STORMWATER MANAGEMENT REPORT

TO SUPPORT RESOURCE CONSENT & PLAN CHANGE APPLICATIONS

FOR A RESIDENTIAL 49 LOT DEVELOPMENT

FOR THE KILNS LTD

AT 34-36 SANDSPIT ROAD, WARKWORTH

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1 INTRODUCTION

This Stormwater Management Plan has been prepared in order to demonstrate the best practicable options (BPO) for stormwater water treatment and the integrated stormwater considerations for the 34 & 36 Sandspit Road development site.

This document is to support the proposed Private Plan Change and to provide guidance to both the Applicant and Auckland Council on how stormwater should be managed under a future land use scenario in order to ensure that adverse effects on the downstream receiving environment are minimised in accordance with the objectives and policies of the Auckland Unitary Plan (AUP) and the Auckland Regionwide Network Discharge Consent (NDC).

2 SITE DESCRIPTION

2.1 Location

The site is located north of the Warkworth CBD, across the Mahurangi River from the town. The northern boundary of the site is bounded by Sandspit Road, and the western and eastern boundaries are bounded by streams (Viponds Creek to the west and an unnamed stream to the east). The subject site is shown in Figure 1 below.

Figure 1 - Site Locality

2.2 Topography

The subject site contains a mixed topography and rises from all boundaries from the river/stream level to a central high point located in the western part of the site. Elevations in the site range from approximately RL2.0 to RL26.0. There are some existing archaeological features in the southern part of the site (the kilns) which are addressed in reports prepared by others.

2.3 Geology

A geotechnical investigation report has been prepared by CMW Geosciences (CMW) and should be referred to in conjunction with this report. CMW determined that the underlying geology comprises Pakiri Formation (sandstone) and Mahurangi Limestone. The soils found to be generally present on the site include:

- Mahurangi Limestone – stiff to hard clays, silts and clay/silt mixtures
- Pakiri Formation – stiff to hard silts, sandy silts and silty clays.

3 EXISTING HYDROLOGY

The subject property contains two main catchments as summarised in Table 1 below.

Table 1 - Existing Catchments

	Area (ha)	1% AEP peak flow (m^3/s)	Receiving Environment	Receiving environment catchment (ha)
Western Catchment	1.81	0.929	Viponds Creek	281.23
Eastern Catchment	1.16	0.596	Un-named stream	101.54

In addition to the two catchments noted above, the approximately 800m^2 separate portion of the site on the western side of Viponds Creek discharges to Viponds Creek.

The site makes up approximately 0.6% of the Vipond Creek catchment area and 1.1% of the un-named stream catchment area.

Viponds Creek and the un-named stream are both culverted under Sandspit Road north of the site. There is no existing stormwater infrastructure within the site.

4 STORMWATER DESIGN PRINCIPLES

Although the stormwater reticulation and treatment system for the development will be designed at the Resource Consent stage, some fundamental design principles can be set for the entire site. The intention is that the future Resource Consent applications would then be assessed against these principles.

In general the stormwater system will follow a treatment train approach, this is shown at a conceptual level in Figure 3.

