REPORT

Tonkin+Taylor

# Maitahi Village Stormwater Assessment Report

## Maitahi Village, Kākā Valley, Nelson

**Prepared for**
CCKV Maitahi Dev Co LP

**Prepared by**
Tonkin & Taylor Ltd

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# Document control

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**Appendix B** Stormwater calculations

**Appendix C** Water sensitive design report - Morphum

## Client summary

This report describes the proposed stormwater management approach for a planned residential subdivision by CCKV Maitai Development Company LP (CCKV) within the Kākā Stream catchment, which sits approximately 2 km outside Nelson and is a tributary of the Maitahi/Mahitahi River. *The site is within the bounds of Schedule X of the NRMP, which contains bespoke stormwater provisions for management and the use of best practice design principles.* Together with the Nelson Tasman Land Development Manual (NTLDM), this has formed the basis for the development of a water sensitive design approach (WSD) to address stormwater management within the future development. This stormwater management approach is consistent with the stormwater management plan produced as part of the PPC28 process.

The water sensitive design approach for the CCKV development area has been developed through close collaboration within a project team that consists of civil and environmental engineers, geologists, landscape architects, water sensitive design specialists, a cultural liaison, ecologists and planners.

The guiding principles for the water sensitive design approach are:

- **Inter-disciplinary planning and design** requires input and skills of a range of disciplines such as engineering, landscape architecture, urban design, planning and ecology.
- **Protect and enhance the values and functions of natural ecosystems,** such as mature vegetation, aquifers, water courses and wetlands.
- **Address stormwater effects close to source** by directing stormwater runoff to mitigation areas to retain/ detain and treat stormwater before entering the receiving environment. This alleviates the potential downstream effects from stormwater volumes, peak flows and contaminants.
- **Mimic natural systems and processes for stormwater management**, such as forests and streams. Retain, infiltrate and transpire stormwater runoff and capture and transform contaminants. WSD promotes the restoration of natural systems and processes and their associated ecosystem services as part of catchment development.

The key elements of the proposed stormwater management approach are a combination of:

- Drainage systems that are designed to convey primary and secondary flows. These consist of built assets (vegetated or rock lined swales, constructed treatment wetlands, culverts and piped networks) and natural systems (streams and natural wetlands). Overland flow paths from the upper catchments pass safely through the subdivision following reserves where possible before connecting into the Kākā Stream.
- Re-alignment and naturalisation of the Kākā Stream to include riparian plantings within an approx. 40 m wide corridor, stream meanders, pools, riffles and other natural in-stream features that improve freshwater ecology, aquatic habitat and the overall health of the Kākā Stream.
- A natural blue-green stream corridor will extend from the Kākā Stream confluence with the Maitahi/Mahitahi River to the upper reaches upstream of the proposed development.
- Stormwater quality treatment of first-flush run-off from all impervious surfaced areas within three constructed wetlands that are co-located within the central blue-green corridor along the Kākā Stream.
- A combination of retention and detention to slow down fast and frequent flows and mimic the natural hydrological regime as closely as possible. Where feasible, the provisions of rain tanks on private lots for re-use of rainwater, in combination with infiltration and extended detention within the wetland areas will avoid streambank erosion and prevent the loss of aquatic habitat.

- Land use changes within the catchment include an increase in impervious surfaces from the proposed subdivision, as well as extensive vegetation improvements within the wider catchment from pasture and scrub to native forest. The balance of these changes result in a minor increase in post-development peak flows of 0.2 $m^3/s$ (+1.2% increase) in the present day scenario (which conservatively assumes full impervious areas, and no vegetation improvement), and a matching or reduction in post development peak flows in future scenarios (depending on the degree of vegetation establishment). Based on the above, it can be concluded that the hydrological effects of the planned vegetation improvements compensate for the effects of the proposed increase in impervious surfaces.
- Flood models have been used to assess the effect from the subdivision on downstream flood hazards. The report concludes that the proposed changes in land use and landform as a result of the development do not result in any increase in downstream flood effects.
- Attenuation of peak flows is not considered necessary and has not been proposed. Note this approach does not meet specific requirements of the NTLDM to provide attenuation in the present day scenario; however, the proposed approach meets the performance outcomes of the NTLDM. In the long term scenario where vegetation improvements have been partially or fully established, the NTLDM requirement is fully met.
- The effects of other interventions such as filling in the Maitahi/Mahitahi valley floor, Kākā Stream works, and bridge structures have also been assessed and the report concludes that these do not increase downstream flood hazards.

# 1 Introduction

This stormwater assessment report has been prepared by Tonkin & Taylor Ltd (T+T) to support a resource consent application by CCKV to subdivide and develop approximately 35.3 ha of the 287 ha of land located within the Kākā Valley catchment, approximately 2 km east of the Nelson CBD. The land was re-zoned (for the purposes of development as part of Private Plan Change 28 (PPC28). Based on the Environment Court decision on 20 November 2024, PP28 is now fully operative and incorporated into the Nelson Resource Management Plan (NRMP) as Schedule X Maitai Bayview Area.

The stormwater management approach in this report focusses on the CCKV development area, named Maitahi Village, which this resource consent application relates to, but also considers the entire catchment that the CCKV development is part of. The following areas in particular have an impact on stormwater management within the catchment:

- Proposed Arvida retirement village within the Maitahi Village area;
- Bayview development in the north-western part of the PPC28 area;
- Vegetation improvements of the wider Kākā Catchment.

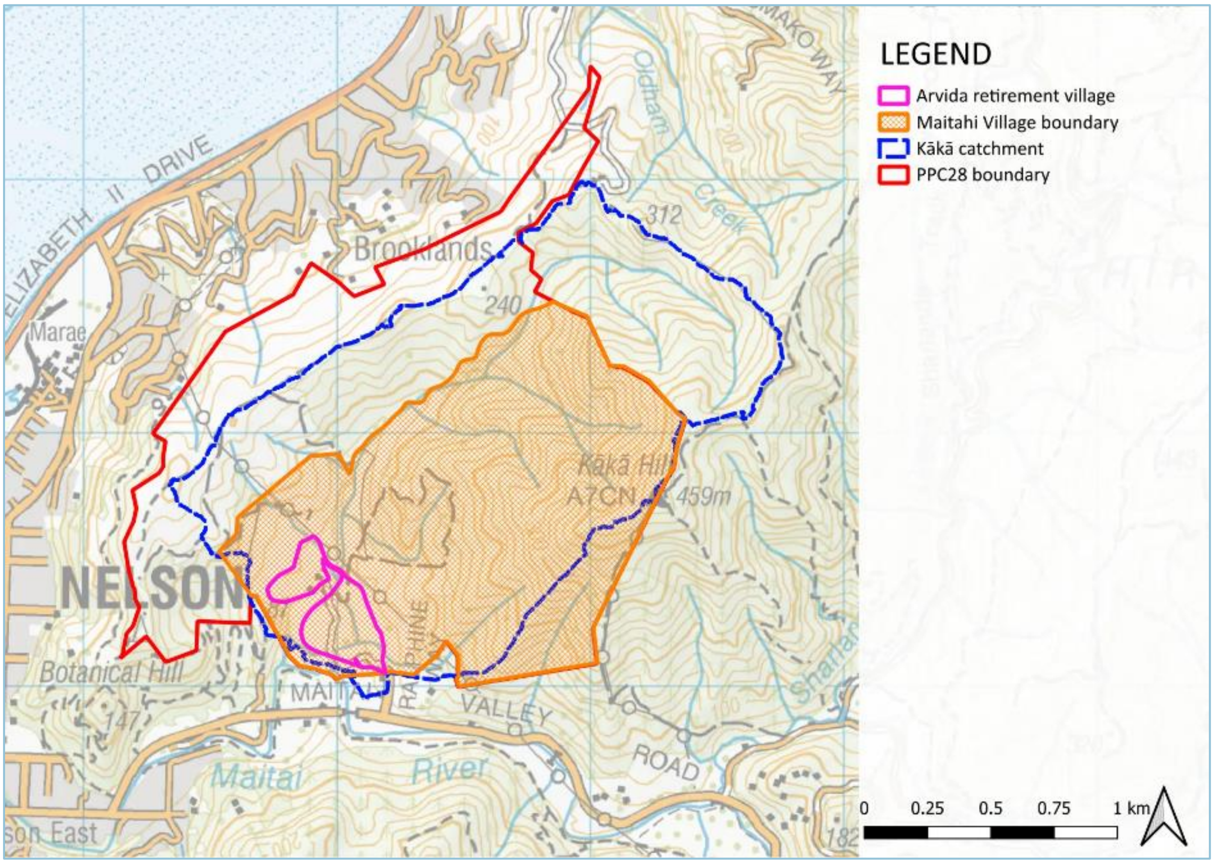


*Figure 1.1: Site location. Basemap source: LINZ*

## 1.1 Report layout

This report has the following layout:

- Section 2 sets out the regulatory objectives and design requirements that this stormwater management report has been developed to meet.

- Section 3 describes the existing site including comments on current land use, hydrological characteristics and ground conditions.
- Section 4 describes the proposed overall approach to manage stormwater for the Maitahi Village in accordance with water sensitive design principles.
- Section 5 provides details on the scope of the proposed development including comment on land use changes, conveyance of stormwater, culvert design and stream alignment.
- Section 6 provides an assessment of flood hazards and compares the post development peak flows to pre-development peak flows. The potential effects from the development on downstream flood hazards are assessed here as well.

# 2 Regulatory and design contexts

The relevant planning and regulatory requirements for future stormwater management within the Maitahi Village are discussed in detail in the following sub-sections.

## 2.1 Schedule X – NRMP

In 2022, a joint privately initiated Plan Change application (PPC28) by CCKV Maitai Dev Co LP and Bayview Nelson Limited was submitted 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)
- Open Space Recreation
- Suburban Commercial
- Rural

In July 2022, a Hearing Panel of Independent Commissioners appointed by the NCC was delegated to hear, consider and make recommendations to Council on PPC28. In September 2022, this panel provided NCC with its recommendation. The Hearing Panel recommended that the proposed rezoning and subsequent changes to the Nelson Resource Management Plan (NRMP) be approved, and the Council accepted that recommendation. After this Council decision, an appeal was made, initiating a Hearing through the Environment Court in February 2024. In November 2024, the Environment Court recommended that the rezoning to the Nelson Resource Management Plan (NRMP) be approved, and the Council accepted that recommendation confirming PP28 is now fully operative and incorporated into the Nelson Resource Management Plan (NRMP) as Schedule X Maitai Bayview Area.

In addition to the rezoning of land, new objectives, policies and a new Schedule X, has been added to the NRMP with an accompanying structure plan. Policies RE6.3 and RE6.4 relate to the required integrated stormwater management approach and ecological and freshwater outcomes.

Schedule X.12 and Schedule X.13 sets out the specific requirements for water sensitive design and stormwater management shall be used alongside the design standards from the Nelson Tasman Land Development Manual, Rev 1 dated September 2020 (NTLDM)

A summary of how the operative NRMP requirements and NTLDM have been addressed in the stormwater design is provided in Section 7 (conclusions) of this report.

## 2.2 Stormwater management plan

As part of the PPC28 application, a stormwater management plan (SMP), titled Stormwater Management Plan, Private Plan Change 28, August 2022, 1012397.1000v3 was produced to provide a framework for how stormwater will be managed across the whole PPC28 area. The purpose of the SMP is to provide guidance to developers and Nelson City Council (NCC) on the proposed integrated stormwater management approach for future development within this area. The intended outcomes of the SMP are outlined below:

- 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 roading and new lots associated with the development are 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.

The SMP is a stormwater management framework that provides high level guidance and objectives for development of the entire PPC28 area. This report sets out, in more detail than the SMP, how stormwater is proposed to be managed specifically within the Maitahi Village area (as shown in **Error! Reference source not found.**) in accordance with Schedule X.13 and other relevant design g uidelines. This report, alongside the other Stormwater reports, address the specific items listed in Schedule X.13.

## 2.3 Engineering standards and design guidelines

The main design guideline for development with the Nelson and Tasman Regions is the Nelson Tasman Land Development Manual, issued in 2020, hereafter referred to as NTLDM 2020. The NTLDM 2020 is intended to provide consistent minimum standards and guidance for network assets that NCC will accept as part of its network.

**Table 2.1: Relevant design guidelines**

| Requirement | Relevant regulatory / design to follow | Comment/description |
|---|---|---|
| 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 objectives 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:<br>a) 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;<br>b) 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;<br>c) 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;<br>d) A management approach that aims to improve water quality;<br>e) Devices and design solutions that are robust, durable and easily maintained;<br>f) A whole-of-life operations, maintenance and replacement or renewal programme that is clearly described, costed, and can be afforded; |

| Requirement | Relevant regulatory / design to follow | Comment/description |
|---|---|---|
| | | g) A stormwater system design that takes into account the foreseeable demands of future development;<br>h) A resilient network infrastructure that performs well against the risk of geotechnical, seismic, flood hazards and coastal hazards (erosion and inundation);<br>i) A design that maintains or improves values associated with freshwater resources, including riparian management and in-stream habitat values;<br>j) Stormwater assets that have high amenity value, and shared use of open-space areas where practicable and agreed to by Reserves and Facilities Manager;<br>k) A network that maintains a high visual amenity that enhances the value of adjoining property and neighbourhood values as a whole.<br>Note all performance outcomes are also subject to the applicable Resource Management Plan objectives and policies and appropriate bylaws, including schedule X when it comes into effect. These take precedence over the requirements of the Nelson Tasman Land Development Manual (NTLDM). |
| Application of principles of water sensitive design | GD04 (Auckland Council, 2015) | The NTLDM 2020 refers developers to further guidance on the implementation of water sensitive design (WSD) measures, available in the Auckland Council guideline document GD2015/004 (Water Sensitive Design for Stormwater). |
| Stormwater management devices design | GD01 (Auckland Council, 2017) | The NTLDM 2020 recommends that the design of WSD should also be guided by the following documents:<br>• Stormwater management devices in the Auckland region. Auckland Council guideline document, GD2017/001 (GD01);<br>• Hamilton City Council Three Waters Practice Notes: HCC01 to HCC07;<br>• Nelson City Council/ Tasman District Council, Bioretention and Wetland Practice Notes, both Version 1, June 2017. |

## 2.4 Iwi consultation

As per Policy RE6.2, any subdivision and development of land within Schedule X shall recognises and provide for cultural values and mātauranga Māori through:

- Recognition of the customary interests, values, rights and responsibilities exercised by Whakatū Tangata Whenua in a manner consistent with the sustainable management of natural and physical resources;
- The protection of Kākā Hill's natural and spiritual values in a manner that respects its cultural significance and the customary interests, values, rights and responsibilities exercised by Whakatū Tangata Whenua;
- Ensuring that Whakatū Tangata Whenua are involved throughout the subdivision and development process and reflects their values, and enables the exercise of kaitiakitanga.

The stormwater management of the proposed development has been developed in a way that aligns with objectives of the Ngati Koata Iwi Management Plan (IMP), these include:

a A holistic whole-of-catchment water sensitive design approach, which is guided by the Ngati Koata design framework aspirations, strategic objectives of the Iwi Environmental Management Plan, and Te Mana o Wai, these include:

- Water sensitive design that mimics natural hydrology as closely as possible, e.g. runoff from the wider catchment will be managed through vegetation improvements, which mimics natural systems and processes.
- Design elements that include on-lot water reuse, soakage basins, and specified roofing materials to avoid contaminant generation.
- Emphasis on green infrastructure and water resource conservation.
- Ensuring climate change impacts are considered throughout the design process.
- The realignment and naturalisation of the Kākā Stream will include riparian plantings, stream meanders, pools, riffles and other natural in-stream features to improve freshwater ecology, aquatic habitat and the overall health of the Kākā Stream.

b Prioritises the freshwater health of Maitahi awa, through addressing the degradation of tributaries feeding into it that contribute to poor water through the provision of stormwater treatment.

c The revegetation of 50% of the catchment from the existing pasture and scrub to native forest cover for areas outside of the development further supports an integrated catchment management.

This approach to stormwater management reflects a commitment and alignment to the Kotahitanga aspiration for stormwater management approach to be 'gentle on Papatuanuku'.

As required by Schedule X.11, a Cultural Impact Assessment (CIA) has been submitted with the resource consent application, which directly addresses stormwater elements outlined above.

# 3 Site description

## 3.1 Maitahi Village

The Maitahi Village portion of the PPC28 development area is shown in Figure 1.1, above. This comprises approximately 35.3 ha of the 287 ha of land that has been rezoned as part of PPC28. The Maitahi Village portion of the site is located along the floor of Kākā Valley and on the adjacent hill slopes to the west and east. This area is located almost entirely within the Kākā Stream Catchment. This report describes the proposed stormwater management approach for the proposed Maitahi Village with consideration of other areas within the Kākā Stream Catchment that directly impact on the Maitahi Village, such as Bayview development and areas of the wider catchment that will have vegetation improvements.

The Arvida retirement village is a separate development within the Maitahi Village. Stormwater management for this area sits outside the scope of this report, however future impervious areas for Arvida have been considered in the analysis of flows from the entire catchment. Specific consideration of stormwater reticulation and treatment is outlined in the work undertaken by Morphum and Davis Ogilve (refer to section 4.2.1 for reference).

In December 2024, a separate resource consent was submitted to cover the required enabling works, outside the Schedule X boundary, to allow services to be bought to the CCKV development. The bounds of these external works extend from approximately Nile Street-Maitai Valley Road intersection to Ralphine Way. These works will involve the installation of new wastewater and water supply infrastructure, transport improvements, and the provision of two footbridges across the Maitai River. Stormwater and flooding effects of these works has been considered as part of that consent application. These activities do not influence the stormwater management of the CCKV areas.

The stormwater management of the wider PPC28 development area is outlined in the stormwater management plan (SMP) that was developed to support the plan change.

## 3.2 Maitahi/Mahitahi River catchment

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

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

The Kākā Stream confluence with the Maitahi/Mahitahi River is at the lower end of the mid catchment, approximately 11 km downstream from the Maitai Dam (the river mouth is approximately 15 km downstream from the dam). This section of the Maitahi/Mahitahi River is typically willow-lined and surrounded by pasture, reserves and limited residential development. 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. The river discharges into the Nelson Haven, with tidal influence on flows and levels in the lower reaches.

## 3.3 Kākā Stream Catchment

The existing conditions of the Kākā Stream and tributaries are described in an Environmental Review Report, prepared by Morphum in 2021. (Preliminary Structure Plan Environmental Review, Maitahi & Bayview Development Private Plan Change Request, Morphum Environmental, dated 13/04/2021) The conditions can be summarised as:

- The Kākā Stream runs in a north to south direction with multiple side gullies (west-east) extending to the ridgelines. Due to the soils and grade across the site many of these gullies are either ephemeral or intermittent and give the impression of minimal flow.
- The Kākā Stream forms a spine through the site and is observed to be reasonably stable in its upper reaches (upstream of existing buildings at 7 Ralphine Way) with a mix of open and forested reaches and diverse instream habitat. The stream channel is considered to be largely natural in the upper reaches (upstream of existing buildings at 7 Ralphine Way) with the downstream (below existing buildings at 7 Ralphine Way) reach having been historically realigned and modified to support drainage and farming of the lower terrace. This lower reach is considered to be degraded with extensive mud substrates, limited in-stream habitat and a tendency to dry out over the summer months.
- It should be noted that since the environmental review by Morphum in 2021, the Kākā Stream and tributaries were impacted by a large flood event in August 2022 which has resulted in significant erosion and bank collapse in places.
- 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.

The extent of the stream network is shown in Figure 3.1.

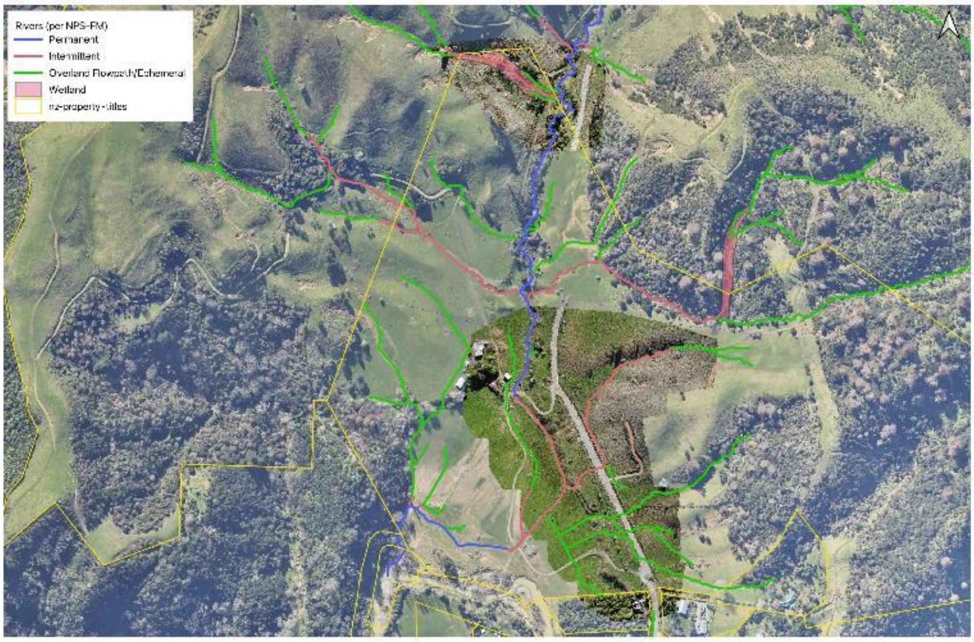


*Figure 3.1: Kākā Stream Catchment and stream classification (source: Robertson Environmental report).*

## 3.4 Hydrological setting

The existing stormwater drainage features within the Maitahi Village are typical of rural undeveloped catchments, and are broadly described below:

- 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;
- 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 existing buildings at 7 Ralphine Way) 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;
- Various artificial and modified watercourses, primarily located on the lower Kākā Valley floor (which is located within the Maitahi/Mahitahi River flood plain).

The receiving environment is the Maitahi/Mahitahi River which flows approximately 5 km downstream before discharging to the Nelson Haven. The Maitahi/Mahitahi River flood waters inundate the lower Kākā Valley floor during flood events.

### 3.4.1 Existing (pre-developed) catchment land use

The existing (pre-developed) land use in the Kākā Catchment is typical of a rural catchment, with portions of pastoral land, scrub and a small area of exotic forest.

A breakdown of this land use, based on Landcare Research's New Zealand Land Cover Database (version 5.0, last updated Nov 2021) and the latest 2024 aerials from Google is shown in Table 3.1.

**Table 3.1: Pre-development land use**

| Land use | Area (ha) |
|---|---|
| Brush (Manuka/Kanuka and Gorse/Broom) | 123.3 |
| Brush/Grass | 22.0 |
| Woods (Indigenous and exotic forest) | 4.5 |
| Woods/Grass | 2.9 |
| Pasture (High and low producing grassland) | 90.4 |
| Dirt (Access roads) | 1.6 |
| Newly Graded Area (Harvested exotic forest) | 9.8 |
| **TOTAL** | 254.4 |

### 3.4.2 Pre-development peak flow assessment

Various methods were used to estimate the peak pre-development flows at the downstream end of the Kākā Stream (at confluence with the Maitahi/Mahitahi River), including:

- NIWA Regional method (Henderson Collins 2018);
- Rational method as per NTLDM and NZBC E1;
- SCS 1986 loss method with Clark Unit Hydrograph transform and frequency storm developed from HIRDS v4 data;
- TUFLOW Rain on Grid (RoG) model using the IL/CL loss model.

Both NIWA Regional method and Rational method provide only peak flow estimates, while the SCS method and TUFLOW RoG methods generate flow hydrographs.

For the SCS and Rational method calculations, the Kākā Stream Catchment is shown in Figure 3.2. The rainfall depths and storm shapes were taken from NIWA HIRDS v4, with effects of climate change based on the shared socioeconomic pathway (SSP) SSP5-8.5, previously known as RCP8.5 as per NTLDM 5.4.6.2. Detailed calculations have been included in Appendix B.

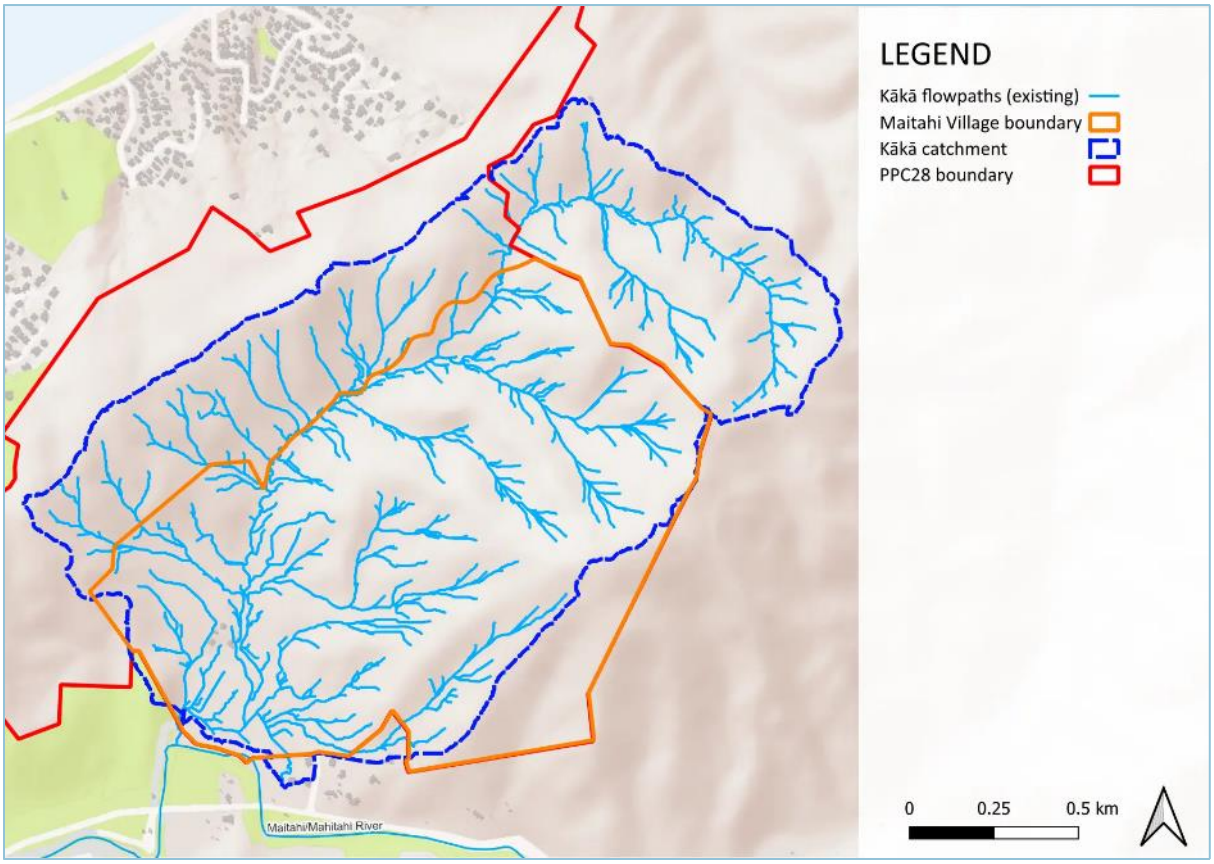


*Figure 3.2: Kākā Stream catchment and flow paths based on 2021 LiDAR data. Basemap: TOSM.*

Table 3.2 below presents the results from the preliminary hydrological assessment for the existing catchment. The associated calculations are attached in Appendix B.

**Table 3.2: Peak runoff estimates for Kākā Stream (at downstream end)**

| Climate | Rainfall event | Pre-development peak flow estimate (m³/s) | | | |
|---|---|---|---|---|---|
| | | NIWA regional method | Rational method | SCS 1986 | TUFLOW RoG model |
| Present-day | 10% AEP | 8.0 | 9.2 | 6.0 | 7.5 |
| | 6.67% AEP | 8.6 | 9.9 | 6.7 | - |
| | 1% AEP | 13.3 | 14.3 | 11.0 | 14.6 |
| 2130 SSP5-8.5 | 10% AEP | - | 13.7 | 9.4 | 12.9 |
| | 6.67% AEP | - | 14.9 | 10.5 | - |
| | 1% AEP | - | 21.7 | 17.1 | 23.6 |

The SCS 1986 loss method has been used as the design flow for further calculations as it is slightly lower than other methods for the pre-development case, which would tend to be conservative in terms of understanding the effect of proposed development land use change. The regional and rational method values are in relatively close agreement with the SCS 1986 estimates, which gives a degree of confidence to the design values. For the SCS 1986 method, the Clark Unit Hydrograph transform method was selected to align with the MaiBkYk model (Maitai River Flood Hazard Mapping Modelling Report, T+T, 2013). This provides consistency when using the MaiBkYk model to assess the effects of the flow changes.

The TUFLOW RoG model values are also in close agreement, though slightly higher than the SCS 1986 values. This confirms the appropriateness of using the TUFLOW model for the purpose of mapping and understanding likely overland flow paths through the site – the flows are in the right order, and slightly conservative (high).

### 3.4.3 Hydraulic conductivity (soil permeability)

Initial hydraulic conductivity (permeability) testing was undertaken in September 2023 in four boreholes. Location and results are provided in the Geotechnical report. Two boreholes, one shallow and one deep, were located on the flat and gently inclined land that forms the lower Kākā Valley floor. Another set of boreholes were located on the eastern hillslope. The results of this testing indicated:

- Tests of the bores on the eastern hillslope indicated low permeability soil and rock that is considered as unsuitable for soakage.
- Tests for bores to the east and west of the lower Kākā Valley floor indicated more permeable soil with hydraulic conductivities in the range of between 0.997 m/day and 7.43 m/day (good permeability) respectively.

The relatively flat and gently inclined land that forms the lower Kākā Valley floor (alluvial silt, sand and gravel) has potential for areas to be utilised for infiltration including lot scale soakage, appropriately designed consolidated rain gardens or consolidated soakage system into near surface sand and gravel layers. We note that there are some zones of silty material within the lower Kākā Valley floor that could impede soakage at specific locations or depths. Site specific permeability testing needs to confirm hydraulic conductivity for the specific soakage locations, in particular in southern soakage area where there are currently no test results.

