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SURFACE/STORMWATER MANAGEMENT STRATEGY

89 Ross Watt Road, Gisborne

ID_Land

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1 Introduction

Alluvium Consulting Australia Pty Ltd (Alluvium) has been engaged by ID_Land to prepare a Surface/Storm Water Management Strategy (SWMS), in support of its permit application for the land parcel at 89 Ross Watt Road, Gisborne.

The purpose of this SWMS is to propose management strategies for:

- Stormwater quantity
- Stormwater quality
- Existing and constructed waterways

Through meeting these objectives, this SWMS acts as a critical component of the development servicing strategy and ensures stormwater is managed in accordance with Melbourne Water's and Council's requirements. The strategy will directly inform the local drainage design for the site and will include appropriate mitigation measures to protect the local environment values.

2 Site Overview

The 89 Ross Watt Road site covers an area of approximately 88 ha, of which about 67ha is developable land. The site is generally bound by Jacksons Creek to the west and south, Ross Watt Road to the north and Swinburne Avenue to the east (refer to Figure 1).

Figure 1. *Site location (subject site shown in red dash line)*

The subject site is within the Jacksons Creek catchment. Rosslynne Reservoir is located to the north of the proposed site, however all of the proposed development naturally drains to the south and enters Jacksons Creek downstream of the reservoir. The topography of the subject site varies with grades on the plateau typically ranging from 0.5 to 2%, whilst the grades on the escarpment to Jacksons Creek are extremely steep.

Jacksons Creek is located immediately to the south of the subject site and is one of the more significant waterways within the metropolitan Melbourne system. The Healthy Waterways Strategy (2018) provides a framework for addressing community expectations and the responsibilities for waterway management. For each of the five major catchments within the Port Phillip and Westernport region (Werribee, Maribyrnong, Yarra, Dandenong and Westernport), the Strategy outlines catchment-specific visions, goals, long-term targets (10 to 50 years) for key values and waterway conditions, and short-term performance objectives (10-years). Effort and investment at catchment and sub-catchment scale are prioritised and aligned to ensure they contribute to broader, regional goals and outcomes. The 89 Ross Watt Road site is located within the Maribyrnong catchment.

The subject site is not located within a Precinct Structure Plan area. Apart from a very small area in the north west corner of the site, the proposed development is not located in a Melbourne Water Development Services Scheme (DSS). The small area that is within the New Gisborne DSS does not have any proposed scheme infrastructure to service the development of this land. Under existing conditions runoff from this small catchment does not actually outfall to the Racecourse Marshlands Reserve (ie the Gisborne Conservation Area) as the flow path is contained by Ross Watt Road and as a result all flows continue to outfall in a south-easterly direction.

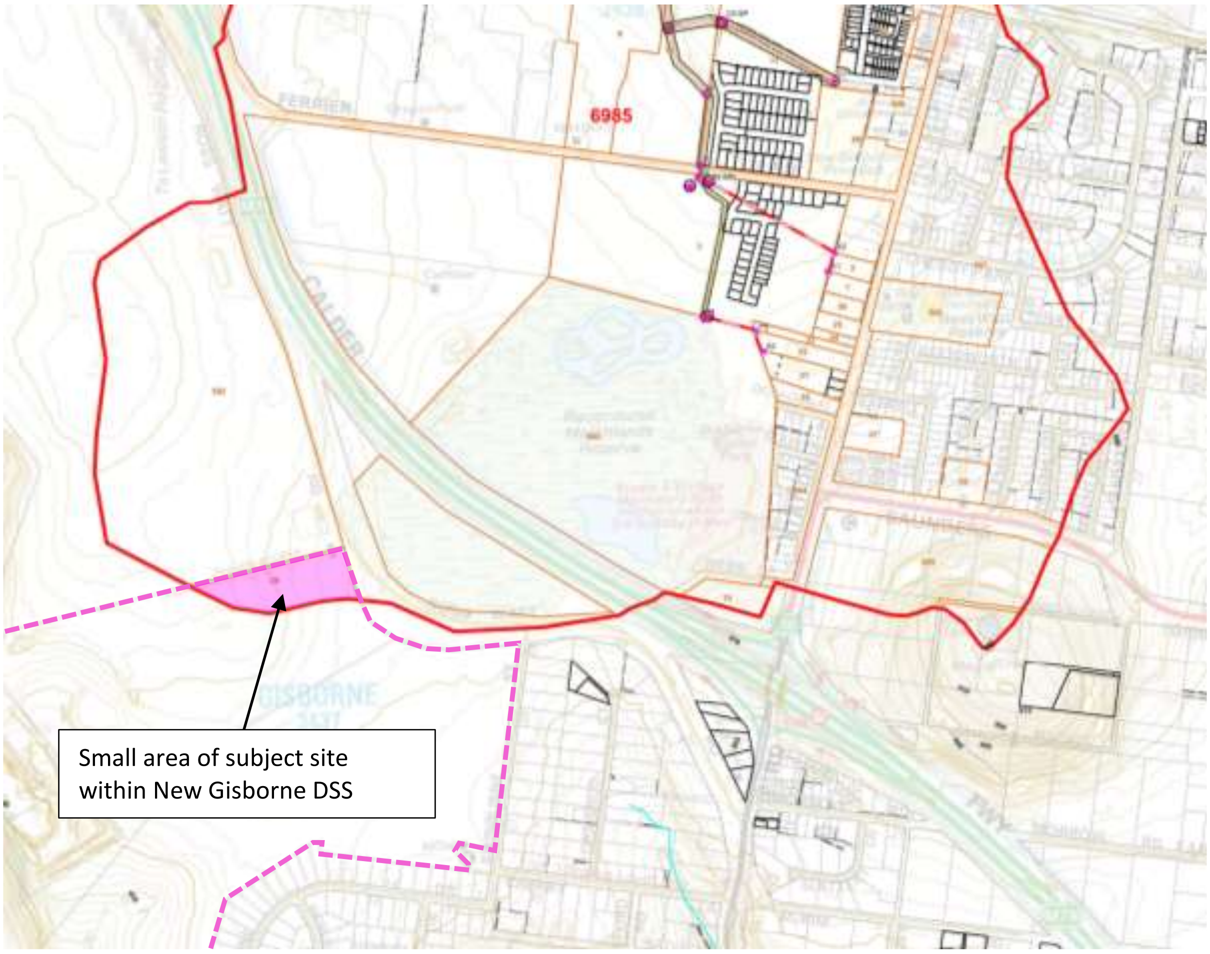


Figure 2 *New Gisborne DSS (subject site shown by pink dash line)*

3 Existing Conditions: Tributaries and Geomorphology

3.1 Waterway/tributary assessment

A detailed field assessment of the existing drainage lines in the study areas was undertaken by a geomorphologist (Alex Sims) and an urban drainage engineer (Jonathon McLean) from Alluvium. The field assessments included a walkover survey of all the drainage lines that discharge to Jackson Creek and drainage pathways to existing road infrastructure. A range of indicators in the field were assessed, including the relationship between the floodplains and drainage lines; the channel planform, gradient and any areas of active or incipient erosion or sedimentation. The field assessment focussed on the physical geomorphic features and processes sensitive to, or likely to be affected by, future altered hydrology.

The field observations were synthesised and combined with the literature review outputs to provide an assessment of the condition and trajectory of waterways and drainage lines within the proposed development sites. Summary results of the baseline geomorphic assessment are provided below.

The main subject of this report is the 350 metre long waterway, located at the southern margin of the proposed Ross Watt Road development area. The study reach is a small drainage line that flow across the steep escarpment edge and into Jacksons Creek (Figure 3). Two additional sites (sites A and B in Figure 3) located along an unnamed waterway to the east of the proposed development were also inspected. The unnamed waterway is expected to receive a portion of the stormwater generated by the proposed development and sites A and B are expected to receive additional stormwater from the surrounding urban area.

The geomorphic processes within the study waterway and at sites A and B were assesses using two methods:

- A desktop assessment of that used high-resolution aerial imagery, Geological and soil mapping and the proposed development layout
- A site assessment that included GPS photos, field notes and the use of a small UAV (drone). The site assessment was used to break the study waterway into reaches, with the boundary between reaches marking the points of change in waterway shape, slope and behaviour. Within each reach, the following was noted:
    - The condition of the bed and banks of the waterway
    - Existing instabilities in the channel that pose a risk to the public (given that the waterway will be included as publicly accessed open space following development

The desktop and field assessments were used to understand the existing condition of the waterways, geomorphic processes operating in the waterways, and the likely response of the waterways to increased flows form stormwater following further development of the catchment.

3.2 Study waterway

Overall, three distinct but relatively short reaches were defined for the study waterway (Figure 4). The reaches are:

- Reach 1: the length of the defined waterway between the current farm dam and the edge of the basalt escarpment.
- Reach 2: the portion of the waterway over the steep escarpment.
- Reach 3: the short section of waterway between the top of the escarpment and Jacksons Creek.

Figure 3. *The study waterway and sites A and B – which were assessed for their suitability to accommodate additional flows*

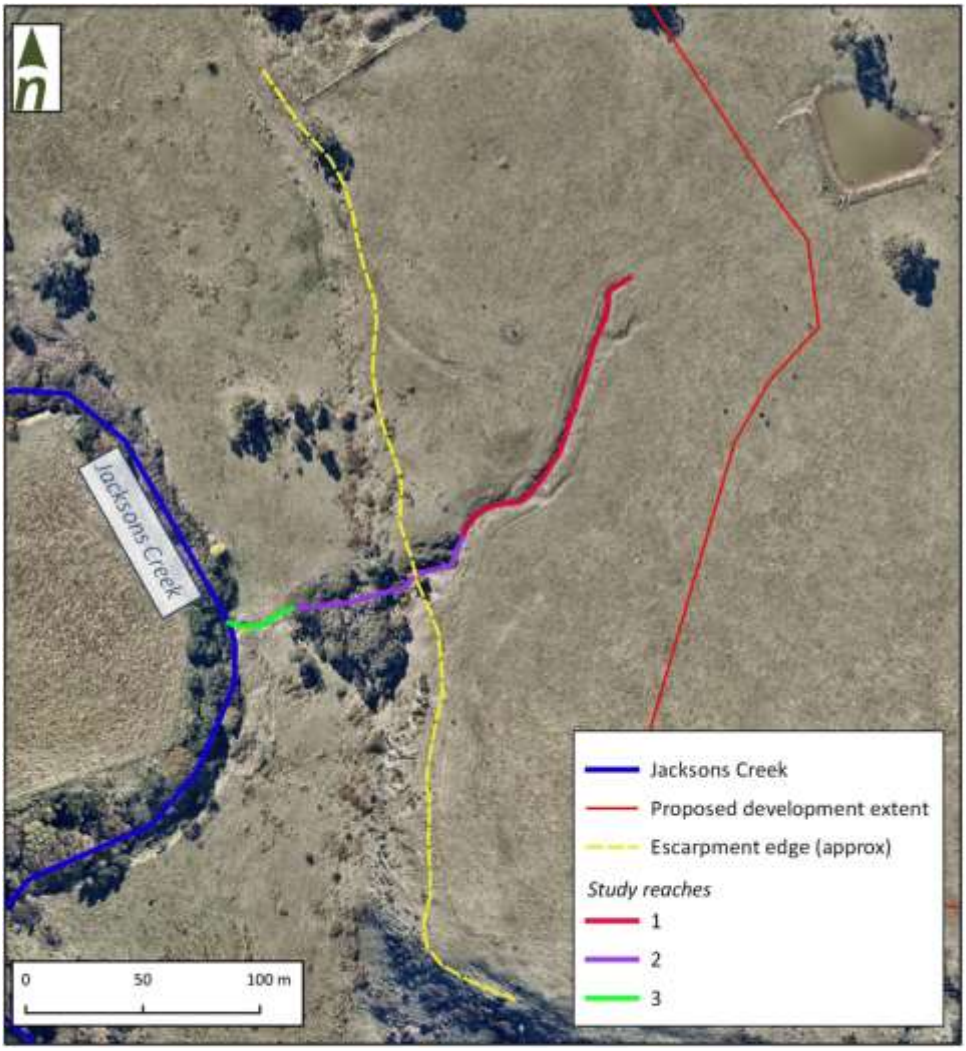


Figure 4. *Reaches of the study waterway*

The condition of each reach and the geomorphic processes shaping the waterway are considered below.

Reach 1
Reach 1 is in the upper part of the site and follows a gentle slope towards the sharp break in slope (the escarpment edge), that defined the valley of Jacksons Creek. Stock have ongoing access to this reach. The head of this reach is defined by a vertical head-cut that appears to be migrating upstream, towards the farm dam. The migrating head cut is fed by runoff from the dam (which has a small spill channel) and from the surrounding paddock. The absence of rilling or other smaller channel features suggests that this head-cut is starved of water in all but very heavy rainfall events. The head cut is the result of stock trampling grass, which exposes soils to erosion during heavy rainfall, but the presence of underlying bedrock and the farm dam limit the opportunities for head cut migration.

The bed of the waterway is comprised of relatively shallow soils derived from the underlying basalt, and occasional outcrops of basalt bedrock, which become more common in a downstream direction. The banks of the reach show numerous signs of erosion, most of which is small, shallow slumping which has been exacerbated by movement of stock. The reach is relatively straight.

Reach 2
Reach two is the steep section of the waterway that flows across the escarpment edge. The channel is roughly v-shaped and does not have well defined banks (rather the valley walls are the banks). The bed of the channel is exposed basalt bedrock with accumulations of shallow soil (which has been transported to the reach from erosion in reach 1). The bed profile is stepped, with the steps in bed profile following natural undulations in

the bedrock or clusters of large basalt boulders, which have been dislodged form the adjacent slope as the channel cut downwards. The large boulders are colluvial (slope) deposits, and likely move downslope by toppling (rather than transport by water). The toppling of the boulders is very rare, and the catchment is unlikely to generate sufficient flow to transport these rocks.

Thick vegetation (gum trees and dense blackberry) covers the downstream part of this reach and these trees are not currently being undermined by erosion.

Reach 3
Reach three is a short section that flows over an alluvial fan – a cone shaped deposit of sediment at the base of a steep, confined waterway - that has formed between the base of the escarpment and the top of the left bank of Jackson Creek (Figure 6)

The alluvial fan is comprised of coarse gravels (likely colluvium eroded form the bedrock in reach 2) and finer sediment (a combination of fine sediment from the upper part of the waterways catchment and sediment deposited by floodwaters of Jacksons Creek).

The channel currently flows along the eastern edge of this small fan and has incised a deep gully at the junction with Jacksons Creek. Incision of the alluvial fan was likely cause by the increased runoff from the catchment following conversion to agriculture, combined with the abrupt drop between the floodplain and the bed of Jacksons Creek. Sediment eroded from the small gully appears to have been deposited in the bed of Jacksons Creek, immediately downstream, where macrophytes have colonised the streambed. The position of the head cut coincides with an informal track, and basalt boulders placed at the head of this small gully appear to have been manually placed in an attempt to limit gully extension.

A natural depression (possibly a former channel) lies on the western side of the alluvial fan (**Figure 5**). Were the apex of the fan (the narrow point at the base of the escarpment where the stream emerges) to become blocked (for example by toppling of boulders from reach 2) then an avulsion (a sudden change in channel position) could occur. The channel avulsion would occur during higher flows and the most likely pathway of the 'new' channel is the depression on the western side of the fan. Channel avulsion would likely erode a second gully on the western side of the fan, similar to the gully already present on the eastern side of the fan. The avulsion and subsequent scour of the new channel may occur rapidly during high flows and would pose a threat to public safety and the visual amenity of the Jackson Creek floodplain.

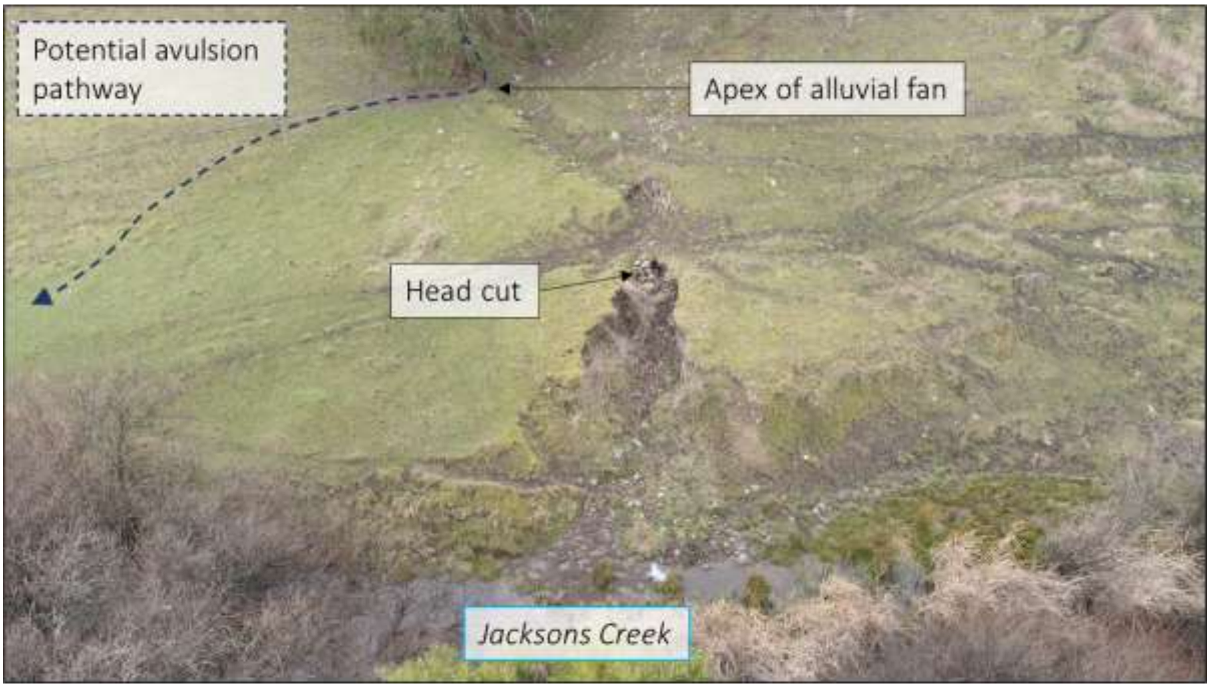


Figure 5.*The alluvial fan* **(***looking upstream) at the base of the study waterway, with the potential avulsion pathway (new rive***r** *course) on the western side (image left) of the fan*

Figure 6. *Overview of geomorphology of the study waterway*

3.3 Site A

Site A is located on a small waterway (ie Honeysuckle Creek) to the east of the proposed development, at the Cherry Lane culvert. Flows discharge from a buried pipe and into the unnamed waterway. The waterway at site A is narrow and well-vegetated. The bed is comprised of sediment ranging in size from silt to gravel. Deposition within the bed of this waterway, which already receives stormwater form the urban sued catchment, suggests that stream power is relatively low. The likelihood of bed incision due to a relatively small increase in stormwater delivery from the proposed development is low.

3.4 Site B

Site B is at the base of the exposed section of Honeysuckle Creek, where flow is directed into a sealed pipe at the culvert beneath Frith Road. This section of the waterway is covered in dense vegetation and basalt boulders can be seen on some sections of the channel bed. This section of waterway is unlikely to be impacted by the increased delivery of stormwater from the proposed development

3.5 Recommendations and findings

The change from an agricultural to urban/recreation land use in and adjacent to the study waterway will remove the main pressures driving erosion of the channel bed and banks: stock. At the same time, the delivery of stormwater to the reach will alter the flow regime of the waterway by increasing the total flow energy available to erode the bed and banks.

The natural valley line has not been mapped by Melbourne Water as a waterway or headwater stream (see Figure 7). Given this status and the low geomorphic value as identified via the field assessment it appears likely that there will not be a requirement to provide a waterway corridor through the site. Therefore, the risk of erosion along reach 1 for developed conditions will not be an issue as a road reserve will be used to convey flows along the valley floor.

