REPORT

Tonkin+Taylor

Stormwater Management Plan

Private Plan Change 28

Prepared for

CCKV Maitahi Dev Co Lp and Bayview Nelson Ltd

Prepared by

Tonkin & Taylor Ltd

Date

August 2022

Job Number

1012397.1000.v3

Exceptional thinking together

www.tonkintaylor.co.nz

Document Control

Title: Stormwater Management Plan					
Date	**Version**	**Description**	**Prepared by:**	**Reviewed by:**	**Authorised by:**
8/06/2022	1	DRAFT “WITHOUT PREJUDICE”	BYMU, CRGR, MGM, DNV	T Bassett D Velluppillai M Mills	M Foley
15/06/2022	2	Final	BYMU, CRGR, MGM, DNV	T Bassett	M Foley
3/08/2022	3	Post-Hearing revision	BYMU, CRGR, MGM, DNV	M Foley	M Foley

Distribution:

CCKV Maitahi Dev Co Lp and Bayview Nelson Ltd	1 PDF copy
Tonkin & Taylor Ltd (FILE)	1 PDF copy

Table of contents

1 Introduction

This Stormwater Management Plan (SMP) has been prepared by Tonkin & Taylor Ltd (T+T) to support a Private Plan Change application (PPC28) by CCKV Maitai Dev Co Lp and Bayview Nelson Limited (hereafter referred to as "the applicant") to re-zone approximately 287 ha of land located within the Kākā Valley, along Botanical Hill and Atawhai Hills (hereafter referred to as "PPC28 area"), from Rural and Rural-Higher Density Small Holdings Area, to a mixture of:

- Residential (Higher, Standard and Lower Density Areas)
- Rural-Higher Density Small Holdings
- Open Space Recreation
- Suburban Commercial

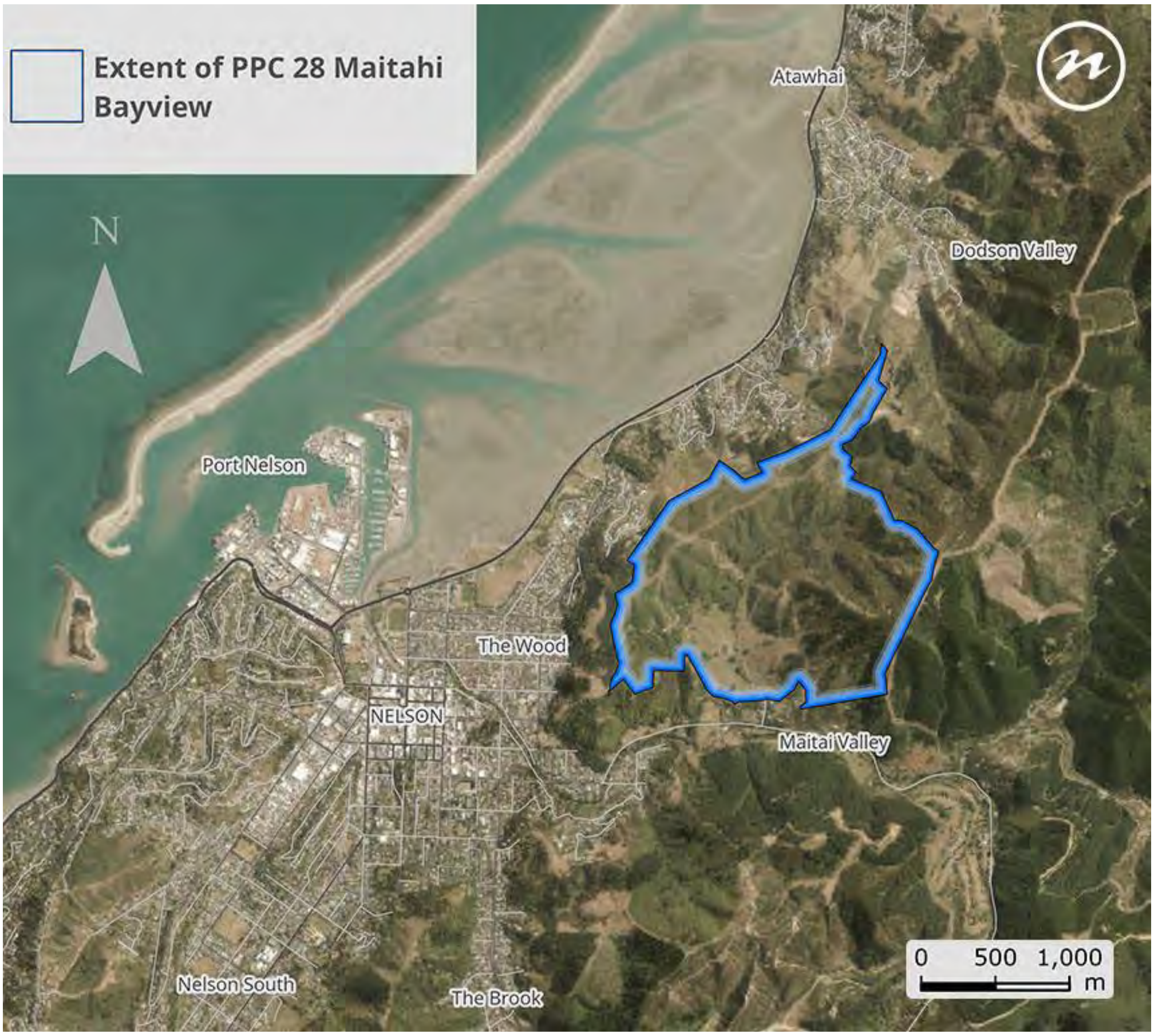


Figure 1: PPC28 extent (source NCC)

T+T previously prepared an "Infrastructure and Flooding Report" (March 2021) and a "Response to Request for Further Information" letter (20 August 2021) to support PPC28. Morphum Environmental Ltd (Morphum) also prepared a "Preliminary Structure Plan Environmental Review" report (April 2021), providing guidance and recommendations in relation to stormwater management and ecological effects management.

1.1 Purpose

This SMP has been prepared to support PPC28 and provides a high-level summary of the proposed stormwater management approach within the PPC28 area, to a level of detail consistent with a Plan Change stage. The SMP is based on current information available at this time and will be updated and developed in more detail as the project progresses, and at future Resource Consent and Subdivision application stages.

The overall purpose of the SMP is to provide guidance to the applicant and Nelson City Council (NCC) on how stormwater will be managed for a future land use scenario, and to support the PPC28 application.

The SMP is consistent with Council's policies and plans. Non-statutory policy and planning documents have also been considered.

1.2 Scope

The scope of the SMP is to:

- Summarise proposed stormwater management options for development of the PPC28 area;
- Demonstrate how stormwater management related expectations under the Nelson Resource Management Plan (NRMP) and Nelson Tasman Land Development Manual (NTLDM) have been met or exceeded; and
- Demonstrate feasibility of design principles for initial approval of concept for stormwater assets to be vested to Council.

1.3 Outcomes of SMP

The outcomes sought by the SMP are:

- An integrated stormwater management approach;
- A water sensitive treatment framework that manages and mitigates the impact of land use changes from agricultural to a zoning mix of predominantly rural, and residential;
- Provide for retention of stream habitat, and protection and enhancement of riparian margins;
- Identification of flood risk areas so that new development is located outside the flood plain;
- Assess and provide options for mitigation of any potential impacts of the proposed development on flood risk to adjacent and downstream property;
- A set of Best Practicable Options (BPO) for stormwater that can be applied to the PPC28;
- Promotion of water conservation where possible and practicable; and
- Identification of opportunities to manage stormwater areas for multiple values and functions.

2 Existing site appraisal

This section of the report summarises the existing characteristics and conditions of the PPC28 area as they relate to stormwater management.

2.1 Summary of data sources

Characteristics	Data source
Topography	Top of the South Maps, Nelson City Council LINZ Data services - Nelson LiDAR 1m DEM (2021)
Geotechnical	PPC28 Geology and Geotechnical Hazards report, prepared by T+T, March 2021 PPC28 Geological mapping, prepared by T+T (Appendix A) PPC28, Impact of geology on sediment yield letter, prepared by T+T dated 10 June 2022
Existing stormwater network	Top of the South Maps, Nelson City Council. PPC28 Infrastructure and Flooding Report, prepared by T+T, March 2021 Response to Request for Further Information letter, T+T, 20 August 2021 Site visit by T+T
Existing hydrological features	Site visit by T+T Site visit by Morphum PPC28 Ecological Opportunities and Constraints Assessment Report, prepared by T+T, March 2021 Preliminary Structure Plan Environmental Review report, prepared by Morphum, April 2021 Field Stream classification map, prepared by Morphum, October 2020 (Appendix A)
Maitahi/Mahitahi River erosion	Ecological Restoration Plan Report, Maitai River, prepared for Nelson City Council by Morphum, July 2020
Flooding and flow paths	Top of the South Maps, Nelson City Council Maitai/Brook/York and Wakapuaka Flood Models report, prepared by T+T, 28 July 2021. Additional flood hazard information - PC28 letter, prepared by T+T, May 2022 PPC28 Infrastructure and Flooding Report, prepared by T+T, March 2021 Response to Request for Further Information letter, prepared by T+T, 20 August 2021
Ecological areas	PPC28 Ecological Opportunities and Constraints Assessment report, prepared by T+T, March 2021 PPC28 Existing terrestrial habitat occupying survey area map, prepared by Robertson Environmental, May 2022 (Appendix A)
Archaeology	PPC28 Historical & Archaeological Assessment, prepared by Amanda Young, December 2020

2.2 Topography and land use

The Maitahi and Bayview areas of the proposed development comprise approximately 287 ha. Broadly the topography and land use of the site comprises:

- Ridgelines of the hills surrounding Kākā Valley, vegetated with open grassland on the western side of the valley and open matagouri scrubland on the eastern side of the valley
- Rolling slopes and hill country forming the Atawhai Hills ridge crest and west facing slopes, vegetated in a mixture of grass, and native and exotic scrub
- Moderate to steep hill country (generally between 22° and 40°) forming the upper slopes of Kākā Valley, vegetated in a mix of scrub, grass and scattered mature native and exotic trees.
- Rolling slopes and hill country (generally between 5° and 22°) west and east facing slopes forming the sides of Kākā Valley and vegetated in a mixture of grass, and native and exotic scrub
- Gently undulating to flat inclined slopes (generally less than 5°) forming the flood plain of the Maitai River (hereafter referred to as Maitahi/Mahitahi River so that the dialects of all Te Tau Ihu Iwi are represented) and Kākā Hill tributary. These areas are predominantly pastoral grazing land with isolated mature exotic trees.

The Kākā Hill tributary (hereafter referred to as "Kākā Stream") flows from its headwaters in the relatively steep and confined upper hill catchment into the relatively shallow meandering channel in the flatter flood plain at its confluence with the Maitahi/Mahitahi River. In the lower reaches the channel has been modified.

The western extent of the PPC28 area is located on outside the Kākā Stream Catchment and runoff generated in this area drains to the north-west towards the Nelson Haven. This area is hereafter referred to as the Walters Bluff/Brooklands Catchment. Stormwater generated in these areas flows down gullies and flow paths within the moderate to steep hill country, some of which is urbanised.

There are two smaller sub-catchments at the peripheries of the PPC28 area which drain directly to the Maitahi/Mahitahi River.

The extent of the principal catchments within the PPC28 area is shown in Figure 2.1 below.

Figure 2.1: Stormwater catchments within the PPC28 area

2.3 Geotechnical overview

2.3.1 Geology

The underlying geology at the site is predominantly hard strong rock on the sloping land in the Kākā Valley and extensively along the Atawhai Hills. The distribution of rock types in the plan change area is shown on Figure 1012397-F3 from the T+T report titled "Private Plan Change request, geology and geotechnical hazards Report" dated March 2021 (ref 1012397.v3). A copy is included in Appendix A.

Botanical Hill formation bedrock dominates the Atawhai Hills and the western slopes of the Kākā Valley where residential zoning is proposed. Grampian Formation bedrock dominates the eastern slopes of Kākā Valley where residential development is shown on the Indicative Masterplan and Structure Plan. These rock types do not produce easily erodible or dispersive clay soils.

Quaternary age deposits that occur within the gently sloping to flat valley floor of the Kākā Valley are dominated by gravel deposits which are also comparatively erosion resistant.

Colluvium soils can be seen in various track excavations within Kākā Valley and on the Atawhai hillsides and form a thin soil veneer overlying the bedrock. These soils are typically at least 50%

gravel, derived from physical weathering of the underlying bedrock. The finer content of these soils is a mix of sand, silt and clay.

2.3.2 Slope stability

Aerial photographs, LiDAR imagery and site observations indicate that most of the land is not subject to slope instability.

There is no evidence of significant, recent slope instability within the PPC28 area. However, there are localised small landslip scarps on some steeper slopes, mainly within gullies and on slopes flanking spur lines, as is typical of Nelson hillside terrain.

Slope stability is discussed in more detail in the T+T report titled "Private Plan Change request, geology and geotechnical hazards Report" dated March 2021.

2.3.3 Soil erosion

The dominant rock types of the PPC28 area are not expected to weather, to sandy or silty soils that are easily erodible. However, the steeper slopes, where bedrock is overlain by a thin veneer of often coarse granular soil (particularly those steeper slopes generally in excess of 30°) may be susceptible to gully and sheet erosion if stripped of topsoil.

The active channel of Kākā Stream upslope of the floodplain has formed a relatively stable channel form having, over several thousand years, eroded and incised into the Quaternary gravel deposits along the valley axis. In places stable bedrock is evident in the stream banks and channel invert. Minor recent erosion and re-deposition of gravels that form the stream bed and channel margins is locally evident. Such erosion is common in hillside stream channels, particularly when natural vegetation has been removed and where the stream has been altered by land management practices.

2.3.4 Geological suitability for development

The landforms above the valley floor in Kākā Valley and forming the Atawhai ridgeline and slopes to the west of the ridgeline reflect the dominant underlying geology and past geological processes.

As discussed in the T+T Geotechnical Report, the landforms have been identified to include areas of Low, Moderate and High geotechnical risk (refer Figure F5 in Appendix A). Moderate and High risk does not preclude subdivision development, but will impact where residential lots can be located, the extent of earthworks and the overall subdivision lot yield on this land. These constraints must be considered as part of future subdivision planning.

2.3.5 Suitability for infiltration

The PPC 28 area includes land that has limited opportunity for infiltration due to the nature of the topography and geology. This includes moderate to steep slopes and areas of high slope instability risk. Much of this land is excluded from potential residential development.

Areas of gently to moderately inclined slopes (for example slopes between 10 and 20 degrees) within the proposed residential zone have potential for engineered lot scale soakage or rain gardens to facilitate groundwater recharge but need further evaluation and design once earthworks and lot layout is developed at the resource consent stage.

The proposed high density zoned land on the flat and gently inclined land that forms the flood plain has potential for large areas to be utilised for infiltration including lot scale soakage, appropriately designed consolidated rain gardens or consolidated soakage systems. It proposed to fill this area by up to approximately 3 m with site-won rock fill material, which could potentially provide a minimum infiltration rate of at 5 mm/hr. This would need to be confirmed through permeability testing once the fill material has been placed.

2.4 Resource Management Plan Overlays

The NRMP identifies the PPC28 area as generally within the Rural Zone and Rural – High Density Small Holdings Area, and partly located within the Landscape, Land Management, Services, Riparian, and Flood Overlays. Of importance to potential development of PPC28, is that the site has areas located within the Land Management, the Flood and the Fault Hazard Overlays.

2.5 Existing stormwater context

2.5.1 Drainage and hydrological features

The existing stormwater drainage features within the PPC28 area are typical of rural undeveloped catchments, and can be broadly described by the following six categories:

- Broad and steep vegetated and grassed slopes which sheet flow into minor watercourses;
- Minor watercourses such as intermittent streams, ephemeral streams and overland flow paths located on either side of the ridge forming tributaries of the Kākā Stream, or directing flow towards the Maitahi/Mahitahi River or to the Nelson Haven via NCC stormwater network. It is noted that existing tributary streams do not meet the current NCC definition for intermittent streams;
- The Kākā Stream which conveys flows from the upper reaches to its confluence with the Maitahi/Mahitahi River. It is noted that the lower reach of the Kākā Stream (downstream of woolshed) has been highly modified/realigned to facilitate 'drainage' of the flat land for farming purposes. This has resulted in a straightened channel which dries up during extended periods of summer. The extent of this channel is shown in Figure 2.2. This area is referred to as the 'flood plain' area.
- Various artificial and modified watercourses. primarily located on the lower flood plain;
- As shown in Figure 2.1, there are two small catchments within the PPC28 boundary that drain directly to the Maitahi/Mahitahi River. These catchments comprise broad and steeply vegetated slopes, with runoff as sheet flow into minor watercourses via intermittent streams, ephemeral streams and overland flow paths that drain directly to the river.
- The receiving Maitahi/Mahitahi River and Nelson Haven.

Figure 2.2: Modified section of Kākā Stream

As part of the previous work on the site, Morphum prepared a field stream assessment for the Kākā Stream Catchment which outlines the existing hydrological network within the site. This plan is attached in Appendix A. Comment on the interactions between groundwater and the flows within the categorised streams is outlined in Section 2.5.3.

2.5.2 Receiving environment

2.5.2.1 Maitahi/Mahitahi River

The Maitahi/Mahitahi River and catchment can broadly be divided into three sections:

- The relatively undeveloped upper catchment with the municipal water supply catchment area;
- Forestry, farming and recreational land use in the mid catchment; and
- Urbanised lower catchment where the river flows through the City.

The Kākā Stream confluence with the Maitahi/Mahitahi River at the lower end of the mid catchment reaches is typically willow-lined and surrounded by pasture and reserves. The lower section of the Maitahi/Mahitahi River within the Nelson urban area is impacted by potentially contaminated urban runoff and periodic E.coli discharges and discharges into the Nelson Haven, with tidal influence on flows and levels in the lower reaches.

The two small catchments within the PPC28 boundary that drain directly to the Maitahi/Mahitahi River are shown on Figure 2.1. These include a western catchment (hereafter referred to as the Bradford Park catchment) that drains to Bradford Park and is conveyed across Maitai Valley Road via a DN675 pipe and an eastern catchment that drains across Maitai Valley Road via a pipe of an unknown diameter.

2.5.2.2 Nelson Haven

The Maitahi/Mahitahi River discharges into Nelson Haven through the Nelson Urban area. The Nelson Haven is a bar-built, fluvial erosion estuary, approximately 1300 ha in area, at the southern end of Tasman Bay. The estuary is ecologically significant as it is an important feeding and roosting habitat for wading birds, including some rare and threatened species[1]. The Nelson Haven receives sediments from the Maitahi/Mahitahi catchment and it is estimated that the Maitai River upstream of the Brook confluence has a sediment yield of approx. 500 m^3/year and that the Brook contributes another approx. 500 m^3/year of gravel to the downstream Maitahi/Mahitahi reaches and ultimately the Nelson Haven[2].

Runoff from the Walters Bluff/Brooklands Catchment presently discharges directly to the Nelson Haven, as either flow conveyed in the NCC stormwater network through a series of culverts under State Highway 6, or as overland flow across the existing urban area.

The Walters Bluff/Brooklands Catchment primarily consists of low to medium density urban development. Stormwater treatment of runoff from roads, hardstands and other existing contaminant-generating surfaces is virtually non-existent, and all runoff currently discharges directly into the Nelson Haven.

2.5.3 Kākā Stream Baseflow

As part of the Preliminary Structure Plan Environmental Review report (Morphum, April 2021, refer Appendix D) the waterways across the Kākā Stream Catchment were identified as having complex hydrology, with many tributaries transitioning from above to below ground flow. It was noted that all tributary streams are likely to be dry for prolonged periods of low rainfall and are classified as ephemeral under the NRMP.

This reflects the site soils upslope of the floodplain which appear to be dominated by fractured rock and colluvium with deposits free draining material in side gullies. The upper reaches of the Kākā Stream were also observed to retain persistent baseflow which is expected to remain across the full year.

The downstream portion of the Kākā Stream where it has been realigned during historic times is characterised by free draining fine soils above high permeability gravel. Stream baseflow is readily lost to ground in this reach in drier months.

2.5.4 Stream erosion

As outlined in Morphum Environmental Review report, the existing conditions of the receiving streams within the PPC28 area are summarised as:

- *"Kākā Stream, and side tributaries, channels, under current land use, are stable with little sign of active scour or erosion.*
- *The stream appears to support a stable channel which displays sinuosity through gentle meanders, point bars, lateral flood benches and stable overhangs.*
- *Whilst a detailed geomorphological assessment was not undertaken, substrates appear to comprise a mix of well bound alluvial sediments through the mid reaches with bedrock and large boulders in upstream reaches. The lower reach (extending from the woolshed to river confluence) appears to be finer sediments (silts) with excessive deposition likely a result of elevated sediments from stock and increased deposition due to flat grade".*

[1] Bell B. D. (1986). The conservation status of New Zealand wildlife. NZ Wildlife Service Occas. Publ. No 12. 103 p

[2] Hoyle, J. and Hicks, D.M. (2015). Maitai River Gravel Management Study. National Institute of Water & Atmospheric Research (NIWA) Report CHC2015-053-November. Prepared for Nelson City Council.

2.5.5 Existing flooding and flow paths

The PPC28 area is subject to flood risk from four separate sources:

- Flooding of the lower Kākā Stream flood plain (Figure 2.3) from both Kākā Stream and the Maitahi/Mahitahi River.
- Flooding in the Kākā Stream Catchment, including the main Kākā Stream channel and contributing minor tributaries
- Flooding of hillside sub-catchments that comprise of vegetated slopes and minor watercourses such as intermittent and ephemeral streams and overland flow paths within the minor Maitahi/Mahitahi River catchments
- Flooding of hillside sub-catchments that comprise of vegetated slopes and minor watercourses such as intermittent and ephemeral streams and overland flow paths within the Walters Bluff/Brooklands sub-catchments

These are described in more detail in the following sections.

2.5.5.1 Maitahi/Mahitahi River flooding

The Maitahi/Mahitahi Catchment is approximately 100 km², with the river flowing through central Nelson City to The Haven. The present day peak 1% annual exceedance probability (AEP) flood flow through the lower reaches is approximately 365 m^3/s (per NIWA's 2021 frequency analysis of data collected at the "Maitai @ Avon Terrace" flow gauge).

Photograph 2.1 shows flooding during the February 1995 flood event. Based on a reported flow of about 295 m^3/s in the City, the frequency of this event is considered to be approximately 2% AEP (1 in 50-year return period).

Photograph 2.1: Looking to the North from Maitahi/Mahitahi Valley Road during the February 1995 flood event. Source: nzfloodpics.com

Photograph 2.2 shows flooding during the December 2011 flood event. This event was measured at 237 m^3/s at the Avon Terrace flow gauge, approximately 5% AEP (1 in 20 year return period).

Photograph 2.2: Maitahi/Mahitahi Valley Road flooding near Ralphine Way during the December 2011 flood event.

The NCC Maitahi/Mahitahi River flood model has been used to provide flows and flooding depths and extents in the lower flood plain. This flood modelling results indicate that a 1% AEP flow event will cause widespread flooding in the rural/semi-rural valley upstream of the City, including in the flood plain at the Kākā Stream confluence. Figure 2.3 below shows 2130 1% AEP flood mapping, based on the existing catchment land use.

Figure 2.3: Maitahi/Mahitahi River flood depths in blue (2130 RCP8.5 1% AEP event) sourced from NCC Maitai River flood model (http://www.nelson.govt.nz/assets/Environment/Downloads/Nelson-Plan/reports/2021/Maitai-Brook-York-Wakapuaka-Flats-2021.pdf). PPC28 boundary in red.

NCC modelling shows flood levels at the flood plain area within the PPC28 area of up to approximately RL 17.6 m (NZVD 2016) for the 2130 1% AEP flooding. These occur during the 12-hour event, which is considered the critical duration at the Kākā Stream confluence (note further downstream, the 24-hour duration event becomes critical). The modelled flows in the Maitahi/Mahitahi River include a contribution from the Kākā Stream. However, the model does not represent/route overland flow paths for runoff within the Kākā Valley (i.e. Kākā Stream flows are input as point flows to the Maitahi/Mahitahi River in the model).

2.5.5.2 Kākā Stream Catchment

Kākā Stream flooding was assessed as follows:

- A range of hydrological methods was used to estimate the peak flows from the catchment.
- A rainfall/runoff model was developed using HEC-HMS v4.9 software
- A 2D direct rainfall model was developed for the Kākā Stream itself (i.e. upstream of the Maitahi/Mahitahi River flood plain), based on TUFLOW software. This model was developed to identify existing flooding and flow path extents.

2.5.5.2.1 Hydrological peak flow assessment

Various methods were used to estimate the peak pre-development flows from the Kākā Stream, including:

- NIWA Regional method (Henderson Collins 2018);
- SCS 1986 loss method with SCS transform and frequency storm developed from HIRDS v4 data;
- Rational method as per NTLDM and NZBC E1.

For the SCS and Rational method calculations, the Kākā Stream Catchment was delineated into five sub-catchments, as shown in Figure 2.4. The rainfall depths and shapes were taken from NIWA

HIRDS v4, with effects of climate change based on RCP8.5M, as per NTLDM 5.4.6.2. Detailed calculations have been included in Appendix B

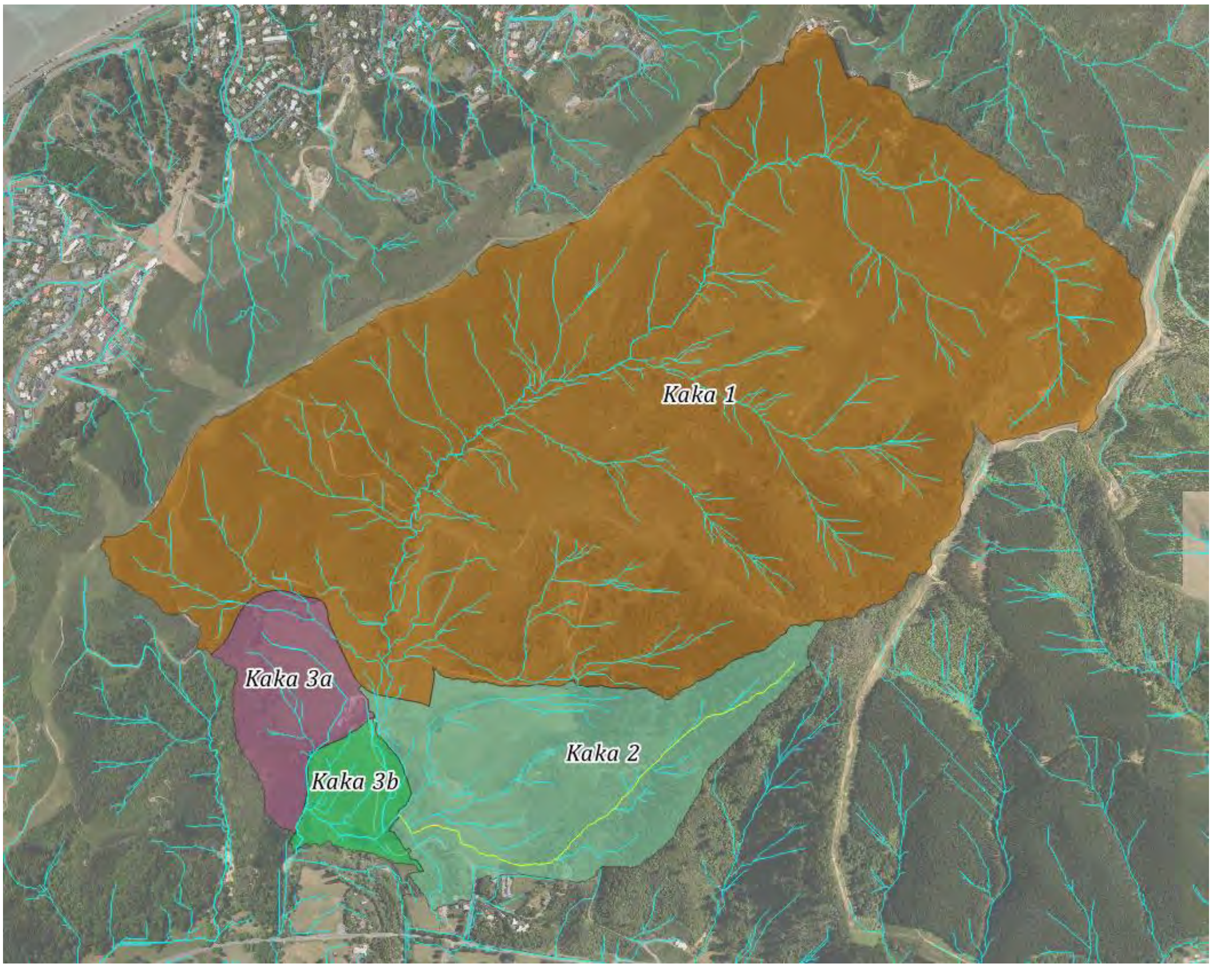


Figure 2.4: Kākā Stream sub-catchments and flow paths based on 2021 LiDAR data and Indicative Masterplan.

Table 2.2 below presents the results from the preliminary hydrological assessment for the existing catchment. The associated calculations are attached in Appendix B.

Table 2.2: Peak 2090 runoff estimates for Kākā Stream

Rainfall frequency	Climate	Pre-development peak flow (m^3/s)
10% AEP	2090 RCP8.5M rainfall	8.0 to 19.3
6.67% AEP		8.6 to 21.1
1% AEP		13.3 to 32.0

2.5.5.2.2 Direct rainfall flood modelling

The TUFLOW model was developed using:

- NCC 2021 LiDAR data (2 m grid, with 1m sub-grid sampling from a 1 m DEM).
- Landcare Research's Land Cover Database 5 (LCDB5) information.

- Landcare Research's Soil Maps.
- NIWA 2130 HIRDS v4 rainfall data and storm profiles.
- NCC Maitai River flood model results as downstream boundary conditions for a range of design events. A flow hydrograph was extracted from the model, and input Maitai River reach in the TUFLOW model.
- Similar hydrological parameters to those in more detailed models within the Nelson Region (these parameters will be reviewed during subsequent more detailed phases of consenting and design for PPC28 development).
- For the purposes of assessing inundation levels (for example in the lower flood plain), the 2130 RCP8.5 climate projection has been used, consistent with the NCC Maitai River flood model, noting that the NTLDM Inundation Practice Note only requires consideration of climate change to 2090.

Initial model runs indicated that the 6-hour rainfall event (based on the HIRDS v4 storm profile) produced the greatest peak flows from the catchment. The 2130 RCP8.5 1% AEP 6-hour event (with peak 6-hour flows in the Maitahi/Mahitahi River) is shown in Figure 2.5.

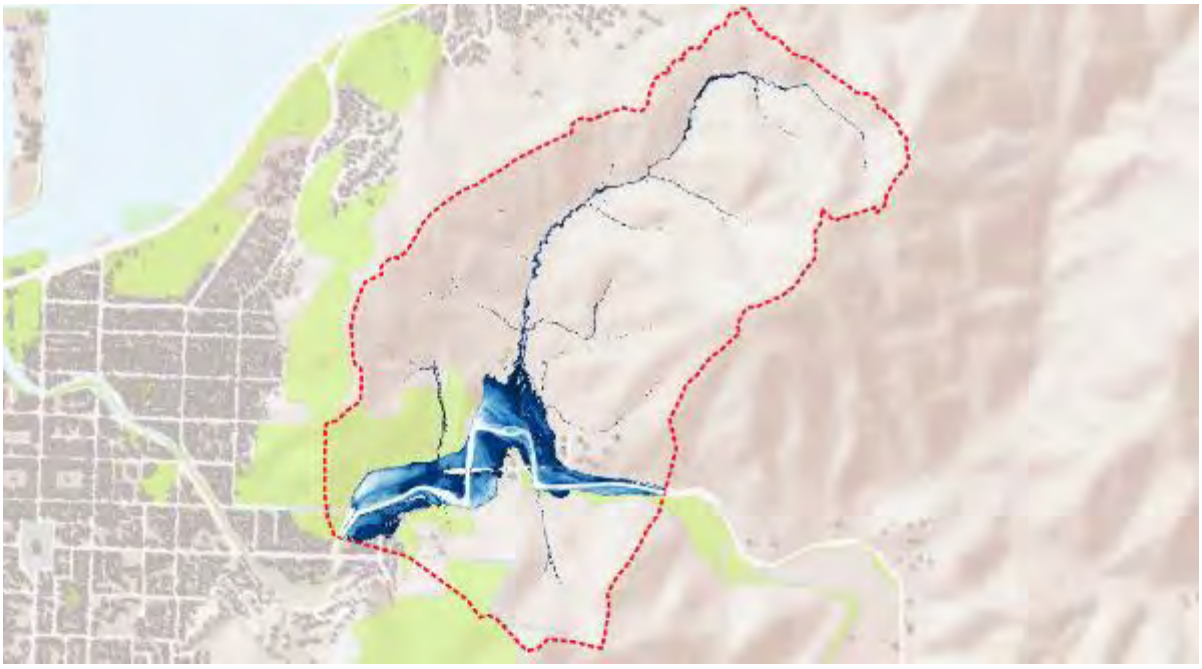


Figure 2.5: Flood depth mapping within the Kākā Stream Catchment in blue – 2130 RCP8.5 1% AEP 6-hour event. The red dashed line is the model boundary.

The modelled peak runoff rates using this rainfall-on-grid method are within the range of other estimates outlined in Table 2.22, and the model is considered adequate to inform the understanding of existing flooding and flow paths. Refer to Appendix E for an explanation of the flood modelling approach.

The model has been used to identify indicative flow paths, depths, widths, velocities and extents throughout the catchment for the 10% and 1% AEP events in both the present day and 2130 RCP8.5 planning horizons. The 6-hour event has been modelled at this stage.

During later stages of consenting and design, various combinations of Maitahi/Mahitahi River and Kākā Stream events will be assessed to determine the most critical design cases. For example, in areas mostly affected by Maitahi/Mahitahi River flooding, the 12-hour event is likely to produce greatest flood depths; whereas for areas where the Kākā Stream flows govern flooding characteristics, the 6-hour event is likely to be more critical. The relative timing of the peak flows from the Kākā Stream Catchment and the greater Maitahi/Mahitahi Catchment will also be considered.

2.5.5.3 Maitahi/Mahitahi River minor catchments

There are two small catchments within the PPC28 boundary that drain directly to the Maitahi/Mahitahi River, are shown in Figure 2.6.

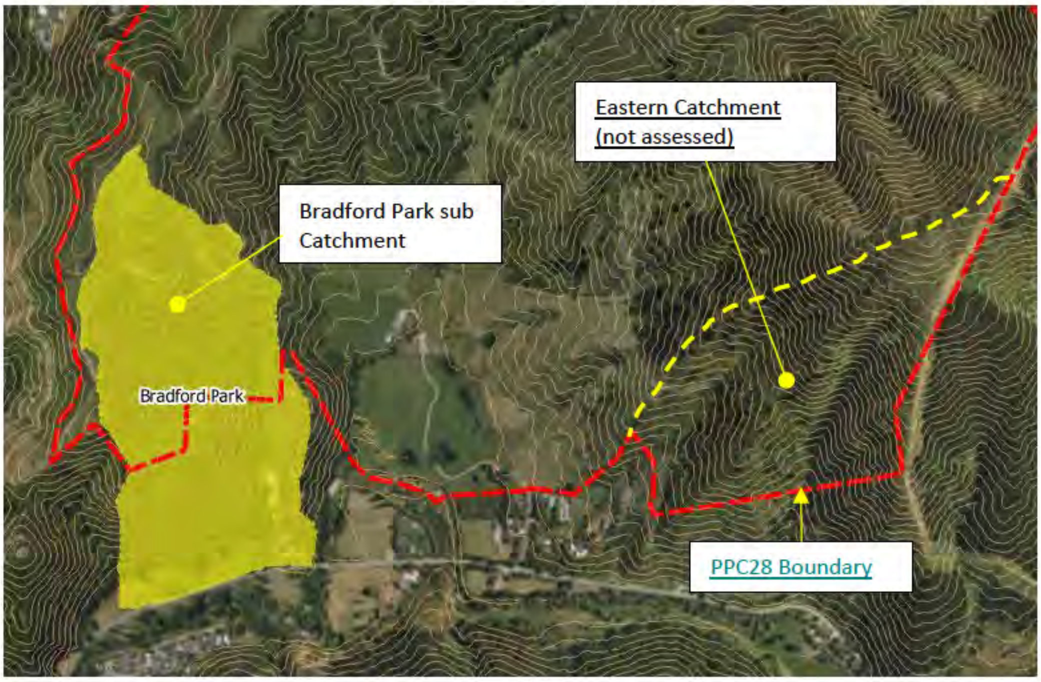


Figure 2.6: Maitahi/Mahitahi River minor catchments

The Bradford Park catchment has been assessed using the SCS and Rational methods, as described in Section 2.5.5.2.1, and were used to determine the peak pre-development flows from the Bradford Park catchment, as shown in Table 2.3 below. The associated calculations are attached in Appendix B. The eastern of the two minor catchments, does not have any development or change of zoning proposed within its boundaries. As a result, there is not expected to be any change in flooding from this catchment and runoff has not been modelled.

Table 2.3: Bradford Park Catchment pre-development peak flows

Rainfall frequency	Climate	Pre-development peak flow (m^3/s)
		Bradford Park Catchment
10% AEP	2090 RCP8.5M rainfall	2.2 – 2.6
6.67% AEP		2.5 – 2.8
1% AEP		3.4 - 4.4

2.5.5.4 Walters Bluff/Brooklands Catchment

The Walters Bluff/Brooklands Catchment generally drains to Nelson Haven to the west, with a small sub-catchment north of the Kākā Valley draining through developed areas in Dodson Valley to discharge ultimately also into Nelson Haven and another series of small catchments draining towards the Wood. These small catchments have not been assessed as no development is expected in these areas.

An initial assessment of the existing NCC piped stormwater network in this catchment indicates that the network is already undersized in relation to design flows from existing land use. Therefore, there is no capacity to accommodate increased flows from development in the PPC28 area. Figure 2.7 shows the NCC stormwater network and mapped overland flow paths.