It is also proposed to fill part of the lower Kākā Valley floor area by up to approximately 3 m with site-won rock fill material, which could potentially also provide a minimum infiltration rate of at least 5 mm/hr. This would need to be confirmed through permeability testing once the fill material has been placed. If soakage is in the vicinity of structures and/or sensitive infrastructure, it would also need to be confirmed that cyclic wetting and drying will not break down the rockfill material, which could weaken the ground and cause settlement.

Other areas within the CCKV land above the lower Kākā Valley floor have not been tested for permeability and are considered unsuitable for infiltration of stormwater due to moderate and steep slopes and/or the presence of shallow bedrock.

# 4 Stormwater management approach

This section presents the proposed approach to manage stormwater runoff from the Maitahi Village. This approach has been identified with consideration of:

- Site-specific constraints and opportunities;
- Relevant provisions within the NRMP (including Schedule X) and NTLDM 2020;
- NPS Freshwater Management 2020;
- Integrated catchment management approach taking into account quantity and quality treatment of stormwater run-off.

## 4.1 General stormwater management and provisional site layout

The stormwater management system proposed for the CCKV portion of the site comprises the following:

- A piped primary stormwater network, sized to convey the 2130[1] SSP5-8.5 6.67% AEP flow, as per NTLDM Table 5-5.
- Three stormwater treatment wetlands that are co-located within the blue-green corridor along the Kākā Stream. Stormwater wetlands are sized to treat the 80-85% of mean annual volume (first-flush) or stormwater resulting from a 3-month ARI rainfall event, as per Schedule X.9 (5). These basins include soakage basin elements to infiltrate treated stormwater into the underlying alluvial gravels.
- Detention tanks on some private lots, where space allows, to retain rainwater from roofs and re-use for toilet flushing.
- Vegetation improvements to approximately 50% of the Kākā Stream Catchment, including within the blue-green corridor and significant areas outside Maitahi Village, from brush and grassland into native forest. A significant portion of this revegetated land is to be protected in perpetuity through a QEII covenant. Ngāti Koata will act as Kaitiaki for Koata Land and may put a Ngā Whenua Rāhui kawenata on Koata land only. Slopes with vegetation improvements will reduce and slow down runoff from these areas and have the ability to largely compensate for the increase of runoff from new impervious areas.
- Overland flow paths from the smaller undeveloped tributaries above the developed areas are provided by open channel to maintain connection to Kākā Stream and to avoid routing these through the treatment wetlands. Overland flow paths are sized to contain the 2130 SSP5-8.5, 1% AEP event, as per NTLDM Table 5-5. Where these flow paths cross a proposed road, culverts sized to the same event are proposed. Additional blockage assessments have been undertaken.
- A vehicle bridge has been proposed at the main Kākā Stream road crossing.

These elements are discussed in detail in the following section and the provisional stormwater layout is shown in Figure A1, Appendix A.

## 4.2 Water sensitive design approach

The effects from the proposed changes in land use on stormwater runoff are managed through the implementation of Water Sensitive Design (WSD) principles. Water sensitive design seeks to protect and enhance natural freshwater systems, sustainably manage water resources, and mimic natural processes to achieve enhanced outcomes for ecosystems and communities. The NTLDM refers to Guideline Document 004 from Auckland Council *(Water Sensitive Design for stormwater, Auckland*

[1] NTLDM 5-5 requires a design horizon of 2090 to be considered for future flows, a more conservative design assumption using the 2130 design horizon has been adopted in this report

*Council, March 2015, guideline document 2015/004*) for guidance on how to implement water sensitive design.

The guiding principles of a water sensitive design approach are:

- **Inter-disciplinary planning and design** requires input and skills of a range of disciplines such as engineering, landscape architecture, urban design, planning and ecology.
- **Protect and enhance the values and functions of natural ecosystems,** such as mature vegetation, aquifers, water courses and wetlands.
- **Address stormwater effects close to source** by directing stormwater runoff to mitigation areas to retain/ detain and treat stormwater before entering the receiving environment. This alleviates the potential downstream effects from stormwater volumes, peak flows and contaminants.
- **Mimic natural systems and processes for stormwater management.** Natural systems, such as forests and streams, retain, infiltrate and transpire stormwater runoff and capture and transform contaminants. WSD promotes the restoration of natural systems and processes and their associated ecosystem services as part of catchment development.

The key components of the stormwater management approach that give effect to the above principles are summarised in the following sub-sections.

A plan showing the location of key components of the stormwater management approach is provided in Appendix A.

### 4.2.1 Inter-disciplinary planning and design

The water sensitive design approach for the Maitahi Village has been developed through close collaboration within a project team that consists of civil and environmental engineers, geologists, landscape architects, water sensitive design specialists, an ecologist and planners.

Through a collaborative and iterative design approach, the project team was able to identify and address risks and opportunities early. This has enabled development of a holistic stormwater management approach that optimises hydraulic, environmental, economic and social benefits.

Details of the stormwater and WSD elements are provided in separate reports that were prepared by:

- Morphum Environmental – Water Sensitive Design Report (hereafter referred to as Morphum Environmental Report)
- Rough Milne Mitchell Landscape Architects (refer to report title) (hereafter referred to as RMM Report)
- Davis Ogilvie (refer to report title) (hereafter referred to as DO report)
- Robertson Environmental (refer to report title) (hereafter referred to as Robertson Environmental report)

### 4.2.2 Retention of stormwater through re-use and infiltration

The increased stormwater runoff from newly created impervious areas has the potential to change the hydrological regime of the Kākā Stream. Run-off from small but frequent rain events can cause erosion of streambanks and loss of aquatic habitat. Development can result in lower dry-weather flows (baseflows), changes to the stream substrate and riparian vegetation, which can lead to degradation of the stream habitat and a loss of diversity in the aquatic community.

It is proposed to mitigate this effect by reducing and slowing down the runoff from these areas during small but frequent events through a combination of:

- **Retention tanks** on individual lots (where space allows), which will collect runoff from roof surfaces in rain tanks and re-use of this water for toilet flushing. Retention tanks are planned for those lots where space allows (medium and low-density areas).
- **Infiltration** of stormwater into the ground mimics the natural hydrology during small rain events (prior to development) and help maintain baseflows in the Kākā Stream. Infiltration is planned in three proposed new soakage basins that would sit behind the western and central wetland. Treated flows from the wetlands will overflow into the soakage basins before infiltrating to ground until the soil is fully saturated or the maximum infiltration rate is exceeded. In these instances, treated flow will overflow into the Kākā Stream.

Details on the re-use and infiltration of stormwater are provided in the Morphum Environmental report attached in Appendix C.

### 4.2.3 Stormwater treatment in wetlands

Stormwater runoff from hard surfaces such as roads, carparks and roofs pick up contaminants that can accumulate in fresh water and marine water receiving environments. The main contaminants of concern from urban stormwater include sediment, dissolved heavy metals (zinc, copper and lead), and hydrocarbons (oils and grease). In addition, runoff from roofs and roads can increase water temperatures. This can all adversely affect stream habitat and health.

These potential effects will be mitigated by treating stormwater runoff in three wetlands situated on the valley floor, where they are integrated within a blue/green corridor along the realigned Kākā Stream. Wetlands have been designed and sized to remove contaminants that are typically associated with urban land use and vehicle movements – primarily sediments, heavy metals, and hydrocarbons. Wetlands will also help to reduce water temperatures before discharging into Kākā Stream.

More detail on the treatment of stormwater, including the locations and concept design of the three proposed wetlands, is provided in the Morphum Environmental report attached in Appendix C.

### 4.2.4 Natural stream design

The lower reach of the Kākā Stream (from the existing buildings at 7 Ralphine Way to the Maitahi/Mahitahi River) is currently considered to be highly modified, comprised of a shallow channel interspersed with multiple smaller intermittent drains and overland flow paths across the lower Kākā Valley floor. This area is also located within the Maitahi/Mahitahi River flood plain.

The development proposes to fill a portion of the valley floor to enable development and enhance and re-naturalise the lower reach of the Kākā Stream. This will involve constructing a naturalised channel in accordance with natural channel design principles, sized to convey the post-development 1% AEP event. The purpose of natural channel design principles is to provide the required hydraulic conveyance of a stream channel and floodway while maximising its potential ecological, cultural, amenity and/or recreational value.

The upper reaches of the Kākā Stream are being left unmodified with general improvements to riparian planting. The main road crossing of the Kākā Stream, utilises a bridge as opposed to a culvert crossing, ensuring that the stream bed can retain an in-situ bed material and ensure ecological connection (e.g. fish passage).

More detail on stream design is provided in the RMM report and Robertson Environmental report.

### 4.2.5 Overland flow paths

Overland flow paths from the undeveloped vegetated slopes and gullies above the proposed development will be retained as open channels to maintain connection to Kākā Stream and to avoid routing these through the treatment wetlands. Overland flow paths through the developed areas will be designed to pass a 2130 SSP5-8.5 1% AEP flow, as required by the NTLDM 2020.

Overland flow paths will follow reserves and roads where possible. As outlined in Figure 3.1, the waterways from the upper undeveloped catchments are typically classified as overland flow path/ephemeral, therefore fish passage has not been considered.

### 4.2.6 Vegetation improvements

The PPC28 area and Kākā Valley Catchment are significantly larger than the area that has been rezoned as residential. The ability of the development to control land use upslope of the development area affords a unique opportunity to manage and improve runoff on a whole of catchment scale rather than solely within the development area. Managing flows through improved land use and vegetation improvements within a catchment is a sustainable approach, provided that the vegetation becomes fully established and is protected from future development or other land use changes. It also potentially avoids or minimises the requirement for other mitigation measures with potentially adverse environmental effects and/or with greater maintenance requirements, e.g. stormwater detention basins.

Significant parts of the catchment (120 ha) are proposed to be improved from an existing state of primarily grassland and brush into forest/bush (native plantings). A key hydrological benefit of forest over grassland is the increased evapotranspiration and retention of water in the catchment, and therefore reduced runoff volumes. In this case, the majority of the proposed vegetation improvements will occur on land that is to be owned by Ngāti Koata who will act as Kaitiaki and may put a kawenata (protective covenant) over the land, similar to a QEII open space covenant. Remaining revegetation areas will be protected through Schedule X requirements in the NRMP.

Based on calculations of runoff rates from existing and proposed land use areas, using published and typical runoff parameters, the reduced runoff from revegetated areas in the Kākā Catchment, together with differing timing of flood peaks from the developed and undeveloped portions of the site, has been demonstrated to compensate for the increased runoff from the additional impervious areas (28.8 ha) within the development area. The effect of vegetation improvement on peak flows is addressed in Section 6.4.1.

Besides the hydrological benefits, vegetation improvement has multiple other benefits such as ecological/habitat improvements, recreational opportunities and improved amenity/aesthetics. It avoids the need to pipe a section of the watercourse, as required for in-line detention basins. It also avoids the requirement for NCC to acquire the additional network asset that will require ongoing management and maintenance.

A disadvantage of vegetation improvements compared with traditional approaches is that the mitigation of flows is not available on day one, but gradually increases over time as vegetation matures. Reaching full canopy cover is generally recognised as the point in time when full benefit is realised. This is generally achieved within 10 to 12 years from planting. However, full mitigation will not be required on day one as the full development will only be achieved gradually and in stages, over a similar timeframe. Conversely, design criteria are based on future flows to account for climate change (2130 SSP5- 8.5) and are not anticipated to eventuate until circa 2121 – 2140.

Taking a whole of catchment approach to stormwater management and managing runoff from the wider catchment through vegetation improvements mimics natural systems and processes, addresses stormwater effects close to source and enhances the values and functions of natural ecosystems.

More detail and associated stormwater calculations and flood risk analysis is provided in Section 6 of this report.

# 5 Proposed development

## 5.1 Land use changes

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

Subsequent to the PPC28 hearing the design of the Maitahi Village portion of PPC28 has been further developed, as outlined below. The proposed development within the Maitahi Village portion of the site comprises:

- Filling within the lower Kākā Valley within the PPC28 area to enable development and the realignment and enhancement of the Kākā Stream;
- Development of the river terraces and intermediate slopes;
- Stormwater management areas located within the riparian corridor.

A post development land use was assumed for this stormwater assessment, based on the latest Maitahi Village scheme plan (detailed in the DO report) for the lower portion of the site, with the land use for the upper section of the site (outside of the proposed Maitahi Village area, but within the Kākā Catchment) based on the indicative masterplan submitted at PPC28. The latest scheme plan produced by Davis Ogilvie (detailed in DO report), the CCKV portion of the site comprises 17.8 ha of impervious area (based on the land use assumptions outlined in 6.2.4.2). This masterplan also proposed areas to be revegetated in native forest, which is shown as a separate scenario due to the time required for the vegetation to grow. These land use scenarios are shown in the Figure 5.1 and Figure 5.2 below and summarised in Table 5.1

**Table 5.1: Proposed changes in land use**

| Land use | Pre-development area (ha) | Post- development area (ha) | Post-development area with vegetation improvements (ha) |
|---|---|---|---|
| Brush (Manuka/Kanuka, Gorse/Broom and riparian planting) | 123.3 | 135.1 | 57.8 |
| Brush/Grass | 22.0 | 21.4 | - |
| Woods (Indigenous and exotic forest) | 4.5 | 3.2 | 124.9 |
| Woods/Grass | 2.9 | 2.9 | - |
| Pasture (High and low producing grassland) | 90.4 | 14.4 | 3.7 |
| Dirt (Access roads) | 1.6 | 1.6 | 1.4 |
| Newly Graded Area (Harvested exotic forest) | 9.8 | 9.8 | 9.8 |
| Urban Parkland/Open Space | - | 36.5 | 27.4 |
| Commercial | - | 0.7 | 0.7 |
| Impervious (Road, roof and hardstand) | - | 28.8 | 28.8 |
| **TOTAL** | 254.4 | 254.4 | 254.4 |

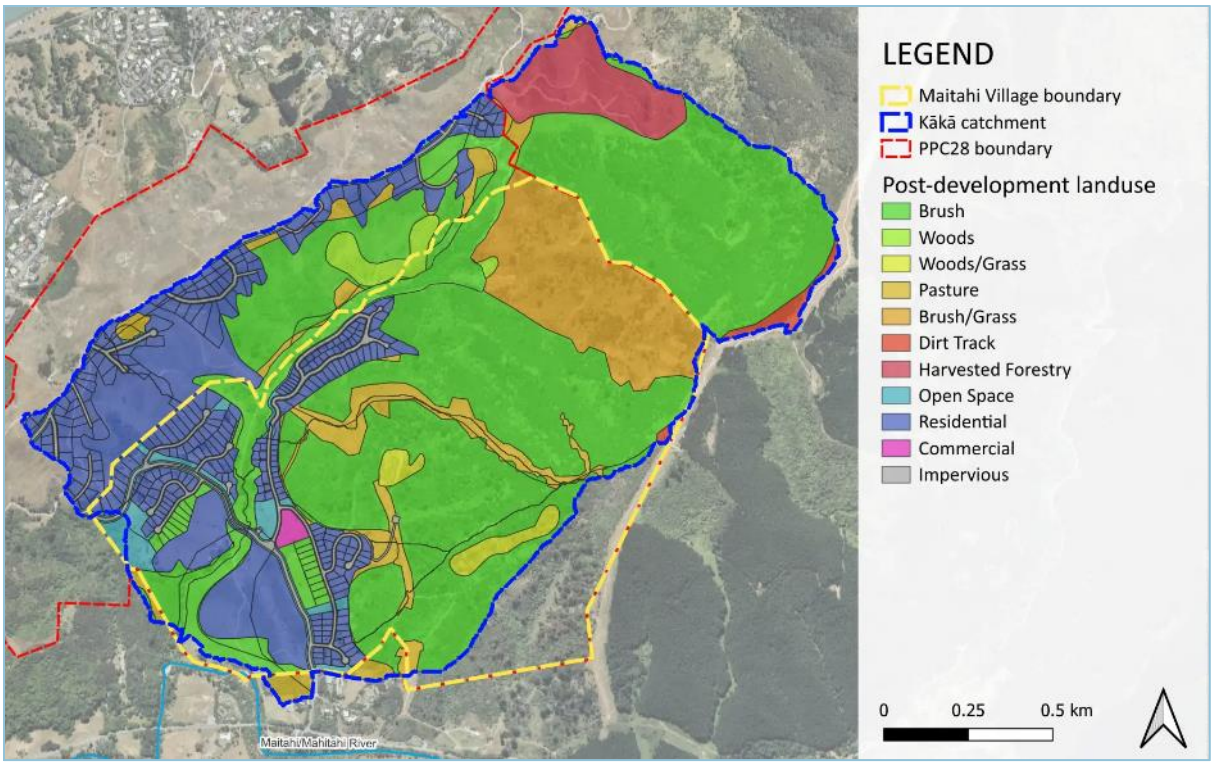


*Figure 5.1: Proposed post-development land use*

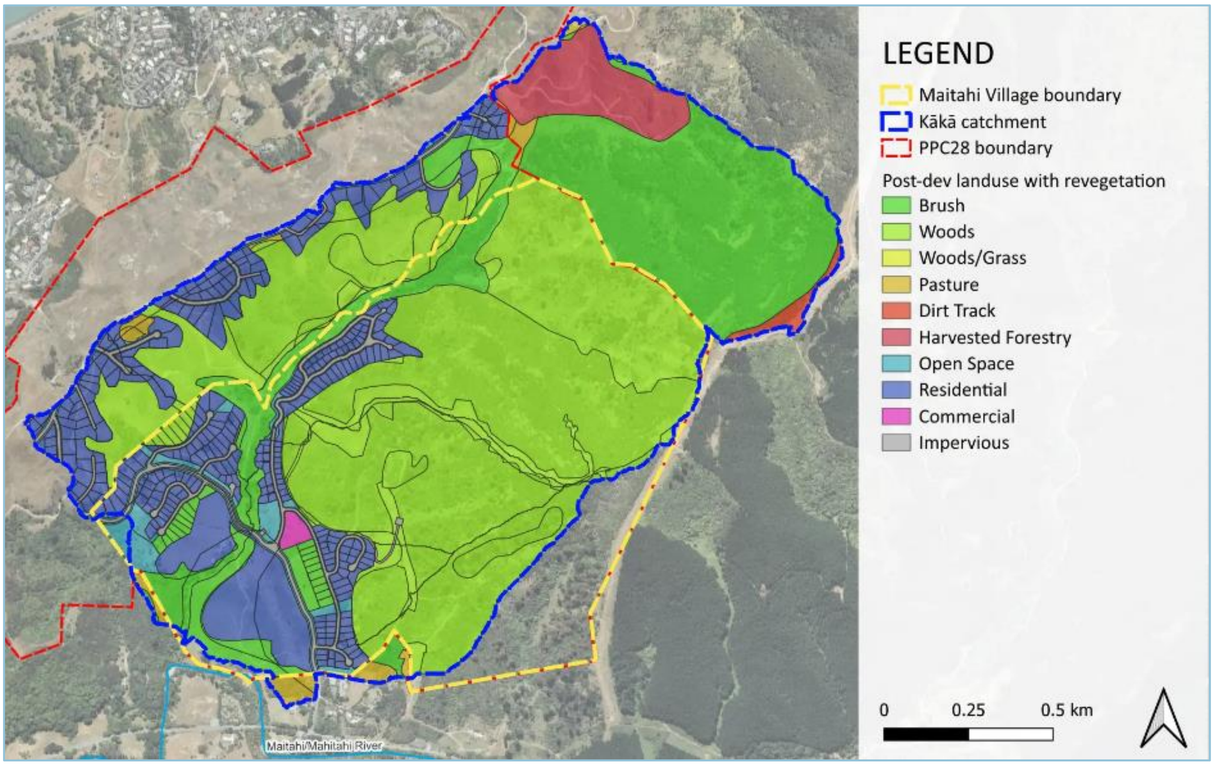


*Figure 5.2: Post-development land use, including proposed wider catchment vegetation improvements*

## 5.2 Stormwater features

The wider stormwater management has been collaboratively developed following an interdisciplinary approach, with specific stormwater elements addressed in the following sections. A figure showing the key stormwater features, outlined below is included in Appendix A, Figure A1.

Davis Ogilvie has prepared a proposed finished landform surface (Version 250121, detailed in the DO report), in coordination with geotechnical engineers. This surface has been used to map post development overland flow paths and flood extents, and to delineate post-development catchments.

### 5.2.1 Developed stormwater 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 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). All 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 within landscaping where feasible (site topography may mean that open channel flow is not appropriate in some places 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 new overland flow channels to proposed attenuation devices.

Refer to DO report for the concept stormwater conveyance design.

### 5.2.2 Overland flow paths

Overland flow paths conveying runoff from the upper undeveloped catchments have been sized as per the NTLDM 2020, with specific consideration of debris management and blockage where culverted. A figure showing these upper catchments with corresponding culverts and open channels is provided in Figure 5.3 below.

The figure also includes the location of a debris bund above the developed area, which will channel flow to Culvert 2.

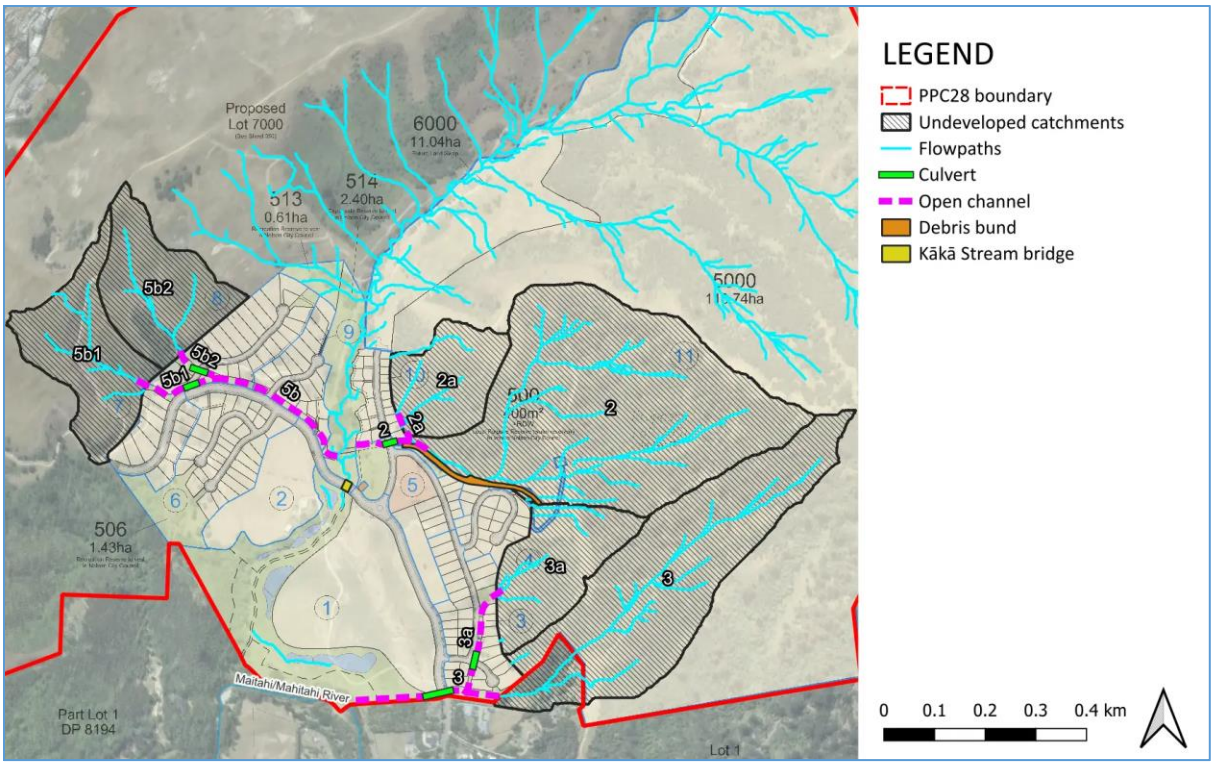


*Figure 5.3: Open channels and culverts to pass overland flow paths from upper catchment*

#### 5.2.2.1 Open channels

Open channels have been sized to pass overland flows from the upper undeveloped catchments through the site. Generally, green corridors have been provided to allow connectivity for these overland flow paths to discharge to Kākā Stream. A 300 mm freeboard provision has been applied for these flow paths and consideration of the flow velocities has been undertaken.

The steep grade of the channels and the large flows being conveyed by them, result in high velocities and shear forces. The use of riprap rock lining is most suitable to avoid scouring with rock sizes ranging from 300 mm to 550 mm. To prevent scour at maximum flow events from both high flows and the water “skipping” off the surface of the rocks and/or channel, the lining should extend up past the maximum flow depth, ideally up to the freeboard requirements.

Section with extremely steep grades (>40%) have been identified as chutes. These generally occur where the channels discharge into Kākā Stream and will require specific design to dissipate energy and reduce the force on the downstream channel/stream which will be undertaken in future design stages.

Open channel sizing and linings have been provided in **Table 5.2** below. Note all sizing and proposed linings are provisional and subject to refinement and confirmation during detailed design.

**Table 5.2: Channel sizing**

| Overland Channel name | Gradient | 1% AEP flow ($m^3/s$) | Peak velocity (m/s) | Dimensions (Bottom width, batter slope) | | | Lining |
|---|---|---|---|---|---|---|---|
| | | | | Bottom width (m) | Batter Slope (1 in XX) | Top width (m) | |
| 5b Type 1 | 10-15% | 1.10 | 1.7 | 1 | 4.00 | 5.8 | Grass |
| 5b1 Chute | 50-60% | 1.10 | 3.4 | TBC during detailed design | | | Rock |
| 5b Type 2 | 20-40% | 1.10 | 3.3 | 1 | 4.00 | 5.8 | Rock |
| 5b Type 3 | 7-18% | 2.12 | 1.8 | 1.5 | 4.00 | 7.1 | Grass |
| 5b Chute | 25-30% | 2.12 | 3.2 | TBC during detailed design | | | Rock |
| 2a Type 1 | 1-10% | 0.74 | 0.7 | 2 | 2.00 | 4.8 | Grass |
| 2 Type 1 | 2-11% | 3.95 | 1.3 | 4 | 4.00 | 12 | Grass |
| 2 Type 2 | 8-18% | 3.95 | 3.9 | 2 | 4.00 | 8 | Rock |
| 2 Chute | 25-100% | 3.95 | 4.8 | TBC during detailed design | | | Rock |
| 3a Type 1 | 1-11% | 0.89 | 0.7 | 2 | 4.00 | 7.6 | Grass |
| 3a Type 2 | 11-22% | 0.89 | 2.5 | 1 | 4.00 | 5.8 | Rock |
| 3b Type 1 | 18% | 2.15 | 3.4 | 2 | 4.00 | 6.8 | Rock |
| 3 Type 2 | 18-25% | 3.04 | 5.1 | 1 | 3.00 | 7.0 | Rock |
| 3c Type 2 | 20% | 3.04 | 5.4 | 1 | 3.00 | 7.0 | Rock |
| 3c Type 1 | 11% | 3.04 | 0.9 | 4 | 4.00 | 8.8 | Grass/planted |

#### 5.2.2.2 Culverts

Culvert sizing has been undertaken to determine culvert dimensions for where the overland flows from the upper catchments pass under roadways, as shown in Figure 5.3. Sizing is provisional only and will be further refined at detailed design stage.

In general the following design criteria have been met:

- Culverts sized to the future 1% AEP event with climate change, as per NTLDM 5.4.6.2.
- Min. 500 mm freeboard applied to road surface, unless significant blockage risk is present than culverts sized to have no surcharge in the 1% AEP flow.
- 600 mm cover achieved in roadway.
- Culverts to be box or circular culverts of standard dimension.

Culvert sizing is summarised below in Table 5.3. Note all sizing is provisional and subject to change as part of detailed design.

**Table 5.3: Culvert sizing**

| Culvert name | 1% AEP flow (m3/s) | Catchment (ha) | Pipe Gradient | Indicative pipe diameter (mm) |
|---|---|---|---|---|
| 5b1 | 1.10 | 57 | 12% | 750 |
| 5b2 | 1.01 | 53 | 20% | 750 |
| 5b-1 | 2.12 | 110 | 14% | 1050 |
| 5b-2 | 2.12 | 110 | 5% | 1050 |
| 2 | 3.95 | 59 | 0.3% | 1600 |
| 3a | 0.89 | 48 | 1% | 825 |
| 3 | 3.04 | 187 | 1% | 1350 |

It is noted that all culverts will require headwalls and energy dissipation devices. Energy dissipation devices may include, but are not limited to, riprap aprons, stilling basins, or stilling well structures.

As per NTLDM 5.5.13, system blockage is to be considered. Given the nature of the upper catchments and the adjacent development a provisional blockage assessment for these culverts was undertaken (see Table 5.4 below).

**Table 5.4: Culvert blockage assessment**

| Culvert name | Catchment Characteristics (Debris Type, Availability & Transportability) | Secondary overflow path | Proposed Debris management and inlet type |
|---|---|---|---|
| 5b1 | Steep rural catchment with pastoral and scrub. | Flow to overtop road and return to OFP. | Duplicate intake (standard NTLDM inlet with secondary scruffy dome intake). |
| 5b2 | Steep rural catchment with pastoral and scrub. | Flow to overtop road and return to OFP. | Duplicate intake (standard NTLDM inlet with secondary scruffy dome intake). |
| 5b-1 | Flow from upstream OFP. | Flow to overtop road and return to OFP. | No additional measures required. |
| 5b-2 | Flow from upstream OFP. | Flow to overtop road and return to OFP | No additional measures required. |
| 2 | Steep upper catchment with known debris flow risk from debris bund. | Road to be shaped to allow for overtopping flow to pass over and not track down road. | Consider concrete lined road section.<br>Duplicate intake (standard NTLDM inlet with secondary scruffy dome intake).<br>Pipe to be oversized to ensure no surcharging in the 1% AEP event.<br>Excavator access to intake. |
| 3a | Small steep rural catchment pastoral and scrub. | Road to be shaped to allow for overtopping to flow north down road to bridge. | Duplicate intake (standard NTLDM inlet with secondary scruffy dome intake). |

| Culvert name | Catchment Characteristics (Debris Type, Availability & Transportability) | Secondary overflow path | Proposed Debris management and inlet type |
|---|---|---|---|
| | | | Pipe to be oversized to ensure no surcharging in the 1% AEP event.<br>Excavator access to be provided at intake. |
| 3 | Rural catchment with pasture and scrub. | Overtopping flows to be contained within the road corridor and flow north to the bridge. | Duplicate intake (standard NTLDM inlet with secondary scruffy dome intake).<br>Pipe to be oversized to ensure no surcharging in the 1% AEP event.<br>Excavator access to be provided at intake. |

Initial concept designs for Catchment 3a included piping of flow for an extended length under the road and under private properties. The risk of pipe blockage at the inlet and resulting safety risks and road damage has led to a design change that retains this overland flow path in an open channel that runs parallel to the road until it meets Channel 3, just upstream of Culvert 3.

