Supporting Growth

Trig Road Corridor Upgrade

Assessment of Stormwater Effects

Version 1.0

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TE TUPU NGĀTAHI
Supporting Growth

WAKA KOTAHI
NZ TRANSPORT AGENCY

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Acronyms

Acronym/Term	Description
AEE	Assessment of Effects on the Environment
AEP	Annual Exceedance Probability
ARI	Annual Recurrence Interval = average period between exceedances of a given flow or rainfall
AT	Auckland Transport
AUP: OP	Auckland Unitary Plan Operative in Part 2016
CoP	Code of Practice
GD01	Stormwater Management Devices in the Auckland Region - Guideline Document 2017/001
HIRDS	High Intensity Rainfall Design System
MPD	Maximum Probable Development
NoR	Notice of Requirement
RMA	Resource Management Act 1991
SH18	State Highway 18
SMAF 1	Stormwater Management Area – Flow 1
SMAF 2	Stormwater Management Area – Flow 2
TDM	Transport Design Manual
TP108	Technical Publication 108: Guidelines for Stormwater Runoff Modelling in the Auckland Region
W3P	Whenuapai 3 Precinct

1 Introduction

1.1 Background

Auckland's population is growing rapidly; driven by both natural growth (more births than deaths) and migration from overseas and other parts of New Zealand. The Auckland Plan 2050 anticipates that this growth will generate demand for an additional 313,000 dwellings and require land for approximately 263,000 additional employment opportunities.

In response to this demand, the Auckland Unitary Plan Operative in Part 2016 (**AUP: OP**) identifies 15,000 hectares of predominantly rural land for future urbanisation. To enable the urban development of greenfield land, appropriate bulk infrastructure needs to be planned and delivered.

The Supporting Growth Programme is a collaboration between Auckland Transport (**AT**) and Waka Kotahi NZ Transport Agency, to investigate, plan and deliver the transport networks needed to support Auckland's future urban growth areas over the next 30 years.

1.2 Purpose of this Report

This report has been prepared to support AT's notice of requirement (**NoR**) and application for resource consents for the Trig Road Corridor Upgrade (the **Project**). The NoR under the Resource Management Act 1991 (**RMA**) is to designate land for the construction, operation and maintenance of the Project.

Trig Road, Whenuapai has been identified in the Supporting Growth Programme as a future arterial corridor that is needed to support the urban development of Whenuapai.

Funding for the upgrade of Trig Road between Hobsonville Road and State Highway 18 (**SH18**) has been made available through the Housing Infrastructure Fund (HIF)[1]. As there is funding available for construction, AT are also applying for the necessary resource consents under the RMA, concurrently with the NoR process.

This report provides an assessment of stormwater effects associated with the construction, operation and maintenance of the Project. This assessment has been prepared to inform the Assessment of Environmental Effects (**AEE**) for the NoR and regional resource consent applications.

The key matters addressed in this report are as follows:

(a) Identify and describe the existing stormwater environment;
(b) Describe the actual and potential adverse stormwater effects of operation of the Project;
(c) Describe the actual and potential adverse stormwater effects of construction of the Project;
(d) Recommend measures as appropriate to avoid, remedy or mitigate potential adverse stormwater effects (including any conditions/management plan required); and
(e) Present an overall conclusion of the level of potential adverse stormwater effects of the Project after recommended measures are implemented.

[1] See North West Housing Infrastructure Fund Assessment of Environmental Effects for further detail regarding the Housing Infrastructure Fund.

2 Project Description

2.1 Project Location

Trig Road is located in Whenuapai, a suburb in the North West area of Auckland. The full length of Trig Road is approximately 2.28km starting from the urban fringe of West Harbour, at the intersection on Hobsonville Road to the south, crossing SH18, and extending towards Brigham Creek Road intersection to the north.

The project area is shown in Figure 1 below, it covers the southern portion of Trig Road between Hobsonville Road and SH18 and a portion of Hobsonville Road between the intersection between Trig Road and Luckens Road.

Figure 1: Locality Plan

2.2 Project Description

The Project consists of the widening and upgrade of Trig Road transport corridor between the SH18 off-ramps and Hobsonville Road. The widening has capacity to provide for a two-lane arterial standard corridor including new footpaths on both sides of the road and a cycleway which is indicatively shown as a bi-direction cycleway on the eastern side of the corridor. The Project will upgrade the current rural standard corridor, currently 20m wide, to an urban standard, proposed to be approximately 22.4 to 24.8m wide, which is appropriate to support the soon to be urban environment on either side of Trig Road.

To safely tie into the existing road network, the Project also includes the signalisation of the intersections at Trig Road / Hobsonville Road and Luckens Road / Hobsonville Road and upgrade of Hobsonville Road between these intersections. This will require some localised widening of the road corridor along Hobsonville Road. The SH18 over-bridge will also be reconfigured to provide for a cycleway, and additional tie in works to the north of the over-bridge within the existing road reserve.

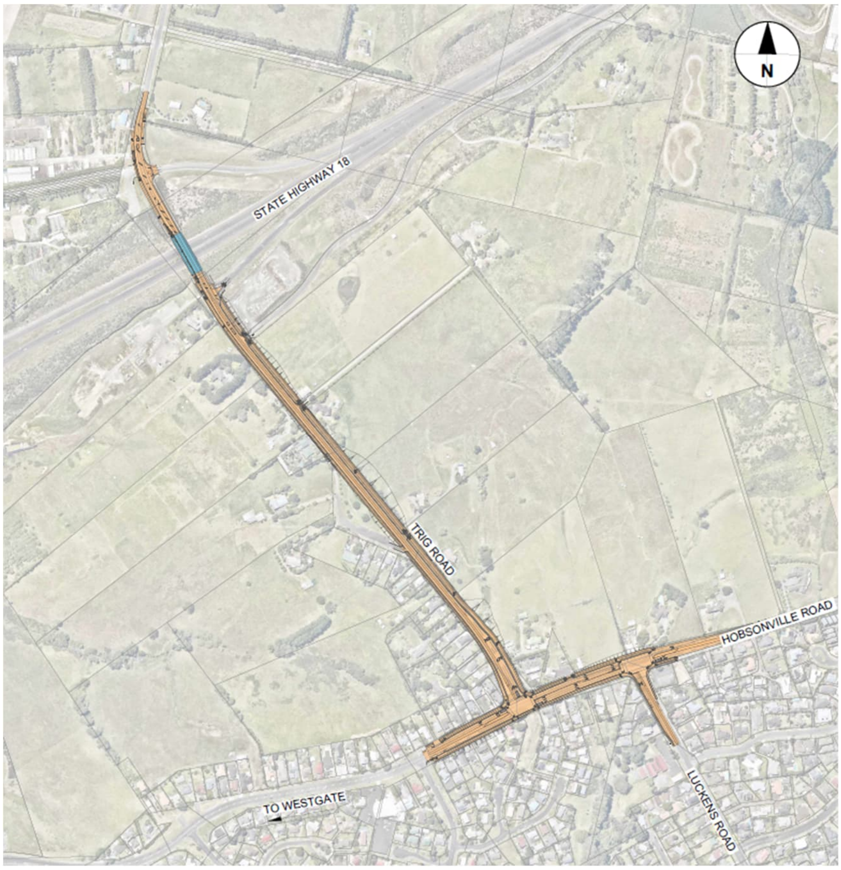


Figure 2: Whenuapai – Trig Road Corridor Upgrade

2.3 Project Features

2.3.1 Cross-Section

The indicative existing Trig Road corridor consists of a ±7m wide two-lane road and 1.5m footpath along the majority of the western side of the road length. While the final layout of the upgraded corridor will be confirmed as part of detailed design, a typical 24m wide cross-section has been developed for the corridor. Refer to Figure 3.

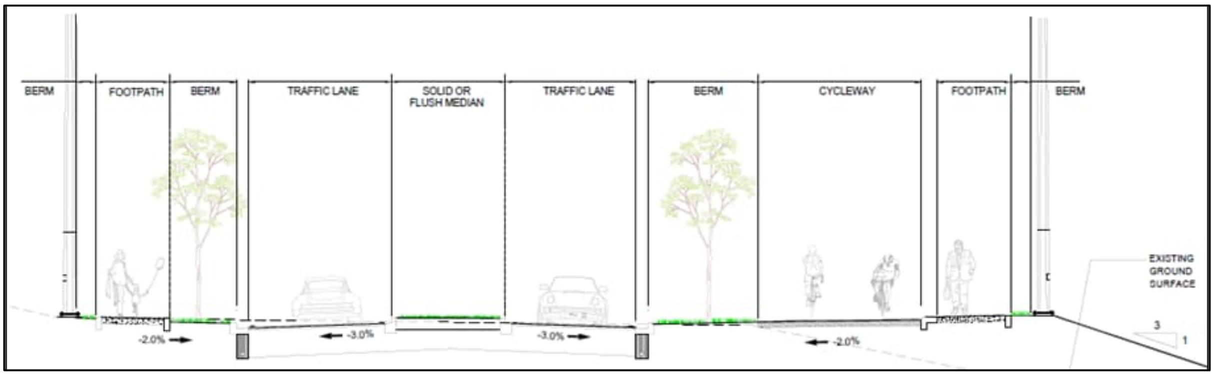


Figure 3: Indicative Trig Road Cross Section

2.3.2 Stormwater Infrastructure

The upgrades to Trig Road will induce necessary upgrades to the existing stormwater infrastructure, allowing for upgrades to accommodate future urban development, and new stormwater management devices. In summary, the specific stormwater infrastructure elements associated with the upgrade of Trig Road will include the following:

- Replacement and upgrading of three existing stormwater culverts under Trig Road, including energy dissipating outfalls
- Construction of new primary stormwater network within the new Trig Road corridor, as well as for portions of Hobsonville Road to be widened
- Installation of new stormwater treatment devices
- Construction of a new dry attenuation pond with energy dissipating outfall to Trig Stream (wetland)

These elements will be discussed in further detail in chapters to follow and are shown in Appendix 2 Stormwater Drawings.

2.4 Indicative Construction Methodology

An indicative construction methodology has been prepared to inform the assessment of the Project and, while subject to change, assists in determining the envelope of effects. An overview of the construction methodology is set out in the AEE. The final construction methodology for the Project will be confirmed during the detailed design phase and finalised once a contractor has been engaged for the work.

A summary of the key components of the indicative construction methodology relevant for this report is outlined in the sub-sections below.

2.4.1 General Construction Overview

The total construction phase of the Project is expected to take approximately 18 to 24 months. It is anticipated that the works will be broken down into separate construction zones based on the type of works required and the nature of the work environment. These anticipated zones are:

- **Zone 1:** Trig Road North of the SH18 bridge
- **Zone 2:** Trig Road South including the SH18 bridge
- **Zone 3:** Hobsonville Road.

2.4.1.1 Construction Methodology

Each zone has different construction activities depending on the type of work to be done and the surrounding environment. In all cases the general sequence of construction is likely to be:

1. Divert or remove services
2. Construct permanent stormwater drainage crossings and environmental controls
3. Move traffic away from works longitudinally
4. Construct earthworks and retaining structures

5. Construct new longitudinal drainage
6. Construct new pavement to half of the road
7. Move traffic onto newly constructed pavement
8. Complete longitudinal drainage
9. Complete pavement and median
10. Move traffic to new alignment
11. Complete footpath and cycleway

3 Assessment Criteria

3.1 Statutory Context

3.1.1 Notice of Requirement

This assessment has been prepared to support the NoR process for the Project. Section 171 of the RMA sets out the matters that must be considered by a territorial authority in making a recommendation on a NoR. This includes consideration of the actual or potential effects (including positive effects) on the environment of allowing the requirement.

3.1.2 Regional Resource Consent Application

AT are also seeking regional resource consents under the AUP: OP and resource consent under the National Environmental Standard for Assessing and Managing Contaminants in Soil to Protect Human Health and National Environmental Standard for Freshwater. The required consents are set out in Section 3.5 of the AEE.

Overall, the application is a Discretionary Activity, therefore in accordance with section 104B of the RMA, Council is not restricted in its discretion when assessing the actual or potential effects associated with the Project.

Notwithstanding Council's unrestricted discretion, the relevant matters of discretion, matters of control, and assessment criteria have been used as a guideline to direct the assessment of effects associated with each trigger for consent.

3.2 Relevant Standards and Guidelines

The following standard documents, guidelines and codes of practice were utilised in the stormwater design development process for the Project:

- AUP: OP – Particularly with regard to:
  - Chapter E1: Water Quality and Integrated Management
  - Chapter E3: Lakes, Rivers, Streams and Wetlands
  - Chapter E8: Stormwater – Discharge and Diversion
  - Chapter E9: Stormwater Quality – High Contaminant Generating Car Parks and High Use Roads
  - Chapter E10: Stormwater Management Area – Flow 1 and Flow 2 (**SMAF 1** and **SMAF 2**)
  - Chapter E26: Infrastructure
  - Chapter E36: Natural Hazards and Flooding
- Auckland Council Stormwater Bylaw 2015
- Auckland Stormwater Network Discharge Consent
- Region-Wide Network Discharge Consent and Associated Catchment Plans
- Auckland Council Code of Practice (**CoP**) for Land Development and Subdivision, Chapter 1- General Requirement and Procedures
- Auckland Council CoP for Land Development and Subdivision, Chapter 4 – Stormwater

- Auckland Council CoP for Land Development and Subdivision, Chapter 7 – Green Infrastructure
- AT CoP for Land Development and Subdivision, Chapter 3 – Transportation
- Transport Design Manual (**TDM**): Road Drainage and Surface Water Control
- Austroads: Guide to Road Design Part 5A: Drainage – Road Surface, Networks, Basins and Subsurface
- Technical Publication No. 108: Guidelines for Stormwater Runoff Modelling in the Auckland Region
- Stormwater Management Devices in the Auckland Region - Guideline Document 2017/001 (**GD01**)

4 Receiving Environment

4.1 Approach to Receiving Environment

A key objective of the Supporting Growth Programme is to protect land now to ensure that the transport networks required to support growth areas in the future, around Auckland, can be provided in an efficient and co-ordinated manner. This Project supports the development of housing in the immediate vicinity of Trig Road and has funding to be constructed in the near future.

In the context of an RMA assessment process, considering the environment as it exists today will not be a true reflection of the real-world environment in which the transport corridor will operate. Accordingly, when considering the environment within which the effects of the construction and operation of the transport corridor are likely to occur, this assessment considers both the existing environment and the likely future environment for the Project area.

Within the Project area there are a range of zones under the AUP: OP which influence the existing and likely future land use patterns for assessment purposes. The Whenuapai Structure Plan signals that the Future Urban zoned land adjacent to Trig Road is likely to contain new medium density and higher density housing. A large suburban park (between 3-5 hectares in size) is proposed on the Western side of Trig Road. Table 1 below provides a summary of the existing and likely future environment as it relates to the Project area.

Table 1: Existing and Future Environment Likelihood of Change

Project area	Environment today	Current Zoning	Likelihood of Change	Likely Future Environment
Context A	Rural	Future Urban	High	Urban
Context B	Urban – Low Density	Future Urban	High	Urban
Context C	Urban – Medium Density	Urban	Moderate	Urban
Context D	Urban	Urban	Moderate	Urban

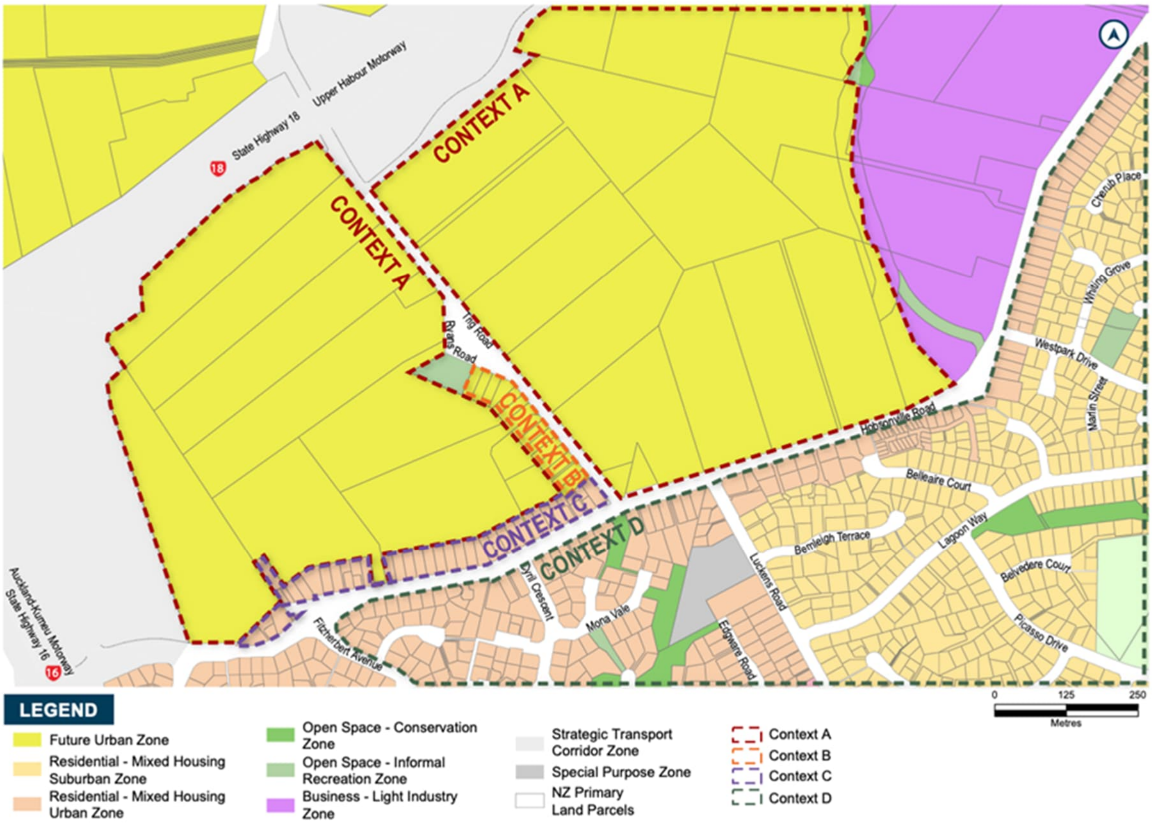


Figure 4: Existing / Future Zoning Scenarios

4.2 Existing Stormwater Management

The stormwater design for Trig Rd aimed at achieving the Healthy Waters Regionwide Network Discharge Consent (NDC) requirements for quality (treatment) and quantity (attenuation). Treatment and attenuation have been allowed for the full proposed road carriageway to meet the NDC requirements.