Figure 7. *Melbourne Water mapped waterways*

This erosion will be most severe in the upstream section where the soil is deeper, and less severe at the downstream end of the reach (adjacent the escarpment edge) where exposed bedrock will prevent channel incision. The following mitigation measures are recommended to:

- prevent widespread erosion that decreases waterway amenity (and in many cases the mitigation measures will enhance waterway amenity relative to existing conditions)
- Prevent erosion that poses a threat to public safety
- Prevent delivery additional fine sediment to Jacksons Creek.

The recommended mitigation measures are:

1. Reach 2 comprises bedrock and will therefore be very resilient to changes in the hydrology due to urbanisation. Flow mitigation of future urban flows is therefore not necessary for this reach for both low and high flow events. Very little remediation is required apart from minor areas of weed removal and re-vegetation on the outer margins of the corridor.
2. Earthworks at the alluvial fan at the downstream end of the water way to ensure that the current channel alignment (to the east of the small fan) is maintained and that the head cut in incise channel does not migrate upstream, towards the base of the escarpment. A small bund or shaping of the channel to ensure that blockages at the fan apex do not trigger an avulsion to the west of the fan should maintain the current alignment.
3. Re-profiling of the downstream end of the channel in reach 3 at the toe of the alluvial fan to remove the incised gully and install a stable rock structure. The aim of these works is to:
    - Control the slope of the channel where it enters Jacksons Creek
    - Prevent a new head cut from forming and then migrating up the fan towards the escarpment.
    - Maintain a safe and high-amenity section of waterway that connects with Jacksons Creek

From a channel stability perspective, additional stormwater delivery to either site A (the head of a small waterway) or Site B (the small culvert at the downstream end of that waterway) will have little to no impact on those waterways. Dense vegetation and large basalt boulders prevents any small increase in total flow energy from eroding the channel bed or banks.

4 Existing conditions: Hydrology

4.1 Major Catchments

There are two main catchments associated with the 89 Ross Watt Road site, an eastern catchment and a western catchment (see Figure 8). A small area (2.3ha) north of the subject site and south of Ross Watt Road flows into the subject area. Although outside the subject site boundary, this area has been included in the hydrological analysis as an “external catchment”.

East Catchment

- Total catchment area is 33.4ha
- Outlet/discharge point is at the corner of Swinburne Ave/Cherry Lane
- A small area to the north of the 89 Ross Watt Road site is shown as part of Melbourne Water’s New Gisborne DSS. However, there is no infrastructure within the scheme to drain future development from this area. Under existing conditions runoff from this area naturally drains outside the subject site temporarily before flowing back into the subject site further to the east (refer to section 4.2).
- Outfall pipe required to be constructed along Cherry Lane
- Will need to retard back to equivalent pre-development peak flow rate for flows up to the 1% AEP event
- Stormwater quality to meet Best Practice pollutant removal targets at the outlet

West Catchment

- Total catchment area is 41ha
- Outlet/discharge point is directly to Jacksons Creek via the existing tributary on the site
- The north-west portion (8.5ha) of the site naturally outfalls to the low point along the western boundary of the site (refer to section 4.3). An overland flow path required at this low point. Post development discharge to be restricted to no more than pre-development conditions. This will require piping of drainage flows (up to say the 5% AEP) to the subject site’s outfall to the south.
- The tributary is sufficiently resilient (ie. bedrock) to convey urban flows from the catchment without attenuation of the hydrology.
- The Planning Scheme shows localised areas along Jacksons Creek (near Station Street) that is impacted by a Land Subject to Inundation Overlays (LSIO) (refer to Figure 9). Based on this overlay the criteria for the developed flows outfalling into Jacksons creek should be to control peak flow rates back to the equivalent pre-developed peak flow rates for rainfall events up to the 1% AEP.
- Stormwater quality to meet Best Practice pollutant removal targets at the outlet
- Remediation works required on the alluvial fan along the lower reach of the tributary prior to connection to Jacksons Creek

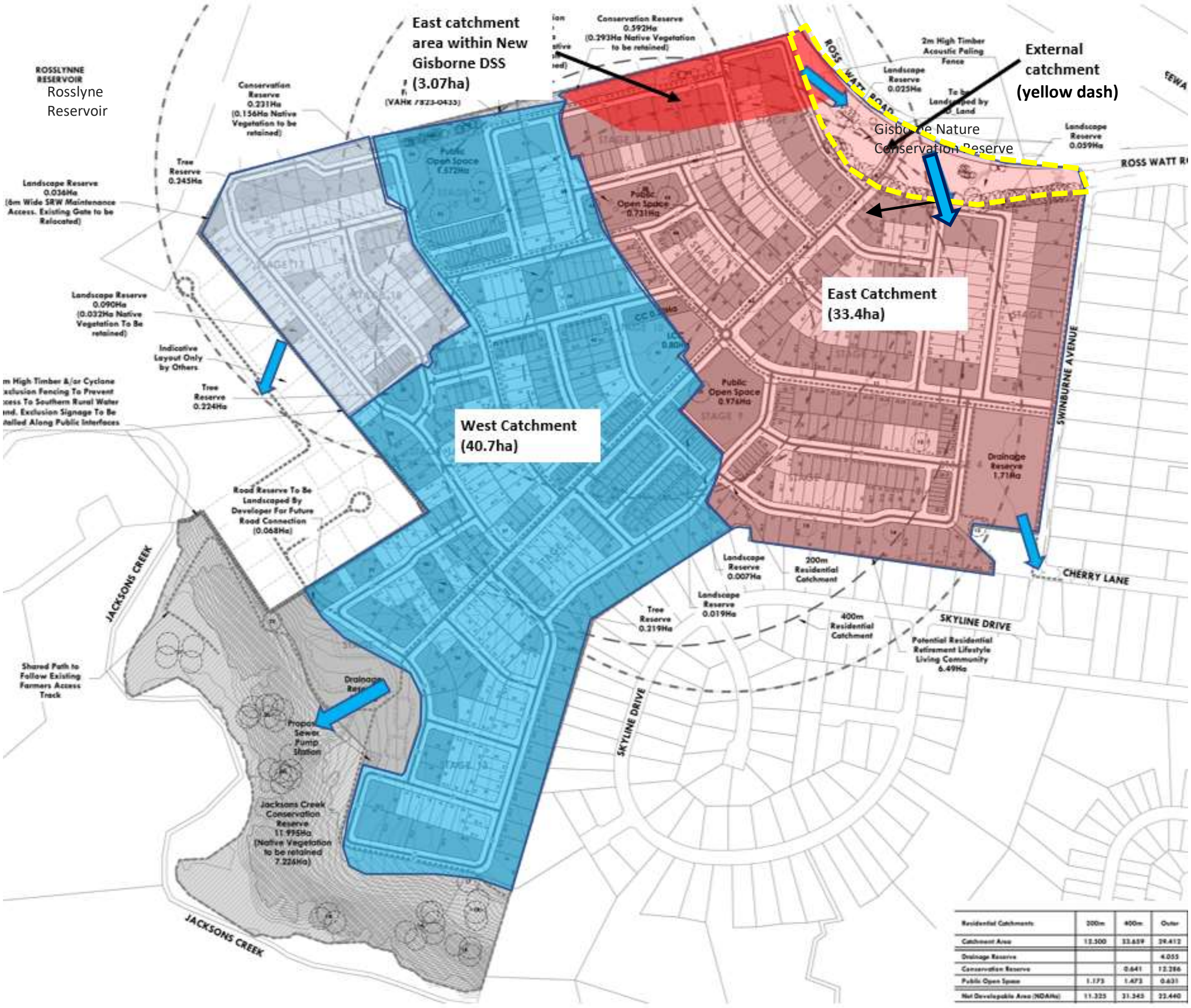


Figure 8 – Major catchment plan

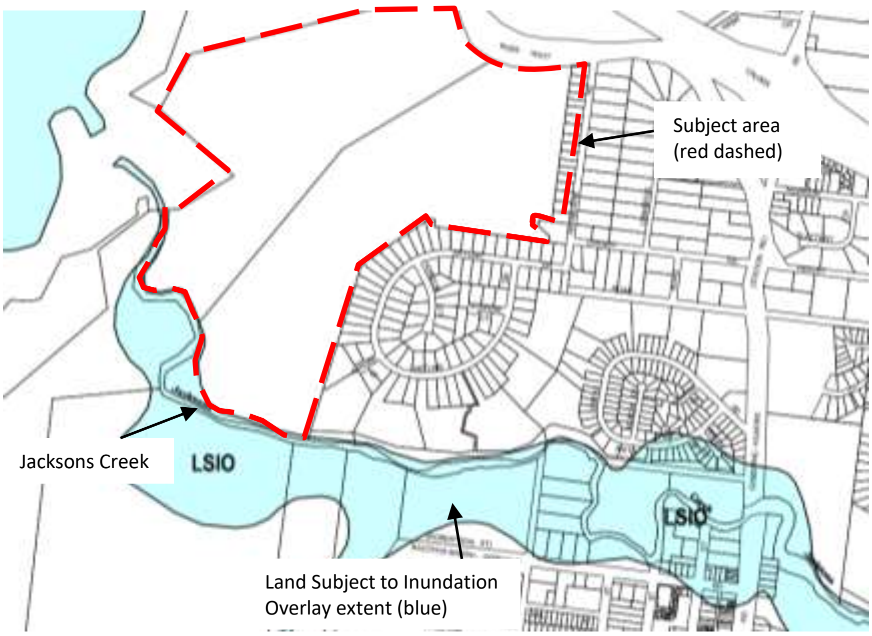


Figure 9 Land Subject to Inundation (LSIO) extent

4.2 Eastern flows near Gisborne Nature Conservation Reserve

The northern catchment area of the subject site within the New Gisborne DSS flows in an easterly direction towards Ross Watt Road. Based on levels from the site survey there is a small depression that runs between the subject site and an unnamed access track for Ross Watt Road, and another more formal swale running in-between Ross Watt Road and the unnamed track (see Figure 10 and Figure 11). Together these depressions/swales convey flows parallel to Ross Watt Road and are discharged back within the subject site. As such, all flows within the subject site remain south of Ross Watt Road and do not enter Gisborne Nature Conservation Reserve (located north of Ross Watt Road).

Development within the subject site will result in flows being conveyed within the road reserves and contained within the subject site. As such no flows will enter the Gisborne Nature Conservation Reserve and there will be no change to the hydrological regime (ie quantity or quality) within the conservation reserve as a result of the development of the 89 Ross Watt Road site.

Figure 10 Depression parallel to Ross Watt Road (looking south)

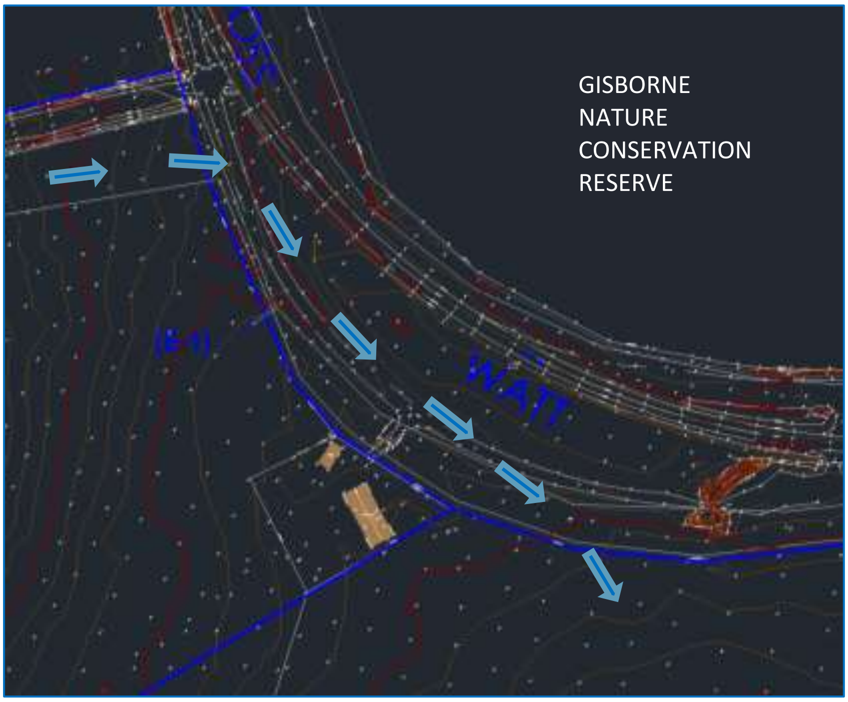


Figure 11 Field survey showing small depression parallel to Ross Watt Road

4.3 Rosslynne Reservoir

Rosslynne Reservoir is a key distribution storage facility for surrounding townships. Melbourne Water, as the water storage manager, has an obligation to protect Melbourne's water supply from a range of potential contaminants. This includes ensuring that urban development does not lead to a decline in water quality and contamination of the Reservoir through stormwater run-off. The protection of the Reservoir is essential to the health of all communities that rely on the Reservoir for drinking water.

An existing ridge line runs along the northern-western boundary of the proposed development site, which defines the catchment that naturally flows into the Rosslynne Reservoir (see Figure 12). As a result of this existing barrier no urban stormwater runoff from the proposed development site is able to enter the Rosslynne Reservoir. The existing ridge line along the northern boundary of the subject site continues through to the reservoir wall/spillway and as a result it is impossible for future urban stormwater runoff to flow into the Rosslynne Reservoir (see Figure 11). A small subcatchment (ie approx 3 hectares) in the north west corner of the development site falls away from the northern boundary ridge line and into a drainage line (ie location 4) to the south that traverses the escarpment before outfalling to Jacksons Creek about 200 metres downstream (ie location 0) of the Rosslynne Reservoir wall/spillway.

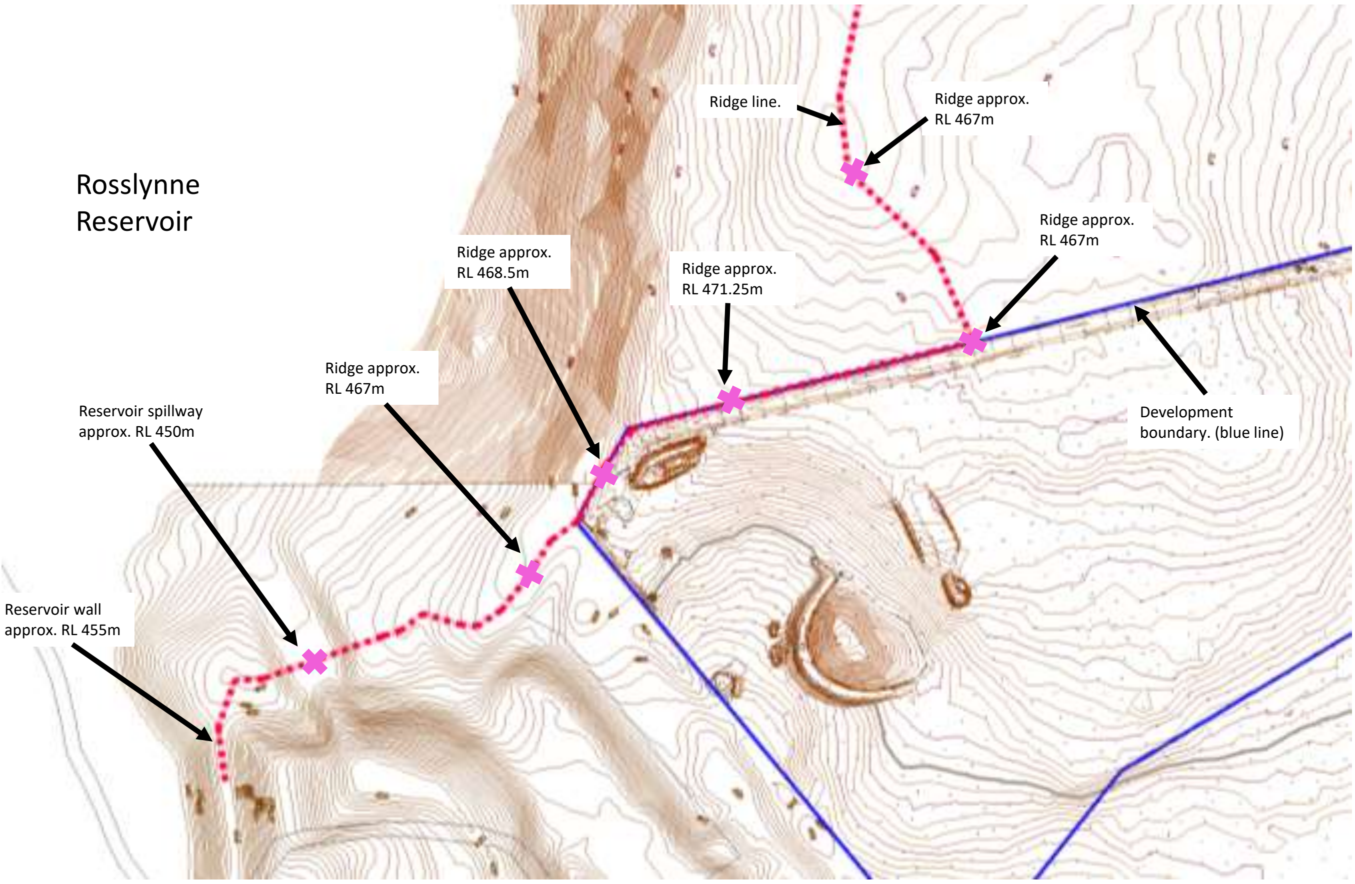


Figure 12 Existing conditions interface with Rosslynne Reservoir (ridge line and contours)

Development within the subject site will result in flows being conveyed by underground pipes and the road reserve as it outfalls to Jacksons Creek. The roads that convey overland flow will constructed in "cut" to provide further protection to the Rosslynne Rservoir. The peak 1% AEP flow rate discharging to the existing low point/drainage line at location 4 will be kept to the equivalent pre-development peak flow rate (note that all developed flows up to the 5% AEP will be conveyed via an underground pipe to the wetland/basin).

Section 7 provides further analysis and detail regarding the protection provided to Rosslynne Reservoir for extreme rainfall events (ie the 1 in 1 million year event) to ensure that that the proposed development will have no urban runoff entering Rosslynne Reservoir.