### 5.2.3 Stormwater treatment

The proposed stormwater reticulation developed by Davis Ogilvie (detailed in the DO report) to service the developed portions of the development area, directs primary flow to a series of treatment wetlands (detailed in the Morphum Environmental report). The proposed treatment catchments and the receiving wetlands are shown in Figure 5.4.

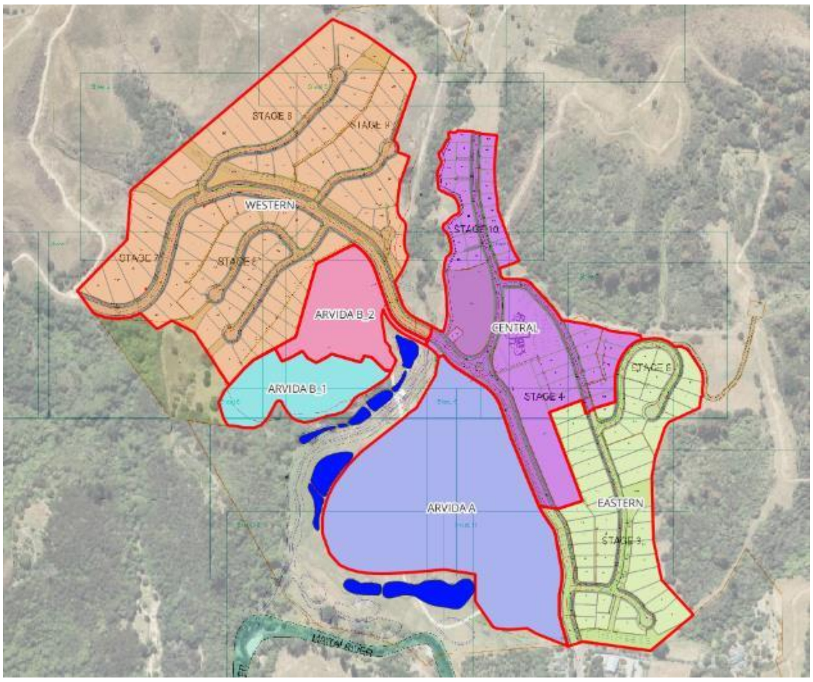


*Figure 5.4: Treatment catchments and wetlands*

## 5.3 Kākā Stream

### 5.3.1 Kākā Stream realignment

The development proposes enhancement and realignment of the lower section of the Kākā Stream. Specific detail on the Kākā Stream realignment design is provided in the RMM report.

The following stormwater input has been considered in these reports as part of the design of the re-aligned stream:

- Sufficient flood capacity to ensure that the 2130 SSP5-8.5M 1% AEP flows can be conveyed within the realigned channel with suitable freeboard to adjacent buildings. Coordination regarding provision of planting and the subsequent impacts on hydraulic roughness at flood water levels.
- Design average Manning's 'n' roughness value of 0.075 is based on guidance provided by Christchurch City Council Waterways, Wetlands and Drainage Guide, Part B: Design, section 22 Hydraulics, February 2003 and Roughness Characteristics of Natural Channels, Barnes, H.H.Jr 1967. This allows for irregular sections of stream including pools, riffles and slight meanders. Plantings will include grasses and reeds within the channel and shrubs and grasses on the banks. This value is more conservative than the NTLDM minimum roughness for open channels (0.055 as per NTLDM 5.5.1.3) to reflect the proposed level of riparian vegetation.
- Assessment on the likely groundwater levels and the ability of the revised channel alignment to intercept these to support base flows.

### 5.3.2 Kākā Stream bridge crossing

A bridge is proposed for the main Kākā Stream road crossing, as shown below in Figure 5.5.

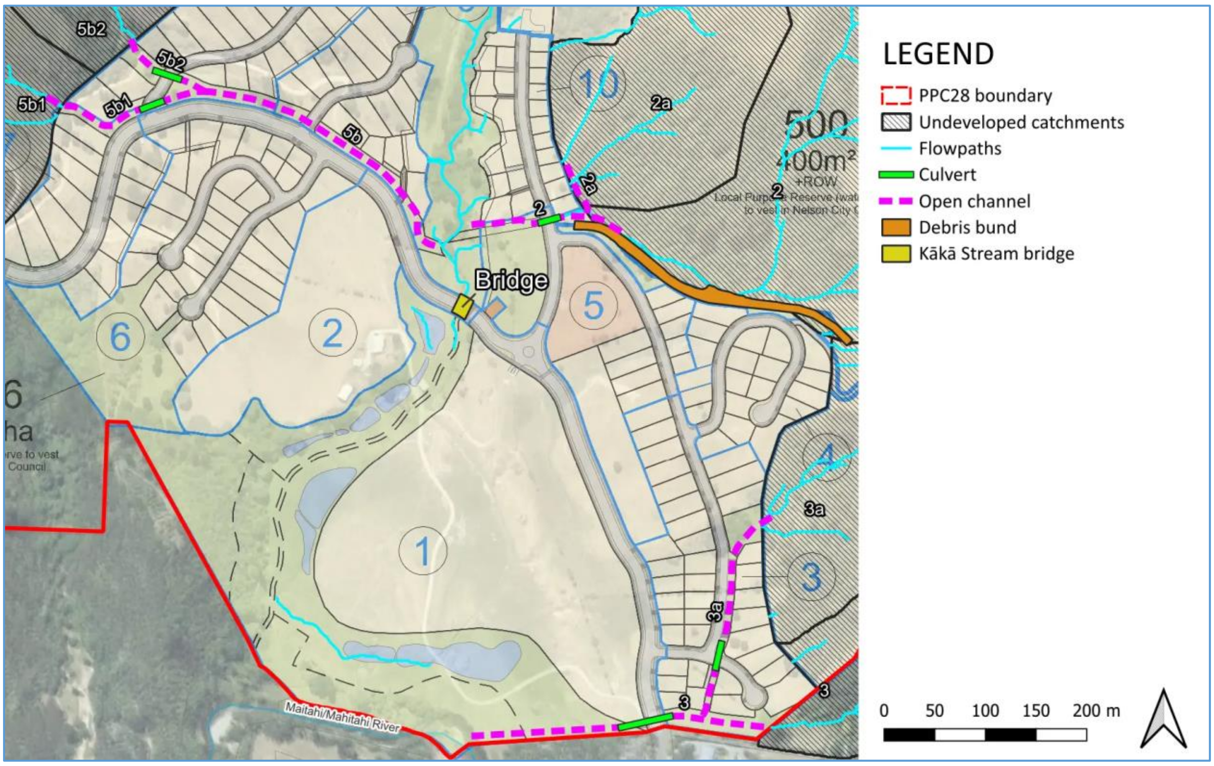


*Figure 5.5: Kākā Bridge location*

A bridge solution will have greater ecological benefits than a culvert due to reducing the realignment length and allowing for better fish passage. There may also be an opportunity for a path under the bridge.

A hydraulic assessment of the bridge crossing was undertaken to determine the design water level at the bridge, based on a preliminary 2130 SSP5-8.5 1% AEP peak flow of 17.1 $m^3/s$. This assessment is based on a target bridge span length of 15 m and considered landform and the existing ground LiDAR to determine a provisional bridge section, as shown in Figure 5.6 below.

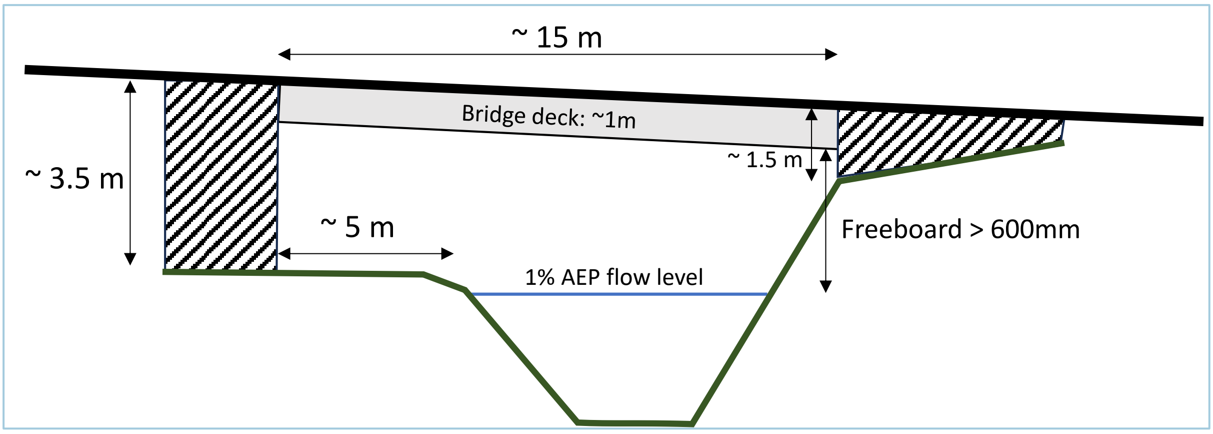


*Figure 5.6: Preliminary bridge hydraulic section.*

The design assumes no piers between abutments, which will be confirmed during detailed design. This shows that the 2130 SSP5-8.5 1% AEP event could be contained within the existing channel, with the potential for a footpath/access under the bridge outside the 1% AEP flow depth. Due to the relative stream and proposed road levels, there is significantly more freeboard available than the 600 mm required by NTLDM Table 5-4.

# 6 Flood risk assessment

The Maitahi/Mahitahi River presents significant flood risk to Nelson City, including the Maitahi Village. This flood risk is expected to increase in the future in response to climate change. This section summarises current and future flood hazard information and assesses the potential effects of the proposed development on downstream flood risks. It also provides information of flood risk throughout the Kākā Valley.

## 6.1 Maitahi/Mahitahi River flooding

The Maitahi/Mahitahi River has a catchment of approximately 100 $km^2$. The present-day peak 1% annual exceedance probability (AEP) flood flow through the lower reaches is currently understood to be approximately 365 $m^3/s$ (per NIWA's 2021 frequency analysis of data collected at the "Maitai @ Avon Terrace" flow gauge).

NCC maintains a calibrated flood model for the river that has been used to provide flows and flooding depths and extents in the lower Kākā Valley. Flood modelling results indicate that a 1% AEP flow event, both present-day and future events, are expected to cause widespread flooding across the rural/semi-rural sections of the Maitahi/Mahitahi River upstream of Nelson, including in the flood plain at the Kākā Stream confluence. Figure 6.1 below shows 2130 1% AEP flood mapping, based on the existing catchment land use and current climate change projections out to the year 2130.

All modelling in this report references the relevant model version. The NCC calibrated model used for these assessments is MaiBkYk_202103_v089. This model has been calibrated for Maitai/Maitahi River and Brook Stream. The calibration process for York Stream is still underway, but the results from v089 are not expected to change from these updates.

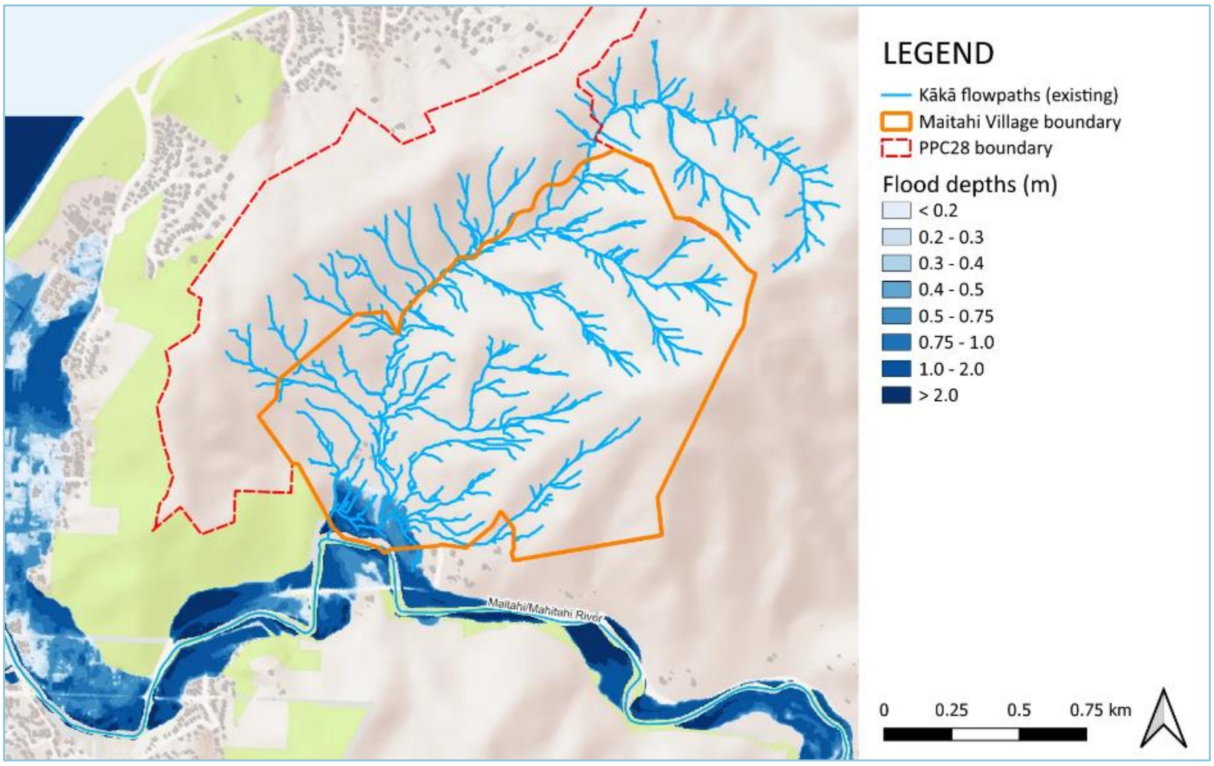


*Figure 6.1: Maitahi/Mahitahi River flood depths in blue (2130 SSP5-8.5M 1% AEP event) sourced from NCC Maitahi/Mahitahi River flood model version 202103v089.*

NCC modelling shows flood levels in the flood overlay area within the Maitahi Village of up to approximately RL 17.6 m (NZVD 2016) for the 2130 1% AEP flooding. These water levels would be expected to occur during the 12-hour event, which is considered the critical duration event at the Kākā Stream confluence (note further downstream in the Nelson urban area, the 24-hour duration event becomes critical). The modelled flows in the Maitahi/Mahitahi River include a contribution from the Kākā Stream. However, the river 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). A separate model has been developed to map flood hazard within the Kākā Catchment itself, as discussed later in this report in Section 6.2.3.

### 6.1.1 Maitai Dam – dam break hazard

The Maitahi/Mahitahi River flood model has also been used by NCC to map dambreak flood hazard resulting from a hypothetical failure of the Maitai Dam. The modelling is covered in the T+T report titled "Maitai Dam – Dam Break Hazard Modelling" v2, dated March 2023. The modelling has been run for both sunny-day and rainy-day dambreak scenarios, and indicates that the flood wave would arrive at the CCKV site approximately 40-50 minutes after the dam break. The modelled flood depths in the rainy-day scenario exceed what would be experienced at the site during the modelled 1% AEP flood event, described above. However, based on the latest dambreak information and the current proposed CCKV landform, we confirm that there is a minimum of 1 m freeboard between the peak dambreak flood levels and the lowest design earthworks platform for residential development (i.e. the Arvida site platform in the lower valley).

## 6.2 Kākā Stream flooding

### 6.2.1 Historic flooding

Flood flows from the Kākā Catchment have typically remained confined within the existing stream extent within the steep sided upper catchment before breaking out and flowing over the valley floor area and interacting with backwater from the Maitahi/Mahitahi River. Based on anecdotal evidence and historic aerial photographs, it is clear that the lower Kākā Stream alignment has varied across the floodplain over time, as can be expected for a flat alluvial fan floodplain. The most recent major flood event occurred in August 2022. Flows produced erosion in the upper gully and transported gravels and sediments downstream. An existing farm culvert (twin 450 mm diameter barrels) and upstream and downstream channel became completely blocked with sediment and gravel. Flood waters and mobilised material were deposited across the lower floodplain. Photos taken during and just after this event are presented in Figure 6.2 and Figure 6.3 below.

*Figure 6.2: Flooding during August 22 flood – lower Kākā floodplain. Source: NTEM facebook page.*

*Figure 6.3: Flood debris post August 22 flood – lower Kākā floodplain. Source: LINZ.*

### 6.2.2 Kākā Stream flood modelling

An assessment of catchment flows and flooding within the Kākā Catchment using a range of approaches, including hydrological modelling (HEC-HMS software using the SCS 1986 method), empirical peak flow estimation methods, and 2d direct rainfall modelling, was undertaken.

TUFLOW software was used to undertake direct rainfall (or Rainfall on Grid (RoG)) modelling. This model was (and is intended in detailed design stages to be) used as a design tool for understanding catchment flow-paths, and to confirm the functioning capacity of proposed flow paths and culverts.

Section 6.2.3 below outlines the development of the TUFLOW direct rainfall model.

Section 6.2.4 below details the estimation of pre and post peak flows using various methods. These flow values have been used to size culverts, a bridge, and overland flow paths, and as the basis for the effects assessment.

### 6.2.3 Direct rainfall flood modelling

A TUFLOW model was developed 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 SSP5-8.5M planning horizons. The following model parameters have been used:

- 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 Maitahi/Mahitahi River flood model (current version 202103v089) results as downstream boundary conditions for a range of design events. A flow hydrograph was extracted from the model and applied as a boundary condition within the TUFLOW model.
- Similar hydrological parameters to those in other models within the Nelson region (these parameters will be reviewed during subsequent more detailed design phases).
- For the purposes of assessing inundation levels (for example in the lower flood plain), the 2130 SSP5-8.5M climate projection has been used, consistent with the NCC Maitahi/Mahitahi River flood model.
- The current model version at the time of this report was Kākā_006.

Modelling indicates that the 6-hour rainfall event (based on the HIRDS v4 storm profile) produces the greatest peak flows from the Kākā catchment. The flood depth and extents resulting from the 2130 SSP5-8.5 1% AEP 6-hour event (with peak 6-hour flows in the Maitahi/Mahitahi River) is shown in Figure 6.4.

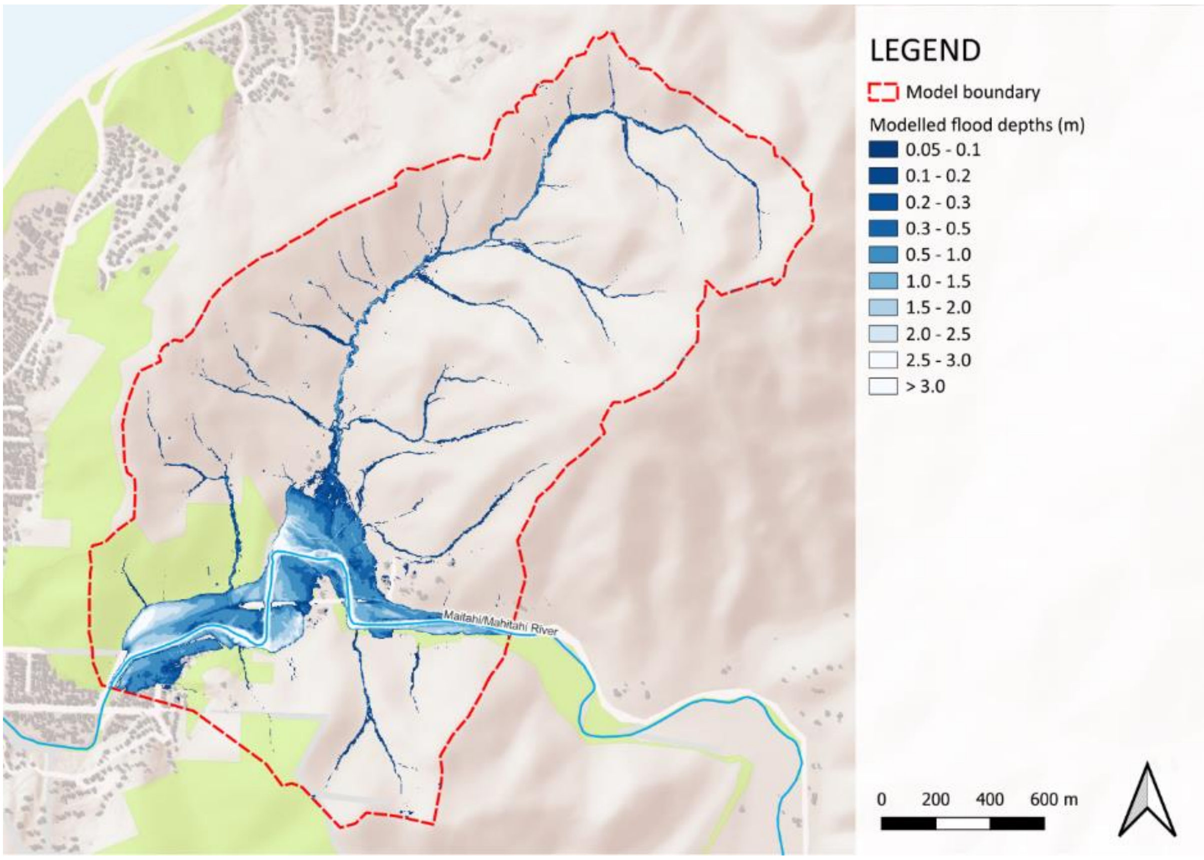


*Figure 6.4: Flood depth mapping within the Kākā Stream Catchment in blue – 2130 SSP5-8.5M 1% AEP 6-hour event (TUFLOW model version Kākā_006). The red dashed line is the model boundary.*

The modelled peak runoff rates using this rainfall-on-grid method are within the range of other estimates outlined in Table 3.2, and the model is considered adequate to inform the understanding of existing flooding and flow paths.

### 6.2.4 Pre- and post-development peak flow assessment

The proposed development of the Kākā Catchment will result in an increase in impervious surfaces, which in turn will also increase the volume of stormwater runoff generated from those areas and, if unmitigated, a resulting increase in downstream peak flows and total runoff volumes during stormwater events.

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

- Recognise the key constraints and opportunities within the Maitahi Village, the wider Kākā Catchment and receiving environments.
- A water-sensitive design approach for the Kākā Stream Catchment, that manages flooding effects.
- Facilitate urban development and protect key infrastructure, people and the environment from significant flooding events, while restoring natural hydrological processes within the catchment and improving ecological values.

The approach to manage peak flow run-off from the catchment is based on managing land use changes and their associated effects on hydrological processes. Increased run-off from impervious areas can be compensated by decreases in run-off from large areas of the catchment that are proposed to be revegetated in native forest. The proposed approach to manage peak flows and mitigate the effects of urban development within the Kākā Catchment is described in more detail in the following sections.

#### 6.2.4.1 Stormwater quantity modelling

Stormwater runoff from the proposed post-development land use within the Kākā Stream Catchment has been modelled using the SCS hydrological method using a single catchment with changes to the predevelopment curve number to reflect increased impervious areas and vegetation improvements to enable a comparison between the peak pre-development and post-development peak runoff.

#### 6.2.4.2 Modelling parameters

The land use assumptions for the SCS hydrological modelling are based on a combination of the more refined proposed site plan for the Mahitahi Village portion of the site and the layout from PPC28 masterplan for the remainder of the site, shown in Figure 6.5.

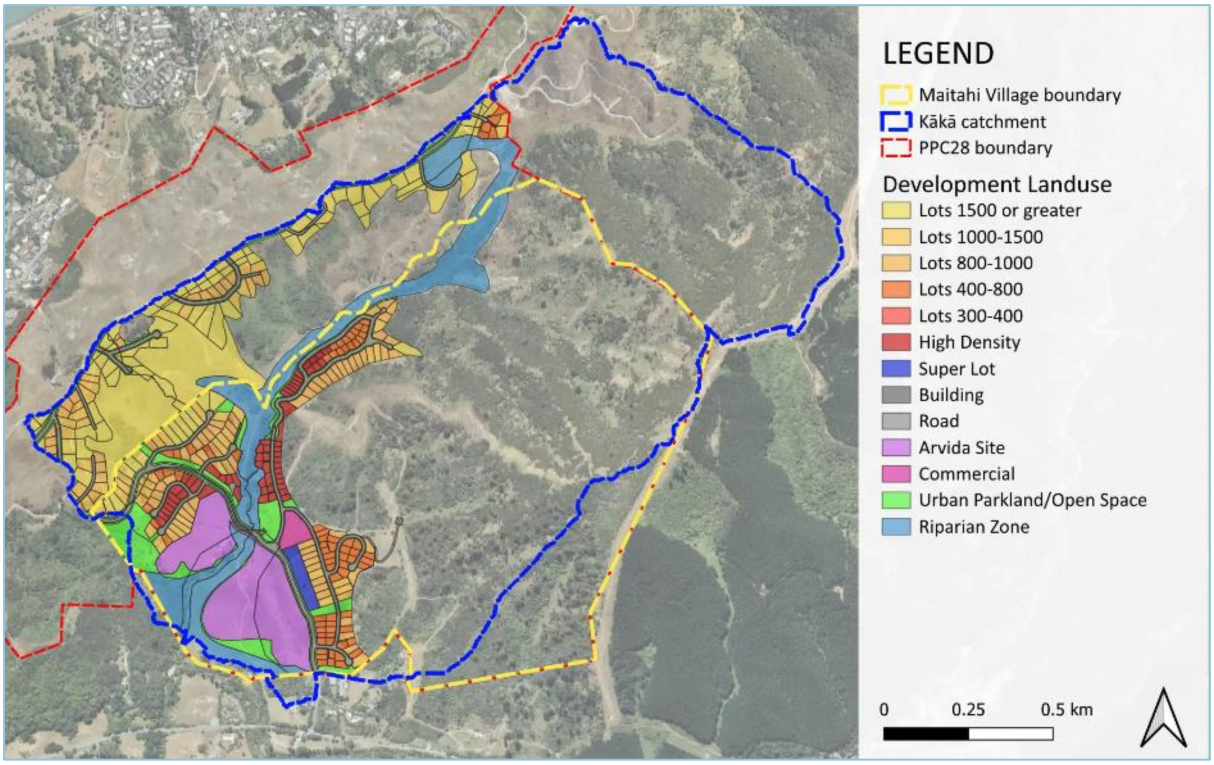


*Figure 6.5: Planned development for areas with impervious surfaces*

To estimate the amount of impervious surfacing in the Kākā Stream Catchment, the below assumptions outlined in Table 6.1 and discussed below, have been used:

- For High Density areas (lots of 300 to 400 m²) the site building coverage has been assumed based on the consent coverage for rule REr.23 of the Nelson Resource Plan as 40 %, with 35% site hard stand area, i.e. total impervious cover of 75%.
- For lots of 400 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% (400 to 800 m²) and 40 % (800 to 1,000 m²) 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 400 m² building areas and between 150 m² and 200 m² hardstand was assumed.
- The Super Lot was assumed to be 33% impervious, due to the slope covering most of the site.
- Roading areas were assumed to be 100% impervious.
- The Arvida site was included at an assumed 70% impervious detailed in the DO report.

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 areas 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 '*Open Space (lawns, parks, golf courses, cemeteries, etc.)*' – good condition to improve the pre-developed land use (*'Pasture'* – fair condition).
- 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 have 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 6.1: Impervious area assessment assumptions**

| Lot sizes | Assumed site coverage (building) | Assumed site hardstand (driveway, etc.) | Site hardstand overall (m²) |
|---|---|---|---|
| 300 m² - 400 m² | 40% | 35% | 225-300 |
| 400 m² - 800 m² | 40% | 20% | 240-480 |
| 800 m² - 1,000 m² | 30% | 20% | 400-500 |
| 1,000 m² - 1,500 m² | 400 m² | 150 m² | 550 |
| 1,500 m² + | 400 m² | 200 m² | 600 |

Based on the above assumptions the extent of imperviousness within Kākā Stream Catchment post development is summarised below Table 6.2 and shows an overall impervious area of 28.8 ha, or 11% of the total catchment area, compared to the predevelopment impervious area of less than 1%.

**Table 6.2: Kākā Stream Catchment impervious areas**

| Developed areas | Total Area (ha) | Impervious coverage | Impervious Area (ha) |
|---|---|---|---|
| Lot areas 300 m² - 400 m² | 3.1 | 75% | 2.3 |
| Lot areas 400 m² - 800 m² | 4.3 | 60% | 2.6 |
| Lot areas 800 m² - 1,000 m² | 6.6 | 50% | 3.3 |
| Lot areas 1,000 m² - 1,500 m² | 6.3 | 47% | 3.0 |
| Lot areas > 1,500 m² | 22.1 | 18% | 4.0 |

| Developed areas | Total Area (ha) | Impervious coverage | Impervious Area (ha) |
|---|---|---|---|
| Super Lot | 0.8 | 33% | 0.3 |
| Roading | 6.4 | 100% | 6.4 |
| Undeveloped areas (Riparian corridor, Open Space Recreation, etc.) | 227.2 | 0% | 0 |
| **Total** | **254.4** | **11%** | **28.8** |

Based on the proposed future land use outlined in Table 6.2, the impervious cover within the Kākā Stream Catchment is expected to increase from less than 1% to approximately 11%. In addition to this increase in impervious areas, the catchment area covered in native forest is expected to increase from less than 2% to approximately 50%, as outlined in Section 4.2.6.