This section of the report will identify the existing stormwater environment of Trig Road and surrounds and identify:

- existing catchment receiving environments;
- existing stormwater management issues; and
- existing stormwater infrastructure.

4.2.1 Existing Ground Conditions

Soil classifications obtained from the New Zealand Geology Maps indicated two main soil groups in the Trig Road area. The two main soil groups are as follows (GNS Science, 2018):

- East Coast Bays Formation (Waitemata Group) forming in the steeper slopes. This group consists of a variation of interbedded, graded sandstone and siltstone, or mudstone and sandstone, as well as local intercalated volcanic grit.
- Puketoka Formation forming in the gentle slopes and low-lying areas. Undifferentiated alluvium can be found in gullies and within flood plains around streams.

These soils comprise of areas of both low permeability as well as pockets with high soakage potential.

4.2.2 Topography, Catchments, Drainage and Receiving Environments

The Whenuapai catchment topography has been identified as a predominately low-lying catchment, with mostly flat to rolling landscapes, with localised areas of steeper terrain mainly to the south. Figures 5 and 6 below indicate the contours, typical topographical flow paths and major receiving waterbodies for the Project area and its surrounding catchment areas with Trig Road highlighted in Figure 5 below.

Figure 5: Whenuapai Catchment Boundary

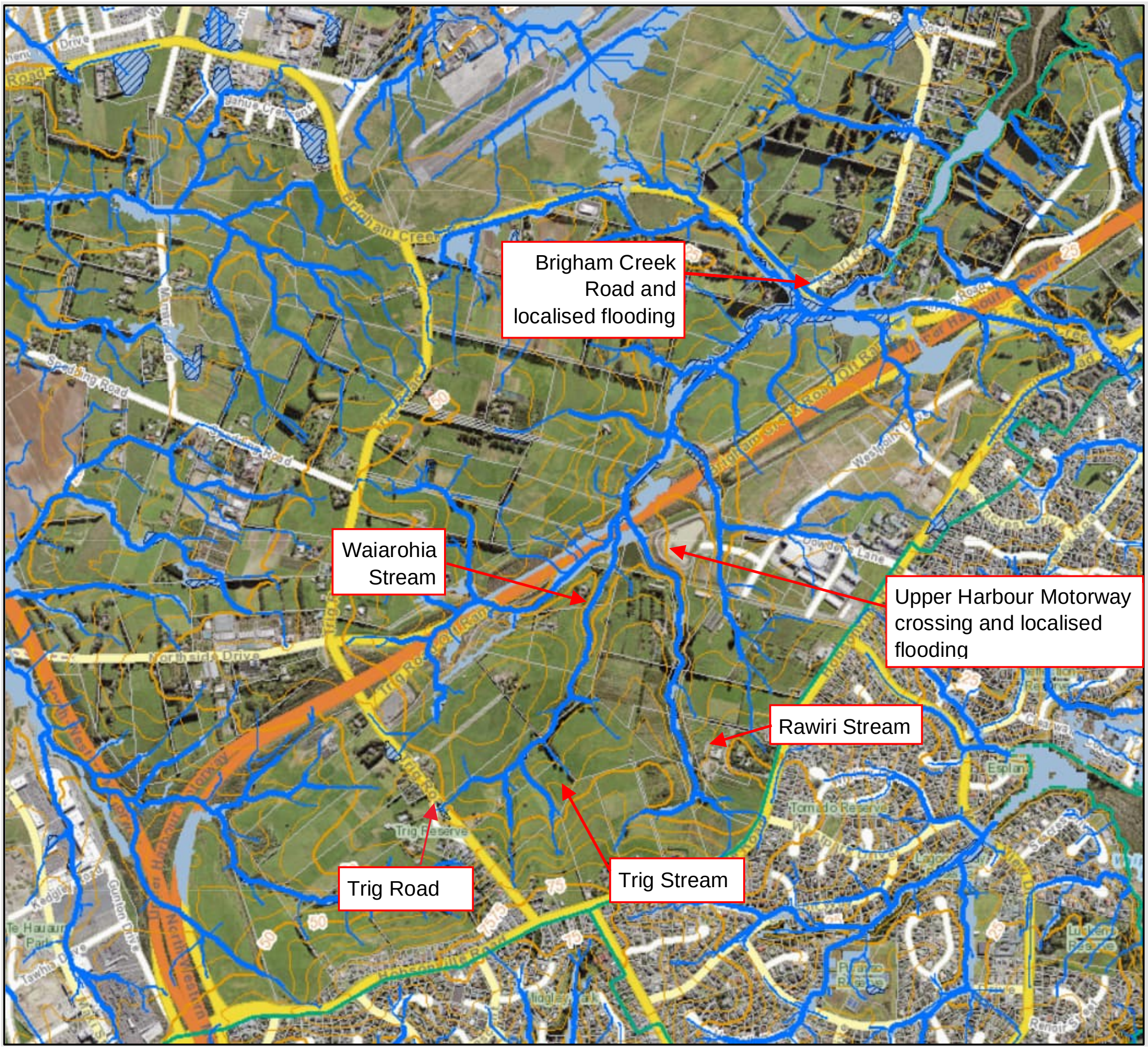


Figure 6: Trig Road surrounding overland flow paths, flood plains and receiving waterbodies

As depicted from the contours, the existing Trig Road alignment is predominately located on a ridge line with the surrounding catchment areas falling away from the road. Trig Road comprises of a steep fall from south-east to north west just off Hobsonville intersection (±8%) for ±300m, with the remaining road length towards the SH18 comprises flatter grades and localised low points.

The catchment area west of Trig Road has a general fall to the west, with two main sub-catchments draining into/forming into a head branch of Totara Creek, which subsequently drains to Brigham Creek.

The catchment area east of Trig Road (and those which form in smaller sub-catchments of localised low points along Trig Road) has a general fall to the east, with three main sub-catchments draining into/forming into head branches of predominately Trig Stream and Rawiri Stream, followed by Waiarohia Stream, all of which subsequently drain towards the Waiarohia Inlet.

Both Brigham Creek and Waiarohia Inlet discharge to the headwaters of the Waitemata Harbour.

A geotechnical study was carried out within the Project area and identified a highwater table and groundwater seepage at the south eastern branch head of Trig Stream (wetland), adjacent to Trig Road, with water encountered at ±800mm below ground level.

4.2.3 Stormwater Quality

The following summary of stream quality for the existing Waiarohia Catchment as shown in Table 2 below.

Table 2: Catchment Stream Quality

Stream Name	Condition	Water Quality	Biological Quality (Stream Ecological Valuation)	Native Fish
Waiarohia Stream	Modified with fine sediment loading Poor quality habitat	Low dissolved oxygen Elevated heavy metals	SEV Moderate	Observed
Trig Stream (wetland)	Slow flowing intermittent in places	Poor	SEV Moderate	No information

Detailed information on stream quality, health and ecological value can be found in the Assessment of Ecological Effects.

4.2.4 Existing Infrastructure

Trig Road drainage (as identified on Auckland Council GEOMAPS data) currently consists of minimal underground stormwater infrastructure, with drainage accommodation requirements limited to the road corridor runoff, localised low-lying catchment along the alignment and drainage from residential properties at the south-eastern end of Trig Road. Surrounding catchment areas currently drain away from the road corridor towards the streams identified above.

Stormwater runoff is collected by open channel drains parallel to Trig Road, diverted through culverts under Trig Road and subsequently discharged into Trig Stream (wetland) and Waiarohia Stream. A portion of underground stormwater network on the southernmost end of Trig Road (closest to Hobsonville Road intersection) discharges into the south eastern branch head of Trig Stream (wetland), where a high watertable has been identified.

Stormwater from the portions of Hobsonville Road included in the Project currently drains to the south via separate Ø225mm underground systems with eventual discharge into Waipateira Stream and Manutewha Stream. Figure 7 shows the existing stormwater layout.

4.2.5 Flooding Hazards and Existing Issues

Figure 7 below (as identified on Auckland Council GEOMAPS data) shows the predicted 1% AEP flood plain and flood prone areas. As depicted in Figure 7 there is generally a low risk for flooding within Trig Road and the surrounding catchments, with no significant identifiable hazard for future development within the surrounding areas.

AC flood prone areas are GIS created areas that allow for the low spot or depression area outlet to be blocked with the upstream flood prone area defined by the overtopping crest level of the surrounding ground.

Notably, there are two flood prone areas at the localised low points along Trig Road which are currently serviced to cater for the drainage requirements of the current land use. The existing drainage crossings will be upgraded as part of the Project, to better cater for these low-lying areas and mitigate any extended negative effects of flooding these areas might have on future urban development as a result of the road widening. This will still not remove the flood prone status but reduce the risk of flooding.

4.2.6 Stormwater Summary

The streams and coastal waters are of poor quality, degraded and sensitive to changes in land use and the consequential change to stormwater flows as a result of urbanisation. As such, according to the AUP: OP, stormwater treatment requirements and SMAF 1 has been applied to the precinct, and consideration for this control has been taken during the design process.

In summary, the following considerations for planning and development within the catchment are required:

Design Approach:

An integrated stormwater management/water sensitive design approach is essential for enabling the development of higher density greenfield sites. The integrated design approach is led by policies E1.3(8) – (10) of the AUP: OP. The integrated design should aim to mitigate or reduce the adverse effects (particularly in regard to increased flows and changes in water quality) of greenfield development on the receiving environment and where possible use the opportunity to enhance existing/degraded receiving environments.

Flood Hazards:

The approach for future development should be to ensure no new flood risks are created, and where possible use the opportunity to reduce the risk of existing flood prone areas through upgraded infrastructure and stormwater diversion.

Two dwellings at risk of flooding around Brigham Creek Road, along with a pump station within the flood plain were identified in previous studies and Geomaps. The stream passes through culverts under SH18 and then crosses Brigham Creek Road where the culverts are insufficient to pass the 100year event. Discussions with Healthy Waters have not yet confirmed whether or not 100year flow attenuation is required. At this stage, 100year attenuation is allowed for within the proposed dry pond to the east of Trig Road.

Stormwater Management Devices:

Various structural devices (i.e. provision of treatment, retention and detention devices, as well as outfalls or erosion mitigation measures) and non-structural management methods (i.e. stream protection/enhancement, retention/infiltration, application of SMAF principles etc.) can be used for an integrated/water sensitive design approach. A combination of the two should be considered for maximum efficiency, protection of the receiving environment and to allow for enhancement of current systems.

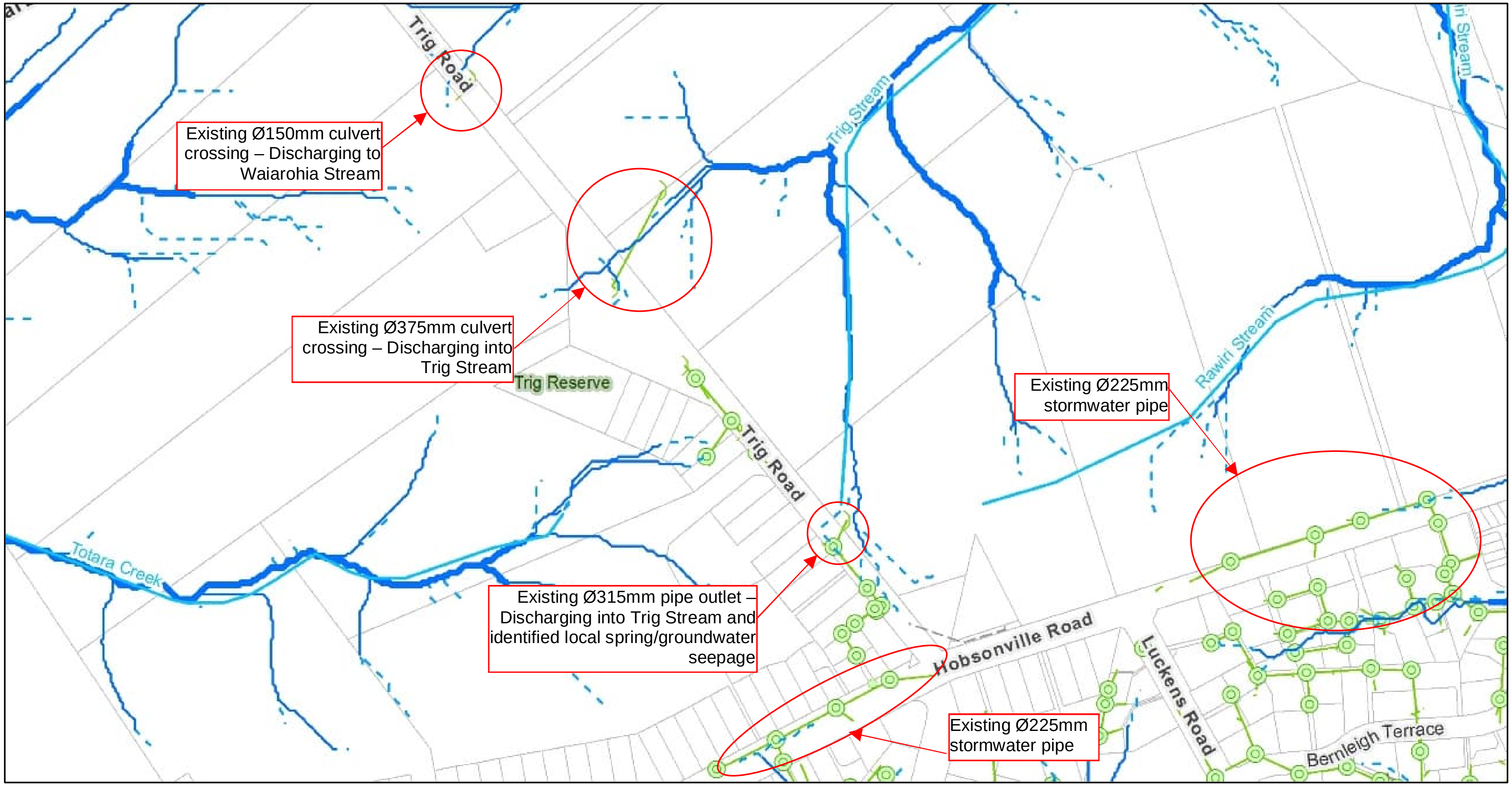


Figure 7: Existing Trig Road Corridor/Hobsonville Road Stormwater Infrastructure (AC – Geomaps 2022)