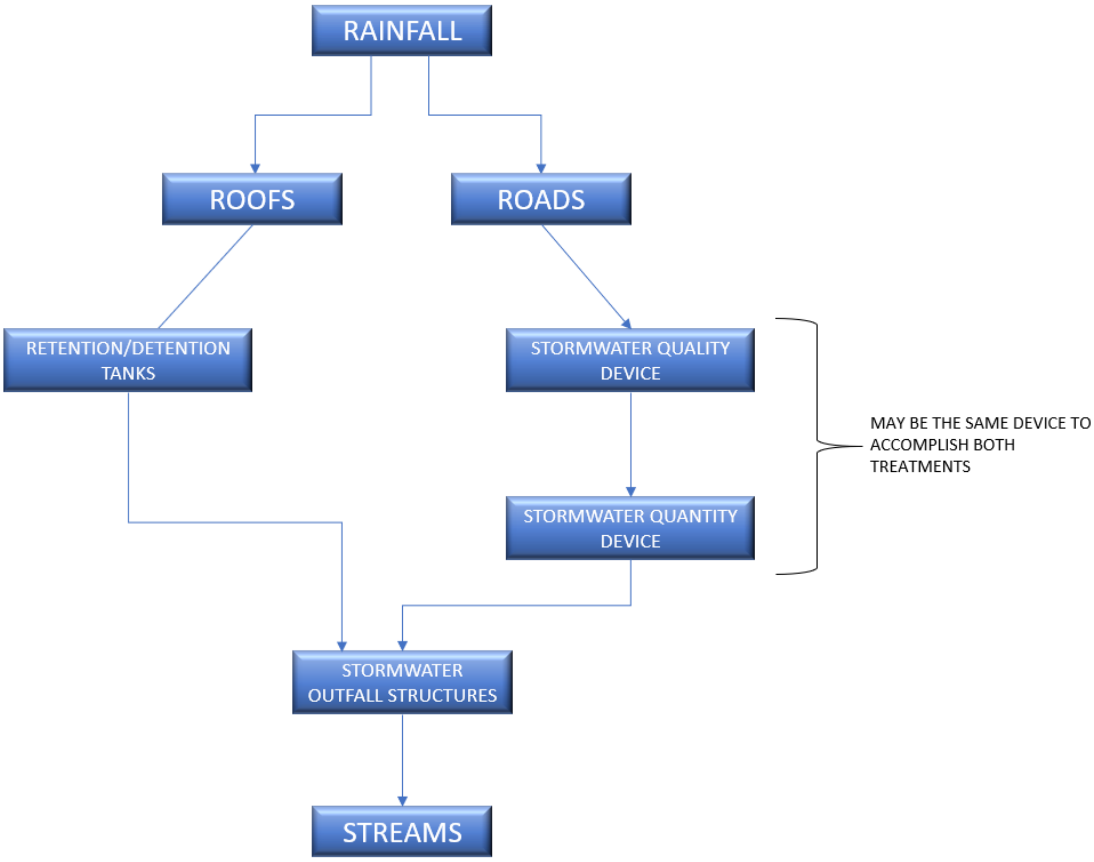

Figure 2 - Stormwater Treatment Train

Stormwater conveyance between the stages of the treatment train will generally be accomplished by way of pipe systems. The use of grassed swales for stormwater conveyance should be investigated during the design process, however it is noted that the combination of topography and narrow road reserves will likely renders swales impractical in most locations on the site.

5 STORMWATER RETICULATION

5.1 Minor Drainage

Due to the proposal to alter the zoning of the site to urban, a corresponding level of development is anticipated. The future development will be provided with piped stormwater networks, consisting of catchpits, manholes and underground pipes in accordance with Auckland Council's Stormwater Code of Practice. Stormwater reticulation generally run along the road reserves and under the private accessways, with road catchpits and private property connections being connected to the public branches.

All stormwater networks within the site will discharge to Viponds Creek. Two stormwater outlets to Viponds Creek are proposed. The two outlets are separated from each other, with one in the Sandspit Road reserve and the other further south, about midway along the Viponds Creek frontage of the site. It is intended that splitting the flows into two outlets will better replicate existing flow patterns than concentrating the flow into one outlet.

Due to the steep topography of the site (particularly around the gullies through which the streams flow), the proposed stormwater pipes discharging to the streams are quite steep (approximately 7% gradient). Therefore substantial erosion protection measures will be required. In general this should take the form of concrete wingwalls and rip-rap aprons in accordance with Auckland Council TR2013-018 Hydraulic Energy Management: Inlet and Outlet Design for Treatment Devices (TR2013-018). Due to the steep gradients there will likely be some stormwater outlets that exceed the limitations of standard rip-rap erosion protection (Froude number of 3 or more), and therefore specific outlet design will be required at the engineering approval stage.

All lots within the development will discharge to a public stormwater conveyance system, rather than being provided with individual outlets. This will ensure that all outlets will be in public ownership and will therefore be maintained to ensure their continued operation for the duration of the design life.

5.2 Major Drainage

Major drainage overland flow paths will primarily be provided along road corridors in accordance with Auckland Transport's Code of Practice. One overland flow path through a private lot (Lot 13) will be required, this will be provided with an easement in accordance with Auckland Council's Stormwater Code of Practice.