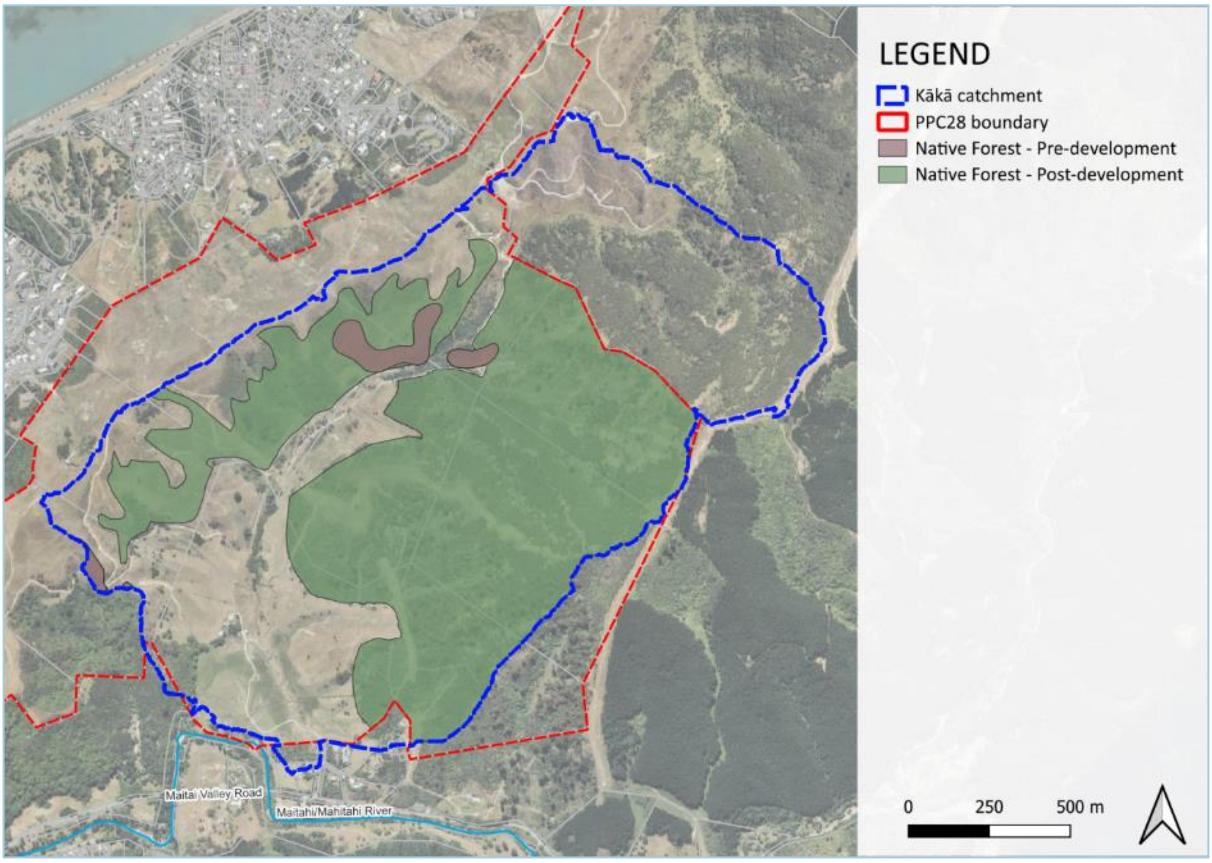


*Figure 6.6: Proposed significant increase in native forest within the Kākā Stream Catchment as part of the development's ecological enhancement and flood mitigation measures.*

The proposed land use changes will gradually develop over time while housing developments progress and vegetation establishes. The pre-development runoff has been compared to three different post development scenarios as shown in Table 6.3. Detailed calculations are included in Appendix B. Note where scenarios state that revegetation/vegetation improvements are proposed, this relates to the proposed conversion from pasture and scrub to native forests in the upper catchment as outlined in Figure 6.6, other vegetation changes (e.g. riparian corridor improvements, berms, etc.) are already incorporated into the post-development scenario.

**Table 6.3: Assessed development scenarios**

| | Pre-development | Post-development | | |
|---|---|---|---|---|
| | | Scenario 1 | Scenario 2 | Scenario 3 |
| Development stage | None | Full | Full | Full |
| Impervious area (ha) | 0 | 28.8 | 28.8 | 28.8 |
| Assumed vegetation establishment | 0% (existing) | 0% establishment | Partially established | Fully established |
| Additional Revegeated/reforested areas (ha) | 0 | 0 | 124.9 | 124.9 |
| Assumed climate.<br>10% and 1% AEP events run for all scenarios | Present-day | Present-day | 2130 SSP5-8.5M | 2130 SSP5-8.5M |

Note: All rainfall events are based on a 6-hour HIRDS v4 storm profile

Scenario 2 has been included to test the sensitivity of the future flooding to the slow establishment of the revegetation areas. It assumes that the 124.9 hectares of revegetation is only partially established and has a higher CN number for flow modelling (In “Fair” condition rather than “Good”).

#### 6.2.4.3 Kākā Stream peak flow modelling

The combined effects of proposed land use changes within the Kākā Stream Catchment have been modelled using the SCS hydrological method. Table 6.4 and Figure 6.7 show that in a present-day rainfall event, with the full impervious surface, but the vegetation improvements in the upper catchment have not had time to establish, but assuming instantaneous and full urban development, the potential flow increase is 0.2 $m^3/s$. It should be noted that in reality, the development will not have reached its full development capacity yet either and these flow changes should therefore be considered conservative. This scenario was modelled for present day rainfall only, as vegetation establishment is assumed to have been long since achieved in 2130.

**Table 6.4: 1% and 10% AEP flows from the Kākā Catchment in present day rainfall scenario**

| Kākā Catchment | Pre-development | Scenario 1<br>Post-development 0% vegetation improvements | |
|---|---|---|---|
| | Flow ($m^3/s$) | Flow ($m^3/s$) | Change in flow ($m^3/s$) |
| 6-hour 1% AEP present day | 10.4 | 10.5 | 0.2 |
| 6-hour 10% AEP present day | 5.3 | 5.5 | 0.2 |

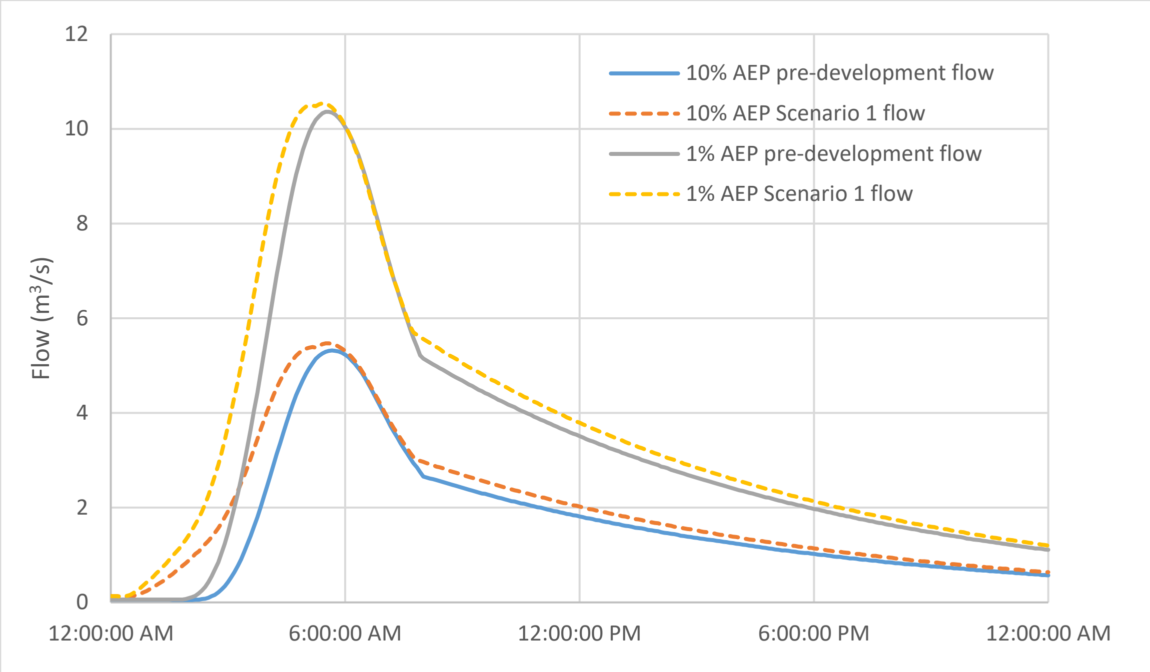


*Figure 6.7: Pre-development and post-development peak flows in the Kākā Catchment for the present day 6-hour storm event*

Table 6.5 and Figure 6.8 show that once partial vegetation improvements are established that there is no increase in flow in a 1% AEP event as a result of the proposed development. By the time that the planned vegetation improvements in the upper catchment are fully established, a decrease in peak flows of 0.5 $m^3/s$ can be expected in a 1% AEP event peak flow. This takes into account future climate rainfall SSP5-8.5 in 2130).

Native forest type vegetation generally takes five years to establish and 10 to 12 years to mature by which time full canopy cover is achieved as well. It should be noted that the areas that are proposed for revegetation will be gifted to Ngāti Koata who may place a kawenata (protective covenant similar to QEII covenant) over it to protect the land use in perpetuity.

**Table 6.5: 1% and 10% AEP flows from the Kākā Catchment in SSP5-8.5m to 2130 scenario**

| Kākā Catchment | Pre-development | Scenario 2 Post-development partial vegetation improvements | | Scenario 3 Post-development full vegetation improvements | |
|---|---|---|---|---|---|
| | Flow ($m^3/s$) | Flow ($m^3/s$) | Change in flow ($m^3/s$) | Flow ($m^3/s$) | Change in flow ($m^3/s$) |
| 6-hour 1% AEP SSP5-8.5M to 2130 | 17.1 | 17.1 | 0 | 16.6 | -0.5 |
| 6-hour 10% AEP SSP5-8.5M to 2130 | 9.2 | 9.1 | -0.1 | 8.8 | -0.4 |

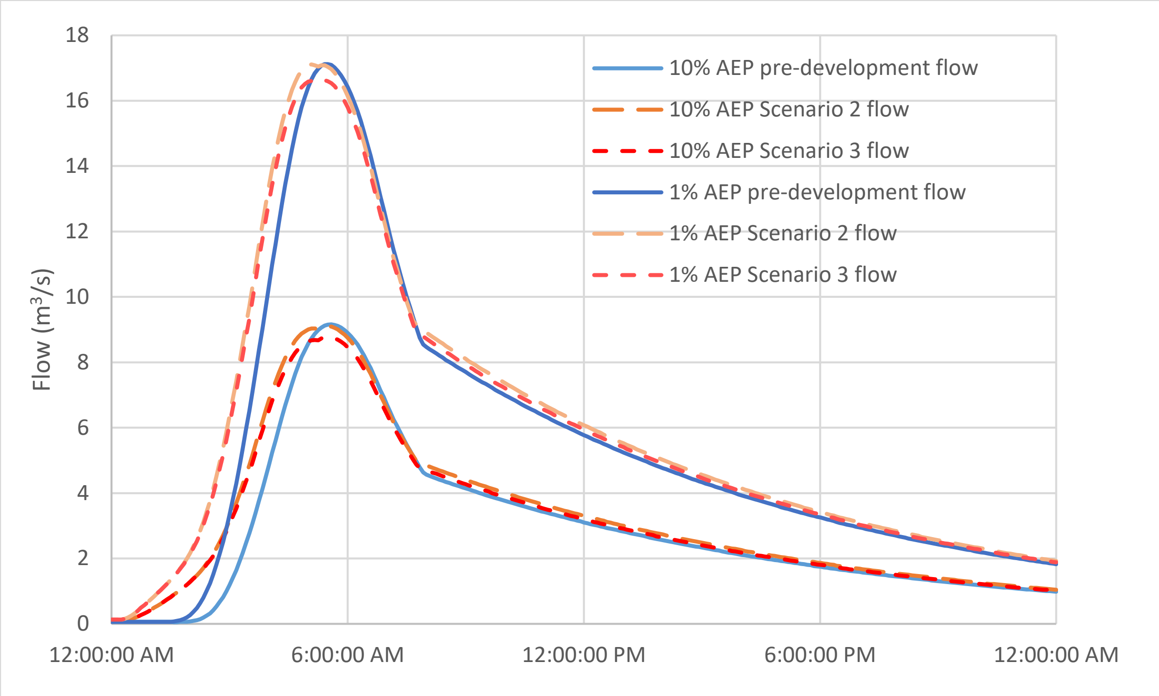


*Figure 6.8: Pre-development and post-development peak flows in the Kākā Catchment, 1% AEP with climate change scenario SSP5-8.5M to 2130, 6-hour storm even, 50% and 100% established revegetation.*

This reduction in peak flood flows is expected to occur because of the vegetation improvements in the upper catchment, as well as the location of the proposed development in the lower portion of the catchment, which results in differing timings of the peak flows from the developed and undeveloped portions of the site. This misalignment of peak flows further reduces peak flows at the downstream extent of the site.

#### 6.2.4.4 Summary of peak flows

The analysis of peak flows from pre-development and post development scenarios from the Kākā Catchment can be summarised as follows:

**Table 6.6: Summary of peak flows**

| Kākā Catchment | Scenario 1<br>Post development 0% vegetation improvements (present day rainfall) | Scenario 2<br>Post-development partial vegetation improvements (with climate change) | Scenario 3<br>Post-development full vegetation improvements (with climate change) |
|---|---|---|---|
| | Change in flow ($m^3/s$) | Change in flow ($m^3/s$) | Change in flow ($m^3/s$) |
| Expected flow increase 1% AEP | 0.2 | 0 | -0.5 |
| Expected flow increase 10% AEP | 0.2 | -0.1 | -0.4 |

The proposed approach of mitigating increases in flow from impervious surfaces by revegetating areas of the catchment in native vegetation and protecting these with a covenant is considered effective.

It should be noted that the proposed approach does not meet NTLDM clause 5.4.13 for the short-term and conservative present day, 0% vegetation establishment scenario, which requires that detention is provided so that post-development do not exceed pre-development peak flows. However, the proposed approach still meets the performance outcomes of the NTLDM as well as having multiple other comparative benefits in this short-term scenario. Section 6.4 of this report addresses this in more detail. The effects of minor increases in flow on downstream flooding have been addressed in Section 6.4.1.

In the long-term scenarios where vegetation improvements have been partially or fully established, the NTLDM clause 5.4.13 requirement is met or exceeded and the proposed development either matches or reduces the peak flow from the Kākā catchment.

#### 6.2.4.5 Relative peak flow timings

The timing of peak flows in the Maitahi/Mahitahi River in relation to peak flow from the Kākā Catchment is represented in Figure 6.9 and Figure 6.10 below. The 6-hour storm is shown, as it is critical for the Kākā Catchment and below peak for the Maitai Catchment, giving the largest overall difference.

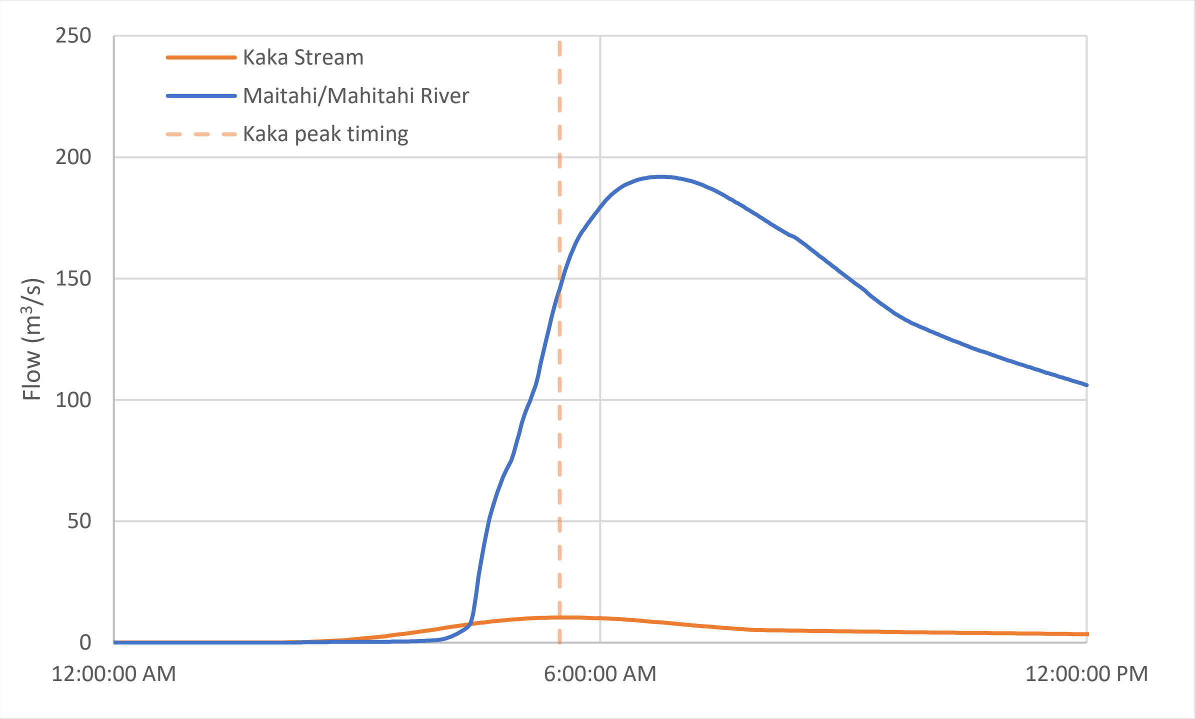


*Figure 6.9: Maitahi/Mahitahi River and Kākā Stream Catchment flows for 1% AEP Present Day 6-hour storm event*

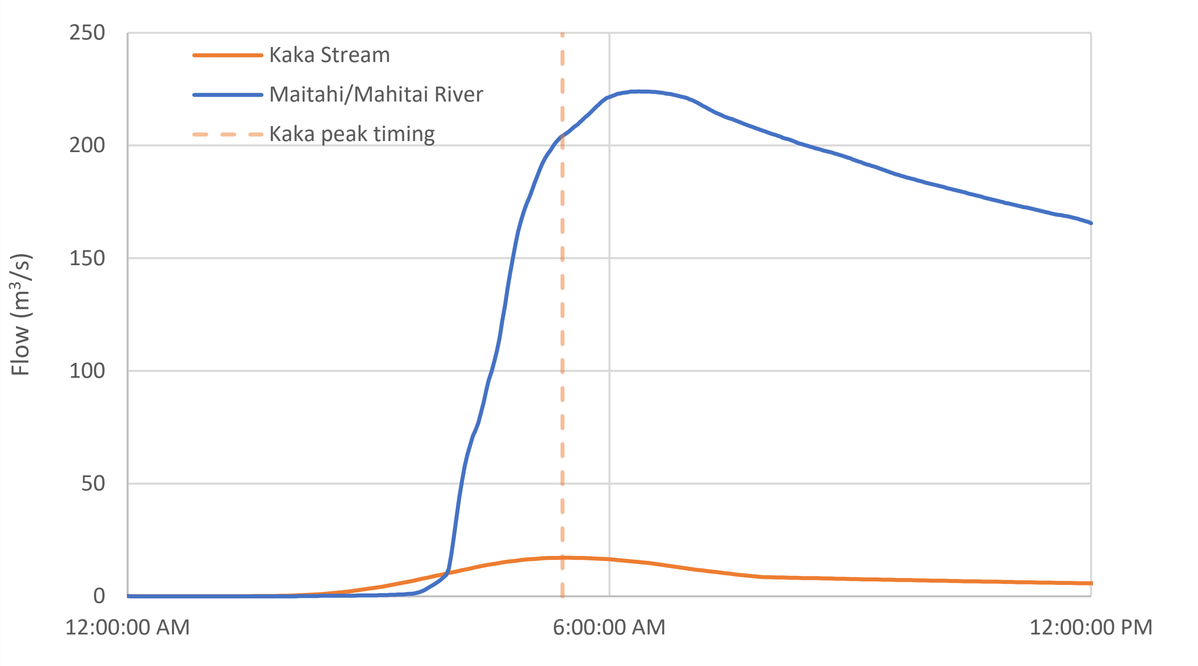


*Figure 6.10: Maitahi/Mahitahi River and Kākā Stream Catchment flows for 1% AEP with climate change scenario SSP5-8.5M to 2130 6-hour storm event*

In any real storm event, the Maitahi/Mahitahi River peak flows are likely to last a relatively long time compared to peak flows from the Kākā Catchment. While the figures above, for a particular design storm, show that the peak of the Kākā Stream outflows occurs earlier than the peak of the larger Maitahi/Mahitahi River flows, more adversely-timed storms are possible, and with reasonable likelihood. In the absence of data to inform a combined probability analysis, we have taken a conservative approach and assumed that peak flows from both catchments coincide during the design storm event. We also note that given the proximity of the peaks in the above scenario, and the relative peaks of the two river branches, the conservativism of this assumption does not greatly affect the overall results.

## 6.3 NTLDM 2020 compliance

As shown in Table 6.6, the proposed approach of mitigating increases in flow from impervious surfaces by revegetating areas of the catchment in native vegetation is effective in the long-term scenarios and meets the requirements of NTLDM 5.4.13. However, the proposed approach is shown to result in a small increase in peak flows for the short-term, present-day scenario, which conservatively assumes full impervious landuse establishment within the catchment, with no upper catchment vegetation improvements. This scenario is very conservative due to the likely staged nature of the development meaning that it is expected that impervious areas will increase gradually alongside vegetation improvements.

In order to provide strict compliance with the requirements of NTLDM 5.4.13, attenuation of post-development peak flows would be required in this short-term scenario. Modelling of the downstream flood effects was undertaken and shows that the minor increase in peak flows in this scenario does not result in any increase in any downstream flood effects. Given the non-compliance with NTLDM 5.4.13 is only temporary and there are no resulting increases in downstream flood effects, the preferred option to manage post development peak flows is through the proposed changes in land use without providing additional attenuation.

To further support the proposed approach, an assessment of the some of the drawbacks of the provision of attenuation basins has been included in indicated in Table 6.7.

**Table 6.7: Pro's and cons of providing attenuation to matching pre- and post-development peak flows**

| Pro's | Cons |
|---|---|
| Attenuation meets the engineering standards of the Nelson Tasman Land Development Manual and allows the model to create an "exact" match between pre- and post-development peak flows for the chosen design storm. | Attenuation function will need to be incorporated within the proposed stormwater treatment wetlands which will result in a higher bund (increase in bund height of 1.5 m) surrounding the wetland. It will likely require pipework and specific outlet configuration. |
| | Incorporating a bunded wetland with combined storage and treatment function will negatively impact on the overall landscape aesthetics, amenity and public usability of this space. |
| | Attenuation will increase the maintenance and management requirements of the wetland area, including safety considerations (greater water depth, dambreak hazard potential). |
| | Only required temporarily |

Given the short-term non-compliance of the proposed approach, the design could be considered 'non-standard'. Section 1.3 of the NTLDM 2020 provides guidance on non-standard design as follows:

*Where there is a divergence from mandatory requirements, additional information and engineering design detail may be required by Council at the time of engineering plan approval or application for resource consent. Council will exercise discretion around the acceptability of any non-standard design and, depending on the relevant process, consider the design against the objectives and policies of the relevant RMP and the applicable performance outcomes of the NTLDM.*

The proposed stormwater approach has been assessed against the performance outcomes in NTLDM Section 5.1 in Table 6.8. This shows that the proposed stormwater meets or exceeds the NTLDM stormwater performance standards.

**Table 6.8: NTLDM Stormwater Performance Standards**

| NTLDM Performance Standards | Proposed approach meets or exceeds performance standard |
|---|---|
| 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. | yes |
| 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. | yes |
| 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. | yes |

| NTLDM Performance Standards | Proposed approach meets or exceeds performance standard |
|---|---|
| A management approach that aims to improve water quality. | yes |
| Devices and design solutions that are robust, durable and easily maintained. | yes |
| A whole-of-life operations, maintenance and replacement or renewal programme that is clearly described, costed, and can be afforded. | tbc |
| A stormwater system design that takes into account the foreseeable demands of future development. | yes |
| A resilient network infrastructure that performs well against the risk of geotechnical, seismic, flood hazards and coastal hazards (erosion and inundation). | yes |
| A design that maintains or improves values associated with freshwater resources, including riparian management and in-stream habitat values. | yes |
| Stormwater assets that have high amenity value, and shared use of open-space areas where practicable and agreed to by Reserves and Facilities Manager. | yes |
| A network that maintains a high visual amenity that enhances the value of adjoining property and neighbourhood values as a whole. | yes |

As the proposed stormwater approach meets the requirements of NTLDM 5.4.13 in the long-term scenarios, and where non-compliant in the short-term scenario, results in no increase in downstream flood effects and meets or exceeds the NTLDM stormwater performance standards, the proposed stormwater approach is considered NTLDM compliant and appropriate for the site.

## 6.4 Assessment of downstream flood effects

NCC holds existing flood mapping information for the Maitahi/Mahitahi River, for a range of present day and future climate scenarios. This mapping shows that by 2130, flooding during a 1% AEP event is expected to be widespread within the Maitahi/Mahitahi Valley. This includes the floodplain at the confluence of the Kākā Stream, where a fill platform is proposed, as well as in the valley upstream and the Nelson urban area downstream. The proposed subdivision development has the potential to affect this flood hazard as follows:

- Increase in peak runoff rate and/or total runoff volume from the developed catchment.
- Changing the timing of peak runoff from the developed catchment may align closer to Maitahi/Mahitahi River flood peak resulting in an increased downstream flood effect.
- Loss of flood storage within the existing Maitahi/Mahitahi floodplain at the confluence of the Kākā Stream due to earthworks encroachment in the Maitahi/Mahitahi River floodplain, where a fill platform is proposed to enable future development.
- Loss of flood storage within the Kākā Stream floodplain, where a bund is proposed for wetland development.

### 6.4.1 Effects of development on Maitahi/Mahitahi River flooding

The NCC Maitahi/Mahitahi River flood model (DHI Mike model MaiBkYk_202103_v089) has been used to assess the combined effects of both the changes in flow and the proposed filling within the lower Kākā Valley. This model was updated with the future landform (Version 250121), provided by Davis Ogilvie, which was developed iteratively to ensure that the offsite flood effects are not exacerbated as a result of the fill. The modelled scenario includes the flow increases in the Kākā Catchment from the site development. The Present-Day event includes Scenario 1 flow increase of

0.2 m³/s, while the 2130 SSP5-8.5M event includes Scenario 2 (as the conservative scenario) flow changes (with 0 m³/s increase).

The 2130 SSP5-8.5M 1% AEP and Present Day 12-hour and 6-hour events were modelled for the proposed earthworks scenario, and results compared to the pre-development scenario.

This has shown that all increases in flood depths caused by the development are local and contained within the CCKV boundary and off-site effects are negligible (Increases in modelled flood depth are less than 0.05 m, which is within the tolerance of model error), as shown in Figure 6.11, Figure 6.13 for the local area, and in Figure 6.15 and Figure 6.17 for the downstream catchment. Based on this assessment it is considered that proposed land use changes in the Kākā Catchment does not increase any flood risks in the Maitahi/Mahitahi River downstream from the confluence with the Kākā Stream.

It should be noted that erosion effects are managed through a combination of options such as rain tanks on lots with re-use of stormwater, soakage into the alluvial gravels and extended detention in the wetlands.

