IN THE MATTER OF	The Resource Management Act 1991
AND	
IN THE MATTER OF	applications for resource consents in relation to Te Ahu a Turanga; Manawatū Tararua Highway Project
BY	**NEW ZEALAND TRANSPORT AGENCY** Applicant

TE AHU A TURANGA: TECHNICAL ASSESSMENT B

STORMWATER MANAGEMENT DESIGN

TABLE OF CONTENTS

INTRODUCTION

1. My full name is David William Hughes.

2. I am a Technical Director / Civil Engineer employed by Aurecon NZ Ltd, where I have worked for the past eight years on major infrastructure projects as a lead stormwater design engineer. Prior to that, I was employed by Arup in London, UK, where I worked for four years on the London 2012 Olympic Park as a senior civil design engineer.

3. I specialise in stormwater design and have fulfilled the role of the Principal Technical Advisor and stormwater drainage / hydrology design lead on several major roading projects in New Zealand and Australia over the past 8 years.

4. I am familiar with the area that the Te Ahu a Turanga; Manawatū Tararua Highway Project ("**Project**") covers, and I have been involved in the development of the proposed operational stormwater design since February 2019.

5. I have also been involved in consultation with representatives from iwi groups who are partners of the project, as well as other stakeholders such as, Horizons Regional Council ("**Horizons**") and Meridian.

6. I have had primary responsibility for the proposed drainage design, which includes the design of the proposed State Highway network drainage (carriageway drainage), cross culverts and stormwater management systems (treatment and detention), and the associated catchment assessments undertaken to inform the design.

7. I am the sole author of this Stormwater Management Design Report (which is in **Volume IV** of the application documents) and I confirm that the details presented in this report reflect the current design.

QUALIFICATIONS AND EXPERIENCE

8. I am a member of Engineering New Zealand and I am a Chartered Professional Engineer.

9. Recent projects in which I have been involved demonstrate my experience in the assessment of effects and design of stormwater management systems for roading projects. A number of relevant Waka Kotahi New Zealand Transport Agency ("**Transport Agency**") projects include:

   (a) Christchurch Northern Corridor project in 2018, where I was the lead stormwater engineer for the Alliance. My responsibilities included managing and delivering the detailed stormwater design for 7km of new motorway and upgrading several connecting arterial roads for Christchurch City Council. The project involved a number of major cross culverts in low lying, weak ground conditions along the project, as well as the design of a considerable length of road network drainage and stormwater management systems required to service the new State highway, and complex hydrological catchment modelling and flood risk assessments in consultation with Christchurch City Council.

(b) SH1 Northern Corridor Improvements in 2017, where I was the lead stormwater engineer and subject matter expert for the consenting phase of the project. My responsibilities involved developing the specimen design and Minimum Design Requirements, and the technical stormwater design reports to support the assessment of environmental effects for the Board of Inquiry process. My responsibilities on the project involved the development of a comprehensive flood mitigation strategy and stormwater management design for the project in consultation with key stakeholders and project partners including iwi, Auckland Council ("**AC**"), Watercare and Auckland Transport ("**AT**").

(c) SH16 Lincoln to Westgate in 2017, where I was the lead stormwater engineer for the Transport Agency. I was responsible for the detailed drainage design for the project, which included developing the technical inputs required to obtain the discharge consents.

(d) SH1 Puhoi to Warkworth in 2016, where I was the lead stormwater engineer for Northlink Tender team. My responsibilities involved managing and delivering the stormwater design for the Tender Design. This work included overseeing the design of major cross culverts and flood relief structures, stormwater management devices, and a considerable length of road network drainage and swale systems. I was also responsible for overseeing the comprehensive hydrological catchment modelling and flood risk assessments for the Puhoi and Mahurangi River catchments, which were undertaken to support the Tender design.

(e) SH1 Southern Corridor Improvements in 2016, where I was the lead stormwater engineer for the Transport Agency. My responsibilities included the management and delivery of the road network drainage systems, cross culverts and the assessment of effects and options assessment for providing treatment and attenuation of stormwater runoff.

I also led the consultation and planning process with AC, iwi and local community groups for stormwater drainage related matters on the project.

(f) SH16 St Lukes Interchange in 2015, where I was the lead stormwater engineer for the Transport Agency. My responsibilities included the detailed design of the road network drainage system, stormwater management devices, and coordination of the design with AC, AT, iwi and the Auckland Motorway Alliance.

10. This Stormwater Management Design Report has been developed on behalf of the Transport Agency to support the application for resource consents in relation to the Project.

CODE OF CONDUCT

11. I confirm that I have read the Code of Conduct for expert witnesses contained in the Environment Court Practice Note 2014. This assessment has been prepared in compliance with that Code, as if it were evidence being given in Environment Court proceedings. In particular, unless I state otherwise, this assessment is within my area of expertise and I have not omitted to consider material facts known to me that might alter or detract from the opinions I express.

PURPOSE AND SCOPE OF THIS REPORT

12. This report explains the proposed stormwater design, details key aspects of the stormwater management systems and the level of treatment that will be achieved during the operational stage of the Project, and how the construction of the system is designed for minimal impact.

13. This report provides an overview of the existing environment and the stormwater elements of the Project's design for which I have been responsible. In particular, this report contains an explanation of:

(a) the Project and the existing environment (as far as it relates to stormwater management);

(b) the relevant design parameters including rainfall, climate change, and external standards that have been applied;

(c) relevant assessment criteria and considerations;

(d) an overview of the proposed design, including:

(i) the network drainage collection and conveyance system;

(ii) cross culverts, including measures proposed to address:

(1) fish passage;

(2) erosion protection; and

(3) stream diversions;

(iii) stormwater quality and quantity management;

(e) proposed stormwater outfalls and erosion mitigation;

(f) the alternatives / best practicable option ("**BPO**") assessment.