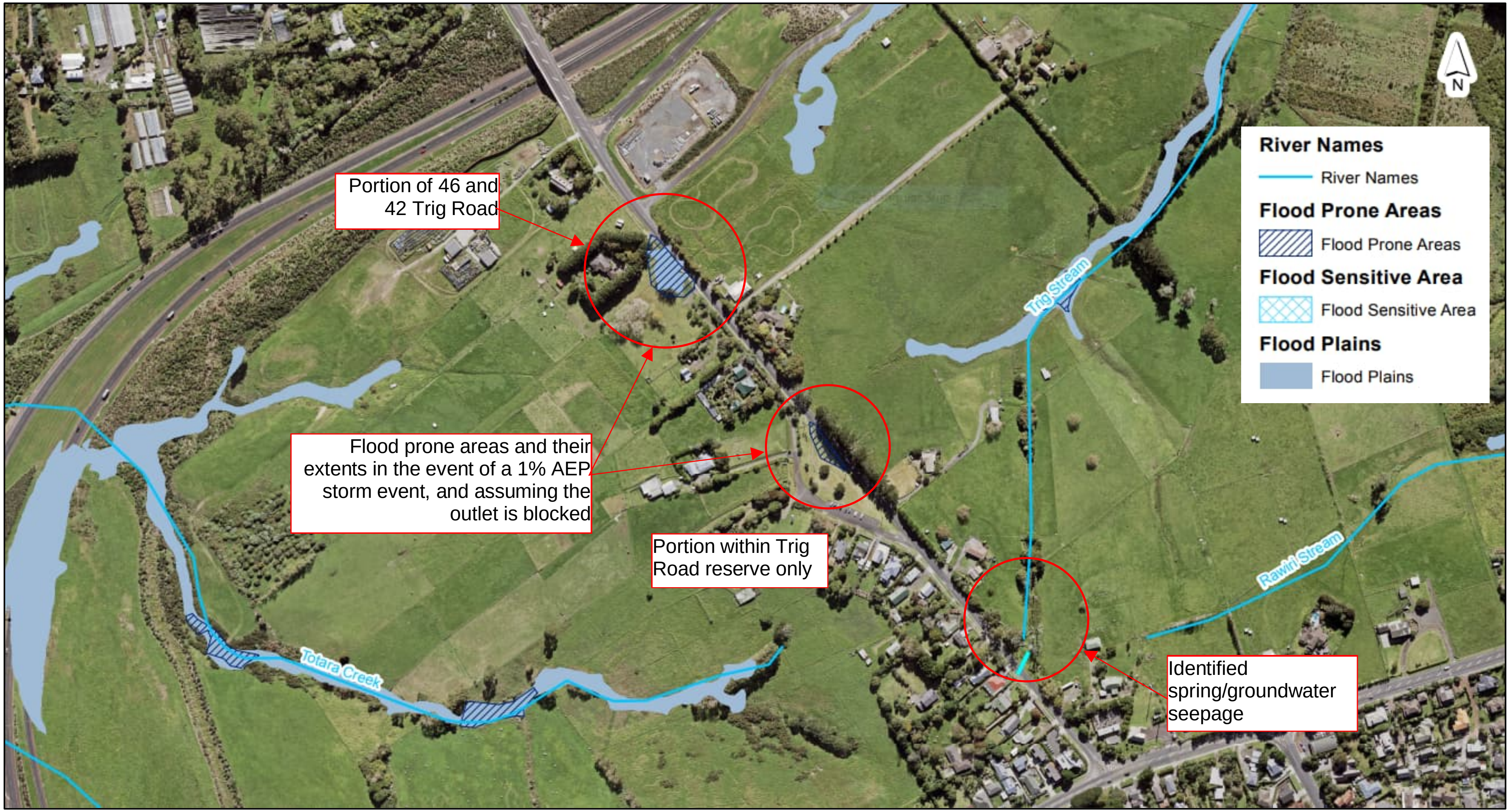


Figure 8: Existing flood plain and flood prone areas along Trig Road (AC – Geomaps 2022)

5 Methodology and Analysis

Chapter Summary

This chapter provides a description of the methodology/approach used in the assessment of the stormwater effects associated with the Project, the details of the design criteria/philosophy followed and the relevant statutory requirements, and the stormwater management methods evaluated under the regulatory guidelines.

In summary the methodology includes evaluation of existing standards and regulatory documents of the AUP: OP pertaining to stormwater and future development, assessment of existing conditions within the Project area, changes to arise through development in terms of impervious area change, subsequent increased runoff rates and water quality changes, followed by selection and design of methods and devices to mitigate the potential identified adverse effects thereof on the environment.

5.1 Assessment Methodology

The methodology used to assess the Project stormwater effects on the receiving environment can be summarised into the following key elements:

a. Evaluation of existing stormwater receiving environments
b. Evaluation of existing catchments and existing stormwater infrastructure
c. Calculation of existing runoff and changes to runoff due to redevelopment of the road corridor
d. Evaluation of water quality due to redevelopment
e. Selection and design of attenuation to mitigate increased discharge effects on the receiving environment
f. Selection of treatment devices to mitigate increase in contaminants entering the receiving environment
g. Design of appropriate primary stormwater system to convey runoff from redevelopment of road corridor
h. Identification of erosion and sediment control issues and determining the approach for mitigating the potential adverse effect thereof
i. Summarising the potential adverse effects to the receiving environment and the proposed mitigation methods of each.

Through the above methodology the stormwater effects of the corridor redevelopment are determined, and appropriate mitigation of these effects are recommended.

5.1.1 Design Software

HEC-HMS Version 4.9 was used for the hydrological modelling for sizing the proposed dry pond in accordance with Auckland Council's Technical Publication 108 (TP108): Guidelines for Stormwater Runoff Modelling in the Auckland and AC's Stormwater Design CoP.

5.2 Design Criteria

The design criteria below were used for the stormwater runoff modelling and management device design, with the objective of satisfying the controlled, restricted discretionary and discretionary standards for resource consent.

Diversion and Discharge:

- A Water Sensitive Design approach has been adopted and application of SMAF 1 requirements.
- Post-development design flows for sub-catchments upstream of culvert crossings have been modelled to accommodate for the Maximum Probable Development (**MPD**) for the zones being urban.
- Peak flow control for specific works is achieved with the utilisation of an on-site detention pond, to enable mitigation of adverse effects on streams and major overland flows during discharge.
- The primary stormwater system collecting runoff from Trig Road has been designed to cater for the 10% AEP rainfall event, and from bridges the 20% AEP rainfall event.
- The secondary stormwater system has been designed to cater for the 1% AEP. The primary system has been used to convey the 1% AEP rainfall event where 1% AEP is diverted away from the road low point towards the dry pond for attenuation.
- TDM: Road Drainage and Surface Water Control was utilised as a guide to risk assessment for a system blockage of 50%.
- Energy dissipation/erosion control measures have been incorporated at pipe outfalls to mitigate scouring and erosion of receiving streams.
- Climate change of 2.1° temperature increase has been accommodated in all calculations.
- Stormwater devices incorporate a flow bypass to prevent overloading during larger storm events, whilst allowing for continued operation and maintenance.
- All stormwater infrastructure has been designed according to the standard requirements as per Auckland Council CoP, AT CoP, TDM: Road Drainage and Surface Water Control, and Austroads: Guide to Road Design Part 5A: Drainage.

Stormwater Quality:

- Stormwater treatment has been incorporated into the stormwater system at the source to cater for the increased runoff contaminants, mitigating the adverse effects to the receiving environment.
- GD01 has been used as the priority for the design and selection of stormwater devices for Trig Road. It provides guides to stormwater choice and design specific to the requirements of the AUP: OP.

Flooding Hazards:

With reference to the General Standards (E8.6.1) for compliance of stormwater diversion and discharge as highlighted in E8 of the AUP:OP (Stormwater – Discharge and Diversion), as well as that Trig Road is in the uppermost reaches of a mainly greenfield receiving environment, and the current zoning plan indicates higher density housing developments proposed for areas surrounding the receiving Trig Stream (wetland) and its associated flood plain, the following criteria have been accounted for in the design and assessment:

- No new/additional habitable floor areas are affected by flooding in the 1% AEP storm event
- No adverse effects on operation and structural integrity of infrastructure in the 1% AEP storm event
- No increase in inundation affecting upstream or downstream properties in the 1% AEP storm event

5.3 Stormwater Management Methods/Infrastructure

Stormwater management device selection and sizing was evaluated in terms of the guidelines laid out in Auckland Council Guidance Document 01 (GD01). A Water Sensitive Design approach has been applied as well as the SMAF 1 requirements. While the Project area is not shown in the AUP: OP as being subject to the SMAF 1 overlay SMAF 1 was adopted for the purposes of this assessment.

Device selection was based on the evaluation of the suggested considerations and devices within GD01 and the characteristic and constraints related to Trig Road.

For higher mitigation within greenfield developments as applicable to the Project area, GD01 suggests the following aspects to be considered (in the order of preference):

- Retention (infiltration) and detention
- Retention (water reuse) and detention
- Detention only

The GD01 suggested devices for retention and detention to satisfy SMAF 1 requirements (with the aim of protection of streams and recharge ground water) are as follows:

- Rainwater tanks (with reuse)
- Bioretention devices (unlined)
- Living roofs
- Pervious paving (unlined)
- Infiltration devices
- Wetlands
- Ponds (dry and wet)

Evaluation of the suggested retention devices against the nature of the Project:

- Rainwater tanks (with reuse) will be uneconomical and are not considered an effective stormwater management tool for the Project.
- Living roofs are not relevant for transport projects.
- Pervious pavement will not comply with the pavement and structural requirements of the Project as it is not suitable for traffic areas of high acceleration, decelerating or turning.
- Swales are not suitable due to the steep road grades, and lack of space due to adjacent residential driveways and future local roads expected off Trig Road.
- Due to potential low permeability of soils around Trig Road as mentioned in section 4.2.1, as well as the large fill embankments expected along the redeveloped corridor, sufficient infiltration rates through unlined devices may not be achievable and could, conceptually, pose stability risks along the embankments due to lateral seepage. The suitability of bioretention devices for achieving SMAF 1 retention requirements will be subject to further geotechnical study at detailed design stage, once these risks have been assessed.
- Permanent waterbodies pose the risk of bird strike within the airspace for Whenuapai Airbase, and as such, stormwater management devices (attenuation ponds) should be designed to optimise full drain down (i.e. dry for the majority of the time). In order to satisfy this requirement an unplanted dry pond has been selected as the most appropriate post-development runoff attenuation method to mitigate the adverse effects on the additional peak

flows on the receiving streams. A dry pond however does not meet the retention or water quality treatment requirements of the AUP: OP and will therefore need to be supplemented with additional stormwater treatment.
- Raingardens for water treatment will be suitable for the majority of Trig Road with appropriate utilisable space and depth available within the proposed berm area on both sides of Trig Road (for varying portions) and within the undeveloped road reserve area west of the carriageway. No berm space is available within the Hobsonville Road portion of the development (east or west), as such, space outside the proposed corridor is considered for treatment devices, as well as redirecting of stormwater into Trig Road for treatment. Limitations and design considerations to accommodate for specific catchment conditions will be detailed in section 6 below. SMAF 1 retention could be incorporated into the raingardens but the suitability thereof would be subject to further geotechnical investigation as described above.
- The use of proprietary devices for treatment/detention/retention is a less economical approach for the Project, with likely increased maintenance costs and frequency, and is therefore not considered.

Selected stormwater management methods based on the above evaluation:

- Dry pond for attenuation for flood mitigation.
- Detention for SMAF 1 will be incorporated into the dry pond attenuation volume.
- Due to suitability of retention through infiltration being subject to further geotechnical investigation at detailed design stage, the 5mm runoff depth will be incorporated into the detention volume for the purpose of this assessment.
- Raingardens for water treatment.

6 Assessment of Stormwater Effects

Chapter Summary

This chapter details the physical changes to stormwater generation over the site as a result of redevelopment of Trig Road as well as the MPD expected to occur as a result of future zoning. Expected post-development impervious areas are calculated, compared with the existing conditions, and used to compute changes to the water quality flows and runoff conditions, and the level of effects on existing stormwater infrastructure and the receiving environment.

In summary of the assessment, flood modelling of upstream catchments for existing and future MPD land use indicate insufficient capacity in the existing crossings and subsequently redevelopment and upgrading of these pipe crossings will enhance current drainage as well as catering for future drainage. The extent of works and changes to the Trig Road and Hobsonville Road cross section result in a combined increase in impervious area of 45.5% and impervious area equating to >50% of the total site which dictates the method for runoff volume calculations as per the GD01.

6.1 Design Parameters

The Whenuapai rainfall depths utilised in the stormwater runoff modelling and stormwater infrastructure design were referenced from the Auckland Council Technical Publication 108: Guidelines for Stormwater Runoff Modelling in the Auckland Region (**TP108)**.

As per the Auckland Council Stormwater CoP (2015), climate change is expected to alter the frequency and intensity of significant rainfall events, and as such rainfall depth are adjusted accordingly to cater for a 2.1^{o} future temperature increase. Table 3 below depicts the selected rainfall depths and the applied climate factors:

Table 3: 24hour rainfall depths and the applied climate change factors

ARI (years)	AEP (%)	TP108 24hr Rainfall Depth (mm)	Climate Change Increase (%)	Adjusted 24hr Rainfall Depth (mm)
10year	10%	135	13.2%	153
50year	2%	180	16.8%	210
100year	1%	200	16.8%	234

Runoff volumes were calculated based on the adjusted 24hr rainfall depths in accordance with Auckland Council Technical Publication 108: Guidelines for Stormwater Runoff Modelling in the Auckland Region (**TP108**).

6.2 Changes to Catchment Runoff

6.2.1 Surrounding Catchments

A flood modelling study was completed as part of this Project for the surrounding catchments adjacent to Trig Road. The assessment evaluated existing development flows and the post-development flows considering the MPD including climate changes. Table 4 below indicates the maximum impervious areas utilised for the post-development runoff, with reference to the possible future zoning (signalled in the Whenuapai Structure Plan) around Trig Road, as discussed in section 4.1.

Table 4: Maximum Impervious Area for Trig Road surrounding catchments

Development Type/Zone	Maximum Impervious Area (as a % of site)
Residential – Terrace Housing and Apartment Building Zone	70
Residential – Mixed Housing Urban Zone	60
Open Space – Informal Recreation Zone	10

As discussed in section 4.2.4 and shown in Figure 7, there are two existing culverts crossings and one pipe outlet which was used in the assessment for the 1% AEP (100 Year ARI) rainfall event. The culverts convey runoff from upstream catchments, under Trig Road, and discharge into the overland flow paths east of Trig Road. The pipe outlet discharges the stormwater conveyed in the existing underground pipe network. The upstream catchments areas are indicated in Figure 9 (pre-development) and Figure 10 (post-development) below. The flood modelling results for the existing development indicated that the existing culverts are of insufficient size to cater for even pre-development flows, which is a probable cause for the flooding potential as highlighted in Figure 8. Using high level LIDAR information and invert levels derived from Auckland Council GEOMAPS, it was also determined that there is currently insufficient cover over the culverts.

The flood modelling for post-development (MPD impervious surfaces) concluded that there will be a minor increase in the 1% AEP flow rates, and appropriately sized pipes have been designed to cater for these flows. It should be noted that the existing cross section of Trig Road is cambered with half the road draining to swales and catering to the pipe crossing flows, whereas the upgraded corridor will drain to a new primary system and flows will not form part of the pipe flows, thus the catchment areas have been slightly reduced.

Table 5 below indicates the pre and post-development flows for each pipe and the existing and proposed pipe sizes. Upgrading of these pipes during the upgrade of Trig Road will essentially reduce the risk of flooding the flood prone areas. Due to the existing steep grades, there are currently higher than desirable velocities at the outfalls. Appropriately designed energy dissipation with the use of riprap and baffles is proposed and will mitigate downstream erosion and scouring, which will be further discussed in Chapter 7.

Table 5: Culvert Size Upgrades

	Pre 1% AEP Flow Rate (m^3/s)	Existing Pipe Size	Post 1% AEP Flow Rate (m^3/s)	Existing Pipe Grade (%)	Proposed Pipe Size
Pipe 1	0.242	1 x Ø150mm	0.375	2.5	1 x Ø525mm
Pipe 2	0.433	1 x Ø375mm	0.691	7.65	1 x Ø600mm
Pipe 3	0.122	1 x Ø315mm	0.118	17	1 x Ø300mm

Figure 9: Pre-development catchments for culvert/pipe flows

Figure 10: Post-development catchments for culvert/pipe flows

6.2.2 Road Corridor Catchments

The Project cross-section indicates an increase to the impervious areas within the corridor (applicable to Trig Road and the upgrades on Hobsonville Road). Through catchment delineation based on topographical information and the proposed vertical alignment of the roads, four major drainage catchments and their drainage low points were identified for calculation of post-development runoff and comparison to pre-development runoff.

Figure 11 shows the post-development catchments, and Table 6 below provides an overview of the catchment extents, catchment sizes and description of discharge location.

Table 6: Catchment Overview

Catchment Description	Total Area (m^2)	Discharge Location
Catchment 1: Hobsonville Road (West)	1,764	Tie into existing underground stormwater network
Catchment 2.A: Hobsonville Road (East)	3,383	Piped stormwater runoff diverted into raingarden/detention pond for treatment and attenuation north of Hobsonville Road, prior to discharge into Rawiri Stream overland flow path
Catchment 2.B: Hobsonville Road (East)	2,013	Tie into existing underground stormwater network
Catchment 3: Portion of Hobsonville Road Trig Road (South)	15,596	Portion of Hobsonville Road's (west) piped stormwater runoff to be diverted into Trig Road underground stormwater network. Underground stormwater network to discharge into raingarden at low point west of Trig Road (unless treated within berm raingarden) and into Dry-Pond east of Trig Road for attenuation, prior to discharge into a tributary to Trig Stream
Catchment 4: Trig Road (North) *(Minor works beyond SH18 bridge to be handled as discussed at the end of section 6.2)*	8,489	Piped stormwater runoff, post treatment by raingardens within the berm, diverted to Catchment 3 low point for discharge into Dry-Pond for attenuation, prior to discharge into a tributary to Trig Stream

Based on the intended scope of physical works depicted in the Project cross-section, changes to impervious area have been calculated based on the increased width of corridor, inclusion of footpaths, cycleways, medians and vehicle stacking lanes. Table 7 below provides an overview of the increase in impervious area for each catchment, used in the calculations for pre- and post-development runoff.