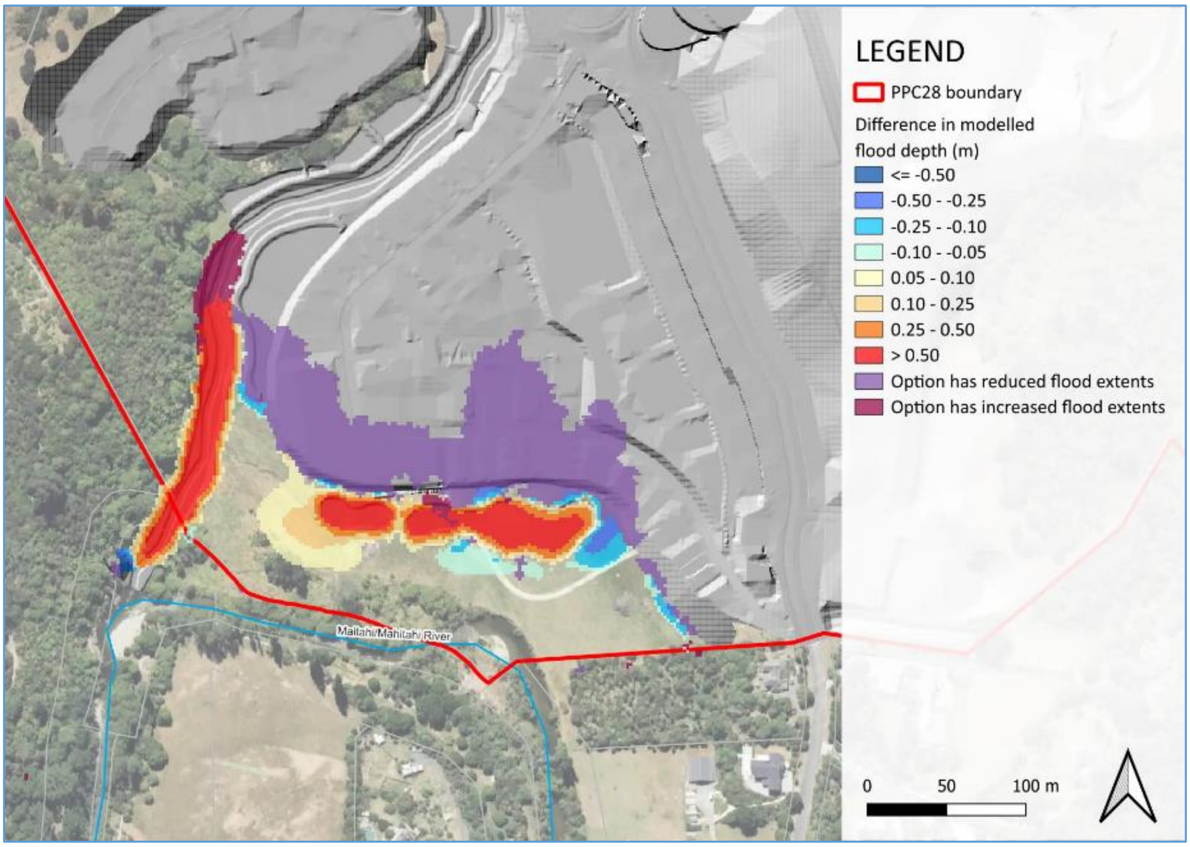


*Figure 6.11: Extent of local **increase** in flood depths as a result of proposed filling (Present Day 1% AEP 6-hr event). Model version Maitahi_202501_v034.*

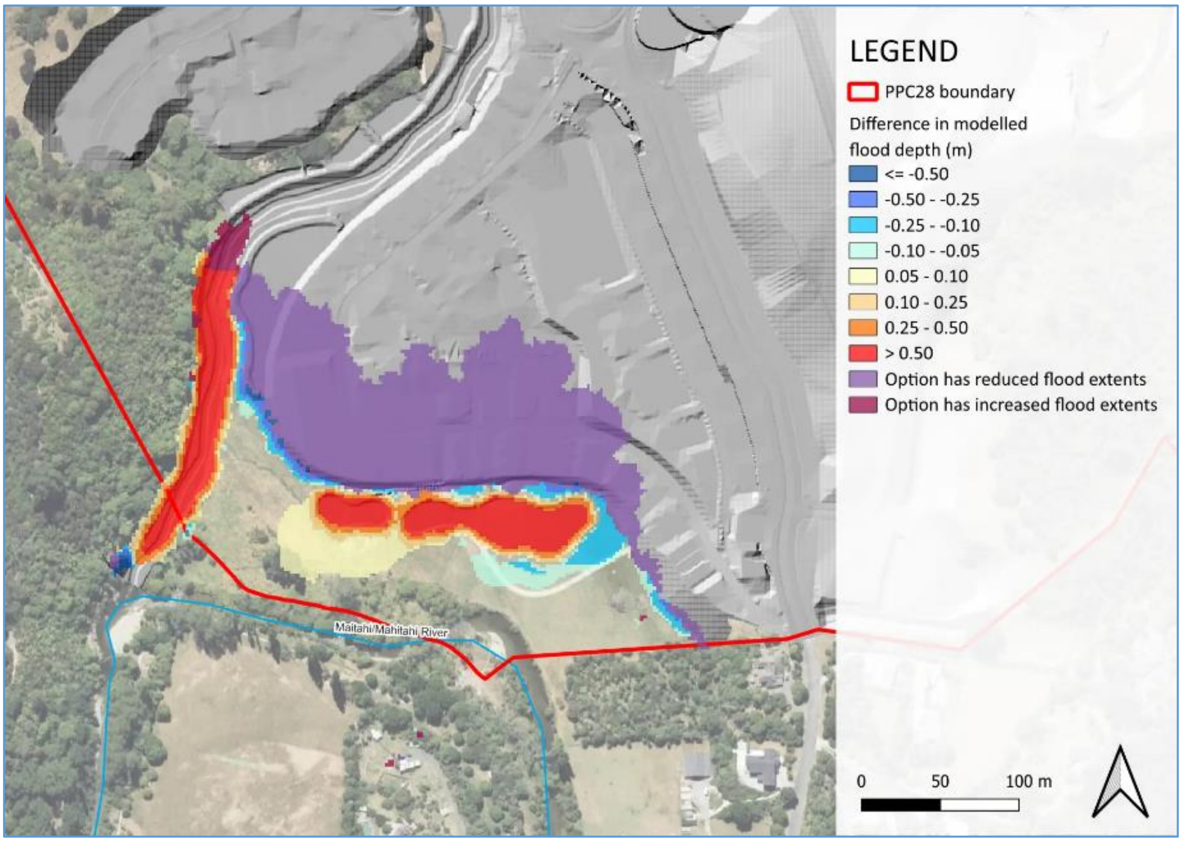


*Figure 6.12: Extent of local **increase** in flood depths as a result of proposed filling (Present Day 1% AEP 12-hr event). Model version Maitahi_202501_v034.*

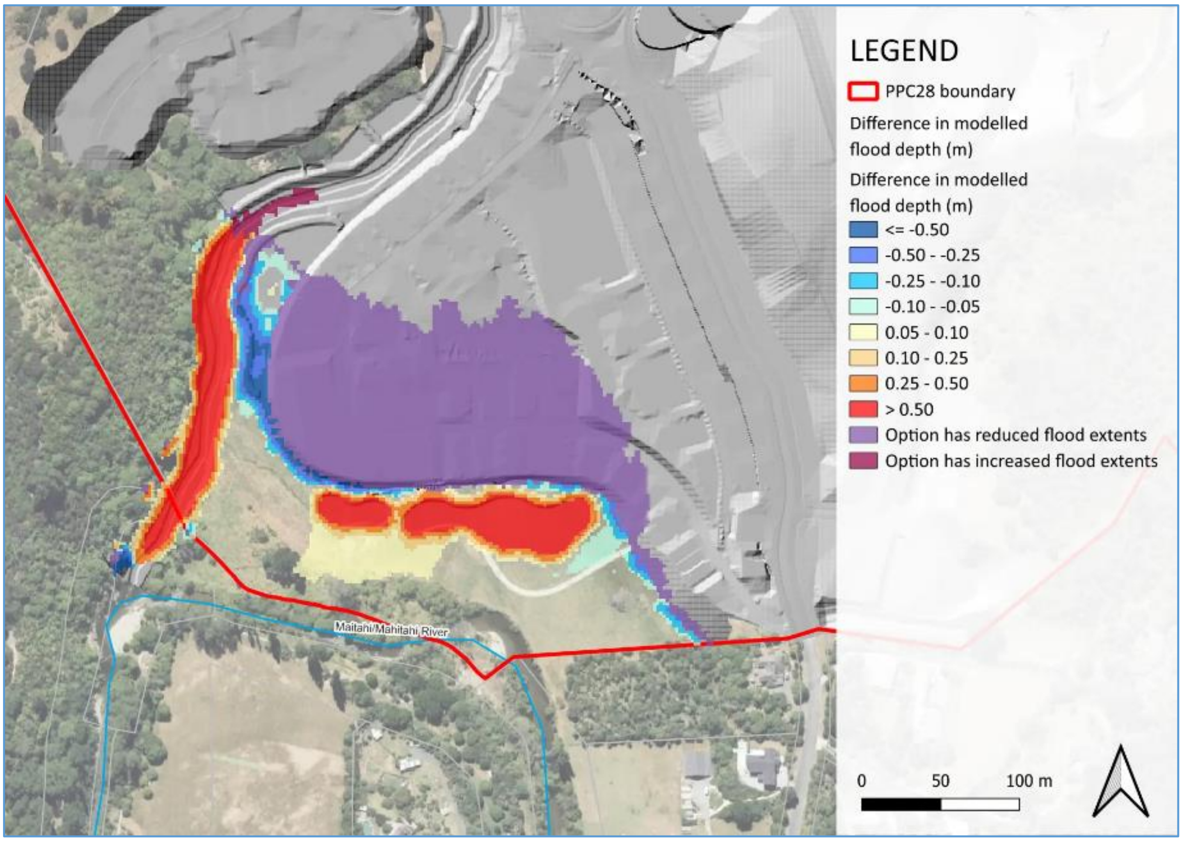


*Figure 6.13: Extent of local **increase** in flood depths as a result of proposed filling (2130 SSP5-8.5M 1% AEP -6hr event). Model version Maitahi_202501_v035.*

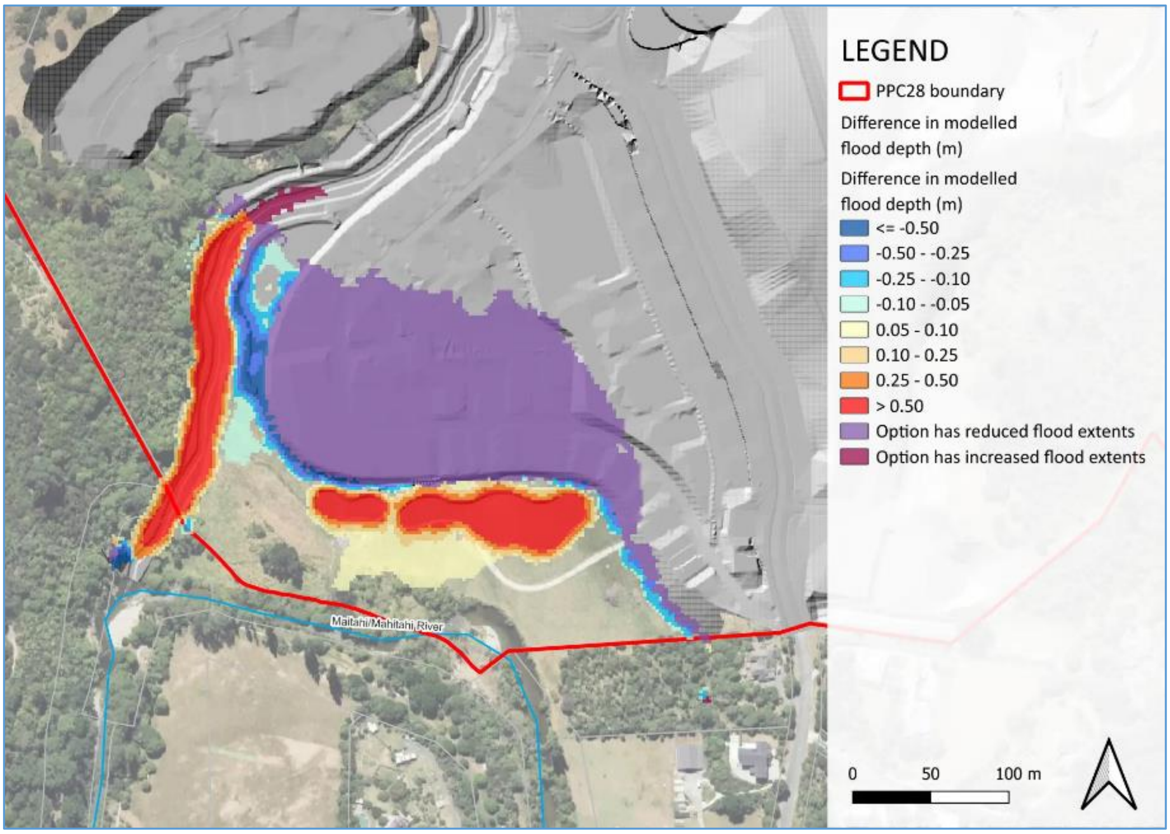


*Figure 6.14: Extent of local **increase** in flood depths as a result of proposed filling (2130 SSP5-8.5M 1% AEP 12-hr event). Model version Maitahi_202501_v035.*

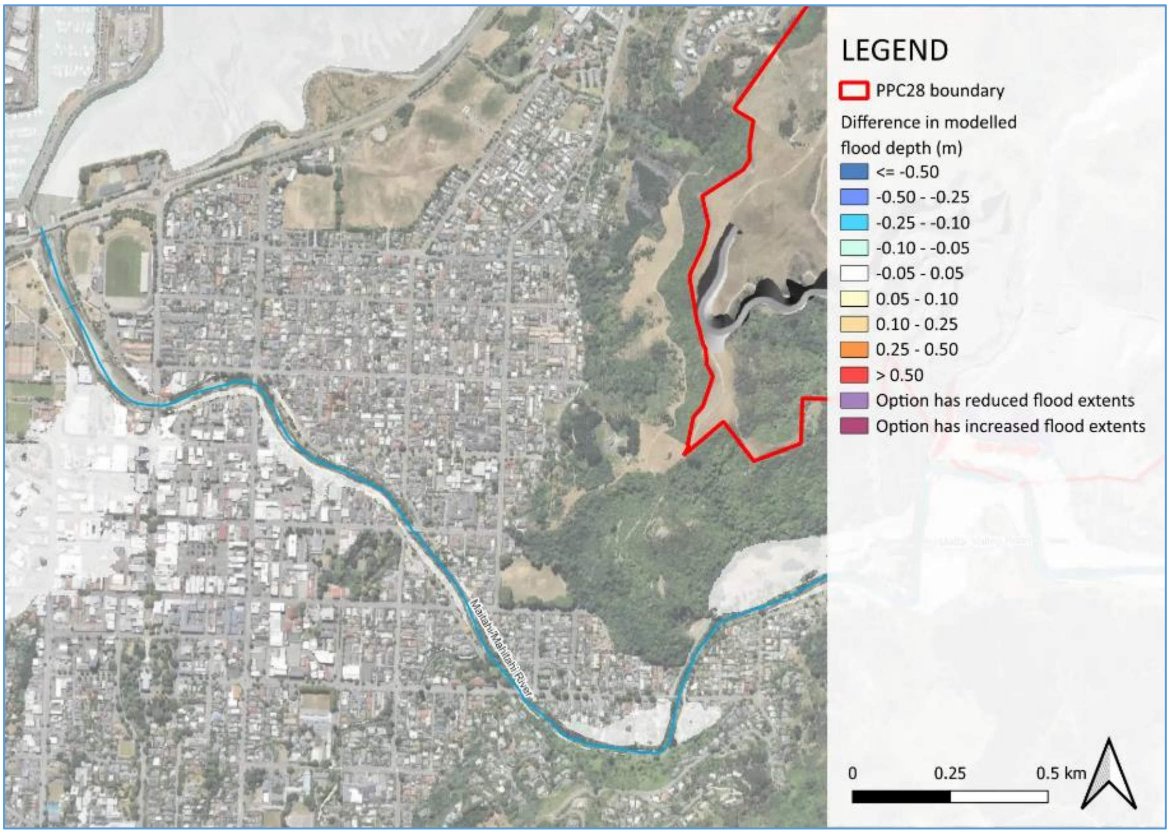


*Figure 6.15: Extent of increase in downstream flood depths as a result of proposed filling (Present Day 1% AEP 6-hr event). Model version Maitahi_202501_v034.*

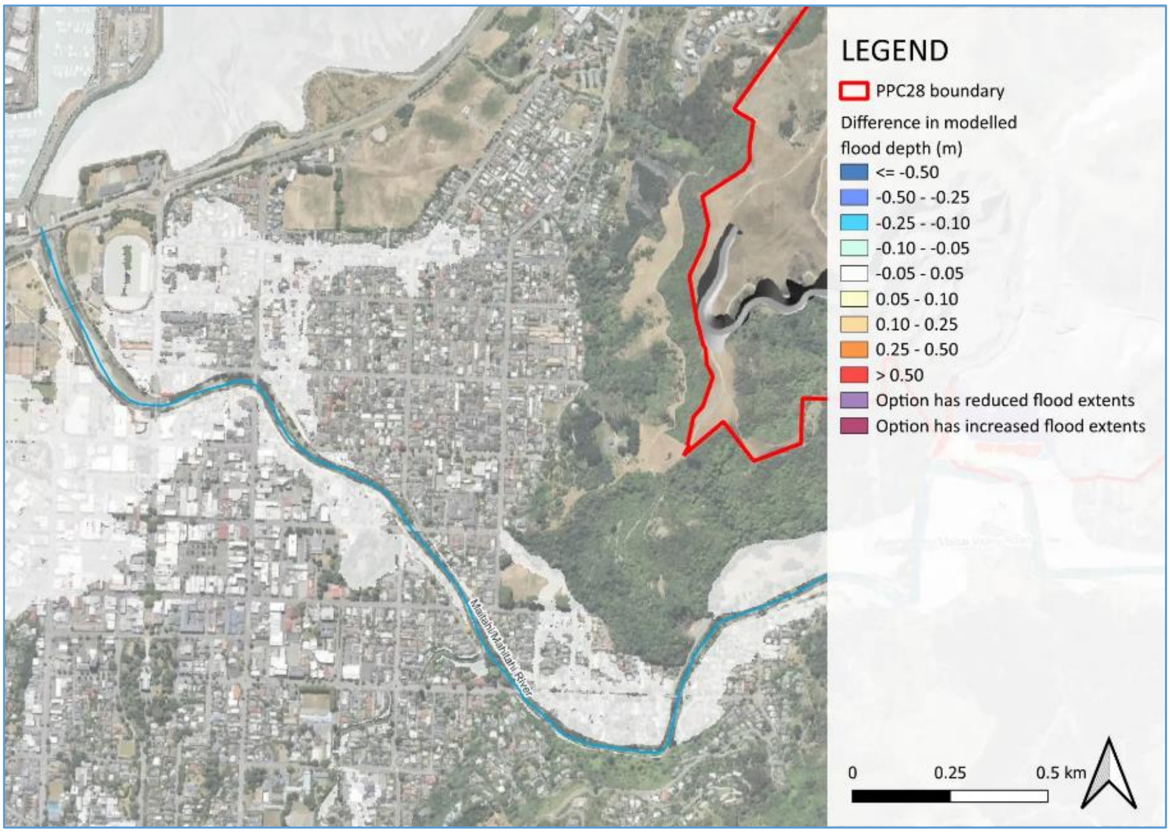


*Figure 6.16: Extent of increase in downstream flood depths as a result of proposed filling (Present Day 1% AEP 12-hr event). Model version Maitahi_202501_v034.*

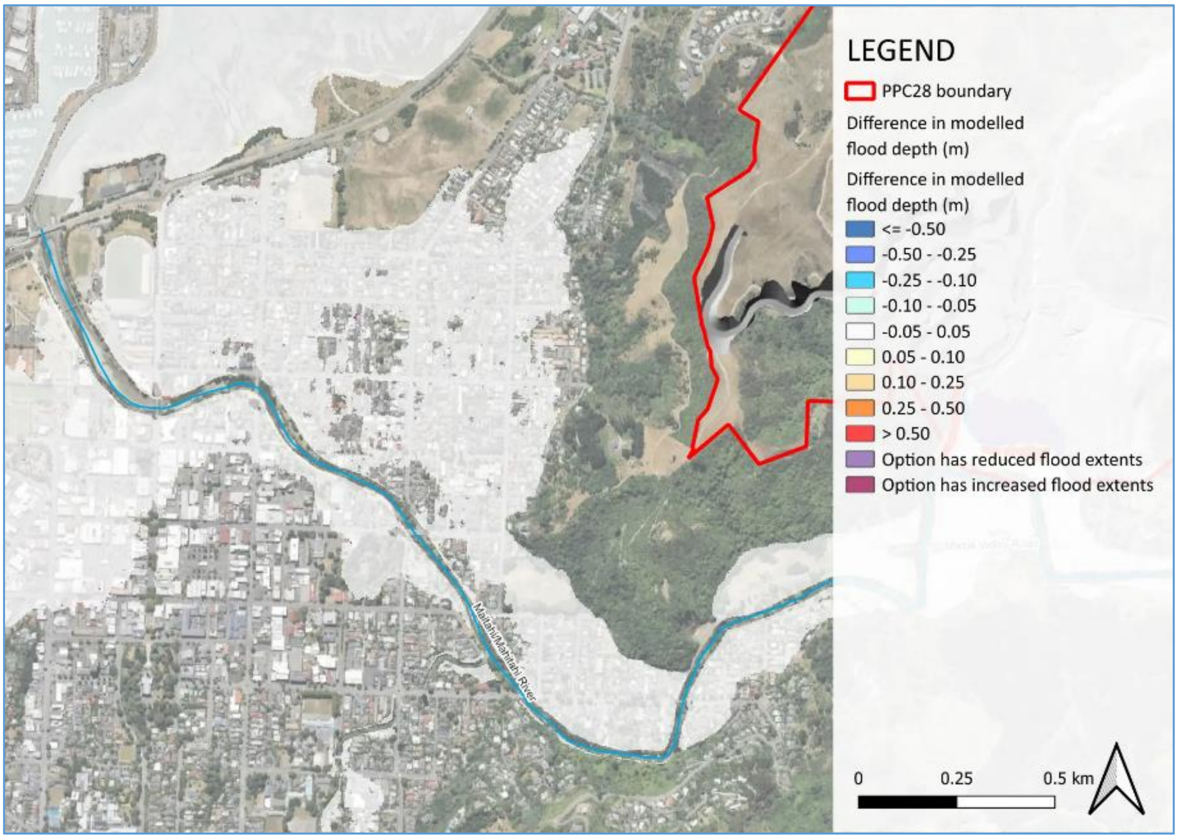


*Figure 6.17: Extent of increase in downstream flood depths as a result of proposed filling (2130 SSP5-8.5M 1% AEP 6-hr event). Model version Maitahi_202501_v035.*

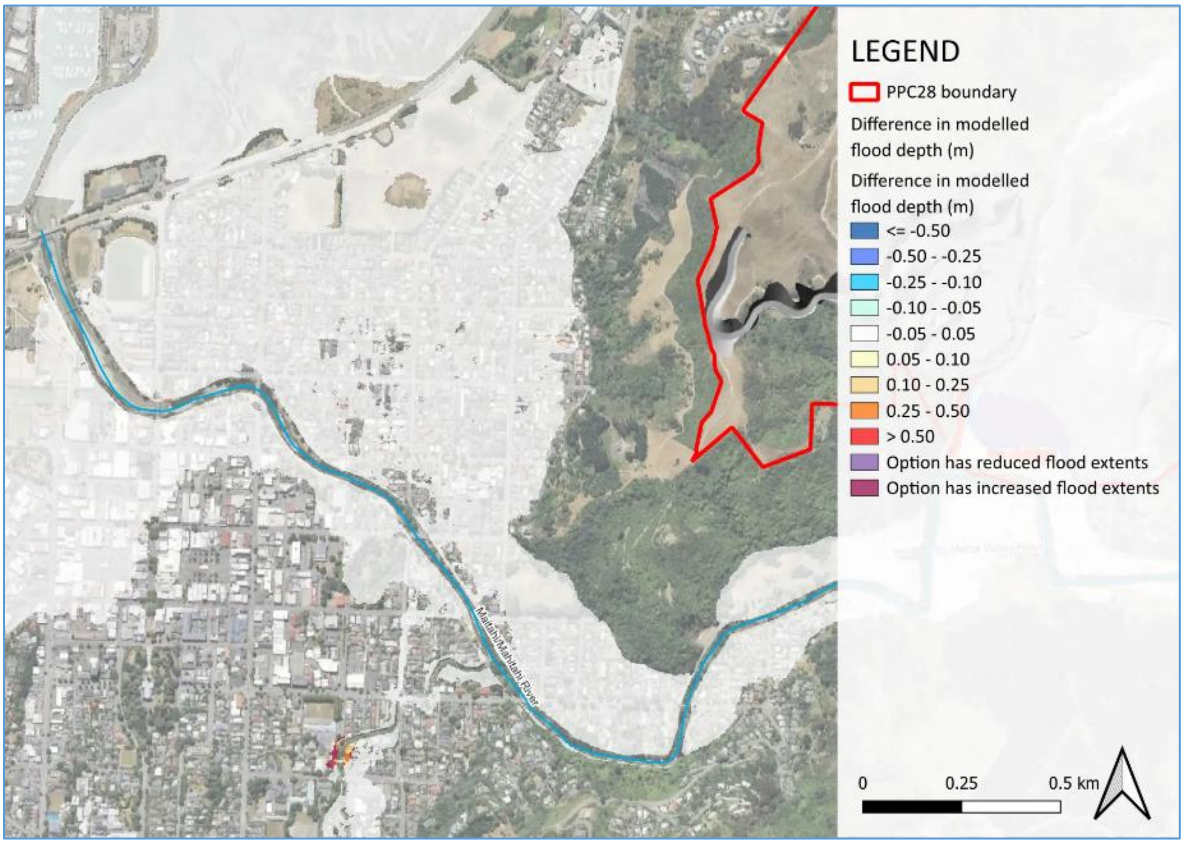


*Figure 6.18: Extent of increase in downstream flood depths as a result of proposed filling (2130 SSP5-8.5M 1% AEP 6-hr event). Model version Maitahi_202501_v035.*

It is recognised that any change in land use or change in levels within the remaining floodplain may cause an offsite flood effect, therefore it is required that:

- Filling is confined to areas identified in the above footprint;
- Any additional planting is not to provide significant increases in roughness.

Through the design process, additional flood modelling will be undertaken based on the landscape architects' proposals to ensure that the proposed improvements in this area do not have an offsite effect.

### 6.4.2 Kākā Valley flooding

A TUFLOW direct rainfall model was used to provide a more detailed understanding of flooding in the post-development scenario. The model version is Kākā_007, and is based on:

- The latest earthworks footprint (Version 250121, detailed in DO report);
- Restored and enhanced Kākā Stream watercourse (refer to Robertson Environmental report);
- Runoff from the modified post-development catchment.

The 2130 SSP5-8.5M 10% and 1% AEP storm events were run through the model. Modelled depths are presented in Figure 6.19 below. This shows the containment of Kākā Stream flood flows within a restored and enhanced stream channel, and the impact of proposed earthworks on the existing floodplain extents.

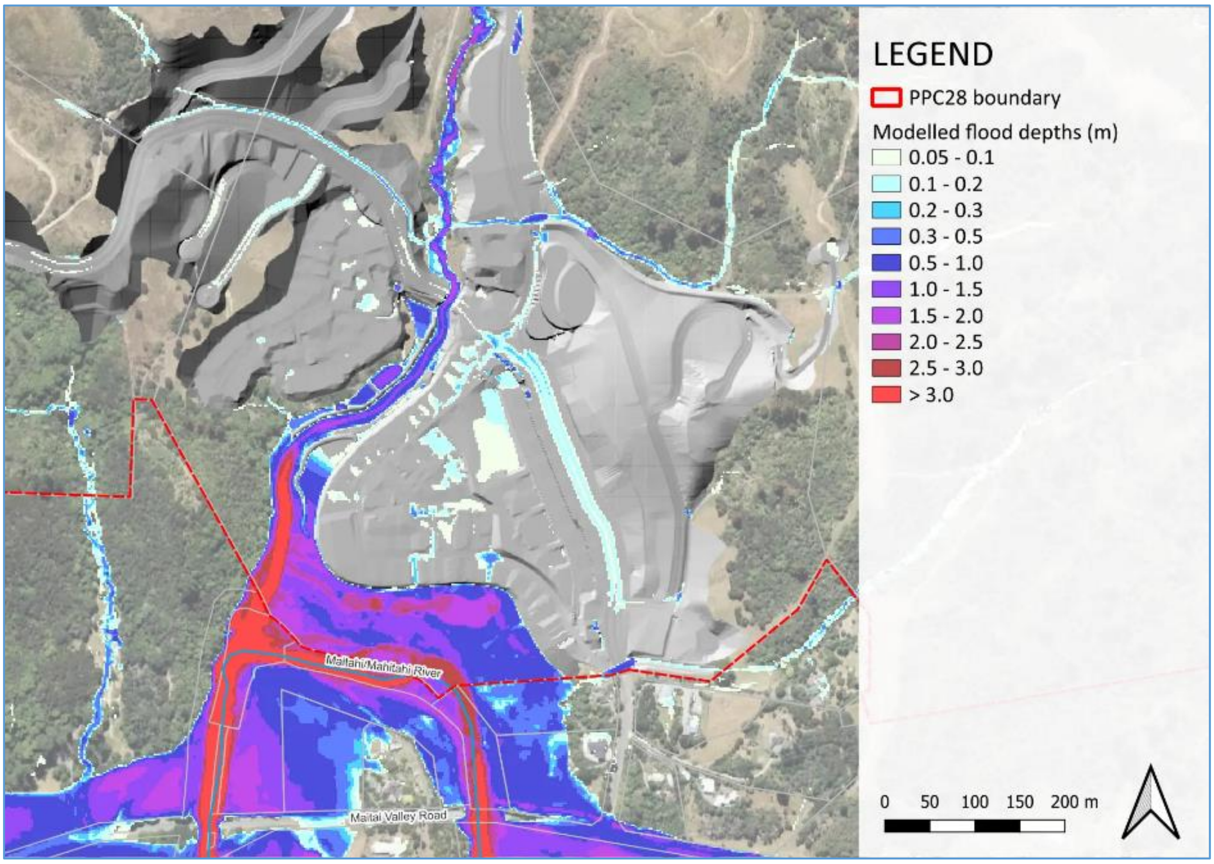


*Figure 6.19: Modelled post-development scenario, including restored and enhanced Kākā Stream, proposed Lower Kākā earthworks, and unattenuated post-development flows from developed catchment (2130 SSP5-8.5M 1% AEP 6hr event). Model version Kākā_007.*

# 7 Conclusions

The stormwater management approach for Maitahi Village has been developed in accordance with the provisions of Policy RE6.3 & RE6.4 and Schedule X12 and X13 of the NRMP and chapter 5 of the NTLDM.

Table 7.1 and Table 7.2 summarise how these requirements are met in the proposed stormwater management approach.