6 STORMWATER QUANTITY MANAGEMENT

6.1 General Considerations

6.1.1 SMAF Control

The land immediately southwest of the site falls within Stormwater Management Area Control – Flow 1 (SMAF 1), as shown in Figure 5 below. This control seeks to protect and enhance Auckland's rivers, streams and aquatic biodiversity in urban areas. The subject site is not currently within an urban area but this plan change seeks to revise the zoning, and will result in the creation of urban zones within the current FUZ. SMAF 1 catchments are defined in the AUP as:

"*those catchments which discharge to sensitive or high value streams that have relatively low levels of existing impervious area.* "

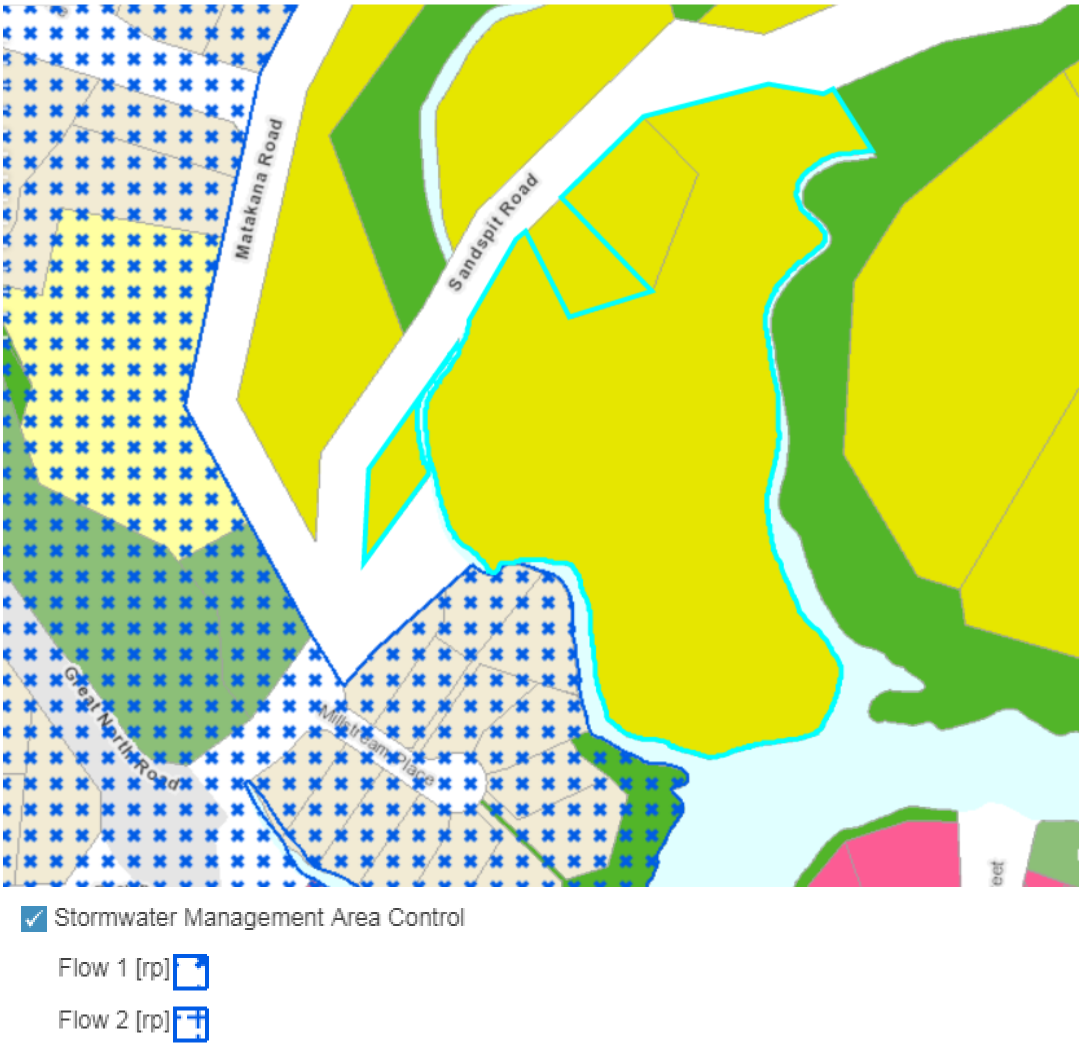

Figure 3 - SMAF Extents

As the subject site has similar topography, pre-development landcover and stream characteristics to the existing SMAF area 1 west of Warkworth, we consider that adopting SMAF 1 for the site is appropriate and consistent with the objectives and policies of the AUP.

6.1.2 Other Stormwater Quantity Considerations

The effects of increased impervious area include a reduction in groundwater recharge, reduced stream flows during periods of dry weather, increased velocity of run off during rainfall events and increased volume of run off during rainfall events.

Auckland Council GD01 Stormwater Management Devices in the Auckland Region (GD01) recommends three main solutions to provide mitigation for the effects of increased impervious area in relation to the quantity of stormwater.