Table 7: Changes to Impervious Area

	Catchment Area (m^2)	Pre-Development			Post-Development		
		Pervious (m^2)	Impervious (m^2)	% Imperviousness	Pervious (m^2)	Impervious (m^2)	% Imperviousness
Catchment 1: Hobson-ville Road (West)	1,764	756	1,008	57%	378	1,386	79%
Catchment (2.A):	3,385	2,290	3,105	58%	258	3,125	92%
(2.B):	2,010				110	1,902	95%
Catchment 3: Trig Road (South)	15,596	8,436	7,160	40%	4,806	10,790	65%
Catchment 4: Trig Road (North)	8,490	5,070	3,420	40%	3,010	5,480	65%
Total	31,245	16,550	14,695	47%	8,564	22,680	73%

The total redeveloped site area equates to 31,245m², with the percent of imperviousness increase from 47% in pre-development condition to 73% in post-development condition. The 22,680m² post-development impervious area equates to >50% of the total catchment area and dictates the method for runoff volume calculations as per the GD01.

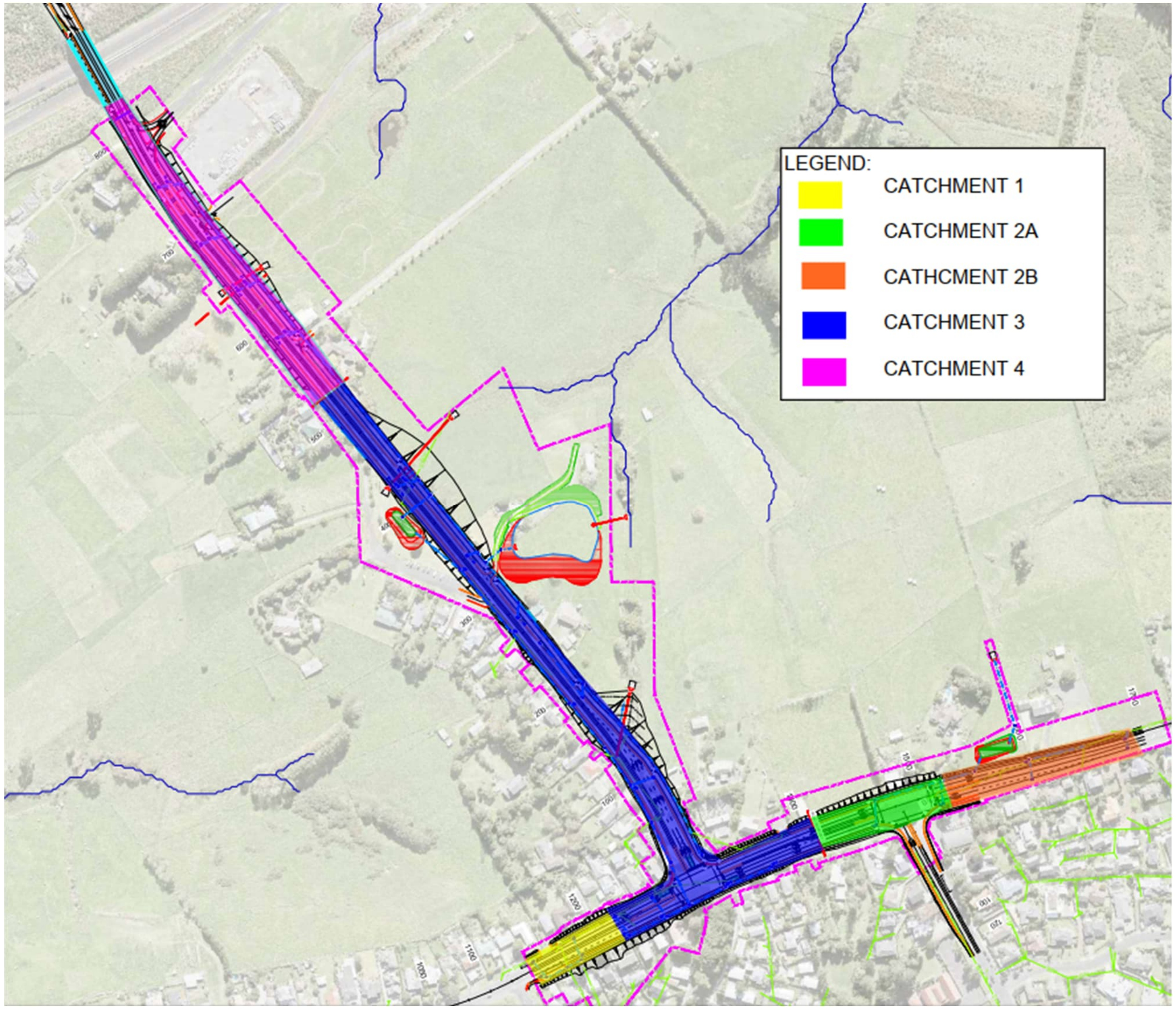


Figure 11: Post-development catchment plan

Pre and post-development runoff has been calculated based on the above pervious and impervious areas, as well as based on proposed discharge locations and areas where flows have been diverted to join other catchments. Volumes are calculated in accordance with TP108. Table 8 provides an overview of the pre- and post-development peak flow rates and runoff volumes for the 1% and 10% AEP storms, 95th percentile storm for stream protection, and water quality volumes for each catchment.

Based on the identified soil description in section 4.2.1 and the TP108 Hydrological Soil Classification, a Group C SCS Soil Group was selected for pre-development runoff modelling purposes. Whenuapai is located in a pasture area with good grass cover, and thus the curve number selected for typical Auckland conditions is 74 (Table 3.3-TP108).

Table 8: Pre and Post Development Runoff Data

	Pre-Development		Post-Development		Post less Pre-Development	
	Peak Flow Rate (m^3/s)	Runoff Volume (m^3)	Peak Flow Rate (m^3/s)	Runoff Volume (m^3)	Peak Flow Rate (m^3/s)	Runoff Volume (m^3)
Catchment 2A (Hobsonville Road east)						
WQV	0.008	45	0.011	65	0.003	20
SP (95th)	0.012	70	0.016	97	0.004	27
10% AEP	0.071	417	0.079	483	0.008	66
2% AEP	0.101	601	0.110	678	0.009	77
1% AEP	0.114	677	0.123	752	0.009	75
Catchment 3 (Trig Road South)						
WQV	0.03	178	0.04	239	0.01	61
SP (95th)	0.047	280	0.061	363	0.014	83
10% AEP	0.311	1824	0.339	2025	0.028	201
2% AEP	0.453	2658	0.481	2901	0.028	243
1% AEP	0.512	3004	0.539	3236	0.027	232
Catchment 4 (Trig Road North)						
WQV	0.015	89	0.021	124	0.006	35
SP (95th)	0.024	141	0.032	188	0.008	47
10% AEP	0.166	966	0.181	1080	0.015	114
2% AEP	0.243	1418	0.258	1554	0.015	136
1% AEP	0.275	1605	0.290	1735	0.015	130

Catchments 1 and 2B (which is tying into existing stormwater systems to the south of Hobsonville Road) have been excluded from Table 8 as the resultant post-development impervious and pervious catchment areas draining into the existing system are significantly less than the predevelopment areas.

As indicated on Preliminary Layout 1 of the attached stormwater drawings in Appendix 2, minor works and amendments to Trig Road continue along SH18 bridge and approximately 210m north of the bridge. These changes include realignment of lanes and road markings within the area of the existing bridge resulting in no change to existing impervious area. The works also involves reconfiguring an existing footpath to incorporate an adjacent cycle path on the western road edge, and an additional stretch of cycle/foot path adjacent the eastern road edge.

The existing road alignment, lanes and kerb and channel configuration will remain predominantly the same, with the addition of ±430m² of impervious area change as a result of the addition of cycle paths. Cycle/foot paths are not considered a high contaminant generating activity and therefore do not contribute adversely to runoff quality nor require treatment.

Runoff from SH18 bridge and the ±210m length of corridor north of the bridge beyond does not contribute towards catchment 4 as above, and the existing drainage (contained within kerbs, discharge into roadside swales) can remain unchanged. Additional runoff volumes generated by the impervious cycle/foot paths are minor and can be discharged into the road and existing system without adverse effects.

6.3 Runoff Quality

As per E9 of the AUP: OP: Stormwater Quality – High Contaminant Generating Activity, stormwater runoff from Trig Road is required to be treated by stormwater management devices, in accordance with GD01 or similarly approved methods.

The Water Quality Volume is typically designed as a function of the “first flush”, with the concept that the initial runoff from a surface during a flood event will contain the highest level of contaminant when compared to later periods of the storm. This provides the most practical and cost-effective approach for treatment, focusing on treatment device design for the high-level contaminants flows, as opposed to treating the entire storm event volume of diluted/low contaminants. As per GD01 the following parameters are utilised as a function of the Water Quality Volume/Flow calculations:

Water Quality Volume (WQV):	90th Percentile of the 24-hour storm event (±25mm)
Water Quality Flow:	10mm/hr
Water Quality Management:	Design performance based
Water Quality Target Areas:	High Contaminant Generating Car Parks and Roads

The rational method was used in the determination of the peak discharge for a 10mm/hr constant rainfall intensity (equivalent to ±90% of the annual rainfall), and for sizing of the water quality device. Table 9 below indicates the calculated water quality flow per catchment for contaminant treatment and device selection.

Table 9: Water Quality Characteristics per Catchment

	Catchment 2A	Catchment 3	Catchment 4
High use road area only	2160m²	6720m²	2400m²
WQV	45	139	50
Water Quality Flow (m^3/s)	0.0057	0.0165	0.0063

7 Mitigation

Chapter Summary

This chapter provides solutions to mitigating the potential effects induced by the changes to the stormwater conditions, such as stormwater attenuation for peak flow control prior to discharging into the receiving Trig Stream (wetland), stormwater treatment to mitigate the effects of increased contaminants entering the receiving environment and primary stormwater system pipe requirements for conveyance of the new stormwater flows.

In summary of solutions, a dry pond was selected in order to satisfy the design constraints relating to potential bird strike at the nearby Whenuapai Airbase and peak flow control, catering for detention up to 1% AEP rainfall and subsequently mitigating downstream flood potential. Raingardens were selected as an effective means for stormwater treatment within the Project area considering road geometry, available space within the corridor and a water sensitive design approach. Stormwater runoff will be contained within the road reserve, collected in standard catchpits or dropped kerb inlets into raingardens, before being conveyed within an underground pipe system for discharge into the dry pond. There is allowance for overland escape during larger storms at low points along Trig Road.

7.1 Attenuation

Two buildings within the catchment have been identified in previous studies as being susceptible to habitable floor flooding during a 1% AEP rainfall event, located in the vicinity of Brigham Creek Road near Waiarohia Stream into which Trig Stream (wetland) feeds. It also highlights the reduction of stormwater runoff from increased impervious areas, by retention and detention as essential to minimising further erosion to the Waiarohia Stream and its tributaries.

To mitigate the contribution to additional downstream flooding of properties at Brigham Creek Road, as well as for protection of the existing Waiarohia stream, stormwater runoff from the redeveloped Trig Road up to the 1% AEP rainfall event will be attenuated. Due to the infiltration constraints described in section 5.3 and only water quality treatment being provided for in the raingardens, retention and detention of the 95th percentile storm (for stream protection) will be incorporated into the dry pond for attenuation.

As mentioned previously, in accordance with the stormwater pond design restrictions relate to potential bird strike at the Whenuapai airfield. Consequently, a dry pond has been selected for attenuation of additional post-development peak flows and meeting the water sensitive design requirements. The minimum design requirements for the dry pond reduces the attractiveness of the area to birds thus mitigating against the risk of bird strike. The minimum design requirements are as follows:

- fully drain down within 48 hours of a 2% AEP storm event; and
- have side slopes at least as steep as 4 vertical to 1 horizontal (4:1) except for:
    - any side slope treated with rock armouring; or
    - any area required for vehicle access, provided that such vehicle access has a gradient of at least 1 vertical to 8 horizontal (1:8)

To satisfy the requirements to minimise bird roosting and mitigate bird strike risk, the pond has been sized to meet the full drawdown requirements. The pond base will also be shaped and graded to fall from the inlet through to intake manhole outlet. This will facilitate in concentrating frequent storm low flows towards the outlet, preventing runoff spread and subsequent frequent wetting of the full pond base which is likely to encourage unwanted plant growth.

The pond has been designed with 1V:5H internal side slopes for maintenance purposes and to allow for mowing of grass. The steep 4V:1H slopes suggested are not practical for the Project environment and would require retaining walls/reinforced earth in order to construct, presenting a considerable cost increase over the engineered earthworks embankment of a 1V:5H slope. With the overall objective of the specific design requirements aiming to minimise bird roosting, the adopted design achieves this through easily maintainable, unplanted grass slopes and the concentrating of frequent storm low flows to ensure a drier pond base to minimise natural plant growth and bird attraction.

The dry pond was designed using HEC-HMS Version 4.9. Please refer to Appendix 3 for details of HEC-HMS model. The HEC-HMS model may be refined at detailed design stage.

The storage volume includes catchments 3 and 4 into the sizing, catering for a total peak storage volume for the post development less pre-development 1% AEP rainfall event, with a discharge allowance at the outfall to match pre-development peak flows into the existing Trig Stream (wetland) overland flow path. The treated water quality flows from all the raingardens in catchment 4 will be discharged into the overland flow path at the low point of catchment 4, and thus only overflows from the raingardens will be directed to the dry pond. Only catchment 3's existing pre-development peak flow was used as the discharge requirement from the dry pond given that catchment 4's overflow runoff from the raingardens will be redirected from its original overland flow path towards the dry pond for attenuation. That is, flows from both catchment 3 and 4 will be directed to the dry pond with the allowable peak outflow rate set at the catchment 3 pre-development peak outflow rate. Table 10 below provides summary of dry pond design, including the pond post-development peak inflow volumes, allowable peak discharge rates, post-development peak discharge rates, inflow volume and peak storage volumes for the 95th Percentile, 10%, 2% and 1% AEP design rainfall events.

Table 10: Dry pond design summary

	95th Percentile (SP)	10% AEP	2% AEP	1% AEP	Remarks
Post-Development Peak Inflow (m^3/s)	0.092	0.52	0.74	0.83	
Allowable Peak Discharge (m^3/s)	0.047	0.31	0.453	0.51	See Note 1
Post-Development Peak Discharge (m^3/s)	0.013	0.16	0.26	0.29	See Note 2
Post-Development Inflow Volume (m^3)	551	3105	4455	4971	
Post-Development Peak Storage (m^3)	276	1259	1654	1807	
Pond Emptying Duration (Hr:min)	27hr:30min	38hr:10	40hr:10min	40hr:20min	See Note 3

Notes:

1. Allowable peak discharge rate is set at the catchment 3 pre-development peak outflow rate.

2. The post-development peak discharge rate is less than the allowable peak discharge rates.
3. Pond emptying duration is the duration to fully drain down the dry pond from the start of the storm event. The dry pond meets the design criteria that it can be fully drained down within 48 hours of a 2% AEP storm event. Please refer to Appendix 3 for more details on dry pond flow charts.

The dry pond has been designed using HEC-HMS model with following parameters and key design elements:

Dimensions:

- Total catchment: 24,085m³
- Total peak storage volume for 1% AEP: ±1,807m³
- Total peak storage water depth: 0.91m
  Side slopes: 1V:5H
- Total pond depth: 1.8m (including freeboard)
- Selected freeboard: 300mm

Inlet Pipe into Dry Pond (from primary system):

- Post developed Flow (100year ARI): 0.83m³/s (100yr post-dev.)
- Selected slope: 0.5%
- 750mm Dia. RCRRJ. with an appropriate wingwall outfall structure complete with baffle blocks, safety grate and downstream riprap protection

Outlet Pipe from Dry Pond (Into Trig Stream (wetland)):

- Allowable discharge flow (100year ARI): 0.51m³/s (100yr pre-dev.)
- Selected slope: 2%
- 600mm Dia. RCRRJ. with an appropriate wingwall outfall structure complete with baffle blocks, safety grate and downstream riprap protection

The dry pond will include a scruffy dome type intake tower/manhole with throttled discharge from the dry pond to match outflows to the 95th percentile (SP), 10% AEP and 1% AEP pre-development flows discharging into a tributary of Trig Stream. The primary stormwater system (discussed in section 7.3) collecting catchment 3 and 4 road drainage has been designed for discharge into the dry pond.