**Table 7.1: Summary of NRMP compliance**

| Requirement | Source | Compliant/ non-compliant/ exceeds | Comment/description |
|---|---|---|---|
| Prioritising the health and well-being of surface waterbodies in a manner that maintains or enhances cultural, recreational and ecosystem values. | NRMP RE6.3 (A) | Compliant | The stormwater management approach is well aligned with the intent of the NPS-FM and NES 2020 which includes improvement of degraded water bodies (Kākā Stream natural channel design) through water quality treatment, protection and enhancement of aquatic habitats through water quality flows and avoiding further degradation of natural wetlands. |
| Ensuring integrated stormwater management, erosion and sediment control and flood hazard mitigation by:<br>• Implementing best-practice erosion and sediment control measures for the duration of all earthworks (as addressed in Policy RE6.5 - Earthworks, and Erosion and Sediment Control);<br>• Integrating flood hazard mitigation solutions that address any identified potential significant adverse effects on downstream flood hazard up to the 2130 RCP8.5 1% AEP event; and<br>• Integrating the management of surface water and ground water. | NRMP RE6.3 (B) | Compliant (ESCP elements addressed elsewhere) | The proposed stormwater management approach mitigates the potential adverse effects on downstream flood hazard up to the 2130 RCP8.5 1% AEP event through catchment vegetation improvements. While a minor increase in a short-term present day post-development peak flows is shown to occur in one scenario, detailed modelling assessments of the post-developed scenarios shows that the minor increase in peak flows does not increase the flood risk downstream of the effect. Future post development scenarios show a matching or reduction of peak flowrates compared to the pre-development scenario.<br>Hydraulic conductivity testing has been executed in different locations to investigate opportunities for infiltration of stormwater and recharge of groundwater. Soakage basins are included as part of the water sensitive design strategy to facilitate the integrated management of surface water and groundwater and to mitigate some of the hydrological effects of the increased impervious areas.<br>The erosion and sediment control approach is addressed in the separate erosion and sediment control documentation. |
| Ensuring urban development:<br>• Uses 'green infrastructure' engineering solutions to mimic and work with natural processes;<br>• Retains, restores and enhances existing elements of the natural drainage system, and integrates these elements into the urban landscape; | NRMP RE6.3 (C) | Compliant | The stormwater management approach mimics natural processes by taking a holistic and whole of catchment approach. Designs include green infrastructure such as wetlands and soakage basins. Overland flow paths connect the upper catchment to the Kākā Stream through blue/green open channels. Catchment hydrology is managed through vegetation improvements within the wider catchment. |

| Requirement | Source | Compliant/ non-compliant/ exceeds | Comment/description |
|---|---|---|---|
| • Conserves the use of water resources through rainwater capture and reuse to meet non potable demands; and<br>• Requires that building materials either exclude or be finished in a manner that prevents water runoff from containing copper or zinc. | | Compliant | The ephemeral soakage wetlands mimic the natural interception, evapotranspiration and infiltration of the natural predeveloped catchment which generates surface runoff only after becoming saturated by the first portion of rain.<br>Where possible, the capture and reuse of roof runoff at lot scale will be encouraged. This will be achieved through rainwater reuse tanks plumbed for internal non potable reuse to replicate natural interception and evapotranspiration for medium density dwellings in the western and central catchment.<br>Restrictions on roofing materials will be enacted, to prevent water runoff from roof surfaces containing copper or zinc. |
| Ensuring Water Sensitive Design principles are utilised in the planning and implementation stages. | NRMP RE6.3 (D) | Compliant | The following water sensitive design principles have guided the development of the stormwater management approach from early planning stages and will continue to guide design processes through to implementation.<br>1. Inter-disciplinary planning and design.<br>2. Protecting and enhancing values and functions of natural ecosystems.<br>3. Addressing stormwater effects as close to the source as possible.<br>4. Mimic natural systems and processes for stormwater management.<br>*Source: Water Sensitive Design for Stormwater, Auckland Council Guideline Document GD2015/004 as referred to in the Nelson Tasman Land Development Manual.* |
| Mimicking pre-development hydrology through retention and detention by matching pre-development mean annual volume of stormwater runoff and pre-development channel forming flows in Kākā Stream to reduce the risk of scour, sediment mobilisation and adverse impacts on instream biota. | NRMP RE6.3 (E) | Compliant | Channel forming flows and the risk of streambank erosion and associated loss of aquatic habitat in Kākā Stream is addressed through a combination of on-site detention tanks for re-use purposes and/or infiltration of stormwater into soakage basins. |
| Providing for the 'first flush' of all site generated stormwater (excluding where on lot reuse or infiltration occurs) to be passed through constructed vegetated treatment devices to avoid temperature fluctuations and minimise concentrations of copper, zinc, hydrocarbons, | NRMP RE6.3 (F) | Compliant | First flush is treated in three separate constructed treatment wetlands to remove contaminants such as heavy metals, hydrocarbons, sediments and temperature prior to discharging to soakage and/or the Kākā Stream. The wetlands are designed in accordance with accepted industry standards (best practice) as referenced in the Nelson Tasman Land Development Manual: |

| Requirement | Source | Compliant/ non-compliant/ exceeds | Comment/description |
|---|---|---|---|
| nutrients and sediment to the smallest amount practicable prior to discharge to Kākā Stream, existing wetlands or Maitahi/Mahitahi River. First flush is to be based on treating 80-85% of mean annual volume or stormwater resulting from 3-month ARI Rainfall events (25 mm rainfall depth or 10 mm/hr rainfall intensity). | | Compliant | • Stormwater Management devices in the Auckland region, Auckland Council Guideline GD2017/001;<br>• Wetland Practice Note for Nelson and Tasman Councils, version 1, 16 June 2017. |
| Providing treatment of runoff from all road surfaces within the Walters Bluff/Brooklands Catchment, subject to the physical possibility to provide devices and Nelson City Council approval as the ultimate asset owner. On the steeper roads servicing small lot areas this is likely to consist of proprietary type treatment devices while on the ridgeline there may be scope for rain-gardens and swales. | NRMP RE6.3 (G) | Not relevant | This item covers areas outside of the CCKV development area |
| Requiring the mapping of areas with suitable infiltration capacity and factoring in design to optimise groundwater recharge where viable as part of integrated water sensitive design strategy. Infiltration capacity is to be protected through construction and optimised in-fill areas with specific design and construction of permeable fill. | NRMP RE6.3 (H) | Compliant | Hydraulic conductivity testing has been executed in different locations to investigate opportunities for infiltration of stormwater and recharge of groundwater. Soakage basins are included as part of the water sensitive design strategy. |
| Providing and protecting overland flow paths through road design and other dedicated pathways to pass peak flows from upper slopes safely. | NRMP RE6.3 (I) | Compliant | Dedicated flow paths are designed to safely pass overland flow (2130 1% AEP) from the undeveloped catchments through the development, following blue/green corridors and connecting the upper catchment with the Kākā Stream.<br>Overland flow paths from the developed areas will be managed through a combination of a reticulation network sized for the primary flow, with secondary flow managed within the roadways |

| Requirement | Source | Compliant/ non-compliant/ exceeds | Comment/description |
|---|---|---|---|
| Maintaining and enhancing the upper reach of Kākā Stream (above the Residential Zone Higher Density Area) | NRMP RE6.3 (J) | Compliant | Upper reaches of the Kākā Stream are retained and protected through a continuous riparian corridor. Significant parts of the catchment (120 ha) are proposed to be revegetated from an existing state of primarily grassland and brush into forest/bush (native plantings). |
| Restoring and enhancing the lower reaches of Kākā Stream through a continuous riparian corridor (Blue-Green Spine) with:<br>• The corridor reflecting natural topography;<br>• Channel meanders and flood benches;<br>• Robust riparian vegetation;<br>• Peak flood capacity;<br>• Ecosystem function and habitat;<br>• Stormwater treatment wetlands in areas of suitable topography;<br>• Public access via well designed walking/cycling paths (excluding roads except at crossing points); and<br>• Natural character values. | NRMP RE6.3 (K) | Compliant | The realignment of the lower Kākā Stream provides for improved ecological outcomes, efficient urban form and is designed in accordance with natural channel design guidelines.<br>• As per the RMM report, public access is included within the blue green corridor.<br>• Connections to the upper reaches of the Kākā Stream are retained and protected through a continuous riparian corridor.<br>• All development areas will eventually drain towards one of three stormwater wetlands for treatment and infiltration. |
| Minimising stream loss and protecting springs and seeps including their flow paths, and providing for 1% annual exceedance probability (AEP) flood flow (including allowance for the effects of climate change to 2130) within the stream including its riparian margin, so as to protect and enhance the Kākā Stream and its tributaries. | NRMP RE6.3 (L) | Compliant | Kākā Stream and its tributaries are protected and enhanced through the generous blue-green corridor width which protects riparian springs and seeps.<br>The realigned Kākā Stream channel has been sized to convey the 2130 peak flow capacity. |
| Providing for the co-location of stormwater treatment wetlands/rain-gardens within the Kākā Stream Blue-Green Spine where this is the most appropriate option to: protect the main stream, | NRMP RE6.3 (M) | Compliant | Two stormwater treatment wetlands are co-located within the Kākā Stream Blue-Green Spine on either side of the stream. A third wetland is located to south of the development within the natural wetland area towards the Maitahi/Mahitahi River. |

| Requirement | Source | Compliant/ non-compliant/ exceeds | Comment/description |
|---|---|---|---|
| increase ecological values, and provide high quality public amenity. Where stormwater treatment is located in the Blue-Green Spine the design shall ensure a minimum 10 m riparian buffer between any device and the stream and support ongoing maintenance access. | | | |
| Managing earthworks and compaction outside residential zones to minimise changes to the hydraulic response of flows directly or indirectly discharging into the Kākā Stream and its tributaries. | NRMP RE6.3 (N) | Compliant | Earthworks and compaction outside residential zones is minimal. |
| Including on-lot management of water quality/quantity through rainwater capture and reuse and soakage (where viable) so as to conserve and reuse water for non-potable internal and external purposes. | NRMP RE6.3 (O) | Compliant | Potable water demand is reduced through on-lot detention tanks that capture rainwater for reuse where feasible. |
| Providing for the integration of peak flood attenuation within the Blue-Green Spine, while ensuring: that stream ecology (including fish passage) is preserved; any off line stormwater treatment devices are protected; natural character is maintained or enhanced; and the health and safety of community and visitors is protected. | NRMP RE6.3 (P) | Compliant | Peak flows are managed at a catchment scale through vegetation improvement, rather than large detention basins within the Blue – Green spine. Ecosystem functions, stormwater wetlands and the health and safety of community are protected.<br>The proposed treatment wetlands are offline and target developed areas only, with the routing of undeveloped stormwater minimised through the provision of overland flow paths. This separation of the developed and undeveloped flows ensures offline stormwater treatment devices are protected from high peak flows and do not unnecessarily oversize these devices. |
| Ensure that indigenous terrestrial and freshwater biodiversity is restored, protected and enhanced as an integral part of subdivision and development, including by:<br>• Restoring and enhancing the degraded lower portion of the Kākā Stream where this provides for improved ecological outcomes, and may | NRMP RE6.4 | Compliant | The realignment of the lower Kākā Stream provides for improved ecological outcomes, efficient urban form and is designed in accordance with natural channel design guidelines.<br>• Existing wetlands have been identified as part of initial ecological walkovers and will be enhanced and protected.<br>• The Blue-Green Spine along the Kākā Stream provides an ecological link between the Maitahi/Mahitahi and the upper parts of the Kākā Catchment. |

| Requirement | Source | Compliant/ non-compliant/ exceeds | Comment/description |
|---|---|---|---|
| include the provision of off-set stream enhancement to ensure a net gain of in-stream values within the Structure Plan area;<br>• Identifying, protecting and enhancing existing natural wetlands, their margins and connections to streams;<br>• Providing for ecological linkages between ecological areas (freshwater and terrestrial) inside and neighbouring Schedule X;<br>• Protecting and enhancing threatened species habitats within Kākā Stream;<br>• Providing significant areas of "Residential Green Overlay" and "Revegetation Overlay" requiring indigenous plantings; and<br>• Prioritising the mauri, health and wellbeing of local waterbodies. | | Compliant | • Other ecological actions have been identified in the ecological report.<br>The proposed SW management prioritises the freshwater health of Maitahi awa, through addressing the degradation of tributaries feeding into it that contribute to poor water through the provision of stormwater treatment.<br>The revegetation of 50% of the catchment from the existing pasture and scrub to native forest cover for areas outside of the development further supports an integrated catchment management |
| Water Sensitive Design<br>Applications for subdivision development or earthworks within Schedule X must provide a report from a suitably qualified and experienced expert(s) that demonstrates that the provisions contained in Policy RE6.3 have been applied in the subdivision and integrated development or earthworks design. | NRMP X.12 | Compliant | The following water sensitive design principles have guided the development of the stormwater management approach from early planning stages and will continue to guide design processes through to implementation:<br>• Inter-disciplinary planning and design.<br>• Protecting and enhancing values and functions of natural ecosystems.<br>• Addressing stormwater effects as close to the source as possible.<br>• Mimic natural systems and processes for stormwater management.<br>Refer to Morphum Environmental report. |
| Stormwater Management Plan<br>Applications for subdivision, development or earthworks within Schedule X must provide a Stormwater Management Plan (SMP) prepared by a suitably qualified and experienced expert(s) that | NRMP X.13 | Compliant | As part of the PPC28 application, a stormwater management plan (SMP), titled Stormwater Management Plan, Private Plan Change 28, August 2022, 10112397.1000v3 was produced to provide a framework for how stormwater will be managed across the whole PPC28 area. The purpose of the SMP is to provide guidance |

| Requirement | Source | Compliant/ non-compliant/ exceeds | Comment/description |
|---|---|---|---|
| demonstrates that the matters contained in Policy RE6.3 have been applied in the subdivision and development design process. Each SMP submitted for subdivision and development or earthworks of this site must be comprehensive and catchment wide. Each SMP must also address any specific matters that are related to the given stage or activity relevant to each application for resource consent. The content of the SMP must include:<br>• Breakdown of sub-catchments including landcover (roads, roofs, hardstand, gardens, open space etc) and associated imperviousness;<br>• Mapping of existing waterways, natural wetlands and overland flow paths;<br>• Mapping of predevelopment infiltration capacities to be adopted in design;<br>• Assumptions for sizing of rainwater tanks (contributing roof areas, people per dwelling and non-potable demands);<br>• Assumptions for the design of all stormwater treatment devices (size relative to contributing catchments, hydraulic function, design attributes, contaminant reduction) including allowance for climate change;<br>• Summary of sub-catchment water quality treatment and hydrological mitigation strategy including areas draining to reuse tanks, soakage, consolidated raingardens or wetlands;<br>• Summary of pre and post-development hydrology including estimates of losses | | Compliant | to developers and Nelson City Council (NCC) on the proposed integrated stormwater management approach for future development within this area.<br>The SMP is a stormwater management framework that provides high level guidance and objectives for development of the entire PPC28 area. This report sets out, in more detail than the SMP, how stormwater is proposed to be managed specifically within the Maitahi Village portion of the Schedule X area in accordance with Schedule X.13 and other relevant design guidelines. This report, alongside the other Stormwater reports, address the specific items listed in Schedule X.13. |

| Requirement | Source | Compliant/ non-compliant/ exceeds | Comment/description |
|---|---|---|---|
| (evapotranspiration/reuse), infiltration and surface runoff reported as mean annual volumes, with assessment of impacts on baseflow and stream channel erosion;<br>• Summary of the existing flood hazard affecting the application area, and the potential adverse effects of the development on flood hazard affecting downstream and off-site properties. This should also include any proposed mitigation measures to address these potential effects, and how any mitigation measures are expected to perform. In particular, how changes to the magnitude, duration and timing of peak flows during the range of design events will be managed so as to avoid or mitigate potential adverse effects such as increased flood risk or stream scour;<br>• Summary of pre and post development water quality including estimates of nutrients, metals and sediments reported as mean annual loads. Include comparison with 'do nothing' approach to show proportion of contaminants reduced through proposed water sensitive design measures; and<br>• Mapping of post developed treatment/soakage locations, waterway enhancements, overland flow paths and flood attenuation devices | | | |

**Table 7.2: Summary of NTLDM 2020 compliance**

| Requirement | Source | Compliant/ non-compliant/ exceeds | Comment/description |
|---|---|---|---|
| The design of stormwater management system shall be consistent with water sensitive design (WSD), using natural processes and soil media to provide sustainable stormwater management.<br>The stormwater design shall aim to:<br>a) Protect and enhance the values and functions of natural ecosystems;<br>b) Address stormwater effects as close to source as possible;<br>c) Mimic natural systems and processes for stormwater management;<br>d) Support inter-disciplinary planning and design where practicable, and<br>e) WSD principles shall be considered during the initial design and planning. | NTLDM 5.3.2 | Compliant | The proposed stormwater management approach has been designed in accordance with water sensitive design principles as set out in the NTLDM and relevant guidance documents referenced in the NTLDM such as *Water Sensitive Design for Stormwater, Auckland Council Guideline Document GD2015/004.*<br>• The Blue-Green Spine along the Kākā Stream provides an ecological link between the Maitahi/Mahitahi and the upper parts of the Kākā Catchment.<br>• Other ecological actions have been identified in the ecological report.<br>• Prioritises the freshwater health of Maitahi awa, through addressing the degradation of tributaries feeding into it that contribute to poor water through the provision of stormwater treatment.<br>• Addresses stormwater effects entirely within the Kaka catchment prior to discharging to the receiving water.<br>• Utilises vegetation improvements and treatment and soakage wetlands which mimics natural process to provide stormwater management. |
| Primary and secondary systems shall be designed | NTLDM 5.4.6.2 | Compliant | Primary and secondary systems have been designed with rainfall projections from NIWA HIRDS, version 4, in accordance with NTLDM 5.4.6.2. |

| Requirement | Source | Compliant/ non-compliant/ exceeds | Comment/description |
|---|---|---|---|
| taking into account the effects of climate change as expected in 2090 based on climate change scenario RPC8.5. | | | |
| 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. | NTLDM Table 5-7 | Exceeds | Approximately 10 mm of rainfall from all newly created impervious surfaces is infiltrated into two separate soakage devices. Treated stormwater from the wetlands will overflow into the soakage areas from where it will infiltrate into the ground. |
| Extended detention is required to detain and slow down flows from frequently occurring storm events:<br>• 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.<br>Any volume that is infiltrated on site may be | NTLDM Table 5-8 | Exceeds | The effects from frequently occurring storm events on streambank erosion are mitigated through a combination of:<br>• Rain tanks on lots for domestic re-use of stormwater, and/or<br>• Infiltration of stormwater in soakage devices.<br>Extended detention is achieved within the three stormwater treatment wetlands. |

| Requirement | Source | Compliant/ non-compliant/ exceeds | Comment/description |
|---|---|---|---|
| subtracted from the extended detention volume. | | | |
| 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). | NTLDM 5.4.13 | Long term compliance (Temporary minor non-compliance) | The proposed land use changes within the Kākā Catchment consist of an increase in impervious surface of 10% and an increase in native forest of 50%. The combined land use changes lead to an expected increase in peak flows (post-development) of 0.2 $m^3/s$ in the present day and either a matching of predevelopment peak flows or a 0.5 $m^3/s$ reduction in 2130 events, depending on vegetation establishment.<br>Modelling shows that the minor increase in peak flows does not increase the flood risk downstream and further detention is therefore not proposed. The proposed stormwater management approach does not strictly meet NTLDM 5.4.13 and should be considered as a “non-standard design” in accordance with NTLDM 1.3. |

# 8 Applicability

This report has been prepared for the exclusive use of our client CCKV Maitahi Dev Co LP, 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 our client will submit this report as part of an application for resource consent and that Nelson City Council as the consenting authority will use this report for the purpose of assessing that application.

Tonkin & Taylor Ltd
Environmental and Engineering Consultants

Report prepared by:

.........................................................

Byron Munro
Water Resources Engineer

Authorised for Tonkin & Taylor Ltd by:

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Maurice Mills
Project Director

Reviewed by Damian Velluppillai, Senior Water Resources Engineer and Wouter Woortman, Principal Water Resources Advisor

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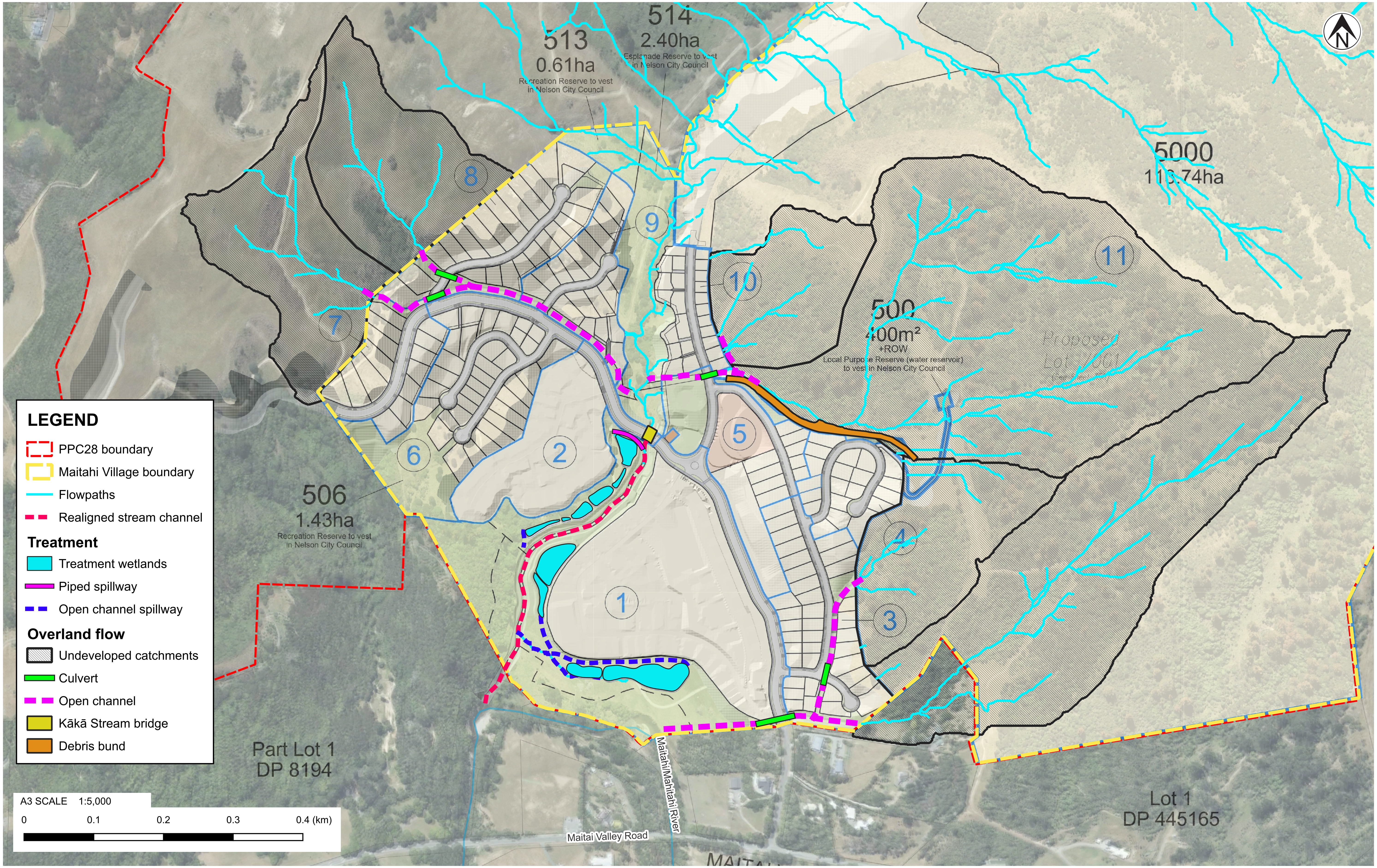
# Appendix A T+T Figure

- **Figure A1: Stormwater Layout Conceptual Design**

\\ttgroup.local\corporate\Nelson\Projects\1012397\1012397.1000\9005 RC Support Stormwater\WorkingMaterial\Stormwater Model\GIS\Kaka_RC_Workings_V2.qgz Layout: Appendix1_StormwaterLayout Drawn by CHGR

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NOTES:
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| REV | DESCRIPTION | GIS | CHK | DATE |
|---|---|---|---|---|
| 0 | First version | CHGR | WOWO | 29/01/25 |

LOCATION PLAN

| | | |
|---|---|---|
| PROJECT No. | 1012397.1000 | |
| DESIGNED | CHGR | JAN.25 |
| DRAWN | CHGR | JAN.25 |
| CHECKED | WOWO | JAN.25 |
| APPROVED | WOWO | 29/01/25 |

CLIENT CCKV Mahitahi Dev Co LP
PROJECT MAHITAHI VILLAGE - STORMWATER REPORT
TITLE STORMWATER LAYOUT CONCEPTUAL DESIGN
SCALE (A3) 1:5,000 FIG No. FIGURE A1. REV 0

# Appendix B Stormwater calculations

# STORMWATER ASSESSMENT - OVERVIEW

| | | | | | |
|---|---|---|---|---|---|
| Project: | CCKV Kākā RC | By: | CHGR | Date: | 21/03/2024 |
| Location: | Kākā Catchment | Checked: | DNV | Date: | 25/03/2024 |

## Design Criteria

Match post development runoff to pre development levels in 2130 climate change 100 year events.
As per NTLDM Standards

## Design Concepts

1) Assess effects of the peak run-off to the streams in the 2130 climate change 100 year ARI storms of post-development vs pre-development flows.

## References

NTLDM 2020
TR 2009/00072 - Review of Hydrologic Properties of Soils in the Auckland Region by Auckland Regional Council
USDA TR-55 Urban Hydrology for Small Watersheds
Maitai River Flood Hazard Mapping Modelling Report (T+T, 2013)

## STORMWATER ASSESSMENT - Runoff Coefficents

| | | | | | |
|---|---|---|---|---|---|
| Project: | CCKV Kākā RC | By: | CHGR | Date: | 21/03/2024 |
| Location: | Kākā Catchment | Checked: | DNV | Date: | 25/03/2024 |

### Calculation Description

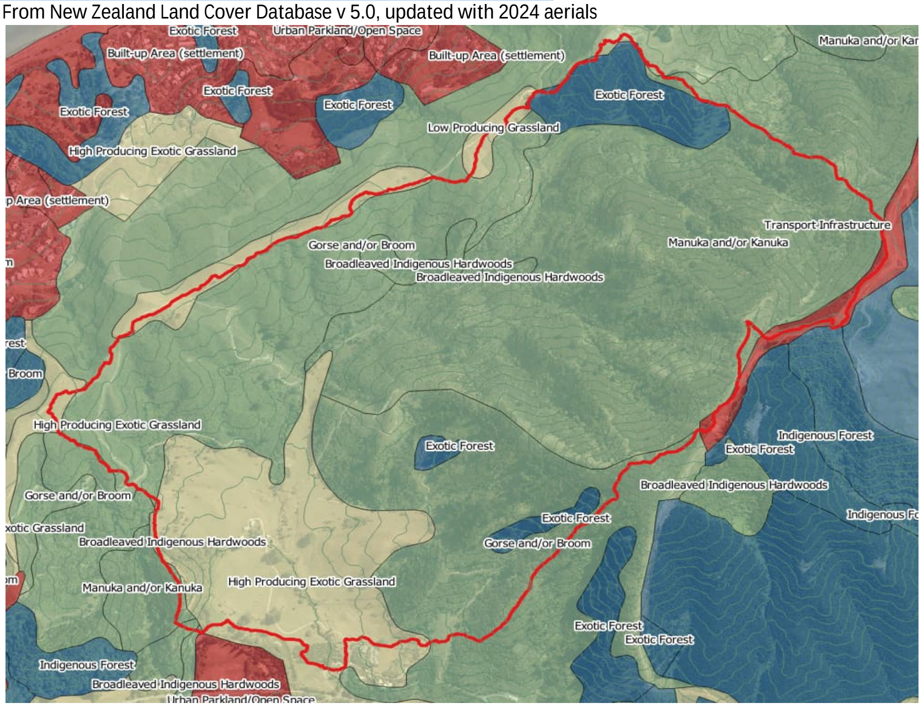
Determination of runoff coefficents for present day and post-development

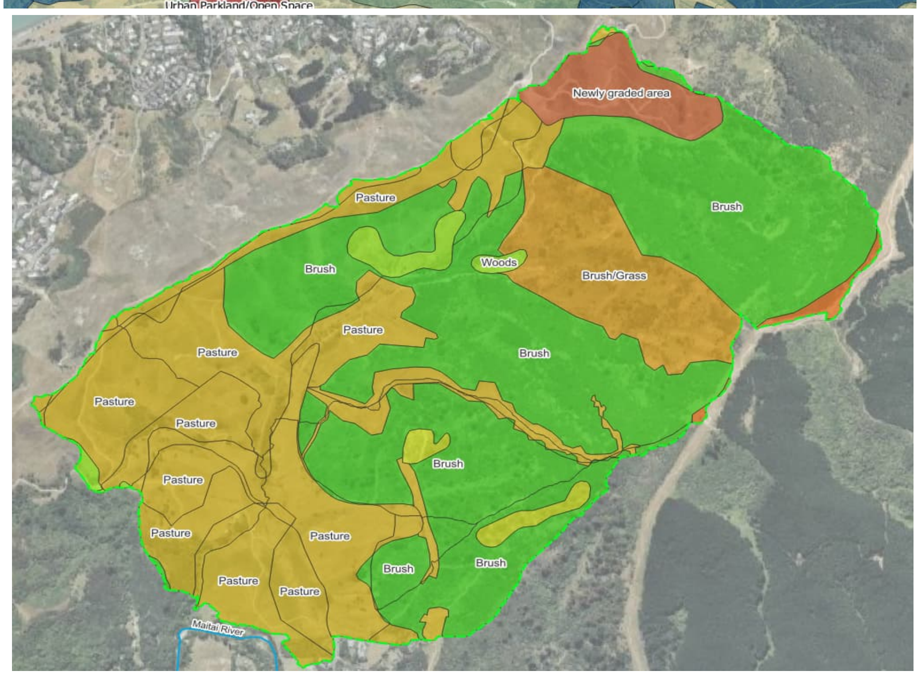
Identify land cover

Determine Hydrologic Soil Class

### Present Day Land Cover

From New Zealand Land Cover Database v 5.0, updated with 2024 aerials



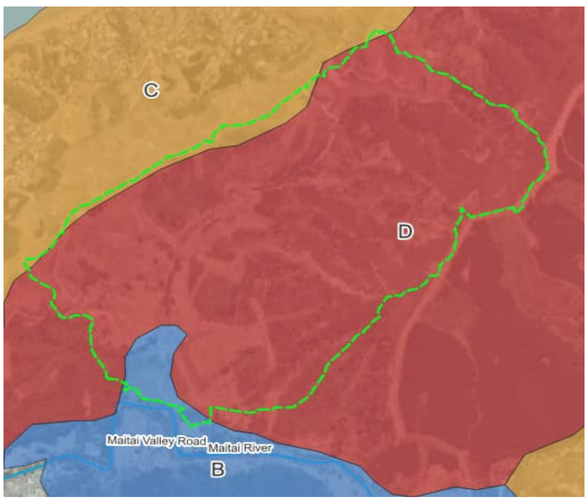
## Hydrologic Soil Classification

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<br>Low Runoff Potential<br>A | Hydro Class 2<br>Moderate Runoff Potential<br>B | Hydro Class 3<br>Moderately High Runoff Potential<br>C | Hydro Class 4<br>High Runoff Potential<br>D | |
|---|---|---|---|---|---|
| Soil Textural Class<br>PS_CLASS[1] | 1 or 2<br>K, S, S/K | 3<br>L, L/S | 4<br>Z, Z/C | 5<br>C | ALL |
| | AND | | | | AND |
| Depth to Slowly Permeable Horizon<br>DLSO_CLASS | > 450 mm<br>>1 | | | | 450 mm or less<br>1[2] |
| | AND | | | | OR |
| Depth to Seasonally High Water Table<br>DRAIN_CLASS | > 300 mm<br>>2 | | | | 300 mm or less<br>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 | Red | Orange | Blue |
|---|---|---|---|
| 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 | 0.60 | |
| 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* | D | 89 | 0.5 | |
| Built-up Area (settlement) | *Residential district 1/4 acre size* | C | 83 | 0.45 | |
| Open Space | *Open Space - good* | B | 61 | 0.25 | |
| Open Space | *Open Space - good* | C | 74 | 0.25 | |
| Open Space | *Open Space - good* | D | 80 | 0.35 | |
| Riparian Zone | *Brush-weed-grass mix - good* | B | 48 | 0.2 | |
| Riparian Zone | *Brush-weed-grass mix - good* | C | 65 | 0.2 | |
| Riparian Zone | *Brush-weed-grass mix - good* | D | 73 | 0.3 | |
| Commercial | *Commercial and Business* | B | 92 | 0.65 | |
| Commercial | *Commercial and Business* | D | 95 | 0.65 | |
| Impervious | *Paved parking lots, roofs, driveways, etc* | | 98 | 0.9 | 2_Coefficients |
| Indigenous Forest | *Woods - good* | C | 70 | 0.20 | |
| Indigenous Forest | *Woods - good* | D | 77 | 0.30 | |