1) *Retention for stream protection and groundwater recharge*

Stormwater retention is provided to ensure water volumes are not conveyed to the primary or secondary stormwater systems, therefore reducing the downstream volume during storm events. Retention is also provided to enable groundwater recharge.

2) *Detention for stream protection*

Detention of stormwater run-off for stream protection aims to maintain the receiving environment, as well as maintaining or improving stream habitat. This is achieved by providing detention of the 95th percentile storm over 24 hours. Further mitigation can be provided by using stream protection measures such as riparian planting and the inclusion of wetlands.

3) *Detention for flood management*

Detention for flood management can be provided by designing stormwater management devices to provide detention for large storm events. These devices release the stored volumes over a longer period of time, to attenuate the increased run-off.

6.2 Stormwater Mitigation Requirements

Each of the above-mentioned mitigation techniques is assessed below to investigate the suitability of options for the subject site.

1) *Retention for stream protection and groundwater recharge*

CMW Geosciences have identified some ground stability concerns on the site and therefore we consider that introducing water to the ground within the developable portion of the site is not recommended. Therefore unlined infiltration/soakage devices such as bioretention, gravel trenches and soakage pits are not recommended to be utilised on the site.

Where necessary for stormwater quality purposes (refer to Section 7) any raingardens or similar devices should be lined with impermeable membranes to prevent potential stability issues, and should be used solely for treatment and not provide any retention function.

Due to both the topography and the geology of the site, existing stormwater runoff is generally via sheet flow towards the streams to the west, east and south. It is recognised that Auckland Council has a preference for returning water to streams via groundwater in order to mimic these existing flow regimes, however this is inappropriate for this site. The site soils have been classified by CMW as highly expansive soils in accordance with NZS 3604 *Timber-framed buildings*. Introducing further moisture to these soils on an irregular basis (i.e. only when it rains) is therefore not recommended, as this may lead to shrinking and swelling of the soils after the development works have been completed, which can result in damage to pavements and structures. A more appropriate methodology for retaining stream baseflows would be to utilise the stormwater reticulation to accomplish this. The stormwater reticulation should be designed to allow for flows to be collected and discharged back into the streams. This will ensure that the streams obtain a base flow that is similar to the existing runoff that they currently receive, and that all of the developed catchment flows are not simply piped downstream into the Mahurangi River.

Detailed design of the future development should ensure that outfalls along the streams receive flows that approximately mimic the existing flows, by dispersing discharge points intermittently along the watercourses. These flows could be directly from a clean stormwater network i.e. roof runoff, or via an outfall from a treatment/detention device. This design principle will go some way to ensuring that baseflows within watercourses are maintained to a similar level to the pre-development condition.

2) *Detention for stream protection*

Based on the recommendation discussed in 6.1.1 that the site should be treated as if it were in the SMAF 1 overlay, detention of stormwater run-off for stream protection should be required to the SMAF 1 standard:

> *provide detention (temporary storage) and a drain down period of 24 hours for the difference between the predevelopment and post-development runoff volumes from the 95th percentile, 24 hour rainfall event minus the 5 mm retention volume or any greater retention volume that is achieved, over the impervious area for which hydrology mitigation is required.*

As discussed previously, retention is not proposed to be provided for impervious areas within the road reserve. Therefore detention for stream protection should be provided for the 95th percentile, 24 hour rainfall event.

3) *Detention for flood management*

As the Mahurangi River is tidal immediately adjacent to the site (as confirmed by the edge of the site being within the coastal inundation overlay), we consider that no peak flow attenuation is required as discussed below.

- The 10% AEP detention requirement is typically to ensure that existing downstream pipe reticulation is not subject to greater flows than for which it has design capacity.

There is no downstream pipe reticulation as any new stormwater reticulation for the site will discharge directly to existing streams which flow into the Mahurangi River.

- The 1% AEP detention requirement, when provided, is for flood protection to ensure that existing downstream buildings are not subject to a greater risk of flooding as a result of upstream development. There are substantial numbers of buildings in Warkworth which are currently within the 1% AEP floodplain (as shown on Auckland Council GeoMaps). The site area represents approximately 0.06% of the 4800ha catchment of the Mahurangi River (catchment area as noted in the Ecological Impact Assessment prepared by Bioresearches). Therefore we consider that any increase in flood level as a result of the proposed development will be negligible and less than minor. Consequently, providing 1% AEP detention would serve no practical benefit.