The dry pond will be located at 7 Trig Road, which is approximately 90m south of the lowest point of Trig-Road, between chainage 280 to 340, to ensure total catchment drainage into the pond mitigating upstream flooding potential, as well as allowing for an overland flow bypass from Trig Road to the attenuation pond during storms greater than that which can be contained within the road reserve, minimising flood risk within the road and accompanying vehicle hazard and damage to infrastructure. The dry pond will be discharged into the tributary to Trig Stream, as indicated in Figure 12 below.

Due to lack of available capacity within the stormwater network south of Hobsonville Road, Catchment 2A will discharge north of Hobsonville Road into the Rawiri overland flow path. Attenuation prior to discharge will be allowed for with the storage volume catered for within the proposed raingarden area. This will be discussed in section 7.2 below.

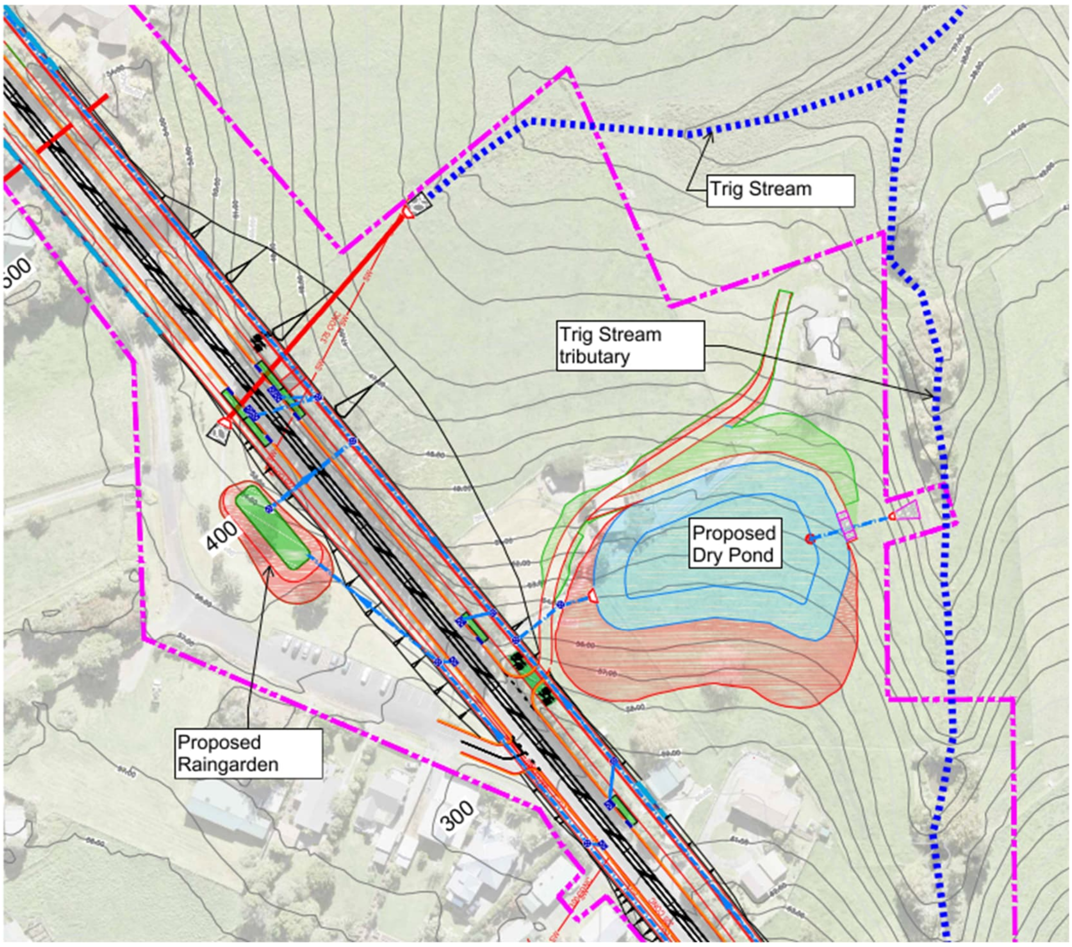


Figure 12: Dry Pond location

7.2 Stormwater Treatment

From guidelines followed in GD01, raingardens were selected as the primary treatment device throughout the Project. Due to topographical, road vertical alignment and space limitations on site, various raingarden configurations were utilised to suit.

7.2.1 Design parameters

As per GD01, the following methodology was used in sizing the raingarden footprint for treatment:

- WQF of 10mm/hr was determined based on the high use road impervious area, as indicated in Table 9, section 6.3.
- Treatment footprint area was determined by the following equation:

$$A = \frac{WQF}{(0.5 \times K(media))}$$

based on the WQF of 10mm/hr passing through a specialised filter media with a standard depth of 500mm and an infiltration rate of max. 1m/hr;

where A - Area of bioretention media bed

WQF	- Water Quality Flow (m^3/hr)
$K_{(media)}$	- Infiltration rate of bioretention media (m/hr)
Safety factor for clogging	- 0.5

- Calculated footprint area was compared with the minimum footprint of 2% of total impervious catchment suggested for raingardens to operate efficiently in terms of maintenance requirements, to ensure sufficient sizing.

Table 11 below indicates the calculated footprint for each catchment using the equation above against the minimum required footprint of 2% of total impervious catchment. For all catchments, the calculated footprint was below the recommended value, therefore the 2% sizing was utilised. If confirmed through geotechnical study that both retention and detention is suitable for incorporation into the raingardens, a minimum footprint of 5% of total impervious catchment would be expected as indicated in the table.

Table 11: Raingarden Sizing per Catchment

	Calculated Treatment Footprint	Min. 2% of Total Impervious Catchment (Treatment Only)	Min. 5% of Total Impervious Catchment (Treatment, Retention and Detention)
C (2A)	43m²	63m²	156m²
C (3)	138m²	216m²	540m²
C (4)	59m²	110m²	274m²

7.2.2 Raingarden configurations

Catchments 2A, 3 and 4 will require treatment prior to discharging into the receiving environment. Each catchment presented various constraints/limitations for sizing and location selection for raingardens, as described in Table 12 below. Refer to the stormwater layouts in Appendix 2 for size and locations described in this section. Required footprint is derived from Table 11 above.

Table 12: Catchment Design Constraints

	Design constraints	Design solution	Raingarden sizing
C (2.A)	• Corridor design width constraints resulted in either small berms or no available berm space either side of carriageway to cater for required raingarden footprint requirements • Catchment area requires attenuation prior to discharge into receiving Rawiri stream overland flow path	• One larger raingarden will be located northeast of the catchment and will allow for a deeper ponding depth to cater for attenuation prior to discharging into the overland flow path	<u>Required footprint = 63m²</u> Design size to accommodate for treatment and 100 Year ARI attenuation (peak storage of 71m³) = 248m² Pond base 1:4 Internal slopes 1:3 External slopes 0.6m Deep
C (3)	• More than 50% of Catchment 3's vertical	• A series of stepped raingardens will be used along the steeper	<u>Required footprint = 216 m²</u>

	alignment is >4% and up to 8%, which does not allow for sufficient infiltration time across raingardens thus ineffective in providing treatment at grade • Residential properties are located on the southwestern side of Trig Road with direct driveway access, therefore berm length along this side of road will be too short and impractical for raingardens. Stormwater will be piped and require treatment further downstream at depth • Hobsonville Road has insufficient berm space for treatment requirements. Stormwater drains into Trig Road via an underground system and will require treatment further downstream at depth where pipe can daylight.	grade of the south eastern road edge • A larger raingarden will be located at the low point of catchment 3 in the available space west of Trig Road, and will cater for piped stormwater runoff from the portion of Hobsonville Road and from the southwestern side carriageway • Raingardens can be utilised both sides of the carriageway for the northern side of catchment 3	*Hobsonville Road portion (to larger raingarden) = 82m^2* *Trig Road South portion = 134m^2* • Minimum raingarden area each side of road = 134/2 = 67m^2 • Raingarden area per inlet (6 inlets per road side) 67/6 = 11m^2 • Selected raingarden size in berm: 6m long x 2m wide = 12m^2 or 12m long x 1m wide = 12m^2 <u>Proposed raingarden footprint</u> • Eastern road edge: o (5 raingarden inlets) = 12 x 5 = 60m^2 • Western road edge: o (2 raingarden inlets) = 12 x 2 = 24m^2 • Larger raingarden on west side: o (1 inlet from east side + 4 inlet from west side) = 12 x 5 = 60m^2 o Hobsonville Road raingarden requirement = 82m^2 o Minimum area of larger raingarden = 60+82= 142m^2 Total proposed raingarden footprint =60+24+142 = 226m^2
C (4)	• No significant design constraints	• Raingardens can be utilised both sides of the carriageway	<u>Footprint required= 110m^2</u> • Minimum raingarden area each side of road = 110/2 = 55m^2 • Raingarden area per inlet (5 inlets per road side) = 55/5 = 11m^2 • Selected raingarden size in berm: • 6m long x 2m wide = 12m^2

Dropped kerb inlets to raingardens will be included along the kerb line on each side of the road. Raingardens will receive a dropped kerb outlet to cater for overflow from raingardens, discharging back into the road. This overflow will be collected in standard catchpits and conveyed via the stormwater pipe network to the dry pond for attenuation. Treated flows from the raingardens in Catchment 3 will be conveyed to discharge into the dry pond. Treated flows from the raingardens in Catchment 4 will be conveyed to discharge into the existing overland flow path at Catchment 4's low point.

Where stepped raingardens are required due to steeper road grades, widths are limited to 2m within the berm to allow for sufficient width for the height transition between the raingarden and adjacent cycle path.

7.3 Primary Stormwater System

The primary stormwater system is designed to accommodate for the 10% AEP rainfall event, and all system elements have been designed to cater for each specific delineated catchment 10% AEP post less pre-development flows as tabulated in the section 6.2.2. Relevant CoP's as stipulated in section 3.2 were used in the design process. The system elements have been designed based on a preliminary approach and will be subject to further detailed design prior to construction.

The following critical assumptions were made for preliminary design of the primary underground system:

Inlets/Catchpits:

- Longitudinal gutter slope for entire catchment taken as equal to the minimum alignment slope for that specific catchment
- Maximum gutter spread = 1.00m
- Manning's n Value = 0.015
- Road Crossfall = 3%
- Gutter Crossfall = 10%
- Gutter Width = 0.3m

Pipe sizing:

- Longitudinal pipe slope for entire catchment taken as equal to the minimum alignment slope for that specific catchment
- Manning's Value for concrete pipes = 0.012
- Pipes designed to be in parallel to the road centreline
- Pipes are reinforced concrete rubber ring joint type (RCRRJ) with 1050mm manholes

Based on the assumptions a maximum flow of 17l/s correlates to a spread width of 1.25m based on Manning's law. According to AT CoP, a standard 460mm by 675mm catchpit should be able to accommodate a nominal inlet capacity of 28l/s when installed on a gradient. Therefore, a standard 460mm by 675mm catchpit installed in accordance with the AT CoP/TDM will be sufficient to provide drainage required for the proposed road upgrades.

The proposed stormwater network will consist of standard catchpit inlets along the kerb line, collecting either road surface runoff or overflow from raingardens, and discharging into the piped underground system for conveyance to the attenuation devices. Each catchment's proposed primary system configuration is described below and should be read in conjunction with the attached stormwater layouts in Appendix 2 and catchment diagram in Figure 11.

7.3.1 Catchment 1

Catchment 1 consists of the remainder of Hobsonville Road west that won't be diverted into Trig Road's stormwater system and will include standard 460mm by 675mm catchpits installed either side of the carriageway, discharging into new stormwater pipes on the southern road edge, tying into the existing stormwater network.

- 10 Year ARI post-development flow = 0.145m^3/s (0.073m^3/s each side of road)
- Min. road longitudinal slope = 1.4%
- Max. pipe size required = Ø300mm
- Approximate catchpit spacing for max. gutter spread = ±40m

Post-development flow contribution to the existing system will be significantly less due to diversion of a portion of runoff into Trig Road stormwater system, thus sufficient capacity in the existing system is assumed.

7.3.2 Catchment 2A

Catchment 2A consists of the upper portion of Hobsonville Road east. Due to insufficient capacity in the existing downstream network to cater for the full redeveloped impervious area of Hobsonville Road east and lack of space within the corridor for treatment devices/attenuation, a portion of the catchment runoff will be diverted outside of the corridor for treatment, attenuation and discharge. The stormwater system will have double catchpits installed on the southern side of the road only, discharging into a stormwater pipe on the northern road edge for conveyance to the proposed raingarden/attenuation device north of Hobsonville Road.

- 10 Year ARI post-development flow = 0.079m^3
- 10 Year ARI pre-development flow = 0.071m^3
- Min. road longitudinal slope = 2.3%
- Max. pipe size required = Ø300mm
- Storage volume allowed for = 200m^3
- Approximate double catchpit spacing max. gutter spread = ±50m

The raingarden/attenuation device will include a scruffy dome overflow manhole with piped outlet to the Rawiri Stream overland flow path.

7.3.3 Catchment 2B

Similar to Catchment 1, Catchment 2B consists of the remainder of Hobsonville Road east that won't be diverted to discharge outside of the road corridor and will include standard 460mm by 675mm catchpits installed either side of the carriageway, discharging into new stormwater pipes on the northern road edge, tying into the existing stormwater network.

- 10 Year ARI post-development flow = 0.042m^3 (0.021m^3 each side of road)
- Min. road longitudinal slope = 5.3%
- Max. pipe size required = Ø300mm
- Approximate catchpit spacing each side of road for max. gutter spread = ±80m

Post-development flow contribution to the existing system will be significantly less due to diversion of a portion of runoff outside of the corridor, thus it is concluded there is sufficient capacity in the existing system.

7.3.4 Catchment 3

Catchment 3 includes a combination of treatment at source via raingardens within the berm space (where space is available) as well as treatment downstream in a larger raingarden at the end of pipe run (where treatment within the road corridor is not possible).

Dropped kerb inlets will be used to discharge channel runoff into the berm raingardens, with dropped kerb outlets to cater for overflow above the required 200mm ponding depth. Treated runoff from the raingarden drainage layer will discharge into the new stormwater pipe network. Raingarden overflow will discharge back into the road where it will be collected in catchpits and conveyed via the new stormwater pipe network for subsequent discharge into the proposed dry pond for attenuation.

The portion of Hobsonville Road contributing to Catchment 3 will include catchpit inlets discharging into a stormwater pipe along the south western edge of Trig Road, conveying runoff to the larger raingarden located downstream, west of Trig Road low point. All stormwater runoff along the south western carriageway (as well as the upper portion of Trig Road near the intersection) will also be collected via catchpit inlets and discharged into the larger raingarden downstream.

- 10 Year ARI post-development flow = 0.34m³/s (0.17m³/s each side of road)
- Min. road longitudinal slope (northern side of low point) = 1.1%
- Max. road longitudinal slope (southern side of low point) = 8%
- Max. pipe size discharging into larger raingarden = Ø450mm
- Max. pipe size discharging into dry pond (combined flow for entire catchment) = Ø750mm
- Approximate catchpit spacing road for max. gutter spread (Trig Road) = Varies (see layouts)
- Approximate catchpit spacing road for max. gutter spread (Hobsonville Road) = ±45m
- Dropped kerbed inlets and raingarden locations as indicated on layout to suit available berm space.

7.3.5 Catchment 4

Catchment 4 includes treatment via raingardens within the berm space at source, on both sides of the road. Dropped kerbed inlets will be used to discharge channel runoff into these raingardens, with dropped kerb outlets to cater for overflow above the required 200mm ponding depth. Treated runoff from the raingarden drainage layer will discharge directly into the existing overland flow path at the Catchment 4 low point. Raingarden overflow will discharge back into the road where it will be collected in catchpits and conveyed via the new stormwater pipe network for subsequent discharge into the proposed dry pond for attenuation.

A low point is located at the centre of catchment 4, however road surface runoff (excluding raingarden treated flows) will be diverted towards the dry pond for attenuation. As such, the stormwater pipes from the low point will be upsized to cater for 1% AEP flows.

- 10 Year ARI post-development flow = 0.18m³/s (0.09m³/s each side of road)
- Min. road longitudinal slope = 1%
- Max. pipe size required = Ø450mm (for 100 Year ARI post-dev. Flow, combined both sides)
- Dropped kerbed inlets as indicated on layout to suit available berm space

7.4 Groundwater

As mentioned in section 4.2.2, groundwater seepage was encountered just off the eastern side of Trig Road at the upper branch of Trig Stream (wetland) overland flow path and discharge point for the underground stormwater system near the intersection to Hobsonville Road.

The Project results in a large fill embankment over this seepage area, and appropriate groundwater management will be required to capture and convey the constant groundwater feed out of the fill embankment footprint. This will typically be achieved by the following, to be designed at detailed design stage and approved by the geotechnical engineer:

- In-situ slope drainage using herringbone counterfort drains, daylighting at proposed new headwall
- Mid-height lateral sand drainage blanket laid within fill new fill embankment

The general counterfort drain configuration is shown on Layout 3 of Appendix 2.