14. This report should be read in conjunction with the Project-wide Design and Construction Report ("**DCR**") in **Volume II,** and the following subject matter expert reports that have been developed to support the Assessment of Environmental Effects ("**AEE**"):

(a) **Mr Campbell Stewart's** Erosion and Sediment Control Technical Assessment Report A, which covers water management and erosion and sediment effects of the Project during construction.

(b) **Mr Keith Hamill's** Water Quality Technical Assessment Report C, which covers an assessment of the effects of discharges to water during construction and an assessment of effects from stormwater discharges to water during operation;

(c) **Dr Jack McConchie's** Hydrological Assessment Report D, which covers the impacts of the stormwater discharges on water quantity in the receiving environment, and the scour assessment undertaken for the design of works in and adjacent to the Manawatū River and Mangamanaia Stream;

(d) **Mr Matt Baber's** Terrestrial Ecology Technical Assessment in Report F, which assesses the effects of the Project on terrestrial ecology including vegetation/habitats and fauna; and

(e) **Ms Justine Quinn's** Freshwater Ecology Technical Assessment Report G, which covers an assessment of the Project's effects on freshwater ecology.

EXECUTIVE SUMMARY

15. The proposed stormwater system design is based on information from site visits, topographical surveys, aerial photographs, consultation with iwi and local stakeholders, and information provided by the Transport Agency.

16. The proposed stormwater system has been designed in accordance with various guidelines and standards listed in **Appendix B.1**, which include the Transport Agency's Standard Specification P46 State Highway Stormwater Specification 2016, the Transport Agency's Stormwater Treatment Standard for State Highway Infrastructure 2010 ("**Transport Agency Treatment Standard 2010**") and Horizons One Plan rules.

17. The potential adverse environmental effects of stormwater discharges relating to the operational phase of the Project are described in detail in **Mr Keith Hamill's** technical assessment report. The potential adverse effects, including cumulative effects, have been considered and appropriately managed in accordance with the guidelines, specifications, and standards stated in **Appendix B.1**. These effects have been avoided, remedied or mitigated by application of a BPO approach. In short, the design solutions to be adopted following the BPO process will:

    (a) minimise sediment and erosion generated during construction of the stormwater devices through the implementation of design features described in paragraph 84.

    (b) reduce earthworks and impacts associated with works over and around existing streams through the implementation of design features described in paragraph 86.

    (c) avoid potential adverse effects and minimise residual effects through provision of stormwater management devices. As part of the assessment, consideration has been given to the proposed systems' ability to achieve the following:

        (i) Treatment of 100% of stormwater runoff from the proposed State highway within the Project area (to a standard of 75% total suspended solids ("**TSS**")[1] removal on a long-term average basis) is provided using planted wetlands, wetland swales and swales.

        (ii) This is a large improvement on the existing situation where there is no formal treatment of stormwater runoff from the existing state highway[2] within the Project area.

[1] Total Suspended Solids (TSS) is the suspended particles that have not dissolved in water. Both organic and inorganic particles can contribute to the suspended solids concentration.
[2] The existing state highway denotes existing roads at the Ashhurst (Fitzherbert East Road (SH57) and Napier Road (SH3)) and Woodville ends of the Project (Woodlands Road, Napier Road and Vogel Street (SH3)).

(iii) Treatment of cut slope runoff through dedicated sediment basins and dual forebay wetlands. These devices will capture and contain sediment from water runoff from cut slopes and prevent sediment from entering the sensitive receiving environment.

(iv) Stormwater erosion effects will be mitigated by:

(1) provision for detention of stormwater runoff from the State highway; and

(2) provision of rip-rap outfall protection works and rock armouring to new and existing outfalls.

(v) Provision has been made for peak flow attenuation (up to the 10-year Annual Recurrence Interval ("**ARI**")[3] storm event) and extended detention in stormwater management systems for runoff from the State highway, in accordance with the Transport Agency Treatment Standard 2010. This will mitigate flooding impacts upstream and downstream of the Project.

(vi) Stormwater management devices have been designed to align with the rural context and the key features requiring ongoing maintenance and repair consider the skills and resources of the maintenance personnel in the region who are expected to be undertaking such works.

(vii) Culverts have been designed to facilitate fish passage where recommended by the Project ecologist specialists. Refer to **Ms Quinn's** technical assessment report for further details.

(viii) The effects of climate change on rainfall over the design life of the Project have been provided for in the design, in accordance with relevant Ministry for the Environment ("**MfE**") guideline listed in **Appendix B.1**.

18. Input from an experienced drainage constructor has been integrated throughout the design to minimise construction impact.

19. In my opinion, the proposed consent conditions adequately address and control the potential effects relating to stormwater management, erosion mitigation and cross drainage requirements for the Project.

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[3] An Annual Recurrence Interval (ARI) is the statistical period (number of years) that is predicted will pass before an event of a given magnitude occurs.

PROJECT DESCRIPTION

20. The Project comprises the construction, operation and maintenance of approximately 11.5km of State highway connecting Ashhurst and Woodville via a route over the Ruahine Ranges. The purpose of the Project is to replace the indefinitely closed existing State Highway 3 ("**SH3**") through the Manawatū Gorge.