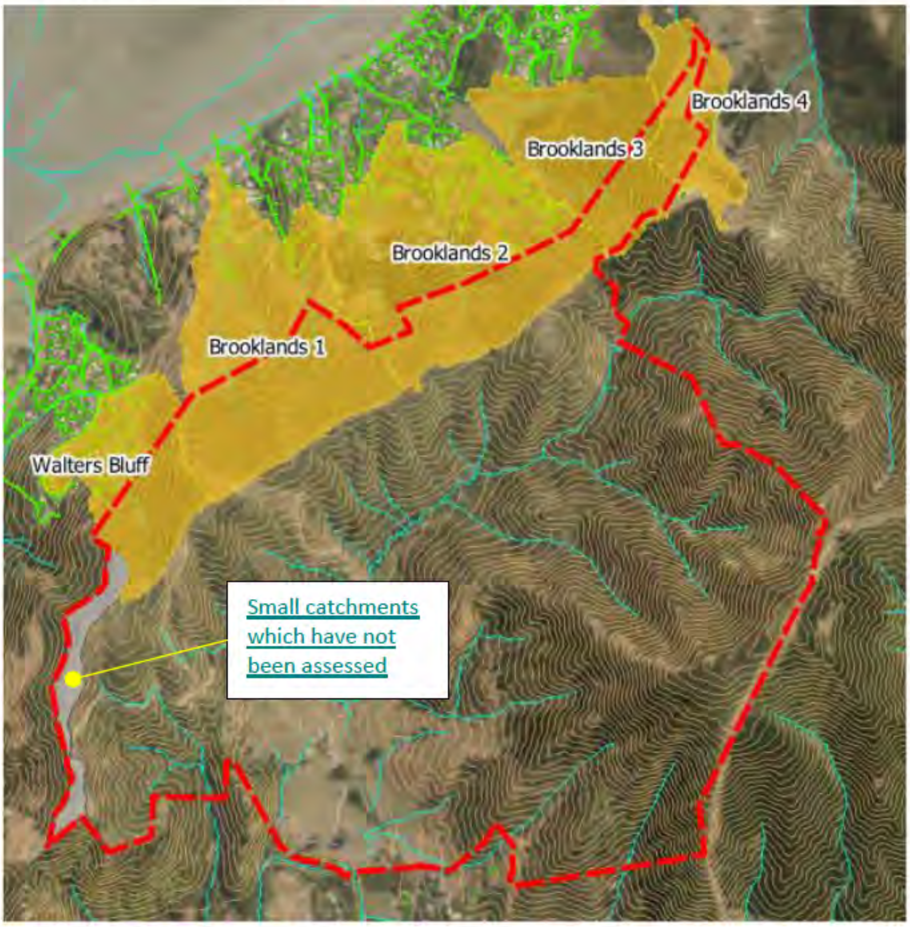


Figure 2.7: Walters Bluff/Brooklands Catchments, overland flow paths and downstream stormwater network

The SCS and Rational methods, as described in Section 2.5.5.2.1, were also used to determine the peak pre-development flows from the five sub-catchments in the Walters Bluff/Brooklands areas. These sub-catchments are shown in Figure 2. below.

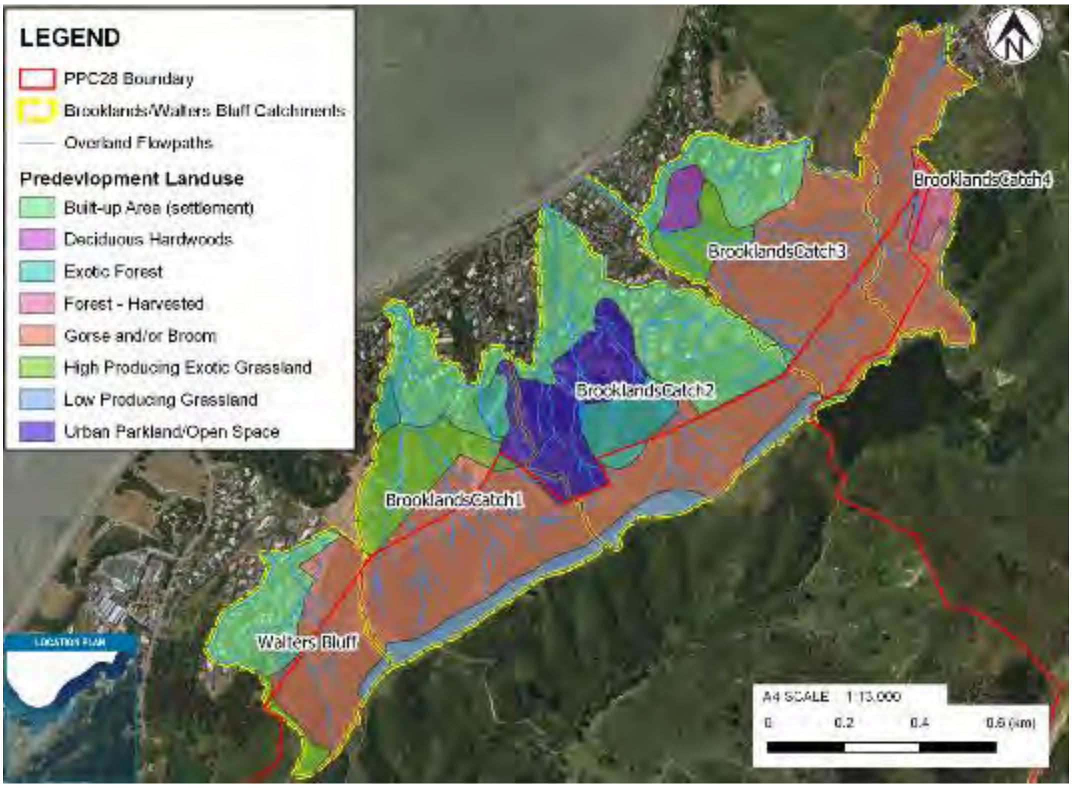


Figure 2.8: Walters Bluff/Brooklands sub-catchments and flow paths based on 2021 LiDAR data.

Table 2.4 below presents the results from the preliminary hydrological assessment for the existing catchment. The associated calculations are attached in Appendix B.

Table 2.4: Peak runoff estimates for Walters Bluff/Brooklands sub-catchments

Rainfall frequency	Climate	Pre-development peak flow (m^3/s)				
		Sub-catch 1	Sub-catch 2	Sub-catch 3	Sub-catch 4	Walters Bluff
10% AEP	2090 RCP8.5M rainfall	2.3 to 2.5	2.9 to 3.1	1.2	0.6 to 0.7	1.1 to 1.2
6.67% AEP		2.7 to 2.8	3.2 to 3.6	1.3 to 1.4	0.7 to 0.8	1.2 to 1.4
1% AEP		3.6 to 4.3	4.9 to 6.6	2.0 to 2.4	1.0 to 1.6	1.8 to 2.3

2.6 Biodiversity

T+T prepared an ecological opportunities and constraints assessment in March 2021, to support the PPC28 application.

The assessment concluded that most terrestrial habitats within the PPC28 area are highly degraded with an abundance of exotic plants and animal pests. The exception is an area of mature kānuka forest on the elevated eastern side of the PPC28 area, being the western face of Kākā Hill.

In terms of aquatic ecology, the lower reaches of Kākā Stream are intermittent and generally degraded. These have been impacted by historical and current agricultural land use practices. The upper Kākā Stream reaches have permanent flow with greater diversity and availability in aquatic habitat for freshwater fauna.

Specific initiatives to increase aquatic habitat values for native species identified within Kākā Stream, to reduce the abundance and influence of pests, and to increase the prevalence of indigenous flora and fauna are included in the ecological opportunities and constraints assessment and will be confirmed at the time of Resource Consent Application.

3 Regulatory and design contexts

The relevant planning and regulatory requirements for future stormwater management within the PPC28 area have been informed by the initial site appraisal are discussed in detail in the following sub-sections.

3.1 Regulatory objectives/policies and design guidelines

The stormwater aspects of the indicative Masterplan layout, the proposed structure plan zonings and PPC28 have been evaluated with consideration of objectives and policies within the NRMP, as well as the relevant design guidelines, as shown in Table 3.1.

Whilst it is noted that the NRMP is limited with regards to clear and definitive requirements, it clearly outlines the intent to manage stormwater in a manner consistent with community values, the Resource Management Act and the NPS-Freshwater Management.

The main design guideline for development with the Nelson and Tasman Regions is the NTLDM (2020). The NTLDM is intended to provide consistent minimum standards and guidance for network assets that Council will accept as part of its network.

Table 3.1: Regulatory and design requirements

Requirement	Relevant regulatory / design to follow	Comment/description
		NRMP objectives and policies
Water management	NRMP DO1.1.6	Make policy decisions on water management having regard to the provisions of resource management plans such as eel management and iwi environmental management plans that promote the sustainable use of water and associated resources.
Drainage, water and utilities	NRMP DO14.3.2	Subdivision and development should provide for: • The disposal of stormwater in a manner which maintains or enhances the quality of surface and ground water, and avoids inundation of any land, and
Water quantity (NPS – Freshwater Management 2014)	NRMP DO18.1.4	When considering an application for a discharge, the consent authority must have regard to the following matters: • The extent to which the change would adversely affect safeguarding the life supporting capacity of freshwater and of any associated ecosystem; and • The extent to which it is feasible and dependable that any adverse effect on the life supporting capacity of freshwater and of any associated ecosystem resulting from the change would be avoided.
Highest practicable water quality	NRMP DO19.1	All surface water bodies contain the highest practicable water quality
Effect of land use activities on surface water bodies	NRMP DO19.1.7	To control land use activities which have potential to adversely affect surface water quality and to encourage land use activities that minimise and filter contaminants entering water bodies.
Stormwater discharges	NRMP DO19.1.8	The level of contaminants in point source stormwater discharges to water bodies will be avoided or remedied.
New development	NRMP DO19.1.10	Maintain existing water quality by requiring use of techniques to limit both nonpoint discharges and control point source stormwater discharges caused by land disturbing activities such as forestry, subdivisions and land development, increased impervious surfaces, and commercial and industrial activities.
Water quality (NPS – Freshwater Management 2014)	NRMP DO19.1.12	When considering any application for a discharge, the consent authority must have regard to the following matters: • The extent to which the discharge would avoid contamination that will have an adverse effect on the life-supporting capacity of fresh water including on any ecosystem associated with fresh water; and • The extent to which it is feasible and dependable that any more than minor adverse effect on fresh water, and on any ecosystem associated with freshwater, resulting from the discharge would be avoided; and

Requirement	Relevant regulatory / design to follow	Comment/description
		• The extent to which the discharge would avoid contamination that will have an adverse effect on the health of people and communities as affected by their secondary contact with fresh water; and • The extent to which it is feasible and dependable that any more than minor adverse effect on the health of people and communities as affected by their secondary contact with freshwater resulting from the discharge would be avoided.
Integrated water management	NRMP DO20.1	A management approach that integrates the expertise of relevant statutory authorities and mana whenua iwi and other stakeholders in the community
NTLDM /Design Guidelines		
Stormwater Design	Chapter 5 - NTLDM 2020	This chapter outlines standards and good practice matters for the design and construction of stormwater systems for land development and subdivision in the Nelson and Tasman Districts. These aim to achieve flood management, environmental and amenity expectations in an effective and efficient matter.
Performance Outcomes	Section 5.1 - NTLDM 2020	The performance outcomes for the design and construction of stormwater systems sought by the standards and good practice matters in this document are as follows: • A management solution that is based on a holistic catchment-based assessment, including consideration of topography, soil and slope, vegetation, built development, existing drainage patterns, freshwater resources, stormwater network infrastructure, natural values and natural hazards; • An integrated design approach to stormwater management, which accommodates stormwater functions including access for maintenance and operations, as well as amenity, recreation and ecological values; • A network that manages stormwater flows to a standard that minimises people and property from harm or damage and nuisance effects, especially from risk to safety, health and well-being; • A management approach that aims to improve water quality; • Devices and design solutions that are robust, durable and easily maintained; • A whole-of-life operations, maintenance and replacement or renewal programme that is clearly described, costed, and can be afforded; • A stormwater system design that takes into account the foreseeable demands of future development; • A resilient network infrastructure that performs well against the risk of geotechnical, seismic, flood hazards and coastal hazards (erosion and inundation); • A design that maintains or improves values associated with freshwater resources, including riparian management and in-stream habitat values;

<table>
<tr><th>Requirement</th><th>Relevant regulatory / design to follow</th><th>Comment/description</th></tr>
<tr><td></td><td></td><td>• Stormwater assets that have high amenity value, and shared use of open-space areas where practicable and agreed to by Reserves and Facilities Manager;
• A network that maintains a high visual amenity that enhances the value of adjoining property and neighbourhood values as a whole.
Note all performance outcomes are also subject to the applicable Resource Management Plan objectives and policies and appropriate bylaws, which take precedence over the requirements of the Nelson Tasman Land Development Manual (NTLDM).</td></tr>
<tr><td>Application of principles of water sensitive design</td><td>GD04 (Auckland Council, 2015)</td><td>The NTLDM 2020 recommends further guidance on the implementation of WSD is available in the Auckland Council guideline document GD2015/004 (Water Sensitive Design for Stormwater)</td></tr>
<tr><td rowspan="3">Stormwater management devices design</td><td>GD01 (Auckland Council, 2017)</td><td rowspan="3">The NTLDM 2020 recommends that the design of WSD should be guided by the following documents
Stormwater management devices in the Auckland region. Auckland Council guideline document, GD2017/001 (GD01)
Hamilton City Council Three Waters Practice Notes: HCC01 to HCC07;
Nelson City Council/ Tasman District Council, Bioretention and wetland Practice Notes, version 1, June 2017.</td></tr>
<tr><td>Three Waters Practice Notes: HCC01 to HCC07 (Hamilton City Council);</td></tr>
<tr><td>Bioretention and Wetland Practice Notes (NCC/TDC, 2017).</td></tr>
</table>

3.2 Mana Whenua Matters

This Stormwater Management Plan has been prepared together with evidence and conferencing for the PPC28 application hearing. While this work has been undertaken on the basis that iwi is supportive of PPC28, further work is required as a part of the detailed design phase to ensure mana whenua values and the principles of Te Mana o te Wai are appropriately integrated into the design process.

As per the applicant's commitment, this will occur alongside the preparation of a Cultural Values Assessment with the recommendations in that assessment being part of the integrated design process. This next step will for a part of the lead up to, and preparation of, a resource consent application to subdivide and develop the site.

4 Proposed development

4.1 Proposed land use

PPC28 proposes to re-zone approximately 287 ha of land located within the from Rural and Rural-Higher Density Small Holdings Area to a mixture of: Residential (Higher, Standard and Lower Density Areas), Rural-Higher Density Small Holdings Area, Open Space Recreation, and Suburban Commercial.

A revised structure plan for the PPC28 area (Rough and Milne, July 2022) is shown in Figure 4.1 and attached in Appendix C

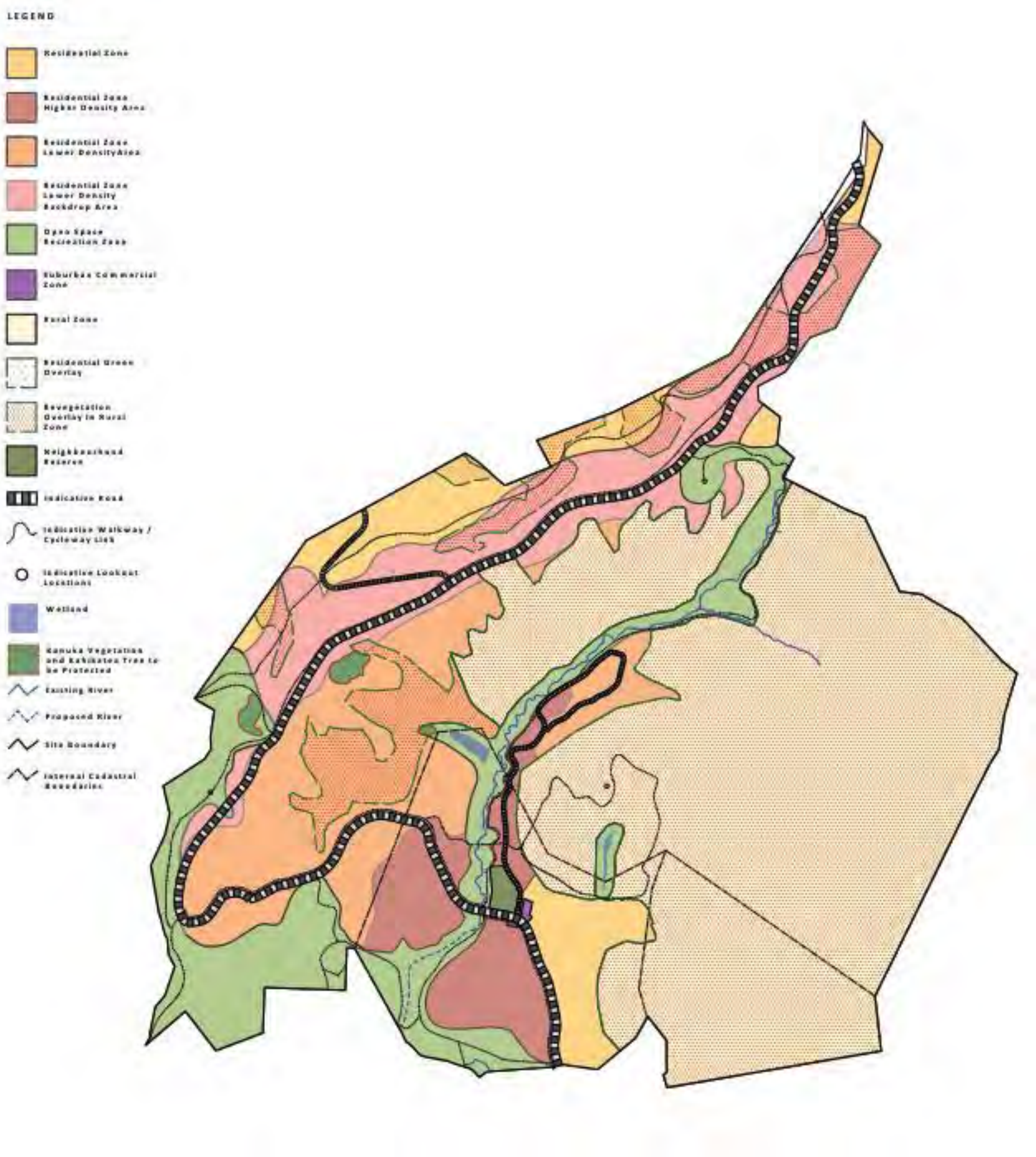


Figure 4.1: Proposed Structure Plan (Rough and Milne, July 2022)

4.2 Site layout

In addition to the revised Structure Plan, an indicative Masterplan has been produced. This was submitted as part of the Urban Design Rebuttal Evidence at the PPC28 hearing. While it is noted that this Indicative Masterplan is intended to outline one feasible development outcome based on the proposed planning provisions, it provides a clearer picture of the overall vision for the PPC28 area. It provides more detail around the proposed road layout and lot sizes for different areas as shown in Figure 4.2 and attached in Appendix C.

Figure 4.2: Indicative Masterplan (Rough and Milne and UrbanShift, July 2022)

4.3 Earthworks

The proposed subdivision layout within the PPC28 area, and the earthworks required to achieve the layout will be developed iteratively in conjunction with detailed geotechnical, environmental and hydrological investigations in advance of any resource consent application. At the plan change stage, this level of detail has not yet been determined.

The feasibility and extent of earthworks will be carefully evaluated with regard to the policies and rules of the NRMP

The methodology around how the earthworks will be managed will be covered through the regulatory process at future stages of the consenting process, with an intent to demonstrate best practice methods to limit the scale and extent of earthworks, manage construction phase impacts and protect/enhance infiltration where appropriate.

5 Stormwater management

This section presents the proposed approach to manage stormwater runoff from development within the PPC28 area. The approach has been identified with consideration of:

- Site-specific constraints and opportunities identified and presented in Section 2.
- Objectives and policies within the NRMP and the NTLDM, refer Table 3.1.

5.1 Principles of stormwater management

The overarching principle for stormwater management in the PPC28 area to achieve the outcomes sought in Section 1.3 is to implement an integrated stormwater management approach, which includes:

- Recognition of the key constraints and opportunities within the PPC28 area and receiving environments.
- Inter disciplinary design, which considers urban, transport, ecology and geotechnical design to develop efficient and effective stormwater solutions
- Approach to facilitate urban development whilst protecting and enhancing freshwater values.
- Developing a set of BPO's for future stormwater management for each specific catchment areas.

This shall be achieved through developing a water-sensitive design approach, as outlined in the NTLDM, that:

- Mitigates the impact of land use change from rural to urban.
- Protects and enhances existing and future stream systems and wetlands for indigenous flora and fauna.
- Connects the community and visitors with freshwater values
- Mitigates hydrological changes.
- Manages flooding effects.
- Eliminate where possible, and otherwise minimise the generation and discharge of contaminants/sediments into Maitahi/Mahitahi River and Nelson Haven.
- Facilitate urban development and protect key infrastructure, people and the environment from significant flooding events.
- Areas which are not to be developed, will be managed in ways to reduce catchment runoff and sediment yield.

5.2 Proposed stormwater management

The proposed approach, which addresses potential adverse effects on stream quality, streambank erosion and degradation of stream health, and increased flood risk, comprises:

- Eliminating where possible and otherwise minimising the generation of contaminants.
- Providing water quality treatment of first-flush runoff from contaminant generating impervious surfaces in the Kākā Stream, Walters Bluff and Brooklands Catchments.
- Providing water quantity management through attenuation to mimic natural frequent flow hydrology and channel forming flows in the Kākā Stream catchment.
- Optimise rainwater capture and re-use to mimic natural evapotranspiration and reduce the volume of water extracted from the Maitahi/Mahitahi River for non-potable uses.

- Designing public stormwater pipes (primary systems) to convey the 6.67% AEP storm flows, including climate change to 2090 (based on RCP8.5) and in accordance with the NTLDM.
- Designing overland flow paths (secondary systems) with sufficient capacity to convey safely the 1% AEP storm flows including climate change to 2090 (based on RCP8.5) and in accordance with the NTLDM.
- Protecting and enhancing existing natural wetlands and their connections to Kākā Stream
- Incorporating existing intermittent streams (and overland flow paths) as elements of future primary and secondary stormwater conveyance systems.
- Protection and improvement of Kākā Stream.
- Managing site development so the offsite flood effects are mitigated, by managing fill extents in the lower Kākā Stream Catchment and providing attenuation to limit post-development peak flows to pre-development levels in all catchments; and
- Ensuring infrastructure (roads, building platforms etc) is kept above the 1% AEP flood event for safety and to prevent water damage.

The requirements for stormwater management that will be adopted for the PPC28 area will exceed or meet the NTLDM stormwater section, as summarised in Table 5.1.

Details of the following aspects of the stormwater system will be addressed as part of subdivision design and land use consenting:

- Overland flow path layout;
- Location and specific use and design of proposed stormwater management device(s), including outfall location; and
- Primary stormwater conveyance network for 6.67% AEP flows.

5.3 Catchment Specific Approach

The proposed stormwater approaches will be tailored for their specific constraints and receiving environments. Therefore, a different treatment strategy will be adopted for discharge to the Kākā Stream compared to where there is a downstream piped stormwater network (Maitahi/Mahitahi River minor catchments and Walters Bluff/Brooklands Catchments)

The proposed catchment specific stormwater management approach is outlined below

5.3.1 Kākā Stream Catchment

The opportunity for improvement of ecological and hydrological function of the Kākā Stream and the community value that is placed on the Maitahi/Mahitahi River in the area around the confluence require that stormwater activities within this catchment need to be carried out using an integrated water sensitive design approach as discussed in Section 5.4 and 5.5.

5.3.2 Walters Bluff/Brooklands Catchments

Stormwater generated in the Walters Bluff/Brooklands Catchments, will discharge directly into the existing NCC stormwater network, where it will be combined with other urban runoff prior to discharge to the Nelson Haven. Given the extent of existing urban development within these catchments, and the characteristics of the existing runoff into the Nelson Haven, it is proposed that as a minimum, stormwater will be managed as per the NTLDM. Options to provide a water sensitive design approach beyond treatment of first-flush runoff from contaminant generating impervious surfaces will be considered in future stages of the design.

5.3.3 Maitahi/Mahitahi River minor catchments

The Maitahi/Mahitahi minor catchments discharge into the Maitahi/Mahitahi River via small streams and overland flow paths. Proposed stormwater management approach for these catchments will be similar to that proposed for the Kākā Stream Catchment.

Table 5.1: Regulatory and design requirements

Activity	Component	Minimum standards	Proposed approach	Reference
Residential lots/ Commercial buildings – Roof area	Water Quality	No requirements	Eliminate the use of high contaminant yielding building products and utilise rainwater tanks to eliminate wind blown contaminants.	NTLDM 5.4.11
	Hydrological mitigation	For impervious areas greater than 50 m^2 and a new and direct discharge point into a stream or open drain hydrological mitigation will be provided to store the equivalent detention volume (EDV) to a 50% AEP event with a two-hour duration, which is to be slowly release over24 hours	Within the Kākā Stream Catchment the following hydrological mitigation will be provided as follows • Residential rainwater tanks with reuse to provide internal and external non potable demands • Where possible (In accordance with site selection criteria defined in the NTLDM table 5-7), retention (removal via infiltration or onsite reuse) of at least 5 mm of runoff depth from all impervious surfaces will be provided • Detention (temporary storage) and a drain down period of 24 hours for equivalent detention volume (EDV) of a 50% AEP event with a two-hour duration minus any retention storage volume, over the impervious area using below options:	

Activity	Component	Minimum standards	Proposed approach	Reference
			o Dual detention/retention rainwater tanks o Underground detention tanks.	
Roads, Hardstand and driveways	Water Quality	Stormwater management of runoff from all impervious surfaces before discharging into the receiving environment.	Isolation of hazardous substances using Pre-treatment Devices including: • Grated catchpits and inlets • Gross Pollutant Traps	NTLDM 5.4.7
	Water Quality	The NTLDM requires stormwater treatment for all stormwater treatment that originates from 'high contaminant' areas – No 'high contaminant' areas, as defined by the NTLDM are proposed as part of PPC28.	Kākā Stream Catchment Additional water quality treatment (above the minimum requirement) is proposed for the Kākā Stream Catchment to reflect the specific constraints and recognise the receiving environment as outlined below: • Minimise the generation of contaminants through the use of inert building materials. • Where contaminants are generated, it is proposed to use green infrastructure to treat the first flush through the following SW devices: o Consolidated raingardens o Wetlands o Soakage	NTLDM 5.4.8 NTLDM 5.4.8.4 NTLDM 5.4.10 NTLDM 5.4.12

Activity	Component	Minimum standards	Proposed approach	Reference
	Infiltration	When within recharge zones (as classified by the NTLDM), a minimum of 5 mm of runoff from the newly created impervious surfaces shall be infiltrated within 24 hours to offset the loss of the initial abstraction of 5 mm of rainfall that uncompacted pre-development pervious areas have.	It is considered that the majority of the PPC28 area is not located within a groundwater recharge zone, but groundwater recharge zones will exist within residential zoned land that is not steeply inclined. The flat and gently inclined slopes within the existing flood plain area that are proposed to be filled will be suitable for engineered infiltration. This may be achieved through the following devices: • Bioretention systems with pervious bases • Lot scale infiltration through trench drains or soakage pits • Permeable pavement	NTLDM 5.4.10
Public spaces only, i.e. Roads, Carparking, HCGA Carriageway, Open Spaces and Riparian Margins	Stormwater conveyance	Convey runoff generated from the 6.67% AEP through a public piped stormwater network, allowing for climate change to tear 2090. Allowance for runoff flows greater than the 6.67% AEP up to the 1% AEP event should be made in overland flow paths. Existing overland flow paths should be protected. Note all runoff estimates are to account for future climate change scenarios as per NTLDM 5.4.6.2	Primary Conveyance: • Intermittent streams • Kerb and channel • Pipe network Secondary Conveyance: • Retain and enhance intermittent streams • Road corridor and public spaces	NTLDM section 5.4.6
Open Spaces and Riparian Margins	Stream hydrology and erosion protection	Enhance water quality, flows, stream channels and their margins and other freshwater values where the current condition is below the relevant thresholds.	• Green outfall (where practicable) • Riparian margin enhancement and planting, where necessary to mitigate identified adverse effects	NTLDM 5.4.9

Activity	Component	Minimum standards	Proposed approach	Reference
Development – hydraulic mitigation	Water Quantity	Provide detention so that post development peak flows shall not exceed pre-development peak flows for the 10% AEP (10-year ARI) and 1% AEP (100-year ARI) events as per the NTLDM. Note all runoff estimates are to account for future climate change scenarios as per NTLDM 5.4.6.2	The detention requirement is to be met through combined detention storage (i.e. servicing numerous houses and road hardstand areas) or detention directly at source (i.e. individual onsite stormwater detention tanks) The options for combined detention are outlined below • Online – this involves the potential restriction of higher flows within the Kākā Stream (or a major tributary) and attenuates both developed and undeveloped catchments within the site • Offline – this involves separating the runoff from the developed areas and providing restrictions for those flows only. Undeveloped catchments within the site will be left to drain as presently.	NTLDM 5.3.13
Mitigate adverse flooding effects within and outside the PPC28	Flood Management	Managing site development so that onsite and offsite flood effects are mitigated. This can be achieved by managing fill extents in the lower Kākā Stream Catchment and through providing attenuation and extended detention to limit post development peak flows to pre-development levels and mitigate the effects of increased duration of flows during rain events; and	All building platforms to be located outside of and set above the 2130 RCP8.5M 1% AEP Maitahi/Mahitahi Flood level, with a suitable allowance for freeboard as per NTLDM. Any earthworks within the lower flood plain shall be designed with appropriate flood mitigation to avoid adverse site and offsite effects and should be limited in extent so as to ensure that they do not cause	NTLDM 5.4.5

Activity	Component	Minimum standards	Proposed approach	Reference
			increases in flood depths in adjacent or downstream property (i.e. modelling should be carried out to assess final earthworks footprints, and demonstrate < 50 mm increase in flood depths within adjacent or downstream property).	
	Conveyance	Ensuring non-flood resilient above ground infrastructure (building platforms) is kept above the 1% AEP flood event for safety and to prevent water damage, unless specifically built with flood resilience.	All building platforms to be located outside of and set above the 1% AEP Flood level, with a suitable allowance for freeboard as per NTLDM. Where Infrastructure is required to be within the 1% AEP Flood extent, e.g. secondary flow paths, roadways, this infrastructure shall be designed to be flood resilient. For events greater than a 10% AEP storm event and up to a 1% AEP storm event, secondary flows will be conveyed along road corridors into existing overland flow paths. Ideally flow paths will be located within public areas (roads and parks) and not private properties. Enhancement of intermittent stream riparian margins, providing public amenity improved ecological value, and assisting flood management with capacity for secondary flows. Any secondary flows are required to be designed/managed to reduce the impact on private or public property. All flow paths will be provided with sufficient freeboard and alternative	

Activity	Component	Minimum standards	Proposed approach	Reference
			flow paths to allow for blockages at the top of development areas, to enable flows to pass from the upper undeveloped slopes through the urbanised areas to the main Kākā Stream corridor at the base. These flow paths will be formally identified and designated (when in private property). This could be a mix of road corridors (with consideration of risks related to depth and velocity) and interconnecting greenways.	

5.4 Water-sensitive design approach

Stormwater from the PPC28 area will discharge either:

- To the Kākā Stream and the Maitahi/Mahitahi River and ultimately to Nelson Haven, or
- For the Walters Bluff/Brooklands Catchment, directly or via Dodson Catchment to Nelson Haven.

Management of stormwater quality and quantity will be critical to protection of the existing Kākā Stream, Maitahi/Mahitahi River and other receiving downstream waterways. As a result, a water-sensitive design (WSD) approach has been adopted for the Kākā Stream Catchment within the PPC28.

Clause 5.4.8.6 of the NTLDM says *"Appropriate stormwater treatment shall be selected based on water-sensitive design principles and designed for on specific land use, associated contamination of concern and site constraints".* NTLDM references national best practice guidance documents which include Auckland Council GD2017/001 (GD01), Hamilton City Council HCC07 and NCC/TDC Bioretention and wetland practice note (2019) which identify roads as a key producer of non-point source pollution resulting from development.

The key water-sensitive design principles outlined in the Section 5.3.2.2 of the NTLDM and how they are proposed to be incorporated in the stormwater management approach are summarised in Table 5.2, and explained in further detail in the following sections.

Note areas outside the Kākā Stream catchment within PPC28, will at a minimum, be designed as per the requirements of the NTLDM, with consideration given to using a water sensitive design approach at future design stages.

Table 5.2: Water-sensitive design principles

Water-sensitive design principles	Application within the development
Protect and enhance the values and functions of natural ecosystems	It is noted that the main stem of the Kākā Stream is proposed to be protected via a designated linear riparian reserve extending along its full length. The width of this riparian reserve was initially defined with a minimum width (40 m) to follow the general stream alignment (i.e. does not vary for all meanders). This riparian reserve will create a natural green corridor and allow for colonisation and/or movement of flora and fauna across the landscape. Vegetated watercourse margins will also function to filter surface runoff from surrounding land.
Address stormwater effects as close to source as possible	Minimise the generation of contaminants from residential buildings through the use of inert building materials and rainwater capture/reuse. Where contaminants are generated (e.g. roads and car parks), green infrastructure will be provided to mimic natural physical, biological and chemical treatment processes prior to discharge to the natural environment.
Mimic natural systems and processes for stormwater management	The enhancement of natural hydrological features by restoring riparian margins with vegetation along stream banks.

Water-sensitive design principles	Application within the development
	Stormwater treatment devices and green infrastructure incorporating evapotranspiration, infiltration and attenuation where practicable.
Support inter-disciplinary planning and design where practicable	PPC28 Ecological Opportunities and Constraints Assessment Report (T+T, 2021) provided specialist Ecological input to development of the stormwater management approach. Preliminary Structure Plan Environmental Review report (Morphum, 2021) provided specialist WSD input to development of the stormwater management approach.
WSD principles shall be considered during the initial design and planning	By adopting the principles and objectives of this SWMP it is considered that WSD principles will be met throughout the design process.

5.5 Integrated stormwater design approach

An integrated design approach is proposed as part of the WSD process within the PPC28. This means the proposed stormwater system will be considered in parallel with the ecology, best practice urban design, and community values. This approach will be developed in more detail through the planning and design processes.

This integrated approach ensures that asset groups, community stakeholders, and operation and maintenance personnel are consulted as part of the stormwater design. Some key considerations are provided below:

- Potential to combine open spaces with stormwater management areas (e.g. attenuation/detention) to allow recreation and increase community value.
- Keep (non-flood resilient) infrastructure above the 1% AEP flood event for safety and to prevent water damage.
- Design stormwater features that provide for landscape amenity, natural character values, social interaction and education/interpretation as appropriate.
- Design stormwater management features to augment and/or buffer existing ecosystem functions and values.
- Promote biodiversity from wetland to upland environments.
- Include WSD responses to hard surfaces and structures such as car parking.
- Design vegetated treatment devices and restored watercourses so that they resist erosion and minimise maintenance requirements.
- Rehabilitate soils and increase regenerating vegetation within open spaces to enhance rainfall retention potential.
- Identify existing site values and functions, receiving environment values, and socio-cultural values.
- Identify areas (e.g. open space network, stream setbacks, areas of restoration) that will protect and enhance ecosystem health.

Key inputs for the integrated design approach are summarised below:

- PPC28 Ecological Opportunities and Constraints Assessment Report, prepared by T+T, March 2021 provided specialist Ecological input to development of the stormwater management approach.

- Preliminary Structure Plan Environmental Review" report prepared by Morphum, April 2021, provided specialist WSD input to development of the stormwater management approach.
- Rough & Milne (RMM) urban design/landscape drawings and indicative cross sections submitted as "Graphic Attachment" with RMM plan change hearing evidence.

5.6 Water quality

The proposed water quality management approach below seeks to achieve optimal stormwater management outcomes:

- Eliminate where possible, and otherwise minimise the generation and discharge of contaminants/sediments into Maitahi/Mahitahi River and Nelson Haven;
- A water-sensitive design approach, as outlined in the NTLDM, will be implemented in the Kākā Stream Catchment that:
  - mitigates the impact of land use change from rural to urban
  - protects and enhances stream systems
  - mitigates hydrological changes
  - manages flooding effects;
- Areas of PPC28 outside of the Kākā Stream Catchment will as a minimum, be managed as per NTLDM requirements, with consideration given to water sensitive design options at future design stages.
- A set of BPO for future stormwater management;
- Areas which are not to be developed, will be managed in ways to reduce catchment runoff and sediment yield.

These outcomes will be met through the adoption of approaches outlined below for the differing land uses. An appropriate level of water quality treatment will be applied for each land use application and anticipated contaminants in the context of the catchment constraints.

As the areas of PPC28 outside of the Kākā Stream Catchment will be managed as per NTLDM requirements, the proposed water quality approach outlined below is not applicable for these areas.

5.6.1 Residential buildings

Use of inert building materials to prevent generation of contaminant-laden runoff within residential lots, i.e. avoiding use of high contaminant yielding building products which have:

- Exposed surface(s) or surface coating of metallic zinc of any alloy containing greater than 10% zinc.
- Exposed surface(s) or surface coating of metallic copper or any alloy containing greater than 10% copper.
- Exposed treated timber surface(s) or any roof material with a copper-containing or zinc-containing algaecide.

5.6.2 Roads, carparks, hardstand, and driveways

Treating runoff from contaminant generating impervious areas (i.e. parking areas and roads regardless of traffic volumes) within the Kākā Stream Catchment, through methods such as:

- Install grated sumps and inlets to the stormwater network for capturing gross contaminants, solids, sediment, and gravels.

- Install catchpits in sumps and manholes to reduce sediment transport through the stormwater network.
- Include near-to-source devices such as consolidated rain gardens, constructed wetlands and permeable pavements. The suitability of these stormwater devices will be assessed on a case-by-case basis will be designed to support efficient maintenance and contribute to high amenity urban design.