7.5 Operation and Maintenance

7.5.1 Dry Pond

Structural elements to facilitate safety and ease of maintenance of the dry pond will be confirmed during detailed design stage and will incorporate at a minimum a 3.0m wide vehicle access no steeper that 1:8, as well as safe access for maintenance workers to inlets and outlets.

Inlets and outfalls should be inspected regularly, as well as specifically after major storm events to clear excess debris build-up or obstructions, and for scour protection maintenance to ensure functional stormwater conveyance and protection of the receiving streams.

Grass should be mowed to maintain aesthetics, and any plant species should be maintained to ensure ecological function.

7.5.2 Raingardens

Raingardens are located within the berm adjacent foot paths, cycle ways or outside of the road corridor where safe access should be achievable. Planting of raingardens should consider on-going maintenance requirements such as weeding/grass cutting frequency and potential of plant growth encroaching into the adjacent footpaths and cycle ways. Raingardens should be regularly inspected, as well as specifically after large storm events to clear excess debris, check for blockages, maintain vegetation and media layers.

7.5.3 Manholes, Inlets and Outfalls

Inlets/catchpits will be provided with a sump to trap heavier/faster settling sediments and debris before connecting the stormwater pipeline and should be regularly maintained by means of a vacuum loading truck (or similar) to remove sediment and debris build up.

Pipes, inlets and outlets should be inspected regularly, as well as specifically after major storm events to clear excess debris build-up or obstructions, and for scour protection maintenance to ensure functional stormwater conveyance and protection of the receiving streams.

Manholes (designed to regulatory standards) will be located where possible outside of trafficable lanes to ensure safe access during maintenance works.

7.6 Summary of Effects and Recommended Mitigation

The table below provides a summary of the stormwater related effects the Project will have on the receiving environment, and how these effects are mitigated and satisfy the requirements under the AUP: OP.

Table 13: Summary of Effects and Methods of Mitigation

Works Activity/Trigger for Resource Consent	Potential Effect on Receiving Environment	Mitigation Method	Conclusion
E8 of the AUP: OP: Stormwater - Discharge and Diversion ***"(A5) Diversion and discharge of stormwater runoff from additional impervious areas greater than 5000m² of road":*** **Redevelopment of Trig Road and the new impervious area to accommodate the new traffic lanes, foot paths and cycleways exceeds 5,000m² of impervious area post-development)**	The 45% increase in impervious area has resulted in a significant peak runoff flow increase across the development, which will be discharged into the downstream receiving Trig Stream (wetland). The receiving environment and surroundings are zoned for mixed-housing development in future. Given the location of the Project in the upper reaches of a greenfield area and the uncertainty of the future developments to be implemented, the increase in discharge may in the future development scenario have the potential to cause: • an increase in scouring or erosion at the discharge point and downstream thereof • adverse effects to stream health and biodiversity as a result of increased cumulative flows • flooding of properties in storm events up to 10% AEP • inundation of buildings on properties in storm events up to the 1% AEP • damage to properties or other infrastructure	• On-site stormwater attenuation is included for peak flow control to ensure discharge of post-development runoff into the receiving environment at a maximum that matches that of pre-development runoff • Stream protection flow has been accounted for and allowed for within the attenuation pond discharge outlet • Outfall structure of attenuation pond will include baffle blocks and rip-rap energy dissipation for ensuring acceptable, non-scouring velocities • The primary stormwater system has been designed to effectively convey the 10% AEP storm event • The 1% AEP storm event will be contained within the road reserve with appropriate bypass allowance from the road low point to the attenuation pond • The existing secondary system/overland flow paths and crossings under Trig Road will be maintained	An on-site attenuation pond for up to the 1% AEP storm event and the appropriately designed outfall structure allows for stream protection flow release, stream protection by energy dissipation at outfall to minimise scouring and erosion, and controlled discharge into the stream during large storm events to prevent downstream flooding. Damage to properties and other infrastructure is avoided by collection and conveyance of runoff within the road and via underground pipe systems, and by ensuring pipe crossings have sufficient capacity for effectively draining upstream catchments for future MPD.

		• The upgrading/upsizing of the crossings for the MPD during the new Trig Road upgrade will allow for enhanced flood control, minimising the potential for flooding as indicated in the flood prone areas	
E9 of the AUP: OP: Stormwater Quality – High Contaminant Generating Activity ***"(A7) Development of a new or redevelopment of an existing high use road greater than 5,000m²":*** **Redevelopment area of Trig Road to accommodate the new traffic lanes, foot paths and cycleways exceeds 5,000m²**	The 45% increase in impervious area (as a redevelopment of high use road) has the potential to increase the concentration of contaminants with the potential to cause: • oils, grease, suspended materials or floating objects to enter the receiving stream • change in colour or visual clarity of receiving stream • release odour generating contaminants into the receiving stream These may result in rendering the water source unfit for consumption by fauna and flora, or have adverse effects on aquatic life and the general ecology of the receiving environment.	• Water treatment has been designed and selected with consideration of GD01 • Raingardens were selected for "at source" treatment within the berms along the carriageway as well as "end of pipe" treatment in larger raingardens, and meet equivalent treatment requirements as per GD01	Raingardens effectively deal with water quality volumes from high contaminant generating roads, removing contaminants from runoff to regulatory requirements prior to discharging into the environment, with ease of incorporation within the project area and its specific constraints.
Minimise bird strike risk through the design of stormwater ponds/wetlands	• Permanent waterbodies attract bird life and present risk of bird strike within the New Zealand Defence Force Airspace Restriction Designation Overlay, and the need for stormwater attenuation within the overlay has the potential to increase the attraction of bird life due to large stored water volumes	• Dry pond design selected over wet pond for attenuation of additional post development run-off ensuring no additional permanent waterbody is allocated within the risk zone • Designed for 1% AEP storm event, fully draining within 24 hours of storm event, resulting in no free-standing water for potential habitation and attraction of bird life.	A fully draining pond will result in no free-standing water for prolonged periods, thus reducing habitability by bird life.

E26 of the AUP:OP: Infrastructure ***"(A55) Stormwater detention/retention ponds/wetlands":*** **A new stormwater detention pond is proposed for attenuation of post-development runoff, to be located at 19 Trig Road.** ***(Not applicable as a trigger for resource consent. Used as a guideline for design)***	• Interference with public use and enjoyment of open space • Potential safety hazard during maintenance works and/or with lack of appropriate access • Potential health and safety effects on public	• Dry pond is not located on existing recreational open space • Dry pond design choice over wet-pond provides aesthetic and amenity potential, with potential for open green space usage during storm events / dry periods • Dry pond provides easier maintenance opportunities and safe access between storm events to structure inlets and outlets • Safe access will be provided into dry pond area • No permanent standing water in dry pond minimises drowning hazard risks • No permanent standing water in dry pond ensures lesser potential for pests, mosquitos and vermin • Dry pond side slopes graded at flatter 1:5 slope to reduce the risk of getting stuck and minimising the need for a dedicated perimeter fence	A fully draining pond, designed with flatter graded internal embankments and vehicle access allowance provides for public safety and safety during maintenance works, as well as providing a potentially multi-purpose use and aesthetically pleasing planted green space during dry periods.

8 Conclusions

The stormwater design approach, elements/infrastructure and concept network layout have been developed to satisfy the regulatory standards and water sensitive design requirements. While subject to refinement in detailed design stage the indicative design demonstrates the stormwater needs of the Project can be met, whilst catering to both current land use and for the expected future development upstream and downstream of the Project area.

The stormwater system will allow for enhancement of the drainage of the upstream catchments along Trig Road and will reduce potential flood effects up to the 100year rainfall event in future development scenarios as well associated with the Trig Rd development. The downstream receiving environment will be protected from additional flood risk by attenuation and by water quality improvement devices. Attenuation will also reduce flood risk to future development downstream of Trig Road.

Through this assessment, the triggers for resource consent have been identified and the potential effects evaluated, and the most well-suited methods and design elements have been selected for mitigation of these effects.

Appendix 1. Relevant Matters of Discretion, Matters of Control, and Assessment Criteria

From the Auckland Unitary Plan

E3. LAKES, RIVERS, STREAMS AND WETLANDS

(A48) Extension of an existing lawful reclamation or drained area.

Activity Status: Non-complying

Assessment Matters: N/A

E8. STORMWATER – DISCHARGE AND DIVERSION

(A5) Diversion and discharge of stormwater runoff from additional impervious areas greater than 5,000m2 of road (which include road ancillary areas that are part of a road, motorway or state highway operated by a road controlling authority) or rail corridor that complies with Standard E8.6.1 and Standard E8.6.4.1

Activity Status: Restricted Discretionary

E8.6.4. Restricted discretionary activity standards:

Activities listed as restricted discretionary in Table E8.4.1

Activity table must comply with the following restricted activity standard. E8.6.4.1. Diversion and discharge of stormwater runoff from additional impervious areas greater than 5,000m2 of road (which include road ancillary areas that are part of a road, motorway or state highway operated by a road controlling authority) or rail corridor

(2) Any road ancillary area must not be used for:

> (a) storage of roading and building materials that are not inert for more than 30 days continuously;
>
> (b) works / building yards.

(3) Where stormwater runoff from an impervious area is discharged into a stream receiving environment, it must be managed by a stormwater management device to meet the hydrology mitigation requirements specified in Table E10.6.3.1.1 Hydrology mitigation requirements.

(4) Stormwater management devices must be provided to reduce or remove contaminants from stormwater runoff.

E8.8. Assessment – restricted discretionary activities

E8.8.1. Matters of discretion

The Council will restrict its discretion to all of the following matters when assessing a restricted discretionary resource consent application:

(1) for diversion of stormwater runoff from lawfully established impervious areas directed into an authorised stormwater network or a combined sewer network that does not comply with Standard E8.6.2.1:

> (a) measures to mitigate additional stormwater flows and potential increases in overflows from the combined sewer network, including future connection to a stormwater network should one become available;

(b) alternative methods of disposal;

(c) effects on the operation and management of the combined sewer network;

(d) operations and maintenance requirements;

(e) monitoring and reporting;

(f) the duration of the consent and the timing and nature of reviews of consent conditions.

(2) for diversion and discharge of stormwater runoff from additional impervious areas greater than 5,000m2 of road (which include road ancillary areas that are part of a road, motorway or state highway operated by a road controlling authority) or rail corridor:

(a) the methods proposed for the management of the adverse effects on receiving environments, including cumulative effects, having regard to:

(i) the nature, volume and peak flow of the stormwater runoff discharge;

(ii) the sensitivity of the receiving environment to stormwater runoff contaminants and flows;

(iii) the extent to which opportunities to reduce existing adverse effects and enhance receiving environments have been identified and utilised; Auckland Unitary Plan Operative in part 7 E8 Stormwater – Discharge and diversion

(iv) where stormwater runoff is discharged to a stream receiving environment, the extent to which the diversion and discharge is managed to achieve the following: • maintain baseflow and interflow at the predevelopment conditions; • reduce the duration and intensity of flows which will cause erosion and habitat degradation; • reduce runoff volumes to pre-development conditions; and • utilise natural flow paths and streams to help slow down water flows; and

(v) the extent to which effects on marine sediment quality, are avoided, remedied or mitigated.

(b) the measures proposed for the management of the adverse effects of the stormwater runoff diversion and discharge on receiving environments having regard to best practicable options;

(c) the measures proposed for the implementation of stormwater management devices and other measures and programmes that give effect to the best practicable option;

(d) the methods proposed for the management and mitigation of flood effects and flood risks, including effects on buildings and property;

(e) the likely effectiveness of the proposed methods and measures to avoid land instability, erosion, scour and flood risk to buildings and property;

(f) the likely effectiveness of the proposed location, design and method of the discharge in managing or mitigating potential adverse effects on the environment;

(g) the methods proposed for the management of stormwater flow and contaminants and for the implementation of stormwater management devices and other measures;

(h) the proposed methods for stormwater runoff disposal through soakage, or infiltration having regard to the need for managing water levels in underlying peat soils and for ground stability, where those conditions are relevant;

(i) the extent to which effects on Mana Whenua values are avoided remedied or mitigated;

(j) the likely effectiveness of the proposed operations and maintenance requirements in ensuring the ongoing and long-term management of adverse effects on the environment; Auckland Unitary Plan Operative in part 8 E8 Stormwater – Discharge and diversion

(k) the extent to which proposal for monitoring and reporting are likely to be sufficient to ensure that any performance failures are addressed without undue delay; and

(l) the proposed duration of the consent and the timing and nature of reviews of consent conditions having regard to:

(i) the need to periodically reassess the consent to take account of any changes in the nature of the discharge or the receiving environment; and

(ii) the need to set duration and review periods having regard to efficiency and effectiveness.

E8.8.2. Assessment criteria

The Council will have regard to the following policies when considering the matters listed above:

(1) for diversion of stormwater runoff from lawfully established impervious areas directed into an authorised stormwater network or a combined sewer network that does not comply with Standard E8.6.2.1:

(a) policies E1.3 (8), (9), (10), (11), (13), (14) and (20) in E1 Water quality and integrated management

(2) for diversion and discharge of stormwater runoff from additional impervious areas greater than 5,000m2 of road (which include road ancillary areas that are part of a road, motorway or state highway operated by a road controlling authority) or rail corridor:

(a) policies E1.3(1) to (14) in E1 Water quality and integrated management.

E9. STORMWATER QUALITY – HIGH CONTAMINANT GENERATING CAR PARKS AND HIGH USE ROADS

(A7) Development of a new or redevelopment of an existing high use road greater than 5,000m2

Activity Status: Controlled

E9.6.2. Controlled activity

All controlled activities in Table E9.4.1 Activity table must comply with the following activity specific standards:

E9.6.2.2. Development of a new or redevelopment of an existing high use road greater than 5,000m2

(1) Stormwater runoff from the impervious area is treated by stormwater management device(s).

(2) Stormwater management device(s) must meet the following:

(a) the device or system must be sized and designed in accordance with Auckland Councils Technical Publication 10: Design Guideline Manual for Stormwater Treatment Devices (2003); or

(b) where alternative devices are proposed, the device must demonstrate it is designed to achieve an equivalent level of contaminant or sediment removal performance to that of Technical Publication 10: Design Guideline Manual for Stormwater Treatment Devices (2003).

E9.7. Assessment – controlled activities

E9.7.1. Matters of control

The Council will reserve its control to all of the following matters when assessing a controlled activity resource consent application:

(2) for the development of a new or redevelopment of an existing high use road greater than 5,000m2:

(a) the effectiveness of the stormwater management device(s) in meeting Standard E9.6.2.2(2);

(b) the potential for adverse effects from the discharge of contaminants on the receiving environment;

(c) the proposed methods for operating and maintaining the stormwater treatment processes and devices to ensure their continued and ongoing effectiveness in meeting Standard E9.6.2.2(2);

(d) the proposed methods for monitoring and reporting on the effectiveness of the treatment process;

(e) the duration of the consent and the timing and nature of reviews of consent conditions; and

(f) the treatment of stormwater runoff from existing high use road impervious areas discharging to the same network.

E9.7.2. Assessment criteria

The Council will consider the relevant assessment criteria below for controlled activities:

(2) for the development of a new, or redevelopment of an existing high use road greater than 5,000m2:

(a) the extent to which the proposed stormwater management device minimises adverse effects on the environment having regard to the nature and sensitivity of the receiving environment;

(b) whether the stormwater management device is appropriately designed, sized and operated for the site and contaminants of concern;

(c) whether the stormwater quality device is durable and will achieve the performance requirements in the long term;

(d) the extent to which operation and maintenance plans have been provided to manage the stormwater management device(s);

(e) whether it is practical to treat existing high use road areas discharging to the same drainage network point and being treated by the same treatment device having regard to all of the following:

(i) site and operational constraints;

(ii) requirements to provide for other utility services;

(iii) the function of roads as overland flow paths conveying stormwater runoff from surrounding land uses which the road controlling authority has limited ability to control;

(iv) safety and operational constraints of the road or discharges; and

(v) topographical limitations and geotechnical and structural requirements; and

(f) the extent to which there is a requirement in the Plan to reconstruct the existing drainage network.

E26. INFRASTRUCTURE

(A55) Stormwater detention/retention ponds/wetlands

Activity Status: Controlled

E26.2.6. Assessment – controlled activities

E26.2.6.1. Matters of control

The Council will reserve its control to all the following matters when assessing a controlled activity resource consent application:

(2) stormwater detention and retention ponds and wetlands:

(a) effects on the use of open space;

(b) provision of safe access for maintenance; and

(c) effects on health and safety.