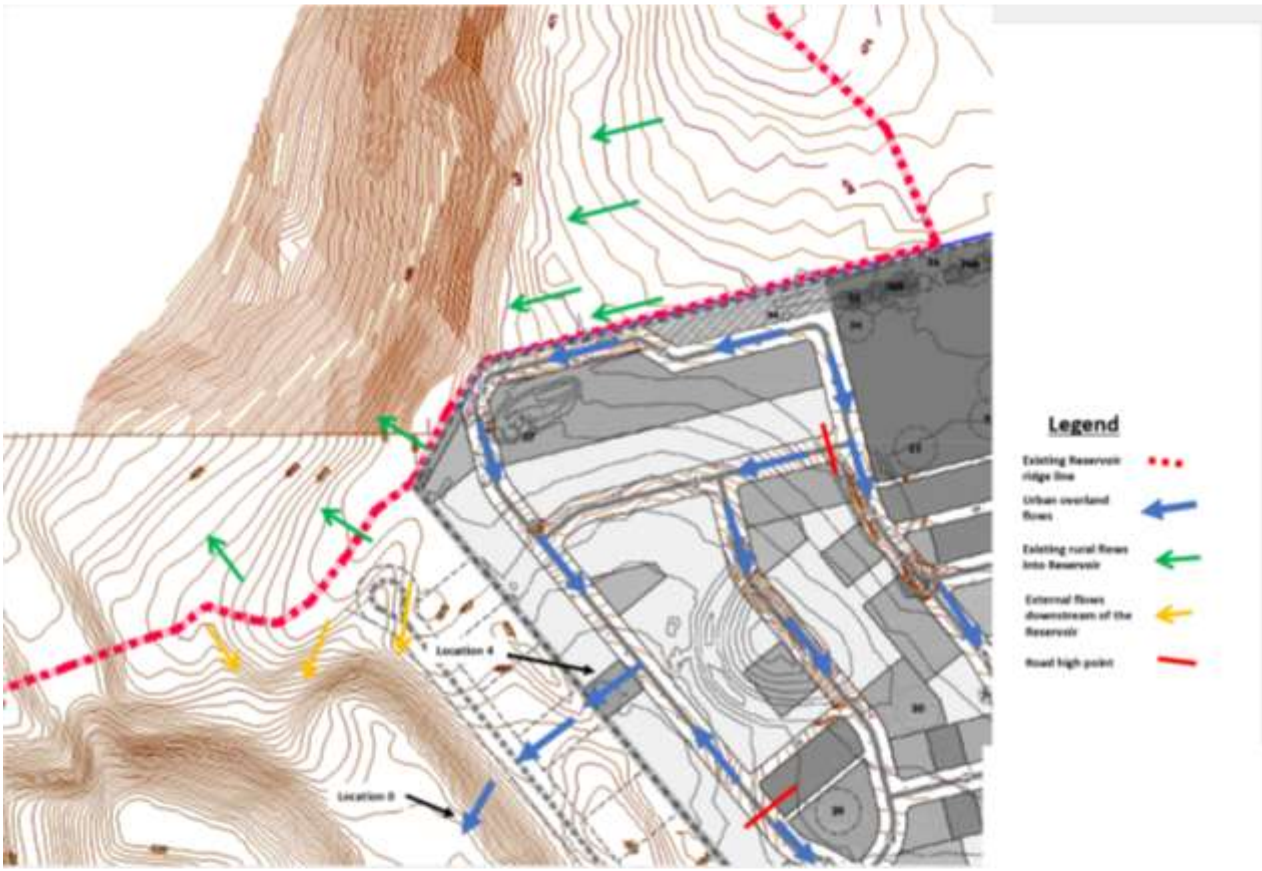


Figure 13 Control of urban stormwater runoff following development to protect Rosslynne Reservoir

4.4 Sub catchment delineation

Catchment delineation was conducted based on available survey data and the proposed road network. Under existing conditions flow paths are determined by the existing topography of the subject site. When the area is developed, flow paths will be influenced by the road network. To accurately compare the two scenarios, catchment delineation for both the existing and developed conditions were conducted based on the proposed road network (see Figure 14).

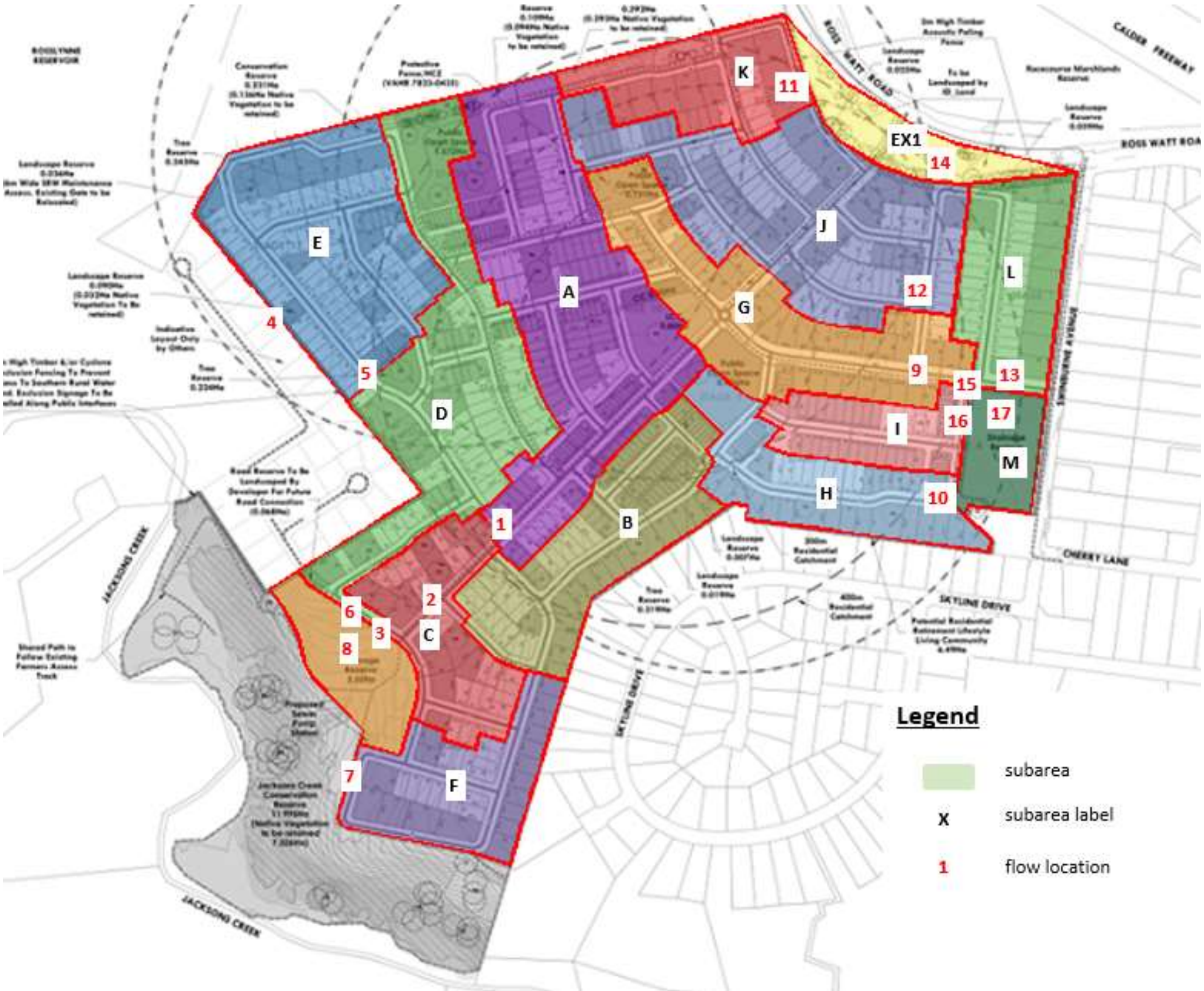


Figure 14 Sub-catchment area plan

Table 1 Descriptions of sub-catchments

Sub-catchment Label	Area (ha)	Comment
A	10.68	Catchment A outfalls through catchment C
B	5.55	Catchment B outfalls through catchment C
C	3.78	Catchment C outfalls to wetland/basin prior to release to Jacksons Creek
D	8.56	Catchment D outfalls through catchment C
E	7.64	Catchment E minor flows (pipe drainage) outfalls through catchment D. For the major drainage system, gap flows will travel overland along the existing low point to Jacksons Creek at no greater than pre-development peak flow rates.
F	4.09	Catchment F outfalls to wetland/basin prior to release to Jacksons Creek
G	6.52	Catchment G outfalls through catchment M
H	4.13	Catchment H outfalls through catchment I
I	2.41	Catchment I outfalls through catchment M
J	9.17	Catchment J outfalls through catchment G
K	3.52	Catchment K outfalls through catchment I
L	3.85	Catchment L outfalls through catchment M
M	1.69	Catchment M outfalls into Swinburne Ave/Cherry Lane
EX1	2.27	External catchment EX1 outfalls through catchment J

4.5 Existing stormwater quantity

The hydrological conditions of the subject were established using the RORB software package and rational method. These tools were used to estimate the peak design flows from the subject area under existing (i.e. pre-development) conditions discharging into Jacksons Creek and Swinburne Ave/Cherry Lane.

The following design rainfall parameters were adopted for the subject site based upon the Bureau of Meteorology's (BOM) "Intensity Frequency Duration (IFD) Tool – AR&R 2019) (refer to Figure 15).

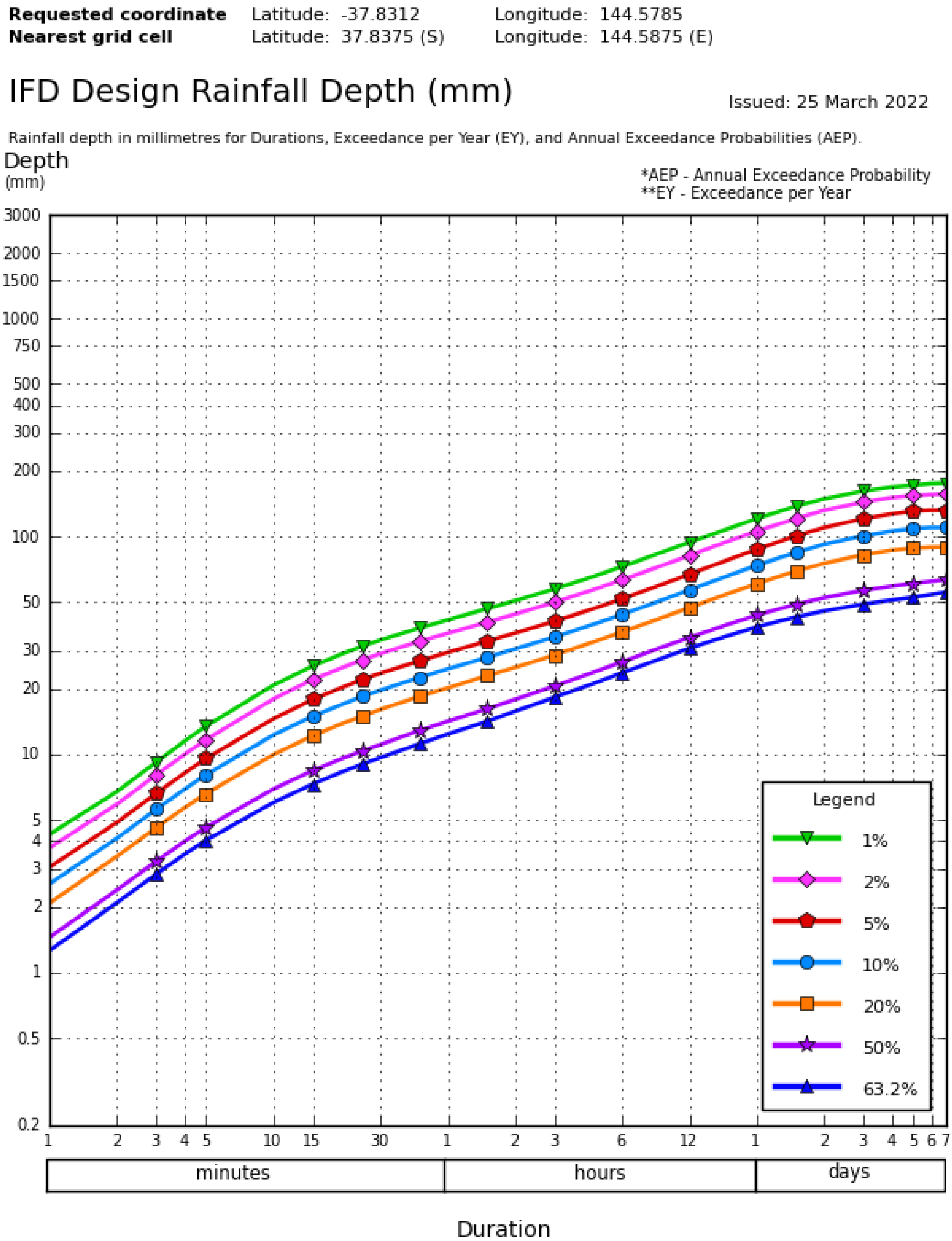


Figure 15 Design rainfall intensities for subject site

Existing Peak flowrates

Under existing conditions, the subject site largely consists of a greenfield used for agricultural purposes with a few residential buildings and a farm dam. As such a fraction of impervious of 0.1 was assumed. Critical flowrates for existing and developed conditions were established using the RORB software package. In accordance with best practice modelling procedures, at least 4 subareas exist upstream from the point of interest. The hydrologic modelling considered a range of design storms, from 10 minutes duration through to 72 hours, for a range of temporal patterns, in order to determine the critical duration event with respect to storage (i.e. the 60th percentile peak flow for a given duration).

The RORB model parameters were "derived" using Melbourne Water's regional equation for the Yarra and Maribyrnong catchments. Table 2 summarises the RORB input variables for the East catchment (-30.9 hectare) and West Catchment (40.5 hectares).

Table 2 RORB Pre-developed input variables

RORB input variable (Pre-developed)	East catchment	West Catchment	Method of derivation
m	0.8	0.8	Standard value
kc	0.65	0.71	Adopted based on Melbourne Water standard equation for Yarra and Maribynong catchments
IL	27	27	Sourced from ARR datahub
CL	3.1	3.1	Sourced from ARR datahub

The table below summarises the flowrates under pre-developed conditions.

Table 3 RORB Pre-developed flowrates

Location	20% AEP flowrate - m^3/s (Crit. duration)	1% AEP flowrate - m^3/s (Crit. duration)
Flow location 4	0.17 (9 hr)	0.73 (1.5 hr)
Flow location 7	0.04 (9 hr)	0.18 (1.5 hr)
West Catchment main outfall	0.61 (9 hr)	2.15 (1.5 hr)
East Catchment main outfall	0.55 (9 hr)	2.03 (1.5 hr)

5 Stormwater Management Objectives

While traditionally stormwater management strategies are typically concerned with meeting 1% AEP flood management and stormwater quality objectives, the unique landscape associated with the Jacksons Creek catchment also requires some additional considerations.

The table below summarises the parameters and stormwater management for the subject site.

Table 4 Objectives

Key issue	Objective	Commentary
Tributary/waterway stability	Ensure the tributary has the stability and resilience to receive runoff from the urbanised catchment	Informed by previous Alluvium's geomorphic field investigations for the site.
Protection of Rosslynne Reservoir	Ensure no runoff from urban development flows into Rosslynne Reservoir	All developed flows from the 89 Ross Watt Road site will flow into Jacksons Creek downstream of the reservoir. Provide Rosslynne Reservoir with protection from urban runoff for the 1 in 1,000,000 rainfall event.
Stormwater quality	Best practice environmental management targets (BPEM) in terms of percentage reduction TSS: 80%, TP: 45%, TN: 45%	
Stormwater quantity	Developed flows to be controlled back pre-developed conditions for events up to the 1% AEP. Minor drainage system of 20% AEP for residential Major drainage system to safely convey flows through developed areas.	LSIO requirement to provide retardation to control peak flow events (eg 1% AEP) back to predevelopment peak flow rates prior to entering Jacksons Creek. Local requirement to provide retardation to control peak flow events (eg 1% AEP) back to predevelopment peak flow rates prior at the Cherry Lane outfall.

6 Stormwater Quantity – Proposed Strategy

The proposed internal drainage system should be designed and constructed in accordance with the minor / major drainage system philosophy. For drainage assets within a catchment area of 60 hectares, Council design standards are expected to apply. For drainage assets greater than 60 hectares, Melbourne Water design standards are expected to apply. The sub-catchments and the location of flows at key points of interest are shown in Figure 14.

6.1 Minor Drainage

The minor drainage system would consist essentially of an underground piped network and should be designed to accommodate a 20% annual exceedance probability (AEP) rainfall event. The calculations adopted a 20% AEP runoff coefficient of 0.57 for residential areas, based on a combined fraction impervious for the site of 0.60. Table 5 summarises the minor drainage flows for the subject site, derived using the rational method.

Table 5 Minor drainage for subject site

Location	Contributing catchment	Area (ha)	tc (min)	I (20% AEP-mm/h)	Minor flows (20% AEP) (m^3/s)	Indicative pipe size (mm)
1	A	10.68	11.84	61.81	1.05	750
2	B	5.55	10.70	64.15	0.56	600
3	A, B, C	20.01	12.48	60.50	1.92	900
4	*	-	-	-	-	-
5	E	7.64	10.66	64.23	0.78	825**
6	D, E	16.20	12.24	60.98	1.56	750
7	F	4.09	8.49	71.35	0.46	450
8	A, B, C, D, E, F	40.30	12.48	60.50	3.86	1050
9	G	6.52	11.30	62.93	0.65	675
10	H	4.13	8.50	71.35	0.47	525
11	0.5K	1.76	6.50	77.0	0.21	375
12	K, J, EX1	14.96	11.80	61.90	1.47	825
13	L	3.85	8.50	71.35	0.43	450
14	EX1	2.27	10.00	65.60	0.24	375
15	K,J,EX1,G	21.48	12.20	60.98	2.07	900
16	H,I	6.54	9.00	69.40	0.72	675
17	G, H, I, J, K, L, I, EX1	33.56	14.98	55.33	2.94	1050

* Minor flows are diverted from Flow location 4 towards Flow location 5.
** Pipe sizing in Catchment E increased to convey up to the 5% AEP event (ie. 1.33 cumecs based on RORB model) - discussed further in Section 6.2

Based on the catchment areas, the entire pipe networks within the subject site is expected to become the responsibility of Council.

Stormwater quantity criteria:

- ✓ Convey minor flows (20% AEP) through residential catchments in a piped network
  - ✓ Maximum pipe size of 1050 mm
  - ✓ All pipes are Council assets

6.2 Major Drainage

The major drainage system will convey the 1% AEP flows through the study area. This consists of the road reserves throughout the development. Generally, the flows required to be conveyed in road reserves will be the gap flow, 1% AEP flow minus the pipe flow (ie 20% AEP) which will be contained within the minor piped drainage system. The calculations adopted a 1% AEP runoff coefficient of 0.70 for residential areas, based on a fraction impervious of 0.60. Table 6 summarises the major drainage flows for the subject site, derived using the rational method.

Table 6 Major drainage flowrates for subject site

Location	Contributing catchment	Area (ha)	tc (min)	I	Major flows	Gap Flow
1	A	10.68	13.5	113.8	2.36	1.32
2	B	5.55	11.9	120.2	1.30	0.73
3	A, B, C	20.01	15.4	106.2	4.13	2.22
4	E	8.15	**	**	2.04	0.71^
5	*	-	-	-	-	-
6	D	8.56	15.00	107.90	1.80	1.07
7	0.5*F	1.60	**	**	0.51	0.26
8	A, B, C, D, (0.5*F)	30.70	**	**	5.83	3.40#
9	G	6.52	12.6	117.60	1.49	0.84
10	H	4.13	10.30	126.70	1.02	0.55
11	(0.5*K)	1.76	8.00	142.50	0.49	0.27
12	K, J, EX1	14.96	13.10	115.50	3.36	1.89
13	L	3.85	9.00	135.00	1.01	0.58
14	EX1	2.27	10.00	128.00	0.56	0.33
15	K,J,EX1,G	21.48	13.60	113.50	4.74	2.67
16	H,I	6.54	11.00	123.90	1.58	0.86

* Flows conveyed away from Flow location 5 due to high point on road
* * Flows calculated using RORB
^ Pipe upsized to convey the 5% AEP design flow (ie. 1.33 cumecs based on RORB model)
# Multiple road discharge points to drainage reserve

The north-west portion of the West catchment (Sub-catchment E) requires the minor drainage to be sized to ensure the resulting 1% AEP gap flow is less than existing conditions at Flow location 4. This has been achieved by increasing the size of the pipe network within Sub-catchment E to be able to convey flows up to the 5% AEP event (see Table 7).

Table 7 Flow location 4 - 1% AEP flows

Location	Existing 1% AEP flows (m^3/s)	Design 1% AEP flows (m^3/s)	Design Gap flow (m^3/s)
4	0.73	2.04	0.71

Based on the road width and slope, and the maximum allowable nature strip cross-fall of 1 in 15, the capacity that can be contained within the main road reserves is shown in Table 8. This capacity has been determined using HEC-RAS based on the DELWP 2019 document "Guidelines for Development in Flood Affected Areas" and Council's requirement that 1% AEP design flows must be contained within the road reserve and must not enter any part of private allotments.

Table 8 Road reserve flow capacities

Road width	Slope	Road capacity (m^3/s)
16 m	2.5 %	2.6
16 m	1.0 %	2.5
16 m	0.5 %	2.3
20 m	0.5 %	2.8
20 m	1.5 %	3.1
24 m	1.0 %	3.1

Based on the above information all overland flows can be safely contained within the proposed road reserves. Figure 16 shows the overland flow paths through the subject site.