21. The Project comprises a median separated carriageway that includes two lanes in each direction over the majority of the route and will connect with State Highway 57 ("**SH57**") east of Ashhurst and SH3 west of Woodville (via proposed roundabouts). A shared use path ("**SUP**") for cyclists and pedestrian users is proposed as well as a number of new bridge structures, including bridge crossings over the Manawatū River and Mangamanaia Stream.

22. The design and detail of each of the elements of the Project are described in:

    (a) Section 3 of the AEE (contained in **Volume I** of the application documents);

    (b) the DCR (contained in **Volume II** of the application documents); and

    (c) the Drawing Set (contained in **Volume III** of the application documents).

23. The works that are the subject of this assessment are those which relate to operational stormwater management; the design of stormwater devices, stream diversions and culverts. At Consenting Design stage, the following are proposed:

    (a) Nine stormwater wetlands; ten stormwater wetland swales; ten flow-through treatment swales; and 17 new sediment basins to treat stormwater from the new highway and cut slopes;

    (b) 25 cross culverts and 8 access culverts to reconnect streams and to assist cross catchment drainage. This includes multi barrel/box culverts CU-08 and ACU-05 that convey significant catchment flow under the road alignment at CH7850 and CH7750 respectively;

    (c) Approximately, 74 cut-off drains of varying size and shape to intercept and convey overland flow away from road embankments and to the appropriate cross culverts; and

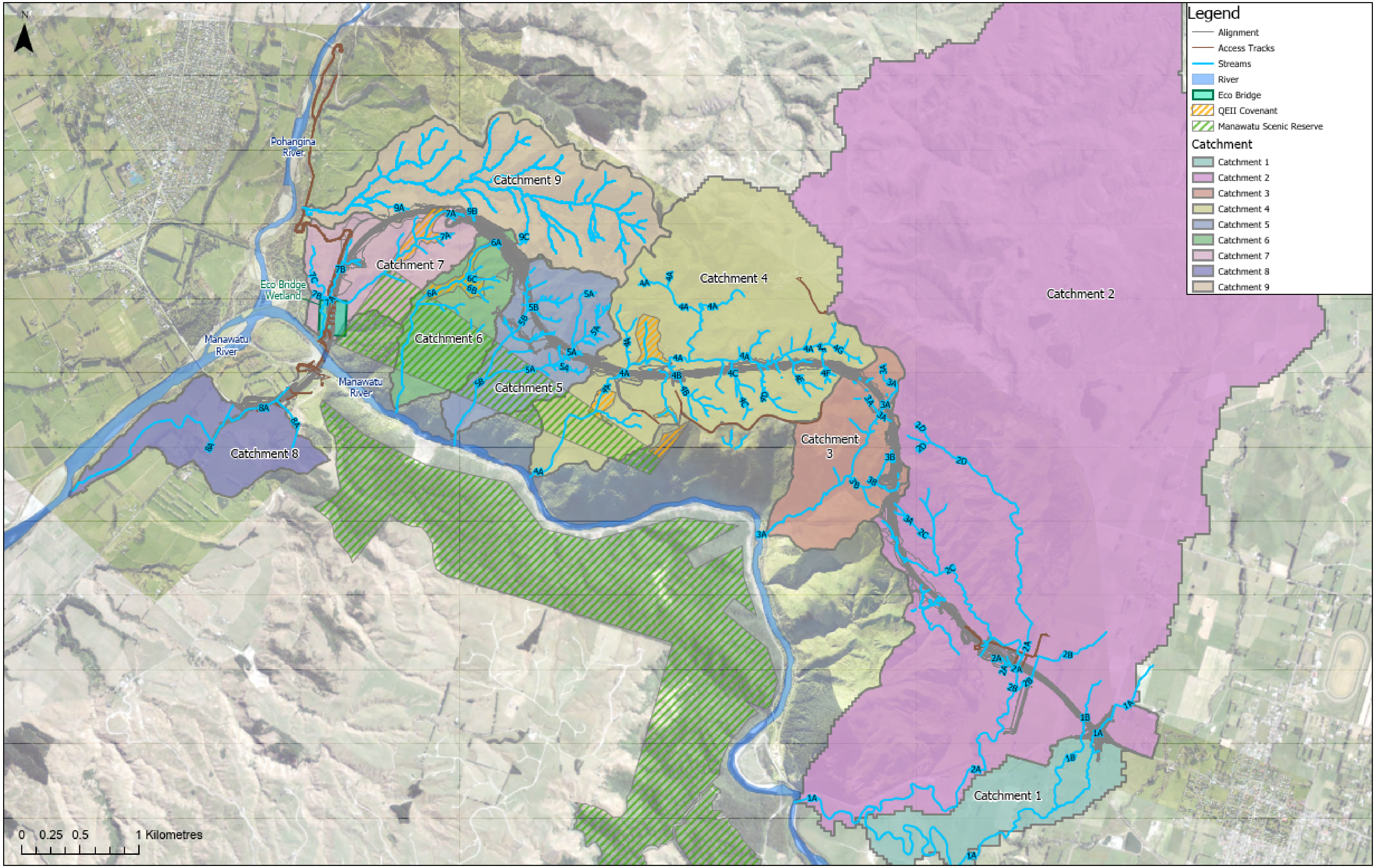
    (d) Approximately, 39 stream diversions of varying size and shape to recreate and reconnect streams and to assist cross catchment drainage (detailed in **APPENDIX B.2: Culvert Catchments and design calculations**).