5.6.3 Catchment approach

Stormwater sub-catchments will be managed with ‘traditional’ pipe networks as the primary drainage system to collect and convey excess flows from lots and runoff from roads.

Sub-catchment stormwater treatment in the Kākā Stream Catchment is to be via consolidated treatment devices to mitigate impacts prior to discharge to any natural waterway beyond the development boundary. Treatment devices will be sized to treat the first flush from contaminated generating surfaces and may include:

- Consolidated rain gardens designed with internal storage, and infiltration to shallow groundwater where feasible pending infiltration suitability assessment:
  - These can be integrated within the proposed Kākā Stream esplanade (where suitable) or in dispersed parklets which support community connection with water management and support amenity, urban ecology and education. These will be designed with careful consideration of lifecycle maintenance. Rain gardens will all be offline to full pipe flow with appropriately design bypass although flood attenuation can be accommodated above the operational water level as required.
- Consolidated constructed wetland designed to be integrated into green spaces and provide a high level of water quality treatment:
  - These will be integrated within the proposed Kākā Stream esplanade, in particular on the lower terrace alongside the re-aligned channel reach. High quality constructed wetlands will support community connection with water management and support amenity, urban ecology and education. Consideration will be given to options to harvest treated water from wetlands to augment irrigation of high amenity planted gardens, community gardens or irrigation of parks. These will be designed with careful consideration of lifecycle maintenance. These wetlands may be integrated with online detention devices
  - Constructed wetlands will all be offline to full pipe flow with appropriately design bypass although flood attenuation can be accommodated above the operational water level as required.
- Generally, provide fewer larger treatment devices, in favour of numerous smaller devices to reduce long term operational costs and enable design with amenity and human connection.

Where the stormwater is to discharge to a downstream piped network beyond the PPC28 boundary (i.e. the Brooklands Catchment), then stormwater will be managed as per the NTLDM requirements.

5.6.4 Receiving environment

The proposed stormwater options will be tailored for their specific constraints and receiving environments. Therefore, a different treatment strategy will be adopted for discharge to the Kākā Stream compared to a downstream piped stormwater network (Walters Bluff/Brooklands Catchments):

- Provide riparian margins that protect and enhance the Kākā Stream, and with the secondary benefit to stormwater management through the disconnection of impervious areas from the receiving environment
- Limiting sediment generation and controlling erosion effectively during earthworks and construction.

The above options are not an exhaustive list and mitigation options suitable for each specific location will be investigated in latter design stages to achieve the water quality management objectives.

5.7 Hydrological mitigation

The proposed rezoning of the site will result in an increase in impervious surfaces and changes to the hydrology of the existing catchment. Thus, there will be a decrease in evapotranspiration and infiltration and a resulting increase in runoff during the smaller but more frequent rainfall events. In addition, the increased hardstand areas will likely also affect the temperature and pH of the runoff compared to natural surface runoff.

This section considers the mitigation of these smaller but more frequent storm events to offset the effects of development. Smaller storm events can also strongly influence the geomorphology of receiving streams and therefore the effects on downstream erosion risk are considered in Section 5.5.2.

The hydrological mitigation measures identified below will be most effective during smaller events but will mitigate (to some extent) effects of increased runoff in all storm events. This mitigation is covered in the NTLDM Section 5.4.11 which requires extended detention to slow down flows from more frequent storm events.

The general approach to water quantity management for small storm events is to implement extended detention according to the following:

- Provide for the retention on site of a minimum of 5 mm of runoff from the newly created impervious surfaces (roofs and driveways) will be infiltrated, when located in an area suitable for infiltration, within 24 hours to offset the loss of the initial abstraction of 5 mm of rainfall in pre-development pervious areas.
- Provide rainwater capture and reuse for internal and external non potable demands (toilets and cold laundry) for all roof areas except where multi-unit developments prohibit.
- Where feasible and geotechnically sound, provide soakage/infiltration for runoff from driveways and parking
- Provide storage of the extended detention volume (EDV) that is the equivalent of a 50% AEP event with a two-hour duration, slowly release over 24-hours. Any volume that is retained within lot (via reuse or infiltration) may be subtracted from the extended detention volume.

Infiltration rates within the site have not been tested yet. This extended detention requirement is expected to be reduced via onsite measures on individual properties and managed within the proposed water quality devices (wetlands/rain gardens).

5.7.1 Spatial requirement

Water quality mitigation measures have been investigated in the Morphum Environmental Memorandum (Appendix D), to ensure there is sufficient area available within the development area to accommodate these. Generally, water quality treatment shall be provided prior to discharge to natural waterways by routing a proportion of stormwater runoff through a treatment device optimally located where flows can be conveyed by gravity. It is noted that modelling has provided recommendations for the required land area for both rain gardens and wetlands (i.e. treatment requirements duplicated). The final development design will include either one of the two devices or a combination in response to site conditions. Calculations supporting the estimation of site hardstand are shown in Table 5.3.

Table 5.3 shows the summary of sub-catchment land use, and the estimated footprint for an assumed development scenario to manage stormwater as estimated by Morphum (Appendix D). It is noted that the reported footprints in Table 5.3 have been updated since the issue of the original memo from Morphum. This is based on the overall site impervious areas which have changed since the latest Indicative Masterplan. Also, the rain gardens/wetlands footprints are for either of these options (i.e. not combined) and the distribution of these is expected to be split into more than one device per sub catchment. A combined stormwater management figure has been provided in Figures 1 and 2, Appendix A. Which shows an indicative treatment and attenuation layout.

The final selection of optimal treatment devices, layout and distribution will be developed in close co-ordination with urban designers, landscape architects, civil designers and geotechnical engineers. In the lower Kākā Stream restoration and enhancement area, there is a large area suitable for development as a wetland. This is expected to comprise a mix of dedicated stormwater treatment and naturalised wetland habitat designed to be visually integrated but hydraulically separate.

Table 5.3: Sub-catchment land use and estimated stormwater management footprint

Sub-catchment	Total Catchment Area (m²)	Impervious %	Sum of Impervious Area (m²)	Assumed roof area (m²)	Assumed Lot Hardstand (m²)	Managed Hardstand (m²)	Un-managed hardstand (m²)	Road impervious (m²)	Raingarden Area (m²)	Wetland Area (m²)
Kaka 1	2,030,115	8%	153,402	71,248	34,247	17,124	17,124	47,907	1,691	3,804
Kaka 2	343,082	21%	73,367	34,383	17,562	8,781	8,781	21,422	785	1,767
Kaka 3a	112,374	39%	44,311	25,044	11,197	5,598	5,598	8,070	355	800
Kaka 3b	59,857	29%	17,554	7,171	3,585	1,793	1,793	6,798	223	503
Bradford Park	155,175	29%	44,783	22,538	10,525	5,263	5,263	11,720	442	993

5.8 Water quantity

The proposed rezoning of the PPC28 area and development resulting in an increase in impervious surfaces will also increase the peak flow and volume of stormwater runoff.

The proposed water quantity management approach seeks to achieve the relevant stormwater management principles:

- Recognise the key constraints and opportunities within the PPC28 site and receiving environments;
- A water-sensitive design approach for the Kākā Stream Catchment, as outlined in the NTLDM, that:
  - mitigates the impact of land use change from rural to urban
  - mitigates hydrological changes
  - manages flooding effects;
- Facilitate urban development and protect key infrastructure, people and the environment from significant flooding events.
- Compliance with the NTLDM for areas of the PPC28 outside the Kākā Stream Catchment

These principles will be met through the adoption of approaches outlined below for the differing catchments.

5.8.1 Water quantity requirements

Section 5.4.13 of the NTLDM states that stormwater runoff shall be detained to mitigate the effects of any additional volume or increased peak discharge rate resulting from the development.

For a greenfields development resulting in additional impervious surfaces, where the downstream receiving network has insufficient capacity for the increased flow and/or where there are known downstream flood risks; attenuation shall be provided such that post-development peak flows do not exceed pre-development peak flows for events between the 10% AEP and the 1% AEP frequency.

To comply with this NTLDM requirement and the WSD water quantity approach, attenuation is proposed to attenuate post-development peak flows in both the Kākā Stream, minor Maitahi/Mahitahi catchments and Walters Bluff/Brooklands Catchments. This will be primarily achieved by the collection, storage and the controlled release of attenuated flows. The outlet is generally designed so that normal flows pass under normal conditions with attenuation only occurring during more infrequent and larger events.

The range of attenuation/detention options includes:

- Storage at source, i.e. individual onsite (private) stormwater detention tanks
- Online stream storage, involving restriction of higher flows within the Kākā Stream (or a major tributary/flow path) to attenuate runoff from both developed and undeveloped catchments within the site Online attenuation typically provides higher storage volumes compared to offline, as they can better utilise natural topography, but often have require more ecological and fish passage considerations
- Offline, involving separation of the runoff from the developed areas and providing attenuation for those flows only. Undeveloped catchments within the PPC28 area would be left to drain as presently.

While there is a general preference for offline storage; due to challenges with identifying suitable areas within the stream network, online storage is sometimes preferred, given the ability to utilise existing flood margins and integrate better with the natural landscape. Online storage can be achieved through carefully designed crossing points which support controlled attenuation in large events whilst retaining the natural (restored) steam and riparian margins.

In the sections below, a post-development peak flow assessment of the Kākā Stream, minor Maitahi/Mahitahi River Catchment and Walters Bluff/Brooklands Catchments is presented and compared to the pre-development peak flows calculated in Section 2.5.

The proposed flood management strategy identifies the use of both online and offline flood detention dams, and indicative pond sizes are presented. Any flood detention device would be required to meet the performance standards of the NTLDM and would be designed in accordance with the NZ Dam Safety Guidelines 2015 (or equivalent operative standards applicable at the time of design). This would include consideration of the potential impacts of a dam break.

Consideration of how these water quantity mitigation options interact with the flood flows with the Maitahi/Mahitahi River is discussed in Section 5.10 below and should be refined in later design stages. The analysis shows that by providing water quantity mitigation of the post-development flows within the Kākā Stream Catchment, the resulting hydrograph entering the Maitahi/Mahitahi River is delayed (i.e. by restricting flow and releasing in a controlled manner, water will arrive at the Maitahi/Mahitahi River slightly later than for the unmitigated option). For any future development stage, the timing of peak flows from the Kākā Stream Catchment should be assessed relative to the timing of elevated water levels in the Maitahi/Mahitahi River. If appropriate the designers could then consider a 'pass-forward' flows approach, or extension of the detention time (through use of additional storage) to mitigate any elevated flood risk associated with timing effects. The initial assessment indicates that the change in timing is small and insignificant in terms of Maitahi/Mahitahi River flows.

5.8.2 Water quantity modelling

Stormwater runoff from the proposed post-development land-use within the PPC28 area has been modelled using the SCS hydrological method to enable a comparison between the peak pre-development and post-development runoff and for preliminary sizing of attenuation devices.

5.8.2.1 Modelling parameters

The land use from within the developed PPC28 area has been characterised using both the latest Structure Plan and the Indicative Masterplan. For the developable areas, the various section sizes and roading layout from the Indicative Master Plan, as shown in Figure 5.1 below, were used to estimate the extent of impervious areas.

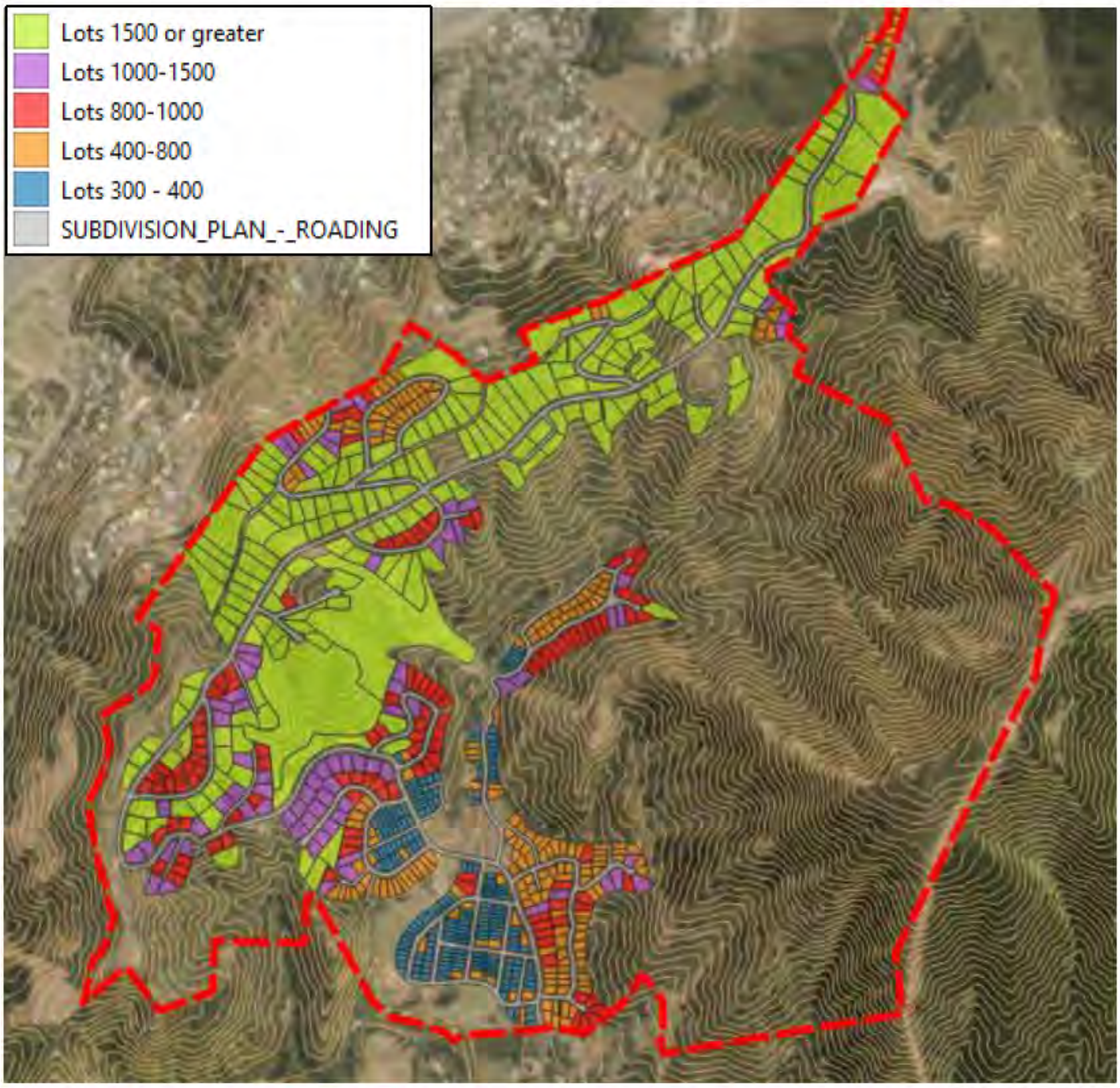


Figure 5.1: indicative masterplan lot layout

In order to estimate the amount of impervious surfacing in the PPC28, the below assumptions outlined in Table 5.4 and discussed below, have been used.

- For lots of up to 1,000 m² area, the site building coverage has been assumed based on the consent coverage for rule REr.23 of the Nelson Resource Plan and varies between 30% and 40 % depending on the assumed zoning. A blanket 20% site hard stand area (driveways, paved areas etc.) has been assumed for each of these lots.
- On the larger lot sections (i.e. 1,000 m² plus), basing the building area and site hardstand areas on a percentage of the overall lot area was not considered appropriate, therefore a conservative assumption of 450 m² building areas and between 150 m² and 200 m² hardstand was assumed.
- Roading areas were assumed to be 100% impervious.

The assumptions around the pervious areas of the site are summarised below

- For Lot areas up to 1,500 m², the areas not classified as impervious have been classified as '*Open Space (lawns, parks, golf courses, cemeteries, etc.)*' – good condition.
- Neighbourhood Reserve have also been classified as '*Open Space (lawns, parks, golf courses, cemeteries, etc.)*' – good condition.

- For lot areas in excess of 1,500 m², the areas not classified as impervious have been classified as '*Brush-weed-grass mixture with brush the major element'* – fair condition) to match the pre-developed landuse.
- Areas to be retained as Rural zone are to be maintained as per the pre-development modelling (this is generally '*Brush-weed-grass mixture with brush the major element'* – fair condition)
- Areas within the site zoned as 'Open Space Recreation Zone', which in part makes up the Kākā Stream riparian corridor has been classified as *Brush-weed-grass mixture with brush the major element'* and its condition improved from fair to good from the pre-development model to reflect additional planting proposed.

Table 5.4: Impervious area assessment assumptions

Lot sizes	Assumed planning category	Site Coverage percentage (building)	Site hardstand (driveway etc)	Assumed building area	Assumed site Hardstand	Site hardstand overall
300m² - 400m²	High density	40%	20%	-	-	180-240
400m² - 800m²	Standard density	40%	20%	-	-	240 - 480
800m² - 1,000m²	Lower Density	30%	20%	-	-	400-500
1,000m² - 1,500m²	Higher Density Small Holdings Area	-	-	450 m²	150 m²	600
1,500m² +	Lower Density Small Holdings Area	-	-	450 m²	200 m²	650

Based on the above assumptions the extent of imperviousness within PPC28 post development is summarised below in Table 5.5 and shows an overall impervious area of 45.6 ha, or 16% of the total PPC28 area. This compares to an expected predevelopment impervious area of less than 1%.

Table 5.5: PPC28 impervious areas

Developed areas	Sum of Area (ha)	Impervious areas	Sum of Impervious Area (ha)
Lot Areas - 300m² - 400m²	6.0	60%	3.6
Lot Areas - 400m² - 800m²	11.6	60%	6.9
Lot Areas - 800m² - 1,000m²	10.2	50%	5.1
Lot Areas - 1,000m² - 1,500m²	9.1	51%	4.7
Lot Areas - 1,500m² +	54.2	22%	12.0
Roading	13.3	100%	13.3
Undeveloped areas (Riparian corridor, Open Space Recreation etc.)	183.3	0%	0
Total	287.7	16%	45.6

The pre-development peak flows may also be analysed further to capture the 'permitted' land use within the currently rural zoned valley, i.e. the potential peak flows given the entire catchment was cleared of vegetation and used primarily as pasture, as is allowed under its rural zoning.

5.8.2.2 Kākā Stream Catchment

Based on the proposed future land uses outlined in Table 5.5, the impervious cover within the Kākā Stream Catchment is expected to increase, from less than 1% to approximately 11%

The post-development land use within the Kākā Stream Catchment has been modelled using the SCS hydrological method, with no detention/attenuation. The results have been compared to the pre-development SCS runoff assessment in Section 2.5.5.2.1 above, with detailed calculations included in Appendix B.

The same sub-catchments have been used, as the extent of fill and sub-catchment modification cannot be confirmed at this design stage, except for sub-catchment 3 which has been split to reflect a potential channel restoration and enhancement.

The post-development peak flow from the Kākā Stream Catchment increases as a result of the changes in land use. As a result, in order to comply with the requirements of NTLDM 5.4.13, attenuation of post-development peak flows will be required to mitigate adverse effects of flood flows in the Kākā Stream at the Maitahi/Mahitahi River confluence.

To demonstrate the feasibility of attenuation, a post-development option was developed within the PPC28 area to identify the likely location of attenuation devices. Conceptual water attention basins have been sited as indicated in Figure 1 and 2 Appendix A and assessed against the critical attenuation event (1 hour 1% AEP (2130 RCP8.5 rainfall)). There is a mixture of online and offline attenuation, with a major attenuation area located upstream of the proposed road crossing. The storage elevation curves for these basins have been derived from existing site contours. The post-development attenuated peak flows are shown in Table 5.6. Hydraulic performance during more events, including the required 10% AEP event, will be refined during detailed design, most likely incorporating a staged inlet/outlet structure.

Table 5.6: 1% AEP Attenuation requirements for Kākā Stream

	Pre-development peak flows (m^3/s)	Post-development peak flows (unmitigated) (m^3/s)	Difference (m^3/s)	Post-development peak flows (mitigated) (m^3/s)	Storage Required (m^3)
Kaka 1	25.4	26.1	0.7	25.4	7,500
Kaka 2	4.5	4.7	0.2	4.5	2,300
Kaka 3a	1.5	1.6	0.1	1.5	1,000
Kaka 3b	0.6	0.7	0.1	0.6	1,100
Kaka at Maitahi/Mahitahi Confluence	32.0	33.1	1.1	32.0	-

5.8.2.2.1 Timing of peaks

The assessment above demonstrates that the feasibility of detention devices to limit post-development flows to pre-development levels in the Kākā Catchment. Detention storage would also typically change the catchment runoff peak timing. Depending on the receiving environment (e.g. into the Maitahi/Mahitahi River) there is the potential to impact on downstream flood flows and levels. To assess this risk the HEC-HMS model was used to route post-development flows through the proposed detention devices.

As previously noted, NIWA's design 1-hour, 6-hour and 12-hour rainfall profiles were modelled using the pre-development catchment. The 6-hour event was assessed to be the critical storm duration, with the peak occurring in this design storm after four hours of rainfall. The location of the peak in any given 6-hour duration storm event will depend on the temporal rainfall pattern of that event and may differ from the design storm.

When the same design storm was modelled over the post-development catchment with the detention dams described above, the results show that the peak runoff at the confluence arrives about fourteen minutes later, as illustrated in Figure 5.1.

Given that the Maitahi/Mahitahi River is much larger than the Kākā Stream, this difference in timing will be negligible in terms of downstream effects (no observable increases in peak flows or flood levels/extents over the pre-development scenario).

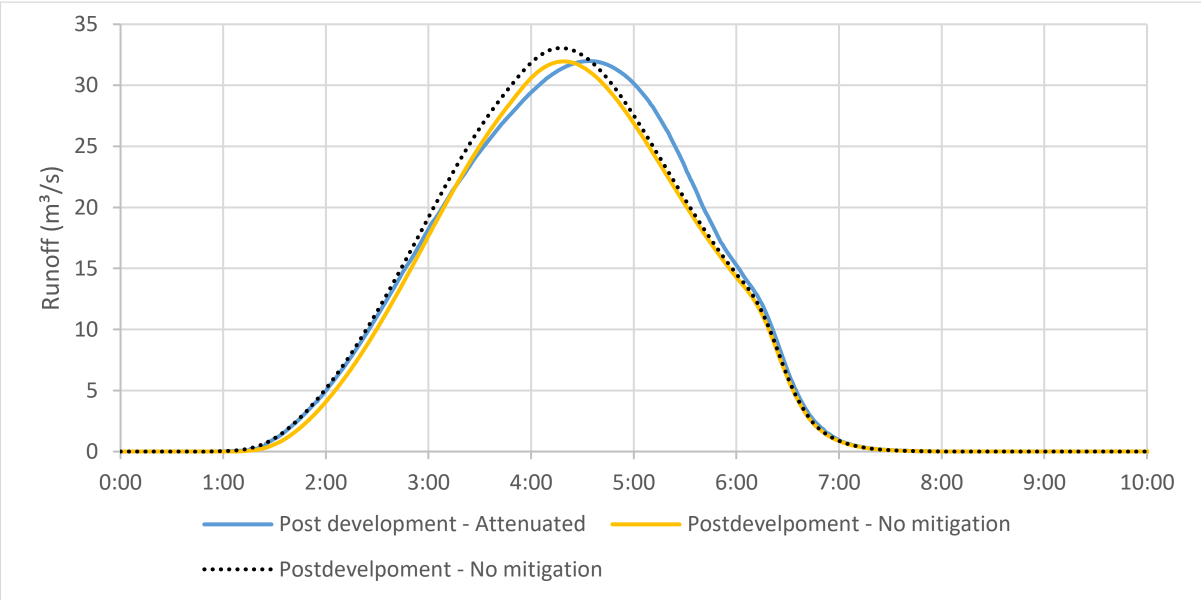


Figure 5.1: Difference in timing of modelled peak runoff from the Kākā Stream catchment, pre-development vs. post-development for the 2130 1% AEP 6-hour event (using NIWA's HIRDS v4 design storm).

5.8.2.3 Minor Maitahi/Mahitahi River catchment

As shown in Figure 2.6, the eastern of the two minor catchments that drain directly in the Maitahi/Mahitahi River, does not have any development or change of zoning proposed within its boundaries. As a result, there is not expected to be any change in flooding from this catchment.

The Branford Park catchment does have development on its upper slopes, as a result there is expected to be an increase in post-development runoff and detention required. As per Section 5.8.2.2.1, the unmitigated (no detention) runoff was estimated, as shown in Table 5.7, for this catchment and confirms that attenuation of post-development peak flows will be required to mitigate adverse effects of flood flows. As a result, a post-development runoff assessment with mitigation (detention) was developed, as shown in Table 5.7.

Table 5.7: Branford Park catchment 1% AEP peak flows

	Pre-development peak flows (m^3/s)	Post-development peak flows (unmitigated) (m^3/s)	Difference (m^3/s)	Post-development peak flows (mitigated) (m^3/s)	Storage Required (m^3)
Branford Park Catchment	4.3	4.6	0.3	4.3	2,100

5.8.2.4 Walters Bluff/Brooklands Catchment

Initial investigations indicate that there is no spare capacity downstream of the PPC28 area in the existing NCC stormwater network in the Walters Bluff/Brooklands Catchment. Therefore, post-development flows within the Walters Bluff/Brooklands Catchment are proposed to be managed so that any capacity issues are not exacerbated, as a result of the PPC28 land use changes. On this basis, the options for the management of water quantity include:

- The provision of detention devices to mitigate the effects of any additional volume or peak discharge that would otherwise result from the development. This will include combination of small detention devices close to source, on site detention devices such as rainwater tanks, previous paving, and bioretention devices such as planting strips, that store and release the stormwater. As a result, the flowrate from the PPC28 area will be limited to the pre-development flow rate.
- Upgrading of the existing piped network or providing a new piped system to convey runoff from the PPC28 area to a discharge point to the Nelson Haven on the northern side of Atawhai Drive.

Appropriate stormwater management options will be investigated in more detail as part of future Resource Consent and Subdivision applications.

The proposed post-development land use, with no attenuation, within the Walters Bluff/Brooklands has been modelled using the SCS hydrological method for the sub-catchments shown in Figure 2.8 and using the proposed land use classifications from Section 5.8.2.1. These have been compared to the pre-development SCS runoff assessment in Section 2.5.5.3 Detailed calculations are included in Appendix B.

Provisional attenuation options were developed to demonstrate that it is feasible within the development area to site the required attenuation devices. Refer to Figure 1 and 2 in Appendix A.

Table 5.8: Attenuation requirements for Walters Bluff/Brooklands sub-catchments

	Pre-development peak flows (m^3/s)	Post-development peak flows (unmitigated) (m^3/s)	Difference (m^3/s)	Post development peak flows (mitigated) (m^3/s)	Storage required (m^3)
Brooklands 1	4.3	4.6	0.3	4.3	2,600
Brooklands 2	4.8	4.9	0.1	4.8	1,500
Brooklands 3	2.1	2.2	0.1	2.1	900
Brooklands 4	1.2	1.3	0.1	1.2	100
Walters Bluff	1.9	2.0	0.1	1.9	1,100

5.8.3 Erosion risk management

Unless carefully managed, urbanisation can lead to adverse stream bank erosion effects due to the increased runoff rate and volume. Mitigation measures (such as extended detention, flood plain management, riparian planting or in-stream works) may be required to manage these when there are already bank erosion and stream stability issues in the downstream watercourses.

Erosion susceptibility is typically mitigated through retention of post-development stormwater flows. Retention requires a portion of flows to kept out of the stormwater network to reduce the risks associated with flash flows in regular small events, this is expected to be achieved via the hydrological mitigation methods, specifically extended detention, outlined in Section 5.7. In addition, the improvements to the riparian plantings are also expected to improve bank erosion vulnerability.

With the requirement to provide extended detention, as well as the proposed extent of riparian improvement, it is not expected that a detailed geomorphological assessment will be required to inform the erosion risk management.

5.8.4 Maitahi/Mahitahi bank erosion

The existing bank of the Maitahi/Mahitahi River has been noted as eroding the northern bank at the bottom end of the site. Figure 5.2 shows the movement of the Maitahi/Mahitahi River into the flood plain and beyond the original boundary since the 1940's. The river has retreated approximately 40 m to the north over this period, resulting in the loss of land within the PPC28 area and neighbouring land to the south-east.

It appears that over time, stopbanks have been constructed and planting established on the southern side of the river. This has reduced the flood storage capacity and constrained natural flood paths, thereby directing increased flow towards the PPC28 area and adjacent private land, contributing to the northern migration of the river and loss of land.

The Ecological Restoration Plan Report, Maitahi/Mahitahi River (Morphum, July 2020) commissioned by NCC recommended bank erosion mitigation, with a focus on creating riparian and wetland habitats. Recent works have removed willows on the southern side of the river as recommended in the report. It is understood that NCC has no programme in place to fully implement the report recommendations, which will be reconsidered in the light of PPC28 outcome.

1940 – 1959 Aerial | 1980 – 1989 Aerial | Present Day Aerial

Figure 5.2: Maitahi/Mahitahi historical river alignment (source topofthesouthmaps.co.nz)

5.9 Conveyance

The primary and secondary stormwater systems will convey stormwater through a suite of treatment devices to Kākā Stream, which in turn discharges runoff into the Maitahi/Mahitahi River. These drainage systems can consist of built assets (i.e. roadside channels, vegetated swales and piped networks) and natural systems (i.e. ephemeral, intermittent and permanent streams and open watercourses and overland flow paths). Stormwater systems will be designed in accordance with the NTLDM 2020.

Primary flows (i.e. runoff from storms up to a 6.67% AEP frequency) will be conveyed through a separate piped network within each sub-catchment, with open channel conveyance to be incorporated with landscaping, where feasible (site topography may mean that open channel flow is not appropriate due to erosion risk). The piped network will generally follow the road layout and will discharge into the attenuation/treatment devices prior to discharge into Kākā Stream.

Secondary flows (i.e. from storms greater than 6.67% AEP frequency and up to a 1% AEP frequency) will be conveyed along road carriageways, existing overland flow paths where they are maintained, or along dedicated overland flow channels to proposed attenuation devices.

5.9.1 Kākā Stream restoration and enhancement

It is proposed to restore and enhance the lower reach of the Kākā Stream (from near the existing woolshed) and construct a naturalised channel with capacity to convey the post-development 1% AEP event. This lower reach of the Kākā Stream is currently considered to be highly modified, currently comprised of a shallow channel interspersed with multiple other smaller intermittent drains and overland flow paths across the flood plain.

5.9.1.1 Integrated Approach

This restoration and enhancement will be further developed in the latter stages using an integrated design approach to ensure that this channel is resilient across the range of flow events up to the 1% AEP frequency, but with a viable ecological corridor from the Maitahi/Mahitahi River confluence to the upper Kākā Stream reaches. This will be integrated with the design of flood detention devices, backwater impacts from the Maitahi/Mahitahi River, and protection of any development in the lower terrace to be factored into hydraulic design assumptions. As part of the Landscape rebuttal evidence, cross sections showing an indicative future development and riparian improvement within the lower reaches of the Kāka Stream were submitted. This indicates the potential integrated approach that will be undertaken for the Kāka Stream, some indicative example sections are shown in Figure 5.4.

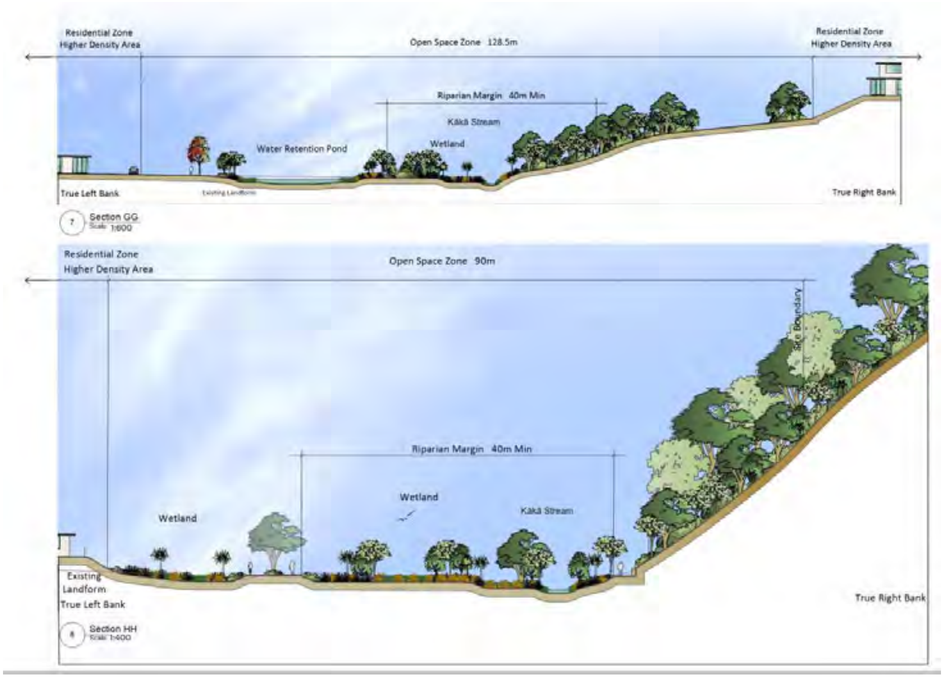


Figure 5.4: Example cross sections (Rough & Milne PPC28 CCKV Maitai Development Co LP and Bayview Nelson Ltd Rebuttal Evidence Graphic Attachment - 7 July 2022)

5.9.1.2 Flood conveyance

As the expected integrated approach to developing the restoration and enhancement is a collaborative and iterative process, in order to demonstrate the feasibility of conveyance within the proposed 40m riparian margin expected to a typical channel profile was developed. The purpose of this channel was to demonstrate that there is sufficient space to convey the post-development 1% AEP event. This profile has conservatively been based on the previous preliminary estimates of peak unmitigated flows for the Kākā Stream (which were based on the structure plan and therefore very conservative) at the point of discharge to the Maitahi/Mahitahi River (refer Section 5.6.2), as well as the mean annual flow reported in NIWA's online flooding tool (4.37 m³/s).

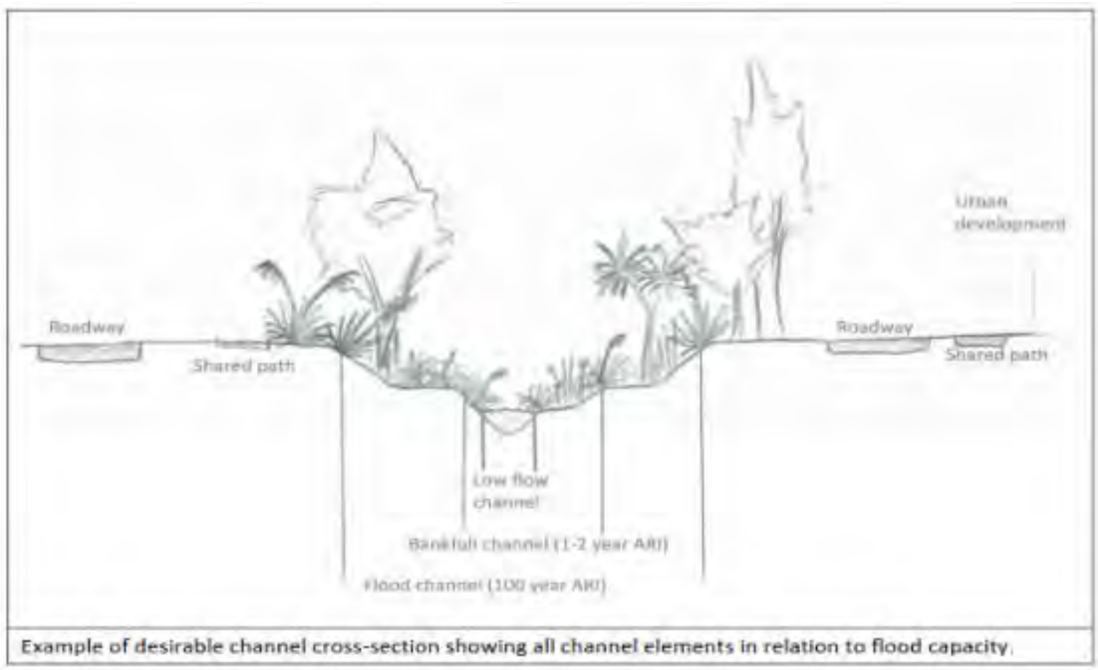


Figure 5.5: Conceptual restored channel profile

The indicative dimensions are shown in the below Figure 5.6.

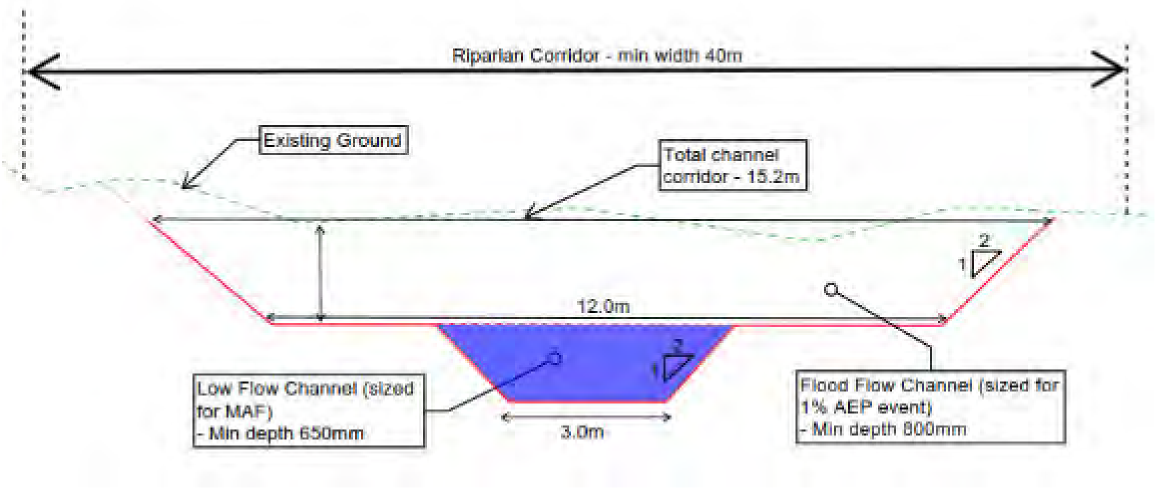


Figure 5.6: Indicative channel cross section

This channel cross section was modelled with an indicative flood plain fill extent to represent the comprehensive housing area to assess (with no mitigation measures applied) the ability to convey safely the proposed flow and assess changes in flood depth, velocity, frequency, and duration within the Kākā Stream. As shown in Figure 5.6, the revised channel does not overtop in the 1% AEP and 10% AEP 2130 RCP8.5M 6hr events. Note refinement of the transition from the Kākā Stream to the Maitahi/Mahitahi River has not been made and consideration of velocity effects at Dennes Hole and potential outlet will be considered at a later design stage.