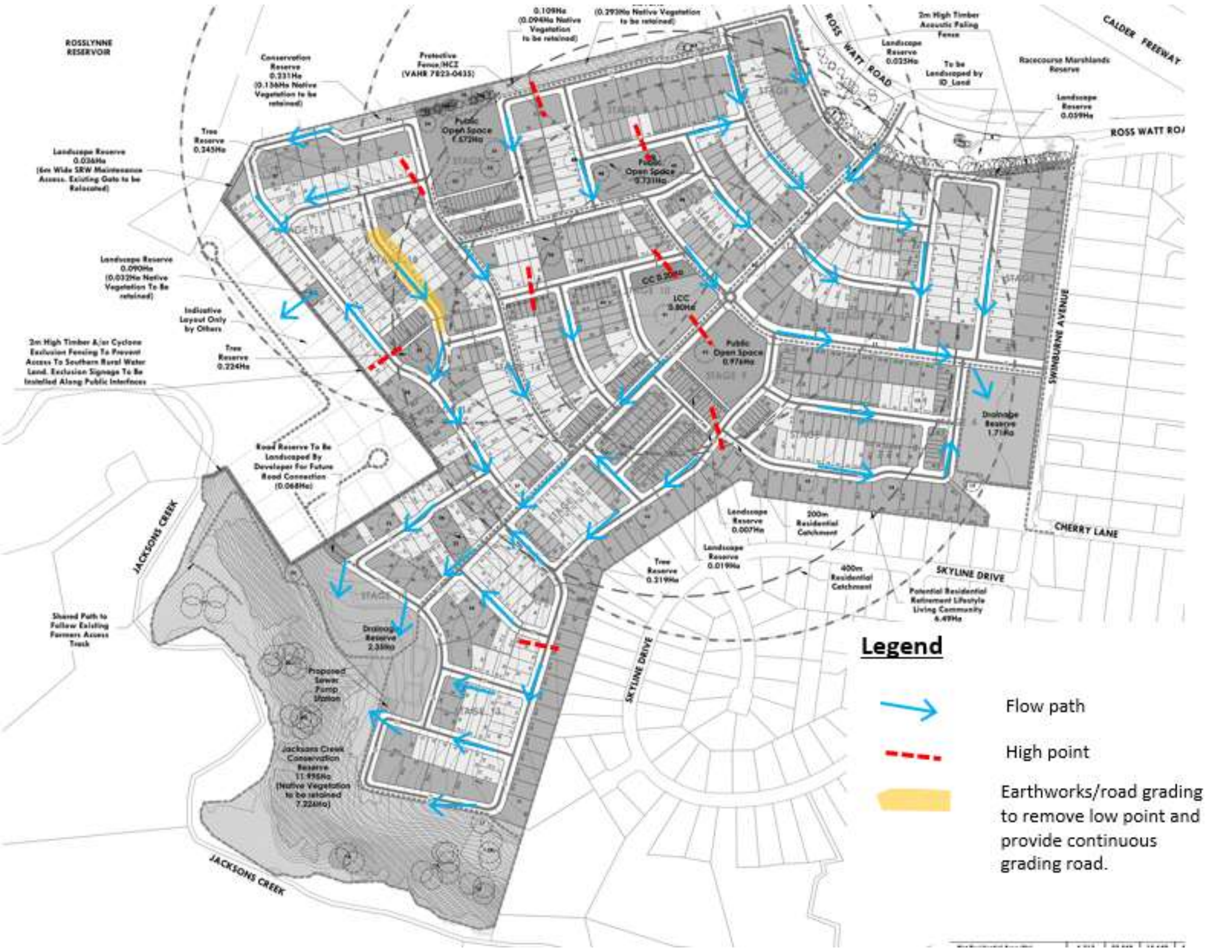


Figure 16 Overland flow paths

Stormwater quantity criteria:

- ✓ Convey internal major flows through road reserves and pipe system
  - Maximum gap flow = 2.67 m^3/s^*

*Flow location 8 in drainage reserve, as such not subject to overland road capacity requirements

6.3 Retardation and Outfall overview

Western Catchment
The outfall from the western catchment is via the existing tributary that flows through the site and outfalls directly to Jacksons Creek.

As outlined in Section 3 and Section 0, the geomorphology assessment has determined that the existing drainage line is bedrock and therefore of sufficient stability to accept the hydrologic flow regime for the post development conditions.

However localised areas along Jacksons Creek downstream of the subject area (in the vicinity of Station Street) are covered by a Land Subject to Inundation Overlay (LSIO). To ensure flooding within these areas does not increase due to development of the subject site, retardation is required to control peak flow rates back to the equivalent predevelopment peak flow rates (for rainfall events up to the 1% AEP) prior to entering Jacksons Creek.

Retardation storage and stormwater treatment will be provided by an integrated treatment asset (West WLRB) within the proposed drainage reserve (2.35ha) adjacent to the existing tributary.

Eastern Catchment
The eastern catchment naturally outfalls to Swinburne Avenue and Cherry Lane. The existing outfall is a swale/table drain along Cherry Lane where it discharges to the open channel known as Honeysuckle Creek (refer to Figure 17). The southern portion of the Swinburne Avenue/Cherry Lane intersection is raised, which results in overland flows in large events (eg. 1% AEP) flowing east along the Cherry Lane road reserve.

The proposed development will need to provide retardation to attenuate post development peak flow rates to the equivalent pre-development peak flow rate for events up to the 1% AEP. The retardation storage will be integrated with the wetland asset (East WLRB) within the proposed drainage reserve (1.70ha) in the south east corner of the site (refer to Figure 18).

The invert level of the subdivisional drainage system and the outlet from the wetland/retarding basin will be significantly lower than existing table drain depth in Swinburne Avenue/Cheery Lane. As a result an underground drainage outfall will need to be constructed along Cherry Lane from the proposed drainage reserve to the outlet at Honeysuckle Creek. The upstream portion of the pipe will control flows up to the 1% AEP before progressively surcharging along Cherry Lane to revert to a 20% AEP capacity pipe (refer to Figure 17).

The minor flows within the east catchment will be conveyed by the pipe network to outfall into the sediment basin associated with the East WLRB.

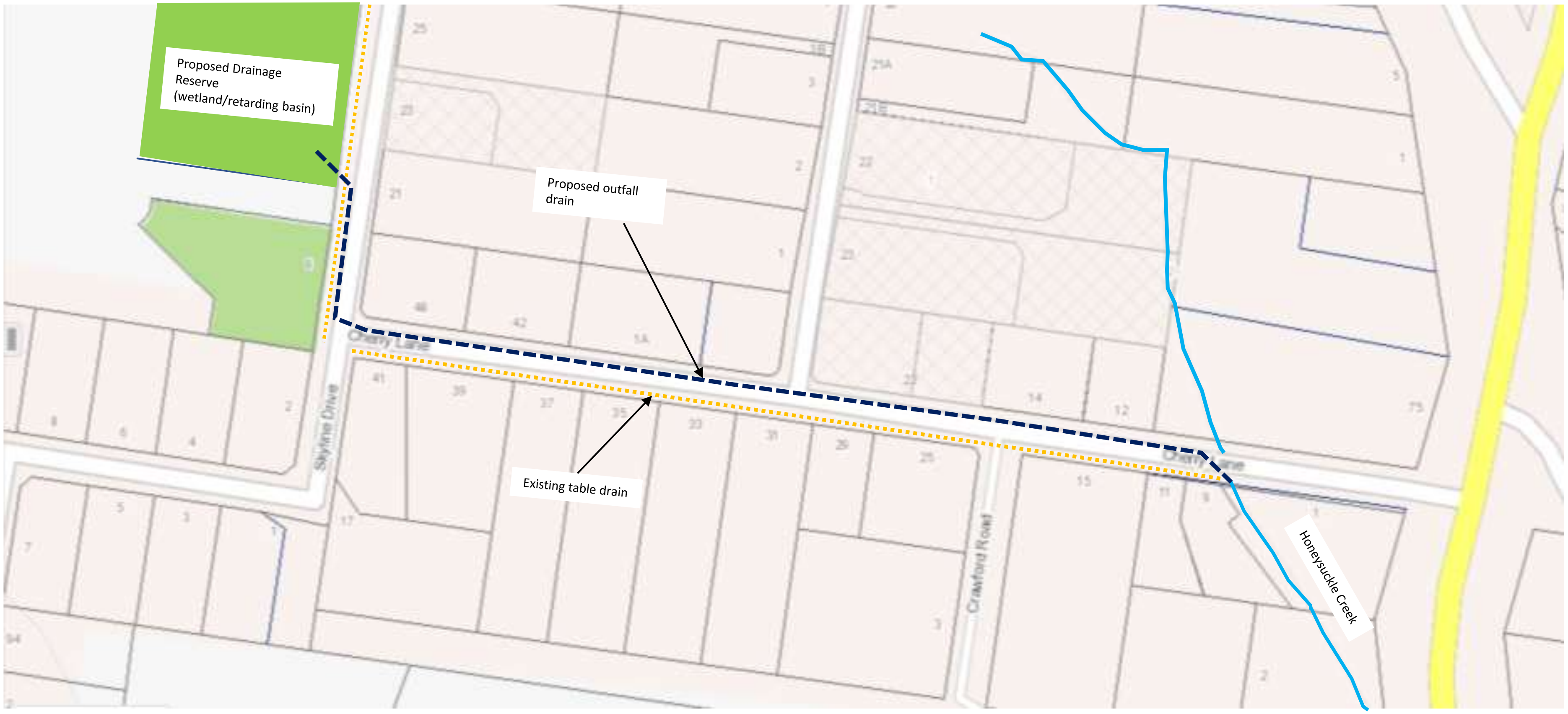


Figure 17 Outfall arrangements along Swinburne Avenue / Cherry Lane

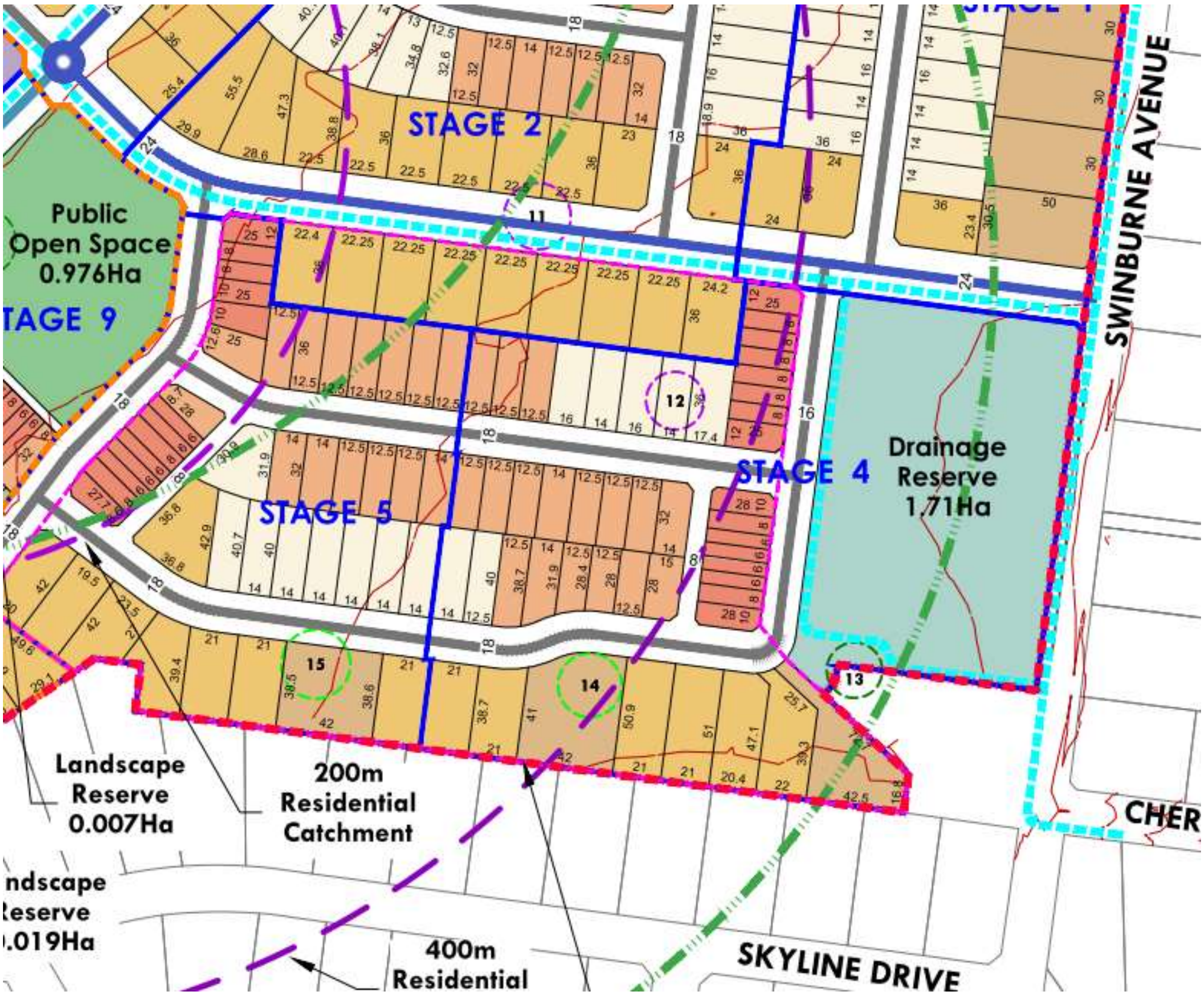


Figure 18 Location of proposed drainage reserve to control stormwater runoff (quality and retardation) from the east catchment

6.4 Retarding basin sizing

In the development scenario of the subject site, detention storage is required to attenuate flows back to the peak flow rates identified in Section 4. Specifically, this requires peak flowrates in developed conditions to be attenuated back to the following pre-developed 1% AEP flowrates:

- West Catchment:2.15 m^3/s
- East Catchment: 2.03 m^3/s

Flows from the Western catchment will discharge directly into Jacksons creek. Flows from the Eastern catchment will be discharged into an underground pipe along Cherry Lane, sized to convey the 1% AEP flowrates from the subject site.

Hydrologic Modelling

The RORB software package was used to produce a hydrological model and determine the retardation storage requirements for the site under developed conditions. Table 9 summarises the RORB input variables used for the developed conditions.

Table 9 Developed RORB inputs variables

RORB input variable (Developed)	West Catchment	East Catchment	Method of derivation
m	0.8	0.8	Standard value
kc	0.71	0.65	Adopted based on Melbourne Water standard equation for Yarra and Maribynong catchments
IL	15.1	15.1	Taken as 60% of ARR datahub value (minus medium pre-burst value)
CL	3.1	3.1	Sourced from ARR datahub

The RORB hydrological model was iteratively run to determine the minimum storage size for the RBWL while still meeting the 1% AEP flowrate requirements. The hydrologic modelling considered a range of design storms, from 10 minutes duration through to 72 hours, for an ensemble of temporal patterns, in order to determine the critical duration event with respect to storage (i.e. the 60th percentile peak flow for a given duration). A summary of the detention modelling results for the 1% AEP event is provided below:

Table 10 Summary retarding basin sizing

	West Catchment	East Catchment
Critical storm duration (hr)	3	2
1% AEP design flows with attenuation (m^3/s)	1.92	1.81
1% AEP existing flow (m^3/s)	2.15	2.03
Peak storage (m^3)	13,000	7,820
Outlet pipe diameter (mm)	2 x 750	1 x 1350