EXISTING ENVIRONMENT

24. The Project is located in the southern foothills of the Ruahine Ranges, and north of the Manawatū Gorge. The Manawatū River flows through the Manawatū Gorge in a westerly direction to the south of the Project alignment.

25. The Project crosses the Manawatū River and nine of its sub-catchments. The sub-catchments are shown in **Figure B.1** below and the Waterways and Catchments Drawing (TAT-3-DG-E-4102-A) in **Volume III**.

Figure B.1: Project Stream crossings and catchments



26. The sub-catchments have been assigned identifiers (numbers) from Catchment 1 to 9, starting at the eastern end of the alignment, and are briefly described below:

(a) Catchment 1 is approximately 1.17 km^2 in area and drains a flat, low-lying floodplain. It is highly modified and dominated by pastoral farming that includes numerous drainage channels.

(b) Catchment 2 (Mangamanaia catchment) is approximately 20.55 km^2 in area and is the largest sub-catchment traversed by the Project. It is largely dominated by pastoral farming with pockets of forests.

(c) Catchment 3 is approximately 1.23 km^2 in area. The Project crosses the very upper portion of the catchment. It is roughly equally split between pastoral land and Manawatū Gorge Scenic Reserve ("**Manawatū Reserve**").

(d) Catchment 4 is approximately 4.12 km^2 in area. The Project traverses the middle reaches of the catchment. It is highly modified and pasteurised with the small Manawatū Reserve in the lower portion of the catchment.

(e) Catchment 5 is approximately 1.20 km^2 in area. The Project crosses a portion of the very upper end of the catchment. It is mainly pastoral land in the upper catchment with the Manawatū Reserve and QEII covenant in the lower catchment.

(f) Catchment 6 is approximately 0.95 km^2 in area, and the Project crosses a small portion of the very upper end of the catchment. It is approximately equally split between pastoral land and the Manawatū Reserve.

(g) Catchment 7 is approximately 1.10 km^2 in area. The Project cuts across the catchment and bridges one of the gullies down to the Manawatū River. Upper catchment is largely pastoral land with the lower catchment being the Manawatū Reserve.

(h) Catchment 8 is approximately 1.01 km^2 in area and drains to the Manawatū River downstream of the Pohangina River confluence. The Project crosses through the centre of this catchment. It is highly modified and used for agricultural land.

(i) Catchment 9 (Mangakino catchment), is approximately 2.20 km^2 in area. The Project only slightly encroaches into this catchment, which is a tributary of the Pohangina River. It has an incised deep vegetated gully system with an extensive area of mature vegetation.

27. There are a number of existing engineered, grassed channels collecting stormwater from the existing State highway.[4] These drainage channels were not intended or designed to provide treatment of stormwater runoff in accordance with the Transport Agency Treatment Standard 2010 and only provide informal treatment.

28. The Saddle Road has been extensively used in place of the indefinitely closed existing State Highway 3 ("**SH3**") and does not have any formal facility along its length to treat stormwater runoff from the existing road.

29. There are also a number of existing engineered watercourses / farm drains and reservoirs located over the Project area which are used for farming operations.

DESIGN OVERVIEW

Background assessments

30. The Transport Agency has separately given notices of its requirement for three designations for the Project ("**NoRs**"), and these NoRs are currently under appeal. I understand that the Transport Agency has asked the Environment Court, as part of those appeals, to modify the NoRs to provide for the Northern Alignment on which the Project's design, and this stormwater assessment, are based.

31. An assessment of the existing stream systems crossing the Project has been carried out using historic design information (drawings and reports) and hydrological information provided by the Transport Agency and Horizons', as well as physical survey of existing stream systems and site visits undertaken with the ecology team, iwi, the network operators and landowners.

32. The assessment of the existing stormwater system and impervious surfaces associated with the existing State highway involved calculating impervious areas using topographical and LiDAR survey, and aerial photography flown in 2018.

33. I have familiarised myself with the technical assessments previously prepared by the Transport Agency in support of the NoRs in relation to the stormwater drainage aspects of the design, including:

    (a) Appendix 3 to the Assessment of Environmental Effects: Road Design Philosophy Statement.

[4] The existing state highway denotes existing roads at the Ashhurst (Fitzherbert East Road (SH57) and Napier Road (SH3)) and Woodville ends of the Project (Woodlands Road, Napier Road and Vogel Street (SH3)).

(b) Technical assessment of **Mr Boyden Evans** of the Landscape, Natural Character and Visual Effects of the NoRs, contained in volume 3 of the NoR documents.

(c) Council-level evidence of **Mr Andrew Whaley** – Project Design.

(d) Council-level evidence of **Mr Boyden Evans** – Landscape, Natural Character and Visual Effects.

General design principles

34. The proposed stormwater design has considered Māori cultural values through a number of design workshops undertaken with project partners over the past six months. This design integration will continue during the development of the detailed design, where representatives from all Project iwi Partners will be involved in the following stormwater design components:

(a) the design of stream diversions and its effects on aquatic taonga;

(b) the design of stormwater management devices, including location, shape and form of treatment devices; and

(c) the design of culverts, provision of fish passage and preservation of the mauri of streams.

35. The BPO approach has been used to determine the most appropriate treatment device and water quantity control measures for the Project. It considers the best method for preventing or minimising the adverse effects on the environment, having regard to:

(a) The nature of the discharge and the sensitivity of the receiving environments to adverse effects;

(b) The financial implications and effects on the environment of that option when compared with another option; and

(c) The current state of technical knowledge and the likelihood that the option can be successfully applied.