E26.2.6.2. Assessment criteria

The Council will consider the relevant assessment criteria for controlled activities from the list below:

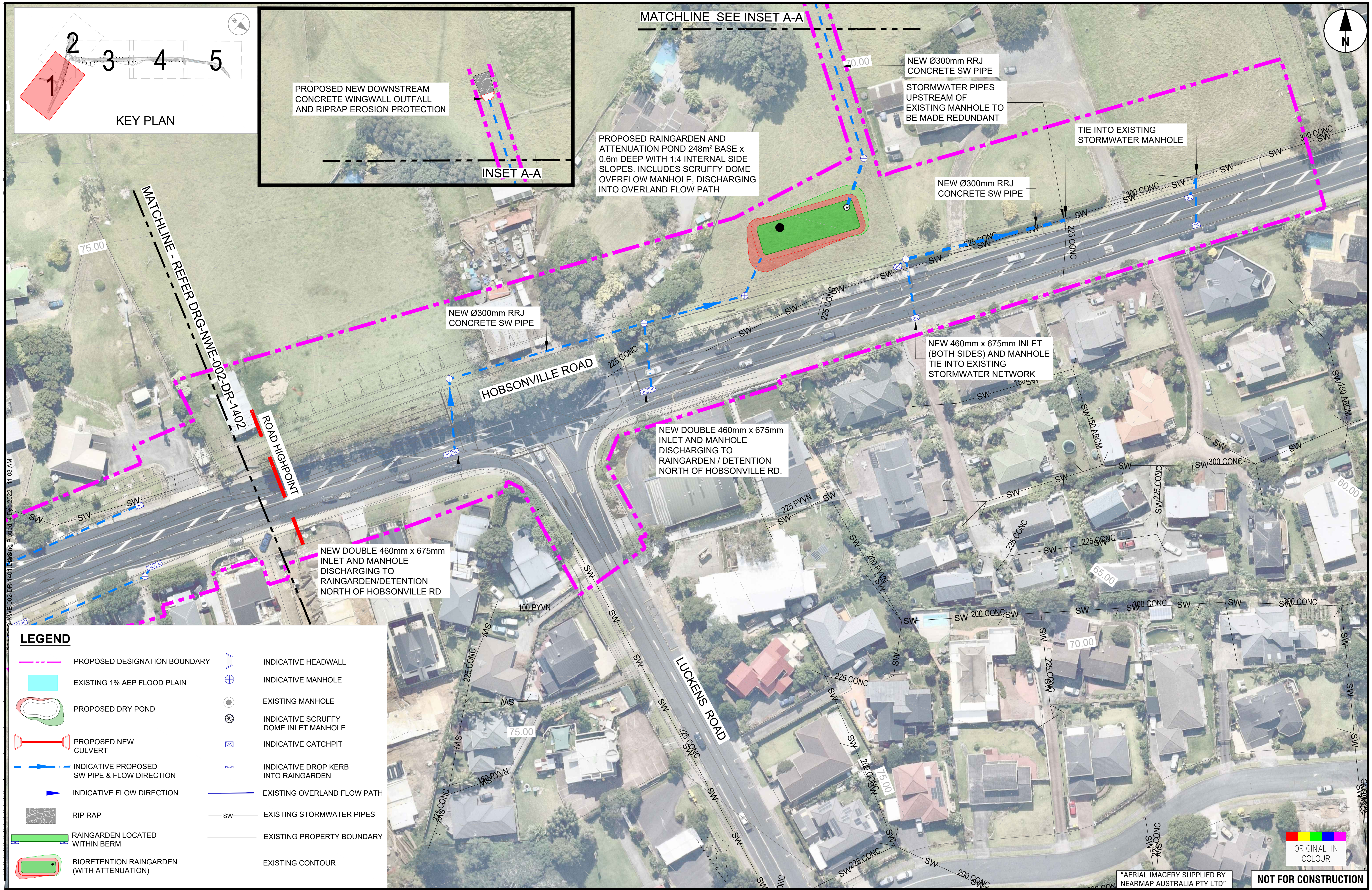
(2) stormwater detention and retention ponds and wetlands:

(a) the extent to which interference with public use and enjoyment of open space is minimised where stormwater detention and retention ponds and wetlands are located in public open space;

(b) whether safe and direct access can be provided to enable the maintenance of stormwater detention and retention ponds and wetlands; and

(c) whether there will be health and safety effects associated with stormwater detention and retention ponds and wetlands and the extent to which these can be mitigated through measures such as fencing.

Appendix 2. Stormwater Drawings



LEGEND

PROPOSED DESIGNATION BOUNDARY	INDICATIVE HEADWALL
EXISTING 1% AEP FLOOD PLAIN	INDICATIVE MANHOLE
PROPOSED DRY POND	EXISTING MANHOLE
	INDICATIVE SCRUFFY DOME INLET MANHOLE
PROPOSED NEW CULVERT	INDICATIVE CATCHPIT
INDICATIVE PROPOSED SW PIPE & FLOW DIRECTION	INDICATIVE DROP KERB INTO RAINGARDEN
INDICATIVE FLOW DIRECTION	EXISTING OVERLAND FLOW PATH
RIP RAP	EXISTING STORMWATER PIPES
RAINGARDEN LOCATED WITHIN BERM	EXISTING PROPERTY BOUNDARY
BIORETENTION RAINGARDEN (WITH ATTENUATION)	EXISTING CONTOUR

REV	REVISIONS	DRAWN	DATE
B	ISSUED FOR NOTICE OF REQUIREMENT LODGEMENT	VDLT	DEC. 2022
A	FOR NOTICE OF REQUIREMENT AND RESOURCE CONSENT	VDLT	AUG. 2020

SURVEYED		
DRAWN	V. DELA TORRE	01.05.20
DRAWING CHECK	J. DELA TORRE	01.05.20
DESIGN	N. WOLFAARDT	20.08.20
DESIGN REVIEW	R. SEYB	20.08.20
APPROVED	B. BUSNARDO	07.12.2022

TE TUPU NGĀTAHI Supporting Growth

WAKA KOTAHI NZ TRANSPORT AGENCY

Project:
SUPPORTING GROWTH PROGRAMME
NORTH WEST - HIF TRIG ROAD (SOUTH)

Drawing Title:
STORMWATER LAYOUT PLAN
SHEET 1 OF 5

Drawing Status: **FOR LODGEMENT**
Drawing Date: 07.12.2022
A1 Scales 1:500 | A3 Scales 1:1000
Discipline: STORMWATER
Drawing No.: SGA-DRG-NWE-002-DR-1401
Revision: B

NOT FOR CONSTRUCTION

REV	REVISIONS	DRAWN	DATE
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A	FOR NOTICE OF REQUIREMENT AND RESOURCE CONSENT	VDLT	AUG. 2020

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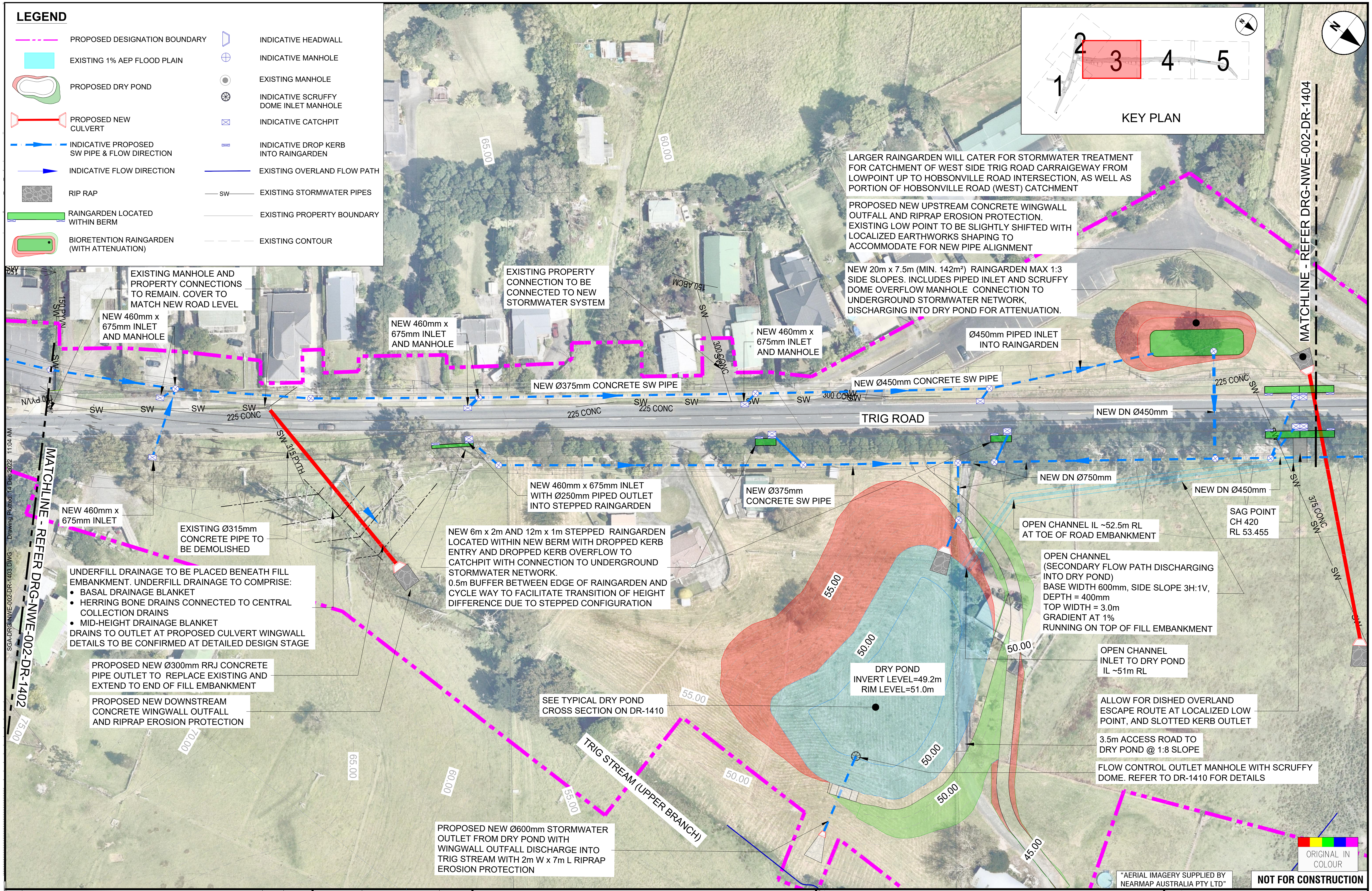
TE TUPU NGĀTAHI Supporting Growth

WAKA KOTAHI NZ TRANSPORT AGENCY

Project:
SUPPORTING GROWTH PROGRAMME
NORTH WEST - HIF TRIG ROAD (SOUTH)

Drawing Title:
STORMWATER LAYOUT PLAN
SHEET 2 OF 5

Drawing Status: FOR LODGEMENT
Drawing Date: 07.12.2022
Scales: A1 1:500 A3 1:1000
Discipline: STORMWATER
Drawing No.: SGA-DRG-NWE-002-DR-1402
Revision: B



REV	REVISIONS	DRAWN	DATE
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DESIGN REVIEW	R. SEYB	20.08.20
APPROVED	B. BUSNARDO	07.12.2022

TE TUPU NGĀTAHI Supporting Growth

WAKA KOTAHI NZ TRANSPORT AGENCY

Project: SUPPORTING GROWTH PROGRAMME
NORTH WEST - HIF TRIG ROAD (SOUTH)

Drawing Title: STORMWATER LAYOUT PLAN
SHEET 3 OF 5

Drawing Status: FOR LODGEMENT
Drawing Date: 07.12.2022
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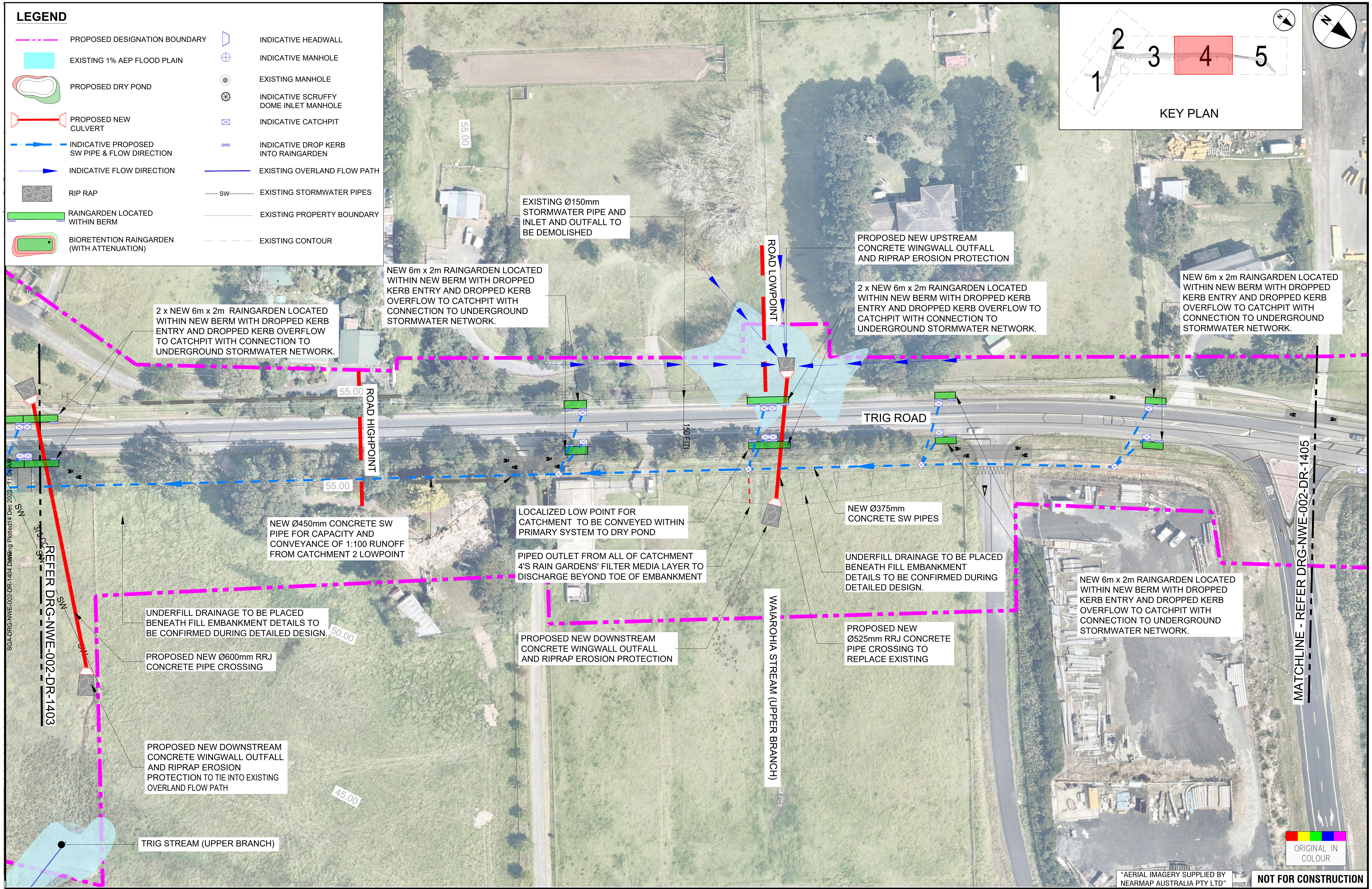
Discipline: STORMWATER
Drawing No. SGA-DRG-NWE-002-DR-1403
Revision B



NOT FOR CONSTRUCTION

REV	REVISIONS	DRAWN	DATE
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A	FOR NOTICE OF REQUIREMENT AND RESOURCE CONSENT	VDLT	AUG. 2020

SURVEYED		
DRAWN	V. DELA TORRE	01.05.20
DRAWING CHECK	J. DELA TORRE	01.05.20
DESIGN	N. WOLFAARDT	20.08.20
DESIGN REVIEW	R. SEYB	20.08.20
APPROVED	B. BUSNARDO	07.12.2022

TE TUPU NGĀTAHI Supporting Growth

WAKA KOTAHI NZ TRANSPORT AGENCY

Project:
SUPPORTING GROWTH PROGRAMME
NORTH WEST - HIF TRIG ROAD (SOUTH)

Drawing Title:
STORMWATER LAYOUT PLAN
SHEET 4 OF 5

Drawing Status: **FOR LODGEMENT**
Drawing Date: 07.12.2022
A1 Scales 1:500 | A3 Scales 1:1000
Discipline: STORMWATER
Drawing No.: SGA-DRG-NWE-002-DR-1404
Revision: B

NOT FOR CONSTRUCTION

REV	REVISIONS	DRAWN	DATE
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A	FOR NOTICE OF REQUIREMENT AND RESOURCE CONSENT	VDLT	AUG. 2020

SURVEYED		
DRAWN	V. DELA TORRE	01.05.20
DRAWING CHECK	J. DELA TORRE	01.05.20
DESIGN	N. WOLFAARDT	20.08.20
DESIGN REVIEW	R. SEYB	20.08.20
APPROVED	B. BUSNARDO	07.12.2022