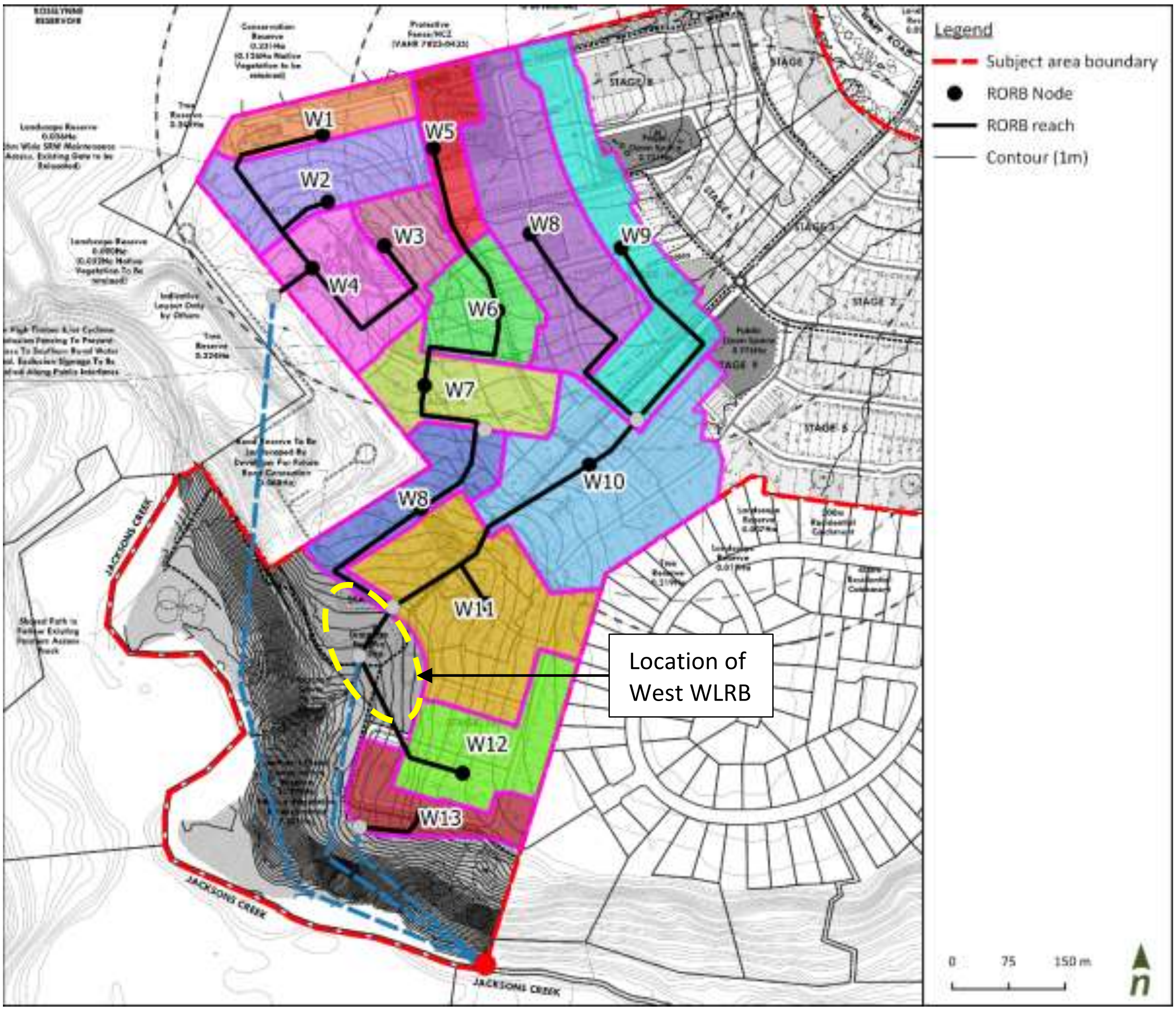


Figure 19 RORB West catchment plan

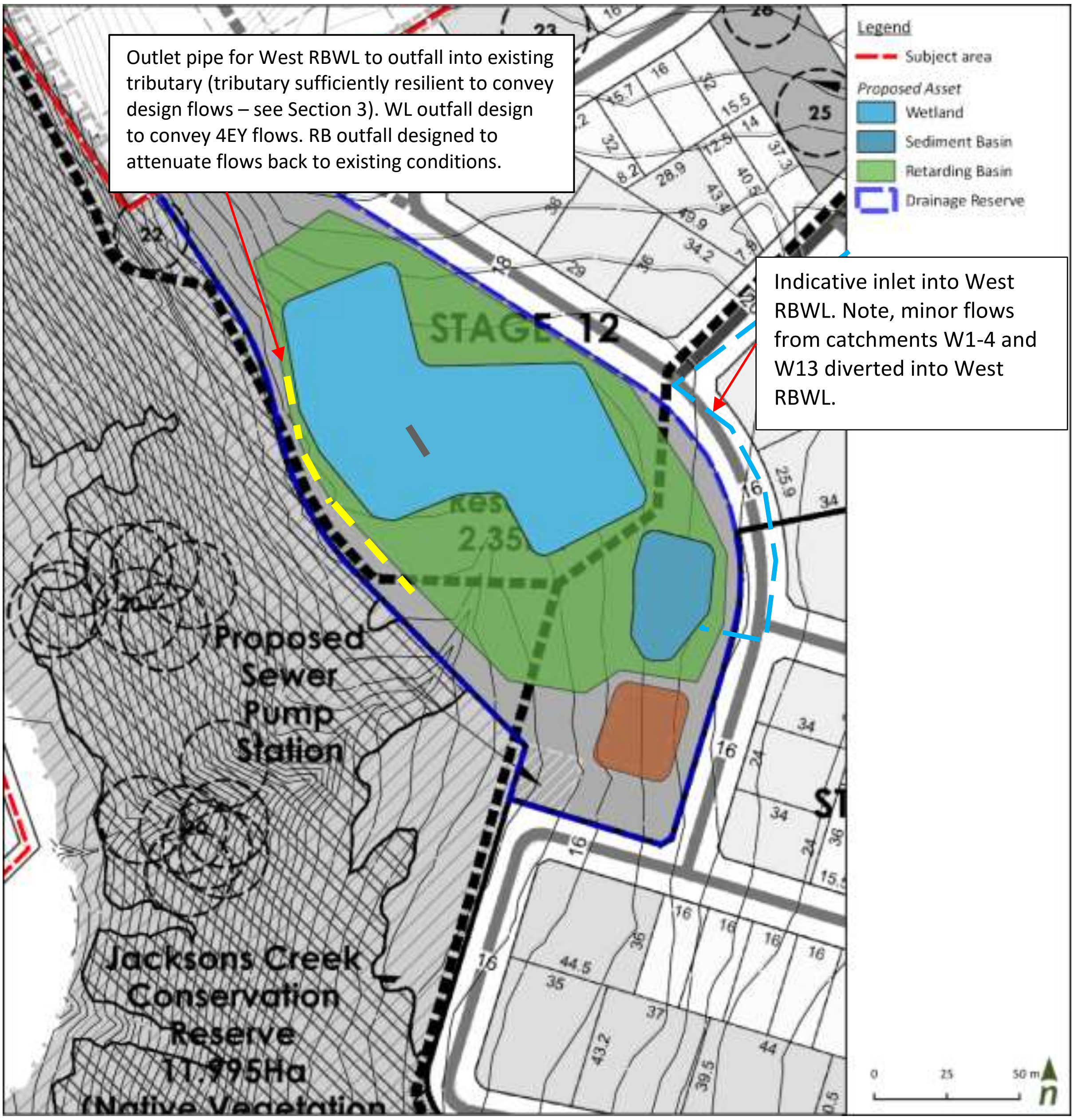


Figure 20 West RBWL proposed asset plan

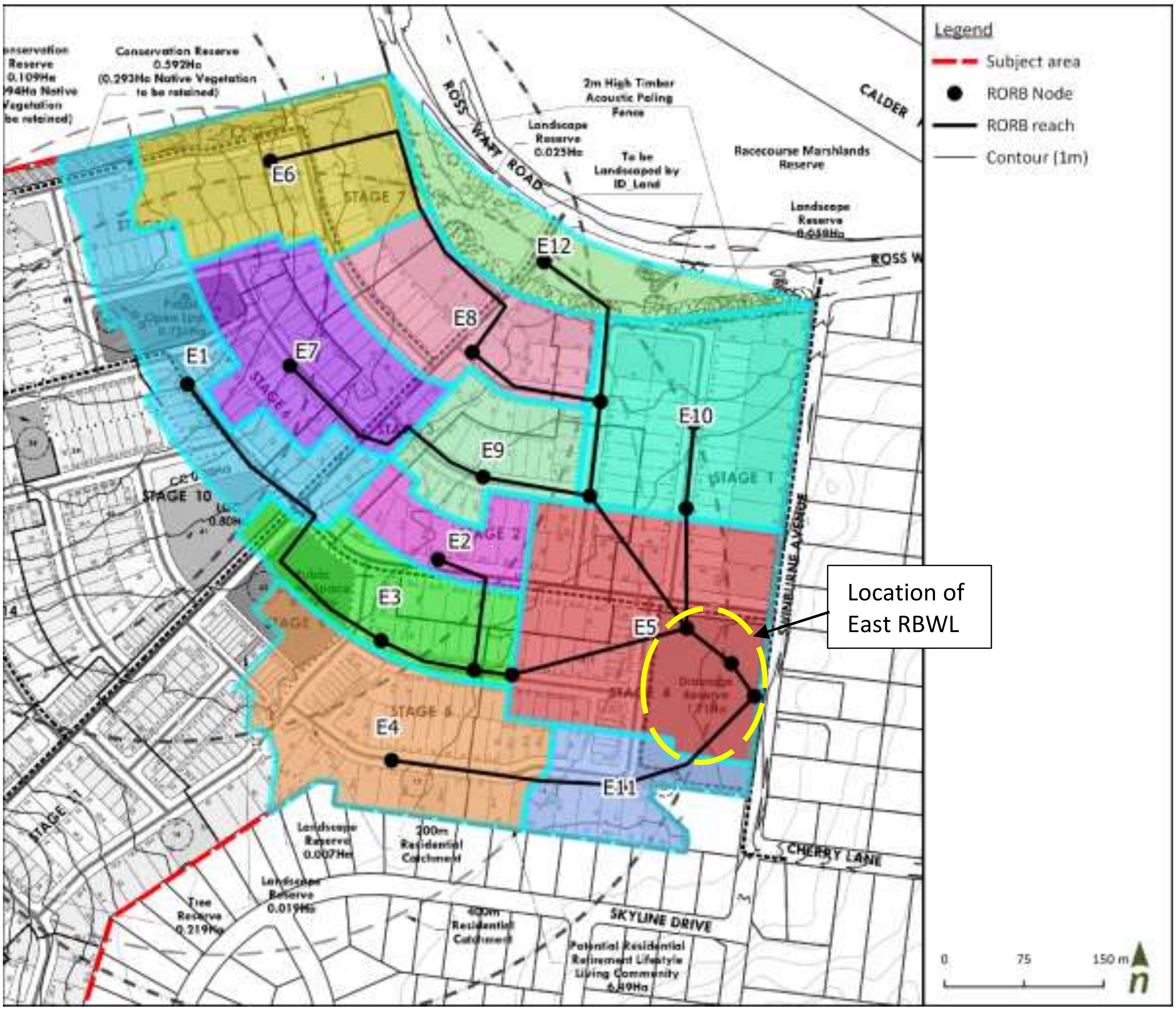


Figure 21 RORB East catchment plan

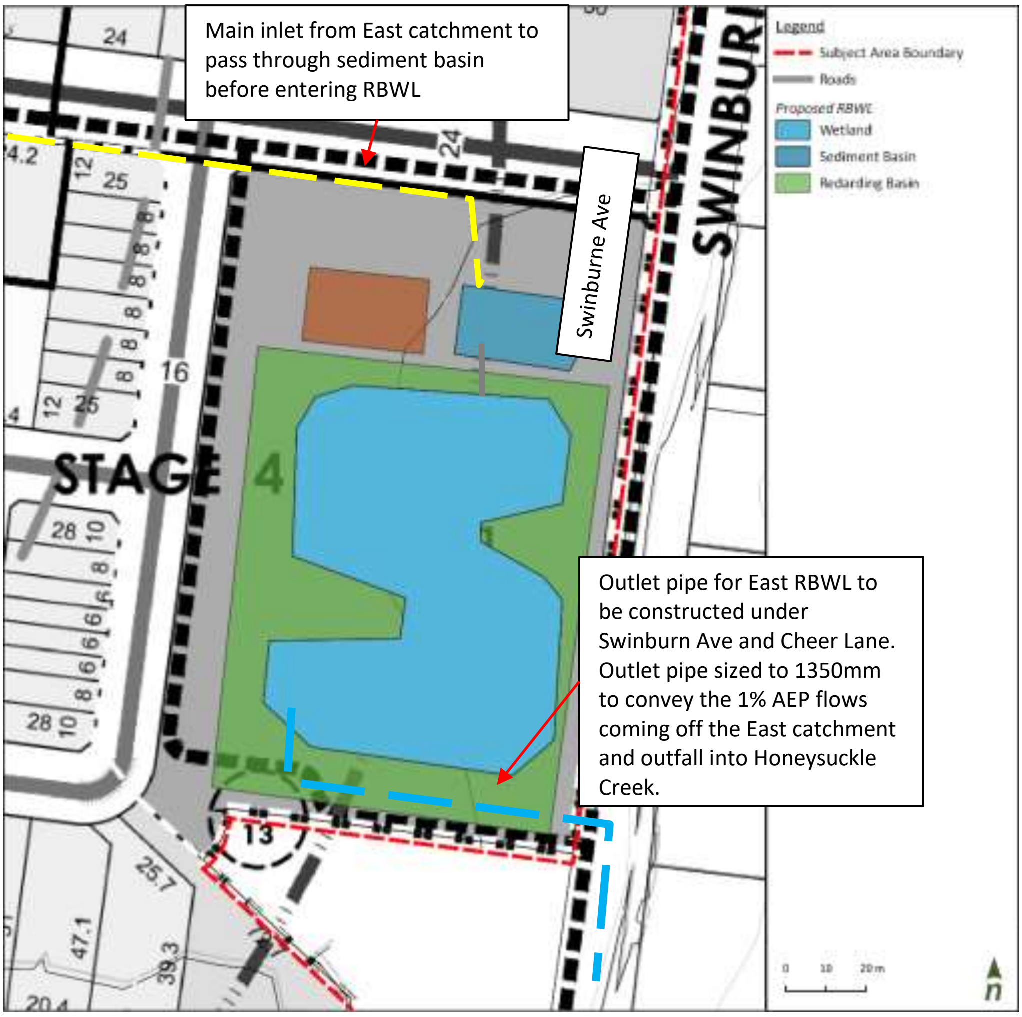


Figure 22 East RBWL proposed asset plan

7 Rosslynne Reservoir Protection

As outlined in Section 4.3, a small portion of the western catchment is close to the ridge line of the Rosslynne Reservoir's 'natural' catchment. Rosslynne Reservoir is a key distribution storage facility for surrounding townships. Melbourne Water, as the water storage manager, has an obligation to protect Melbourne's water supply from a range of potential contaminants. This includes ensuring that urban development does not lead to a decline in water quality and contamination of the Reservoir through stormwater run-off. The protection of the Reservoir is essential to the health of all communities that rely on the Reservoir for drinking water.

A similar situation occurs around the Greenvale Reservoir, where Melbourne Water has developed the "*Greenvale Reservoir Catchment: Drinking Quality Risk Management Plan (March 2008)*". Development adjacent or within the Greenvale Reservoir Protection Area necessitates protective measures be constructed to ensure no waterborne contaminates enter the Reservoir. The key criteria is that the Greenvale Reservoir requires a 1 in 1 million year level of protection from urban development runoff.

Alluvium has adopted the same principles for the Rosslynne Reservoir based on the Greenvale Reservoir criteria. That is the ridge line is required to provide a 1 in 1 million year level of protection from urban development runoff.

7.1 Hydrology - Analysis of extreme events (up to the PMP)

Probable Maximum Precipitation (PMP) is defined by the World Meteorological Organization (1986) as 'the greatest depth of precipitation for a given duration meteorologically possible for a given size storm area at a particular location at a particular time of year'.

The Bureau of Meteorology has prepared a guidance document to estimate the probable maximum precipitation for durations up to three or six hours in Australia. The document is titled "The Estimation of Probable Maximum Precipitation in Australia: Generalised Short Duration Method (GSDM)" and is suitable for application to small catchments and small reservoirs anywhere in Australia. The method allows for two classes of terrain and takes into account the local moisture availability and the mean elevation of the catchment.

Alluvium has applied the GSDM method to assess the extreme rainfall events for the Ross Watt Road deveolpment. The catchment adjacent to the existing Rosslynne Reservoir is very small (less than 3 hectares) therefore the critical storm duration (or time of concentration) is likely to be short. As a result Alluvium has considered durations up to 1 hour. The terrain is considered "smooth" as the elevation change is less than 50 metres over a horizontal distance of 400 metres. A summary of the PMP rainfall estimate calculations is provided in Table 11.

Table 11. PMP estimation

Storm duration (hours)	Initial Rainfall Depth (mm)	Moisture Adjustment Factor (MAF)	PMP (mm)	Rainfall Intensity (mm/h)
0.25	250	0.55	138	759
0.50	360	0.55	198	574
0.75	460	0.55	253	506
1.00	570	0.55	314	471

The rainfall intensity was determined using the Generalised Short Duration Method Temporal Distribution (see Figure 23)

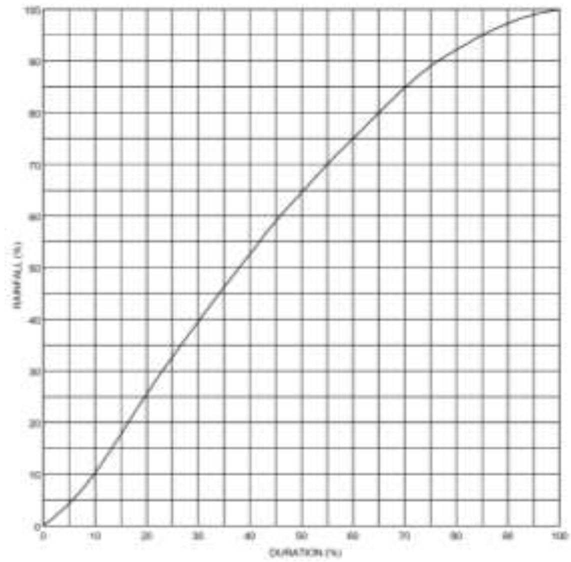


Figure 23. Generalised Short Duration Method Temporal Distribution

Using deterministic methods of estimating PMP rather than statistical methods, means that the assignment of Annual Exceedance Probabilities (AEPs) to the PMP estimates is not straightforward. The uncertainties associated with any estimate of the exceedance probability of a PMP depth are very large. However, by using the same assumptions to estimate AEPs for each of the PMP methods, the results can provide useful guidance in a comparative sense (Pearce, 1994).

Kennedy and Hart (1984) used notional AEPs for various PMP methods as a means of indicating the different security levels provided by the different methods. Laurenson and Kuczera (1999) issued interim estimates of the AEP which included a modification of Kennedy and Hart's (1984) figures. They recommended an AEP of between 10^{-6} to 10^{-7} for small catchment areas.

Therefore based on the above the PMP values in Table 11 provide a reasonable estimation of the 1 in 1 million AEP, which is the level of protection required for the Rosslynne Reservoir.

The urban catchment in the vicinity of the existing ridge line is small (ie less than 3 hectares) as shown in Figure 24. This catchment has been minimised by diverting overland flows away from the area though rod reserve gradings. A summary of the 1 in 1 million year design flows at various locations within this subcatchment is provided in Table 12.

Table 12. 1 in 1,000,000 Year Design Flow Estimate (refer to Fig 24 for flow locations)

Location	Catchment Area (ha)	Design Flow Estimate (cumecs)
C-C	0.278	0.59
B-B	0.871	1.84
D-D	0.540	1.14
A-A	2.859	6.03

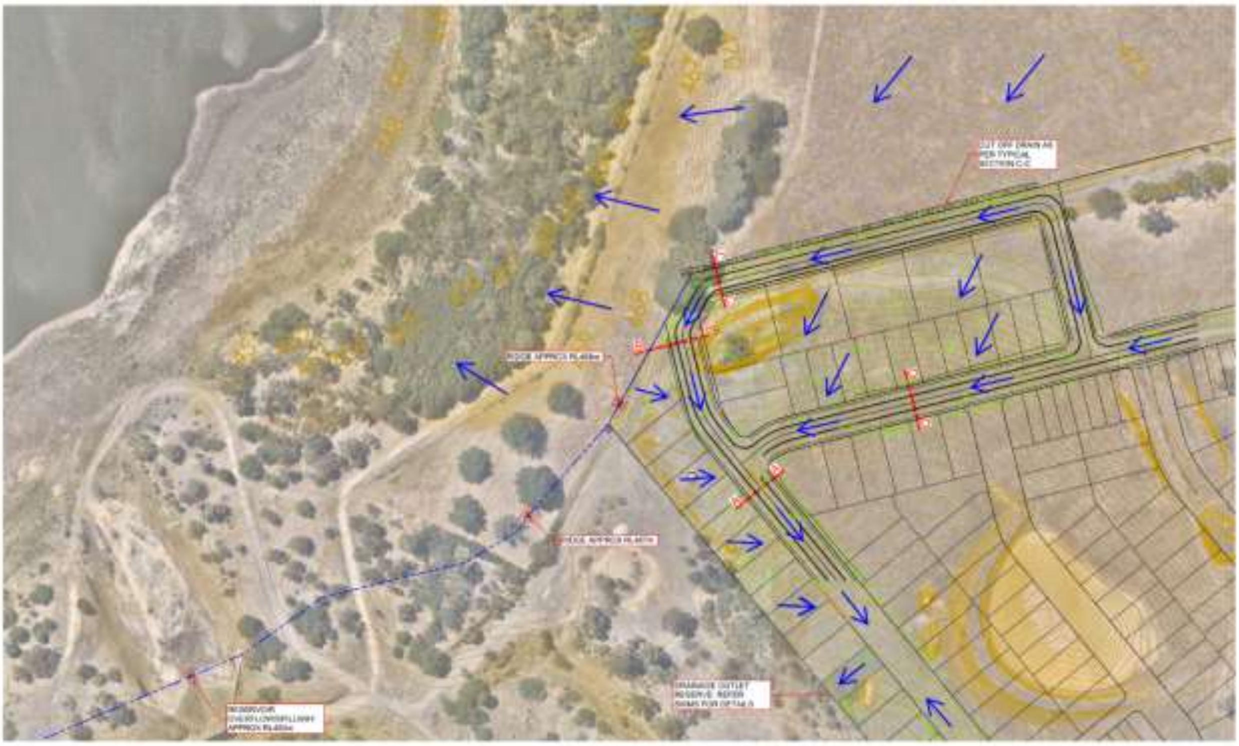


Figure 24 Flow location and Catchment plan for 1 in 1,000,00 year event analysis

7.2 Hydraulic Analysis of 1 in 1 million year event

The 1 in 1,000,000 design flows that were estimated in Section 7.1 have been hydraulically analysed to determine the depth of flow within the road reserve. Using the scenario at Greenvale Reservoir as the precedent, the depth of flow and the 600mm freeboard will be contained within the road reserve by constructing the road in cut and providing retaining wall structures at the front of the lots (see Figure 25 as an example of development adjacent to Greenvale Reservoir). The rear of the lots will continue to fall towards the top of the retaining wall, therefore the actual protection to the Rosslynne Reservoir will exceed the minimum criteria of 600mm above the 1 in 1,000,000 year flow depth in the development.