Table B.1 provides a summary of the merits and constraints of the different stormwater management devices considered for treatment of stormwater runoff from the Project. The stormwater design drawings contained in **Volume III** provide further details on the chosen type of stormwater management devices across the Project.

Table B.1: Stormwater Management Device Comparison as part of BPO Assessment

Stormwater Management Device	Advantages	Disadvantages	BPO for Project (Y/N)
Planted flow-through Swales	Effective at treating stormwater runoff by filtration, infiltration, adsorption and biological uptake. Planted conveyance swales can also be used to provide informal pre-treatment before discharging to wetlands or other dedicated treatment devices.	Requires a considerable length and reduced longitudinal grade to function for stormwater runoff treatment (achieve necessary hydraulic residence time). Swales adjacent to the highway can increase earthworks footprint, construction cost, particularly when in cut. Do not provide adequate volume storage for peak flow attenuation.	**Yes**
Filter Strips	Filter strips are based on the concept of stormwater treatment being achieved via filtration of sheet flow runoff from an adjacent road surface. Potential for erosion and scour is reduced due to there being no point discharge. Effective at TSS concentration reduction, removal of Cu, Pb and Zn.	Do not provide quantity control. Require a large area for the device immediately adjacent to the pavement surface (i.e. along the side of the carriageway), increasing earthworks footprint, construction cost when in cut. Not suitable for areas with moderate to steep slopes and areas where the area adjacent to the highway is constrained.	No
Rain Gardens	Effective at treating stormwater runoff by filtration, infiltration, adsorption and biological uptake. Discharge flow over a relatively large area, and therefore the potential of erosion and scour due to the discharge is reduced.	A large footprint is often required. High maintenance costs due to regular maintenance requirements - dense planting and high sediment loads can lead to clogging if not maintained regularly Do not provide adequate volume storage for peak flow attenuation. Not suited to longitudinal, constrained environments in remote locations where a higher level of traffic management for maintenance activities is required.	No
Proprietary Filter Cartridges	Stormwater360 StormFilters are NZTA's preferred proprietary for high traffic load applications and have been used on recent NZTA projects around NZ for water quality treatment. Targeted removal of metals and hydrocarbons. Proprietary Filter Cartridges can fit in tight spaces, so are good when treatment is required in constrained physical environments.	Do not provide adequate volume storage for peak flow attenuation. High maintenance requirement and underground / confined space maintenance required. Reduced resilience in seismic areas.	No

Stormwater Management Device	Advantages	Disadvantages	BPO for Project (Y/N)
Sand Filters	Effective at removal of hydrocarbons. Effective at removal of finer sediments.	Suited for small catchment areas. Hydraulic head requirement through sand filters is larger than that through the proprietary filter devices. Sand filters require a large physical space and more space for maintenance activities. They do not provide adequate volume storage for peak flow attenuation. They require maintenance on a more frequent basis and are prone to clogging.	No
Dry Ponds	Provides greater detention and attenuation volumes for the same footprint than wet ponds and wetlands.	No water quality treatment function.	No
Wet Ponds	Provides water quality and quantity control. Smaller footprint than wetlands. Low maintenance.	Deeper permanent water depth than wetlands - increased safety risk. Warming of water temperature due to pond surface area - can impact on downstream ecology. Standing water potentially can attract birds, which is not acceptable to Meridian.	No
Planted Wetlands	Provides water quality and quantity control. Lower maintenance than other devices such as rain gardens and Proprietary Filter Cartridges. Visual amenity and are a better habitat for wildlife. Aligned with NoR Conditions in respect of planting on Meridian land. Preferred stormwater management device by Project iwi partners due to improved water quality performance (through filtering, absorption and uptake) and integration with natural surrounding landscape.	Larger footprint than wet ponds due to shallow nature of the device. Can require additional maintenance than ponds through a greater coverage of planting.	**Yes**

36. In addition, to determining the most appropriate treatment device and water quantity control measures for the Project, BPO was also adopted in modifying design to minimise impact on terrestrial ecology and flora and fauna where

possible. An example of this is Wetland W05, which has been shaped to protect existing high value Ramarama growth adjacent to the proposed highway.

37. The following key design principles for the proposed stormwater management devices, network drainage and culverts have been adopted:

    (a) Incorporation of a total stormwater management system that mimics the existing hydrologic regime and setting - this includes an open channel collection and conveyance network, treatment devices, stormwater cross drainage culverts and diversions, and outfalls including erosion protection. The form and functionality of this approach is aligned with the Project design team's integrated water management / whole-of-landscape approach which attempts to blend stormwater management solutions into the surrounding rural landscape, whereby the stormwater system design utilises, and is complementary to, the existing and future forms, terrain, and catchment flow characteristics.

    (b) Consideration of the potential effects of increased flows from increased impervious areas on upstream and downstream networks and receiving environments.

    (c) Consideration of the preferences of the Transport Agency and 'safety and good practice in design' considerations with respect to construction, operation, maintenance and general access for stormwater management devices.

    (d) Provision of stormwater management devices that comply with stormwater quality and quantity requirements (treatment, detention, retention and attenuation) set by Horizons and the Transport Agency Treatment Standard 2010.

    (e) Existing channel and stream systems adjacent to the Project (including streams, farm drains, farm culverts, and reservoirs) are proposed to be retained where possible. The criteria for retaining existing assets include that:

        (i) the location of the existing asset is not affected by the proposed works;

        (ii) the condition of the existing asset is acceptable (i.e. there are no major structural defects and an acceptable design life is retained); and

        (iii) the hydraulic capacity of the existing asset is acceptable.