# STORMWATER ASSESSMENT - CATCHMENTS

Project: CCKV Kākā RC | By: CHGR | Date: 21/03/2024

Location: Kākā Catchment | Checked: DNV | Date: 25/03/2024

## Calculation Description

Categorise catchment into Pre and Post Development Areas

### Pre Development

| Cover Type | Condition | Hydrologic Soil Class | Curve Number | Kākā Full |
|---|---|---|---|---|
| Brush | Fair | D | 77 | 1083274 |
| Brush | Poor | D | 83 | 149926 |
| Brush/Grass | Poor | D | 86 | 220049 |
| Woods | Fair | D | 79 | 6270 |
| Woods | Poor | D | 83 | 38300 |
| Woods/Grass | Fair | C | 76 | 158 |
| Woods/Grass | Fair | D | 82 | 28793 |
| Pasture | Fair | B | 69 | 88494 |
| Pasture | Fair | C | 79 | 1915 |
| Pasture | Poor | C | 86 | 75837 |
| Pasture | Fair | D | 84 | 687729 |
| Pasture | Poor | D | 89 | 49719 |
| Dirt | (blank) | D | 89 | 15619 |
| Newly Graded Area | (blank) | D | 91 | 97516 |
| | | | Total (m2) | 2543600 |
| | | | Total (hec) | 254.36 |

Post Development

| Cover Type | Condition | Hydrologic Soil Class | Curve Number | Kākā Full |
|---|---|---|---|---|
| Brush | Fair | D | 77 | 1045501 |
| Brush | Poor | D | 83 | 115319 |
| Brush/Grass | Poor | D | 86 | 214355 |
| Woods | Fair | D | 79 | 214 |
| Woods | Poor | D | 83 | 32253 |
| Woods/Grass | Fair | C | 76 | 158 |
| Woods/Grass | Fair | D | 82 | 28793 |
| Pasture | Fair | B | 69 | 7672 |
| Pasture | Fair | C | 79 | 374 |
| Pasture | Poor | C | 86 | 11727 |
| Pasture | Fair | D | 84 | 106699 |
| Pasture | Poor | D | 89 | 17315 |
| Dirt | (blank) | D | 89 | 15619 |
| Newly Graded Area | (blank) | D | 91 | 97516 |
| Brush | Good | B | 48 | 39403 |
| Brush | Good | C | 65 | 9313 |
| Brush | Good | D | 73 | 141829 |
| Open Space | Good | B | 61 | 12996 |
| Open Space | Good | C | 74 | 34652 |
| Open Space | Good | D | 80 | 317294 |
| Commercial | (blank) | B | 92 | 0 |
| Commercial | (blank) | D | 95 | 6867 |
| Impervious | (blank) | | 98 | 287827 |
| | | | Total (m2) | 2543697 |
| | | | Total (hec) | 254.37 |
| | | | % Imp | 11.59 |

Post Development Revegetated — Large areas of site outside development converted to native forest

| Cover Type | Condition | Hydrologic Soil Class | Curve Number | Kākā Full |
|---|---|---|---|---|
| Brush | Fair | D | 77 | 387329 |
| Brush | Poor | D | 83 | 34 |
| Brush/Grass | Poor | D | 86 | 0 |
| Woods | Fair | D | 79 | 214 |
| Woods | Poor | D | 83 | 0 |
| Woods/Grass | Fair | C | 76 | 158 |
| Woods/Grass | Fair | D | 82 | 0 |
| Pasture | Fair | B | 69 | 7672 |
| Pasture | Fair | C | 79 | 374 |
| Pasture | Poor | C | 86 | 4835 |
| Pasture | Fair | D | 84 | 16114 |
| Pasture | Poor | D | 89 | 8187 |
| Dirt | (blank) | D | 89 | 13628 |
| Newly Graded Area | (blank) | D | 91 | 97516 |
| Brush | Good | B | 48 | 39403 |
| Brush | Good | C | 65 | 9313 |
| Brush | Good | D | 73 | 141829 |
| Open Space | Good | B | 61 | 12996 |
| Open Space | Good | C | 74 | 33303 |
| Open Space | Good | D | 80 | 227755 |
| Commercial | (blank) | B | 92 | 0 |
| Commercial | (blank) | D | 95 | 6867 |
| Impervious | (blank) | | 98 | 287827 |
| Woods | Good | C | 70 | 8241 |
| Woods | Good | D | 77 | 1240101 |
| | | | Total (m2) | 2543697 |
| | % Imp | 11.59 | Total (hec) | 254.37 |

Post Development 50% Revegetated

Large areas of site outside development converted to native forest, used as fair condition rather than good to simulate 50% cover

| Cover Type | Condition | Hydrologic Soil Class | Curve Number | Kākā Full |
|---|---|---|---|---|
| Brush | Fair | D | 77 | 387329 |
| Brush | Poor | D | 83 | 34 |
| Brush/Grass | Poor | D | 86 | 0 |
| Woods | Fair | D | 79 | 214 |
| Woods | Poor | D | 83 | 0 |
| Woods/Grass | Fair | C | 76 | 158 |
| Woods/Grass | Fair | D | 82 | 0 |
| Pasture | Fair | B | 69 | 7672 |
| Pasture | Fair | C | 79 | 374 |
| Pasture | Poor | C | 86 | 4835 |
| Pasture | Fair | D | 84 | 16114 |
| Pasture | Poor | D | 89 | 8187 |
| Dirt | (blank) | D | 89 | 13628 |
| Newly Graded Area | (blank) | D | 91 | 97516 |
| Brush | Good | B | 48 | 39403 |
| Brush | Good | C | 65 | 9313 |
| Brush | Good | D | 73 | 141829 |
| Open Space | Good | B | 61 | 12996 |
| Open Space | Good | C | 74 | 33303 |
| Open Space | Good | D | 80 | 227755 |
| Commercial | (blank) | B | 92 | 0 |
| Commercial | (blank) | D | 95 | 6867 |
| Impervious | (blank) | | 98 | 287827 |
| Woods | Fair | C | 73 | 8241 |
| Woods | Fair | D | 79 | 1240101 |
| | | | Total (m2) | 2543697 |
| | % Imp | 11.59 | Total (hec) | 254.37 |

# STORMWATER ASSESSMENT - TIME OF CONCENTRATION

## Pre-development

| | | | | | |
|---|---|---|---|---|---|
| Project: | CCKV Kākā RC | By: | CHGR | Date: | 21/03/2024 |
| Location: | Kākā Catchment | Checked: | DNV | Date: | 25/03/2024 |

## Calculation Description

Calculate time of concentration using a variety of methods

| Geometry | Full Catchn | Unit |
|---|---|---|
| Length | 3,916 | m |
| Area | 2,543,600 | m2 |
| Max RL | 409 | RL m |
| Min RL | 13 | RL m |
| Height Diff. | 396 | m |
| Slope | 0.10 | m/m |
| Slope (Equal Areas) | 0.06 | m/m |
| Mannings n | 0.045 | |
| C | 81.01 | |

### Time of Concentration (minutes)

| | | |
|---|---|---|
| E1/VM1 (TDC Stds) | 43 | |
| USDA | 42 | |
| Bransby Williams | 81 | |
| TP108 | 59 | |
| USSCS | 28 | |
| Average | 51 | |
| Selected | 59 | minutes |

TP108 has been selected as the Time of Concentration to align with the calibration parameters used by the MaiBkYk model developed by T+T for NCC
Maitai River Flood Hazard Mapping Modelling Report (T+T, 2013)

# STORMWATER ASSESSMENT - TIME OF CONCENTRATION

## Post-development

Project: CCKV Kākā RC
By: CHGR
Date: 21/03/2024

Location: Kākā Catchment
Checked: DNV
Date: 25/03/2024

## Calculation Description

Calculate time of concentration using a variety of methods

| Geometry | Full Catchn | Unit |
|---|---|---|
| Length | 3,639 | m |
| Area | 2,543,600 | m2 |
| Max RL | 409 | RL m |
| Min RL | 12 | RL m |
| Height Diff. | 397 | m |
| Slope | 0.11 | m/m |
| Slope (Equal Areas) | 0.07 | m/m |
| Mannings n | 0.045 | |
| C | 81.13 | |

### Time of Concentration (minutes)

| | | |
|---|---|---|
| E1/VM1 (TDC Stds) | 42 | |
| USDA | 39 | |
| Bransby Williams | 74 | |
| TP108 | 54 | |
| USSCS | 25 | |
| Average | 47 | |
| Selected | 54 | minutes |

# STORMWATER ASSESSMENT - TIME OF CONCENTRATION

## Post-development with revegetation

Project: CCKV Kākā RC | By: CHGR | Date: 21/03/2024

Location: Kākā Catchment | Checked: DNV | Date: 25/03/2024

## Calculation Description

Calculate time of concentration using a variety of methods

| Geometry | Full Catchn | Unit |
|---|---|---|
| Length | 3,639 | m |
| Area | 2,543,600 | m2 |
| Max RL | 409 | RL m |
| Min RL | 12 | RL m |
| Height Diff. | 397 | m |
| Slope | 0.11 | m/m |
| Slope (Equal Areas) | 0.07 | m/m |
| Mannings n | 0.045 | |
| C | 79.51 | |

| Time of Concentration (minutes) | |
|---|---|
| E1/VM1 (TDC Stds) | 42 |
| USDA | 39 |
| Bransby Williams | 74 |
| TP108 | 55 |
| USSCS | 25 |
| Average | 47 |

Selected 55 minutes

# STORMWATER ASSESSMENT - TIME OF CONCENTRATION

## Post-development with 50% revegetation

| | | | | | |
|---|---|---|---|---|---|
| Project: | CCKV Kākā RC | By: | CHGR | Date: | 21/03/2024 |
| Location: | Kākā Catchment | Checked: | DNV | Date: | 25/03/2024 |

## Calculation Description

Calculate time of concentration using a variety of methods

| Geometry | Full Catchn | Unit |
|---|---|---|
| Length | 3,639 | m |
| Area | 2,543,600 | m2 |
| Max RL | 409 | RL m |
| Min RL | 12 | RL m |
| Height Diff. | 397 | m |
| Slope | 0.11 | m/m |
| Slope (Equal Areas) | 0.07 | m/m |
| Mannings n | 0.045 | |
| C | 80.50 | |

### Time of Concentration (minutes)

| | | |
|---|---|---|
| E1/VM1 (TDC Stds) | 42 | |
| USDA | 39 | |
| Bransby Williams | 74 | |
| TP108 | 54 | |
| USSCS | 25 | |
| Average | 47 | |
| Selected | 54 | minutes |

# STORMWATER ASSESSMENT - HYDROLOGY

Project: CCKV Kākā RC　　By: CHGR　　Date: 21/03/2024

Location: Kaka Hill　　Checked: DNV　　Date: 25/03/2024

## Calculation Description

Use HIRDS Data to determine hydrology

## HIRDS Data

HIRDS V4 Depth-Duration-Frequency Results

Depth-Duration-Frequency results (produced on 4/03/2024)
Sitename: Kaka Catchment
Coordinate system: WGS84
Longitude: 173.3152
Latitude: -41.2628

| DDF Model Parameters | c | d | e | f | g | h | i |
|---|---|---|---|---|---|---|---|
| Values: | -0.002338 | 0.514672 | -0.02643 | -0.001084 | 0.259042 | -0.010248 | 3.0196863 |

| Example: | Duration (hr) | ARI (yrs) | x | y | Rainfall Depth (mm) |
|---|---|---|---|---|---|
| | 24 | 100 | 3.178054 | 4.600149 | 199.1662 |

| | | 5 | 10 | 15 | 20 | 30 | 60 | 120 | 180 | 360 | 540 | 720 | 1440 | 2880 | 4320 | 5760 | 7200 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|

Rainfall depths (mm) :: User defined temperature increase 3.833°C

| ARI | AEP | 5m | 10m | 15m | 20m | 30m | 1h | 2h | 3h | 6h | 9h | 12h | 24h | 48h | 72h | 96h | 120h |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1.58 | 0.633 | 7.22 | 11.04 | 14.03 | 16.56 | 20.77 | 30.05 | 41.82 | 49.77 | 64.66 | 74.55 | 81.47 | 99.16 | 117.05 | 126.88 | 133.36 | 137.99 |
| 2 | 0.5 | 7.95 | 12.15 | 15.44 | 18.21 | 22.84 | 33.01 | 45.92 | 54.63 | 70.93 | 81.76 | 89.32 | 108.65 | 128.18 | 138.89 | 145.95 | 150.99 |
| 5 | 0.2 | 10.67 | 16.28 | 20.65 | 24.35 | 30.50 | 44.01 | 61.11 | 72.72 | 94.46 | 108.80 | 118.82 | 143.95 | 169.62 | 184.23 | 192.89 | 199.47 |
| 10 | 0.1 | 12.75 | 19.42 | 24.62 | 29.01 | 36.31 | 52.33 | 72.59 | 86.32 | 112.03 | 128.96 | 140.78 | 170.42 | 200.62 | 217.78 | 227.94 | 235.64 |
| 20 | 0.05 | 14.92 | 22.70 | 28.76 | 33.87 | 42.37 | 60.99 | 84.50 | 99.34 | 130.56 | 150.00 | 163.47 | 197.12 | 232.50 | 251.47 | 263.89 | 271.88 |
| 35 | 0.033 | 16.74 | 25.46 | 32.23 | 37.95 | 47.45 | 68.23 | 94.46 | 112.26 | 145.74 | 167.37 | 182.33 | 219.69 | 258.90 | 279.90 | 293.62 | 302.43 |
| 40 | 0.025 | 17.18 | 26.12 | 33.07 | 38.92 | 48.66 | 69.96 | 96.83 | 115.30 | 149.76 | 171.96 | 187.33 | 225.69 | 265.15 | 287.48 | 300.64 | 310.60 |
| 50 | 0.02 | 17.97 | 27.30 | 34.56 | 40.67 | 50.84 | 73.07 | 101.10 | 120.36 | 155.87 | 178.94 | 194.90 | 234.73 | 276.49 | 298.82 | 313.41 | 322.76 |
| 60 | 0.017 | 18.58 | 28.23 | 35.73 | 42.04 | 52.54 | 75.49 | 105.75 | 127.19 | 170.38 | 185.20 | 221.27 | 277.99 | 337.12 | 370.93 | 393.79 | 410.55 |
| 80 | 0.013 | 19.62 | 29.79 | 37.69 | 44.34 | 55.40 | 79.56 | 109.99 | 130.90 | 169.39 | 194.40 | 211.68 | 254.76 | 299.89 | 323.98 | 338.66 | 349.76 |
| 100 | 0.01 | 20.39 | 30.95 | 39.15 | 46.06 | 57.53 | 82.60 | 114.15 | 135.82 | 176.17 | 202.14 | 220.08 | 264.82 | 310.71 | 335.60 | 351.84 | 362.21 |
| 250 | 0.004 | 23.65 | 35.84 | 45.30 | 53.25 | 66.46 | 95.28 | 131.48 | 156.30 | 202.43 | 232.07 | 252.52 | 303.39 | 355.43 | 383.57 | 401.88 | 413.53 |
| 15 | 0.066 | 13.83 | 21.06 | 26.69 | 31.44 | 39.34 | 56.66 | 78.54 | 92.83 | 121.29 | 139.48 | 152.12 | 183.77 | 216.56 | 234.63 | 245.92 | 253.76 |

Rainfall depths (mm) :: Historical Data

| ARI | AEP | 5m | 10m | 15m | 20m | 30m | 1h | 2h | 3h | 6h | 9h | 12h | 24h | 48h | 72h | 96h | 120h |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1.58 | 0.633 | 4.92 | 7.53 | 9.56 | 11.28 | 14.15 | 20.47 | 28.87 | 34.86 | 47.00 | 55.20 | 61.45 | 77.71 | 94.87 | 104.79 | 111.55 | 116.55 |
| 2 | 0.5 | 5.42 | 8.28 | 10.52 | 12.41 | 15.56 | 22.49 | 31.70 | 38.26 | 51.56 | 60.53 | 67.37 | 85.15 | 103.89 | 114.71 | 122.08 | 127.53 |
| 5 | 0.2 | 7.16 | 10.92 | 13.85 | 16.33 | 20.46 | 29.52 | 41.53 | 50.07 | 67.35 | 78.98 | 87.84 | 110.82 | 134.96 | 148.86 | 158.31 | 165.27 |
| 10 | 0.1 | 8.48 | 12.93 | 16.39 | 19.31 | 24.17 | 34.84 | 48.95 | 58.97 | 79.23 | 92.84 | 103.20 | 130.04 | 158.18 | 174.35 | 185.32 | 193.39 |
| 20 | 0.05 | 9.88 | 15.03 | 19.05 | 22.43 | 28.06 | 40.39 | 56.69 | 68.25 | 91.59 | 107.25 | 119.16 | 149.98 | 182.21 | 200.70 | 213.22 | 222.43 |
| 35 | 0.033 | 11.06 | 16.82 | 21.30 | 25.07 | 31.35 | 45.08 | 63.20 | 76.05 | 101.97 | 119.34 | 132.54 | 166.67 | 202.30 | 222.70 | 236.51 | 246.65 |
| 40 | 0.025 | 11.35 | 17.25 | 21.85 | 25.71 | 32.15 | 46.22 | 64.79 | 77.95 | 104.50 | 122.28 | 135.80 | 170.72 | 207.18 | | 242.16 | 252.52 |
| 50 | 0.02 | 11.84 | 17.99 | 22.78 | 26.80 | 33.50 | 48.15 | 67.48 | 81.16 | 108.76 | 127.24 | 141.29 | 177.56 | 215.39 | 237.04 | 251.67 | 262.41 |
| 60 | 0.017 | 12.25 | 18.60 | 23.54 | 27.71 | 34.62 | 49.75 | 69.69 | 83.81 | 112.28 | 131.34 | 145.81 | 183.19 | 222.16 | 244.44 | 259.50 | 270.55 |
| 80 | 0.013 | 12.90 | 19.58 | 24.77 | 29.15 | 36.41 | 52.30 | 73.23 | 88.04 | 117.88 | 137.86 | 153.02 | 192.16 | 232.93 | 256.22 | 271.95 | 283.48 |
| 100 | 0.01 | 13.41 | 20.35 | 25.74 | 30.28 | 37.82 | 54.30 | 76.00 | 91.35 | 122.27 | 142.96 | 158.66 | 199.17 | 241.33 | 265.41 | 281.66 | 293.57 |
| 250 | 0.004 | 15.55 | 23.56 | 29.78 | 35.01 | 43.69 | 62.63 | 87.53 | 105.13 | 140.50 | 164.12 | 182.04 | 228.17 | 276.07 | 303.34 | 321.73 | 335.17 |
| 15 | 0.066 | 9.18 | 13.98 | 17.72 | 20.87 | 26.12 | 37.62 | 52.82 | 63.61 | 85.41 | 100.05 | 111.18 | 140.01 | 170.19 | 187.52 | 199.27 | 207.91 |

Time of Concentration

| | 59.5 | | 54.4 | |
|---|---|---|---|---|
| | Pre-development | | Post Revegetated 50% | |
| AEP | Rainfall Depth (mm) | Rainfall Intensity (mm/hr) | Rainfall Depth (mm) | Rainfall Intensity (mm/hr) |
| 10 | 51.4 | 51.9 | 49.0 | 54.0 |
| 15 | 55.7 | 56.2 | 53.1 | 58.5 |
| 100 | 81.2 | 82.0 | 77.4 | 85.4 |

| | 59.5 | | 54.0 | |
|---|---|---|---|---|
| | Pre-development | | Post-development | |
| AEP | Rainfall Depth (mm) | Rainfall Intensity (mm/hr) | Rainfall Depth (mm) | Rainfall Intensity (mm/hr) |
| 10 | 34.4 | 34.7 | 32.7 | 36.3 |
| 15 | 37.2 | 37.5 | 35.3 | 39.2 |
| 100 | 53.6 | 54.1 | 50.9 | 56.5 |

# STORMWATER ASSESSMENT - PRE-DEVELOPMENT SCENARIO

Project: CCKV Kākā RC — By: CHGR — Date: 21/03/2024
Location: Kākā Catchment — Checked: DNV — Date: 25/03/2024

## Calculation Description

Kākā Full

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) CN classification | Condition | SCS Method: Curve Number CN* | Area (hectares) | Product of CN x Area | Rational Method: C | Product |
|---|---|---|---|---|---|---|---|---|
| | | Pervious Areas (List) | | | | | | |
| 2 | Class D soils | Brush | Fair | 77 | 108.33 | 8,341 | 0.35 | 37.91 |
| 3 | Class D soils | Brush | Poor | 83 | 14.99 | 1,244 | 0.35 | 5.25 |
| 4 | Class D soils | Brush/Grass | Poor | 86 | 22.00 | 1,892 | 0.375 | 8.25 |
| 5 | Class D soils | Woods | Fair | 79 | 0.63 | 50 | 0.35 | 0.22 |
| 6 | Class D soils | Woods | Poor | 83 | 3.83 | 318 | 0.35 | 1.34 |
| 7 | Class C soils | Woods/Grass | Fair | 76 | 0.02 | 1 | 0.275 | 0.00 |
| 8 | Class D soils | Woods/Grass | Fair | 82 | 2.88 | 236 | 0.375 | 1.08 |
| 9 | Class B soils | Pasture | Fair | 69 | 8.85 | 611 | 0.30 | 2.65 |
| 10 | Class C soils | Pasture | Fair | 79 | 0.19 | 15 | 0.30 | 0.06 |
| 11 | Class C soils | Pasture | Poor | 86 | 7.58 | 652 | 0.30 | 2.28 |
| 12 | Class D soils | Pasture | Fair | 84 | 68.77 | 5,777 | 0.40 | 27.51 |
| 13 | Class D soils | Pasture | Poor | 89 | 4.97 | 442 | 0.40 | 1.99 |
| 14 | Class D soils | Dirt | NA | 89 | 1.56 | 139 | 0.50 | 0.78 |
| 15 | Class D soils | Newly Graded Area | NA | 91 | 9.75 | 887 | 0.60 | 5.85 |
| | | Subtotal for Pervious Areas | | | 254.36 | 20,607 | | 95.18 |
| | | Impervious Areas (List) | | | | | | |
| | | Subtotal for Impervious Areas | | | 0.00 | 0 | | 0.00 |
| | | | | Totals | 254.36 | 20,607 | | 95.18 |
| | | | | | 2.5436 km² | | | |

The following HEC-HMS parameters have been selected to align with the MaiBkYk model developed by T+T for NCC Maitai River Flood Hazard Mapping Modelling Report (T+T, 2013)

CN (weighted) : total product / total area = 20,607 / 254.360 = 81.01

C (weighted) 0.3742

**2. Time of Concentration** The Clark hydrograph method has been selected to align with the MaiBkYk model

Time of Concentration $t_c$ = 0.99 hrs — 59.45 min

Storage Coefficient R = 2.5 $t_c$ = 2.48 hrs — 148.63 min

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

Total = 59.5 mm
Pervious = 59.5 mm
Impervious = mm

**4. Initial Abstraction** This has been selected to align with the MaiBkYk model and with the limitations outlined in TR55

Ia = 0.2S = 11.9058

*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 6 hour and 12 hour storm durations
Both Present Day and RCP 8.5

**5. Results**

Pre-Development RCP8.5 2130

Results — Peak Discharge (m3/s)

| hr | Q10 | Q15 | Q100 |
|---|---|---|---|
| 6 | 9.16 | 10.28 | 17.12 |
| 12 | 9.41 | 10.46 | 16.82 |

Pre-Development Present Day

Results — Peak Discharge (m3/s)

| hr | Q10 | Q15 | Q100 |
|---|---|---|---|
| 6 | 5.32 | 6.01 | 10.36 |
| 12 | 6.01 | 6.72 | 11.04 |

**Rational Method**

59 min

RCP8.5 2130

| | Q10 | Q15 | Q100 |
|---|---|---|---|
| Rainfall intensity | 51.9 | 56.2 | 82.0 |
| Peak Flow Rate, Q : | 13.74 | 14.87 | 21.69 |

Present Day

| | Q10 | Q15 | Q100 |
|---|---|---|---|
| Rainfall intensity | 34.7 | 37.5 | 54.1 |
| Peak Flow Rate, Q : | 9.19 | 9.92 | 14.32 |

## STORMWATER ASSESSMENT - POST-DEVELOPMENT SCENARIO

Project: CCKV Kākā RC — By: CHGR — Date: 21/03/2024
Location: Kākā Catchment — Checked: DNV — Date: 25/03/2024

### Calculation Description

Kākā Full

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): CN classification | Condition | 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) | | | | | | |
| 2 | Class D soils | Brush | Fair | 77 | 104.55 | 8,050 | 0.35 | 36.59 |
| 3 | Class D soils | Brush | Poor | 83 | 11.53 | 957 | 0.35 | 4.04 |
| 4 | Class D soils | Brush/Grass | Poor | 86 | 21.44 | 1,843 | 0.375 | 8.04 |
| 5 | Class D soils | Woods | Fair | 79 | 0.02 | 2 | 0.35 | 0.01 |
| 6 | Class D soils | Woods | Poor | 83 | 3.23 | 268 | 0.35 | 1.13 |
| 7 | Class C soils | Woods/Grass | Fair | 76 | 0.02 | 1 | 0.275 | 0.00 |
| 8 | Class D soils | Woods/Grass | Fair | 82 | 2.88 | 236 | 0.38 | 1.08 |
| 9 | Class B soils | Pasture | Fair | 69 | 0.77 | 53 | 0.30 | 0.23 |
| 10 | Class C soils | Pasture | Fair | 79 | 0.04 | 3 | 0.30 | 0.01 |
| 11 | Class C soils | Pasture | Poor | 86 | 1.17 | 101 | 0.30 | 0.35 |
| 12 | Class D soils | Pasture | Fair | 84 | 10.67 | 896 | 0.40 | 4.27 |
| 13 | Class D soils | Pasture | Poor | 89 | 1.73 | 154 | 0.40 | 0.69 |
| 14 | Class D soils | Dirt | NA | 89 | 1.56 | 139 | 0.50 | 0.78 |
| 15 | Class D soils | Newly Graded Area | NA | 91 | 9.75 | 887 | 0.60 | 5.85 |
| 16 | Class B soils | Brush | Good | 48 | 3.94 | 189 | 0.20 | 0.79 |
| 17 | Class C soils | Brush | Good | 65 | 0.93 | 61 | 0.20 | 0.19 |
| 18 | Class D soils | Brush | Good | 73 | 14.18 | 1,035 | 0.30 | 4.25 |
| 19 | Class B soils | Open Space | Good | 61 | 1.30 | 79 | 0.25 | 0.32 |
| 20 | Class C soils | Open Space | Good | 74 | 3.47 | 256 | 0.25 | 0.87 |
| 21 | Class D soils | Open Space | Good | 80 | 31.73 | 2,538 | 0.35 | 11.11 |
| | | Subtotal for Pervious Areas | | | 224.90 | 17,750 | | 80.60 |
| | | Impervious Areas (List) | | | | | | |
| 22 | Class B soils | Commercial | Commercial and Busine | 92 | 0.00 | 0 | 0.65 | 0.00 |
| 23 | Class D soils | Commercial | Commercial and Busine | 95 | 0.69 | 65 | 0.65 | 0.45 |
| 24 | | Impervious | Paved parking lots, roo | 98 | 28.78 | 2,821 | 0.90 | 25.90 |
| | | Subtotal for Impervious Areas | | | 29.47 | 2,886 | | 26.35 |
| | | | | Totals | 254.37 | 20,636 | | 106.95 |

* from Table 3.3

CN (weighted) : total product / total area = 20,636 / 254.370 = 81.13 — 0.4204

Weighted CN Pervious = 78.92 — 0.416667

Weighted CN Impervious = 97.93

**2. Time of Concentration**

Time of Concentration $t_c$ = 0.90 hrs — 54.04 min

Storage Coefficient R = 2.5 $t_c$ = 2.25 hrs — 135.09 min

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

Total = 59.1 mm
Pervious = 67.8 mm
Impervious 5.4 mm

**4. Initial Abstraction**

**Initial abstraction - impervious** Ia = 0.2S = 1.074
**Initial abstraction - Compound** Ia = 0.2S = 11.82

*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 6 hour and 12 hour storm durations
Both Present Day and RCP 8.5

**5. Results**

Post-Development Present Day

Results — Peak Discharge (m3/s)

| hr | Q10 | Q15 | Q100 |
|---|---|---|---|
| 6 | 5.47 | 6.16 | 10.54 |
| 12 | 6.04 | 6.76 | 11.14 |