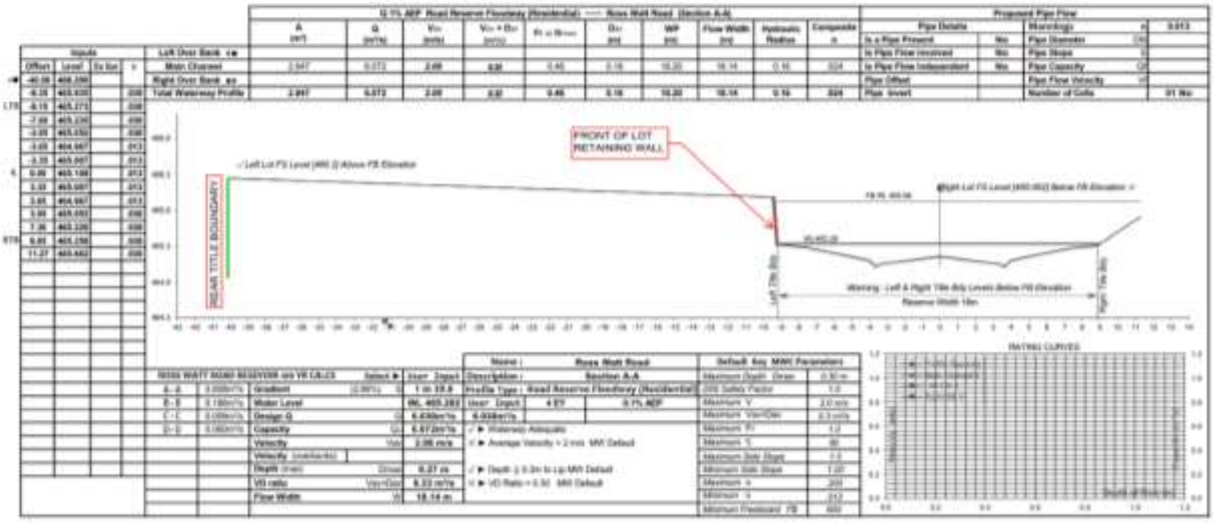
Figure 25 Containment of 1 in 1 million year event flow depth and 600mm freeboard via retaining walls at the front of lots (image at Riverglen Dr within the Greenvale Reservoir catchment)

A summary of the flow depths and freeboard levels at the key locations are provided in Table 13, whilst the cross sections are shown in Figure 26. This demonstrates that the proposed development meets the Rosslynne Reservoir protection criteria associated with urban stormwater runoff.

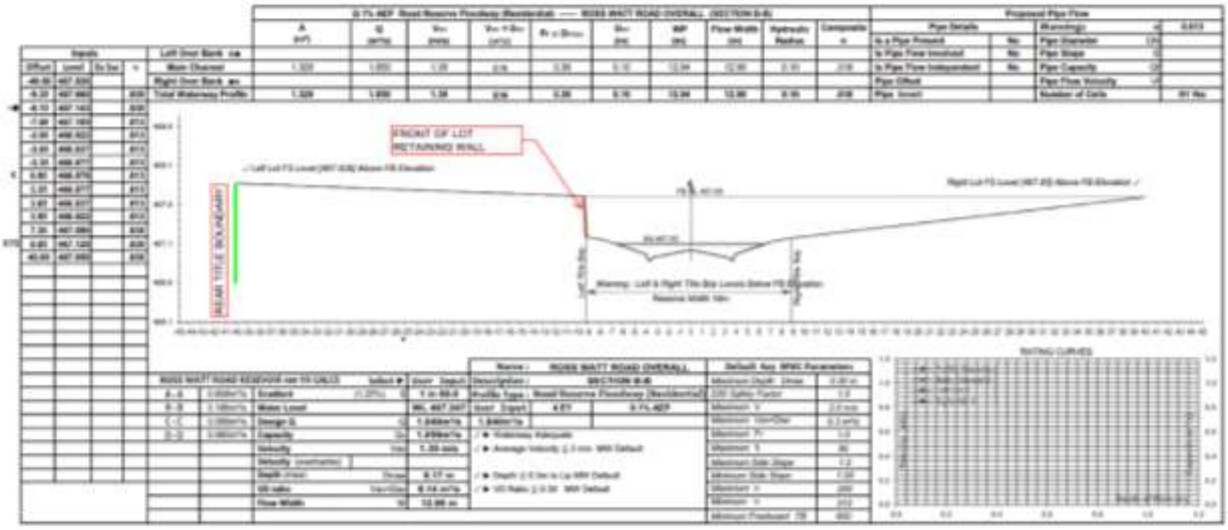
Table 13. 1 in 1,000,000 Flow Depths and Freeboard to Rosslynne Reservoir

Location	Flow depth (mm) *RL (m AHD)*	Freeboard within road reserve RL (m AHD)	Rear of Lot Level (RL m AHD)	Freeboard to Rosslynne Reservoir (mm)
C-C	170mm RL 469.54	600mm RL 479.14	NA	600mm
B-B	213mm RL 467.05	610mm RL 467.66	RL 467.826	776mm
A-A	313mm RL 465.28	655mm RL 465.935	RL 466.20	920mm

SECTION A-A



SECTION B-B



SECTION C-C

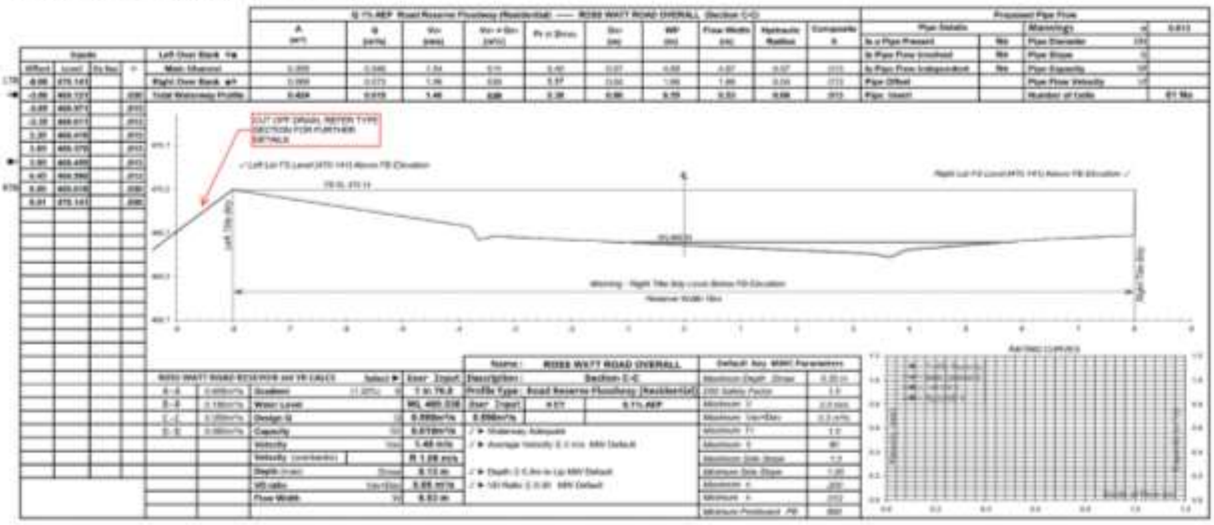


Figure 26 Flow depths (1 in 1 million year event) within road reserve cross sections

8 Stormwater Quality

Alluvium understands that a key principle for the development of the site is that all stormwater is to be treated to best practice (ie Best Practice Environmental Management Guidelines (BPEM)) before being discharged into a waterway. The following BPEM targets have been adopted:

- 70% removal of the total Gross Pollutant load
- 80% removal of total Suspended Solids (TSS)
- 45% removal of total Nitrogen (TN)
- 45% removal of total Phosphorus (TP)

The catchments and stormwater treatment train have been modelled via MUSIC using parameters defined in Table 14. The analysis has been based on the latest Melbourne Water MUSIC modelling guidelines. This includes:

- The ten year rainfall template for the Kooweerup station between the years 1971 – 1980
- Soil store parameters with a soil store capacity of 120mm and a field capacity of 50mm.
- Fraction impervious value of 0.60 for residential area

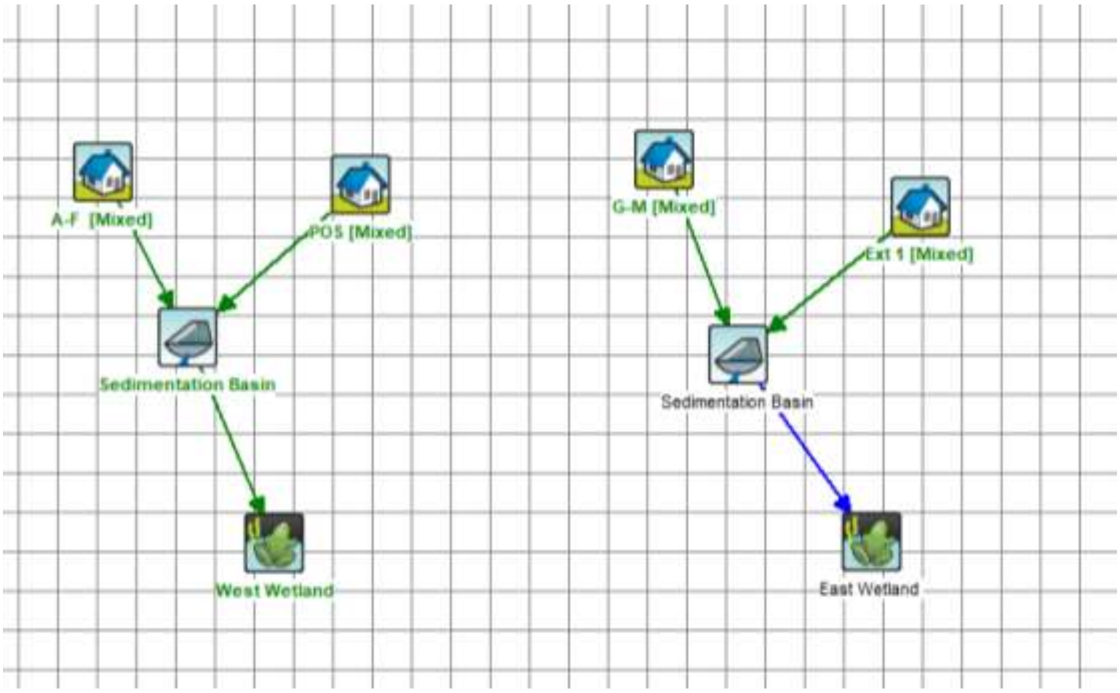


Figure 27. *MUSIC model for the west and east catchments*

The configuration of the treatment train is provided in Table 14. It consists of a sediment basin and wetland located in each of the two main catchments (ie west catchment and east catchment). Wetland performance is given in Table 15, demonstrating the design meets the BPEM pollutant reduction targets.

Table 14. Treatment asset parameters

Description	*West Catchment*		*East Catchment*	
	Sediment Basin	*Wetland*	*Sediment Basin*	*Wetland*
NWL area, m^2	950	6800	700	5800
Average depth, m	1.0	0.40	1.0	0.40
Extended detention, m	0.35	0.35	0.35	0.35
Residence time, h	-	72		72

Table 15. Overall treatment performance of the system

Parameter	West Catchment	East Catchment
Total Suspended Solids (TSS) removed	83.6%	83.3%
Total Phosphorus (TP) removed	70.0	70.1%
Total Nitrogen (TN) removed	45.0%	45.0%

The sediment pond has been sized in accordance with Melbourne Waters sediment pond design guidelines using the Fair and Geyer equation, design calculations are provided in Table 16.

Table 16. Sediment basin design parameters and checks (west catchment)

	Parameter	Proposed design
Conditions	Contributing Catchment (ha)	41
	Area of Basin (m^2)	950
Capture Efficiency	Settling Velocity of Target Sediment (mm/s) [Particle size 125 µm]	11
	Hydraulic Efficiency (λ)	0.19
	Permanent Pool Depth, dp (m)	1.5 (empty); 0.5 (full)
	Extended detention depth, de	0.35
	Number of CTSR's, n	1.23
	Depth below permanent pool that is sufficient to retain sediment, d* (m)	0.5
	Design Discharge (m^3/s) [4EY]	0.78
	Capture Efficiency	95.1%
	Check (>95%)	OK
Sediment Storage	Sediment Loading rate, Lo (m^3/ha/yr)	2.0
	Desired clean-out frequency, Fr	5
	Storage volume required, St	405
	Available sediment storage volume	500
	Check (Available storage > required storage)	OK
Sediment dewatering	Depth for dewatering area (m)	0.5
	Area required for dewatering (m^2)	810

Table 17. Sediment basin design parameters and checks (east catchment)

	Parameter	Proposed design
Conditions	Contributing Catchment (ha)	33.4
	Area of Basin (m^2)	700
Capture Efficiency	Settling Velocity of Target Sediment (mm/s) [Particle size 125 µm]	11
	Hydraulic Efficiency (λ)	0.19
	Permanent Pool Depth, dp (m)	1.5 (empty); 0.5 (full)
	Extended detention depth, de	0.35
	Number of CTSR's, n	1.23
	Depth below permanent pool that is sufficient to retain sediment, d* (m)	0.5
	Design Discharge (m^3/s) [4EY]	0.58
	Capture Efficiency	95.2%
	Check (>95%)	OK
Sediment Storage	Sediment Loading rate, Lo (m^3/ha/yr)	2.0
	Desired clean-out frequency, Fr	5
	Storage volume required, St	322
	Available sediment storage volume	360
	Check (Available storage > required storage)	OK
Sediment dewatering	Depth for dewatering area (m)	0.5
	Area required for dewatering (m^2)	644

The location of the proposed wetlands within the drainage reserve is shown in Figure 28.

A conceptual layout has been prepared for each asset which includes provision for a 4-metre maintenance access/path around the periphery of the treatment area (ie 50%), sediment dewatering area and batters. The topography within the vicinity of the western wetland is relatively steep, therefore the wetland has been aligned to run parallel to the contours (refer to Figure 29). For the western wetland batters will vary from 1 in 4 (planted) and 1 in 6 (grassed) due to the topography.