5.10 Flood management

The proposed development has the potential to affect existing flood hazard in various ways, including:

- A net reduction in perviousness across the catchment leading to increased runoff (higher flows during rainfall events that could cause increased flooding within and downstream of the PPC28 area);
- Loss of flood storage within the flood plain due to earthworks encroachment (particularly in the Maitahi/Mahitahi River flood plain, where a fill platform is proposed);
- Changes to overland flow paths resulting from building platforms and new road alignments;
- Concentration of fewer overland flow paths;
- Possible coincident timing of peak flood flows.

This section sets out flood approaches that are proposed to mitigate these potential effects.

The proposed flood management approach is based on relevant stormwater management principles:

- A water-sensitive design approach, as outlined in the NTLDM, that manages flooding effects
- Facilitate urban development and protection of key infrastructure, people and the environment from significant flooding events.

5.10.1 Filling within the Maitahi/Mahitahi River flood plain

The applicant proposes filling within the Maitahi/Mahitahi River flood plain within the PPC28 area, and restoration and enhancement of the Kākā Stream. The loss of flood plain storage could displace and redirect floodwaters during an extreme event, causing adverse flooding effects on adjacent and/or downstream property.

As reported elsewhere the NCC Maitahi/Mahitahi River flood model has been used to assess the effects of proposed filling within the flood plain. This modelling assumes fill-only (i.e. no cut for offset flood storage) and a vertical fill wall. The fill would be graded down to natural ground at its boundary. This was described in detail in *Additional flood hazard information - PC28 letter*, prepared by T+T May 2022.

The design has been further developed, and the proposed earthworks footprint revised for modelling purposes. The 2130 RCP8.5M 1% AEP 12 hour event was modelled for a potential earthworks scenario, and results compared to the pre-development scenario. This has shown that the flood plain can be filled in such a way that any off-site effects are negligible, i.e. within model tolerance levels (less than 0.05 m), as shown in Figure 5.7.

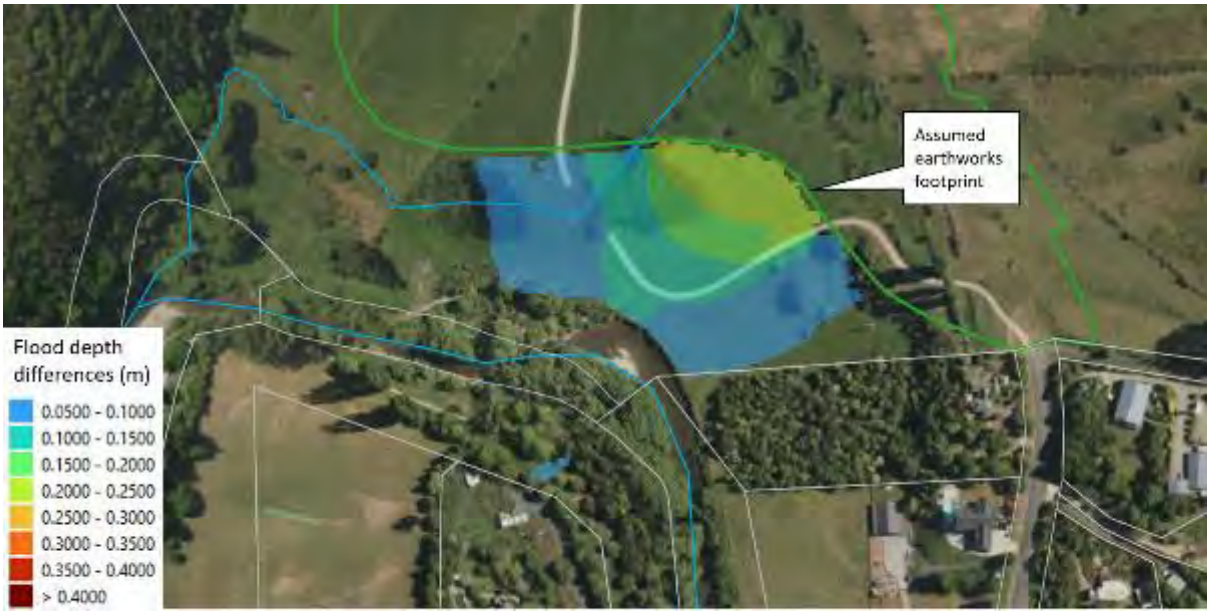


Figure 5.7: Extent of local ***increase*** *in flood depths as a result of proposed filling (2130 RCP8.5M 1% AEP 12hr event).*

For completeness, a range of present-day and 2130 storm events have also been analysed. The modelling shows that there are no adverse off-site effects for the full range of modelled events.

The TUFLOW direct rainfall model was also used to clarify flooding in the post-development scenario. The model is based on:

- The revised earthworks footprint
- Restored and enhance Kākā Stream watercourse (refer Section 5.9.1 below for restoration and enhancement details);
- Runoff from the modified post-development catchment (assuming NO attenuation – in reality, these flows would be routed through attenuation devices).

The 2130 RCP8.5M 10% and 1% AEP storm events were run through the model. Modelled depths are presented in Figure 5.8 below. This shows the containment of Kākā Stream flood flows within a restored and enhance stream channel, and the impact of a proposed earthworks on the existing floodplain extents. The modelled effects on adjacent and downstream property are less than 50 mm in terms of depth differences, and therefore the modelling demonstrates that a feasible option exists for mitigating the potential effects on flooding of development within the PPC28 area.

Figure 5.8: Modelled post-development scenario, including restored and enhanced Kākā Stream, proposed flood plain earthworks as per green polygon, and unattenuated post-development flows from developed catchment (2130 RCP8.5M 1% AEP 6hr event in blue, 10% AEP event in purple).

5.10.2 Other flood effects mitigation measures

To ensure that there are no other adverse flooding effects within and outside the development, the following mitigation options are recommended to manage flood risk:

- All building platforms to be located outside of and set above the 2130 RCP8.5M 1% AEP Maitahi/Mahitahi flood level, with allowance for freeboard as required by the NTLDM.
- Infrastructure to be located outside the 2130 RCP8.5M 1% AEP Maitahi/Mahitahi Flood level, unless designed to be flood resilient.
- For events greater than a 10% AEP storm event and up to a 1% AEP storm event, secondary flows will be conveyed along road corridors into existing overland flow paths. Ideally flow paths will be located within public areas (roads and parks) and not private properties.
- Enhancement of intermittent stream riparian margins, providing public amenity, improved ecological value, and assisting flood management with capacity for secondary flows.
- Secondary flows to be designed/managed to reduce the impact on private or public property. All flow paths will be provided with sufficient freeboard and alternative flow paths in case of blockages at the top of development areas, to convey runoff from the upper undeveloped slopes through the urbanised areas to the main Kākā Stream corridor downstream. These flow paths will be formally identified and designated (when in private property). This could be a mix of road corridors (with consideration of risks related to depth and velocity) and interconnecting greenways.

5.11 Risks

Table 5.9 presents the identified risks to the proposed stormwater management within the development and addresses how these risks might be mitigated or managed. It is expected that this list will be further populated as more risks are identified.

Table 5.9: Risk Register

What is the risk to the proposed stormwater management?	How can this be mitigated / managed?	When does this risk need to be addressed?	What is the resultant level of risk?
Detention requirements for the full PPC28 area cannot be achieved/is not economically viable	Through the resource/subdivision consent process Reduced site development	At the resource/subdivision consent process	The site will not get resource/subdivision consent for the full development
Water quality measures for the full PPC28 area cannot be achieved/is not economically viable	Through the resource/subdivision consent process Reduced site development	At the resource/subdivision consent process	The site will not get resource/subdivision consent for the full development
Conveyance of stormwater from the Walters Bluff/ Brooklands catchment to the Nelson Haven cannot be achieved/is not economically viable	Through the resource/subdivision consent process. Reduced site development	At the resource/subdivision consent process	The site will not get resource/subdivision consent for the full development
Further refinement of the proposed earthworks footprint in the Maitahi/Mahitahi flood plain could result in off-site flood effects.	Through the resource/subdivision consent process. Reduced site development	At the resource/subdivision consent process	The site will not get resource/subdivision consent for the full development

5.12 Implementation of stormwater network

To be addressed at Resource consent stage

6 Conclusions

The initial assessment indicates no fundamental stormwater management issues related to the future development of the PPC28 area and demonstrates that there are feasible options, using the nominated stormwater management approaches, to meet the stormwater objectives

The proposed approach is based on conventional stormwater management techniques to meet NTLDM provisions, and to integrate with existing and future stormwater provisions in the Kākā Stream, Walters Bluff and Brooklands Catchments and provides appropriate assessment criteria on which future subdivision proposal can be evaluated against.

7 Applicability

This report has been prepared for the exclusive use of our client CCKV Maitahi Dev Co Lp and Bayview Nelson Ltd, with respect to the particular brief given to us and it may not be relied upon in other contexts or for any other purpose, or by any person other than our client, without our prior written agreement.

We understand and agree that this report will be used by Nelson City Council in undertaking its regulatory functions in connection with Private Plan Change 28.

Tonkin & Taylor Ltd

Report (Stormwater section) prepared by:

....

Maurice Mills

Senior Civil Engineer

Report (Flooding section) prepared by:

....

Damian Velluppillai

Senior Water Resources Engineer

Reviewed and Authorised for Tonkin & Taylor Ltd by:

....

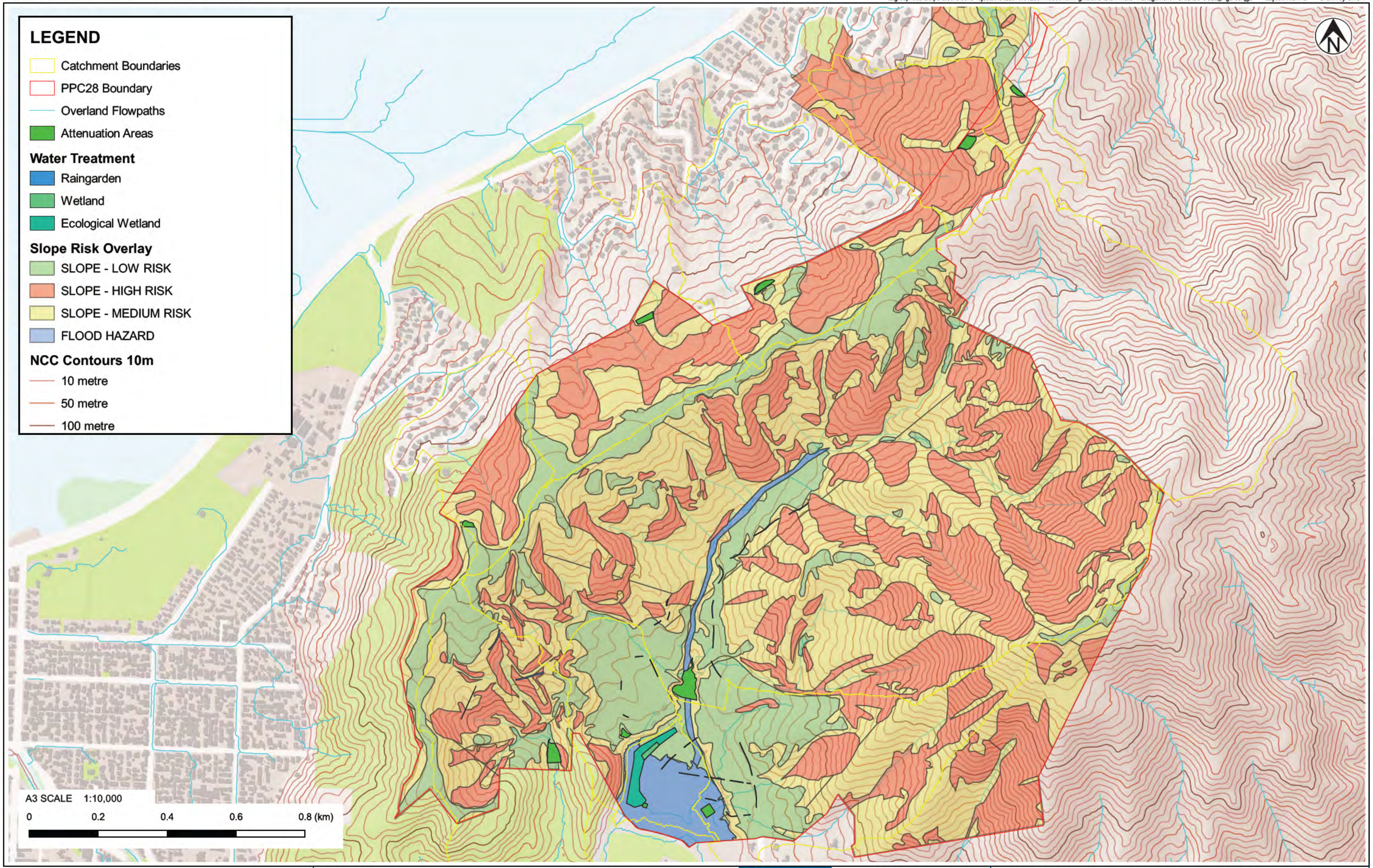
Mark Foley

Project Director

bymu, chgr, mgm, dnv
p:\1012397\1012397.1000\issueddocuments\plan hearing\smp\20220803.sw management report v6.post hearing update with updated master plan.docx

Appendix A: Figures

\\ttgroup. oca \corporate\Ne son\Projects\1012397\1012397.1000\WorkingMateria \Stormwater Management P an\GIS\PCC28_Figures.qgz Layout: Risk A3 Drawn by CHGR



Tonkin+Taylor

Exceptional thinking together www.tonkintaylor.co.nz

NOTES:

Indicative areas only. Stormwater attenuation locations subject to confirmation during the consent process.

REV	DESCRIPTION	GIS	CHK	DATE
0	First version	CHGR	YYYY	10/09/20

LOCATION PLAN

PROJECT No.		
DESIGNED	CHGR	AUG.22
DRAWN	CHGR	AUG.22
CHECKED		
APPROVED		DATE

CLIENT CCKL Mahitahi Dev Co LP & Bayview Nelson Ltd

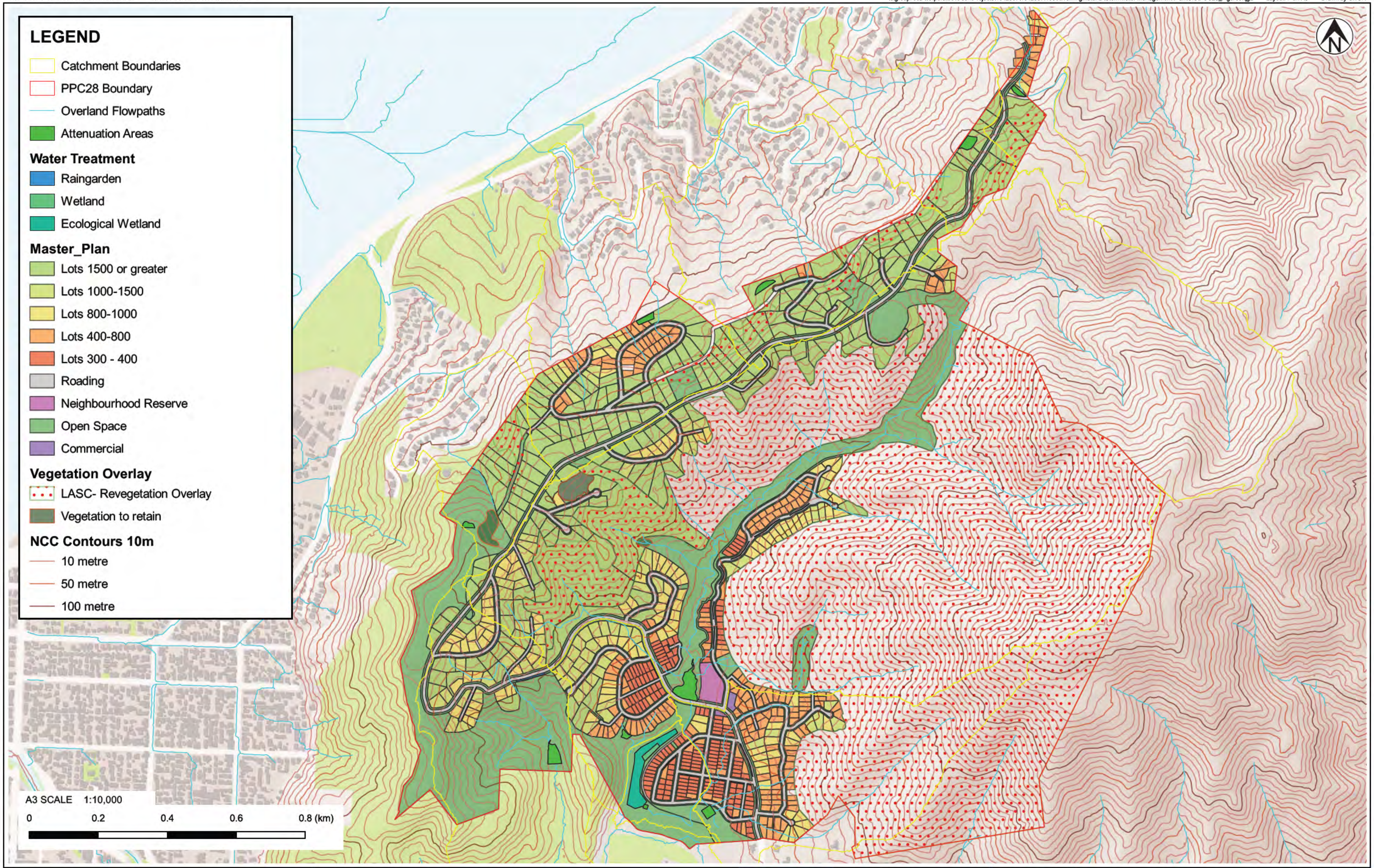
PROJECT PRIVATE PLAN CHANGE 38 - STORMWATER MANAGEMENT REPORT

TITLE STORMWATER ATTENUATION AND TREATMENT INDICATIVE AREAS: SLOPE RISK

SCALE (A3) 1:10,000 **FIG No.** FIGURE 1. **REV** 0

COPYRIGHT ON THIS FIGURE IS RESERVED DO NOT SCALE FROM THIS FIGURE

\\ttgroup. oca \corporate\Ne son\Projects\1012397\1012397.1000\WorkingMateria \Stormwater Management P an\GIS\PCC28_Figures.qgz Layout: P an A3 Drawn by CHGR



Tonkin+Taylor

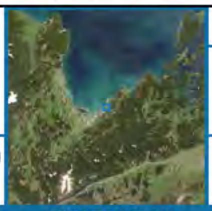
Exceptional thinking together www.tonkintaylor.co.nz

NOTES:

Indicative areas only. Stormwater attenuation locations subject to confirmation during the consent process.

AERIAL PHOTOGRAPHY, CONTOURS AND SERVICES SOURCED FROM TOP OF THE SOUTH MAPS [www.topofthesouthmaps.co.nz]. LICENSED UNDER A CREATIVE COMMONS ATTRIBUTION 4.0 INTERNATIONAL LICENSE.

REV	DESCRIPTION	GIS	CHK	DATE
0	First version	CHGR	YYYY	10/09/20



LOCATION PLAN

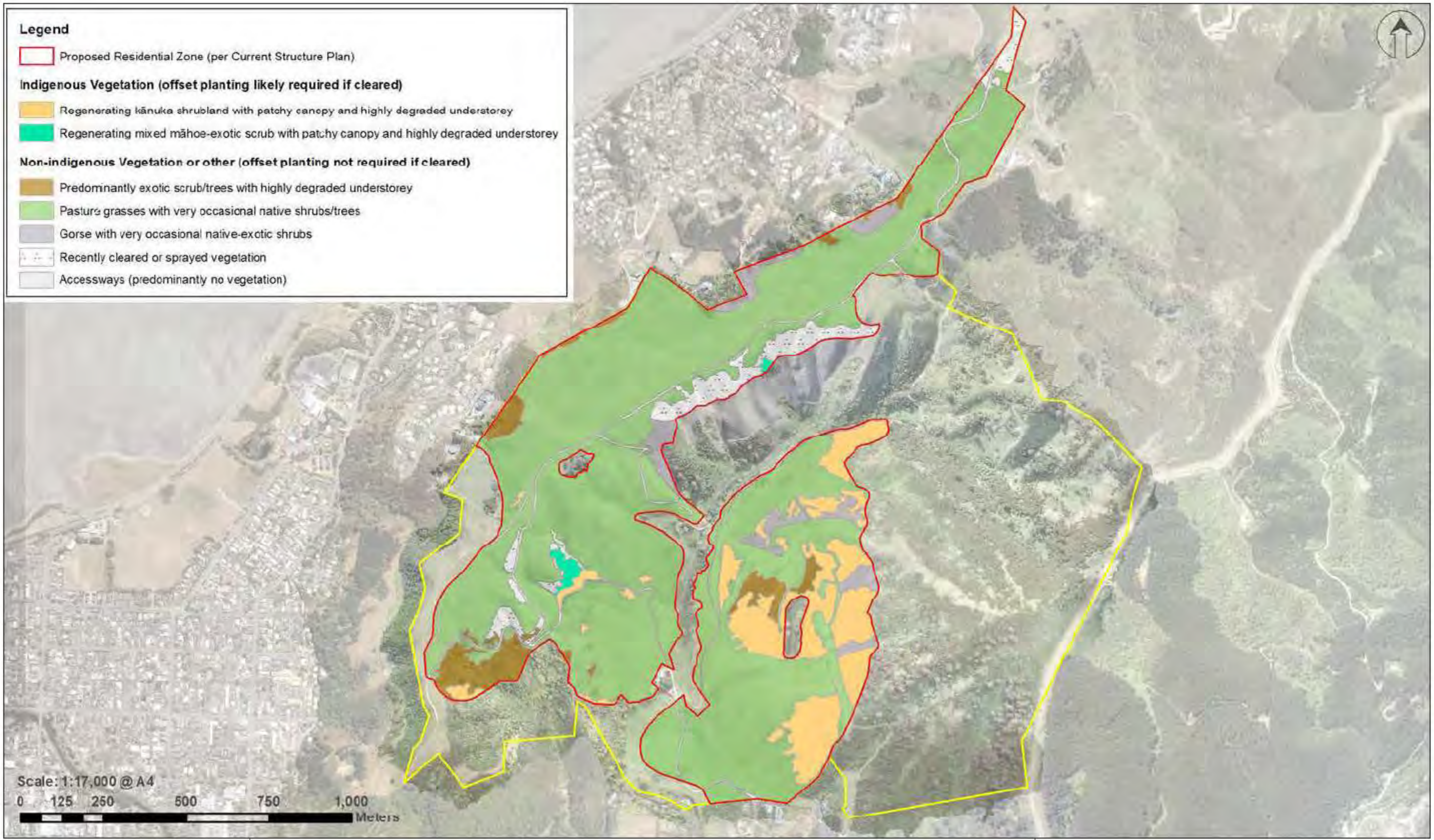
PROJECT No.		
DESIGNED	CHGR	AUG.22
DRAWN	CHGR	AUG.22
CHECKED		
APPROVED		DATE

CLIENT CCKL Mahitahi Dev Co LP & Bayview Nelson Ltd

PROJECT PRIVATE PLAN CHANGE 38 - STORMWATER MANAGEMENT REPORT

TITLE STORMWATER ATTENUATION AND TREATMENT INDICATIVE AREAS: MASTER PLAN

SCALE (A3) 1:10,000 **FIG No.** FIGURE 2. **REV** 0



expert ecological services.

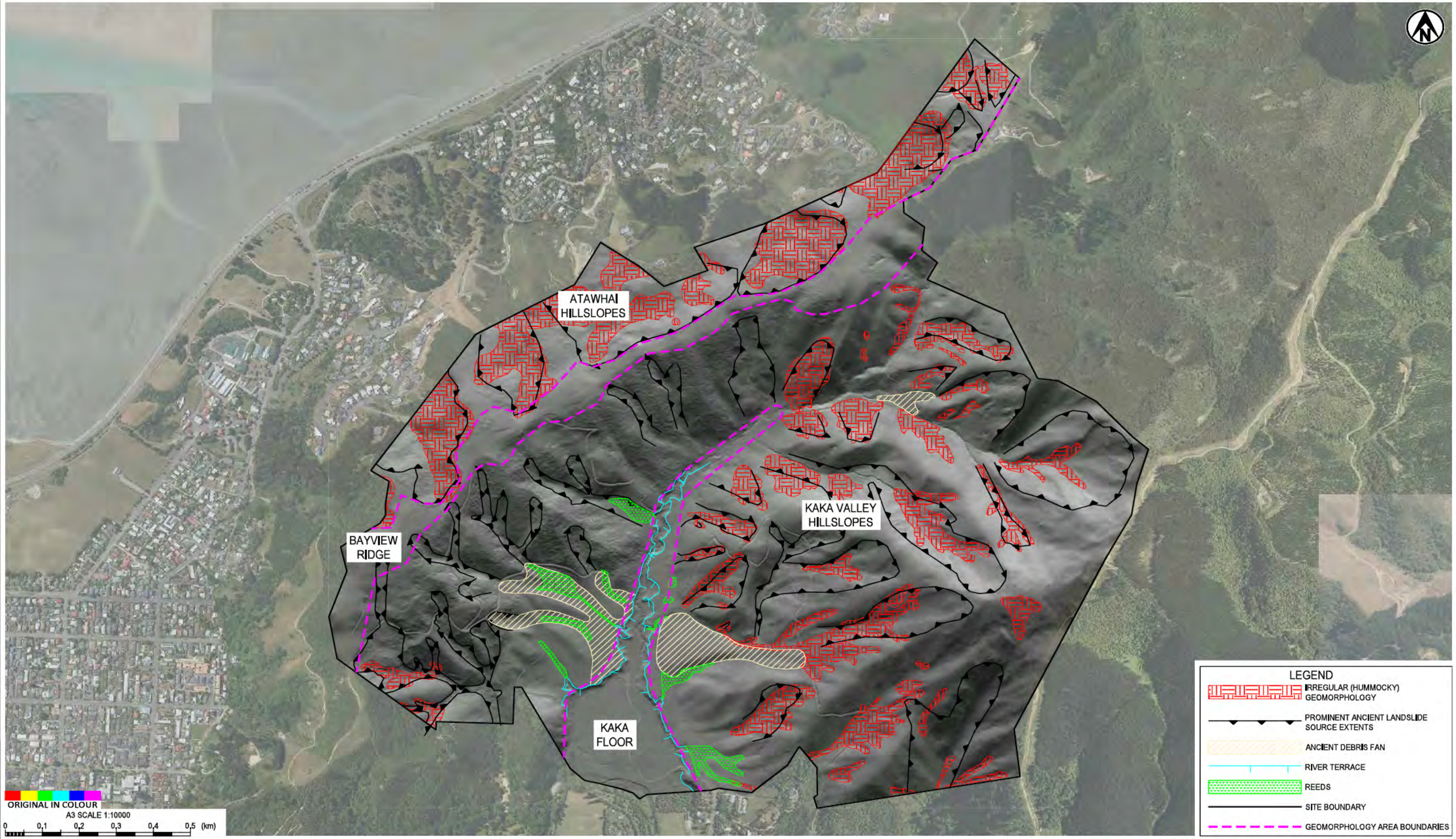
Figure 4.2. Broad scale (indicative) map of existing habitats within the proposed residential zone / study area based on the mapping of vegetation features visible in high resolution aerial imagery flown 28-29 April 2022, supported by ground-truthing to validate the visible features.

PROJECT: PRIVATE PLAN CHANGE 28 - MAITAHI BAYVIEW

Existing Terrestrial Habitat Occupying Survey Area

| Date: 3 May 2022 | Revision: A | Aerial: UAV April 2022
Habitat map prepared by Robertson Environmental Limited

Project Manager: Ben.Robertson@robertsonenviro.co.nz



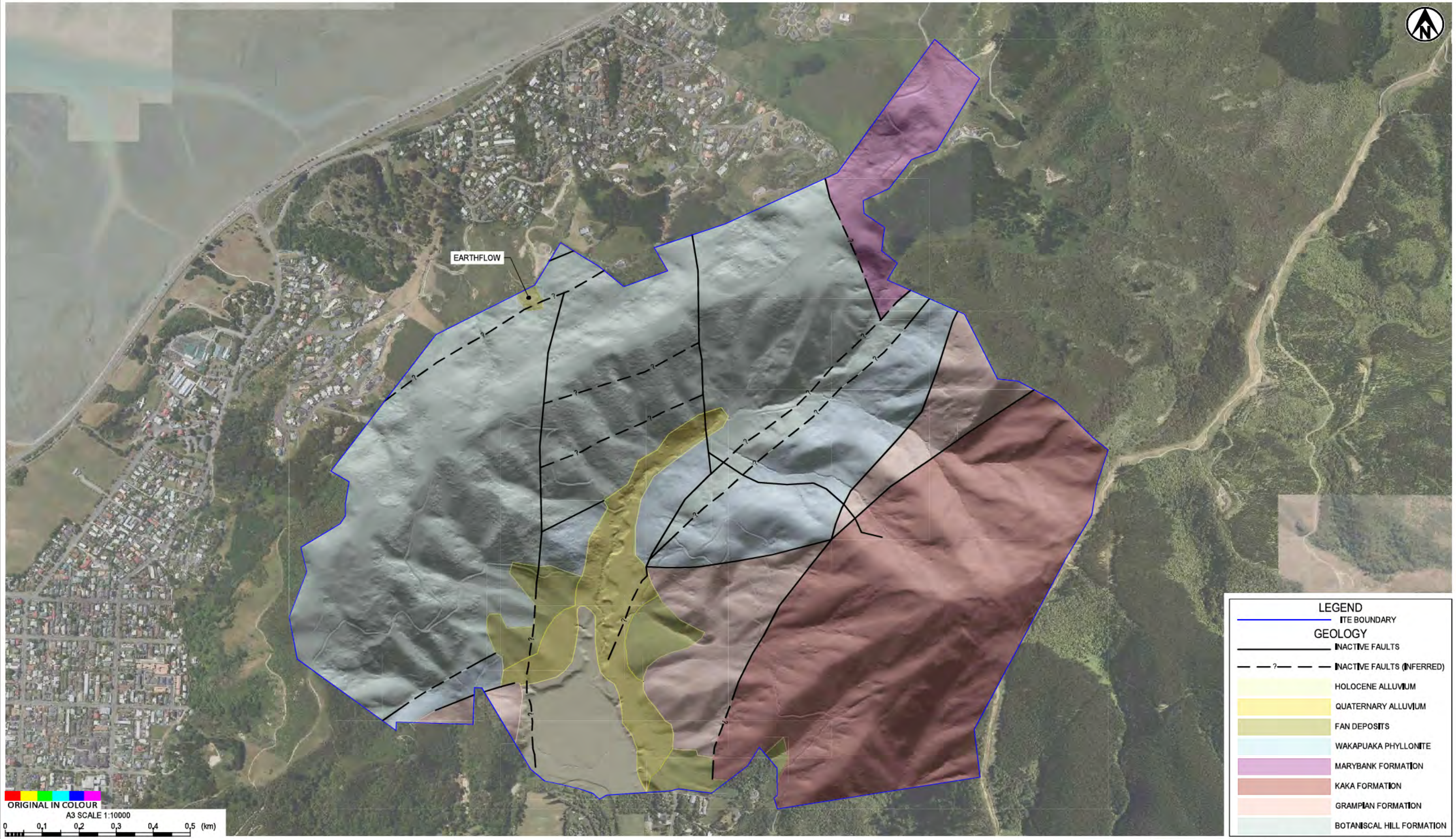
Tonkin+Taylor
Exceptional thinking together www.tonkintaylor.co.nz

NOTES:
1. AERIAL SOURCED FORM TOP OF THE SOUTH MAPS <https://www.topofthesouthmaps.co.nz/app/> AND LICENSED FOR RE-USE UNDER THE CREATIVE COMMONS ATTRIBUTION 4. INTERNATIONAL LICENSE .

PROJECT No.	1012397	
DESIGNED	MRF	Mar.21
DRAWN	DFL	Mar.21
CHECKED	DJA	Mar.21
MARK FOLEY	31/03/2021	
APPROVED	DATE	

CLIENT CCKV MAITAI DEV CO LP AND BAYVIEW NELSON LI ITED
PROJECT PRIVATE PLAN CHANGE REQUEST
ITLE GEOMORPHOLOGY PLAN
SCALE (A3) 1:10,000 FIG No. 1012397-F2 REV 2

P:\1012397\WorkingMaterial\CAD\FIG\1012397-F3.dwg 2021-Mar-31 5:35:25 pm Plotted By: DANIEL FOLEY-LOGAN



NOTES:

1. AERIAL SOURCED FORM TOP OF THE SOUTH MAPS <https://www.topofthesouthmaps.co.nz/app/> AND LICENSED FOR RE-USE UNDER THE CREATIVE COMMONS ATTRIBUTION 4. INTERNATIONAL LICENSE .
. GEOLOGICAL SOURCE MAP JOHNSTON, M. , 1981 GEOLOGICAL MAP OF NEW ZEALAND 1:50,000, SHEET 027 AS DUN MOUNTAI , LOWER HUTT: NEW ZEALAND GEOLOGICAL SURVEY.

Tonkin+Taylor

Exceptional thinking together www.tonkintaylor.co.nz

PROJECT No.	1012397	
DESIGNED	SAPR	Jan,21
DRAWN	DFL	Jan,21
CHECKED	DJA	Jan,21
MARK FOLEY	31/03/2021	
APPROVED	DATE	

CLIENT CCKV MAITAI DEV CO LP AND BAYVIEW NELSON LI ITED

PROJECT PRIVATE PLAN CHANGE REQUEST

ITLE OUTLINE OF BEDROCK GEOLOGY PLAN

SCALE (A3) 1:10,000 FIG No. 1012397-F3 REV 2

P:\1012397\WorkingMaterial\CAD\FIG\1012397-F4.dwg 2021-Mar-31 5:35:38 pm Plotted By: DANIEL FOLEY-LOGAN

Tonkin+Taylor
Exceptional thinking together   www.tonkintaylor.co.nz

NOTES:
1. AERIAL SOURCED FORM TOP OF THE SOUTH MAPS <https://www.topofthesouthmaps.co.nz/app/> AND LICENSED FOR RE-USE UNDER THE CREATIVE COMMONS ATTRIBUTION 4. INTERNATIONAL LICENSE.
. NELSON RESOURCE MANAGEMENT PLAN OVERLAYS SOURCED FROM NELSON CITY COUNCIL GIS LICENSED FOR RE-USE UNDER THE CREATIVE COMMONS ATTRIBUTION 4. INTERNATIONAL LICENSE.

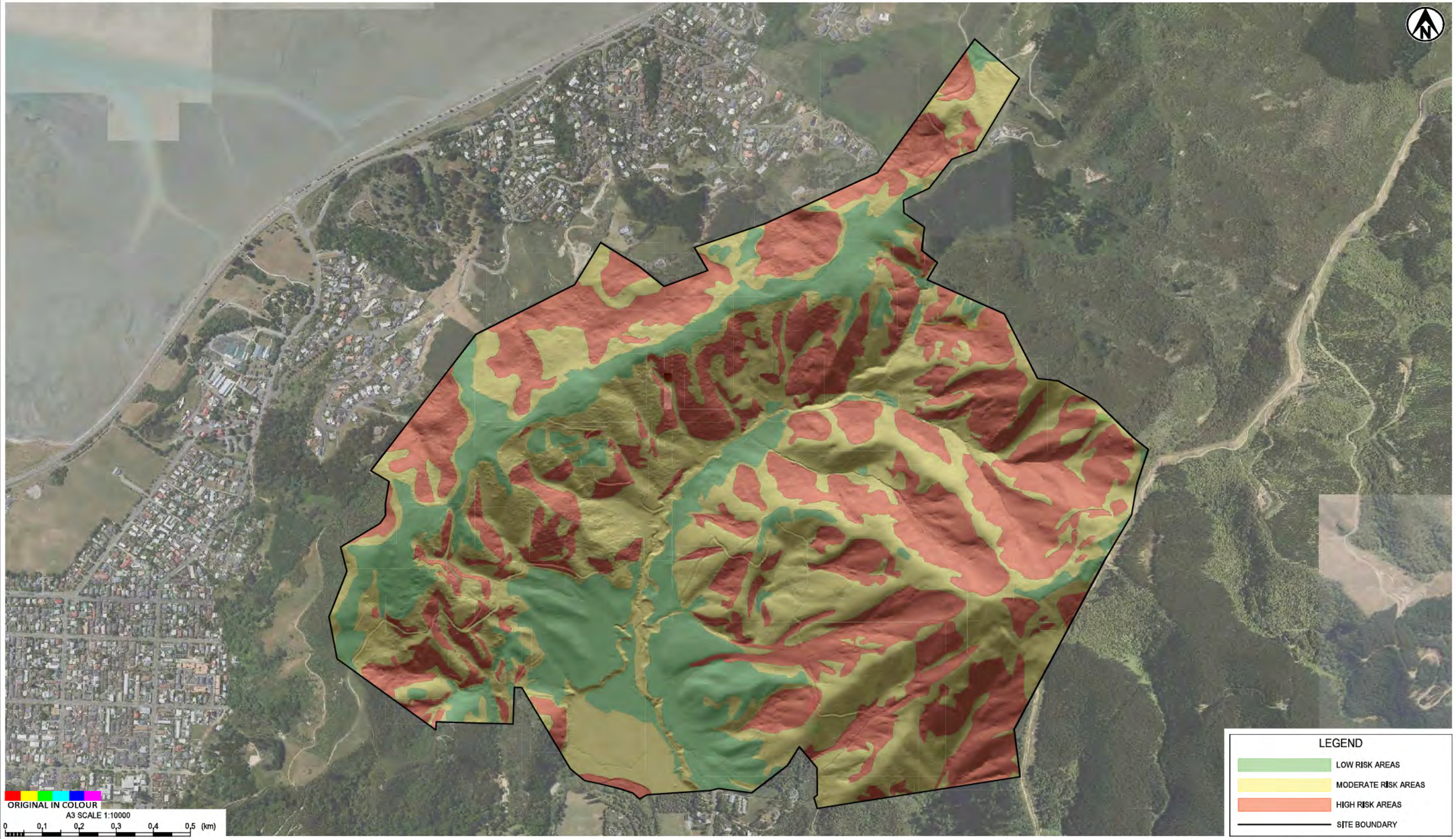
PROJECT No.	1012397	
DESIGNED	MRF	May.20
DRAWN	DFL	May.20
CHECKED	DJA	Jan.21
	MARK FOLEY	31/03/2021
	APPROVED	DATE

CLIENT CCKV MAITAI DEV CO LP AND BAYVIEW NELSON LI ITED
PROJECT PRIVATE PLAN CHANGE REQUEST
TITLE NELSON RESOURCE MANAGEMENT PLAN OVERLAYS

SCALE (A3) 1:10,000   FIG No. 1012397-F4   REV 2

COPYRIGHT ON THIS FIGURE IS RESERVED   DO NOT SCALE FROM THIS FIGURE - IF IN DOUBT, ASK.

