel up to 35mm	
End of log 1.5m (Unable to Penetrate Further)		

Percolation Rate Calculation:

Time (s)	Water Depth (m)
240	0.350
840	0.100

Minimum Slope - Lower
Minimum Slope - Upper

Bore Hole Diameter: 0.100 m
Minimum Gradient: 4.2E-04 m/s = 0.03 m/min
Soakage Rate =

$$k = \frac{D \times \text{gradient} \times 1000}{4 \times d \quad **}$$

k	=	2.78 l/m ² /min
	=	166.67 mm/hr



PERCOLATION TEST RESULTS



Client: Kotare Properties Ltd
Project: 100 Swayne Road, Cambridge North
Job No. WE1769

Tested by: AM/CB
Date Tested: 5 September, 2017
Revision: A

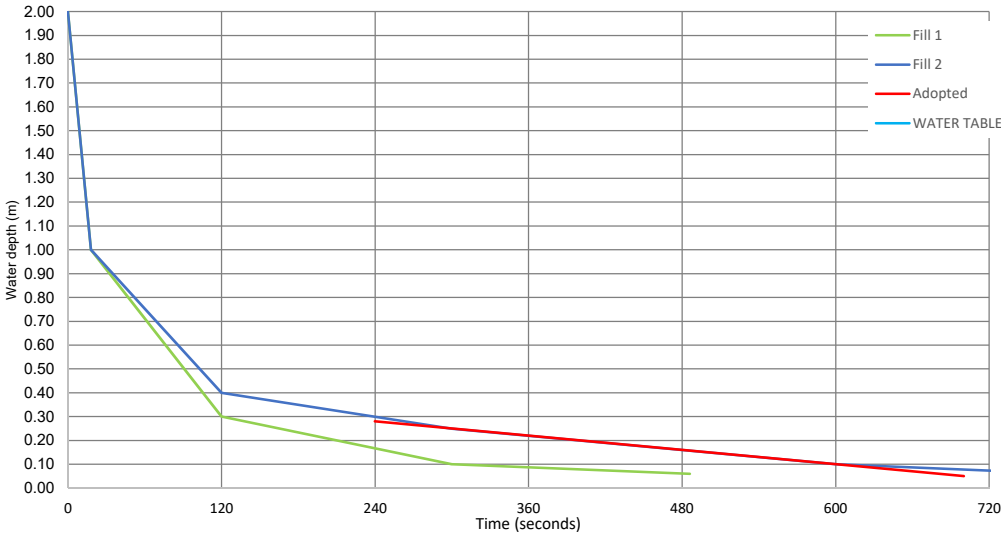
Test No. **ST-013** **Lot 21**

Test carried out in accordance with On-site Stormwater soakage Guidelines - Cambridge North Residential Zone

Falling head test	
y	Hole is pre-soaked for at least 4 hours in winter and 17 hours in summer, and then for 10 minutes immediately prior to the test
y	Drop in water level is recorded at intervals of 30 minutes or less
y	Test is continued for 4 hours or until holes is empty
y	Stop test or refill hole when water level is 0.35m above the base of the bore
y	Test is repeated at least 3 times or until a constant drainage curve is obtained
y	Soakage rate is determined from the minimum slope of the curve

Field Notes:
Water drained very quickly.
No water table observed.

Depth of hole: 2.00 m
Water table depth: m



Soil Log		WT
Depth (m)	Soil Description	
0.0m	0.0 TOPSOIL, Brown, Dry, Soft	
0.5m	0.250 SILT, Orangey Brown, Friable, Dry, Traces of Sands	
1.0m	0.900 SAND, Moist, Light Brown Traces of Silt Contains Gravel up to 30mm	
1.5m		
2.0m	End of log 2.0m	

Percolation Rate Calculation:

Time (s)	Water Depth (m)
240	0.280
700	0.050

Minimum Slope - Lower
Minimum Slope - Upper

Bore Hole Diameter: 0.100 m
Minimum Gradient: 5.0E-04 m/s = 0.03 m/min
Soakage Rate = $k = \frac{D \times \text{gradient} \times 1000}{4 \times d \quad **}$
k = 4.55 l/m²/min
= 272.73 mm/hr