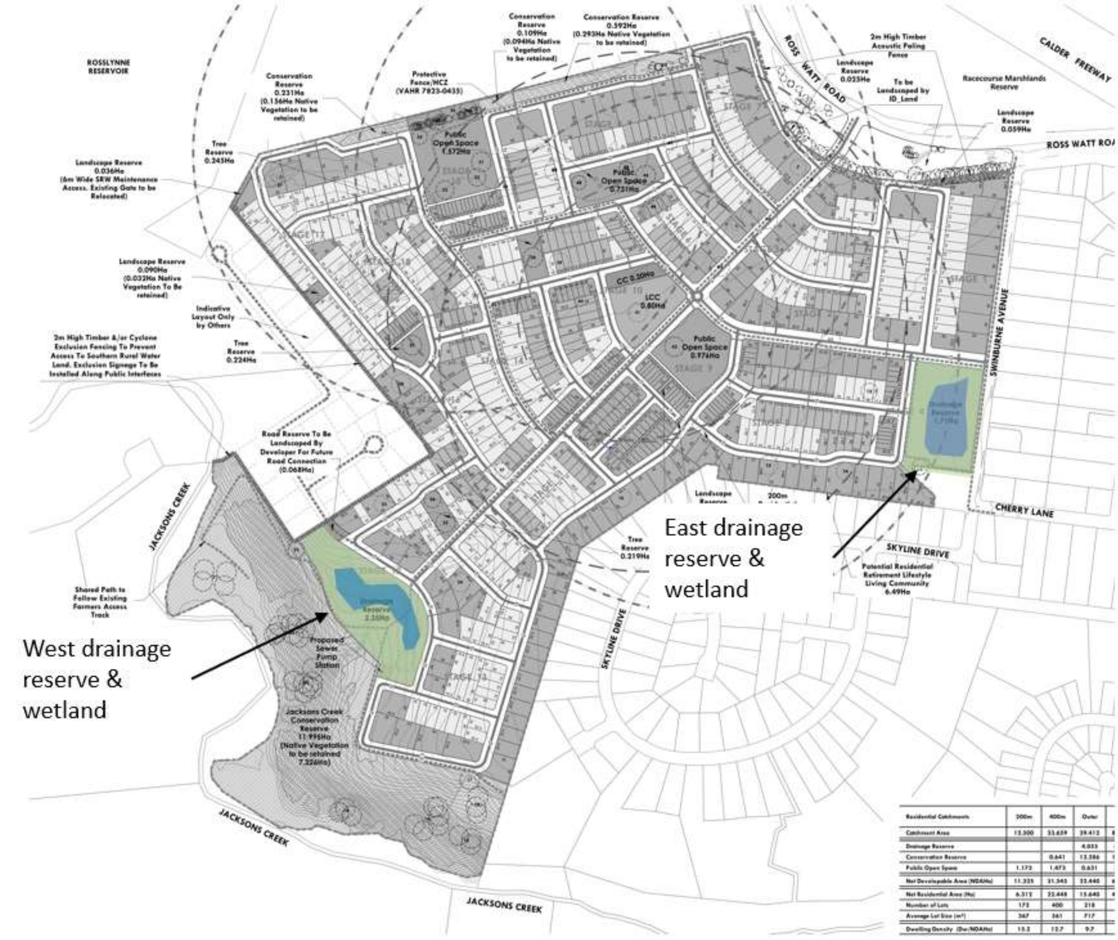


Figure 28. *Proposed wetland locations*

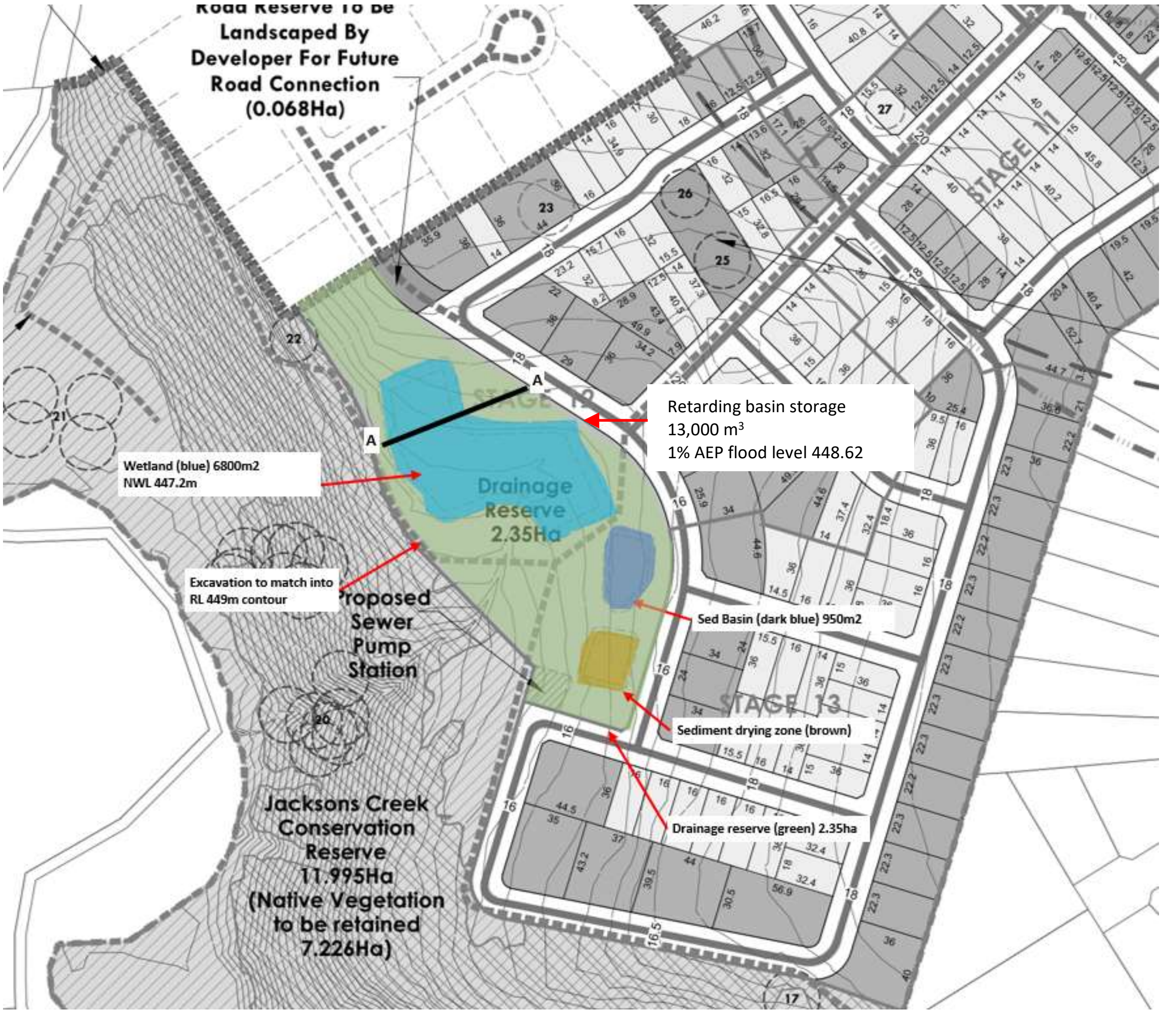


Figure 29. *Proposed west wetland layout*

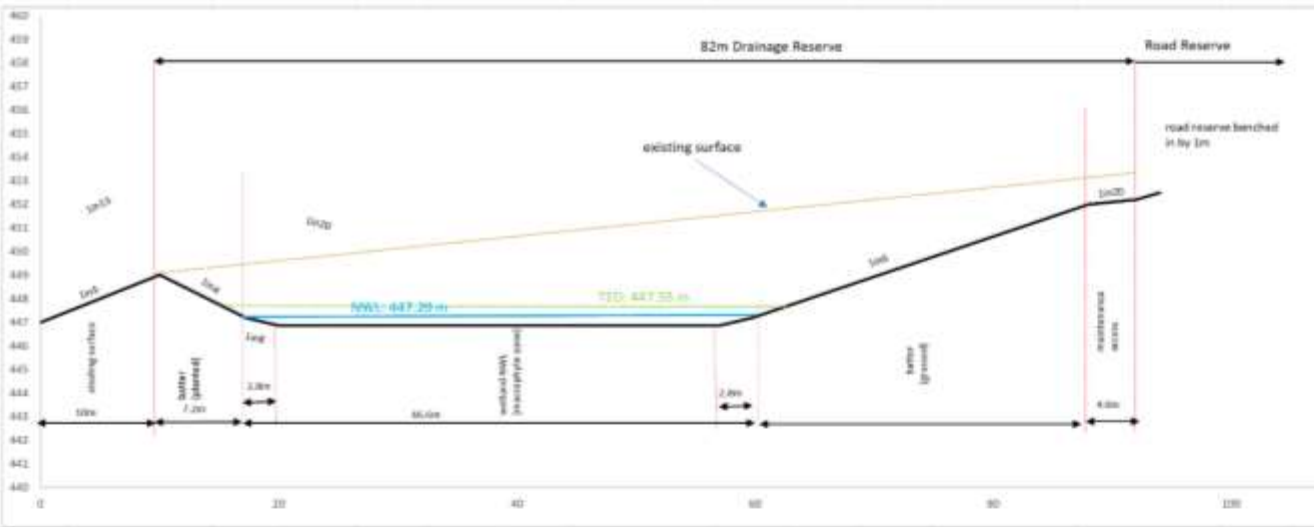


Figure 30. *Proposed west wetland cross-section (A-A)*

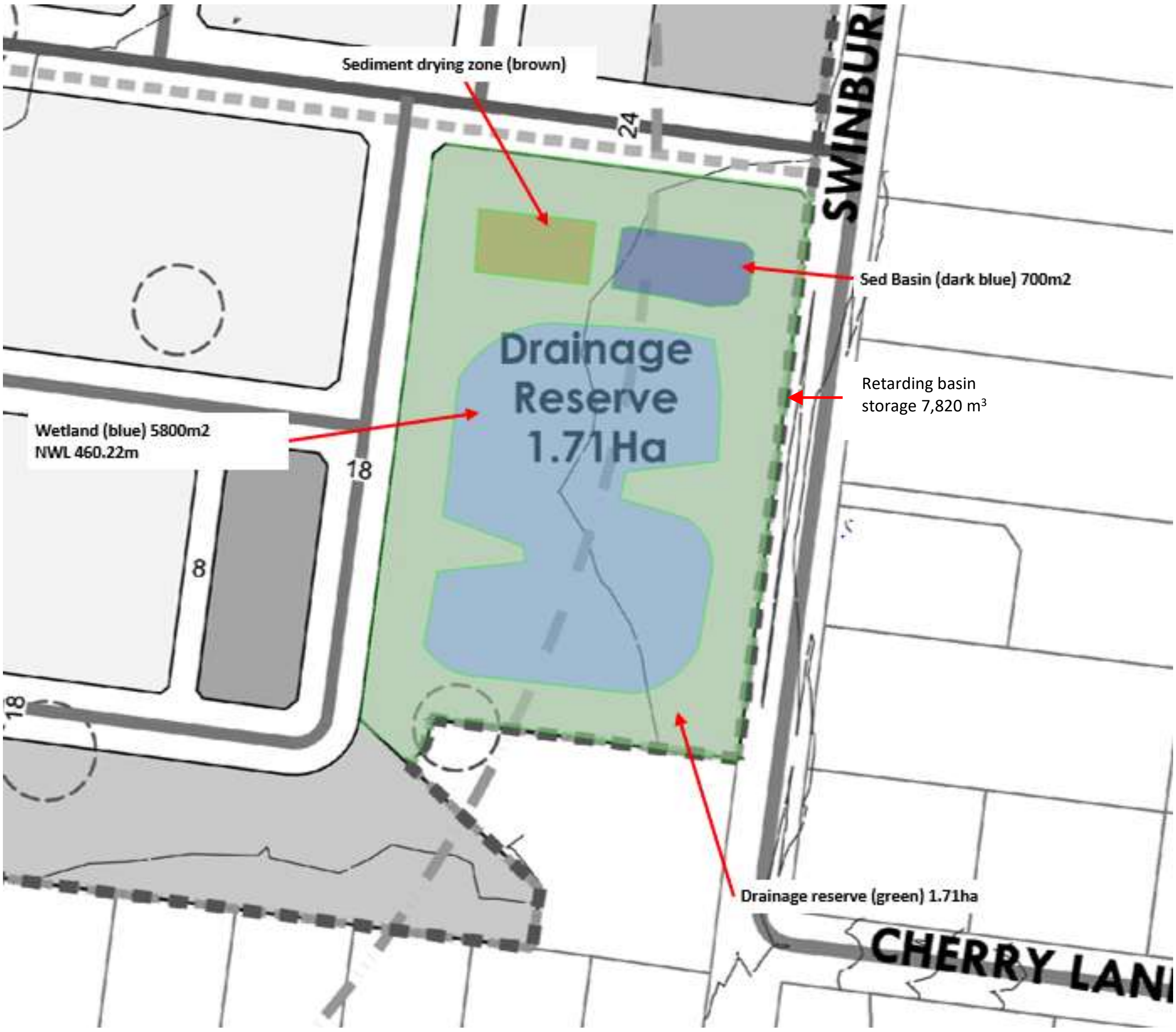


Figure 31. *Proposed east wetland layout*

9 Sodic and Dispersive Soils Assessment and Management Plan

Sodic soils are so named due to high levels of sodium (>6% exchangeable Na). When soils come into contact with low electrolyte water (i.e. rainwater), the water is drawn between the clay platelets causing the clay to swell and then disperse into the water. In the presence of a divalent cation such as calcium, its flocculating power is such that the swelling does not result in separation of clay particles and subsequent dispersion. Sodium is a monovalent cation with the lowest flocculating power of the cations. The relative weakness of sodium results in separation of clay particles following entry of water and subsequent swelling and dispersion. The separation of clay particles into the water phase is termed 'dispersion'. Dispersed clay particles become suspended and are vulnerable to transport in water. The development of tunnel or gully erosion is often strongly evidenced in sodic landscapes. Transport of dispersed clays, along with silts and sand mobilised by high energy water flows, eventually gives rise to turbidity in water columns and sediment deposition in waterways.

Declan McDonald from Regen Soils (a pre-eminent sodic soils specialist) has undertaken field investigations and a report with recommendations for managing sodic soils on the Ross Watt Road site, including the existing drainage line along the escarpment, the proposed wetland/basin reserve and the outfall to Jacksons Creek (see Appendix B for the full report).

Sampled soils showed high stability in the topsoils due to high organic matter, low exchangeable sodium and relatively high calcium. These properties change with depth. Organic matter is generally not tested below the topsoil as levels of organic matter quickly drop below 15cm and do not contribute significantly to soil stability. The focus of dispersive conditions in subsoils are sodium, calcium and magnesium levels as the proportions of these cations strongly influence soil stability.

The samples subsoils show a definite trend with elevated ESP's (up to 22.8%) and other drivers of dispersion. Given the positive identification of drivers of sodic/dispersive conditions in almost all subsoil samples, and the likelihood of dispersion being initiated by disturbance, it is appropriate to regards this site as potentially dispersive and to recommend treatments to stabilise soils.

9.1 Sodic / dispersive soil management plan

The Regen Soils investigation found that the Ross Watt Road site is susceptible to dispersion but are amenable to improvement and stabilisation. The Regen Soils report has quantified risks associated with sodic-magnesic soils and identified that stabilisation of these soils is necessary prior to installation or construction of physical assets.

Regen Soils confirmed that the existing drainage line (ie reach 2 in Figure 4) through the escarpment revealed bedrock, which is consistent with the geomorphology assessment undertaken by Alluvium (see Section 3). The report states that where bedrock is present that the issue of potential dispersion does not apply. However between the toe of the escarpment and Jacksons Creek (ie reach 3 in Figure 4) dispersive soils are present and the waterway stabilisation works will need to include subsoil remediation. Therefore reach 3 and the wetland/retarding basin at the top of the escarpment will need to follow the "Sodic/Dispersive Soil Management Plan" recommendations detailed in the Regen Soils report (see Appendix B). The key extracts and recommendations from this report are provided below.

Stabilisation of disturbed sodic soils will require lime (calcium carbonate) and gypsum (calcium sulfate) at high rates. Topsoils require treatment with agricultural lime (calcium carbonate). Note that other forms of lime such as quick lime or hydrated lime are not recommended for this task. Calcium carbonate is relatively insoluble so its incorporation into the topsoil is recommended. Subsoils require treatment with gypsum (calcium sulfate). Note that lime and gypsum are not interchangeable. Lime must be used for topsoils and gypsum must be used for subsoils.

The primary aim is to reduce sodium and magnesium to levels where the risk of dispersion is greatly reduced. The application of lime or gypsum applies calcium at high rates which displaces sufficient quantities of sodium and magnesium to chemically stabilise the soil. Treated subsoils should be capped with topsoil. Topsoils contain higher levels of organic matter than subsoils and this will further assist stabilisation of the soil profile.

It must be noted that while lime and gypsum applications will chemically stabilise these soils and reduce the risks of dispersion, they are not substitutes for mechanical erosion control structures such as silt fencing, erosion control matting or sediment ponds. Mechanical erosion control structures will need to be maintained until earthworks have been completed and exposed soil surfaces stabilised with plants or turf.

There are small differences in cation balances across the site. This allows for generic application rates to be developed for all parts of the site. Note that rates differ substantially for soils of differing depths. This means that, for example, where excavation does not exceed 50cm, the application rates shown in tables 18 & 19 apply. Where excavation exceeds 1m and soils are thoroughly mixed up following topsoil stripping, bulk rates of gypsum as specified in table 2 apply.

Given that this development will include sewer or other deep installations, recommended treatments recognise the challenges in treating soils of differing depths. Deep trench excavation will, of necessity, mix soils of different chemical properties. Calculation of a single treatment is provided given that these layers are likely to be excavated and mixed together. The recommendations below ensure backfilling operations adequately stabilise subsoils to avoid future ground movement.

- Recommendations aim to provide simple instructions for contractors to follow. The following practices should be adopted for all soils on-site:
- Topsoils and subsoils shall be stripped and stockpiled separately in view of the variation in their properties. Topsoil depths averaged about 10-15cm.
- If subsoils are likely to be thoroughly mixed at excavation and the same soil is used for backfilling of trenches or filling of low areas, gypsum application will be required at the rate specified in table 2 below. If imported material (e.g. crushed rock) is used for backfilling, the crushed rock must be treated with gypsum as specified below in table 4.
- Soil stockpiles (topsoil and / or subsoil) should not exceed 2 metres in height and must never be trafficked. As noted above, these soils, even when treated, have a high potential for compaction. This creates large blocky structures which hamper proper consolidation (recompaction) at re-instatement.
- Stockpiled topsoils and subsoils should have the following additives applied as shown in tables 18 & 19 below.

Table 18. Bulk gypsum application rates

Soil horizon	Lime application rate (kg/m^3)	Gypsum application rate (kg/m^3)
Topsoil		
A: 0 -15cm	2.0	
Subsoils		
B1: 15 - 50cm		8.0
B2: 50-100cm		12.3
B3: 100-200cm+		10
B1:B3 combined		10

Where potentially dispersive soils have been exposed but not excavated (e.g. soil remaining poststripping), the Table 19 rates of gypsum should be applied.

Table 19. Area gypsum application rates (note that units are different between Table 18 & Table 19)

Soil depth	Gypsum application rate (kg/m^2)
Topsoil	
A: 0 -15cm	n/a
Subsoils	
B1: 15 - 50cm	0.8
B2: 50-100cm	1.25
B3: 100-200cm+	1.0
B1:B3 combined	1.0

Lime or gypsum applied to stockpiled topsoil and subsoils must be thoroughly incorporated throughout the soil matrix using a trommel screen, mixing bucket or similar. Following incorporation, the soils should be watered well (via irrigation or rainfall if not already at >40% moisture content) to allow the lime or gypsum to stabilise the soil.

Gypsum applied to exposed in situ subsoils must be surface applied and worked into the top 10cms by ripping and watered in well.

<u>*Trench management*</u>

If imported material (e.g., crushed rock) is used for trench backfilling, the following method is recommended.

- Apply gypsum to the crushed rock in 250mm lifts at 2.5 times the square metre rate, i.e., if the square metre rate is 1.0kg/m2 , apply gypsum at 1.0 x 2.5 = 2.5kg / m2 / 250mm lift (see table 20).

This treatment of trench material is necessary to ensure adequate electrolyte is present in zones of likely preferential water flow (i.e., the interface between the native soil and imported materials) to reduce the risk of dispersion and erosion around the trench

Table 20. Trench backfilling with crushed rock

Trench backfilling with crushed rock	Gypsum application
Backfill trench at 250mm lifts. Continue at 250mm lifts to 150mm from finished surface. Place treated topsoil and plant / sow	At each lift, surface apply $2.5kg/m^2$. No need to work in before placing the next lift.

There is no withholding period following incorporation of gypsum to subsoils and if the soils are used for trench backfilling, they may be placed immediately with amended topsoils placed on top of the subsoil. Due to the high rates of lime and gypsum application, it is recommended that soils are irrigated or allowed to thoroughly wet up to activate the lime or gypsum and allow leaching of high salt levels before use. The longer the time between lime or gypsum application and beneficial reuse, the better. Application of lime or gypsum at stripping and stockpiling will allow sufficient time for these materials to activate in topsoils or subsoils.

This Sodic and Dispersive Soils Management Plan aims to identify risks associated with potential ingress or movement of water into or through sodic / dispersive soils. In places where water ingress or movement is limited or unlikely – such as beneath road pavement – treatment with gypsum is optional. If alternative road stabilisation techniques such as lime stabilisation is required, it will remove any requirement for gypsum stabilisation

10 Timing of Stormwater Assets

The development has two catchment outfalls; one to the east and one to the west. All of the underground drainage from the development outfalls to these locations which includes an ultimate stormwater quality treatment train consisting of a sediment basin and a wetland.

From a timing perspective it is proposed to deliver the key stormwater assets in a phase approach as outlined below:

- *Phase 1:*
  - East Catchment:
    - Temporary sediment basin and retardation storage to be constructed with the first stage in the east catchment (which will provide treatment and storage for approx 200 lots)
    - Provide the temporary sediment basin and retardation within the envelope of the ultimate drainage reserve. This will include a proposed temporary outfall pipe to convey flows to the table drain in Cheery Lane (the pipe will daylight about 50 metres downstream of the intersection).
- *Phase 2:*
  - East Catchment:
    - The ultimate wetland and retarding basin to be designed and tendered before the title of the 200th lot in the east catchment. This will also include the ultimate outfall pipe works along Cherry Lane.
    - Construction of the ultimate wetland, retarding basin and outfall pipe to be completed before title of 300th lot in the east catchment. This timing would align with the Cherry Lane upgrade.

- *Phase 3:*
  - West Catchment:
    - Temporary sediment basin and retardation storage to be constructed with the first stage in the west catchment (which will provide treatment and storage for approx 200 lots)
    - Provide the temporary sediment basin and retardation within the envelope of the ultimate drainage reserve.
    - Undertake stabilisation works on the alluvial fan outfall to Jacksons Creek with the first stage in the western catchment.
- *Phase 4:*
  - West Catchment:
    - The ultimate wetland and retarding basin to be designed and tendered before the title of the 200th lot in the west catchment.
    - Construction of the ultimate wetland and retarding basin to be completed before title of 300th lot in the west catchment.

11 Integrated Water Management Plan

An Integrated Water Management (IWM) Plan will be prepared for the site post permit. The IWM assessment will consider the opportunities to incorporate rainwater tanks, passive irrigation, water efficiency and stormwater harvesting in addition to the sediment basins and wetlands already identified in Section 8 of this report. Given the catchment scale the evaluation and feasibility of these opportunities will be discussed with Council during the process.

12 Conclusion

This Storm Water Management Strategy (SWMS) report has proposed a management strategy for stormwater quantity and quality for the 89 Ross Watt Road development site. A hydrological assessment has been conducted for the site and stormwater infrastructure and assets have been preliminarily designed to meet stormwater quantity and quality objectives. Through meeting these objectives, this SWMS acts as a critical component of the development servicing strategy and ensures stormwater is managed in accordance with Melbourne Water's and Council's requirements.

A sodic soils and geomorphology assessment has been undertaken which identified that the development site is susceptible to dispersion but are amenable to improvement and stabilisation. As a result a sodic/dispersive soils management plan has been prepared which provides the required recommendations and actions.

APPENDIX A

DEVELOPMENT CONCEPT LAYOUT


LEGEND & LAND BUDGET
89 ROSS WATT ROAD
GISBORNE
OVERALL SUBDIVISION
LAYOUT PLAN
SCALE 1 : 2500 @ A3
BREESE PITT DIXON
CALDER FREEWAY
ROSS WATT ROAD
SWINBURNE AVENUE
CHERRY LANE
SKYLINE DRIVE
JACKSONS CREEK
REVISIONS
NOTES

APPENDIX B

SODIC / DISPERSIVE SOILS ASSESSMENT

(REGEN SOILS)

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PO Box 58
Ascot Vale
Vic 3032
18th October 2022

Alluvium Consulting
Level 1, 105-115 Dover St
Cremorne
Vic., 3121

Attn. Jonathon Mclean

Re: 89 Ross Watt Rd, Gisborne

Dear Jonathon,

Thank you for the opportunity to undertake an assessment of sodic / dispersive conditions at the above site.

Introduction

I attended site on Monday 3rd October with a drill rig from Ground Science. Ground conditions were considerably worse than anticipated following heavy rainfall. The weight of the drill rig was too much for the soft ground and following repeated bogging, the rig was dispatched and I continued with the investigation using hand tools.

As outlined in my proposal, investigations of sodic / dispersive properties should be undertaken to depth as dispersive properties typically increase to depths of about 2m. I was not equipped to sample to 2m by hand. However, at two locations adjacent to Jackson's Creek, erosion of creek banks allowed inspection and sampling of soil profiles to 2m. At the other four sampling sites, sampling was undertaken to 1m.

Figure 1 shows the location of sample points across the study area.

Figure 1. Sample locations

Figures 2 & 3 show the geomorphic context and the location of the proposed drainage reserve.

Sample locations in figure 1 adequately cover areas potentially impacted by the development.