P:\1012397\WorkingMaterial\CAD\FIG\1012397-F5.dwg 2021-Mar-31 5:36:03 pm Plotted By: DANIEL FOLEY-LOGAN



NOTES:

1. AERIAL SOURCED FORM TOP OF THE SOUTH MAPS <https://www.topofthesouthmaps.co.nz/app/> AND LICENSED FOR RE-USE UNDER THE CREATIVE COMMONS ATTRIBUTION 4. INTERNATIONAL LICENSE.

Tonkin+Taylor

Exceptional thinking together   www.tonkintaylor.co.nz

PROJECT No.	1012397	
DESIGNED	MRF	May.20
DRAWN	DFL	May.20
CHECKED	DJA	Jan.21
MARK FOLEY		31/03/2021
APPROVED		DATE

CLIENT	CCKV MAITAI DEV CO LP AND BAYVIEW NELSON LI ITED
PROJECT	PRIVATE PLAN CHANGE REQUEST
ITLE	GEOTECHNICAL RISK RATING FOR LAND DEVELOPMENT
SCALE (A3)	1:10,000
FIG No.	1012397-F5
REV	2

Appendix B: Stormwater Calculations

STORMWATER ASSESSMENT - OVERVIEW

Project:	PPC28 SWMP	**By:**	CHGR	**Date:**	1/08/2022
Location:	Kaka Hill	**Checked:**	BYMU	**Date:**	1/08/2022

Design Criteria

Assess peak pre and post development scenarios - Size attenuation to match post development runoff to pre development levels in present day 100 year events.

Design Concepts

1) Provide attenuation for the peak run-off to the streams in the present day 100 year ARI storms to predevelopment levels.

References

NTLDM 2020
TR 2009/00072 - Review of Hydrologic Propoerties of Soils in the Auckland Region by Auckland Regional Council
USDA TR-55 Urban Hydrology for Small Watersheds

STORMWATER ASSESSMENT - Runoff Coefficents

Project: PPC28 SWMP **By:** CHGR **Date:** 1/08/2022

Location: Kaka Hill **Checked:** BYMU **Date:** 1/08/2022

Calculation Description

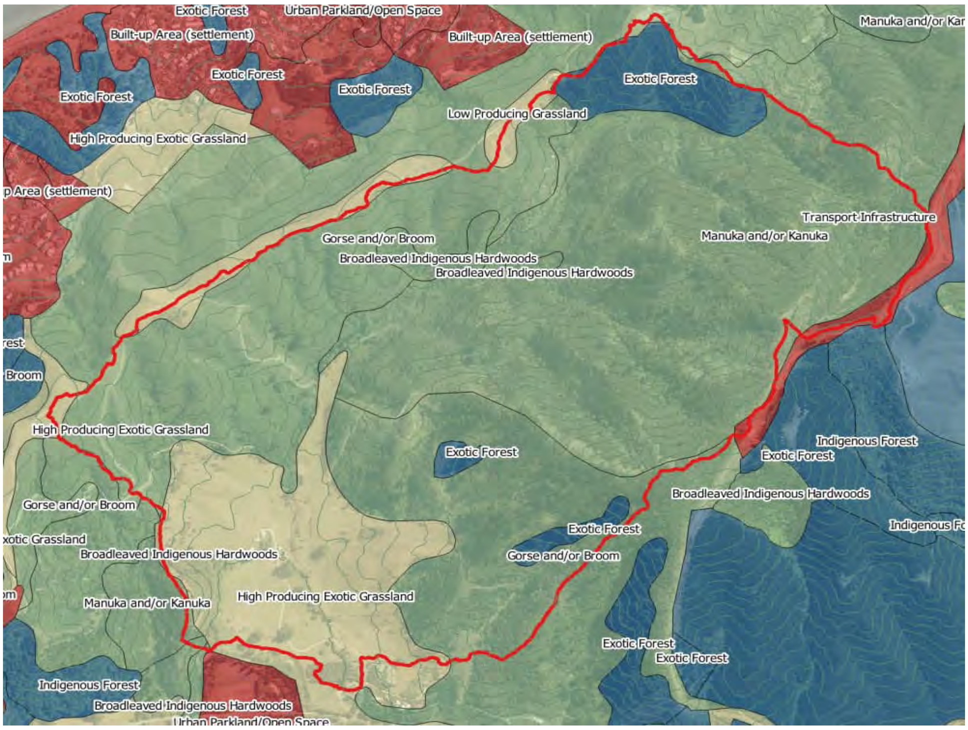
Determination of runoff coefficents for present day and post-development

Identify land cover

Determine Hydrologic Soil Class

Present Day Land Cover

From New Zealand Land Cover Database v 4.1



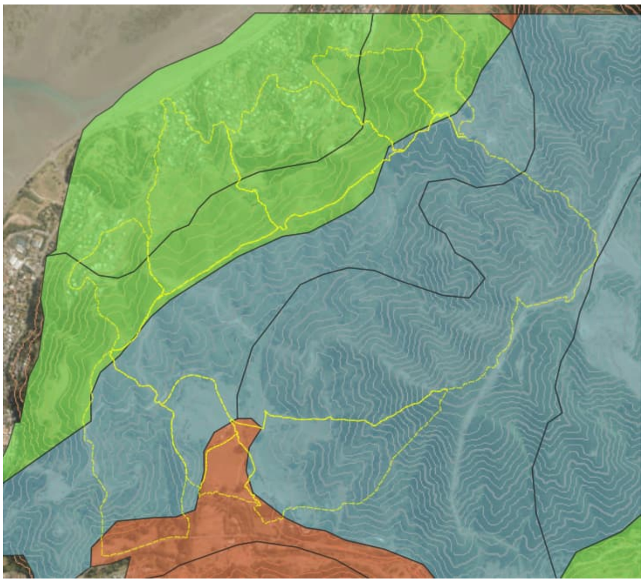
Hydrologic Soil Classification

Method: TR 2009/00072 - Review of Hydrologic Properties of Soils in the Auckland Region by Auckland Regional Council

Table 8: Proposed Soil Hydrologic Classes for Auckland Region

Hydrolic Soil Class	Hydro Class 1 Low Runoff Potential A	Hydro Class 2 Moderate Runoff Potential B	Hydro Class 3 Moderately High Runoff Potential C	Hydro Class 4 High Runoff Potential D	
Soil Textural Class **PS_CLASS[1]**	1 or 2 K, S, S/K	3 L, L/S	4 Z, Z/C	5 C	ALL
	AND				AND
Depth to Slowly Permeable Horizon **DLSO_CLASS**	> 450 mm >1				450 mm or less 1[2]
	AND				OR
Depth to Seasonally High Water Table **DRAIN_CLASS**	> 300 mm >2				300 mm or less 1 or 2[2]

[1] Use PS_CLASS only when SOILTYPE is not available within the LRIS GIS data. Peat soils all fall into Class 4.
[2] Selection of the depth to the seasonally high water table and to a slowly permeable horizon were based on the



Map Colour	Blue	Green	Brown
PS_CLASS	Z	Z	L/K
DSLO_CLASS	1	2	5
DRAIN_CLASS	5	5	5
Hydrologic Soil Class	**D**	**C**	**B**

Runoff Coefficents

Classified into Rational method Runoff Coefficients and Curve Numbers
According to NTLDM Engineering Standards and USDA TR-55 Urban Hydrology for Small Watersheds

Cover Type	CN classification	Hydrologic Soil Class	Curve Number	Runoff Coeficient
Deciduous Hardwoods	*Woods - fair*	B	60	0.25
Deciduous Hardwoods	*Woods - fair*	C	73	0.25
Deciduous Hardwoods	*Woods - fair*	D	79	0.35
Broadleaved Indigenous Hardwoods	*Woods - fair*	B	60	0.25
Broadleaved Indigenous Hardwoods	*Woods - fair*	D	79	0.35
Indigenous Forest	*Woods - fair*	B	60	0.25
Indigenous Forest	*Woods - fair*	D	79	0.25
Manuka and/or Kanuka	*Brush-weed-grass mix - fair*	B	56	0.25
Manuka and/or Kanuka	*Brush-weed-grass mix - fair*	D	77	0.35
Exotic Forest	*Woods - grass combo - fair*	C	76	0.25
Exotic Forest	*Woods - grass combo - fair*	D	82	0.35
Forest - Harvested	*Newly graded area (pervious areas only, no vegetation)*	C	91	0.25
Gorse and/or Broom	*Brush-weed-grass mix - fair*	C	70	0.25
Gorse and/or Broom	*Brush-weed-grass mix - fair*	D	77	0.35
High Producing Exotic Grassland	*Pasture - fair*	B	69	0.3
High Producing Exotic Grassland	*Pasture - fair*	C	79	0.3
High Producing Exotic Grassland	*Pasture - fair*	D	84	0.4
Low Producing Grassland	*Pasture - poor*	C	86	0.3
Low Producing Grassland	*Pasture - poor*	D	89	0.4
Urban Parkland/Open Space	*Open Space - fair*	C	79	0.3
Urban Parkland/Open Space	*Open Space - fair*	D	84	0.3
Transport Infrastructure	*Dirt - fair*	D	89	0.5
Built-up Area (settlement)	*Residential district 1/4 acre size*	C	83	0.45
Open Space	*Open Space - fair*	B	69	0.3
Open Space	*Open Space - fair*	C	79	0.3
Open Space	*Open Space - fair*	D	84	0.4
Rural	*Brush-weed-grass mix - fair*	C	70	0.3
Rural	*Brush-weed-grass mix - fair*	D	77	0.4
Commercial	*Commercial and Business*	B	92	0.65
Commercial	*Commercial and Business*	D	95	0.65
Impervious	*Paved parking lots, roofs, driveways, etc*		98	0.95

STORMWATER ASSESSMENT - CATCHMENTS

Project: PPC28 SWMP | **By:** CHGR | **Date:** 1/08/2022

Location: Kaka Hill | **Checked:** BYMU | **Date:** 1/08/2022

Calculation Description

Categorise catchment into Pre and Post Development Areas

Pre Development

Cover Type	Hydrologic Soil Class	Curve Number	Kaka 1	Kaka 2	Kaka 3a	Kaka 3b	Brooklands 1	Brooklands 2	Brooklands 3	Brooklands 4	Walters Bluff	Bradford Park
Deciduous Hardwoods	B	60	0	0	0	0	0	0	0	0	0	33
Deciduous Hardwoods	C	73	0	0	0	0	0	0	1672	0	0	0
Deciduous Hardwoods	D	79	0	0	0	0	0	0	0	0	0	2
Broadleaved Indigenous Hardwoods	B	60	0	0	0	0	0	0	0	0	0	783
Broadleaved Indigenous Hardwoods	D	79	38729	0	103	0	0	0	0	0	0	140146
Indigenous Forest	B	60	0	0	0	0	0	0	0	0	0	19805
Indigenous Forest	D	79	64	0	0	0	0	0	0	0	0	21812
Manuka and/or Kanuka	B	56	0	0	0	0	0	0	0	0	0	10208
Manuka and/or Kanuka	D	77	1042826	107	1793	0	0	0	0	180	0	67864
Exotic Forest	C	76	158	0	0	0	17266	37454	0	0	56	0
Exotic Forest	D	82	107629	18744	0	0	0	816	1245	357	0	0
Forest - Harvested	C	91	0	0	0	0	0	0	0	18159	0	0
Gorse and/or Broom	C	70	47279	0	0	0	169816	97150	150480	70289	92831	3266
Gorse and/or Broom	D	77	673108	168051	4560	0	0	85	4525	8841	109	46220
High Producing Exotic Grassland	B	69	3250	21049	11831	56733	0	0	0	0	0	23883
High Producing Exotic Grassland	C	79	1895	0	0	0	61908	483	18567	0	7975	6824
High Producing Exotic Grassland	D	84	64204	135132	94088	3124	0	0	0	0	0	5507
Low Producing Grassland	C	86	29094	0	0	0	27736	22227	0	0	3682	0
Low Producing Grassland	D	89	5972	0	0	0	0	1350	31	0	0	0
Urban Parkland/Open Space	C	79	0	0	0	0	16231	85571	0	0	0	0
Urban Parkland/Open Space	D	84	0	0	0	0	0	0	0	0	0	648
Transport Infrastructure	D	89	15906	0	0	0	0	0	0	0	0	0
Built-up Area (settlement)	C	83	0	0	0	0	54674	123887	5230	0	50522	0
		Total (m2)	2030115	343082	112374	59857	347631	369024	181749	97826	155175	347000
		Total (hec)	203.01	34.31	11.24	5.99	34.76	36.90	18.17	9.78	15.52	34.70

Post Development

Cover Type	Hydrologic Soil Class	Curve Number	Kaka 1	Kaka 2	Kaka 3a	Kaka 3b	Brooklands 1	Brooklands 2	Brooklands 3	Brooklands 4	Walters Bluff	Bradford Park
Deciduous Hardwoods	B	60	0	0	0	0	0	0	0	0	0	33
Deciduous Hardwoods	C	73	0	0	0	0	0	0	1672	0	0	0
Deciduous Hardwoods	D	79	0	0	0	0	0	0	0	0	0	2
Broadleaved Indigenous Hardwoods	B	60	0	0	0	0	0	0	0	0	0	783
Broadleaved Indigenous Hardwoods	D	79	32253	0	0	0	0	0	0	0	0	25764
Indigenous Forest	B	60	0	0	0	0	0	0	0	0	0	19805
Indigenous Forest	D	79	64	0	0	0	0	0	0	0	0	21812
Manuka and/or Kanuka	B	56	0	0	0	0	0	0	0	0	0	10208
Manuka and/or Kanuka	D	77	943054	107	1793	0	0	0	0	180	0	49296
Exotic Forest	C	76	158	0	0	0	17266	32711	0	0	56	0
Exotic Forest	D	82	107629	18744	0	0	0	786	1144	357	0	0
Forest - Harvested	C	91	0	0	0	0	0	0	0	12686	0	0
Gorse and/or Broom	C	70	10640	0	0	0	30299	11228	108504	41569	27413	0
Gorse and/or Broom	D	77	355648	165854	0	0	0	0	2335	8841	0	0
High Producing Exotic Grassland	B	69	0	7762	49	2358	0	0	0	0	0	23883
High Producing Exotic Grassland	C	79	0	0	0	0	61888	483	18567	0	1090	0
High Producing Exotic Grassland	D	84	1756	14069	6095	73	0	0	0	0	0	68
Low Producing Grassland	C	86	1435	0	0	0	0	0	0	0	0	0
Low Producing Grassland	D	89	1679	0	0	0	0	254	0	0	0	0
Urban Parkland/Open Space	C	79	0	0	0	0	14887	85369	0	0	0	0
Urban Parkland/Open Space	D	84	0	0	0	0	0	0	0	0	0	0
Transport Infrastructure	D	89	15906	0	0	0	0	0	0	0	0	0
Built-up Area (settlement)	C	83	0	0	0	0	54674	123887	5230	0	50522	0
Open Space	B	69	1907	9128	8451	38792	0	0	0	0	0	0
Open Space	C	79	16874	0	0	0	29818	15068	2648	7465	30648	6393
Open Space	D	84	191550	50031	35109	1084	0	90	417	0	20	123191
Rural	C	70	26591	0	0	0	71932	63648	30896	16280	33933	1638
Rural	D	77	175370	3124	17241	0	0	840	1222	0	0	23932
Commercial	B	92	0	211	0	0	0	0	0	0	0	0
Commercial	D	95	0	1293	0	0	0	0	0	0	0	0
Impervious		98	147613	70010	40344	7563	18053	11285	3312	2192	2111	40221

Total (m2)	2030127	340334	109083	49871	298816	345649	175946	89571	145792	347029
Total (hec)	203.01	34.03	10.91	4.99	29.88	34.56	17.59	8.96	14.58	34.70

STORMWATER ASSESSMENT - TIME OF CONCENTRATION KAKA 1

Project:	PPC28 SWMP	**By:**	CHGR	**Date:**	1/08/2022
Location:	Kaka Hill	**Checked:**	BYMU	**Date:**	1/08/2022

Calculation Description

Calculate time of concentration using a variety of methods

Geometry	Full Catchı	Unit
Length	3,329	m
Area	2,030,115	m2
Max RL	415	RL m
Min RL	22.006	RL m
Height Diff.	393	m
Slope	0.12	m/m
Slope (Equal Areas)	0.08	m/m
Mannings n	0.045	

Time of Concentration (minutes)

E1/VM1 (TDC Stds)	40	
USDA	36	
Bransby Williams	68	
USSCS	23	
Average	**42**	
Selected	**42**	**minutes**

STORMWATER ASSESSMENT - TIME OF CONCENTRATION KAKA 2

Project: PPC28 SWMP **By:** CHGR **Date:** 1/08/2022

Location: Kaka Hill **Checked:** BYMU **Date:** 1/08/2022

Calculation Description

Calculate time of concentration using a variety of methods

Geometry	Full Catchı	Unit
Length	1,232	m
Area	343,082	m2
Max RL	371	RL m
Min RL	15.892	RL m
Height Diff.	355	m
Slope	0.29	m/m
Slope (Equal Areas)	0.19	m/m
Mannings n	0.045	

Time of Concentration (minutes)

E1/VM1 (TDC Stds)	24
USDA	19
Bransby Williams	25
TP108	
USSCS	8
Average	**19**

Selected	**19**	**minutes**

STORMWATER ASSESSMENT - TIME OF CONCENTRATION KAKA 3a

Project: PPC28 SWMP **By:** CHGR **Date:** 1/08/2022

Location: Kaka Hill **Checked:** BYMU **Date:** 1/08/2022

Calculation Description

Calculate time of concentration using a variety of methods

Geometry	Full Catchı	Unit
Length	699	m
Area	112,374	m2
Max RL	68	RL m
Min RL	12.917	RL m
Height Diff.	55	m
Slope	0.08	m/m
Slope (Equal Areas)	0.04	m/m
Mannings n	0.045	

Time of Concentration (minutes)

E1/VM1 (TDC Stds)	26
USDA	26
Bransby Williams	21
TP108	
USSCS	8
Average	**20**

Selected 20 **minutes**

STORMWATER ASSESSMENT - TIME OF CONCENTRATION KAKA 3b

Project: PPC28 SWMP **By:** CHGR **Date:** 1/08/2022

Location: Kaka Hill **Checked:** BYMU **Date:** 1/08/2022

Calculation Description

Calculate time of concentration using a variety of methods

Geometry	Full Catchı	Unit
Length	633	m
Area	59,857	m2
Max RL	20	RL m
Min RL	12.917	RL m
Height Diff.	7	m
Slope	0.01	m/m
Slope (Equal Areas)	0.01	m/m
Mannings n	0.045	

Time of Concentration (minutes)

E1/VM1 (TDC Stds)	37
USDA	43
Bransby Williams	29
TP108	
USSCS	16
Average	**31**

Selected	**31**	**minutes**

STORMWATER ASSESSMENT - TIME OF CONCENTRATION BROOKLANDS 1

Project:	PPC28 SWMP	**By:**	CHGR	**Date:**	1/08/2022
Location:	Kaka Hill	**Checked:**	BYMU	**Date:**	1/08/2022

Calculation Description

Calculate time of concentration using a variety of methods

Geometry	Full Catchı	Unit
Length	1,051	m
Area	347,631	m2
Max RL	179	RL m
Min RL	3.043	RL m
Height Diff.	176	m
Slope	0.17	m/m
Slope (Equal Areas)	0.12	m/m
Mannings n	0.045	

Time of Concentration (minutes)

E1/VM1 (TDC Stds)	25
USDA	21
Bransby Williams	24
TP108	
USSCS	8
Average	**20**

Selected **20** **minutes**

STORMWATER ASSESSMENT - TIME OF CONCENTRATION BROOKLANDS 2

Project:	PPC28 SWMP	**By:**	CHGR	**Date:**	1/08/2022
Location:	Kaka Hill	**Checked:**	BYMU	**Date:**	1/08/2022

Calculation Description

Calculate time of concentration using a variety of methods

Geometry	Full Catchi	Unit
Length	787	m
Area	369,024	m2
Max RL	212	RL m
Min RL	19.718	RL m
Height Diff.	193	m
Slope	0.24	m/m
Slope (Equal Areas)	0.22	m/m
Mannings n	0.045	

Time of Concentration (minutes)

E1/VM1 (TDC Stds)	21
USDA	16
Bransby Williams	17
TP108	
USSCS	6
Average	**15**

Selected	**15**	**minutes**

STORMWATER ASSESSMENT - TIME OF CONCENTRATION BROOKLANDS 3

Project: PPC28 SWMP **By:** CHGR **Date:** 1/08/2022

Location: Kaka Hill **Checked:** BYMU **Date:** 1/08/2022

Calculation Description

Calculate time of concentration using a variety of methods

Geometry	Full Catchı	Unit
Length	724	m
Area	181,749	m2
Max RL	219	RL m
Min RL	32.7	RL m
Height Diff.	186	m
Slope	0.26	m/m
Slope (Equal Areas)	0.24	m/m
Mannings n	0.045	

Time of Concentration (minutes)

E1/VM1 (TDC Stds)	21	
USDA	15	
Bransby Williams	16	
TP108		
USSCS	5	
Average	**14**	
Selected	**14**	**minutes**

STORMWATER ASSESSMENT - TIME OF CONCENTRATION BROOKLANDS 4

Project: PPC28 SWMP **By:** CHGR **Date:** 1/08/2022

Location: Kaka Hill **Checked:** BYMU **Date:** 1/08/2022

Calculation Description

Calculate time of concentration using a variety of methods

Geometry	Full Catchı	Unit
Length	706	m
Area	97,826	m2
Max RL	247	RL m
Min RL	118.505	RL m
Height Diff.	129	m
Slope	0.18	m/m
Slope (Equal Areas)	0.19	m/m
Mannings n	0.045	

Time of Concentration (minutes)

E1/VM1 (TDC Stds)	22	
USDA	16	
Bransby Williams	18	
TP108		
USSCS	6	
Average	**15**	
Selected	**15**	**minutes**

STORMWATER ASSESSMENT - TIME OF CONCENTRATION WALTERS BLUFF

Project:	PPC28 SWMP	**By:**	CHGR	**Date:**	1/08/2022
Location:	Kaka Hill	**Checked:**	BYMU	**Date:**	1/08/2022

Calculation Description

Calculate time of concentration using a variety of methods

Geometry	Full Catchi	Unit
Length	840	m
Area	155,175	m2
Max RL	190	RL m
Min RL	50.387	RL m
Height Diff.	140	m
Slope	0.17	m/m
Slope (Equal Areas)	0.15	m/m
Mannings n	0.045	

Time of Concentration (minutes)

E1/VM1 (TDC Stds)	24
USDA	18
Bransby Williams	21
TP108	
USSCS	7
Average	**17**

Selected	17	**minutes**

STORMWATER ASSESSMENT - TIME OF CONCENTRATION BRADFORD PARK

Project: PPC28 SWMP **By:** CHGR **Date:** 1/08/2022

Location: Kaka Hill **Checked:** BYMU **Date:** 1/08/2022

Calculation Description

Calculate time of concentration using a variety of methods

Geometry	Full Catchı	Unit
Length	1,571	m
Area	347,000	m2
Max RL	190	RL m
Min RL	10	RL m
Height Diff.	179	m
Slope	0.11	m/m
Slope (Equal Areas)	0.07	m/m
Mannings n	0.045	

Time of Concentration (minutes)

E1/VM1 (TDC Stds)	31	
USDA	30	
Bransby Williams	39	
TP108		
USSCS	13	
Average	**28**	
Selected	**28**	**minutes**

STORMWATER ASSESSMENT - HYDROLOGY

Project: PPC28 SWMP		**By:** CHGR		**Date:**	1/08/2022
Location: Kaka Hill		**Checked:** BYMU		**Date:**	1/08/2022

Calculation Description

Use HIRDS Data to determine hydrology

HIRDS Data

HIRDS V4 Depth-Duration-Frequency Results

Depth-Duration-Frequency results (produced on Wednesday 4th of December 2019)
Sitename: Kaka Hill
Coordinate system: WGS84
Longitude: 173.3103
Latitude: -41.2686

DDF Model Parameter		c	d	e	f	g	h	i
	Values:	-0.001962	0.506263	-0.03105	0	0.25879	-0.010225	3.0270055
	Example:	Duration (h	ARI (yrs)	x	y	Rainfall Depth (mm)		
		24	100	3.178054	4.600149	193.9891		

		5	10	15	20	30	60	120	180	360	720	1440	2880	4320	5760	7200

Rainfall depths (mm) :: RCP8.5 for the period 2101-2120

ARI	AEP	5m	10m	15m	20m	30m	1h	2h	3h	6h	12h	24h	48h	72h	96h	120h
1.58	0.633	6.7	10.4	13.3	15.7	19.8	28.5	39.4	46.7	60.4	75.8	92.3	109.5	119.4	126.3	131.4
2	0.5	7.4	11.5	14.6	17.3	21.7	31.3	43.3	51.3	66.3	83.2	101.2	119.9	130.8	138.3	143.9
5	0.2	9.8	15.3	19.5	23.1	28.9	41.6	57.5	68.2	88.1	110.4	133.8	158.5	173.2	182.5	189.9
10	0.1	11.7	18.2	23.2	27.5	34.4	49.5	68.2	80.9	104.4	130.7	158.4	187.4	204.6	215.6	224.3
20	0.05	13.7	21.3	27.1	32.0	40.1	57.6	79.4	93.5	121.6	151.8	183.2	217.2	236.4	249.7	258.9
30	0.033	14.9	23.1	29.5	34.8	43.6	62.6	86.2	102.1	131.9	164.5	198.5	235.2	256.0	270.3	280.2
40	0.025	15.8	24.4	31.2	36.8	46.0	66.1	91.0	107.9	139.4	173.9	209.8	247.8	270.3	284.6	295.9
50	0.02	16.5	25.5	32.5	38.4	48.1	69.0	94.9	112.6	145.1	181.0	218.2	258.4	281.1	296.7	307.6
60	0.017	17.1	26.4	33.6	39.7	49.7	71.2	99.1	118.6	157.5	202.9	253.7	307.9	340.1	362.7	379.9
80	0.012	18.0	27.9	35.5	41.8	52.4	75.1	103.3	122.4	157.7	196.6	236.9	280.3	304.8	320.9	333.4
100	0.01	18.7	28.9	36.8	43.5	54.4	77.9	107.2	127.1	164.0	204.3	246.2	290.5	315.9	333.3	345.4
250	0.012	21.7	33.5	42.6	50.2	62.8	89.9	123.5	146.3	188.6	234.6	282.4	332.8	361.6	381.3	395.0
15	0.066	12.9	20.0	25.6	30.2	37.8	54.4	74.9	88.5	114.7	143.4	173.4	205.4	223.9	236.2	245.3

Depth standard error (mm) :: Historical Data

ARI	AEP	10m	20m	30m	1h	2h	6h	12h	24h	48h	72h	96h	120h
1.58	0.633	0.97	1.3	1.5	2.2	3	5.9	8.9	4.2	4.6	4	9	6.1
2	0.5	1.1	1.4	1.6	2.4	3.3	6.4	9.8	4.6	4.9	4.3	9.9	6.7
5	0.2	1.6	2.1	2.3	3.5	4.7	8.5	13	6.6	7.1	6.4	14	9.6
10	0.1	2	2.9	3.1	4.5	6.1	10	16	8.8	9.4	9	17	13
20	0.05	2.6	3.9	4.2	5.9	8.1	13	19	12	13	13	21	17
30	0.033	3	4.6	5.1	7	9.5	15	21	14	15	15	24	20
40	0.025	3.3	5.1	5.8	7.8	11	16	23	15	17	17	27	22
50	0.02	3.6	5.6	6.4	8.6	12	18	25	17	18	19	29	24
60	0.017	3.9	6.1	6.9	9.2	13	19	26	18	20	21	31	26
80	0.013	4.3	6.8	7.8	10	14	21	29	20	22	23	34	29
100	0.01	4.7	7.4	8.6	11	15	22	31	22	24	25	36	32
250	0.004	6.5	10	13	16	22	31	41	30	34	36	49	45

Time of Concentration

	42		19		20		31		20		15		14		15		17		28	
	Kaka 1		Kaka 2		Kaka 3a		Kaka 3b		Brooklands 1		Brooklands 2		Brooklands 3		Brooklands 4		WB		BP	
AEP	Rainfall Depth (mm)	Rainfall Intensity (mm/hr)	Rainfall Depth (mm)	Rainfall Intensity (mm/hr)	Rainfall Depth (mm)	Rainfall Intensity (mm/hr)	Rainfall Depth (mm)	Rainfall Intensity (mm/hr)	Rainfall Depth (mm)	Rainfall Intensity (mm/hr)	Rainfall Depth (mm)	Rainfall Intensity (mm/hr)	Rainfall Depth (mm)	Rainfall Intensity (mm/hr)	Rainfall Depth (mm)	Rainfall Intensity (mm/hr)	Rainfall Depth (mm)	Rainfall Intensity (mm/hr)	Rainfall Depth (mm)	Rainfall Intensity (mm/hr)
10	40.0	57.5	25.9	81.6	26.7	79.6	34.0	65.5	26.4	80.3	22.6	91.1	22.1	92.9	23.1	89.6	24.7	84.8	32.2	68.4
15	46.6	67.0	30.2	95.1	31.2	92.9	39.7	76.3	30.8	93.7	26.4	106.3	25.8	108.4	26.9	104.5	28.8	98.9	37.5	79.8
100	63.1	90.7	41.1	129.2	42.3	126.1	53.8	103.5	41.8	127.2	35.9	144.4	35.0	147.3	36.6	142.1	39.2	134.4	50.9	108.2

STORMWATER ASSESSMENT - PRE-DEVELOPMENT SCENARIO

Project: PPC28 SWMP **By:** CHGR **Date:** 1/08/2022

Location: Kaka Hill **Checked:** BYMU **Date:** 1/08/2022

Calculation Description

Kaka 1

Determine peak flow rate with variety of methods
Determine runoff volume for pond sizing calculations

SCS Method

1. Runoff Curve Number (CN) and Initial Abstraction (Ia)

	Soil name and classification	Cover description (cover type, treatment, and hydrologic condition): LCDB	CN classification	SCS Method: Curve Number CN*	SCS Method: Area (hectares)	SCS Method: Product of CN x Area	Rational Method: C	Rational Method: Product
		Pervious Areas (List)						
B	Class B soils	Deciduous Hardwoods	Woods - fair	60	0.00	0	0.25	0.00
C	Class C soils	Deciduous Hardwoods	Woods - fair	73	0.00	0	0.25	0.00
D	Class D soils	Deciduous Hardwoods	Woods - fair	79	0.00	0	0.35	0.00
B	Class B soils	Broadleaved Indigenous Hardwo	Woods - fair	60	0.00	0	0.25	0.00
D	Class D soils	Broadleaved Indigenous Hardwo	Woods - fair	79	3.87	306	0.35	1.36
B	Class B soils	Indigenous Forest	Woods - fair	60	0.00	0	0.25	0.00
D	Class D soils	Indigenous Forest	Woods - fair	79	0.01	1	0.25	0.00
B	Class B soils	Manuka and/or Kanuka	Brush-weed-grass mix - fa	56	0.00	0	0.25	0.00
D	Class D soils	Manuka and/or Kanuka	Brush-weed-grass mix - fa	77	104.28	8,030	0.35	36.50
C	Class C soils	Exotic Forest	Woods - grass combo - fa	76	0.02	1	0.25	0.00
D	Class D soils	Exotic Forest	Woods - grass combo - fa	82	10.76	883	0.35	3.77
C	Class C soils	Forest - Harvested	Newly graded area (pervio	91	0.00	0	0.25	0.00
C	Class C soils	Gorse and/or Broom	Brush-weed-grass mix - fa	70	4.73	331	0.25	1.18
D	Class D soils	Gorse and/or Broom	Brush-weed-grass mix - fa	77	67.31	5,183	0.35	23.56
B	Class B soils	High Producing Exotic Grassland	Pasture - fair	69	0.33	22	0.3	0.10
C	Class C soils	High Producing Exotic Grassland	Pasture - fair	79	0.19	15	0.3	0.06
D	Class D soils	High Producing Exotic Grassland	Pasture - fair	84	6.42	539	0.4	2.57
C	Class C soils	Low Producing Grassland	Pasture - poor	86	2.91	250	0.3	0.87
D	Class D soils	Low Producing Grassland	Pasture - poor	89	0.60	53	0.4	0.24
			Subtotal for Pervious Areas		201.42	15,614		70.20
		Impervious Areas (List)						
C	Class C soils	Urban Parkland/Open Space	Open Space - fair	79	0.00	0	0.3	0.00
D	Class D soils	Urban Parkland/Open Space	Open Space - fair	84	0.00	0	0.3	0.00
D	Class D soils	Transport Infrastructure	Dirt - fair	89	1.59	142	0.5	0.80
C	Class C soils	Built-up Area (settlement)	Residential district 1/4 acr	83	0.00	0	0.45	0.00
			Subtotal for Impervious Areas		1.59	142		0.80
				Totals	203.01	15,756		71.00
					2.030115 km²			

CN (weighted) : $\frac{\text{total product}}{\text{total area}} = \frac{15,756}{203.012} = 77.61$ 0.3497

For ungaged watersheds, the SCS suggests that th time of concentration, t_c, as:

$t_{lag} = 0.6\, t_c$

For ungaged watersheds, the SCS suggests that the UH lag time may be related to time of concentration, t_c, as:

$$t_{lag} = 0.6\, t_c \quad (38)$$

2. Time of Concentration https://www.hec.usace.army.mil/software/hec-hms/documentation/HEC-HMS_Technical%20Reference%

Time of Concentration t_c = 0.70 hrs 41.74 min

SCS Lag for HEC-HMS : t_p = $0.6\ t_c$ = 0.42 hrs 25.04555 min

3. Soil Storage Parameter : S = ((1000/CN)-10)*25.4

Total = 73.3 mm
Pervious = 73.7 mm
Impervious = mm

4. Initial Abstraction

Ia = 0.2S = 14.65638

above parameters used in SCS method analysis in HEC HMS

5. Rainfall data

Using Region-specific temporal patterns produced in HIRDS v4 by NIWA for 1 hour, 6 hour and 12 hour storm durations
RCP8.5

5. Results

Pre-Development
Results Peak Discharge (m3/s)

hr	Q10	Q15	Q100
1	8.7	10.4	22.2
6	15.5	16.7	25.4
12	9.1	10.1	16.6

Rational Method

42 min

		Q10	Q15	Q100
Rainfall intensity		57.5	67.0	90.7
Peak Flow Rate, Q :		11.34	13.22	17.91

Calculation Description

Kaka 2

Determine peak flow rate with variety of methods
Determine runoff volume for pond sizing calculations

SCS Method

1. Runoff Curve Number (CN) and Initial Abstraction (Ia)

Soil name and classification	Cover description (cover type, treatment, and hydrologic condition) – LCDB	CN classification	SCS Method: Curve Number CN*	SCS Method: Area (hectares)	SCS Method: Product of CN x Area	Rational Method: C	Rational Method: Product
	Pervious Areas (List)						
Class B soils	Deciduous Hardwoods	*Woods - fair*	60	0.00	0	0.25	0.00
Class C soils	Deciduous Hardwoods	*Woods - fair*	73	0.00	0	0.25	0.00
Class D soils	Deciduous Hardwoods	*Woods - fair*	79	0.00	0	0.35	0.00
Class B soils	Broadleaved Indigenous Hardwo	*Woods - fair*	60	0.00	0	0.25	0.00
Class D soils	Broadleaved Indigenous Hardwo	*Woods - fair*	79	0.00	0	0.35	0.00
Class B soils	Indigenous Forest	*Woods - fair*	60	0.00	0	0.25	0.00
Class D soils	Indigenous Forest	*Woods - fair*	79	0.00	0	0.25	0.00
Class B soils	Manuka and/or Kanuka	*Brush-weed-grass mix -*	56	0.00	0	0.25	0.00
Class D soils	Manuka and/or Kanuka	*Brush-weed-grass mix -*	77	0.01	1	0.35	0.00
Class C soils	Exotic Forest	*Woods - grass combo - f*	76	0.00	0	0.25	0.00
Class D soils	Exotic Forest	*Woods - grass combo - f*	82	1.87	154	0.35	0.66
Class C soils	Forest - Harvested	*Newly graded area (perv*	91	0.00	0	0.25	0.00
Class C soils	Gorse and/or Broom	*Brush-weed-grass mix -*	70	0.00	0	0.25	0.00
Class D soils	Gorse and/or Broom	*Brush-weed-grass mix -*	77	16.81	1,294	0.35	5.88
Class B soils	High Producing Exotic Grassland	*Pasture - fair*	69	2.10	145	0.3	0.63
Class C soils	High Producing Exotic Grassland	*Pasture - fair*	79	0.00	0	0.3	0.00
Class D soils	High Producing Exotic Grassland	*Pasture - fair*	84	13.51	1,135	0.4	5.41
Class C soils	Low Producing Grassland	*Pasture - poor*	86	0.00	0	0.3	0.00
Class D soils	Low Producing Grassland	*Pasture - poor*	89	0.00	0	0.4	0.00
		Subtotal for Pervious Areas		34.31	2,729		12.58
	Impervious Areas (List)						
Class C soils	Urban Parkland/Open Space	*Open Space - fair*	79	0.00	0	0.3	0.00
Class D soils	Urban Parkland/Open Space	*Open Space - fair*	84	0.00	0	0.3	0.00
Class D soils	Transport Infrastructure	*Dirt - fair*	89	0.00	0	0.5	0.00
Class C soils	Built-up Area (settlement)	*Residential district 1/4 ac*	83	0.00	0	0.45	0.00
	Subtotal for Impervious Areas			0.00	0		0.00
			Totals	34.31	2,729		12.58
				0.343082 km²			