6.3 Recommended Stormwater Quantity Requirements

It is recommended the SMAF 1 control area be extended to cover the 34 & 36 Sandspit Road site. The objectives, policies and standards of *E10 Stormwater management area - Flow 1 and Flow 2* of the AUP would then apply to the site.

7 STORMWATER QUALITY MANAGEMENT

7.1 General Considerations

Stormwater quality treatment is required for proposed roads and other paved surfaces (e.g. parking bays) within the site. We consider that stormwater quality treatment will not need to be provided for roof areas as long as the houses do not include any high contaminant yielding roofing, spouting, cladding material or architectural features.

Stormwater treatment will also be required for paved trafficable areas within private property (such as private roads/accessways), but this should be provided within the private property, not within the road reserve. It should be noted that the best treatment option for public roads will not necessarily be the best option for private roads, and vice versa.

Stormwater quality treatment devices should be selected and designed at the resource consent stage in accordance with the stormwater device selection toolbox in section 8.

7.2 Stream Quality

Land disturbance within 20m of watercourses is a significant contributor to sediment loads in waterways. Apart from the proposed pedestrian bridge, no built form development is proposed to be undertaken within 20m Viponds Creek or Mahurangi River, or within 10m of the un-named stream. We note that vegetation clearance will be limited within the AUP significant ecological area overlay around the un-named stream and the retention of the existing bush will ensure that a buffer is maintained between the area of works and the existing stream.

Any land disturbance (ie earthworks) required to be undertaken in order to facilitate any future development will be provided with erosion and sediment control in accordance with Auckland Council GD05 requirements. This will ensure that any adverse impacts on the streams are less than minor and are relatively short in duration (being confined to the earthworks period only).

7.3 Water Temperature

Stream environments can be adversely affected by large fluctuations in water temperature which can occur as a result of stormwater runoff. Stormwater runoff from impervious areas in Auckland is substantially warmer (particularly during summer) than the temperature of the receiving environment. We note the following considerations pertaining to stormwater temperature:

- Concrete underground pipes – it has been demonstrated overseas that relatively short distances of underground concrete pipes can reduce the temperature of stormwater by several degrees. The majority of stormwater pipes within the development are anticipated to be concrete, so a substantial amount of cooling of the stormwater will occur within the pipe networks.

- Raingardens – as discussed elsewhere in this report, raingardens are proposed to be utilized to provide stormwater quality treatment for the development. Raingardens are noted in GD01 as being an effective method for reducing stormwater temperatures.
- Shading – as discussed previously, the bulk of the streams within the site will be planted or will retain the existing vegetation. The extensive vegetation will provide shading of the streams which will help to reduce the water temperature.

8 STORMWATER TREATMENT DEVICE SELECTION

8.1 Objectives and Selection Considerations

Stormwater treatment devices utilised within the development will need to accomplish the following objectives:

- Provide detention of the 95th percentile storm and release over 24 hours (for all impervious areas)
- Provide retention of the first 5mm of rainfall (roof runoff only)
- Provide stormwater quality treatment (paved areas subject to vehicle traffic only)

There are a range of devices that are able to accomplish one or more of these objectives, Table 15 of Auckland Council's GD01 provides a good overview of this and is reproduced below.

	Quantity control					Quality control								
Key ● Effective ○ Partially effective - Not effective	1% AEP	Detention of 50% and 10% AEP	90th & 95th percentile detention	Groundwater recharge	Retention	Sediment	Gross pollutants	Heavy metals	Oils and grease	Nutrients	Organics	Hydrocarbons	Indicator bacteria	Temperature
Pervious pavement - unlined	-	-	●	○	●	●	-[b]	-[b]	-[b]	-[b]	-[b]	-[b]	-[b]	-[b]
Pervious pavement - lined	-	-	●	-	-	●	-[b]	-[b]	-[b]	-[b]	-[b]	-[b]	-[b]	-[b]
Living roof	-	-	●[a]	-	●	○	NA	○	NA	○	○	NA	○	●
Rainwater tank (no reuse)	-	○	●	-	-	●	NA	○	NA	○	○	NA	○	○
Rainwater tank (with reuse)	-	○	●	-	●	●	NA	○	NA	○	○	NA	○	○
Infiltration device	-	○	●[a]	●	●	-	-	-	-	-	-	-	-	●
Swale (lined)	-	-	-	-	-	●	○	○	○	○	○	○	○	●
Bioretention swale (unlined)	-	-	●	●	●	●	●	●	●	●	●	●	●	●
Rain garden	-	-	●	●	●	●	●	●	●	●	●	●	●	●
Stormwater tree pit[c]	-	-	○	○	●	●	●	●	●	●	●	●	●	●
Planter box	-	-	○	○	●	●	●	●	●	●	●	●	●	●
Constructed wetland	-[d]	●	●	-	○	●	●	●	●	●	●	●	○	○
Wet pond	●	●	●	-	-	●	●	○	○	○	○	○	○	-
Dry pond (detention basin)	●	●	●	-	-	-	-	-	-	-	-	-	-	●