PERCOLATION TEST RESULTS



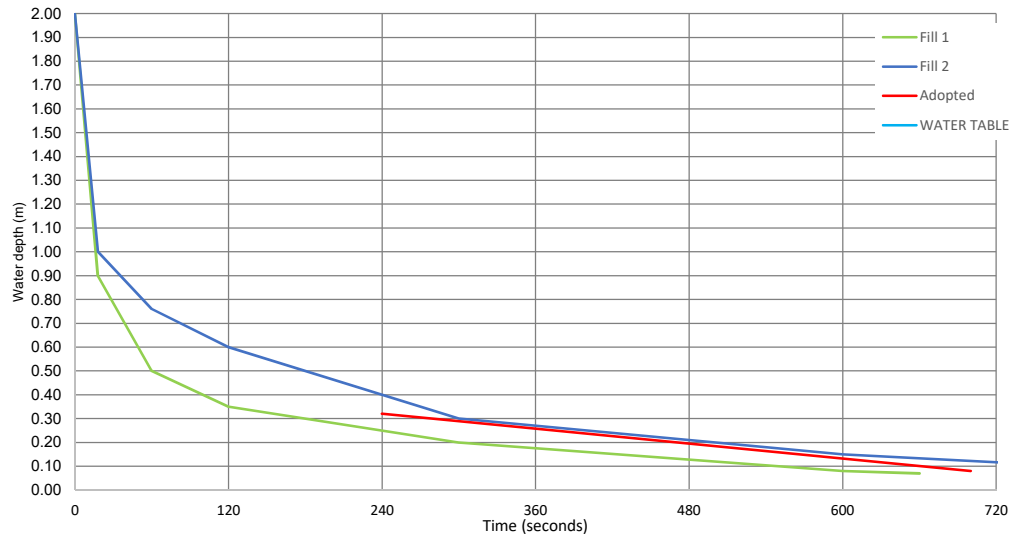
Client: Kotare Properties Ltd
Project: 100 Swayne Road, Cambridge North
Job No. WE1769

Tested by: AM/CB
Date Tested: 5 September, 2017
Revision: A

Test No. **ST-014** **Lot 24**

Test carried out in accordance with On-site Stormwater soakage Guidelines - Cambridge North Residential Zone

Falling head test	
y	Hole is pre-soaked for at least 4 hours in winter and 17 hours in summer, and then for 10 minutes immediately prior to the test
y	Drop in water level is recorded at intervals of 30 minutes or less
y	Test is continued for 4 hours or until holes is empty
y	Stop test or refill hole when water level is 0.35m above the base of the bore
y	Test is repeated at least 3 times or until a constant drainage curve is obtained
y	Soakage rate is determined from the minimum slope of the curve



Percolation Rate Calculation:

Time (s)	Water Depth (m)
240	0.320
700	0.080

Minimum Slope - Lower
Minimum Slope - Upper

Bore Hole Diameter: 0.100 m
Minimum Gradient: 5.2E-04 m/s =
Soakage Rate =

0.03 m/min

$$k = \frac{D \times \text{gradient} \times 1000}{4 \times d \quad **}$$

k	=	3.91 l/m ² /min
	=	234.78 mm/hr

Field Notes:

Water drained very quickly.
No water table observed.

Depth of hole: 2.00 m
Water table depth: m

Soil Log

Depth (m)	Soil Description	WT
0.0m	0.0 TOPSOIL, Brown, Dry, Soft	
0.5m	0.250 SILT, Orangey Brown, Friable, Dry, Traces of Sands	
1.0m	0.850 SAND, Moist, Light Brown	
1.5m	Traces of Silt but decreasing with depth Contains Gravel up to 35mm	
2.0m	End of log 2.0m	



TO Robin Walker
COPY Paul King
FROM Sarah Dudson and Charlotte Mills
DATE 11 June 2014
FILE 3-cw966.07/VP09
SUBJECT 86 Swayne Rd – Stormwater Design Guidance

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1 Introduction

The purpose of this memo is to outline the stormwater design requirements for the proposed development at 86 Swayne Road (based on the sketch plans provided and shown below in Figure 1) to ensure the design is consistent with the preliminary design requirements in the Cambridge North Residential Area (CNRA) stormwater model.