CN (weighted) : $\frac{\text{total product}}{\text{total area}} = \frac{2,729}{34.308} = 79.54$ 0.3666

For ungaged watersheds, the SCS suggests that the UH lag time may be related to time of concentration, t_c, as:

$$t_{lag} = 0.6\,t_c \qquad (38)$$

2. Time of Concentration https://www.hec.usace.army.mil/software/hec-hms/documentation/HEC-HMS_Technical%20Reference

Time of Concentration t_c = 0.32 hrs 19.07 min

SCS Lag for HEC-HMS : t_p = 0.6 t_c = 0.19 hrs 11.441 min

3. Soil Storage Parameter : S = ((1000/CN)-10)*25.4

Total = 65.3 mm
Pervious = 65.3 mm
Impervious = mm

4. Initial Abstraction

Ia = 0.2S = 13.06764

above parameters used in SCS method analysis in HEC HMS

5. Rainfall data

Using Region-specific temporal patterns produced in HIRDS v4 by NIWA for 1 hour, 6 hour and 12 hour storm durations
RCP8.5

5. Results

Pre-Development
Results Peak Discharge (m3/s)

hr	Q10	Q15	Q100
1	2.0	2.4	4.8
6	2.7	3.0	4.5
12	1.6	1.8	2.9

Rational Method

19 min

		Q10	Q15	Q100
Rainfall intensity		81.6	95.1	129.2
Peak Flow Rate, Q :		2.85	3.33	4.52

Calculation Description

Kaka 3a

Determine peak flow rate with variety of methods
Determine runoff volume for pond sizing calculations

SCS Method

1. Runoff Curve Number (CN) and Initial Abstraction (Ia)

Soil name and classification		Cover description (cover type, treatment, and hydrologic condition)		SCS Method: Curve Number CN*	SCS Method: Area (hectares)	SCS Method: Product of CN x Area	Rational Method: C	Rational Method: Product
		LCDB	CN classification					
		Pervious Areas (List)						
Class B soils		Deciduous Hardwoods	Woods - fair	60	0.00	0	0.25	0.00
Class C soils		Deciduous Hardwoods	Woods - fair	73	0.00	0	0.25	0.00
Class D soils		Deciduous Hardwoods	Woods - fair	79	0.00	0	0.35	0.00
Class B soils		Broadleaved Indigenous Hardwo	Woods - fair	60	0.00	0	0.25	0.00
Class D soils		Broadleaved Indigenous Hardwo	Woods - fair	79	0.01	1	0.35	0.00
Class B soils		Indigenous Forest	Woods - fair	60	0.00	0	0.25	0.00
Class D soils		Indigenous Forest	Woods - fair	79	0.00	0	0.25	0.00
Class B soils		Manuka and/or Kanuka	Brush-weed-grass mix	56	0.00	0	0.25	0.00
Class D soils		Manuka and/or Kanuka	Brush-weed-grass mix	77	0.18	14	0.35	0.06
Class C soils		Exotic Forest	Woods - grass combo	76	0.00	0	0.25	0.00
Class D soils		Exotic Forest	Woods - grass combo	82	0.00	0	0.35	0.00
Class C soils		Forest - Harvested	Newly graded area (pe	91	0.00	0	0.25	0.00
Class C soils		Gorse and/or Broom	Brush-weed-grass mix	70	0.00	0	0.25	0.00
Class D soils		Gorse and/or Broom	Brush-weed-grass mix	77	0.46	35	0.35	0.16
Class B soils		High Producing Exotic Grassland	Pasture - fair	69	1.18	82	0.3	0.35
Class C soils		High Producing Exotic Grassland	Pasture - fair	79	0.00	0	0.3	0.00
Class D soils		High Producing Exotic Grassland	Pasture - fair	84	9.41	790	0.4	3.76
Class C soils		Low Producing Grassland	Pasture - poor	86	0.00	0	0.3	0.00
Class D soils		Low Producing Grassland	Pasture - poor	89	0.00	0	0.4	0.00
		Subtotal for Pervious Areas			11.24	922		4.34
		Impervious Areas (List)						
Class C soils		Urban Parkland/Open Space	Open Space - fair	79	0.00	0	0.3	0.00
Class D soils		Urban Parkland/Open Space	Open Space - fair	84	0.00	0	0.3	0.00
Class D soils		Transport Infrastructure	Dirt - fair	89	0.00	0	0.5	0.00
Class C soils		Built-up Area (settlement)	Residential district 1/4	83	0.00	0	0.45	0.00
		Subtotal for Impervious Areas			0.00	0		0.00
				Totals	11.24	922		4.34

0.112374 km²

CN (weighted) : $\frac{\text{total product}}{\text{total area}} = \frac{922}{11.237} = 82.02$ 0.3866

2. Time of Concentration

Time of Concentration t_c = 0.34 hrs 20.13 min

SCS Lag for HEC-HMS : t_p = 0.6 t_c = 0.20 hrs 12.07525 min

3. Soil Storage Parameter : S = ((1000/CN)-10)*25.4

Total = 55.7 mm
Pervious = 55.7 mm
Impervious = mm

4. Initial Abstraction

Ia = 0.2S = 11.13576

above parameters used in SCS method analysis in HEC HMS

5. Rainfall data

Using Region-specific temporal patterns produced in HIRDS v4 by NIWA for 1 hour, 6 hour and 12 hour storm durations
RCP8.5

5. Results

Pre-Development
Results Peak Discharge (m3/s)

hr	Q10	Q15	Q100
1	0.8	0.9	1.7
6	0.9	1.0	1.5
12	0.6	0.6	1.0

Rational Method

20 min

		Q10	Q15	Q100
Rainfall intensity		79.6	92.9	126.1
Peak Flow Rate, Q :		0.96	1.12	1.52

Calculation Description

Kaka 3b

Determine peak flow rate with variety of methods
Determine runoff volume for pond sizing calculations

SCS Method

1. Runoff Curve Number (CN) and Initial Abstraction (Ia)

Soil name and classification	Cover description (cover type, treatment, and hydrologic condition)		SCS Method			Rational Method	
			Curve Number CN*	Area (hectares)	Product of CN x Area	C	Product
	LCDB	CN classification					
	Pervious Areas (List)						
Class B soils	Deciduous Hardwoods	Woods - fair	60	0.00	0	0.25	0.00
Class C soils	Deciduous Hardwoods	Woods - fair	73	0.00	0	0.25	0.00
Class D soils	Deciduous Hardwoods	Woods - fair	79	0.00	0	0.35	0.00
Class B soils	Broadleaved Indigenous Hardwo	Woods - fair	60	0.00	0	0.25	0.00
Class D soils	Broadleaved Indigenous Hardwo	Woods - fair	79	0.00	0	0.35	0.00
Class B soils	Indigenous Forest	Woods - fair	60	0.00	0	0.25	0.00
Class D soils	Indigenous Forest	Woods - fair	79	0.00	0	0.25	0.00
Class B soils	Manuka and/or Kanuka	Brush-weed-grass mix -	56	0.00	0	0.25	0.00
Class D soils	Manuka and/or Kanuka	Brush-weed-grass mix -	77	0.00	0	0.35	0.00
Class C soils	Exotic Forest	Woods - grass combo -	76	0.00	0	0.25	0.00
Class D soils	Exotic Forest	Woods - grass combo -	82	0.00	0	0.35	0.00
Class C soils	Forest - Harvested	Newly graded area (per	91	0.00	0	0.25	0.00
Class C soils	Gorse and/or Broom	Brush-weed-grass mix -	70	0.00	0	0.25	0.00
Class D soils	Gorse and/or Broom	Brush-weed-grass mix -	77	0.00	0	0.35	0.00
Class B soils	High Producing Exotic Grassland	Pasture - fair	69	5.67	391	0.3	1.70
Class C soils	High Producing Exotic Grassland	Pasture - fair	79	0.00	0	0.3	0.00
Class D soils	High Producing Exotic Grassland	Pasture - fair	84	0.31	26	0.4	0.12
Class C soils	Low Producing Grassland	Pasture - poor	86	0.00	0	0.3	0.00
Class D soils	Low Producing Grassland	Pasture - poor	89	0.00	0	0.4	0.00
		Subtotal for Pervious Areas		5.99	418		1.83
	Impervious Areas (List)						
Class C soils	Urban Parkland/Open Space	Open Space - fair	79	0.00	0	0.3	0.00
Class D soils	Urban Parkland/Open Space	Open Space - fair	84	0.00	0	0.3	0.00
Class D soils	Transport Infrastructure	Dirt - fair	89	0.00	0	0.5	0.00
Class C soils	Built-up Area (settlement)	Residential district 1/4 a	83	0.00	0	0.45	0.00
		Subtotal for Impervious Areas		0.00	0		0.00
			Totals	5.99	418		1.83
				0.059857 km²			

CN (weighted) : $\frac{\text{total product}}{\text{total area}}$ = $\frac{418}{5.986}$ = 69.78 0.3052

2. Time of Concentration

Time of Concentration t_c = 0.52 hrs 31.20 min

SCS Lag for HEC-HMS : t_p = 0.6 t_c = 0.31 hrs 18.71971 min

3. Soil Storage Parameter : S = ((1000/CN)-10)*25.4

Total = 110.0 mm
Pervious = 110.0 mm
Impervious = mm

4. Initial Abstraction

Ia = 0.2S = 21.99714

above parameters used in SCS method analysis in HEC HMS

5. Rainfall data

Using Region-specific temporal patterns produced in HIRDS v4 by NIWA for 1 hour, 6 hour and 12 hour storm durations
RCP8.5

5. Results

Pre-Development
Results Peak Discharge (m3/s)

hr	Q10	Q15	Q100
1	0.1	0.1	0.4
6	0.4	0.4	0.6
12	0.2	0.2	0.4

Rational Method

31 min

		Q10	Q15	Q100
Rainfall intensity		65.5	76.3	103.5
Peak Flow Rate, Q :		0.33	0.39	0.53

Calculation Description

Brooklands 1

Determine peak flow rate with variety of methods
Determine runoff volume for pond sizing calculations

SCS Method

1. Runoff Curve Number (CN) and Initial Abstraction (Ia)

Soil name and classification	Cover description (cover type, treatment, and hydrologic condition) LCDB	CN classification	SCS Method: Curve Number CN*	SCS Method: Area (hectares)	SCS Method: Product of CN x Area	Rational Method: C	Rational Method: Product
	Pervious Areas (List)						
Class B soils	Deciduous Hardwoods	Woods - fair	60	0.00	0	0.25	0.00
Class C soils	Deciduous Hardwoods	Woods - fair	73	0.00	0	0.25	0.00
Class D soils	Deciduous Hardwoods	Woods - fair	79	0.00	0	0.35	0.00
Class B soils	Broadleaved Indigenous Hardwo	Woods - fair	60	0.00	0	0.25	0.00
Class D soils	Broadleaved Indigenous Hardwo	Woods - fair	79	0.00	0	0.35	0.00
Class B soils	Indigenous Forest	Woods - fair	60	0.00	0	0.25	0.00
Class D soils	Indigenous Forest	Woods - fair	79	0.00	0	0.25	0.00
Class B soils	Manuka and/or Kanuka	Brush-weed-grass mix	56	0.00	0	0.25	0.00
Class D soils	Manuka and/or Kanuka	Brush-weed-grass mix	77	0.00	0	0.35	0.00
Class C soils	Exotic Forest	Woods - grass combo	76	1.73	131	0.25	0.43
Class D soils	Exotic Forest	Woods - grass combo	82	0.00	0	0.35	0.00
Class C soils	Forest - Harvested	Newly graded area (pe	91	0.00	0	0.25	0.00
Class C soils	Gorse and/or Broom	Brush-weed-grass mix	70	16.98	1,189	0.25	4.25
Class D soils	Gorse and/or Broom	Brush-weed-grass mix	77	0.00	0	0.35	0.00
Class B soils	High Producing Exotic Grassland	Pasture - fair	69	0.00	0	0.3	0.00
Class C soils	High Producing Exotic Grassland	Pasture - fair	79	6.19	489	0.3	1.86
Class D soils	High Producing Exotic Grassland	Pasture - fair	84	0.00	0	0.4	0.00
Class C soils	Low Producing Grassland	Pasture - poor	86	2.77	239	0.3	0.83
Class D soils	Low Producing Grassland	Pasture - poor	89	0.00	0	0.4	0.00
	Subtotal for Pervious Areas			27.67	2,048		7.37
	Impervious Areas (List)						
Class C soils	Urban Parkland/Open Space	Open Space - fair	79	1.62	128	0.3	0.49
Class D soils	Urban Parkland/Open Space	Open Space - fair	84	0.00	0	0.3	0.00
Class D soils	Transport Infrastructure	Dirt - fair	89	0.00	0	0.5	0.00
Class C soils	Built-up Area (settlement)	Residential district 1/4 a	83	5.47	454	0.45	2.46
	Subtotal for Impervious Areas			7.09	582		2.95
			Totals	34.76	2,630		10.31

0.347631 km²

CN (weighted) : $\frac{\text{total product}}{\text{total area}} = \frac{2,630}{34.763} = 75.64$ 0.2967

2. Time of Concentration

Time of Concentration	t_c =			0.33	hrs	19.73 min
SCS Lag for HEC-HMS :	t_p =	0.6 t_c	=	0.20	hrs	11.8405 min

3. Soil Storage Parameter : S = ((1000/CN)-10)*25.4

Total	=	81.8	mm
Pervious	=	89.3	mm
Impervious	=		mm

4. Initial Abstraction

Ia = 0.2S = 16.35832

above parameters used in SCS method analysis in HEC HMS

5. Rainfall data

Using Region-specific temporal patterns produced in HIRDS v4 by NIWA for 1 hour, 6 hour and 12 hour storm durations
RCP8.5

5. Results

Pre-Development

Results Peak Discharge (m3/s)

hr	Q10	Q15	Q100
1	1.5	1.8	4.0
6	2.5	2.8	4.3
12	1.5	1.7	2.8

Rational Method

20 min

		Q10	Q15	Q100
Rainfall intensity		80.3	93.7	127.2
Peak Flow Rate, Q :		2.30	2.69	3.65

Calculation Description

Brooklands 2

Determine peak flow rate with variety of methods
Determine runoff volume for pond sizing calculations

SCS Method

1. Runoff Curve Number (CN) and Initial Abstraction (Ia)

Soil name and classification	Cover description (cover type, treatment, and hydrologic condition)		SCS Method: Curve Number CN*	SCS Method: Area (hectares)	SCS Method: Product of CN x Area	Rational Method: C	Rational Method: Product
	LCDB	CN classification					
	Pervious Areas (List)						
Class B soils	Deciduous Hardwoods	Woods - fair	60	0.00	0	0.25	0.00
Class C soils	Deciduous Hardwoods	Woods - fair	73	0.00	0	0.25	0.00
Class D soils	Deciduous Hardwoods	Woods - fair	79	0.00	0	0.35	0.00
Class B soils	Broadleaved Indigenous Hardwo	Woods - fair	60	0.00	0	0.25	0.00
Class D soils	Broadleaved Indigenous Hardwo	Woods - fair	79	0.00	0	0.35	0.00
Class B soils	Indigenous Forest	Woods - fair	60	0.00	0	0.25	0.00
Class D soils	Indigenous Forest	Woods - fair	79	0.00	0	0.25	0.00
Class B soils	Manuka and/or Kanuka	Brush-weed-grass mix -	56	0.00	0	0.25	0.00
Class D soils	Manuka and/or Kanuka	Brush-weed-grass mix -	77	0.00	0	0.35	0.00
Class C soils	Exotic Forest	Woods - grass combo -	76	3.75	285	0.25	0.94
Class D soils	Exotic Forest	Woods - grass combo -	82	0.08	7	0.35	0.03
Class C soils	Forest - Harvested	Newly graded area (perv	91	0.00	0	0.25	0.00
Class C soils	Gorse and/or Broom	Brush-weed-grass mix -	70	9.72	680	0.25	2.43
Class D soils	Gorse and/or Broom	Brush-weed-grass mix -	77	0.01	1	0.35	0.00
Class B soils	High Producing Exotic Grassland	Pasture - fair	69	0.00	0	0.3	0.00
Class C soils	High Producing Exotic Grassland	Pasture - fair	79	0.05	4	0.3	0.01
Class D soils	High Producing Exotic Grassland	Pasture - fair	84	0.00	0	0.4	0.00
Class C soils	Low Producing Grassland	Pasture - poor	86	2.22	191	0.3	0.67
Class D soils	Low Producing Grassland	Pasture - poor	89	0.14	12	0.4	0.05
		Subtotal for Pervious Areas		15.96	1,179		4.13
	Impervious Areas (List)						
Class C soils	Urban Parkland/Open Space	Open Space - fair	79	8.56	676	0.3	2.57
Class D soils	Urban Parkland/Open Space	Open Space - fair	84	0.00	0	0.3	0.00
Class D soils	Transport Infrastructure	Dirt - fair	89	0.00	0	0.5	0.00
Class C soils	Built-up Area (settlement)	Residential district 1/4 ac	83	12.39	1,028	0.45	5.57
	Subtotal for Impervious Areas			20.95	1,704		8.14
			Totals	36.90	2,883		12.27
				0.369024 km²			

CN (weighted) : $\frac{\text{total product}}{\text{total area}}$ = $\frac{2,883}{36.902}$ = 78.13   0.3326

2. Time of Concentration

Time of Concentration t_c = 0.25 hrs 14.90 min

SCS Lag for HEC-HMS : t_p = 0.6 t_c = 0.15 hrs 8.94121 min

3. Soil Storage Parameter : S = ((1000/CN)-10)*25.4

Total = 71.1 mm
Pervious = 89.8 mm
Impervious = mm

4. Initial Abstraction

Ia = 0.2S = 14.21702

above parameters used in SCS method analysis in HEC HMS

5. Rainfall data

Using Region-specific temporal patterns produced in HIRDS v4 by NIWA for 1 hour, 6 hour and 12 hour storm durations
RCP8.5

5. Results

Pre-Development
Results Peak Discharge (m3/s)

hr	Q10	Q15	Q100
1	2.7	3.2	6.6
6	2.9	3.2	4.8
12	1.7	1.9	3.1

Rational Method

15 min

		Q10	Q15	Q100
Rainfall intensity		91.1	106.3	144.4
Peak Flow Rate, Q :		3.11	3.63	4.93

Calculation Description

Brooklands 3

Determine peak flow rate with variety of methods
Determine runoff volume for pond sizing calculations

SCS Method

1. Runoff Curve Number (CN) and Initial Abstraction (Ia)

Soil name and classification	Cover description (cover type, treatment, and hydrologic condition)		SCS Method: Curve Number CN*	SCS Method: Area (hectares)	SCS Method: Product of CN x Area	Rational Method: C	Rational Method: Product
	LCDB	CN classification					
	Pervious Areas (List)						
Class B soils	Deciduous Hardwoods	Woods - fair	60	0.00	0	0.25	0.00
Class C soils	Deciduous Hardwoods	Woods - fair	73	0.17	12	0.25	0.04
Class D soils	Deciduous Hardwoods	Woods - fair	79	0.00	0	0.35	0.00
Class B soils	Broadleaved Indigenous Hardwo	Woods - fair	60	0.00	0	0.25	0.00
Class D soils	Broadleaved Indigenous Hardwo	Woods - fair	79	0.00	0	0.35	0.00
Class B soils	Indigenous Forest	Woods - fair	60	0.00	0	0.25	0.00
Class D soils	Indigenous Forest	Woods - fair	79	0.00	0	0.25	0.00
Class B soils	Manuka and/or Kanuka	Brush-weed-grass mix	56	0.00	0	0.25	0.00
Class D soils	Manuka and/or Kanuka	Brush-weed-grass mix	77	0.00	0	0.35	0.00
Class C soils	Exotic Forest	Woods - grass combo	76	0.00	0	0.25	0.00
Class D soils	Exotic Forest	Woods - grass combo	82	0.12	10	0.35	0.04
Class C soils	Forest - Harvested	Newly graded area (pe	91	0.00	0	0.25	0.00
Class C soils	Gorse and/or Broom	Brush-weed-grass mix	70	15.05	1,053	0.25	3.76
Class D soils	Gorse and/or Broom	Brush-weed-grass mix	77	0.45	35	0.35	0.16
Class B soils	High Producing Exotic Grassland	Pasture - fair	69	0.00	0	0.3	0.00
Class C soils	High Producing Exotic Grassland	Pasture - fair	79	1.86	147	0.3	0.56
Class D soils	High Producing Exotic Grassland	Pasture - fair	84	0.00	0	0.4	0.00
Class C soils	Low Producing Grassland	Pasture - poor	86	0.00	0	0.3	0.00
Class D soils	Low Producing Grassland	Pasture - poor	89	0.00	0	0.4	0.00
	Subtotal for Pervious Areas			17.65	1,258		4.56
	Impervious Areas (List)						
Class C soils	Urban Parkland/Open Space	Open Space - fair	79	0.00	0	0.3	0.00
Class D soils	Urban Parkland/Open Space	Open Space - fair	84	0.00	0	0.3	0.00
Class D soils	Transport Infrastructure	Dirt - fair	89	0.00	0	0.5	0.00
Class C soils	Built-up Area (settlement)	Residential district 1/4	83	0.52	43	0.45	0.24
	Subtotal for Impervious Areas			0.52	43		0.24
			Totals	18.17	1,301		4.80
				0.181749 km²			

CN (weighted) : $\frac{\text{total product}}{\text{total area}}$ = $\frac{1{,}301}{18.175}$ = 71.58   0.2641

2. Time of Concentration

Time of Concentration t_c = 0.24 hrs 14.26 min

SCS Lag for HEC-HMS : t_p = 0.6 t_c = 0.14 hrs 8.555903 min

3. Soil Storage Parameter : S = ((1000/CN)-10)*25.4

Total = 100.8 mm
Pervious = 102.5 mm
Impervious = mm

4. Initial Abstraction

Ia = 0.2S = 20.16875

above parameters used in SCS method analysis in HEC HMS

5. Rainfall data

Using Region-specific temporal patterns produced in HIRDS v4 by NIWA for 1 hour, 6 hour and 12 hour storm durations
RCP8.5

5. Results

Pre-Development
Results Peak Discharge (m3/s)

hr	Q10	Q15	Q100
1	0.8	1.0	2.4
6	1.2	1.3	2.1
12	0.7	0.8	1.4

Rational Method

14 min

		Q10	Q15	Q100
Rainfall intensity		92.9	108.4	147.3
Peak Flow Rate, Q :		1.24	1.45	1.97

Calculation Description

Brooklands 4

Determine peak flow rate with variety of methods
Determine runoff volume for pond sizing calculations

SCS Method

1. Runoff Curve Number (CN) and Initial Abstraction (Ia)

Soil name and classification	Cover description (cover type, treatment, and hydrologic condition)		SCS Method: Curve Number CN*	SCS Method: Area (hectares)	SCS Method: Product of CN x Area	Rational Method: C	Rational Method: Product
	LCDB	CN classification					
	Pervious Areas (List)						
Class B soils	Deciduous Hardwoods	Woods - fair	60	0.00	0	0.25	0.00
Class C soils	Deciduous Hardwoods	Woods - fair	73	0.00	0	0.25	0.00
Class D soils	Deciduous Hardwoods	Woods - fair	79	0.00	0	0.35	0.00
Class B soils	Broadleaved Indigenous Hardwo	Woods - fair	60	0.00	0	0.25	0.00
Class D soils	Broadleaved Indigenous Hardwo	Woods - fair	79	0.00	0	0.35	0.00
Class B soils	Indigenous Forest	Woods - fair	60	0.00	0	0.25	0.00
Class D soils	Indigenous Forest	Woods - fair	79	0.00	0	0.25	0.00
Class B soils	Manuka and/or Kanuka	Brush-weed-grass mix	56	0.00	0	0.25	0.00
Class D soils	Manuka and/or Kanuka	Brush-weed-grass mix	77	0.02	1	0.35	0.01
Class C soils	Exotic Forest	Woods - grass combo	76	0.00	0	0.25	0.00
Class D soils	Exotic Forest	Woods - grass combo	82	0.04	3	0.35	0.01
Class C soils	Forest - Harvested	Newly graded area (pe	91	1.82	165	0.25	0.45
Class C soils	Gorse and/or Broom	Brush-weed-grass mix	70	7.03	492	0.25	1.76
Class D soils	Gorse and/or Broom	Brush-weed-grass mix	77	0.88	68	0.35	0.31
Class B soils	High Producing Exotic Grassland	Pasture - fair	69	0.00	0	0.3	0.00
Class C soils	High Producing Exotic Grassland	Pasture - fair	79	0.00	0	0.3	0.00
Class D soils	High Producing Exotic Grassland	Pasture - fair	84	0.00	0	0.4	0.00
Class C soils	Low Producing Grassland	Pasture - poor	86	0.00	0	0.3	0.00
Class D soils	Low Producing Grassland	Pasture - poor	89	0.00	0	0.4	0.00
	Subtotal for Pervious Areas			9.78	730		2.54
	Impervious Areas (List)						
Class C soils	Urban Parkland/Open Space	Open Space - fair	79	0.00	0	0.3	0.00
Class D soils	Urban Parkland/Open Space	Open Space - fair	84	0.00	0	0.3	0.00
Class D soils	Transport Infrastructure	Dirt - fair	89	0.00	0	0.5	0.00
Class C soils	Built-up Area (settlement)	Residential district 1/4 a	83	0.00	0	0.45	0.00
	Subtotal for Impervious Areas			0.00	0		0.00
			Totals	9.78	730		2.54

0.097826 km²

CN (weighted) : total product / total area = 730 / 9.783 = 74.59   0.2596

2. Time of Concentration

Time of Concentration t_c = 0.26 hrs 15.46 min

SCS Lag for HEC-HMS : t_p = 0.6 t_c = 0.15 hrs 9.27508 min

3. Soil Storage Parameter : S = ((1000/CN)-10)*25.4

Total = 86.5 mm
Pervious = 86.5 mm
Impervious = mm

4. Initial Abstraction

Ia = 0.2S = 17.30793

above parameters used in SCS method analysis in HEC HMS

5. Rainfall data

Using Region-specific temporal patterns produced in HIRDS v4 by NIWA for 1 hour, 6 hour and 12 hour storm durations
RCP8.5

5. Results

Pre-Development
Results Peak Discharge (m3/s)

hr	Q10	Q15	Q100
1	0.5	0.7	1.5
6	0.7	0.8	1.2
12	0.4	0.5	0.8

Rational Method

15 min

		Q10	Q15	Q100
Rainfall intensity		89.6	104.5	142.1
Peak Flow Rate, Q :		0.63	0.74	1.00

Calculation Description

Walters Bluff

Determine peak flow rate with variety of methods
Determine runoff volume for pond sizing calculations

SCS Method

1. Runoff Curve Number (CN) and Initial Abstraction (Ia)

Soil name and classification	Cover description (cover type, treatment, and hydrologic condition) – LCDB	CN classification	SCS Method: Curve Number CN*	SCS Method: Area (hectares)	SCS Method: Product of CN x Area	Rational Method: C	Rational Method: Product
	Pervious Areas (List)						
Class B soils	Deciduous Hardwoods	Woods - fair	60	0.00	0	0.25	0.00
Class C soils	Deciduous Hardwoods	Woods - fair	73	0.00	0	0.25	0.00
Class D soils	Deciduous Hardwoods	Woods - fair	79	0.00	0	0.35	0.00
Class B soils	Broadleaved Indigenous Hardwo	Woods - fair	60	0.00	0	0.25	0.00
Class D soils	Broadleaved Indigenous Hardwo	Woods - fair	79	0.00	0	0.35	0.00
Class B soils	Indigenous Forest	Woods - fair	60	0.00	0	0.25	0.00
Class D soils	Indigenous Forest	Woods - fair	79	0.00	0	0.25	0.00
Class B soils	Manuka and/or Kanuka	Brush-weed-grass mix -	56	0.00	0	0.25	0.00
Class D soils	Manuka and/or Kanuka	Brush-weed-grass mix -	77	0.00	0	0.35	0.00
Class C soils	Exotic Forest	Woods - grass combo -	76	0.01	0	0.25	0.00
Class D soils	Exotic Forest	Woods - grass combo -	82	0.00	0	0.35	0.00
Class C soils	Forest - Harvested	Newly graded area (per	91	0.00	0	0.25	0.00
Class C soils	Gorse and/or Broom	Brush-weed-grass mix -	70	9.28	650	0.25	2.32
Class D soils	Gorse and/or Broom	Brush-weed-grass mix -	77	0.01	1	0.35	0.00
Class B soils	High Producing Exotic Grassland	Pasture - fair	69	0.00	0	0.3	0.00
Class C soils	High Producing Exotic Grassland	Pasture - fair	79	0.80	63	0.3	0.24
Class D soils	High Producing Exotic Grassland	Pasture - fair	84	0.00	0	0.4	0.00
Class C soils	Low Producing Grassland	Pasture - poor	86	0.37	32	0.3	0.11
Class D soils	Low Producing Grassland	Pasture - poor	89	0.00	0	0.4	0.00
		Subtotal for Pervious Areas		10.47	746		2.68
	Impervious Areas (List)						
Class C soils	Urban Parkland/Open Space	Open Space - fair	79	0.00	0	0.3	0.00
Class D soils	Urban Parkland/Open Space	Open Space - fair	84	0.00	0	0.3	0.00
Class D soils	Transport Infrastructure	Dirt - fair	89	0.00	0	0.5	0.00
Class C soils	Built-up Area (settlement)	Residential district 1/4 a	83	5.05	419	0.45	2.27
	Subtotal for Impervious Areas			5.05	419		2.27
			Totals	15.52	1,165		4.95

0.155175 km²

CN (weighted) : total product / total area = 1,165 / 15.517 = 75.08   0.3189

2. Time of Concentration

Time of Concentration t_c = 0.29 hrs 17.48 min

SCS Lag for HEC-HMS : t_p = 0.6 t_c = 0.17 hrs 10.4874 min

3. Soil Storage Parameter : S = ((1000/CN)-10)*25.4

Total = 84.3 mm
Pervious = 102.4 mm
Impervious = mm

4. Initial Abstraction

Ia = 0.2S = 16.85955

above parameters used in SCS method analysis in HEC HMS

5. Rainfall data

Using Region-specific temporal patterns produced in HIRDS v4 by NIWA for 1 hour, 6 hour and 12 hour storm durations
RCP8.5

5. Results

Pre-Development
Results Peak Discharge (m3/s)

hr	Q10	Q15	Q100
1	0.9	1.0	2.3
6	1.1	1.2	1.9
12	0.7	0.7	1.2

Rational Method

17 min

		Q10	Q15	Q100
Rainfall intensity		84.8	98.9	134.4
Peak Flow Rate, Q :		1.17	1.36	1.85

Calculation Description

Bradford Park

Determine peak flow rate with variety of methods
Determine runoff volume for pond sizing calculations

SCS Method

1. Runoff Curve Number (CN) and Initial Abstraction (Ia)

Soil name and classification	Cover description (cover type, treatment, and hydrologic condition)		SCS Method: Curve Number CN*	SCS Method: Area (hectares)	SCS Method: Product of CN x Area	Rational Method: C	Rational Method: Product
	LCDB	CN classification					
	Pervious Areas (List)						
Class B soils	Deciduous Hardwoods	Woods - fair	60	0.00	0	0.25	0.00
Class C soils	Deciduous Hardwoods	Woods - fair	73	0.00	0	0.25	0.00
Class D soils	Deciduous Hardwoods	Woods - fair	79	0.00	0	0.35	0.00
Class B soils	Broadleaved Indigenous Hardwo	Woods - fair	60	0.08	5	0.25	0.02
Class D soils	Broadleaved Indigenous Hardwo	Woods - fair	79	14.01	1,107	0.35	4.91
Class B soils	Indigenous Forest	Woods - fair	60	1.98	119	0.25	0.50
Class D soils	Indigenous Forest	Woods - fair	79	2.18	172	0.25	0.55
Class B soils	Manuka and/or Kanuka	Brush-weed-grass mix -	56	1.02	57	0.25	0.26
Class D soils	Manuka and/or Kanuka	Brush-weed-grass mix -	77	6.79	523	0.35	2.38
Class C soils	Exotic Forest	Woods - grass combo -	76	0.00	0	0.25	0.00
Class D soils	Exotic Forest	Woods - grass combo -	82	0.00	0	0.35	0.00
Class C soils	Forest - Harvested	Newly graded area (per	91	0.00	0	0.25	0.00
Class C soils	Gorse and/or Broom	Brush-weed-grass mix -	70	0.33	23	0.25	0.08
Class D soils	Gorse and/or Broom	Brush-weed-grass mix -	77	4.62	356	0.35	1.62
Class B soils	High Producing Exotic Grassland	Pasture - fair	69	2.39	165	0.3	0.72
Class C soils	High Producing Exotic Grassland	Pasture - fair	79	0.68	54	0.3	0.20
Class D soils	High Producing Exotic Grassland	Pasture - fair	84	0.55	46	0.4	0.22
Class C soils	Low Producing Grassland	Pasture - poor	86	0.00	0	0.3	0.00
Class D soils	Low Producing Grassland	Pasture - poor	89	0.00	0	0.4	0.00
	Subtotal for Pervious Areas			34.64	2,627		11.44
	Impervious Areas (List)						
Class C soils	Urban Parkland/Open Space	Open Space - fair	79	0.00	0	0.3	0.00
Class D soils	Urban Parkland/Open Space	Open Space - fair	84	0.06	5	0.3	0.02
Class D soils	Transport Infrastructure	Dirt - fair	89	0.00	0	0.5	0.00
Class C soils	Built-up Area (settlement)	Residential district 1/4 a	83	0.00	0	0.45	0.00
	Subtotal for Impervious Areas			0.06	5		0.02
			Totals	34.70	2,632		11.46
				0.347 km²			

CN (weighted) : $\frac{\text{total product}}{\text{total area}}$ = $\frac{2,632}{34.700}$ = 75.85   0.3302

2. Time of Concentration

Time of Concentration t_c = 0.47 hrs 28.23 min

SCS Lag for HEC-HMS : t_p = 0.6 t_c = 0.28 hrs 16.93972 min

3. Soil Storage Parameter : S = ((1000/CN)-10)*25.4

Total = 80.9 mm
Pervious = 80.9 mm
Impervious = mm

4. Initial Abstraction

Ia = 0.2S = 16.17214

above parameters used in SCS method analysis in HEC HMS

5. Rainfall data

Using Region-specific temporal patterns produced in HIRDS v4 by NIWA for 1 hour, 6 hour and 12 hour storm durations RCP8.5

5. Results

Pre-Development

Results Peak Discharge (m3/s)

hr	Q10	Q15	Q100
1	1.7	2.0	4.4
6	2.6	2.8	4.3
12	1.5	1.7	2.8

Rational Method

28 min

		Q10	Q15	Q100
Rainfall intensity		68.4	79.8	108.2
Peak Flow Rate, Q :		2.18	2.54	3.45

STORMWATER ASSESSMENT - POST-DEVELOPMENT SCENARIO

Project: PPC28 SWMP **By:** CHGR **Date:** 1/08/2022

Location: Kaka Hill **Checked:** BYMU **Date:** 1/08/2022

Calculation Description

Kaka 1

Determine peak flow rate with variety of methods
Determine runoff volume for pond sizing calculations

SCS Method

1. Runoff Curve Number (CN) and Initial Abstraction (Ia)

	Soil name and classification	Cover description (cover type, treatment, and hydrologic condition) LCDB	CN classification	Curve Number CN*	Area (hectares)	Product of CN x Area
		Pervious Areas (List)				
B	Class B soils	Deciduous Hardwoods	Woods - fair	60	0.00	0
C	Class C soils	Deciduous Hardwoods	Woods - fair	73	0.00	0
D	Class D soils	Deciduous Hardwoods	Woods - fair	79	0.00	0
B	Class B soils	Broadleaved Indigenous Hardwo	Woods - fair	60	0.00	0
D	Class D soils	Broadleaved Indigenous Hardwo	Woods - fair	79	3.23	255
B	Class B soils	Indigenous Forest	Woods - fair	60	0.00	0
D	Class D soils	Indigenous Forest	Woods - fair	79	0.01	1
B	Class B soils	Manuka and/or Kanuka	Brush-weed-grass mix -	56	0.00	0
D	Class D soils	Manuka and/or Kanuka	Brush-weed-grass mix -	77	94.31	7,262
C	Class C soils	Exotic Forest	Woods - grass combo -	76	0.02	1
D	Class D soils	Exotic Forest	Woods - grass combo -	82	10.76	883
C	Class C soils	Forest - Harvested	Newly graded area (per	91	0.00	0
C	Class C soils	Gorse and/or Broom	Brush-weed-grass mix -	70	1.06	74
D	Class D soils	Gorse and/or Broom	Brush-weed-grass mix -	77	35.56	2,738
B	Class B soils	High Producing Exotic Grassland	Pasture - fair	69	0.00	0
C	Class C soils	High Producing Exotic Grassland	Pasture - fair	79	0.00	0
D	Class D soils	High Producing Exotic Grassland	Pasture - fair	84	0.18	15
C	Class C soils	Low Producing Grassland	Pasture - poor	86	0.14	12
D	Class D soils	Low Producing Grassland	Pasture - poor	89	0.17	15
B	Class B soils	Open Space	Open Space - fair	69	0.19	13
C	Class C soils	Open Space	Open Space - fair	79	1.69	133
D	Class D soils	Open Space	Open Space - fair	84	19.16	1,609
C	Class C soils	Rural	Brush-weed-grass mix -	70	2.66	186
D	Class D soils	Rural	Brush-weed-grass mix -	77	17.54	1,350
		Subtotal for Pervious Areas			186.66	14,548
		Impervious Areas (List)				
C	Class C soils	Urban Parkland/Open Space	Open Space - fair	79	0.00	0
D	Class D soils	Urban Parkland/Open Space	Open Space - fair	84	0.00	0
D	Class D soils	Transport Infrastructure	Dirt - fair	89	1.59	142
C	Class C soils	Built-up Area (settlement)	Residential district 1/4 a	83	0.00	0
B	Class B soils	Commercial	Commercial and Busine	92	0.00	0
D	Class D soils	Commercial	Commercial and Busine	95	0.00	0
		Impervious	Paved parking lots, roof	98	14.76	1,447
		Subtotal for Impervious Areas			16.35	1588
	* from Table 3.3			Totals	203.01	16,136