TE TUPU NGĀTAHI Supporting Growth

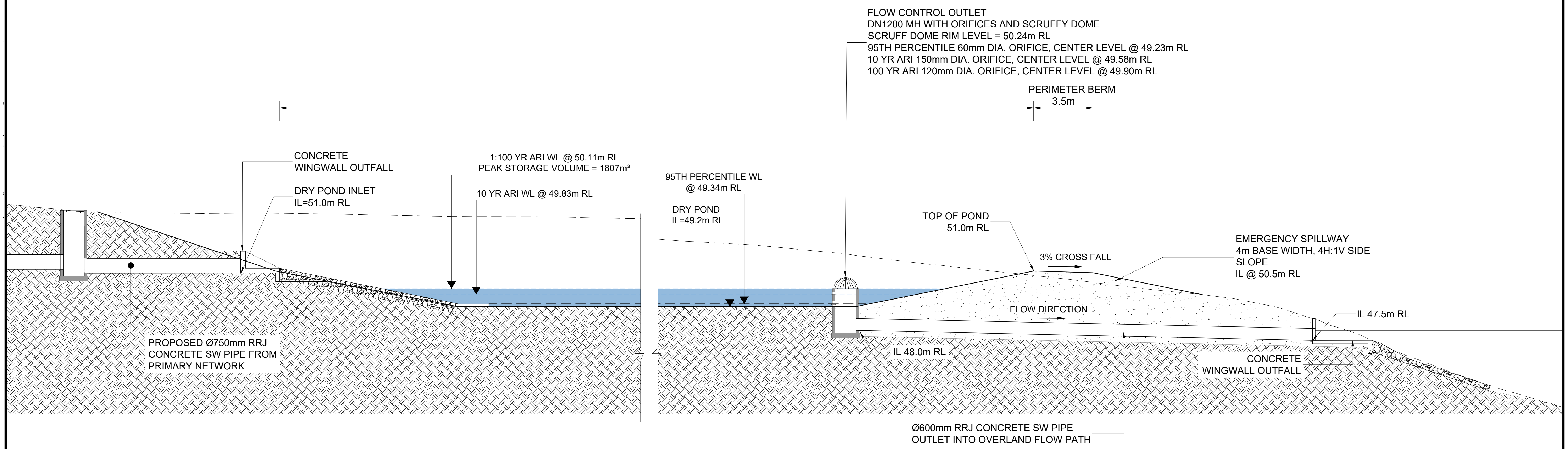
WAKA KOTAHI NZ TRANSPORT AGENCY

Project:
SUPPORTING GROWTH PROGRAMME
NORTH WEST - HIF TRIG ROAD (SOUTH)

Drawing Title:
STORMWATER LAYOUT PLAN
SHEET 5 OF 5

Drawing Status: **FOR LODGEMENT**
Drawing Date: 07.12.2022
A1 Scales 1:500 | A3 Scales 1:1000
Discipline: STORMWATER
Drawing No. SGA-DRG-NWE-002-DR-1405
Revision **B**

SGA-DRG-NWE-002-DR-1405 Drawing Plotted 14 Dec 2022 11:05 AM



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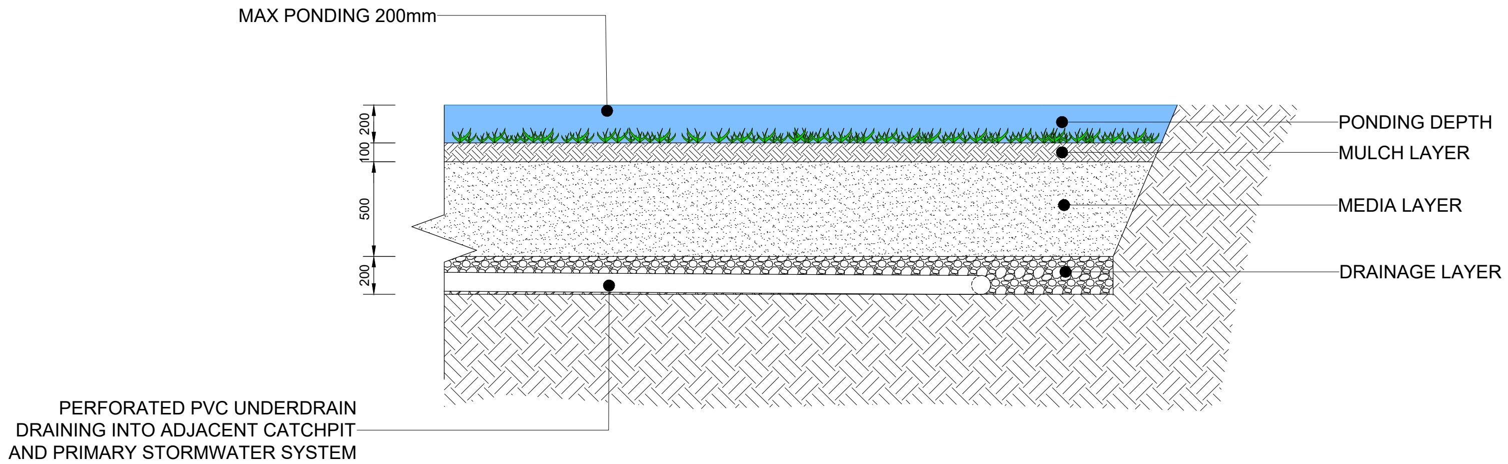
Scale 1:100



B | TYPICAL RAINGARDEN LONG SECTION
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Scale 1:20

ORIGINAL IN COLOUR

NOT FOR CONSTRUCTION

SGA-DRG-NWE-002-DR-1410.dwg Drawing Plotted 14 Dec 2022 11:05 AM

REV	REVISIONS	DRAWN	DATE
B	ISSUED FOR NOTICE OF REQUIREMENT LODGEMENT	VDLT	DEC. 2022
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TE TUPU NGĀTAHI Supporting Growth

WAKA KOTAHI NZ TRANSPORT AGENCY

Project:
SUPPORTING GROWTH PROGRAMME
NORTH WEST - HIF TRIG ROAD (SOUTH)

Drawing Title:
STORMWATER
DRY POND AND RAINGARDEN TYPICAL CROSS SECTIONS

Drawing Status: **FOR LODGEMENT**
Drawing Date: 07.12.2022
A1 Scales: AS SHOWN
A3 Scales: HALF SCALE
Discipline: STORMWATER
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Revision: B

Appendix 3. HEC-HMS Model

General

The hydrological model was built using HEC-HMS v4.9 to reflect the proposed development and associated imperviousness within the catchment. The modelling was done in accordance with . for sizing the proposed dry pond in accordance with Auckland Council's Technical Publication 108 (TP108): Guidelines for Stormwater Runoff Modelling in the Auckland and AC's Stormwater Design CoP.

The HEC-HMS model may be revised in detailed design phase for optimisation.

Model Inputs

The post-development HEC-HMS basin model is shown in Figure A3-1 below, where Trig Road South is equivalent to Catchment 3 and Trig Road North is equivalent to Catchment 4 in Figure 6-3 in the main report.

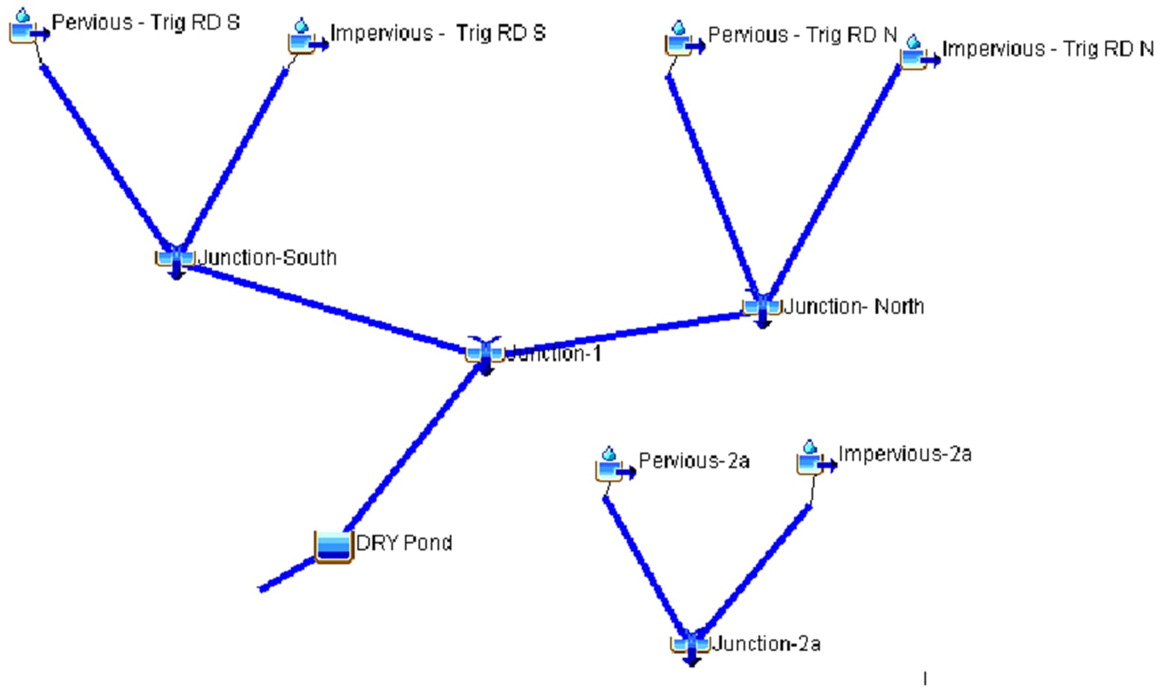

Figure A3-1. HEC-HMS basin model for Trig Road – Post Development

A pre-development basin model was run to estimate pre-development flows.

Design Rainfall

Five design storm events were modelled in HEC-HMS and the following is the design rainfall depth

Design storm Event Description	AEP (%)	24hr Rainfall Depth (mm)	Climate Change Increase (%)	Adjusted 24hr Rainfall Depth (mm)	Reference source
10year ARI	10%	135	13.2%	153	AC TP108
50year ARI	2%	180	16.8%	210	AC TP108
100year ARI	1%	200	16.8%	234	AC TP108
WQV rainfall	N/A	25	N/A	N/A	AC GD01 – 90th percentile rainfall depth
95th Percentile rainfall	N/A	35	N/A	N/A	AC GD01

Rainfall Temporal Pattern

The rainfall temporal pattern was applied in accordance with the *Auckland Code of Practice for Land Development and Subdivision, Chapter 4: Stormwater*, Version 3.0, January 2022. The pattern is shown in Table 2 below for the existing and future rainfall scenarios.

Table 2: TP108 Normalised 24-hour temporal rainfall intensity profile

Time (hrs: mins)	Time interval (min)	TP108 normalised rainfall intensity (I/I24)	
		Existing condition	Future climate change*
0:00 – 6:00	360	0.34	0.33
6:00 – 9:00	180	0.74	0.73
9:00 – 10:00	60	0.96	0.95
10:00 – 11:00	60	1.40	1.40
11:00 – 11:30	30	2.20	2.20
11:30 – 11:40	10	3.80	3.82
11:40 – 11:50	10	4.80	4.86
11:50 – 12:00	10	8.70	8.86
12:00 – 12:10	10	16.20	16.65
12:10 – 12:20	10	5.90	5.95
12:20 – 12:30	10	4.20	4.24
12:30 – 13:00	30	2.90	2.92
13:00 – 14:00	60	1.70	1.70
14:00 – 15:00	60	1.20	1.19
15:00 – 18:00	180	0.75	0.75
18:00 – 24:00	360	0.40	0.39

* Assuming 2.1°C increase in temperature

Dry Pond Storage Capacity

Elevation-area function as shown in table below was used to estimate the storage capacity of the dry pond in HEC-HMS model. Linear interpolation is assumed in elevation between pond invert and rim.

Elevation (m RL)	Area (1000 m^2)	Remarks
49.2	1.243	Pond invert level
51.0	2.863	Pond rim level

The dry pond was designed and 3D-modelled in Civil3D software to obtain cut-fill extent and set invert and rim level. The areas at the pond invert level of 49.2m RL and at the rim level of 51.0m RL were measured from Civil3D.

Model Results

Table below show the HEC-HMS model results for the dry pond's water level, peak discharge rate, peak storage volume, and emptying duration for the five design storm events. Pond emptying duration is the duration to fully drain down the dry pond from the start of the storm event.

Design Storm Event	Water Level (m RL)	Peak Inflow (m^3/s)	Peak Discharge (m^3/s)	Peak Storage Vol (m^3)	Inflow Vol (m^3)	Pond Emptying Duration (Hr:min)
WQV	49.30	0.06	0.01	190	363	25hr:50min
95th Percentile	49.34	0.09	0.01	276	551	27hr:30min
10% AEP	49.83	0.52	0.16	1259	3105	38hr:10min
2% AEP	50.03	0.74	0.26	1654	4455	40hr:10min
1% AEP	50.11	0.83	0.29	1807	4971	40hr:20min

Figures A3-2 and A3-3 below show the inflow and outflow graphs for 2% AEP and 1% AEP design storm event for 48 hours duration.

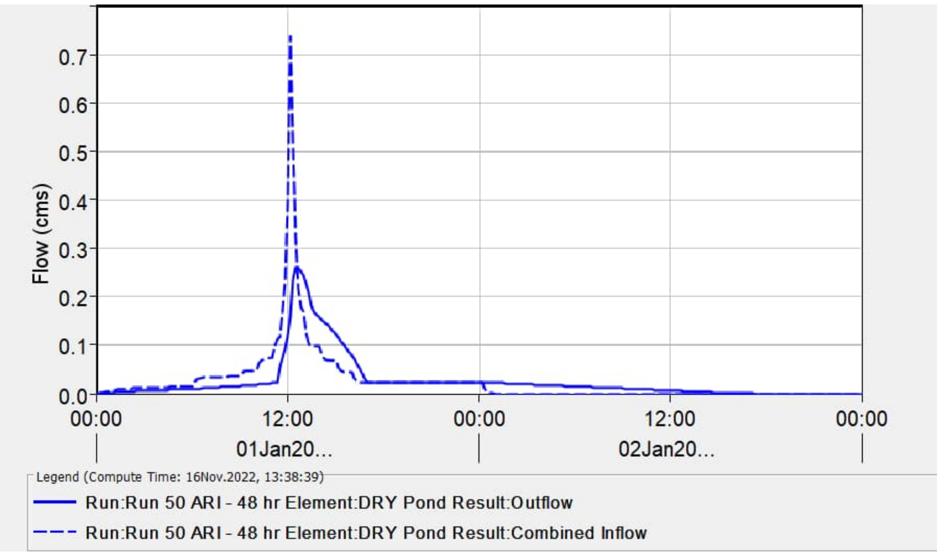

Figure A3-2. Dry Pond – 2% AEP (50yr ARI) Inflow and Outflow Graph (Post-Development)

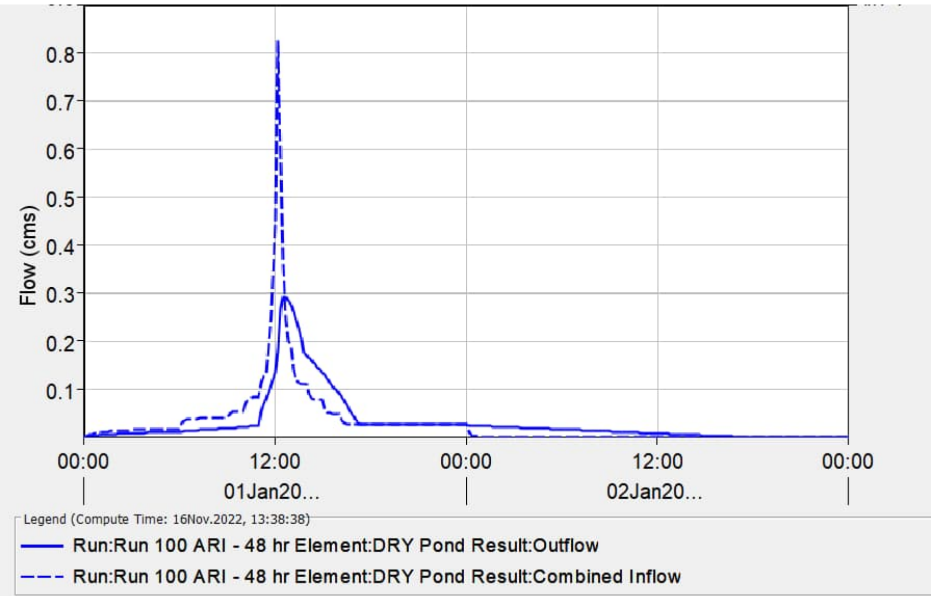

Figure A3-2. Dry Pond – 1% AEP (100yr ARI) Inflow and Outflow Graph (Post-Development)

Conclusions

The HEC-HMS model results indicated that the dry pond meets the attenuation requirements by having the peak post-development discharge rates are less than the allowable peak discharge rates as shown in table below. The dry pond also meets the design criteria that it can be fully drained down within 48 hours of a 2% AEP storm event.

Design Storm Event	Allowable Peak Discharge (m^3/s)	Post-Dev Peak Discharge (m^3/s)
95th Percentile	0.047	0.01
10% AEP	0.31	0.16
2% AEP	0.45	0.26
1% AEP	0.51	0.29

There will be opportunities to optimise the dry pond design in detailed design phase. The current dry pond is likely to be oversized by comparing the attenuated discharge flow rate vs. pre-development allowable peak discharge flow rate.