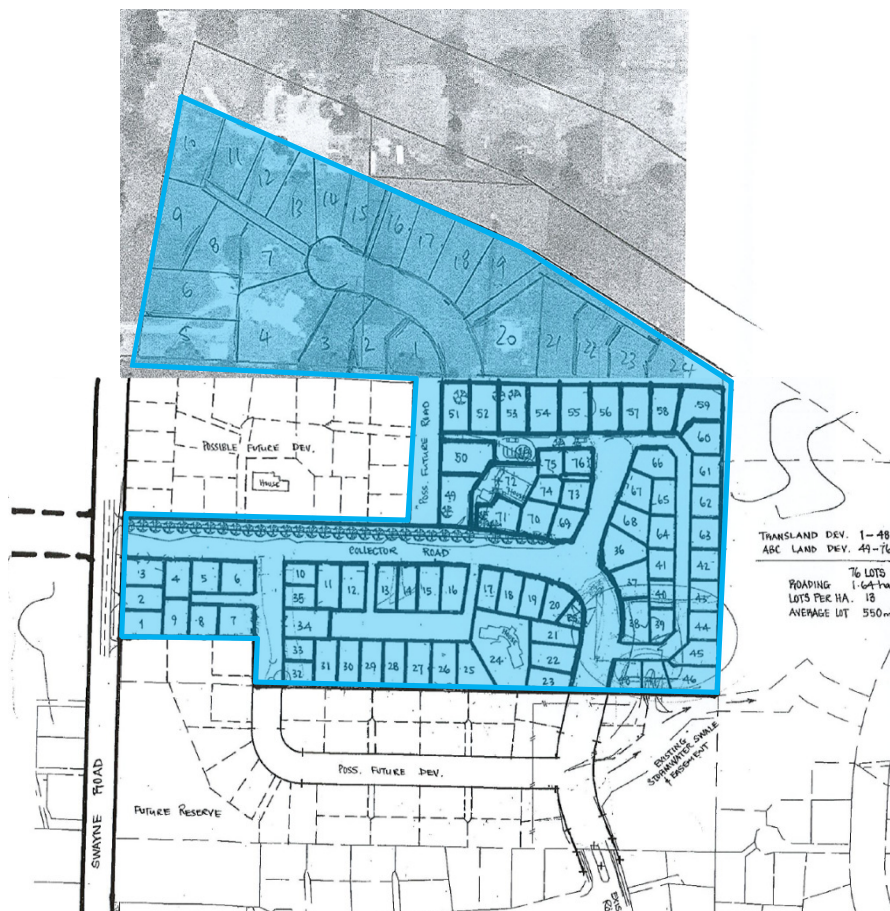


Figure 1. Proposed 86 Swayne Rd development

The layout of the proposed development at 86 Swayne Rd shown in Figure 1 differs somewhat from the assumed layout of future development areas assumed in the model, as shown in Figure 2. This revised layout is acceptable, so long as the stormwater design is consistent with the preliminary design requirements in the model. The catchment split between the North-eastern Swale and the main trunk pipe reticulation needs to be maintained, along with the recommended pipe sizes, as discussed in the following sections.