CN (weighted) : total product / total area = 16,136 / 203.013 = 79.48

Weighted CN Pervious = 77.94
Weighted CN Impervious = 97.12

2. Time of Concentration

Time of Concentration	t_c =		0.70	hrs	41.74 min
SCS Lag for HEC-HMS :	t_p =	0.6 t_c =	0.42	hrs	25.04555 min

3. Soil Storage Parameter : S = ((1000/CN)-10)*25.4

Total	=	65.6	mm
Pervious	=	71.9	mm
Impervious	=	7.5	mm

4. Initial Abstraction

Initial abstraction - Pervious	Ia = 0.2S	=	14.38
Initial abstraction - impervious	Ia = 0.2S	=	1.50
Initial abstraction - Compound	Ia = 0.2S	=	13.11436

above parameters used in SCS method analysis in HEC HMS

5. Rainfall data

Using Region-specific temporal patterns produced in HIRDS v4 by NIWA for 1 hour, 6 hour and 12 hour storm durations
RCP8.5

5. Results

Pre-Development
Results Peak Discharge (m3/s)

hr	Q10	Q15	Q100
1	10.0	11.9	24.3
6	16.0	17.4	26.1
12	9.5	10.6	17.0

Calculation Description

Kaka 2

Determine peak flow rate with variety of methods
Determine runoff volume for pond sizing calculations

SCS Method

1. Runoff Curve Number (CN) and Initial Abstraction (Ia)

Soil name and classification	Cover description (cover type, treatment, and hydrologic condition)		SCS Method: Curve Number CN*	Area (hectares)	Product of CN x Area
	LCDB	CN classification			
	Pervious Areas (List)				
Class B soils	Deciduous Hardwoods	*Woods - fair*	60	0.00	0
Class C soils	Deciduous Hardwoods	*Woods - fair*	73	0.00	0
Class D soils	Deciduous Hardwoods	*Woods - fair*	79	0.00	0
Class B soils	Broadleaved Indigenous Hardwo	*Woods - fair*	60	0.00	0
Class D soils	Broadleaved Indigenous Hardwo	*Woods - fair*	79	0.00	0
Class B soils	Indigenous Forest	*Woods - fair*	60	0.00	0
Class D soils	Indigenous Forest	*Woods - fair*	79	0.00	0
Class B soils	Manuka and/or Kanuka	*Brush-weed-grass m*	56	0.00	0
Class D soils	Manuka and/or Kanuka	*Brush-weed-grass m*	77	0.01	1
Class C soils	Exotic Forest	*Woods - grass comb*	76	0.00	0
Class D soils	Exotic Forest	*Woods - grass comb*	82	1.87	154
Class C soils	Forest - Harvested	*Newly graded area (*	91	0.00	0
Class C soils	Gorse and/or Broom	*Brush-weed-grass m*	70	0.00	0
Class D soils	Gorse and/or Broom	*Brush-weed-grass m*	77	16.59	1,277
Class B soils	High Producing Exotic Grassland	*Pasture - fair*	69	0.78	54
Class C soils	High Producing Exotic Grassland	*Pasture - fair*	79	0.00	0
Class D soils	High Producing Exotic Grassland	*Pasture - fair*	84	1.41	118
Class C soils	Low Producing Grassland	*Pasture - poor*	86	0.00	0
Class D soils	Low Producing Grassland	*Pasture - poor*	89	0.00	0
Class B soils	Open Space	*Open Space - fair*	69	0.91	63
Class C soils	Open Space	*Open Space - fair*	79	0.00	0
Class D soils	Open Space	*Open Space - fair*	84	5.00	420
Class C soils	Rural	*Brush-weed-grass m*	70	0.00	0
Class D soils	Rural	*Brush-weed-grass m*	77	0.31	24
		Subtotal for Pervious Areas		26.88	2,111
	Impervious Areas (List)				
Class C soils	Urban Parkland/Open Space	*Open Space - fair*	79	0.00	0
Class D soils	Urban Parkland/Open Space	*Open Space - fair*	84	0.00	0
Class D soils	Transport Infrastructure	*Dirt - fair*	89	0.00	0
Class C soils	Built-up Area (settlement)	*Residential district 1/*	83	0.00	0
Class B soils	Commercial	*Commercial and Bus*	92	0.02	2
Class D soils	Commercial	*Commercial and Bus*	95	0.13	12
	Impervious	*Paved parking lots, r*	98	7.00	686
		Subtotal for Impervious Areas		7.15	700
* from Table 3.3			Totals	34.03	2,811

CN (weighted) : $\frac{\text{total product}}{\text{total area}} = \frac{2,811}{34.033} = 82.59$

Weighted CN Pervious = 78.52
Weighted CN Impervious = 97.93

2. Time of Concentration

Time of Concentration t_c = 0.32 hrs 19.07 min
SCS Lag for HEC-HMS : t_p = 0.6 t_c = 0.19 hrs 11.441 min

3. Soil Storage Parameter : S = ((1000/CN)-10)*25.4

Total	=	53.5	mm
Pervious	=	69.5	mm
Impervious	=	5.4	mm

4. Initial Abstraction

Initial abstraction - Pervious Ia = 0.2S = 13.90
Initial abstraction - impervious Ia = 0.2S = 1.07
Initial abstraction - Compound Ia = 0.2S = 10.71

above parameters used in SCS method analysis in HEC HMS

5. Rainfall data

Using Region-specific temporal patterns produced in HIRDS v4 by NIWA for 1 hour, 6 hour and 12 hour storm durations RCP8.5

5. Results

Pre-Development
Results Peak Discharge (m3/s)

hr	Q10	Q15	Q100
1	2.5	2.9	5.6
6	2.9	3.2	4.7
12	1.7	1.9	3.0

Calculation Description

Kaka 3a

Determine peak flow rate with variety of methods
Determine runoff volume for pond sizing calculations

SCS Method

1. Runoff Curve Number (CN) and Initial Abstraction (Ia)

Soil name and classification	Cover description (cover type, treatment, and hydrologic condition)		SCS Method: Curve Number CN*	SCS Method: Area (hectares)	SCS Method: Product of CN x Area
	LCDB	CN classification			
	Pervious Areas (List)				
Class B soils	Deciduous Hardwoods	Woods - fair	60	0.00	0
Class C soils	Deciduous Hardwoods	Woods - fair	73	0.00	0
Class D soils	Deciduous Hardwoods	Woods - fair	79	0.00	0
Class B soils	Broadleaved Indigenous Hardwo	Woods - fair	60	0.00	0
Class D soils	Broadleaved Indigenous Hardwo	Woods - fair	79	0.00	0
Class B soils	Indigenous Forest	Woods - fair	60	0.00	0
Class D soils	Indigenous Forest	Woods - fair	79	0.00	0
Class B soils	Manuka and/or Kanuka	Brush-weed-grass m	56	0.00	0
Class D soils	Manuka and/or Kanuka	Brush-weed-grass m	77	0.18	14
Class C soils	Exotic Forest	Woods - grass comb	76	0.00	0
Class D soils	Exotic Forest	Woods - grass comb	82	0.00	0
Class C soils	Forest - Harvested	Newly graded area (	91	0.00	0
Class C soils	Gorse and/or Broom	Brush-weed-grass m	70	0.00	0
Class D soils	Gorse and/or Broom	Brush-weed-grass m	77	0.00	0
Class B soils	High Producing Exotic Grassland	Pasture - fair	69	0.00	0
Class C soils	High Producing Exotic Grassland	Pasture - fair	79	0.00	0
Class D soils	High Producing Exotic Grassland	Pasture - fair	84	0.61	51
Class C soils	Low Producing Grassland	Pasture - poor	86	0.00	0
Class D soils	Low Producing Grassland	Pasture - poor	89	0.00	0
Class B soils	Open Space	Open Space - fair	69	0.85	58
Class C soils	Open Space	Open Space - fair	79	0.00	0
Class D soils	Open Space	Open Space - fair	84	3.51	295
Class C soils	Rural	Brush-weed-grass m	70	0.00	0
Class D soils	Rural	Brush-weed-grass m	77	1.72	133
		Subtotal for Pervious Areas		6.87	551
	Impervious Areas (List)				
Class C soils	Urban Parkland/Open Space	Open Space - fair	79	0.00	0
Class D soils	Urban Parkland/Open Space	Open Space - fair	84	0.00	0
Class D soils	Transport Infrastructure	Dirt - fair	89	0.00	0
Class C soils	Built-up Area (settlement)	Residential district 1/	83	0.00	0
Class B soils	Commercial	Commercial and Bus	92	0.00	0
Class D soils	Commercial	Commercial and Bus	95	0.00	0
	Impervious	Paved parking lots, r	98	4.03	395
		Subtotal for Impervious Areas		4.03	395
* from Table 3.3			Totals	10.91	947

CN (weighted) : $\frac{\text{total product}}{\text{total area}} = \frac{947}{10.908} = 86.79$

Weighted CN Pervious = 80.21
Weighted CN Impervious = 98.00

2. Time of Concentration

Time of Concentration t_c = 0.34 hrs 20.13 min
SCS Lag for HEC-HMS : t_p = 0.6 t_c = 0.20 hrs 12.07525 min

3. Soil Storage Parameter : S = ((1000/CN)-10)*25.4

Total = 38.7 mm
Pervious = 62.7 mm
Impervious = 5.2 mm

4. Initial Abstraction

Initial abstraction - Pervious Ia = 0.2S = 12.54 0-
Initial abstraction - impervious Ia = 0.2S = 1.04
Initial abstraction - Compound Ia = 0.2S = 7.73

above parameters used in SCS method analysis in HEC HMS

5. Rainfall data

Using Region-specific temporal patterns produced in HIRDS v4 by NIWA for 1 hour, 6 hour and 12 hour storm durations
RCP8.5

5. Results

Pre-Development
Results Peak Discharge (m3/s)

hr	Q10	Q15	Q100
1	1.1	1.2	2.1
6	1.0	1.1	1.6
12	0.6	0.7	1.0

Calculation Description

Kaka 3b

Determine peak flow rate with variety of methods
Determine runoff volume for pond sizing calculations

SCS Method

1. Runoff Curve Number (CN) and Initial Abstraction (Ia)

Soil name and classification	Cover description (cover type, treatment, and hydrologic condition) LCDB	CN classification	SCS Method: Curve Number CN*	Area (hectares)	Product of CN x Area
	Pervious Areas (List)				
Class B soils	Deciduous Hardwoods	*Woods - fair*	60	0.00	0
Class C soils	Deciduous Hardwoods	*Woods - fair*	73	0.00	0
Class D soils	Deciduous Hardwoods	*Woods - fair*	79	0.00	0
Class B soils	Broadleaved Indigenous Hardwo	*Woods - fair*	60	0.00	0
Class D soils	Broadleaved Indigenous Hardwo	*Woods - fair*	79	0.00	0
Class B soils	Indigenous Forest	*Woods - fair*	60	0.00	0
Class D soils	Indigenous Forest	*Woods - fair*	79	0.00	0
Class B soils	Manuka and/or Kanuka	*Brush-weed-grass m*	56	0.00	0
Class D soils	Manuka and/or Kanuka	*Brush-weed-grass m*	77	0.00	0
Class C soils	Exotic Forest	*Woods - grass comb*	76	0.00	0
Class D soils	Exotic Forest	*Woods - grass comb*	82	0.00	0
Class C soils	Forest - Harvested	*Newly graded area (*	91	0.00	0
Class C soils	Gorse and/or Broom	*Brush-weed-grass m*	70	0.00	0
Class D soils	Gorse and/or Broom	*Brush-weed-grass m*	77	0.00	0
Class B soils	High Producing Exotic Grassland	*Pasture - fair*	69	0.24	16
Class C soils	High Producing Exotic Grassland	*Pasture - fair*	79	0.00	0
Class D soils	High Producing Exotic Grassland	*Pasture - fair*	84	0.01	1
Class C soils	Low Producing Grassland	*Pasture - poor*	86	0.00	0
Class D soils	Low Producing Grassland	*Pasture - poor*	89	0.00	0
Class B soils	Open Space	*Open Space - fair*	69	3.88	268
Class C soils	Open Space	*Open Space - fair*	79	0.00	0
Class D soils	Open Space	*Open Space - fair*	84	0.11	9
Class C soils	Rural	*Brush-weed-grass m*	70	0.00	0
Class D soils	Rural	*Brush-weed-grass m*	77	0.00	0
	Subtotal for Pervious Areas			4.23	294
	Impervious Areas (List)				
Class C soils	Urban Parkland/Open Space	*Open Space - fair*	79	0.00	0
Class D soils	Urban Parkland/Open Space	*Open Space - fair*	84	0.00	0
Class D soils	Transport Infrastructure	*Dirt - fair*	89	0.00	0
Class C soils	Built-up Area (settlement)	*Residential district 1/*	83	0.00	0
Class B soils	Commercial	*Commercial and Bus*	92	0.00	0
Class D soils	Commercial	*Commercial and Bus*	95	0.00	0
	Impervious	*Paved parking lots, r*	98	0.76	74
	Subtotal for Impervious Areas			0.76	74
* from Table 3.3			Totals	4.99	368

CN (weighted) : $\frac{\text{total product}}{\text{total area}} = \frac{368}{4.987} = 73.75$

Weighted CN Pervious = 69.41
Weighted CN Impervious = 98.00

2. Time of Concentration

Time of Concentration t_c = 0.52 hrs 31.20 min
SCS Lag for HEC-HMS : t_p = 0.6 t_c = 0.31 hrs 18.71971 min

3. Soil Storage Parameter : S = ((1000/CN)-10)*25.4

Total = 90.4 mm
Pervious = 111.9 mm
Impervious = 5.2 mm

4. Initial Abstraction

Initial abstraction - Pervious Ia = 0.2S = 22.39
Initial abstraction - impervious Ia = 0.2S = 1.04
Initial abstraction - Compound Ia = 0.2S = 18.08

above parameters used in SCS method analysis in HEC HMS

5. Rainfall data

Using Region-specific temporal patterns produced in HIRDS v4 by NIWA for 1 hour, 6 hour and 12 hour storm durations
RCP8.5

5. Results

Pre-Development
Results Peak Discharge (m3/s)

hr	Q10	Q15	Q100
1	0.2	0.3	0.6
6	0.4	0.5	0.7
12	0.3	0.3	0.5

Calculation Description

Brooklands 1

Determine peak flow rate with variety of methods
Determine runoff volume for pond sizing calculations

SCS Method

1. Runoff Curve Number (CN) and Initial Abstraction (Ia)

Soil name and classification	Cover description (cover type, treatment, and hydrologic condition) LCDB	CN classification	Curve Number CN*	Area (hectares)	Product of CN x Area
	Pervious Areas (List)				
Class B soils	Deciduous Hardwoods	*Woods - fair*	60	0.00	0
Class C soils	Deciduous Hardwoods	*Woods - fair*	73	0.00	0
Class D soils	Deciduous Hardwoods	*Woods - fair*	79	0.00	0
Class B soils	Broadleaved Indigenous Hardwo	*Woods - fair*	60	0.00	0
Class D soils	Broadleaved Indigenous Hardwo	*Woods - fair*	79	0.00	0
Class B soils	Indigenous Forest	*Woods - fair*	60	0.00	0
Class D soils	Indigenous Forest	*Woods - fair*	79	0.00	0
Class B soils	Manuka and/or Kanuka	*Brush-weed-grass m*	56	0.00	0
Class D soils	Manuka and/or Kanuka	*Brush-weed-grass m*	77	0.00	0
Class C soils	Exotic Forest	*Woods - grass comb*	76	1.73	131
Class D soils	Exotic Forest	*Woods - grass comb*	82	0.00	0
Class C soils	Forest - Harvested	*Newly graded area (*	91	0.00	0
Class C soils	Gorse and/or Broom	*Brush-weed-grass m*	70	3.03	212
Class D soils	Gorse and/or Broom	*Brush-weed-grass m*	77	0.00	0
Class B soils	High Producing Exotic Grassland	*Pasture - fair*	69	0.00	0
Class C soils	High Producing Exotic Grassland	*Pasture - fair*	79	6.19	489
Class D soils	High Producing Exotic Grassland	*Pasture - fair*	84	0.00	0
Class C soils	Low Producing Grassland	*Pasture - poor*	86	0.00	0
Class D soils	Low Producing Grassland	*Pasture - poor*	89	0.00	0
Class B soils	Open Space	*Open Space - fair*	69	0.00	0
Class C soils	Open Space	*Open Space - fair*	79	2.98	236
Class D soils	Open Space	*Open Space - fair*	84	0.00	0
Class C soils	Rural	*Brush-weed-grass m*	70	7.19	504
Class D soils	Rural	*Brush-weed-grass m*	77	0.00	0
	Subtotal for Pervious Areas			21.12	1,571
	Impervious Areas (List)				
Class C soils	Urban Parkland/Open Space	*Open Space - fair*	79	1.49	118
Class D soils	Urban Parkland/Open Space	*Open Space - fair*	84	0.00	0
Class D soils	Transport Infrastructure	*Dirt - fair*	89	0.00	0
Class C soils	Built-up Area (settlement)	*Residential district 1/*	83	5.47	454
Class B soils	Commercial	*Commercial and Bus*	92	0.00	0
Class D soils	Commercial	*Commercial and Bus*	95	0.00	0
	Impervious	*Paved parking lots, r*	98	1.81	177
	Subtotal for Impervious Areas			8.76	748
* from Table 3.3			Totals	29.88	2,320

CN (weighted) : total product / total area = 2,320 / 29.882 = 77.63

Weighted CN Pervious = 74.40
Weighted CN Impervious = 85.41

2. Time of Concentration

Time of Concentration t_c = 0.33 hrs 19.73 min
SCS Lag for HEC-HMS : t_p = 0.6 t_c = 0.20 hrs 11.8405 min

3. Soil Storage Parameter : S = ((1000/CN)-10)*25.4

Total = 73.2 mm
Pervious = 87.4 mm
Impervious = 43.4 mm

4. Initial Abstraction

Initial abstraction - Pervious Ia = 0.2S = 17.481
Initial abstraction - impervious Ia = 0.2S = 8.677
Initial abstraction - Compound Ia = 0.2S = 14.64

above parameters used in SCS method analysis in HEC HMS

5. Rainfall data

Using Region-specific temporal patterns produced in HIRDS v4 by NIWA for 1 hour, 6 hour and 12 hour storm durations
RCP8.5

5. Results

Pre-Development
Results Peak Discharge (m3/s)

hr	Q10	Q15	Q100
1	2.2	2.5	5.0
6	2.8	3.1	4.6
12	1.7	1.9	3.0

Calculation Description

Brooklands 2

Determine peak flow rate with variety of methods
Determine runoff volume for pond sizing calculations

SCS Method

1. Runoff Curve Number (CN) and Initial Abstraction (Ia)

Soil name and classification	Cover description (cover type, treatment, and hydrologic condition)		SCS Method: Curve Number CN*	Area (hectares)	Product of CN x Area
	LCDB	CN classification			
	Pervious Areas (List)				
Class B soils	Deciduous Hardwoods	*Woods - fair*	60	0.00	0
Class C soils	Deciduous Hardwoods	*Woods - fair*	73	0.00	0
Class D soils	Deciduous Hardwoods	*Woods - fair*	79	0.00	0
Class B soils	Broadleaved Indigenous Hardwo	*Woods - fair*	60	0.00	0
Class D soils	Broadleaved Indigenous Hardwo	*Woods - fair*	79	0.00	0
Class B soils	Indigenous Forest	*Woods - fair*	60	0.00	0
Class D soils	Indigenous Forest	*Woods - fair*	79	0.00	0
Class B soils	Manuka and/or Kanuka	*Brush-weed-grass m*	56	0.00	0
Class D soils	Manuka and/or Kanuka	*Brush-weed-grass m*	77	0.00	0
Class C soils	Exotic Forest	*Woods - grass comb*	76	3.27	249
Class D soils	Exotic Forest	*Woods - grass comb*	82	0.08	6
Class C soils	Forest - Harvested	*Newly graded area (*	91	0.00	0
Class C soils	Gorse and/or Broom	*Brush-weed-grass m*	70	1.12	79
Class D soils	Gorse and/or Broom	*Brush-weed-grass m*	77	0.00	0
Class B soils	High Producing Exotic Grassland	*Pasture - fair*	69	0.00	0
Class C soils	High Producing Exotic Grassland	*Pasture - fair*	79	0.05	4
Class D soils	High Producing Exotic Grassland	*Pasture - fair*	84	0.00	0
Class C soils	Low Producing Grassland	*Pasture - poor*	86	0.00	0
Class D soils	Low Producing Grassland	*Pasture - poor*	89	0.03	2
Class B soils	Open Space	*Open Space - fair*	69	0.00	0
Class C soils	Open Space	*Open Space - fair*	79	1.51	119
Class D soils	Open Space	*Open Space - fair*	84	0.01	1
Class C soils	Rural	*Brush-weed-grass m*	70	6.36	446
Class D soils	Rural	*Brush-weed-grass m*	77	0.08	6
		Subtotal for Pervious Areas		12.51	912
	Impervious Areas (List)				
Class C soils	Urban Parkland/Open Space	*Open Space - fair*	79	8.54	674
Class D soils	Urban Parkland/Open Space	*Open Space - fair*	84	0.00	0
Class D soils	Transport Infrastructure	*Dirt - fair*	89	0.00	0
Class C soils	Built-up Area (settlement)	*Residential district 1/*	83	12.39	1,028
Class B soils	Commercial	*Commercial and Bus*	92	0.00	0
Class D soils	Commercial	*Commercial and Bus*	95	0.00	0
	Impervious	*Paved parking lots, r*	98	1.13	111
		Subtotal for Impervious Areas		22.05	1813
* from Table 3.3			Totals	34.56	2,725

CN (weighted) : $\frac{\text{total product}}{\text{total area}} = \frac{2{,}725}{34.565} = 78.83$

Weighted CN Pervious = 72.86
Weighted CN Impervious = 82.22

2. Time of Concentration

Time of Concentration t_c = 0.25 hrs 14.90 min
SCS Lag for HEC-HMS : t_p = 0.6 t_c = 0.15 hrs 8.94121 min

3. Soil Storage Parameter : S = ((1000/CN)-10)*25.4

Total	= 68.2	mm
Pervious	= 94.6	mm
Impervious	= 54.9	mm

4. Initial Abstraction

Initial abstraction - Pervious Ia = 0.2S = 18.924
Initial abstraction - impervious Ia = 0.2S = 10.986
Initial abstraction - Compound Ia = 0.2S = 13.64

above parameters used in SCS method analysis in HEC HMS

5. Rainfall data

Using Region-specific temporal patterns produced in HIRDS v4 by NIWA for 1 hour, 6 hour and 12 hour storm durations RCP8.5

5. Results

Pre-Development
Results Peak Discharge (m3/s)

hr	Q10	Q15	Q100
1	3.1	3.6	7.2
6	3.0	3.3	4.9
12	1.8	2.0	3.2

Calculation Description

Brooklands 3

Determine peak flow rate with variety of methods
Determine runoff volume for pond sizing calculations

SCS Method

1. Runoff Curve Number (CN) and Initial Abstraction (Ia)

Soil name and classification	Cover description (cover type, treatment, and hydrologic condition)		SCS Method: Curve Number CN*	Area (hectares)	Product of CN x Area
	LCDB	CN classification			
	Pervious Areas (List)				
Class B soils	Deciduous Hardwoods	*Woods - fair*	60	0.00	0
Class C soils	Deciduous Hardwoods	*Woods - fair*	73	0.17	12
Class D soils	Deciduous Hardwoods	*Woods - fair*	79	0.00	0
Class B soils	Broadleaved Indigenous Hardwo	*Woods - fair*	60	0.00	0
Class D soils	Broadleaved Indigenous Hardwo	*Woods - fair*	79	0.00	0
Class B soils	Indigenous Forest	*Woods - fair*	60	0.00	0
Class D soils	Indigenous Forest	*Woods - fair*	79	0.00	0
Class B soils	Manuka and/or Kanuka	*Brush-weed-grass m*	56	0.00	0
Class D soils	Manuka and/or Kanuka	*Brush-weed-grass m*	77	0.00	0
Class C soils	Exotic Forest	*Woods - grass comb*	76	0.00	0
Class D soils	Exotic Forest	*Woods - grass comb*	82	0.11	9
Class C soils	Forest - Harvested	*Newly graded area (*	91	0.00	0
Class C soils	Gorse and/or Broom	*Brush-weed-grass m*	70	10.85	760
Class D soils	Gorse and/or Broom	*Brush-weed-grass m*	77	0.23	18
Class B soils	High Producing Exotic Grassland	*Pasture - fair*	69	0.00	0
Class C soils	High Producing Exotic Grassland	*Pasture - fair*	79	1.86	147
Class D soils	High Producing Exotic Grassland	*Pasture - fair*	84	0.00	0
Class C soils	Low Producing Grassland	*Pasture - poor*	86	0.00	0
Class D soils	Low Producing Grassland	*Pasture - poor*	89	0.00	0
Class B soils	Open Space	*Open Space - fair*	69	0.00	0
Class C soils	Open Space	*Open Space - fair*	79	0.26	21
Class D soils	Open Space	*Open Space - fair*	84	0.04	3
Class C soils	Rural	*Brush-weed-grass m*	70	3.09	216
Class D soils	Rural	*Brush-weed-grass m*	77	0.12	9
		Subtotal for Pervious Areas		16.74	1,196
	Impervious Areas (List)				
Class C soils	Urban Parkland/Open Space	*Open Space - fair*	79	0.00	0
Class D soils	Urban Parkland/Open Space	*Open Space - fair*	84	0.00	0
Class D soils	Transport Infrastructure	*Dirt - fair*	89	0.00	0
Class C soils	Built-up Area (settlement)	*Residential district 1/*	83	0.52	43
Class B soils	Commercial	*Commercial and Bus*	92	0.00	0
Class D soils	Commercial	*Commercial and Bus*	95	0.00	0
	Impervious	*Paved parking lots, r*	98	0.33	32
		Subtotal for Impervious Areas		0.85	76
* from Table 3.3			Totals	17.59	1,272

CN (weighted) : total product / total area = 1,272 / 17.595 = 72.28

Weighted CN Pervious = 71.44
Weighted CN Impervious = 88.82

2. Time of Concentration

Time of Concentration t_c = 0.24 hrs 14.26 min
SCS Lag for HEC-HMS : t_p = 0.6 t_c = 0.14 hrs 8.555903 min

3. Soil Storage Parameter : S = ((1000/CN)-10)*25.4

Total = 97.4 mm
Pervious = 101.6 mm
Impervious = 32.0 mm

4. Initial Abstraction

Initial abstraction - Pervious Ia = 0.2S = 20.312
Initial abstraction - impervious Ia = 0.2S = 6.397
Initial abstraction - Compound Ia = 0.2S = 19.48

above parameters used in SCS method analysis in HEC HMS

5. Rainfall data

Using Region-specific temporal patterns produced in HIRDS v4 by NIWA for 1 hour, 6 hour and 12 hour storm durations
RCP8.5

5. Results

Pre-Development
Results Peak Discharge (m3/s)

hr	Q10	Q15	Q100
1	0.9	1.1	2.6
6	1.3	1.4	2.2
12	0.7	0.8	1.4

Calculation Description

Brooklands 4

Determine peak flow rate with variety of methods
Determine runoff volume for pond sizing calculations

SCS Method

1. Runoff Curve Number (CN) and Initial Abstraction (Ia)

Soil name and classification	Cover description (cover type, treatment, and hydrologic condition) LCDB	CN classification	Curve Number CN*	Area (hectares)	Product of CN x Area
	Pervious Areas (List)				
Class B soils	Deciduous Hardwoods	Woods - fair	60	0.00	0
Class C soils	Deciduous Hardwoods	Woods - fair	73	0.00	0
Class D soils	Deciduous Hardwoods	Woods - fair	79	0.00	0
Class B soils	Broadleaved Indigenous Hardwo	Woods - fair	60	0.00	0
Class D soils	Broadleaved Indigenous Hardwo	Woods - fair	79	0.00	0
Class B soils	Indigenous Forest	Woods - fair	60	0.00	0
Class D soils	Indigenous Forest	Woods - fair	79	0.00	0
Class B soils	Manuka and/or Kanuka	Brush-weed-grass m	56	0.00	0
Class D soils	Manuka and/or Kanuka	Brush-weed-grass m	77	0.02	1
Class C soils	Exotic Forest	Woods - grass comb	76	0.00	0
Class D soils	Exotic Forest	Woods - grass comb	82	0.04	3
Class C soils	Forest - Harvested	Newly graded area (	91	1.27	115
Class C soils	Gorse and/or Broom	Brush-weed-grass m	70	4.16	291
Class D soils	Gorse and/or Broom	Brush-weed-grass m	77	0.88	68
Class B soils	High Producing Exotic Grassland	Pasture - fair	69	0.00	0
Class C soils	High Producing Exotic Grassland	Pasture - fair	79	0.00	0
Class D soils	High Producing Exotic Grassland	Pasture - fair	84	0.00	0
Class C soils	Low Producing Grassland	Pasture - poor	86	0.00	0
Class D soils	Low Producing Grassland	Pasture - poor	89	0.00	0
Class B soils	Open Space	Open Space - fair	69	0.00	0
Class C soils	Open Space	Open Space - fair	79	0.75	59
Class D soils	Open Space	Open Space - fair	84	0.00	0
Class C soils	Rural	Brush-weed-grass m	70	1.63	114
Class D soils	Rural	Brush-weed-grass m	77	0.00	0
		Subtotal for Pervious Areas		8.74	652
	Impervious Areas (List)				
Class C soils	Urban Parkland/Open Space	Open Space - fair	79	0.00	0
Class D soils	Urban Parkland/Open Space	Open Space - fair	84	0.00	0
Class D soils	Transport Infrastructure	Dirt - fair	89	0.00	0
Class C soils	Built-up Area (settlement)	Residential district 1/	83	0.00	0
Class B soils	Commercial	Commercial and Bus	92	0.00	0
Class D soils	Commercial	Commercial and Bus	95	0.00	0
	Impervious	Paved parking lots, r	98	0.22	21
		Subtotal for Impervious Areas		0.22	21
* from Table 3.3			Totals	8.96	673

CN (weighted) : total product / total area = 673 / 8.957 = 75.16

Weighted CN Pervious = 74.59
Weighted CN Impervious = 98.00

2. Time of Concentration

Time of Concentration	t_c =			0.26	hrs	15.46 min
SCS Lag for HEC-HMS :	t_p =	0.6 t_c	=	0.15	hrs	9.27508 min

3. Soil Storage Parameter : S = ((1000/CN)-10)*25.4

Total	=	83.9	mm
Pervious	=	86.5	mm
Impervious	=	5.2	mm

4. Initial Abstraction

Initial abstraction - Pervious	Ia = 0.2S =	17.306
Initial abstraction - impervious	Ia = 0.2S =	1.037
Initial abstraction - Compound	Ia = 0.2S =	16.79

above parameters used in SCS method analysis in HEC HMS

5. Rainfall data

Using Region-specific temporal patterns produced in HIRDS v4 by NIWA for 1 hour, 6 hour and 12 hour storm durations RCP8.5

5. Results

Pre-Development
Results Peak Discharge (m3/s)

hr	Q10	Q15	Q100
1	0.7	0.8	1.6
6	0.8	0.8	1.3
12	0.4	0.5	0.8

Calculation Description | **Walters Bluff**

Determine peak flow rate with variety of methods
Determine runoff volume for pond sizing calculations

SCS Method

1. Runoff Curve Number (CN) and Initial Abstraction (Ia)

Soil name and classification	Cover description (cover type, treatment, and hydrologic condition)		SCS Method: Curve Number CN*	Area (hectares)	Product of CN x Area
	LCDB	CN classification			
	Pervious Areas (List)				
Class B soils	Deciduous Hardwoods	Woods - fair	60	0.00	0
Class C soils	Deciduous Hardwoods	Woods - fair	73	0.00	0
Class D soils	Deciduous Hardwoods	Woods - fair	79	0.00	0
Class B soils	Broadleaved Indigenous Hardwo	Woods - fair	60	0.00	0
Class D soils	Broadleaved Indigenous Hardwo	Woods - fair	79	0.00	0
Class B soils	Indigenous Forest	Woods - fair	60	0.00	0
Class D soils	Indigenous Forest	Woods - fair	79	0.00	0
Class B soils	Manuka and/or Kanuka	Brush-weed-grass m	56	0.00	0
Class D soils	Manuka and/or Kanuka	Brush-weed-grass m	77	0.00	0
Class C soils	Exotic Forest	Woods - grass comb	76	0.01	0
Class D soils	Exotic Forest	Woods - grass comb	82	0.00	0
Class C soils	Forest - Harvested	Newly graded area (	91	0.00	0
Class C soils	Gorse and/or Broom	Brush-weed-grass m	70	2.74	192
Class D soils	Gorse and/or Broom	Brush-weed-grass m	77	0.00	0
Class B soils	High Producing Exotic Grassland	Pasture - fair	69	0.00	0
Class C soils	High Producing Exotic Grassland	Pasture - fair	79	0.11	9
Class D soils	High Producing Exotic Grassland	Pasture - fair	84	0.00	0
Class C soils	Low Producing Grassland	Pasture - poor	86	0.00	0
Class D soils	Low Producing Grassland	Pasture - poor	89	0.00	0
Class B soils	Open Space	Open Space - fair	69	0.00	0
Class C soils	Open Space	Open Space - fair	79	3.06	242
Class D soils	Open Space	Open Space - fair	84	0.00	0
Class C soils	Rural	Brush-weed-grass m	70	3.39	238
Class D soils	Rural	Brush-weed-grass m	77	0.00	0
		Subtotal for Pervious Areas		9.32	681
	Impervious Areas (List)				
Class C soils	Urban Parkland/Open Space	Open Space - fair	79	0.00	0
Class D soils	Urban Parkland/Open Space	Open Space - fair	84	0.00	0
Class D soils	Transport Infrastructure	Dirt - fair	89	0.00	0
Class C soils	Built-up Area (settlement)	Residential district 1/	83	5.05	419
Class B soils	Commercial	Commercial and Bus	92	0.00	0
Class D soils	Commercial	Commercial and Bus	95	0.00	0
	Impervious	Paved parking lots, r	98	0.21	21
		Subtotal for Impervious Areas		5.26	440
* from Table 3.3			Totals	14.58	1,121

CN (weighted) : $\frac{\text{total product}}{\text{total area}} = \frac{1,121}{14.579} = 76.87$

Weighted CN Pervious = 73.07
Weighted CN Impervious = 83.60

2. Time of Concentration

Time of Concentration	t_c =		0.29	hrs	17.48 min
SCS Lag for HEC-HMS :	t_p =	0.6 t_c =	0.17	hrs	10.4874 min

3. Soil Storage Parameter : S = ((1000/CN)-10)*25.4

Total	=	76.4	mm
Pervious	=	93.6	mm
Impervious	=	49.8	mm

4. Initial Abstraction

Initial abstraction - Pervious	Ia = 0.2S =	18.720
Initial abstraction - impervious	Ia = 0.2S =	9.964
Initial abstraction - Compound	Ia = 0.2S =	15.28

above parameters used in SCS method analysis in HEC HMS

5. Rainfall data

Using Region-specific temporal patterns produced in HIRDS v4 by NIWA for 1 hour, 6 hour and 12 hour storm durations
RCP8.5

5. Results

Pre-Development
Results Peak Discharge (m3/s)

hr	Q10	Q15	Q100
1	1.1	1.3	2.6
6	1.2	1.3	2.0
12	0.7	0.8	1.3

Calculation Description | **Bradford park**

Determine peak flow rate with variety of methods
Determine runoff volume for pond sizing calculations

SCS Method

1. Runoff Curve Number (CN) and Initial Abstraction (Ia)

Soil name and classification	Cover description (cover type, treatment, and hydrologic condition)		SCS Method: Curve Number CN*	Area (hectares)	Product of CN x Area
	LCDB	CN classification			
	Pervious Areas (List)				
Class B soils	Deciduous Hardwoods	Woods - fair	60	0.00	0
Class C soils	Deciduous Hardwoods	Woods - fair	73	0.00	0
Class D soils	Deciduous Hardwoods	Woods - fair	79	0.00	0
Class B soils	Broadleaved Indigenous Hardwo	Woods - fair	60	0.08	5
Class D soils	Broadleaved Indigenous Hardwo	Woods - fair	79	2.58	204
Class B soils	Indigenous Forest	Woods - fair	60	1.98	119
Class D soils	Indigenous Forest	Woods - fair	79	2.18	172
Class B soils	Manuka and/or Kanuka	Brush-weed-grass m	56	1.02	57
Class D soils	Manuka and/or Kanuka	Brush-weed-grass m	77	4.93	380
Class C soils	Exotic Forest	Woods - grass comb	76	0.00	0
Class D soils	Exotic Forest	Woods - grass comb	82	0.00	0
Class C soils	Forest - Harvested	Newly graded area (	91	0.00	0
Class C soils	Gorse and/or Broom	Brush-weed-grass m	70	0.00	0
Class D soils	Gorse and/or Broom	Brush-weed-grass m	77	0.00	0
Class B soils	High Producing Exotic Grassland	Pasture - fair	69	2.39	165
Class C soils	High Producing Exotic Grassland	Pasture - fair	79	0.00	0
Class D soils	High Producing Exotic Grassland	Pasture - fair	84	0.01	1
Class C soils	Low Producing Grassland	Pasture - poor	86	0.00	0
Class D soils	Low Producing Grassland	Pasture - poor	89	0.00	0
Class B soils	Open Space	Open Space - fair	69	0.00	0
Class C soils	Open Space	Open Space - fair	79	0.64	51
Class D soils	Open Space	Open Space - fair	84	12.32	1,035
Class C soils	Rural	Brush-weed-grass m	70	0.16	11
Class D soils	Rural	Brush-weed-grass m	77	2.39	184
		Subtotal for Pervious Areas		30.68	2,383
	Impervious Areas (List)				
Class C soils	Urban Parkland/Open Space	Open Space - fair	79	0.00	0
Class D soils	Urban Parkland/Open Space	Open Space - fair	84	0.00	0
Class D soils	Transport Infrastructure	Dirt - fair	89	0.00	0
Class C soils	Built-up Area (settlement)	Residential district 1/	83	0.00	0
Class B soils	Commercial	Commercial and Bus	92	0.00	0
Class D soils	Commercial	Commercial and Bus	95	0.00	0
	Impervious	Paved parking lots, r	98	4.02	394
		Subtotal for Impervious Areas		4.02	394
* from Table 3.3			Totals	34.70	2,777