**Rational Method**

54 min

Present Day

| | Q10 | Q15 | Q100 |
|---|---|---|---|
| Rainfall intensity | 36.3 | 39.2 | 56.5 |
| Peak Flow Rate, Q : | 10.78 | 11.64 | 16.81 |

# STORMWATER ASSESSMENT - POST-DEVELOPMENT REVEGETATED SCENARIO

Project: CCKV Kākā RC — By: CHGR — Date: 21/03/2024
Location: Kākā Catchment — Checked: DNV — Date: 25/03/2024

## Calculation Description

Kākā Full

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) – CN classification | Condition | 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) | | | | | | |
| 2 | Class D soils | Brush | Fair | 77 | 38.73 | 2,982 | 0.35 | 13.56 |
| 3 | Class D soils | Brush | Poor | 83 | 0.00 | 0 | 0.35 | 0.00 |
| 4 | Class D soils | Brush/Grass | Poor | 86 | 0.00 | 0 | 0.375 | 0.00 |
| 5 | Class D soils | Woods | Fair | 79 | 0.02 | 2 | 0.35 | 0.01 |
| 6 | Class D soils | Woods | Poor | 83 | 0.00 | 0 | 0.35 | 0.00 |
| 7 | Class C soils | Woods/Grass | Fair | 76 | 0.02 | 1 | 0.275 | 0.00 |
| 8 | Class D soils | Woods/Grass | Fair | 82 | 0.00 | 0 | 0.38 | 0.00 |
| 9 | Class B soils | Pasture | Fair | 69 | 0.77 | 53 | 0.30 | 0.23 |
| 10 | Class C soils | Pasture | Fair | 79 | 0.04 | 3 | 0.30 | 0.01 |
| 11 | Class C soils | Pasture | Poor | 86 | 0.48 | 42 | 0.30 | 0.15 |
| 12 | Class D soils | Pasture | Fair | 84 | 1.61 | 135 | 0.40 | 0.64 |
| 13 | Class D soils | Pasture | Poor | 89 | 0.82 | 73 | 0.40 | 0.33 |
| 14 | Class D soils | Dirt | NA | 89 | 1.36 | 121 | 0.50 | 0.68 |
| 15 | Class D soils | Newly Graded Area | NA | 91 | 9.75 | 887 | 0.60 | 5.85 |
| 16 | Class B soils | Brush | Good | 48 | 3.94 | 189 | 0.25 | 0.99 |
| 17 | Class C soils | Brush | Good | 65 | 0.93 | 61 | 0.25 | 0.23 |
| 18 | Class D soils | Brush | Good | 73 | 14.18 | 1,035 | 0.35 | 4.96 |
| 19 | Class B soils | Open Space | Good | 61 | 1.30 | 79 | 0.25 | 0.32 |
| 20 | Class C soils | Open Space | Good | 74 | 3.33 | 246 | 0.25 | 0.83 |
| 21 | Class D soils | Open Space | Good | 80 | 22.78 | 1,822 | 0.35 | 7.97 |
| 25 | Class C soils | Woods | Good | 70 | 0.82 | 58 | 0.20 | 0.16 |
| 26 | Class D soils | Woods | Good | 77 | 124.01 | 9,549 | 0.30 | 37.20 |
| | | Subtotal for Pervious Areas | | | 224.90 | 17,339 | | 74.14 |
| | | Impervious Areas (List) | | | | | | |
| 22 | Class B soils | Commercial | Commercial and Busine | 92 | 0.00 | 0 | 0.65 | 0.00 |
| 23 | Class D soils | Commercial | Commercial and Busine | 95 | 0.69 | 65 | 0.65 | 0.45 |
| 24 | | Impervious | Paved parking lots, roofs | 98 | 28.78 | 2,821 | 0.90 | 25.90 |
| | | Subtotal for Impervious Areas | | | 29.47 | 2,886 | | 26.35 |
| | | | | Totals | 254.37 | 20,225 | | 100.49 |

* from Table 3.3

CN (weighted) : total product / total area = 20,225 / 254.370 = 79.51 — 0.3951

Weighted CN Pervious = 77.10
Weighted CN Impervious = 97.93

**2. Time of Concentration**

Time of Concentration $t_c$ = 0.92 hrs — 55.04 min
Storage Coefficient R = 2.5 $t_c$ = 2.29 hrs — 137.61 min

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

Total = 65.5 mm
Pervious = 75.5 mm
Impervious = 5.4 mm

**4. Initial Abstraction**

**Initial abstraction - impervious** Ia = 0.2S = 1.074
**Initial abstraction - Compound** Ia = 0.2S = 13.09

*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 6 hour and 12 hour storm durations
Both Present Day and RCP 8.5

**5. Results**

Post-Development Revegetated RCP8.5 2130
Results Peak Discharge (m3/s)

| hr | Q10 | Q15 | Q100 |
|---|---|---|---|
| 6 | 8.77 | 9.87 | 16.63 |
| 12 | 9.01 | 10.04 | 16.44 |

**Rational Method**

55 min

RCP8.5 2130

| | Q10 | Q15 | Q100 |
|---|---|---|---|
| Rainfall intensity | 54.0 | 58.5 | 85.4 |
| Peak Flow Rate, Q : | 15.10 | 16.35 | 23.85 |

# STORMWATER ASSESSMENT - POST-DEVELOPMENT 50% REVEGETATED SCENARIO

Project: CCKV Kākā RC | By: CHGR | Date: 21/03/2024
Location: Kākā Catchment | Checked: DNV | Date: 25/03/2024

## Calculation Description

Kākā Full

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) – CN classification | Condition | 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) | | | | | | |
| 2 | Class D soils | Brush | Fair | 77 | 38.73 | 2,982 | 0.35 | 13.56 |
| 3 | Class D soils | Brush | Poor | 83 | 0.00 | 0 | 0.35 | 0.00 |
| 4 | Class D soils | Brush/Grass | Poor | 86 | 0.00 | 0 | 0.375 | 0.00 |
| 5 | Class D soils | Woods | Fair | 79 | 0.02 | 2 | 0.35 | 0.01 |
| 6 | Class D soils | Woods | Poor | 83 | 0.00 | 0 | 0.35 | 0.00 |
| 7 | Class C soils | Woods/Grass | Fair | 76 | 0.02 | 1 | 0.275 | 0.00 |
| 8 | Class D soils | Woods/Grass | Fair | 82 | 0.00 | 0 | 0.38 | 0.00 |
| 9 | Class B soils | Pasture | Fair | 69 | 0.77 | 53 | 0.30 | 0.23 |
| 10 | Class C soils | Pasture | Fair | 79 | 0.04 | 3 | 0.30 | 0.01 |
| 11 | Class C soils | Pasture | Poor | 86 | 0.48 | 42 | 0.30 | 0.15 |
| 12 | Class D soils | Pasture | Fair | 84 | 1.61 | 135 | 0.40 | 0.64 |
| 13 | Class D soils | Pasture | Poor | 89 | 0.82 | 73 | 0.40 | 0.33 |
| 14 | Class D soils | Dirt | NA | 89 | 1.36 | 121 | 0.50 | 0.68 |
| 15 | Class D soils | Newly Graded Area | NA | 91 | 9.75 | 887 | 0.60 | 5.85 |
| 16 | Class B soils | Brush | Good | 48 | 3.94 | 189 | 0.25 | 0.99 |
| 17 | Class C soils | Brush | Good | 65 | 0.93 | 61 | 0.25 | 0.23 |
| 18 | Class D soils | Brush | Good | 73 | 14.18 | 1,035 | 0.35 | 4.96 |
| 19 | Class B soils | Open Space | Good | 61 | 1.30 | 79 | 0.30 | 0.39 |
| 20 | Class C soils | Open Space | Good | 74 | 3.33 | 246 | 0.30 | 1.00 |
| 21 | Class D soils | Open Space | Good | 80 | 22.78 | 1,822 | 0.30 | 6.83 |
| 25 | Class C soils | Woods | Fair | 73 | 0.82 | 60 | 0.25 | 0.21 |
| 26 | Class D soils | Woods | Fair | 79 | 124.01 | 9,797 | 0.35 | 43.40 |
| | | | Subtotal for Pervious Areas | | 224.90 | 17,590 | | 79.47 |
| | | Impervious Areas (List) | | | | | | |
| 22 | Class B soils | Commercial | Commercial and Busine | 92 | 0.00 | 0 | 0.65 | 0.00 |
| 23 | Class D soils | Commercial | Commercial and Busine | 95 | 0.69 | 65 | 0.65 | 0.45 |
| 24 | | Impervious | Paved parking lots, roof | 98 | 28.78 | 2,821 | 0.90 | 25.90 |
| | | | Subtotal for Impervious Areas | | 29.47 | 2,886 | | 26.35 |
| | | | | Totals | 254.37 | 20,476 | | 105.82 |

* from Table 3.3

CN (weighted) : total product / total area = 20,476 / 254.370 = 80.50   0.4160

Weighted CN Pervious = 78.21
Weighted CN Impervious = 97.93

**2. Time of Concentration**

Time of Concentration $t_c$ = 0.91 hrs   54.43 min
Storage Coefficient R = $2.5\ t_c$ = 2.27 hrs   136.07 min

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

Total = 61.5 mm
Pervious = 70.8 mm
Impervious = 5.4 mm

**4. Initial Abstraction**

**Initial abstraction - impervious** Ia = 0.2S = 1.074
**Initial abstraction - Compound** Ia = 0.2S = 12.31

*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 6 hour and 12 hour storm durations
Both Present Day and RCP 8.5

**5. Results**

Post-Development Revegetated RCP8.5 2130
Results Peak Discharge (m3/s)

| hr | Q10 | Q15 | Q100 | |
|---|---|---|---|---|
| 6 | 9.10 | 10.22 | 17.11 | Time of Peak 5:25 |
| 12 | 9.30 | 10.35 | 16.80 | Time of Peak 9:05 |

**Rational Method**

54 min

RCP8.5 2130

| | Q10 | Q15 | Q100 |
|---|---|---|---|
| Rainfall intensity | 54.0 | 58.5 | 85.4 |
| Peak Flow Rate, Q : | 15.90 | 17.21 | 25.11 |

# Appendix C Water sensitive design report - Morphum

- **Maitahi Stormwater Plan, Water Sensitive Design Report, Draft, Morphum Environmental, 24/01/2024, P04349**

Co-creating a thriving ecosystem

# Maitahi Village - Stormwater Management

## Water Sensitive Design Report

**Final**

Prepared for CCKV Maitai Dev Co LP

## Document Control

**Client Name:** CCKV Maitai Dev Co LP

**Project Name:** Maitahi Village - Stormwater Management

**Project Number:** P04349

**Document:** Water Sensitive Design Report

## Revision History

| Status | Date Issued | Author | Reviewed By | Released By |
|---|---|---|---|---|
| Draft | 25/03/2024 | Tim Dodd | Stu Farrant | Dave Cox |
| Final | 24/01/2025 | Tim Dodd/S Farrant | Stu Farrant | Dave Cox |

## Reviewed by:

**Reviewer:** Stu Farrant **Signature:**

## Released by:

**Reviewer:** Dave Cox **Signature:**

# Contents

# 1. Context

Morphum Environmental Ltd (Morphum) were engaged to support the stormwater design of the Maitahi Kākā Hill Development in the Matai Valley, Nelson. Morphum's role is to provide technical water sensitive design (WSD) expertise to the project team to ensure the development has robust and resilient stormwater management integrated across the site to support the aspirations to protect and enhance the freshwater values and ecological conditions of Kākā Stream and the Maitai/Maitahi River. This will be achieved by the implementation of best practise water sensitive design to meet the requirements of Schedule X (NRMP). This report describes the proposed stormwater treatment concept and design assumptions and should be read in conjunction with the full Stormwater Management Plan (SMP) which has been prepared by Tonkin & Taylor. The SMP should be referred to for specific site context, further details, and site plan/maps.

## 1.1. Water Sensitive Design Scope

Morphum were engaged to provide specialist design services including overall WSD strategy development, sizing of stormwater management elements and input into integration with landscape architecture. These works are intended to ensure the appropriate design and implementation of water quality treatment devices and hydrological controls for operational stormwater from all impervious surfaces throughout the development, including roads, residential lots, commercial areas and the Arvida retirement villages. Principles of water sensitive design have been applied at multiple layers of the development and hence has been an iterative process with the civil and landscape design teams.

## 1.2. Defined Objectives

The site was recently rezoned for residential development through private plan change 28 (PPC28). This plan change introduced 'Schedule X' which is now operative and sets out requirements that must be met for development within the plan change area. These Schedule X requirements take precedent over the standards of the Nelson Tasman Land Development Manual (LDM) and were agreed on through PPC28 to provide certainty that the development from existing rural land use could be done in a manner which protected and enhanced freshwater values across the site and downstream. The Schedule X provisions have informed our design approach specifically those which respond to stormwater treatment and water sensitive design. Key provisions from Schedule X are included below:

***RE6.3*** *- A comprehensive and integrated management approach including, but not limited to:*

- A. *Prioritising the health and well-being of surface waterbodies in a manner that maintains or enhances cultural, recreational and ecosystem values.*
- B. *Ensuring integrated stormwater management, erosion and sediment control and flood hazard*
- C. *Ensuring urban development:*
    - a. *Uses 'green infrastructure' engineering solutions to mimic and work with natural processes;*
    - b. *Retains, restores and enhances existing elements of the natural drainage system, and integrates these elements into the urban landscape;*
    - c. *Conserves the use of water resources through rainwater capture and reuse to meet non potable demands; and*

- d. *Requires that building materials either exclude or be finished in a manner that prevents water runoff from containing copper or zinc.*

D. *Ensuring Water Sensitive Design principles are utilised in the planning and implementation stages.*

E. *Mimicking pre-development hydrology through retention and detention by matching pre-development mean annual volume of stormwater runoff and pre-development channel forming flows in Kākā Stream to reduce the risk of scour, sediment mobilisation and adverse impacts on instream biota.*

F. *Providing for the 'first flush' of all site generated stormwater (excluding where on lot reuse or infiltration occurs) to be passed through constructed vegetated treatment devices to avoid temperature fluctuations and minimise concentrations of copper, zinc, hydrocarbons, nutrients and sediment to the smallest amount practicable prior to discharge to Kākā Stream, existing wetlands or Maitahi/Mahitahi River. First flush is to be based on treating 80-85% of mean annual volume or stormwater resulting from 3-month ARI Rainfall events (25mm rainfall depth or 10mm/hr rainfall intensity).*

H. *Requiring the mapping of areas with suitable infiltration capacity and factoring in design to optimise groundwater recharge where viable as part of integrated water sensitive design strategy. Infiltration capacity is to be protected through construction and optimised in-fill areas with specific design and construction of permeable fill.*

I. *Providing and protecting overland flow paths through road design and other dedicated pathways to pass peak flows from upper slopes safely.*

K. *Restoring and enhancing the lower reaches of Kākā Stream through a continuous riparian corridor (Blue-Green Spine) with:*
   - a. *The corridor reflecting natural topography;*
   - b. *Channel meanders and flood benches;*
   - c. *Robust riparian vegetation;*
   - d. *Peak flood capacity;*
   - e. *Ecosystem function and habitat;*
   - f. *Stormwater treatment wetlands in areas of suitable topography;*
   - g. *Public access via well designed walking/cycling paths (excluding roads except at crossing points); and*
   - h. *Natural character values.*

M. *Providing for the co-location of stormwater treatment wetlands/rain-gardens within the Kākā Stream Blue-Green Spine where this is the most appropriate option to: protect the main stream, increase ecological values, and provide high quality public amenity. Where stormwater treatment is located in the Blue-Green Spine the design shall ensure a minimum 10m riparian buffer between any device and the stream and support ongoing maintenance access.*

N. *Managing earthworks and compaction outside residential zones to minimise changes to the hydraulic response of flows directly or indirectly discharging into the Kākā Stream and its tributaries.*

O. *Including on-lot management of water quality/quantity through rainwater capture and reuse and soakage (where viable) so as to conserve and reuse water for non-potable internal and external purposes.*

P. *Providing for the integration of peak flood attenuation within the Blue-Green Spine, while ensuring: that stream ecology (including fish passage) is preserved; any off line stormwater treatment devices are protected; natural character is maintained or enhanced; and the health and safety of community and visitors is protected.*

## 1.3. Design Approach

Greenfield urban development can result in adverse impacts due to the generation and discharge of urban contaminants and the change in hydrology which results in increased stormwater volumes and flowrates during small frequent rainfall events. These impacts are a direct reflection of the increase in impervious surfaces including roofs, hardstand and roads which prevent the natural interception and evapotranspiration of rainfall by vegetation/shallow soils and result in contaminants including heavy metals, hydrocarbons, sediments and nutrients discharging to receiving waterways as well as biophysical contaminants including temperature and fluctuating dissolved oxygen which are known to adversely impact of freshwater ecology.

A water sensitive design approach must address the characteristics of runoff from impervious surfaces to avoid negatively impacting the health of receiving freshwater environments. The aim of WSD is therefore to mimic the natural hydrological response of the catchment and remove contaminates from runoff before discharge to receiving waterways. The proposed stormwater management strategy for the Maitahi Village Development will achieve a high level of environmental protection and meet the requirements of PC28 through three key stormwater management techniques:

1. Capture and reuse of roof runoff at lot scale. This will be achieved through rainwater reuse tanks plumbed for internal non potable reuse (toilet flushing) to replicate natural interception and evapotranspiration for medium density dwellings in the western and central catchment.
2. Treatment of all road and hardstand (driveways) and untreated roofs (where rainwater reuse not adopted) runoff before discharge to receiving environment through mix of biological, chemical and physical processes in constructed stormwater treatment wetlands and isolated proprietary devices where necessary.
3. Discharge of treated flows from wetlands to areas of constructed ephemeral channels and soakage wetlands to buffer the stream from hydrological changes and support groundwater recharge.

Based on the proposed site wide water sensitive design approach, runoff from impervious surfaces will be effectively managed to ensure that flows which ultimately discharge to Kākā Stream will only occur in moderate to large rainfall events and will have either passed through a comprehensive treatment train to appropriately manage the first flush of rainfall or, in the case of large rainfall events, will have purposely bypassed the constructed wetlands to avoid potential damage of biological processes.

# 2. Proposed Water Sensitive Design Elements

The site of the Maitahi Village project is separated into a series of development typologies with different building densities and development conditions in each. For each of these areas, estimates of the expected impervious area and presence or absence of on-lot reuses tanks informs the requirements for stormwater quality treatment and frequent flow soakage. The stormwater network for the development operates in three sub catchments, each with a treatment wetland and ephemeral soakage wetland at the downstream end prior to discharge to Kākā stream. The proposed constructed wetlands are sized to capture first flush stormwater from impervious surfaces across the connected catchment. Treatment wetlands are sized at 4% of the contributing impervious catchment area. The ephemeral soakage wetlands are sized to infiltrate the first 10mm of rainfall across the impervious catchment (excluding roofs using reuses tanks) within a 24hr period. This is intended to mimic the natural interception, evapotranspiration and infiltration of the natural predeveloped catchment which generates surface runoff only after becoming saturated by the first portion of rain.

## 2.1. On lot Reuse Tanks

For the medium density development zone in the western and central sub catchments rainwater reuse tanks shall be integrated into each dwelling and will be plumbed to internal non-potable uses including toilets and cold water laundry. Table 2 shows the assumptions applied in the sizing of proposed tanks.

Table 1: Water Reuse Assumptions

| | |
|---|---|
| **No. people per dwelling** | 2.9 |
| **Water demand (L/person/d)** | 165 |
| **Water demand (L/dwelling/d)** | 479 |
| **Non-potable fraction - internal (%)** | 40 |
| **Non-potable fraction - external (%)** | 15 |
| **Constant daily reuse (toilet & laundry) (kL/dwelling/d)** | 0.191 |
| **Variable annual reuse (irrigation) (kL/dwelling/y)** | 26.2 |

Runoff from a range of roof areas was modelled using the Model for Urban Stormwater Improvement Conceptualisation (MUSIC). Ten years of local rainfall data and different tank sizes were tested to optimise the efficiency and runoff reduction. These tanks were selected based on demonstrating approximately 25% reduction in the mean annual rainfall volume and to capture the first flush of stormwater to mitigate potential water quality impacts. Table 2 provides a summary of the required rainwater reuse tank sizes to achieve the intended hydrological controls.

Table 2 Required rainwater reuse tank sizing.

| **Connected roof area ($m^2$)** | **0-99** | **100 -149** | **150 -199** | **200+** |
|---|---|---|---|---|
| **Required tank Volume (L)** | 2,500 | 3,000 | 4,000 | 5,000 |

This addresses the increase in runoff volume associated with impervious surfaces, by reducing the runoff from the roof areas by approximately 25%.

Development lots which include rainwater reuse tanks are therefore determined to effectively 'self-manage' stormwater from their roof areas which are therefore subtracted from the effective catchment area applied in the sizing of downstream treatment wetlands.

The roof area for tank sizing assumed 85% of the impervious area for the total is roof with, the remaining 15% of impervious area constituting the driveway which will drain toward the road and public stormwater network.

Rainwater reuse tanks will be designed to overflow to the stormwater network, but this will only occur during large events or in periods of prolonged rainfall when the undeveloped catchment would naturally be saturated and generating runoff. Whilst rainwater reuse tanks will provide capture an initial portion of high intensity rain events following prolonged dry spells this has not been allowed for in flood modelling which has assumed that reuse tanks are full at the start of large rain events.

## 2.2. Constructed treatment wetlands

Water quality treatment to remove urban contaminates such as dissolved heavy metals and hydrocarbons will be provided by constructed treatment wetlands. The proposed wetlands will include a permanent depth of water (on average 350 mm with variable depths up to 1,200 mm) and will be densely planted with emergent aquatic vegetation. The central and southern wetlands will also include a 350 mm deep extended detention depth which will be engaged during rainfall events with an average drawdown over 24 – 48 hours following rainfall. Runoff from the connected catchment will flow through the vegetated wetlands following rainfall with contaminants removed through physical, biological and chemical processes. The key features of the proposed treatment wetlands will be:

1. Upstream bypass structure to direct water quality flows to the wetlands with high flows (>1/3 of the 2-year ARI) to discharge direct to the stream
2. Outlet from network with appropriate erosion protection and access for routine inspection and maintenance
3. Sediment pool (forebay) designed to remove coarser particulate contaminants with maintenance access. The forebay will be approximately 10% of the total footprint.
4. Concrete level spreader/submerged weir to distribute uniform flow across the full width of the wetlands
5. Wetland area with water depth ranging between 100 – 1200mm and variety of suitable local plants. The main wetland area will comprise 80% of the total footprint and will be heavily vegetated with shallow and deep marsh species
6. Open water outlet pool with submerged outlet pipe, hydraulic control for extended detention and connection to downstream ephemeral soakage wetland
7. Impermeable lining to prevent drawdown between rainfall events and support biological processes in wetland.

Figure 1 shows an image of a recently constructed wetland with the open water on the right being the sediment forebay.

Figure 1 Constructed stormwater wetland with forebay to the right of path

## 2.3. Ephemeral soakage wetlands

Roof water reuse tanks are not proposed for the high density lots due to space limitations or for a portion of the southern catchment where there is available space for soakage in the proposed integrated ephemeral wetlands. Therefore, all sub catchments will include dedicated retention devices to provide hydrological controls and reduce the volume of stormwater discharged to Kākā Stream in small frequent rainfall events. For catchments which do not include rainwater reuse, this is provided in the form of centralised planted dry basins which receive runoff from the treatment wetlands. Each basin has a set storage volume that allows the first flush of treated stormwater to infiltrate to ground (storage for 10mm of rain across the connected impervious catchment). Drawdown is based on preliminary infiltration rates that will support drawdown of stored water over a 24 hour timeframe. If the rainfall event exceeds the first flush volume the basin will then spill to the stream channel via a defined spillway outlet weir. This will provide effective stormwater retention and mitigates the impacts of development on frequent flow hydrology. The key features of the ephemeral soakage wetland are;

1. Outlet connection from adjacent treatment wetland with appropriate erosion protection
2. Planted basin with ~1m maximum depth of standing water following rainfall
3. Suitable substrate for infiltration without excessive construction phase compaction
4. Outlet weir to stream channel with appropriate erosion protection for longer duration events

# 3. Summary of Catchment Solutions

The development area has been divided into three hydrological sub catchments which will drain into separate treatment trains prior to discharge to Kākā Stream. These have been delineated based on a combination of the natural topography and site levels and the availability of space within the Kākā stream green corridor suitable for the integration of the proposed constructed wetland systems (including stormwater treatment and dedicated soakage).

## 3.1. Western Sub Catchment

The western sub catchment is on the true right bank of Kākā Stream and covers the Arvida B retirement village site, 84 residential lots and several public roads. Table 3 shows the sizing details for impervious surfaces and treatment devices in the catchment. Figures provided in the Stormwater Management report and landscape package should be referred to for details on the location of catchments and proposed treatment wetlands. Due to the steep topography on the true right bank of the re-aligned Kākā Stream, the constructed wetland is required to step over several elevations with a connecting reach of vegetated swale (with drop structures) and another drop structure across the lower wetland terrace also. The detailed design of this system will need to carefully consider the hydraulics to support intended function and ensure flows are spread across the full width. Any water quality improvements associated with the swale connections between wetland swells have not been accounted for in the inferred water quality modelling but will provide further improvements. The treatment area shown in Table 3 for the constructed wetland is the sum of the 3 tiers shown in landscape plans.

Table 3: Western sub catchment sizing details

| | |
|---|---|
| **Total contributing road area** | 18,400 $m^2$ |
| **Disconnected roof area (reuse tanks)** | 20,400 $m^2$ |
| **Hardstand to wetland (lots with tanks and general)** | 14,100 $m^2$ |
| **High density zone (roofs)** | 7,300 $m^2$ |
| **Half of Arvida B (roof & driveways)** | 10,700 $m^2$ |
| **Total connected impervious catchment** | 50,500$m^2$ |
| **Constructed wetland treatment area** | *1,450 $m^2$ |
| **Ephemeral soakage area** | *350 $m^2$ |

It is noted that the current wetland design remains slightly undersized for the assumed catchment. At detailed design and once actual development areas are fully resolved this will be refined through potentially increasing the footprint of the wetland, designing inlet hydraulic to align with clause F of Schedule X 6.3 and reducing the overall catchment imperviousness.

Half of Arvida B is unable to drain toward the inlet end of the proposed treatment wetland. Road and roof surfaces in this zone will therefore be treated by proprietary filter devices (specification yet to be determined) and discharged toward the nearby overland flow path without on-lot retention. This development area will therefore not meet the full requirements of the Clause E of Schedule X 6.3 however it makes up a small (~ 15%) and spatially constrained portion of the impervious catchment. The opportunity for this runoff to be retained via soakage will be investigated further at detailed design in tandem with the specification of a suitable proprietary device but residual shortfall may remain.

## 3.2. Central Sub catchment

The central sub catchment is on the true left bank of Kākā Stream and covers Half of the Arvida A retirement village site, 35 residential lots, a small commercial zone and several public roads. Table 4 shows the sizing details for impervious surfaces and treatment devices in the catchment.

Table 4: Central sub catchment sizing details

| | |
|---|---|
| **Total contributing road area** | 10,260 $m^2$ |
| **Disconnected roof area (reuse tanks)** | 7860 $m^2$ |
| **Driveways to wetland (lots with tanks)** | 7,600 $m^2$ |
| **High density zone (roofs)** | 4,470 $m^2$ |
| **Half of Arvida A (roof & driveways)** | 23,750 $m^2$ |
| **Total connected impervious catchment** | 46,080 $m^2$ |
| **Constructed wetland treatment area** | 1,840 m2 |
| **Ephemeral soakage area** | 460 m2 |

## 3.3. Eastern sub catchment

The eastern sub catchment is located on the east side of the Arvida A south of the central area. This sub catchment include half of the Arvida A retirement village site, 54 residential lots and several public roads. Table 5 shows the sizing details for impervious surfaces and treatment devices in the catchment.

Table 5: Southern sub catchment sizing details

| | |
|---|---|
| **Total contributing road area** | 9,200 m2 |
| **Total contributing roof & driveways** | 20,000 m2 |
| **Half of Arvida A (roof & driveways)** | 23,750 m2 |

| | |
|---|---|
| **Total connected impervious catchment** | 52,950 m2 |
| **Constructed wetland treatment area** | 2,100 m2 |
| **Ephemeral soakage area** | 530 m2 |

## 3.4. Maintenance and Operation

The proposed stormwater management devices will require reactive and proactive maintenance. Design of all wetlands and soakage basins will ensure all devices has suitable vehicle access to the forebays for intermittent sediment removal. Monitoring the wetland for blockages after storms and ensuring invasive plant species do not overwhelm the wetlands or outlets will also be important for operation. A detailed maintenance plan with maps and clear explanations of requirements for each feature will be prepared and provided prior to construction, this document can be used to inform contractor engagement for maintenance works after establishment and vesting.

Arvida (or the nominated the retirement village operator) will need to enter a maintenance contract for upkeep of any onsite proprietary storm filter devices confirmed during detailed design and ensure that residents and contractors are aware of the connection with downstream wetland systems and the need to protect these and Kākā Stream from unintended discharges.

The upkeep of reuse tanks will be the responsibility of the property owner, but a consent notice should be written to ensure this responsibility is properly administered.

# 4. Summary

For the Maitahi Village project water sensitive design is used to meet the requirements of Nelson City Council's schedule X provisions by mimicking the natural hydrology of the Kākā Stream catchment and treating stormwater runoff from impervious surfaces through constructed wetland systems. On lot water reuse and first flush soakage basins are used to mitigate the increase in runoff volumes from development. Constructed wetlands shall receive inflows from impervious surfaces and provide controlled water quality treatment with extended detention to manage a range of water quality issues prior to discharge to the ephemeral soakage basins. Further, all roofing materials shall be specified to avoid the generation of Zinc or Copper. The integration of these stormwater management devices and measures within the blue green corridor defined by the restored Kākā Stream will support the wider ecological/biodiversity aspirations alongside other benefits related to landscape amenity, community connections and passive recreation. The combination of these water sensitive design elements means the development will meet national best practise standards and likely improve downstream water quality as sediment and nutrient runoff from agricultural practise is replaced with urban design that manages contaminates and hydrology to a high standard.

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