Where any of the above criteria cannot be met, the existing asset is proposed to be abandoned and/or replaced.

Design methodology

38. The design of the stormwater drainage and management systems for the Project has taken into account the key design standards and guidance documents listed in **APPENDIX B.1: Stormwater Design Standards and Guidelines**.

39. The predominant soil group across the Project has been identified by the geotechnical team as mudstone. On this basis, curve numbers for runoff calculations were chosen in accordance with NRCS NEH, Part 630, Hydrology, Chapter 7 Hydrologic Soil Groups.[5] For the detailed geomorphic setting of the Project, refer to **Dr McConchie's** technical assessment report.

40. As discussed in **Dr McConchie's** report, an assessment of climate change impact and a comparison of the design rainfalls derived from the empirical data and HIRDS v4[6] was undertaken, which determined the rainfall parameters used for the stormwater design.

41. Design rainfalls from HIRDS v4 were adjusted for climate change by assuming 2.3°C warming (i.e. RCP 6.0)[7] and the percentage increases out to 2120.[8]

42. The Rational Method[9] has been applied to catchment areas of less than 50 hectares, and the NRCS (SCS) Curve Number Method [10] was used for catchments exceeding 50 hectares in size in accordance with the Project minimum requirements.

43. The design flows for the Manawatū River and Mangamanaia Stream bridge crossings were provided by Horizons, and the design flows for the Eco Viaduct Bridge, which incorporates a stream crossing, were developed using flood frequency analysis (McKerchar & Pearson). Further detail on the design flows

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[5] The Natural Resources Conservation Service (NRCS) National Engineering Handbook (NEH) is a widely and generally apply method to determine the direct runoff from a given storm event based on a number of variables, including catchment soil type.

[6] The High Intensity Rainfall Design System (HIRDS) is an online tool, designed by National Institute of Water and Atmospheric Research (NIWA), that estimates the magnitude and frequency of design rainfall parameters at any point in New Zealand.

[7] This is one of the Representative Concentration Pathways (RCP) adopted by the Intergovernmental Panel on Climate Change.

[8] As noted above, climate change effects on predicted rainfall levels have been calculated in accordance with MfE guidelines. Climate change is expected to affect design through increased intensity and frequency of heavy rainfall events.

[9] Rational Method is in accordance with Transport Agency Treatment Standard 2010 and has been widely used internationally and is suitable for small catchments with relatively uniform land use.

[10] The NRCS, formerly known as Soil Conservation Service (SCS), curve number method is used to calculate stormwater runoff. This method can be applied to watersheds which have more than one hydrologic soil-cover so is more widely accepted and practical for calculation of runoff from larger catchments.

and velocities used for the bridge scour assessment and design is covered in **Dr McConchie's** technical assessment report.

Stormwater Design Elements

Network Drainage

44. The network drainage design for the reticulation of stormwater runoff from the road carriageways has been developed to a conceptual level. During detailed design, the network drainage system will be designed for the 10-year ARI rainfall event with secondary or overflow systems designed for the 100-year ARI rainfall event. In the locations where there is no secondary overland flow path available, the reticulation system will be designed to convey the 100-year ARI peak flow.

45. Where possible, open conveyance channels have been designed in place of the piped network to improve resilience and minimise ongoing maintenance of buried infrastructure.

46. In appropriate locations the open channels will be planted with species that are able to cope with extended wet and dry conditions. This open channel approach provides improved resilience, it also provides cultural and environmental benefits through a 'treatment train' approach, whereby runoff from the road carriageway is being subject to an element of pre-treatment prior to being discharged through dedicated downstream stormwater management devices.

47. The following design factors have been applied to drainage assets on bridges to minimise the risk of scour to the bridge abutments:

    (a) Double catchpits located upstream of all bridges to capture and convey runoff from the carriageway prior to the bridge to minimise flow across abutment joints and bridge drainage requirements; and

    (b) Rock lined emergency spillway provided for open channels near abutments to ensure any blockages to the piped system do not result in an erosion risk to the bridge abutments or the adjacent road embankments.

48. All stormwater runoff from the State highway will be conveyed to a stormwater management device and treated before being released to the environment.

Stormwater Management (stormwater quality and quantity control)

49. The Project proposes to create approximately 383,000m^2 of total new impervious area as described in Section 4.2.5 of the DCR. For the purposes of

this assessment only those impervious areas that are roadway, comprising the proposed carriageway, the existing road (State highway) tie ins and the Gateway Park, are being treated in accordance with the Transport Agency Treatment Standard 2010.

50. Stormwater runoff from the other surfaces including the SUP, unsealed access tracks and viewing platforms will not be entrained with any contaminants and therefore will not discharge to a dedicated treatment device. Instead, they will discharge onto the adjacent land and naturally dissipate and infiltrate or will discharge directly to the nearest downstream watercourse via vegetated conveyance channels.

51. All impervious areas created as part of the Project are designed to drain to a wetland, wetland swale or treatment swale to provide water quality treatment.[11] These devices have been chosen for the Project stormwater treatment system as they provide the following key advantages over other device options:

(a) they can provide stream channel erosion control through extended detention;

(b) their proven effectiveness for water quality treatment through their being sized to accommodate the water quality flow[12] or volume and capture of the first flush;[13]

(c) they require less frequent maintenance as they are not prone to clogging;

(d) wetland and wetland swales are more suitable for treating larger catchment areas where they can provide peak flow control, flow attenuation and flood protection.