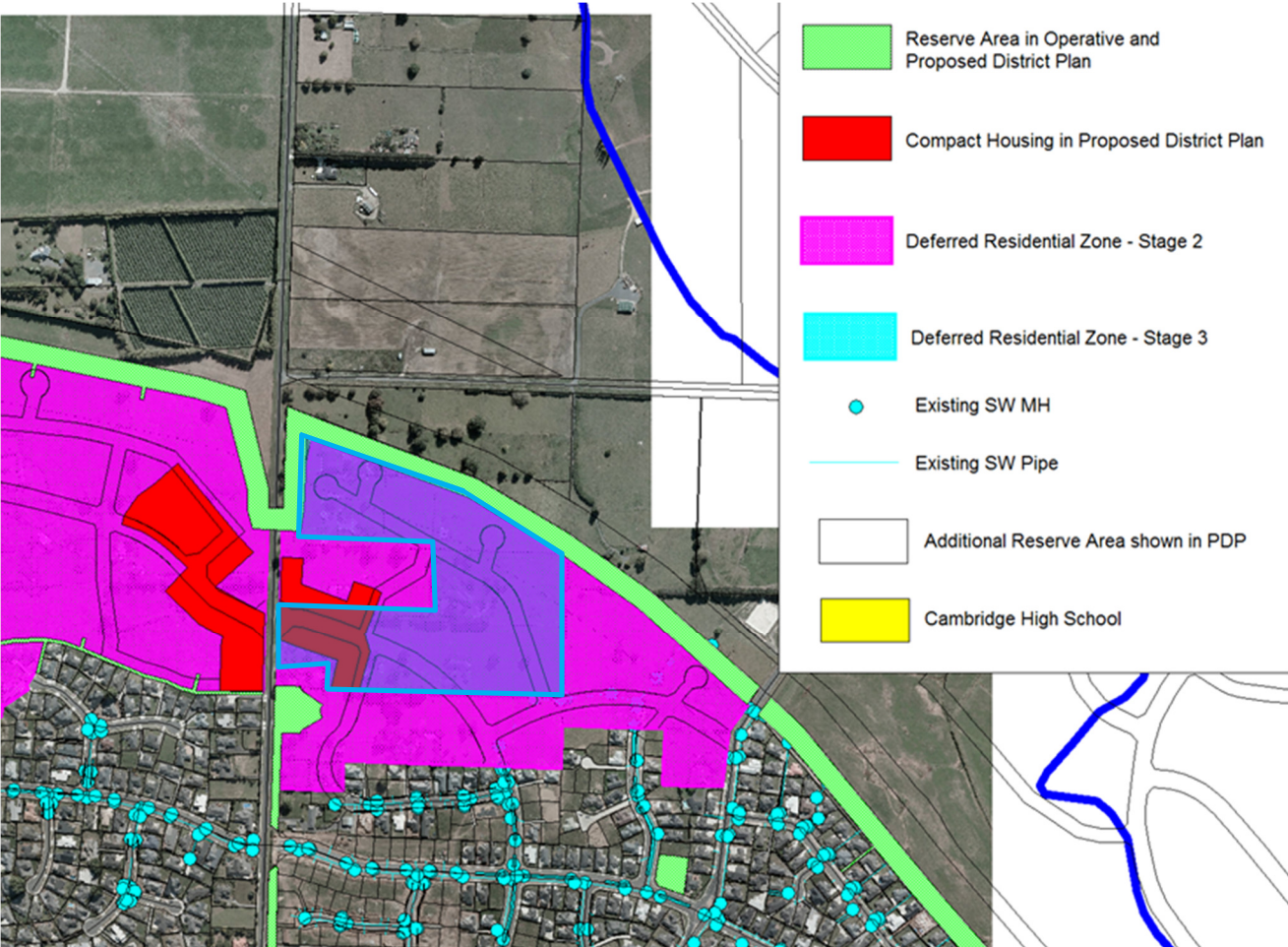


Figure 2. Layout of future development area used in the model

2 Stormwater Design Philosophy

The following table sets out the Stormwater Design Philosophy applicable to any development within the CNRA. The following subsections provide additional detail, as necessary.



Table 1. CNRA Stormwater Design Philosophy

Parameter	Design LOS
Minimum design capacity for public primary reticulation	Primary piped reticulation designed to 20% AEP.
Minimum design capacity for secondary stormwater system	2% AEP for secondary overland flow paths.
Minimum building floor levels	2% AEP for industrial, commercial and habitable floors.
Minimum freeboard allowance	500mm for all cases.
On-site soakage	On-site soakage designed for 10% AEP at all sites where testing indicates at least 80mm/hr infiltration and suitable groundwater levels. Consideration of alternative solutions where on-site soakage is unsuitable.
Overland flow paths	Overland flow path provided within the road corridor with unrestricted connectivity to swales.

2.1 Primary piped reticulation

The stormwater model includes proposed stormwater infrastructure to support a fully developed CNRA. The fully developed scenario assumes 70% impervious area for Residential Zoned areas and 75% impervious area for Compact Housing Zoned areas.

As the proposed layout of the development at 86 Swayne Rd differs from the assumed layout used in the model, we can only provide indicative stormwater infrastructure sizing and alignment at this stage, as shown in Figure 5. We recommend the developer provides a copy of their preliminary design plans, once available, so that these can be incorporated into the model to confirm that the design meets Waipa District Council Levels of Service.