Figure 6 - Stormwater Treatment Device Effectiveness (Auckland Council GD01 Table 15)

As discussed in Sections 6 & 7, some of these devices are not suitable for use on the subject site (any device utilising infiltration) or are unlikely to be utilised due to the nature of the development (living roofs, wetlands). As such there is no need to consider all devices at this stage. We consider that site-specific stormwater treatment device selection toolboxes are an appropriate means by which the most appropriate options for the site can be laid out at this stage, and can then serve as a starting point for device selection at the resource consent design phase of the development. Due to the different treatment objectives pertaining to different catchments, separate toolboxes have been prepared for private lots (excluding private accessways/ roads) and for vehicle-trafficked areas (including private accessways/ roads/carparks but excluding single dwelling driveways which do not require stormwater quality treatment).

8.2 Selection Toolbox – Private Lots

Devices chosen for private lots will need to provide stormwater detention and retention but will not be required to provide stormwater quality treatment as long as the houses do not include any high contaminant yielding roofing, spouting, cladding material or architectural features. If houses were to be constructed with high contaminant yielding roofing or similar features then stormwater quality treatment would need to be provided for these lots.

When selecting stormwater devices for private lots there are important considerations that differ from publicly owned devices. Proper and regular maintenance of private stormwater devices is crucial to ensure their continued operation, just as it is for public devices, however due to the fact that they are privately owned and operated it is more difficult for regulatory authorities to ensure maintenance of them. For this reason, local and international literature suggests that stormwater treatment devices on private lots tend to be better maintained when they are perceived by the lot owners to provide a clear benefit to them. This contrasts with conventional design thinking which is to hide these devices and make them more of a ‘black box’ system. When selecting devices for private lots consideration should therefore be given to simplicity and practicality, rather than focussing purely on treatment outcomes. The most suitable devices are discussed below.

Pervious pavement – lined

Advantages

- Utilises driveway area and therefore doesn't require any additional footprint.
- The bulk of the maintenance required will be related to movement of the individual paving blocks and damage to edge restraints, it is likely that damage to these components would be repaired by the property owner regardless of whether the pavement was pervious or not.

Disadvantages

- As unlined systems are not appropriate for the soils present on the site retention would most likely need to be provided in a separate device. Having multiple treatment devices on each lot is likely to be undesirable to lot purchasers and result in poorer maintenance outcomes. The volume stored in the pervious pavement can theoretically be pumped and used for non-potable purposes but this is highly unlikely to be practical or cost-effective for a residential development.

Rainwater tanks - reuse

Advantages

- Can provide retention and detention in a single device.
- Retention can be used for non-potable water supply (laundry, toilet flushing, outdoor taps) which may improve the property owner's awareness of and attitude towards maintenance.
- A wide range of shapes, sizes and configurations are available 'off the shelf' which makes tanks a cost-effective option appropriate for most sites.

Disadvantages

- If located above ground could be considered unsightly.
- Reuse of the water inside a house requires dual plumbing and likely a pump as well, this increases the cost and complexity of the system.

Planter boxes

Advantages

- Relatively simple and cost-effective construction.
- Likely to be considered aesthetically pleasing and add amenity value to properties.

Disadvantages

- Site soils are unsuitable for infiltration and therefore planter boxes are unlikely to be able to provide retention, unless evapotranspiration is considered to provide sufficient retention. Assuming an evapotranspiration rate of 3mm/day in accordance with GD01, a 150m^2 roof area would require 90m^2 of planter box area to provide sufficient evapotranspiration to achieve stormwater retention. This is unlikely to be a practicable area.

Although rainwater tanks are the only device likely to be capable of providing both retention and detention for private lots, there are various arrangements that may be more appropriate for certain areas or stages of the development. These include but are not limited to:

- Above ground rainwater tanks to provide retention only, with overflow running to pervious paving or planter boxes to provide detention.

- Planter boxes to provide retention for houses with small roof areas (such as terraced houses), with overflow running to underground tanks to provide detention.