CN (weighted) : total product / total area = 2,777 / 34.703 = 80.02

Weighted CN Pervious = 77.66
Weighted CN Impervious = 98.00

2. Time of Concentration

Time of Concentration t_c = 0.47 hrs 28.23 min
SCS Lag for HEC-HMS : t_p = 0.6 t_c = 0.28 hrs 16.93972 min

3. Soil Storage Parameter : S = ((1000/CN)-10)*25.4

Total = 63.4 mm
Pervious = 73.1 mm
Impervious = 5.2 mm

4. Initial Abstraction

Initial abstraction - Pervious Ia = 0.2S = 14.611
Initial abstraction - impervious Ia = 0.2S = 1.037
Initial abstraction - Compound Ia = 0.2S = 12.68

above parameters used in SCS method analysis in HEC HMS

5. Rainfall data

Using Region-specific temporal patterns produced in HIRDS v4 by NIWA for 1 hour, 6 hour and 12 hour storm durations
RCP8.5

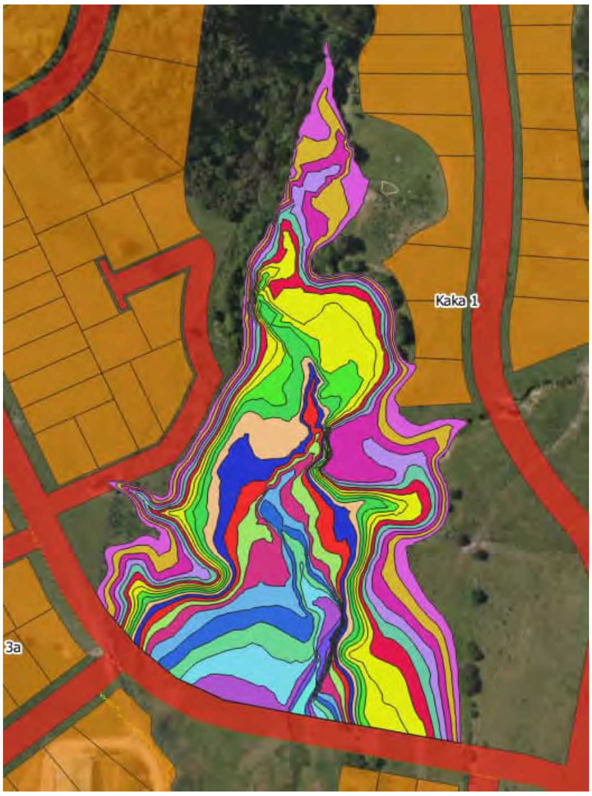
5. Results

Pre-Development
Results Peak Discharge (m3/s)

hr	Q10	Q15	Q100
1	2.3	2.7	5.3
6	2.8	3.1	4.6
12	1.7	1.8	3.0

Kaka 1				
ELEVATION	Area	Volume m³		Volume 000m³
23	53.41	0	0	0
23.5	137.373	47.69575	0.5	0.047696
24	468.314	199.1175	1	0.199118
24.5	980.337	561.2803	1.5	0.56128
25	1453.306	1169.691	2	1.169691
25.5	1959.204	2022.819	2.5	2.022819
26	2441.074	3122.888	3	3.122888
26.5	2984.877	4479.376	3.5	4.479376
27	3459.342	6090.431	4	6.090431
27.5	3972.629	7948.423	4.5	7.948423
28	4637.65	10100.99	5	10.10099
28.5	5336.281	12594.48	5.5	12.59448
29	5986.934	15425.28	6	15.42528
29.5	6663.556	18587.9	6.5	18.5879
30	7615.8	22157.74	7	22.15774
30.5	8669.439	26229.05	7.5	26.22905
31	9476.837	30765.62	8	30.76562
31.5	10199.341	35684.66	8.5	35.68466
32	11121.522	41014.88	9	41.01488
32.5	12398.507	46894.89	9.5	46.89489
33	13495.366	53368.36	10	53.36836
33.5	14608.857	60394.41	10.5	60.39441

Refer
\\ttgroup.local\corporate\Nelson\Projects\1012397\1012397.1000\Workin



Idealised pond

Kaka 2

Pond Geometry		
Pond invert l	0	m RL
Pond base length	30	m
Pond base width	30	m
Internal pond batter slope	2	H:1V
Inlet slope batter	2	H:1V
Dead storage level (height above invert)	0.0	m
Live storage level (height above invert)	1.3	m

Computed storage - elevation details

Depth	length	width	Area	Volume	Volume 00	Elevation
0.0	30.0	30.0	900	0	0.00	0.0
0.1	30.4	30.4	924	91	0.09	0.1
0.2	30.8	30.8	949	185	0.18	0.2
0.3	31.2	31.2	973	281	0.28	0.3
0.4	31.6	31.6	999	380	0.38	0.4
0.5	32.0	32.0	1024	481	0.48	0.5
0.6	32.4	32.4	1050	584	0.58	0.6
0.7	32.8	32.8	1076	691	0.69	0.7
0.8	33.2	33.2	1102	800	0.80	0.8
0.9	33.6	33.6	1129	911	0.91	0.9
1.0	34.0	34.0	1156	1025	1.03	1.0
1.1	34.4	34.4	1183	1142	1.14	1.1
1.2	34.8	34.8	1211	1262	1.26	1.2
1.3	35.2	35.2	1239	1385	1.38	1.3
1.4	35.6	35.6	1267	1510	1.51	1.4
1.5	36.0	36.0	1296	1638	1.64	1.5
1.6	36.4	36.4	1325	1769	1.77	1.6
1.7	36.8	36.8	1354	1903	1.90	1.7
1.8	37.2	37.2	1384	2040	2.04	1.8
1.9	37.6	37.6	1414	2180	2.18	1.9
2.0	38.0	38.0	1444	2323	2.32	2.0
2.1	38.4	38.4	1475	2469	2.47	2.1
2.2	38.8	38.8	1505	2618	2.62	2.2
2.3	39.2	39.2	1537	2770	2.77	2.3
2.4	39.6	39.6	1568	2925	2.92	2.4
2.5	40.0	40.0	1600	3083	3.08	2.5
2.6	40.4	40.4	1632	3245	3.25	2.6
2.7	40.8	40.8	1665	3410	3.41	2.7
2.8	41.2	41.2	1697	3578	3.58	2.8
2.9	41.6	41.6	1731	3749	3.75	2.9
3.0	42.0	42.0	1764	3924	3.92	3.0

Kaka 3a

ELEVATION	Area	Volume m³		Volume 000m³
21	35	0	0	0
21.5	92.8	31.95	0.5	0.03195
22	164.3	96.225	1	0.096225
22.5	226.4	193.9	1.5	0.1939
23	289.5	322.875	2	0.322875
23.5	351.8	483.2	2.5	0.4832
24	421.4	676.5	3	0.6765
24.5	514	910.35	3.5	0.91035
25	613.3	1192.175	4	1.192175
25.5	752	1533.5	4.5	1.5335

Idealised pond

Kaka 3b

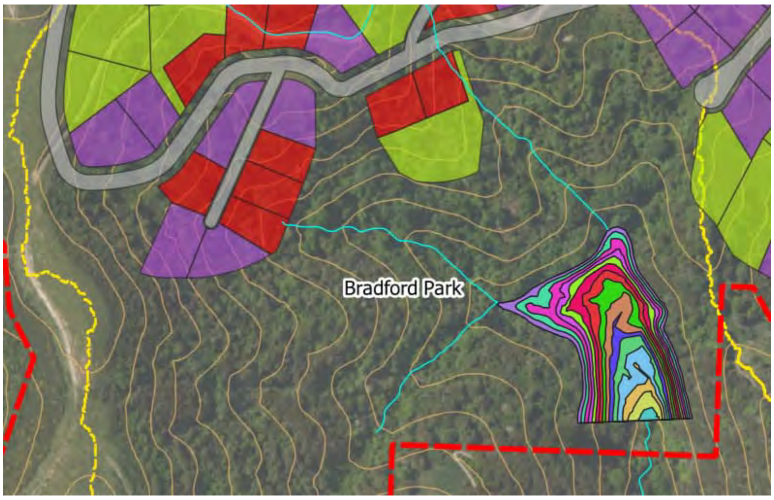
Pond Geometry		
Pond invert	0	m RL
Pond base length	12	m
Pond base width	12	m
Internal pond batter slope	2	H:1V
Inlet slope batter	2	H:1V
Dead storage level (height above invert)	0.0	m
Live storage level (height above invert)	1.3	m

Computed storage - elevation details

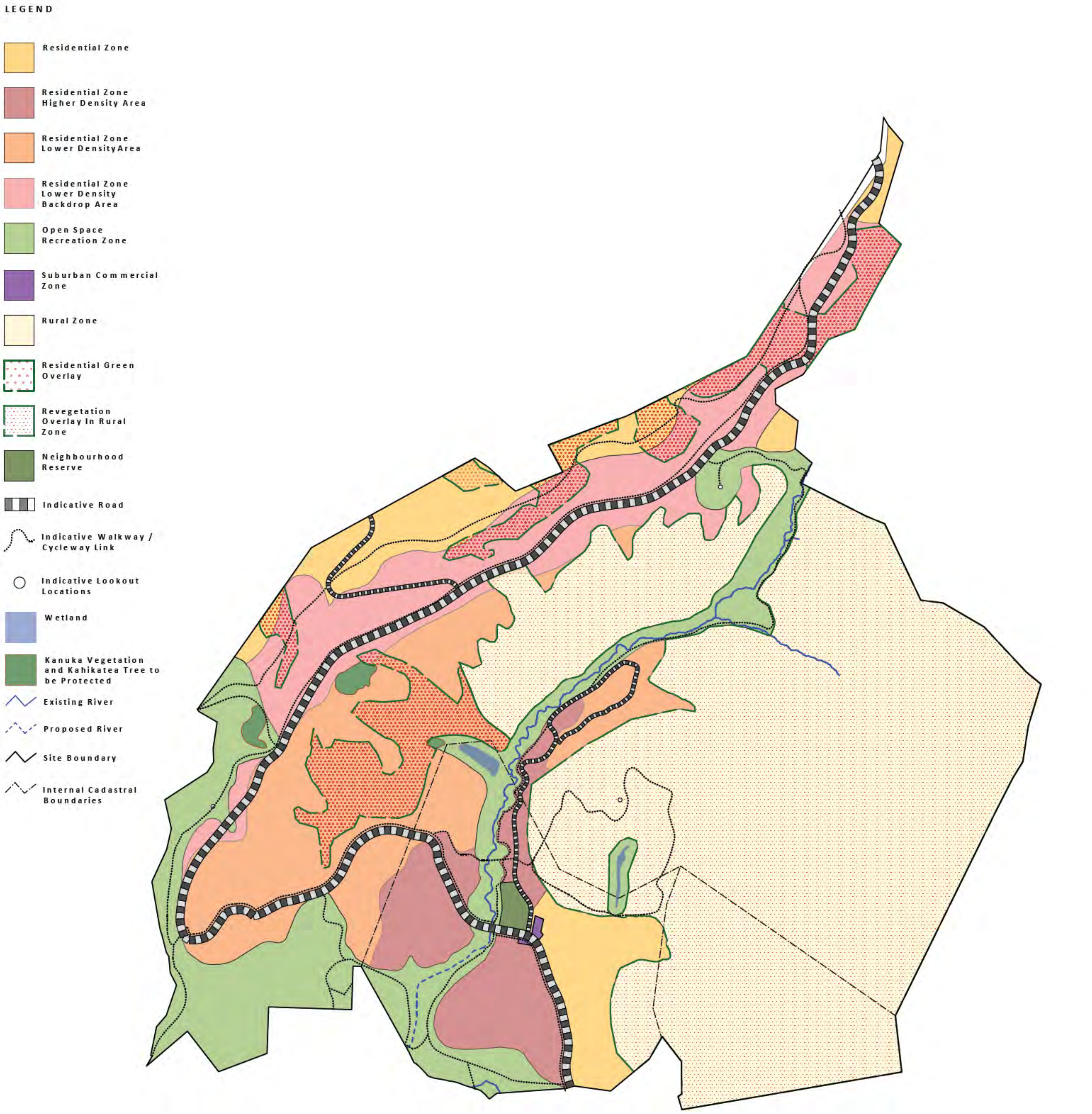
Depth	length	width	Area	Volume	Volume 000m³	Elevation
0.0	12.0	12.0	144	0	0.00	0.0
0.1	12.4	12.4	154	15	0.01	0.1
0.2	12.8	12.8	164	31	0.03	0.2
0.3	13.2	13.2	174	48	0.05	0.3
0.4	13.6	13.6	185	66	0.07	0.4
0.5	14.0	14.0	196	85	0.08	0.5
0.6	14.4	14.4	207	105	0.10	0.6
0.7	14.8	14.8	219	126	0.13	0.7
0.8	15.2	15.2	231	149	0.15	0.8
0.9	15.6	15.6	243	172	0.17	0.9
1.0	16.0	16.0	256	197	0.20	1.0
1.1	16.4	16.4	269	224	0.22	1.1
1.2	16.8	16.8	282	251	0.25	1.2
1.3	17.2	17.2	296	280	0.28	1.3
1.4	17.6	17.6	310	310	0.31	1.4
1.5	18.0	18.0	324	342	0.34	1.5
1.6	18.4	18.4	339	375	0.38	1.6
1.7	18.8	18.8	353	410	0.41	1.7
1.8	19.2	19.2	369	446	0.45	1.8
1.9	19.6	19.6	384	484	0.48	1.9
2.0	20.0	20.0	400	523	0.52	2.0
2.1	20.4	20.4	416	564	0.56	2.1
2.2	20.8	20.8	433	606	0.61	2.2
2.3	21.2	21.2	449	650	0.65	2.3
2.4	21.6	21.6	467	696	0.70	2.4
2.5	22.0	22.0	484	743	0.74	2.5
2.6	22.4	22.4	502	793	0.79	2.6
2.7	22.8	22.8	520	844	0.84	2.7
2.8	23.2	23.2	538	897	0.90	2.8
2.9	23.6	23.6	557	951	0.95	2.9
3.0	24.0	24.0	576	1008	1.01	3.0

Bradford Park

ELEVATION	Area	Volume m³		Volume 000m³
35	53.41	0	0	0
36	137.373	85.1015	1	0.085102
37	468.314	280.8635	2	0.280864
38	980.337	668.5358	3	0.668536
39	1453.306	1294.177	4	1.294177
40	1959.204	2119.842	5	2.119842
41	2441.074	3186.509	6	3.186509
42	2984.877	4560.137	7	4.560137
43	3459.342	6243.464	8	6.243464
44	3972.629	8228.783	9	8.228783
45	4637.65	10503.41	10	10.50341
46	5336.281	13052.46	11	13.05246
47	5986.934	15917.05	12	15.91705
48	6663.556	19152.71	13	19.15271
49	7615.8	22755.99	14	22.75599



Appendix C: Structure Plan and Indicative Masterplan



Attachment B1.1:

Maitahi Bayview Structure Plan - Part of Schedule X

Scale 1:10,000 @ A3

RMM
ROUGH MILNE MITCHELL LANDSCAPE ARCHITECTS
CHRISTCHURCH +64 3 366 3268
WĀNAKA +64 3 974 7940
AUCKLAND +64 21 244 8630
DUNEDIN +64 27 488 8795
NELSON +64 27 250 0500
rmmla.co.nz info@rmmla.co.nz

Indicative Masterplan

Legend

	Residential Lots 300m² - 400m²
	Residential Lots 400m² - 800m²
	Residential Lots 800m² - 1000m²
	Residential Lots 1000m² - 1500m²
	Residential Lots 1500m² or Greater
	Open Space / Recreation Area
	Suburban Commercial Lot
	Rural Area / Revegetation Overlay In Rural Zone
	Wetland
	Neighborhood Reserve
	Indicative Roads
	Indicative Walkway/ Cycleway Link
	Kākā Stream
	Site Boundary
	Residential Green Overlay

Scale 1:10000@A3

Appendix D: Morphum memo

Memorandum

Date:	[Publish Date]
To:	Neil Donaldson (CCKV Maitai Dev Co LP and Bayview Nelson Ltd)
From:	Stu Farrant
CC:	Maurice Mills (Tonkin & Taylor)
Project Number:	Project Number
Reviewed by:	Mark Lowe
Released by:	Caleb Clarke

Subject: Preliminary water management summary for SMP

This memorandum has been prepared by Morphum Environmental Ltd (Morphum) to support the development of the high level Stormwater Master Plan (SMP) being developed for the proposed Maitahi residential development. This SMP was requested by appointed technical experts representing submitters to the PPC28 application and Nelson City Council. Specifically, the SMP was requested during pre-hearing expert conferencing which was undertaken on ………… This conferencing identified that whilst the intent for the development to provide a high level of protection of the Kaka Stream and Maitai River ecosystem was documented through the application there was limited supporting evidence to demonstrate how this might be achieved on the ground. This is important to provide an appropriate level of confidence in the ability for the development to meet the stated stormwater management principles presented in the PPC28 application as X9.

Morphum were previously engaged to undertake a *Preliminary Structure Plan Environmental Review* (report dated 13/04/2021). This included 18 recommended principles which were adapted to form the basis of X9 principles and recommendations around how development related stormwater could be managed in a manner which protects the receiving environments from adverse impacts related to water quality and quantity. This supporting report should be referred to for further context.

At this stage of the development planning, no formal development typologies, urban design layouts or stormwater network design has been undertaken which would support more refined sub catchment analysis to inform the SMP. Therefore, a number of assumptions and committed development approaches are instead provided to define how the development will be progressed in a manner which protects the existing ecosystem function and enables restoration activities to enhance values. These approaches and assumptions are outlined in this memorandum with resulting spatial footprints which will need to be incorporated into design development in an integrated manner when it commences. All catchment delineation and estimates of imperviousness are based on catchment analysis undertaken by Tonkin & Taylor to inform their flood flow estimation. It is noted that these assumptions are considered conservative (given the topographical constraints that will limit developable land) with an expectation that spatial footprints for consolidated stormwater treatment devices will be reduced in later stages based on comprehensive water/contaminant balance modelling. Calculated footprints were increased by a factor of 30%.

Maitahi Development approach

The following points summarise the approach to land development which will have a direct influence on site wide stormwater planning.

1. All dwellings to include rainwater capture with reuse to service internal and external non potable demands to intercept an initial volume of runoff as a surrogate for naturally occurring evapotranspiration losses. This will include internally plumbed tanks which augment reticulated mains supply for fit for purpose non potable demands including toilet flushing, cold water laundry and external uses as a minimum. Modelling shall be undertaken to develop relationship between roof area and tank size to support an average of 80% reliability of supply and a reduction of roof runoff of at least 60% mean annual volume. This equates to an initial retention depth of between 5 – 10 mm which will be realised across the majority of daily timesteps and in particular will be met during summer conditions when stream flows are reduced and vulnerable to flashy inflows of contaminated stormwater. Development specific design guidelines will define required tank sizes for a range of connected roof areas.
2. All dwellings on suitable ground will include infiltration via porous manholes positioned to receive runoff from driveways and overflow from rainwater tanks. These will be sized based on relationship with roof area (and rainwater harvest) to provide a combined initial retention depth of approximately 10 mm. It is noted that this will only be suitable for dwelling on lower parts of the development due to the risk of ground instability and uncontrolled seepages to downslope properties from higher lots.
3. Stormwater sub catchments to be managed with 'traditional' pipe networks to collect excess flows from lots and runoff from roads. Sub catchment stormwater to be managed via consolidated treatment devices to mitigate impacts prior to discharge to any natural waterway or pipe networks which flow beyond the development boundary. Treatment devices will include;
    a. Consolidated raingardens designed with internal storage and infiltration to shallow groundwater. These can be integrated within the proposed Kaka Stream esplanade (where suitable) or in dispersed parklets which support community connection with water management and support amenity, urban ecology and education. These will be designed with careful consideration of lifecycle maintenance. Raingardens will all be offline to full pipe flow with appropriately design bypass although flood attenuation can be accommodated above the operational water level as required.
    b. Consolidated constructed wetland designed to be integrated into green spaces and provide a high level of water quality treatment. These will be integrated within the proposed Kaka Stream esplanade, in particular on the lower terrace alongside the re-aligned channel reach. High quality constructed wetlands will support community connection with water management and support amenity, urban ecology and education. Consideration will be given to options to harvest treated water from wetlands to augment irrigation of high amenity planted gardens, community gardens or irrigation of parks. These will be designed with careful consideration of lifecycle maintenance. Raingardens will all be offline to full pipe flow with appropriately design bypass although flood attenuation can be accommodated above the operational water level as required.
    c. Passive irrigation of integrated green infrastructure such as street trees, verge planting and restoration planting. Careful design of any passive irrigation will need to ensure that peak flows are appropriately managed to prevent uncontrolled overland flow whilst enabling frequent small rainfall events to support healthy urban greenery with benefits in biodiversity, evapotranspiration and micro climate.

It is noted that modelling has provided recommendations for the required land area for both raingardens and wetlands (i.e. treatment requirements duplicated). In reality the final development design will include either one of the two devices or a combination in response to site conditions.

Maitahi Development assumptions

The following assumptions have been used to inform the nominated preliminary size of required devices in the SMP (refer Tonkin & Taylor).

1. Sub catchment delineated based on existing hydrologic catchments. These were delineated by T&T and are consistent with their reporting.
2. Residential development types (as proposed in structure plan) used to infer imperviousness which was then agglomerated across the sub catchment to give an estimated impervious area for developable land within each sub catchment. Non development land (rural, open space etc) excluded for the purposes of water quality.
3. Residential roofs (connected to rainwater tanks) assumed to comprise 50% of impervious cover
4. Residential hardstand (driveways) assumed to be 20% of impervious cover
5. Roads assumed to be 30% of impervious cover (15% of total development catchment). Roads assumed to be 80% impervious within corridor
6. Roof runoff effectively mitigated for quantity and quality via appropriately sized rainwater reuse tanks
7. Hardstand runoff effectively managed for quantity and quality for 50% of lots
8. Raingardens sized at 2% of connected impervious catchments (increased by 30% to allow for batters etc). Raingardens to be modelled to demonstrate ability to pass 80-85% of mean annual volume through filter media with underlying saturated zone and infiltration to be refined to meet overall groundwater recharge aspirations,
9. Wetlands sized at 4.5% of connected impervious catchments (increased by 30% to allow for batters etc). Wetlands to be modelled to demonstrate ability to pass 80-85% of mean annual volume through wetland with extended detention included. Further detention of flows may be achievable via harvest of a portion of treated stormwater.

Table 1 shows the summary of catchment landuse breakdowns and the resulting required footprint to manage site generated stormwater. It is noted that the reported footprints for raingardens/wetlands are for either of these options (i.e. will not need combined total) and the distribution of these is expected to be split into more than one device per sub catchment. The final selection of optimal treatment devices, layout and distribution will be developed in close co-ordination with urban designers, landscape architects, civil designers and Geotech.

Stu Farrant
Water Sensitive Design Lead
Morphum Environmental Ltd
Phone: [redacted]
[redacted]

Table 1 Estimated development areas, impervious land covers and calculated stormwater management device sizes

Sub-catchment	Combined Developed Area (m^2)	Impervious %	Sum of Impervious Area (m^2)	Assumed roof area (m^2)	Managed Hardstand (m^2)	Un-managed hardstand (m^2)	Road impervious (m^2)	Raingarden Area (m^2)	Wetland Area (m^2)
1	834,081	19%	158,475	79,238	15,848	15,848	25,356	1,071	2,410
2	297,879	42%	125,109	62,555	12,511	12,511	20,017	846	1,903
3	216,558	30%	64,967	32,484	6,497	6,497	10,395	439	988
4	318,538	39%	124,230	62,115	12,423	12,423	19,877	840	1,890
5A	72,291	57%	41,206	20,603	4,121	4,121	6,593	279	627
5B	34,302	65%	22,296	11,148	2,230	2,230	3,567	151	339
Grand Total	**1,773,649**		**536,284**	**268,142**	**53,628**	**53,628**	**85,805**	**3,625**	**8,157**

NOTE THIS TABLE HAD BEEN SUPERSEDED BY TREATMENT TABLE IN THE MAIN BODY OF THE STORMWATER MANAGEMENT PLAN

Appendix E: Flood model approach memo

FLOOD MODEL APPROACH SUMMARY

1 Modelling approach

A computational flood model was developed to assist the assessment of effects on flood hazard of the proposed Private Plan Change 28 (PPC28). The purpose of the flood model is to provide an understanding of what areas within the Kākā Tributary catchment are currently likely to be subject to flooding in response to extreme rainfall events, and how this flooding may be affected by development within the PPC28 area.

A two-dimensional (2D) direct rainfall model was built, covering the PPC28 area, using TUFLOW HPC software.

T+T selected the TUFLOW HPC engine as run-times are faster compared to a classic CPU approach and a finer resolution can be achieved by enabling smaller grid sizes. A finer resolution means a more accurate representation of overland flow paths.

2 Model inputs

2.1 General parameters

The general parameters used in the TUFLOW model are summarised in Table 2.1.

Table 2.1: TUFLOW parameters

Parameter	Value
Model Cell Size	2 m x 2 m (4 m²)
Timestep	The TUFLOW HPC model uses an adaptive timestep, based on a maximum Courant number of 1
Viscosity	The default approach for viscosity in TUFLOW is the Wu method.

2.2 Spatial data

2.2.1 Model extent

The extent of the model was set to include the Kākā Tributary catchment and floodplain, and sufficient coverage of the Maitahi/Mahitahi River to allow for an understanding of the interaction between the two floodplains, as presented in outlined in Figure 2-1.

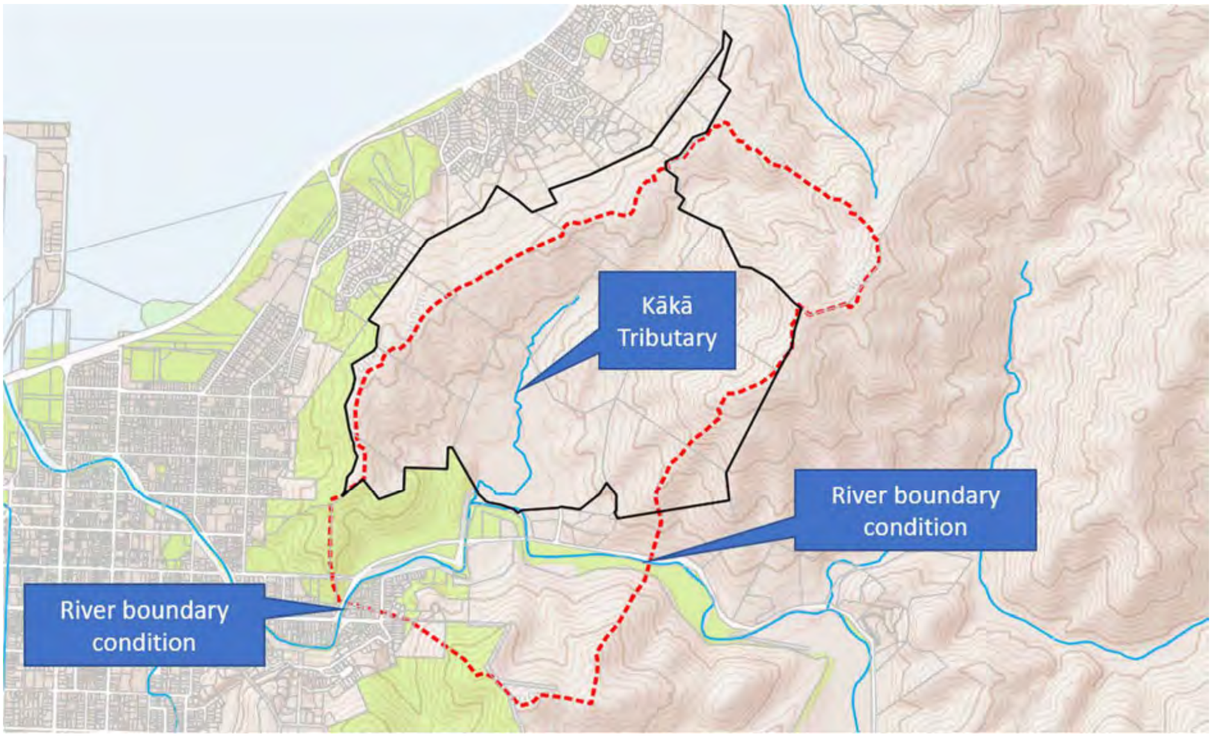


Figure 2-1: Kākā Tributary TUFLOW model extent (shown with red dashed line). The PPC28 area is shown in black.

2.2.2 Model terrain

The base digital elevation model (DEM) for ground level used in the model was acquired from Nelson City Council (NCC) based on a 2021 LiDAR survey in New Zealand Vertical Datum 2016 (NZVD2016). The DEM represents a bare earth terrain with all buildings and above-ground features having been removed.

For the post-development scenario, the LiDAR DEM was augmented with design surfaces supplied by the applicant for both the realigned Kākā Tributary and the proposed filling within the lower Kākā floodplain.

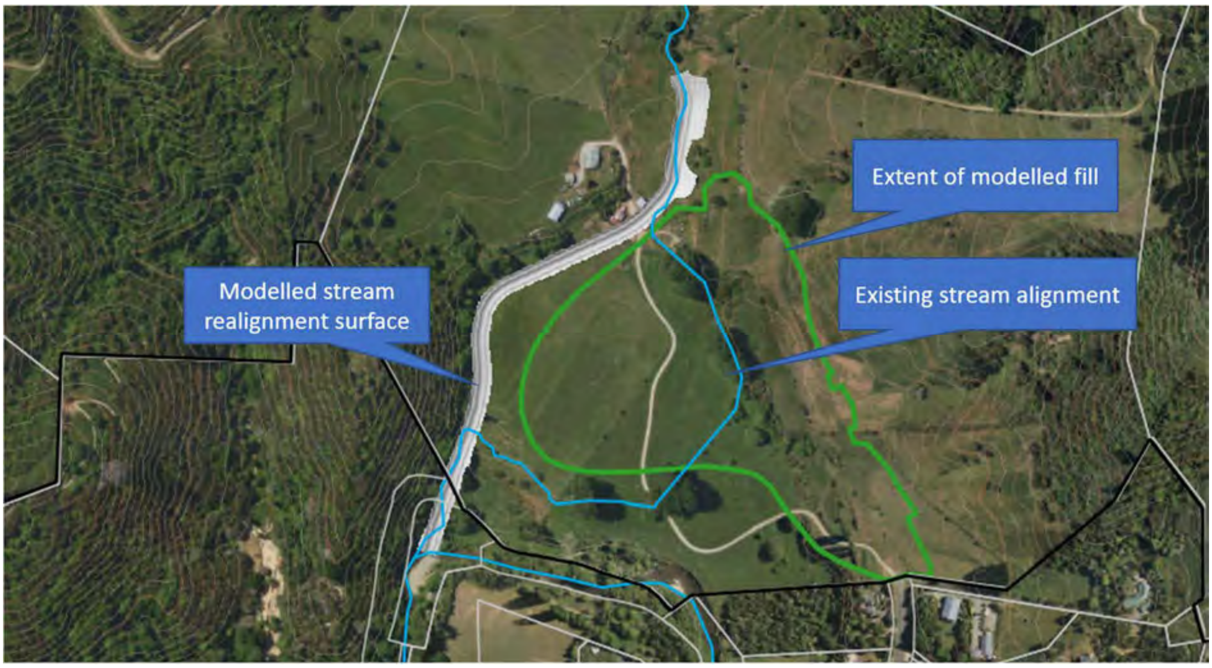


Figure 2-2: Modelled post-development terrain modifications

2.2.3 Channels and in-stream structures

For the purposes of this modelling assessment, channels were represented using the 2m grid, and culverts and other in-stream structures such as culverts and any other local stormwater infrastructure were ignored. The exception to this was the inclusion of Jickells and Gibbs bridges on the Maitahi/Mahitahi River. Given the importance of these structures in controlling the overall channel capacity in this area, these structures were modelled using available bridge survey data.

2.2.4 Land Use

Roughness values adopted in the model were based on land use as categorised in Landcare Research's Land Cover Database version 5 (LCDB5). This database was released in December 2019 and is the most current at the time of modelling. This data is freely available from the Land Research Information Systems portal.

In addition to this, road centrelines were located in GIS and buffered to a width of 8 m. These areas were included on top of the land use layer and separate road Manning roughness values were adopted.

Table 2.2: LCDB5 Land types and corresponding Manning's n

Description	Code	Manning's n	Percentage Impervious
Built-up Area	1	Depth Varying	25%
Urban Parkland/ Open Space	2	0.033	0
Transport Infrastructure	5	0.016	0
Coastal Sand and Gravel	10	0.025	0
Lake and Pond	20	0.02	100%
Estuarine Open Water	22	0.022	100%
Short-rotation Cropland	30	0.1	0

Description	Code	Manning's n	Percentage Impervious
Orchard and Other Perennial	33	0.05	0
High Producing Exotic Grass	40	0.05	0
Low Producing Grassland	41	0.09	0
Herbaceous Freshwater Vegetation	45	0.1	0
Herbaceous Saline Vegetation	46	0.1	0
Gorse and Broom	51	0.125	0
Manuka and/or Kanuka	52	0.1	0
Broadleaved Indigenous Hard	54	0.1	0
Mixed Exotic Shrubland	56	0.08	0
Forest Harvested	64	0.16	0
Deciduous Hardwoods	68	0.125	0
Indigenous Forest	69	0.15	0
Exotic Forest	71	0.15	0
Road layer	88	0.02	100%

Depth varying Manning's n was used for 'Built-up Area'. This allows for a low roughness to be used at shallow depths to represent roofs and driveways. At higher depths, an increased roughness is applied to represent overland flow through urban areas where fences and buildings provide an impediment to flow, the depth varying roughness is outlined in Table 2.3.

Table 2.3: Depth varying manning's n coefficients for 'Built-up Area'

Depth	Manning's n
Less than 50 mm	0.015
50 mm – 100 mm	The value varies linearly from 0.015 to 0.05
Greater than 100 mm	0.05

2.3 Boundary data

2.3.1 Rainfall inputs

Rainfall in the model is simulated using a 'rain on grid' methodology. As for NCC's urban stormwater modelling, rainfall hyetograph is applied for over the entire model area.

Rainfall depths were generated using NIWA's High Intensity Rainfall Design System (HIRDS) V4 for a range of event durations and exceedance probabilities. Both the present day rainfall and rainfall including the "representative concentration pathway" (RCP) 8.5 climate change horizon to 2130 were simulated, as has been used for NCC's flood modelling.

2.3.2 Infiltration losses

The Horton loss model was used to model the rainfall infiltration losses in the model. The Horton approach uses the equation:

$$f = f_c + (f_0 - f_c)e^{-kt}$$

Where f_0 is the initial infiltration rate in mm/h, f_c is the final (indefinite) infiltration rate, t is time in hours and k is the Horton decay rate. For the TUFLOW implementation, the time (t) is the period of time that the cell is wet.

For the base case with starting parameters, the values adopted are summarised in Table 2-4. These parameters are best developed through calibration, which has not been carried out in detail as part of this model build.

Table 2-4 identifies the infiltration parameters used by the model for different soil types.

Table 2-4. Soil infiltration parameters using Horton Loss model

Soil type	**Initial loss (mm)**	**Initial loss rate, f_0 (mm/hr)**	**Ultimate infiltration rate, fc (mm/hr)**	**Horton decay rate, k (1/hr)**
Very poorly drained	0.05	0.5	0.45	0.42
Poorly drained	0.2	2.0	1.5	0.29
Imperfectly drained	0.35	3.5	3.0	0.26
Moderately drained	0	8	7.5	0.23
Well drained	0	25	22.5	0.21

2.3.3 Maitahi/Mahitahi River boundary

The model includes a section of the Maitahi/Mahitahi River, and uses the results of existing NCC river flood modelling (2021) as boundary conditions. The NCC model was developed using DHI Software's MikeFlood package. Relevant storms were extracted from the existing NCC modelling results and applied directly to the TUFLOW model boundary. Given that the two models were created using different software, the modelling results were compared to ensure consistency within the area of interest.

3 Model validation

The existing peer reviewed NCC model of the Maitahi/Mahitahi River has been calibrated and validated. However, no flow/level data exists to use to calibrate the Kākā Tributary modelling.

The adoption of land-use and infiltration characteristics as above, and as used in NCC's urban stormwater modelling, together with HIRDS v4 rainfall data and profiles, yielded peak flow estimates that were at the upper end of the range of peak flows as assessed previously using other methods for the pre-development scenario, and as presented in the body of the Stormwater Management Plan (SMP). While there is inherent uncertainty in the current understanding of peak flow rates from this catchment due to the lack of gauging records, the modelling was considered to be at the upper end of the range of expected values and therefore appropriate for use in providing an indication of existing flood hazard and potential effects of development.

4 Model results

The results of the modelling are presented in the body of the SMP, and in the T+T letter report titled "Additional Flood Hazard Information – PC28", dated 05 May 2022.