Note that the indicative pipe sizing shown in Figure 5 assumes no on-site soakage as this development area is predominantly Zone C – poor soakage (discussed further in Section 2.3). However, if soakage is found to be feasible and/or alternative solutions are implemented (refer Section 2.3), there is potential to reduce the size of the stormwater reticulation required.

2.2 Minimum building floor levels and freeboard allowance

The 500 mm freeboard shall be applied from the top of kerb or the maximum model flood level, whichever is higher, as shown in Figures 3 and 4 respectively.

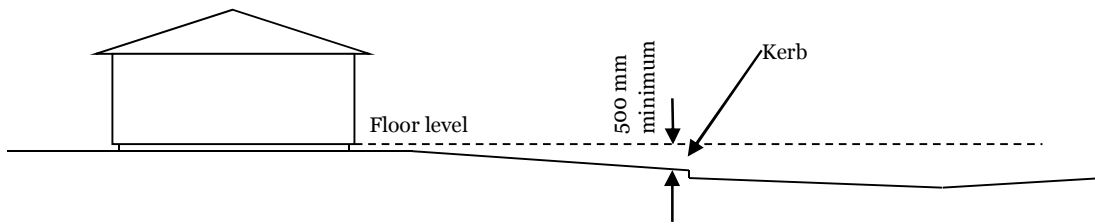


Figure 2: Minimum Floor Level set from Top of Kerb (NTS)

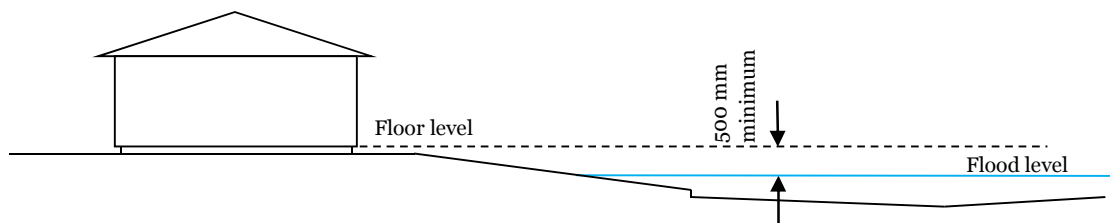


Figure 4: Minimum Floor Level set from Flood Level (NTS)

2.3 On-site soakage

Soakage potential across the CNRA is categorised into three areas:

- Zone A – good soakage (360-720 mm/hr)
- Zone B – moderate soakage (72 -144 mm/hr)
- Zone C – poor soakage (7.2 -18 mm/hr)

The relatively free draining soils are limited to the western end of the CNRA. Soils with poor soakage are generally found in the north and east of the CNRA. Tongues of poor quality soil can be found throughout the CNRA.

The proposed development at 86 Swayne Rd is located predominantly in Zone C, which indicates that on-site soakage may be unsuitable. However, there is an area in the southwest of the site that is categorised as Zone B which may be suitable for on-site soakage as shown in Figure 5.

On-site soakage testing shall be carried out in accordance with the procedures detailed in the Stormwater Soakage Guidelines, Opus (2012) to determine soakage potential across the development site. On-site soakage is not recommended in areas of less than 80 mm/hour subsoil infiltration or high groundwater.

Where on-site soakage is found to be unsuitable, the following alternative solutions should be considered:

- » Specific design to overcome marginally suitable sites. WDC may at their discretion reduce the required design capacity of the soakage system or may allow connection to the Council's piped stormwater network.
- » Rainwater detention tanks (with a storage volume of approximately 10 m³).
- » Alternative on-site detention facilities.
- » Connection to the Council's piped stormwater network.

If all sites include soakage and/or attenuation designed to 10% AEP, there is potential for an overall reduction in the size of stormwater reticulation required.

2.4 Overland flow paths

Where possible, all roads must be constructed to form a continuous overland flow path from the development to the existing road network downstream. Where a continuous overland flow path along the road is not feasible, provision shall be made for either

- » an overland flow path in the form of a drain or swale (via an easement from the low point in the road to such a point that it can be discharged to an existing road or swale), or
- » a piped system sized to convey the 1% AEP flow (located within the road or an easement).

3 Summary of Stormwater Design Requirements

Figure 5 summarises the stormwater design requirements for the proposed development at 86 Swayne Rd. Note in particular, the catchment area that is assumed to discharge to the North-eastern Swale.