The designers of the development should refer to the toolbox in Table 2 below when determining which stormwater treatment devices represent the Best Practicable Option for private lots. Whole of life costs should also be included in the assessment.

Table 2 - Selection Toolbox - Private Lots

	Detention	Retention	Footprint	Maintenance	Cost/complexity
Pervious Paving	Yes	Unlikely	High	Low	Moderate
Rainwater Tank	Yes	Yes	Low	Detention – Low Retention - Moderate	Detention – Low Retention - Moderate
Planter Box	Yes	Possible	Detention – Moderate Retention - High	Low	Low

8.3 Selection Toolbox – Roading (public or private)

Devices chosen for roading will need to provide stormwater detention (of the full 95th percentile storm) and stormwater quality treatment but will not be required to provide retention. The reasons for this have been discussed previously. Devices used to provide treatment for public roads will need to be located in public land (either road reserve or recreation reserve). Devices used to provide treatment for private roads will need to located within the private road land. As noted previously, the best treatment option for public roads will not necessarily be the best treatment option for private roads and vice versa. Operational and maintenance considerations are important for these devices and there are additional considerations such as public safety that need to be taken into account for public roads in particular. The most suitable devices are discussed below.

<u>Pervious pavement – lined</u>

Advantages

- Utilises pavement area and therefore doesn't require any additional footprint area.
- Passive systems can be at up to 12% gradient which is similar to the maximum public road gradient (12.5% based on Auckland Transport Code of Practice). However passive systems only treat provide treatment of the water that falls on them directly, rather than upstream runoff.
- Can provide some water quality treatment.
- Can accept surface runoff directly and therefore reduces the extent of conventional stormwater infrastructure required (pipes and structures).

Disadvantages

- Needs to be relatively flat for active systems (5% max.). Active systems are able to provide treatment of upstream runoff, however they need to be much flatter than passive systems
- Should ideally receive flows after pre-treatment to remove larger sediments, as the project consists of residential streets sediment loads should be low.
- A higher level of regular maintenance than most other treatment options will be required.

We understand that Auckland Transport does not permit pervious paving to be used in road carriageways, although it is noted that the AT Code of Practice does state that it may be utilised under specific circumstances subject to approval by Auckland Transport. We consider that pervious paving may be able to be used on carparking bays but would also be subject to Auckland Transport's approval.

<u>Rainwater tanks – no reuse</u>

Advantages

- Flexible solution that can be tailored to different topographies – for instance many small tanks or one large tank.
- Maintenance requirements are well established and can maintenance safely be undertaken from the surface.
- In flat areas pipes can be oversized to act as a detention tank, this can mean the conventional piped drainage system effectively provides the detention storage.

Disadvantages

- Underground tanks within road reserve will not be accepted by Auckland Transport and therefore are only appropriate for private roads.
- Structural considerations make underground tanks quite expensive in areas subject to substantial vehicle traffic.
- Do not provide any water quality treatment and would need to be paired with another device to accomplish this.

Swale

Advantages

- Can provide stormwater conveyance as well as quality treatment and can therefore be a cost-effective solution.
- Can be incorporated into landscape design to be aesthetically pleasing.
- Straightforward to construct and maintain.
- In some situation (depending on topography) house connections may also be able to discharge to swales, further improving the cost-effectiveness.

Disadvantages

- Require a sizeable amount of width which may render them impractical on many of the roads within the development. Increasing the road reserve widths to facilitate the use of swales would mean reducing lot areas which makes it an unlikely option in most cases.
- Do not provide detention and would need to be paired with another device to accomplish this.
- Are not suitable for slopes greater than 8%.
- When located on roads with large numbers of vehicle crossings the number of culverts required under the crossings can dramatically reduce the effective swale length, reducing the treatment effectiveness. The culverts also add cost and complexity to construction and block more easily than the swale which can lead to maintenance issues.

Bioretention (Swale or Raingardens)

Advantages

- Can provide both stormwater quality and quantity treatment.
- Can be incorporated into landscape design to be aesthetically pleasing.

Disadvantages

- Require a sizeable amount of width which may render them impractical on many of the roads within the development.
- Bioretention swales are not suitable for slopes greater than around 5% as the number of check dams required becomes excessive.
- Maintenance can be difficult and expensive, particularly when located adjacent to road carriageways.
- The bioretention structure is quite deep (potentially >1m from surface level) which can lead to clashes with other services.

Tree Pits

Advantages

Can provide both stormwater quality and quantity treatment, although unlikely to be able to provide enough detention for the entire road network.