52. In addition, promotion of dense vegetation growth improves safety of the general public and improved water temperature control compared to open water bodies such as ponds, while providing visual amenity.

53. The design of stormwater management devices (treatment and detention systems) has been developed in accordance with the Horizons One Plan rules and guidelines and the Transport Agency Treatment Standard 2010, and provides for:

(a) nine stormwater treatment wetlands (W01 to W09);

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[11] Wetland and wetland swales are vegetated and provide storage, peak-flow attenuation in addition to treatment. Treatment swales provide water quality treatment through the provision of Hydraulic Residence Time (HRT) as well as filtration, adsorption and other benefits.

[12] Water quality flow describes a particular flow rate that is treated by stormwater quality devices to treat stormwater to the standard level required.

[13] The first flush is the initial runoff from a surface containing the highest proportion of contaminant load compared to runoff in the remainder of the storm.

(b) ten stormwater treatment wetland swales (WS01 to WS10);

(c) ten flow-through treatment swales (TS01 to TS10); and

(d) 17 new sediment basins (SB1 to SB17).

54. During the detailed design when further coordination / design refinement with input from all Project iwi partners will take place, minor amendments to the size, shape and form of the proposed stormwater management devices are expected, however any such changes will not reduce the performance (stormwater quality and quantity) of the devices.

55. The Project's design provides treatment of stormwater runoff from all proposed State highway surface areas within the Project.[14] Treatment is provided to a high standard of removal of 75% of TSS on a long-term average basis. This is a significant improvement over the current situation where runoff from existing state highway surfaces, which currently has no treatment (namely the existing SH3 Napier Road), will be fully treated by the proposed new system.

56. A 'treatment train' approach to manage stormwater runoff from all proposed State highway surface areas within the Project[15] has been adopted, including dedicated 'at-source' catchpit devices, planted or rock-lined swales for capture and conveyance of stormwater runoff in most situations, and planted wetlands and wetland swales as the primary means for treating stormwater runoff from the Project.

57. Increased impervious surfaces can increase runoff, potentially increasing erosion and downstream flood levels in large rainfall events. On this basis, peak-flow attenuation and extended detention to varying levels have been provided for in the design of wetlands and wetland swales. This will reduce the rate of discharge during critical storm events to their pre-development levels to mitigate effects associated with erosion and flooding of the downstream receiving environment.

58. Extended detention has been provided in stormwater management devices to mitigate erosion of the downstream environment in accordance with the Transport Agency Treatment Standard 2010, where:

(a) Where the catchment imperviousness is greater than 3% of the total contributing catchment to a stream in a rural environment;[16]

[14] Refer stormwater design drawings contained in volume III of the application for Project extents and areas treated.
[15] Refer stormwater design drawings contained in volume III of the application for Project extents and areas treated.
[16] In accordance with 7.1.3.1 of the Transport Agency Treatment Standard 2010.

(b) Where the stormwater management device discharges to a natural channel that is or will be subject to erosion;

(c) Where the Project significantly increases the overall contributing catchment flow in the receiving stream (i.e. more peak flow is resulting in a stream due to the rerouting of runoff across catchments from the Project stormwater system).

59. The peak flow attenuation requirements for mitigation of downstream flood risk for the Project are outlined in **Table B.2**. These criteria are based on the assessment undertaken by **Dr McConchie** of the wider hydrological setting of the Project, where it was determined that during storm events greater than the 10-year ARI storm, any runoff from the Project will behave in the same manner as the existing soils. Therefore, the Project will not cause any increase flood risk to the downstream receiving environment due to the insignificance of the additional runoff caused by the Project.

60. On this basis, only peak flow attenuation for events up to 10-year ARI storm have been considered for the design, and have been provided for in the following situations:

(a) Where there is a dwelling that is adjacent to a stream system that the Project discharges to, which is immediately downstream of the Project;

(b) Where there is a constrained asset immediately downstream (i.e. an existing or proposed culvert) that the Project discharges to;

(c) Where there is known flooding issues within the catchment (i.e. adjacent to the Mangamanaia and Mangapapa Streams downstream of the project); and

(d) Where the discharge point from the Project is located within the top portion of the receiving catchment. In addition to the extended detention provisions allowed for in the design, all outlets from wetlands and wetland swales to the receiving environment will be installed with rip rap erosion protection and, where required, energy dissipation structures.

Table B.2 Proposed Stormwater Management Devices and Design Criteria

Catchment ID	Stormwater Management Device	Design Criteria Proposed		
		Water Quality Treatment	Extended Detention	10-year ARI Peak Flow Attenuation *
1	WS07	**Yes**	**Yes**	**Yes**
	WS08	**Yes**	**Yes**	**Yes**
	WS09	**Yes**	**Yes**	**Yes**

	WS10	**Yes**	**Yes**	**Yes**
2	W08	**Yes**	**Yes**	**Yes**
	W09	**Yes**	**Yes**	**No**
	WS04	**Yes**	**Yes**	**No**
	WS05	**Yes**	**Yes**	**Yes**
	WS06	**Yes**	**Yes**	**Yes**
3	W07	**Yes**	**Yes**	**Yes**
4	W06	**Yes**	**Yes**	**No**
	WS01	**Yes**	**Yes**	**No**
	WS02	**Yes**	**Yes**	**No**
	WS03	**Yes**	**Yes**	**Yes**
7	W03	**Yes**	**Yes**	**No**
	W04	**Yes**	**Yes**	**Yes**
	W05	**Yes**	**Yes**	**Yes**
8	W01	**Yes**	**Yes**	**Yes**
Manawatū River	W02	**Yes**	**No**	**No**

*** Determination of** *Attenuation requirement is based on* ***Dr McConchie's*** *technical assessment report (Sections 36 and 39)*

61. Three wetlands (W05, W07 and W08) and four wetland swales (WS01, WS08, WS09 and WS10) treat stormwater from multiple catchments and would, in the absence of other measures, alter the quantum of stormwater discharging to the receiving stream. The potential adverse effects of such changes in discharge at these locations is considered minimal due to the change in runoff being a small proportion of the total runoff in a wider catchment context. As a result, any potential effects will be so small that they could not be identified and quantified.