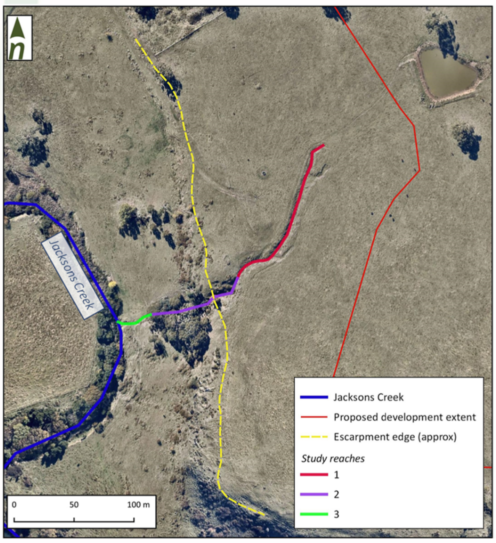

Figure 2. Geomorphic context

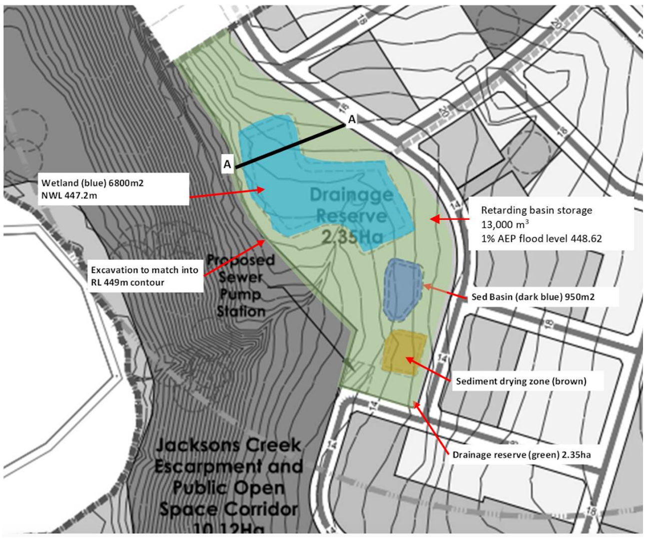

Figure 3. Proposed drainage reserve

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Results

Laboratory analysis was conducted on a total of 20 samples – six topsoils samples and 14 subsoil samples. Full laboratory results are provided in Appendix A. Summary results are shown in table 1.

Topsoil Analysis

Topsoil pH values were moderately acidic across the site. Soil salinity levels are low. The cation exchange capacity is low to moderate. Exchangeable Sodium Percentage (ESP) results are all low. The ESP of a soil is a primary measure of its dispersion risk. In general, calcium to magnesium ratios (Ca:Mg) are acceptable.

The topsoil samples showed no susceptibility to dispersion in the Emerson Aggregate Test (EAT) with no dispersion recorded in any sample. Organic matter levels have a strong influence on dispersion in topsoils and results vary from 6% to 8.7% which are acceptable.

Subsoil Analysis

Subsoils were sampled at three depths – 0.5 m, 1m and, at two locations, 2m. Subsoil depths are labelled B1, B2 and B3 respectively. The aim of splitting subsoils is to understand how conditions change down the profile. This is relevant to development decisions which require excavation, stockpiling and re-use of soils. Different levels of dispersion risk down the profile may require specific levels of amelioration.

Subsoil pHs range from moderately acid to strongly alkaline. Typically pH results become more alkaline with depth. This is the case at sample locations 2, 3, 4 and 5 but was not shown in samples 1 and 6. Note the positions of sample 1 & 6 at similar elevation on the east and west sides of the dam.

Depth	pH	Electrical conductivity (dS/m)	Calcium (%)	Magnesium (%)	Sodium - ESP (%)	Calcium / Magnesium Ratio
Surface	5.83	0.07	57.17	34	2.7	1.73
0.5m (B1)	6.68	0.08	31.33	56	8.75	0.6
1.0m (B2)	6.6	0.49	22.2	54.33	14.83	0.45
2.0m (B3)	7.65	0.695	17.6	58	22.8	0.3

Table 1. Summary average data from topsoils and subsoils

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Table 1 summarises data from the different sample depths. The data show that conditions change and become strongly sodic and magnesic below the topsoil. Calcium : magnesium ratios in the topsoil are low – they should be greater than 2:1 at a minimum – and in subsoils are very low. Dispersion in subsoil samples was assessed by the Emerson Aggregate Test. Results were mixed with topsoil samples consistently stable, but subsoil samples varied from highly dispersive to non-dispersive.

Discussion

Sodic Soils

Sodic soils are so named due to high levels of sodium (>6% exchangeable Na). When sodic soils come into contact with low electrolyte water (i.e. rainwater), the water is drawn in between the clay platelets causing the clay to swell and then disperse into the water. In the presence of a divalent cation such as calcium, its flocculating power is such that the swelling does not result in separation of clay particles and subsequent dispersion. Sodium is a monovalent cation with the lowest flocculating power of the cations. The relative weakness of sodium results in separation of clay particles following entry of water and subsequent swelling and dispersion. The separation of clay particles into the water phase is termed 'dispersion'.

Dispersed clay particles become suspended and are vulnerable to transport in water. The development of tunnel or gully erosion is often strongly evidenced in sodic landscapes. Transport of dispersed clays, along with silts and sand mobilised by high energy water flows, eventually gives rise to turbidity in water columns and sediment deposition. Once initiated, this process is difficult to correct and turbid water can remain so for very long periods causing environmental impacts at some distance from the point source.

In addition to problems of dispersion, sodic soils are also vulnerable to compaction on productive soils, or weak foundations for infrastructure development if soils are not properly stabilised.

Magnesic soils

Magnesic soils are so called due to high levels of magnesium (>25% exchangeable magnesium). While magnesium does not predispose a soil to dispersion to the same degree as sodium, the presence of high magnesium in conjunction with moderate or high sodium exacerbates the risk of dispersion. In addition, high magnesium allows soils to set very hard when dry (high soil strength) but when wet,

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soil strength is very low. These properties can reduce the stability of soils creating risks for infrastructure.

Soils at Ross Watt Rd

As discussed above, intended sampling to 2m was thwarted by ground conditions on the day. As a result, only two sites were sampled to 2m and both of these were close to Jackson's Creek at the lowest point in the study area.

Sampled soils showed high stability in the topsoils due to high organic matter, low exchangeable sodium and relatively high calcium. These properties change with depth. Organic matter is generally not tested below the topsoil as levels of organic matter quickly drop below 15cm and do not contribute significantly to soil stability. The focus of dispersive conditions in subsoils are sodium, calcium and magnesium levels as the proportions of these cations strongly influence soil stability.

Sampling for this investigation was carried out at three discrete elevations down the catena. Samples 1 & 6 were taken from a level just below the dam, samples 2 & 5 were taken just above the escarpment, and samples 3 & 4 were taken from the flats adjacent to Jackson's Creek.

Soils at locations 1 and 6 showed similar properties. Topsoils are stable but sodium and magnesium levels climb sharply at 50cm with sodium increasing further at 1m. It is interesting to note that the Emerson Aggregate Test results returned a dispersive result for only one sample – 50cm sample at location 6. Further analysis of the data reveal that elevated aluminium at 1m in both location 1 and location 6 has stabilised these soils. Aluminium is a tri-valent cation. Its influence over dispersion is strongly determined by pH (Rengasamy et al, 2016). In contrast to our understanding of how the other principal cations influence dispersion, the variable charge of aluminium depends on pH and presents difficulties in determining its behaviour when soils are disturbed.

Sample locations 2 and 5 are on either side of the drainage line at the top of the mini-escarpment. These soils are broadly similar with the exception of more strongly sodic conditions at 50cm and 1m on the western side. While results for ESP from the western side show sodic conditions at 50cm and 1m, only the 1m sample returned a moderately dispersive result under the Emerson Aggregate Test. It is noted that erosion of the drainage line reveals apparent bedrock at the upper levels of the escarpment. This suggests a relatively shallow soil profile of less than 2m.

This area is likely to be at the centre of excavation for the proposed drainage reserve. It must be stated that if excavation meets bedrock, then the issue of potential dispersion does not apply as all soil will have been removed. However, as the excavation moves to the eastern and western sides of the drainage line, it is possible that bedrock may not be reached and the drainage reserve / wetland will be constructed over soil. If this is the case, treatment of soils as detailed in the Sodic / Dispersive Soil Management Plan below will be essential.

Sample locations 3 and 4 were on the flat adjacent to Jackson's Creek. Results show moderate to strong dispersive potential as indicated by the ESP results. This is not unexpected as salts would be expected to accumulate at lower levels in the landscape. However, results from the eastern side at 50cm and 2m, and from the western side at 2m, did not show dispersion under the Emerson Aggregate Test. In both instances, the underlying drivers of dispersion are clear with moderate to very high ESP's, high magnesium and low calcium.

On-going erosion was observed in the cut from the escarpment through to Jackson's Creek and this will need to be stabilised as part of the proposed works. Reconstruction of the channel will involve placement of rock to help stabilise the channel. The potentially high water velocities generated by a combination of slope and rock placement have the potential to destabilise sodic / dispersive soils. It is therefore essential that the reconstructed channel be treated with gypsum at high rates as detailed in the Plan below.

In spite of the fact that sampling to 2m was not possible at four of the six intended locations, results show a definite trend with elevated ESP's and other drivers of dispersion. It is determined that a sufficiently clear picture has emerged that negates the need for further sampling and testing of deep soils at this time.

Given the positive identification of drivers of sodic / dispersive conditions in almost all subsoil samples, and the likelihood of dispersion being initiated by disturbance, it is appropriate to regard this site as potentially dispersive and to recommend treatments to stabilise soils. The rapid change in elevation across the study area further confirms this recommendation.

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Sodic / dispersive soil management plan

Stabilisation of disturbed sodic soils will require lime (calcium carbonate) and gypsum (calcium sulfate) at high rates. Topsoils require treatment with agricultural lime (calcium carbonate). Note that other forms of lime such as quick lime or hydrated lime are not recommended for this task. Calcium carbonate is relatively insoluble so its incorporation into the topsoil is recommended.

Subsoils require treatment with gypsum (calcium sulfate). Note that lime and gypsum are not interchangeable. Lime must be used for topsoils and gypsum must be used for subsoils.

The primary aim is to reduce sodium and magnesium to levels where the risk of dispersion is greatly reduced. The application of lime or gypsum applies calcium at high rates which displaces sufficient quantities of sodium and magnesium to chemically stabilise the soil. Treated subsoils should be capped with topsoil. Topsoils contain higher levels of organic matter than subsoils and this will further assist stabilisation of the soil profile.

It must be noted that while lime and gypsum applications will chemically stabilise these soils and reduce the risks of dispersion, they are not substitutes for mechanical erosion control structures such as silt fencing, erosion control matting or sediment ponds. Mechanical erosion control structures will need to be maintained until earthworks have been completed and exposed soil surfaces stabilised with plants or turf.

There are small differences in cation balances across the site. This allows for generic application rates to be developed for all parts of the site. Note that rates differ substantially for soils of differing depths. This means that, for example, where excavation does not exceed 50cm, the application rates shown in tables 2 & 3 apply. Where excavation exceeds 1m and soils are thoroughly mixed up following topsoil stripping, bulk rates of gypsum as specified in table 2 apply.

Given that this development will include sewer or other deep installations, recommended treatments recognise the challenges in treating soils of differing depths. Deep trench excavation will, of necessity, mix soils of different chemical properties. Calculation of a single treatment is provided given that these layers are likely to be excavated and mixed together. The recommendations below ensure backfilling operations adequately stabilise subsoils to avoid future ground movement.

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Recommendations aim to provide simple instructions for contractors to follow. The following practices should be adopted for all soils on-site:

- Topsoils and subsoils shall be stripped and stockpiled separately in view of the variation in their properties. Topsoil depths averaged about 10-15cm.
- If subsoils are likely to be thoroughly mixed at excavation and the same soil is used for backfilling of trenches or filling of low areas, gypsum application will be required at the rate specified in table 2 below. If imported material (e.g. crushed rock) is used for backfilling, the crushed rock must be treated with gypsum as specified below in table 4.
- Soil stockpiles (topsoil and / or subsoil) should not exceed 2 metres in height and must never be trafficked. As noted above, these soils, even when treated, have a high potential for compaction. This creates large blocky structures which hamper proper consolidation (re-compaction) at re-instatement.
- Stockpiled topsoils and subsoils should have the following additives applied as shown in tables 2 & 3 below:

Soil horizon	Lime application rate (kg/m^3)	Gypsum application rate (kg/m^3)
Topsoil		
A: 0 -15cm	2.0	
Subsoils		
B1: 15 - 50cm		8.0
B2: 50-100cm		12.3
B3: 100-200cm+		10
B1:B3 combined		10

Table 2. Bulk gypsum application rates

Where potentially dispersive soils have been exposed but not excavated (e.g. soil remaining post-stripping), the following rates of gypsum should be applied:

Soil depth	Gypsum application rate (kg/m^2)
Topsoil	
A: 0 -15cm	n/a
Subsoils	
B1: 15 - 50cm	0.8
B2: 50-100cm	1.25
B3: 100-200cm+	1.0
B1:B3 combined	1.0

Table 3. Areal gypsum application rates (NOTE gypsum application rate units differ between the two tables)

Lime or gypsum applied to stockpiled topsoil and subsoils must be thoroughly incorporated throughout the soil matrix using a trommel screen, mixing bucket or similar. Following incorporation, the soils should be watered well (via irrigation or rainfall if not already at >40% moisture content) to allow the lime or gypsum to stabilise the soil.

Gypsum applied to exposed *in situ* subsoils must be surface applied and worked into the top 10cms by ripping and watered in well.

Trench management

If imported material (e.g., crushed rock) is used for trench backfilling, the following method is recommended.

Apply gypsum to the crushed rock in 250mm lifts at 2.5 times the square metre rate, i.e., if the square metre rate is 1.0kg/m^2, apply gypsum at 1.0 x 2.5 = 2.5kg / m^2 / 250mm lift (see table 4).

This treatment of trench material is necessary to ensure adequate electrolyte is present in zones of likely preferential water flow (i.e., the interface between the native soil and imported materials) to reduce the risk of dispersion and erosion around the trench.

Trench backfilling with crushed rock	Gypsum application
Backfill trench at 250mm lifts. Continue at 250mm lifts to 150mm from finished surface. Place treated topsoil and plant / sow	At each lift, surface apply 2.5kg/m^2. No need to work in before placing the next lift.

Table 4. Trench backfilling with crushed rock

There is no withholding period following incorporation of gypsum to subsoils and if the soils are used for trench backfilling, they may be placed immediately with amended topsoils placed on top of the subsoil. Due to the high rates of lime and gypsum application, it is recommended that soils are irrigated or allowed to thoroughly wet up to activate the lime or gypsum and allow leaching of high salt levels before use. The longer the time between lime or gypsum application and beneficial reuse, the better. Application of lime or gypsum at stripping and stockpiling will allow sufficient time for these materials to activate in topsoils or subsoils.

This Sodic and Dispersive Soils Management Plan aims to identify risks associated with potential ingress or movement of water into or through sodic / dispersive soils. In places where water ingress or movement is limited or unlikely – such as beneath road pavement – treatment with gypsum is optional. If alternative road stabilisation techniques such as lime stabilisation is required, it will remove any requirement for gypsum stabilisation.

Summary

This investigation has found that the investigated soils at 89 Ross Watt Rd, Gisborne are susceptible to dispersion but are amenable to improvement and stabilisation. This report has quantified risks associated with sodic-magnesic soils. It indicates that risks exist and that stabilisation of these soils is necessary prior to installation or construction of physical assets.

Please contact me if you have any questions.

Best wishes,

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Declan McDonald

Principal Soil Scientist

ATTACHMENTS:

Appendix A – full analytical results

Disclaimer

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89 Ross Watt Rd

Appendix A - Full analytical results

Sample Name		**S1.1**	**S1.2**	**S1.3**	**S2.1**	**S2.2**	**S2.3**	**S3.1**	**S3.2**	**S3.3**	**S3.4**	**S4.1**	**S4.2**	**S4.3**	**S4.4**	**S5.1**	**S5.2**	**S5.3**	**S6.1**	**S6.2**	**S6.3**
pH (1:5 Water)		5.9	6.9	5.6	5.8	6.9	7.7	5.9	5.9	4.7	7.4	5.9	6.4	8.1	7.9	5.8	7.7	8.4	5.7	6.3	5.1
pH (1:5 CaCl2)		5.0	5.8	4.4	4.9	5.6	6.5	5.0	5.1	4.5	7.0	5.0	4.7	6.5	7.0	5.0	6.6	7.1	4.8	4.8	4.2
Electrical Conductivity (1:5 w	dS/m	0.07	0.06	0.15	0.08	0.05	0.07	0.07	0.15	2.25	1.21	0.07	0.04	0.08	0.18	0.07	0.11	0.12	0.07	0.05	0.26
Phosphorus (Colwell)	mg/kg	<5	<5	<5	6	<5	<5	6	<5	6	7	8	<5	<5	57	9	<5	<5	<5	<5	<5
Available Potassium	mg/kg	150	140	110	180	130	120	130	59	59	34	170	31	63	87	350	140	59	130	26	98
Calcium (Amm-acet.)	cmol(+)/kg	4.4	2.6	1.6	8.3	14.0	15.0	4.2	1.7	1.0	1.1	4.8	2.1	3.7	4.5	11.0	18.0	13.0	3.1	0.9	0.8
Potassium (Amm-acet.)	cmol(+)/kg	0.38	0.36	0.27	0.46	0.33	0.31	0.34	0.15	0.15	0.09	0.44	0.08	0.16	0.22	0.91	0.35	0.15	0.34	0.07	0.25
Magnesium (Amm-acet.)	cmol(+)/kg	2.4	9.9	11.0	5.0	15.0	17.0	3.5	2.3	8.5	8.0	3.2	4.1	9.0	9.8	4.4	20.0	13.0	1.8	3.1	9.0
Sodium (Amm-acet.)	cmol(+)/kg	0.21	1.10	2.10	0.41	1.40	1.60	0.23	0.55	5.90	5.30	0.23	0.67	1.80	1.40	0.21	3.00	2.70	0.21	0.61	2.40
Calcium/Magnesium Ratio		1.8	0.3	0.2	1.7	0.9	0.9	1.2	0.7	0.1	0.1	1.5	0.5	0.4	0.5	2.5	0.9	1.0	1.7	0.3	0.1
Aluminium (KCl)	cmol(+)/kg	<0.1	<0.1	2.3	<0.1	<0.1	<0.1	0.1	0.1	0.7	0.1	0.2	0.5	0.1	<0.1	0.2	<0.1	<0.1	0.2	0.3	4.3
Cation Exch. Cap.	cmol(+)/kg	7.4	13.9	16.9	14.2	30.8	34.7	8.4	4.7	16.3	14.6	8.9	7.3	14.8	15.9	16.3	41.9	29.2	5.6	5.0	16.7
Sodium % of Cations (ESP)	%	2.80	7.70	13.00	2.90	4.40	4.70	2.80	12.00	36.00	37.00	2.60	9.20	12.00	8.60	1.30	7.20	9.30	3.80	12.00	14.00
Aluminium Saturation	%	<1.0	<1.0	14.0	<1.0	<1.0	<1.0	1.6	2.5	4.5	0.9	2.0	6.1	0.9	<1.0	1.1	<1.0	<1.0	3.0	5.8	26.0
Organic Carbon (W&B)	%	3.7			4.9			3.5				3.8				5.0			3.5		
Aluminium (KCl)	mg/kg	<9.0	<9.0	210.0	<9.0	<9.0	<9.0	12.0	11.0	66.0	12.0	16.0	40.0	11.0	<9.0	16.0	<9.0	<9.0	15.0	26.0	380.0
Calcium (Amm-acet.)	%	59.0	19.0	9.4	58.0	45.0	44.0	50.0	35.0	5.9	7.2	55.0	28.0	25.0	28.0	65.0	43.0	44.0	56.0	18.0	4.9
Magnesium (Amm-acet.)	%	33.0	71.0	63.0	36.0	50.0	50.0	41.0	48.0	52.0	55.0	36.0	56.0	61.0	61.0	27.0	48.0	46.0	31.0	63.0	54.0
Potassium (Amm-acet.)	%	5.20	2.60	1.60	3.20	1.10	0.89	4.10	3.20	0.92	0.60	4.90	1.10	1.10	1.40	5.60	0.83	0.52	6.10	1.30	1.50
Organic Matter (W&B * 1.72	%	6.3			8.4			6.0				6.5				8.7			6.0		
Emerson Class		7	8	7	7	7	7	7	7	6	8	7	1	1	8	7	8	2	8	2	7