- Can be incorporated into landscape design to be aesthetically pleasing.

Disadvantages

- Maintenance can be difficult and expensive, particularly when located adjacent to road carriageways.
- Can only treat small catchment areas and therefore large numbers would be required.
- We understand that tree pits are not generally accepted by Auckland Transport and therefore they are only likely to be appropriate for private roads.

Constructed Wetlands or Wet Ponds

Advantages

- Can provide both stormwater quality and quantity treatment.
- Can be incorporated into landscape design to be aesthetically pleasing (more so for wetlands than ponds).
- Can treat large catchment areas making maintenance and asset management straightforward

Disadvantages

- Require regular effective maintenance to maintain aesthetic values.
- Require large footprints of flat land.
- Have substantial safety risks for the public and require effective fencing and signage.
- Not suitable for land that may be subject to instability.

The designers of the development should refer to the toolbox in Table 3 below when determining which stormwater treatment devices represent the Best Practicable Option for public or private roading. Whole of life costs as well as the safety of maintenance personnel (particularly for public roads) should also be included in the assessment.

It should also be noted that there are proprietary devices available that are likely to be suitable to provide stormwater quality treatment for the roads. The potential for using proprietary devices could be investigated further during the design of each stage of the development, including an assessment of whole of life costs as for the devices listed in the toolbox. We understand that proprietary devices are not generally accepted by Auckland Transport, however they may appropriate for private roads and should be considered.

Table 3 – Selection Toolbox - Roading

	Detention	Quality	Footprint	Maintenance	Cost/complexity
Pervious Paving	Yes	Some	Low	High	Moderate
Rainwater Tank	Yes	No	Low	Low	Moderate
Swale	No	Yes	Moderate	Low	Low
Bioretention Swale	Yes	Yes	Moderate	High	Moderate
Raingarden	Yes	Yes	Moderate	High	Moderate
Tree Pit	Some	Yes	Low	High	Moderate
Constructed Wetland	Yes	Yes	High	Moderate	High
Wet Pond	Yes	Yes	High	Low	Moderate

9 FLOODING CONSIDERATIONS

There is an existing 1% AEP flood plain shown on Auckland Council's GeoMaps system around the western, eastern and southern boundaries of the site, as shown in Figure 2 below. This flood plain arises from flooding of the Mahurangi River.

Figure 4 - Existing Flood Plain

There is also minor encroachment of the *coastal inundation – 1% AEP plus 1m of sea level rise* control into the site. For the purposes of this Stormwater Management Plan we consider that the flooding is the more pertinent natural hazard.

The flood plain is confined to the steeper areas of the site and generally correlates to the *Significant Ecological Area* overlay in the east of the site. No development is proposed within the flood plain and based on the steep topography of the site we consider that the future residential development will be able to achieve the required 500mm freeboard above the flood plain.

9.1 Hydrologic Analysis

Hydrologic analysis of the effects of the development on the main Mahurangi River catchment has been undertaken using HEC-HMS software. The results are summarised in Table 4.

Table 4 – Hydrologic Model Results – Mahurangi River

	Pre-development	Post-development	Subject Site
Catchment area (ha)	49.06	49.06	1.43 (developed area only)
Weighted curve number	77	77.002	88.2
1% AEP peak flow rate (m^3/s)	583.92	583.81	0.71
Time to peak (hrs:mins)	14:49	14:49	12:15
Runoff Volume (m^3)	12,953	12,954	4.5

It can be seen from Table 4 that the development of the site results in a negligible increase in runoff volume of $1m^3$. The model demonstrates a slight reduction in peak flow rate of $0.11m^3/s$, this is due to the fact that the peak flow rate from the subject site occurs over two hours earlier than the peak flow rate from the catchment. Therefore the effects of the development on flooding in the Mahurangi River catchment are considered to be less than minor.

We consider that the anticipated future development within the site will not impact the flood plain or result in an increase in flood levels upstream or downstream of the site. Consequently, an increase in the risk of inundation of buildings and properties upstream or downstream of the site will be less than minor.

10 CONCLUSION

While stormwater flows from the site will increase as a result of the future development associated with the proposed plan change, this report outlines the existing catchment characteristics and proposed stormwater mitigation requirements. The provision of stormwater treatment and detention for road runoff, and detention where necessary for roof runoff, is suggested to mitigate the likely effects of the future development of this site. Selection of stormwater devices should give consideration to the Best Practicable Option for the specific application and should be in accordance with the selection toolboxes contained within this report.