62. The stormwater design has been modified to minimise impacts on terrestrial ecology and flora and fauna where possible. An example of this is Wetland W05, which has been shaped to protect existing high value Ramarama growth adjacent to the proposed highway.

63. In summary, the Project is expected to have a minimal residual effect on the receiving environment, due to the proposed treatment devices and treatment train approach applied in the design. In addition, the Project will provide extended detention and peak flow attenuation of stormwater runoff where required to mitigate any effects associated with erosion and / or flood risk of the sensitive downstream receiving environment.

Culverts

64. There are 25 new cross culverts proposed that cross the main alignment and 8 access culverts proposed that cross access tracks over the Project, as detailed the Culvert Schedule contained in **APPENDIX B.2: Culvert Catchments and design calculations** . Culverts have been located where streams or overland

flow cross the proposed works and they have been designed to maintain the natural flow regime as far as practicably possible.

65. There are also a number of existing culverts serving existing roads at either end of the Project area. The existing culverts to be retained and proposed new culverts are shown on the stormwater consent design drawings[17].

66. All cross culverts (existing and new) that cross the State highway have been designed to meet or exceed the following hydraulic conditions:

(a) Convey the 10-year ARI storm event flow without surcharge of the pipe; and

(b) Convey the 100-year ARI storm event flow without a headwater depth larger than twice the culvert diameter, whilst ensuring a minimum 500mm freeboard from the peak water level to the outer edge line level of the highway is provided where possible, refer to **Figure B.2**.

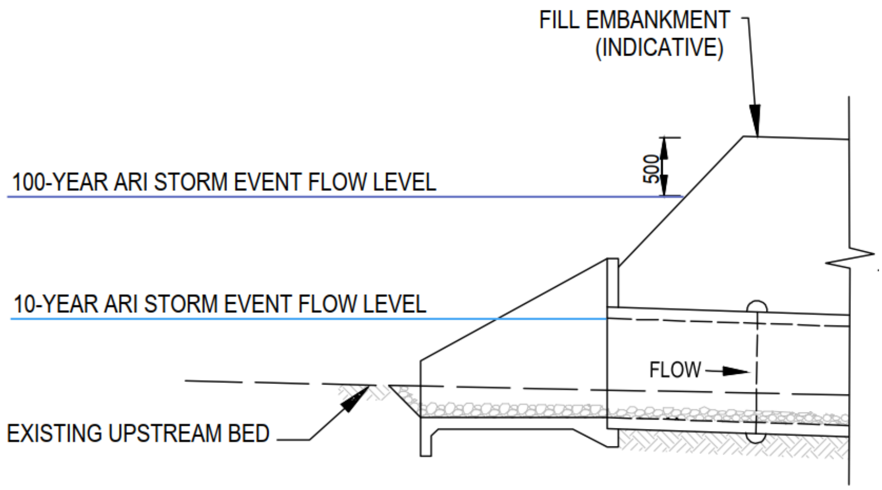

Figure B.2: Typical Culvert Inlet Side Profile

67. All new culverts will be constructed in reinforced concrete and fish passage will be provided as required, as described in **Ms Quinn's** technical assessment report. The existing KiwiRail culvert conveying Stream 7, under the Palmerston North – Gisborne Rail Line has been identified as restricting fish passage.

[17] The stormwater design drawings are contained in volume III of the application documents.

Further investigation will be conducted during the detailed design stage to assess whether fish passage improvements are required.

68. All culverts (box and circular) with provision for fish passage have been set below the upstream and downstream waterway bed level, to provide natural substrate through the culvert at low flows.

69. A preliminary blockage assessment of all existing and new culverts has been undertaken for the design, and the proposed mitigation is detailed on the stormwater consent design drawings. Results from the assessment indicate that a number of culverts may be affected by blockage of the inlet due to a vegetated upstream catchment. These are likely to require some form of inlet blockage mitigation such as inlet oversizing, debris racks or provision of a secondary inlet.

70. At this stage of the Project, a detailed condition assessment of the existing culverts at the Ashhurst and Woodville tie-ins has not been carried out. I believe that the likelihood of the condition assessment indicating full replacement is low, based on a visual inspection of the headwalls and upstream and downstream channel assessments. However, should any of the culverts proposed for retention be found defective or in poor condition during the detailed design phase, they will be repaired or replaced with the same size culvert to retain the natural flow regime in the upstream and downstream system.

Culvert inlet and outlet structures

71. Erosion protection measures at inlet and outlet structures have been designed to cater for a 100-year ARI rainfall event including climate change in accordance with HEC-14.[18] This philosophy is based on providing flow expansion structures at all culvert outlets to dissipate energy and provide erosion protection to natural ground. These impact structures can include:

    (a) Concrete wing wall with apron (either pre-cast or cast in-situ as necessary);

    (b) Rock riprap aprons or reno mattress aprons;

    (c) Rock stilling basins;[19] and

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[18] HEC-14: *Hydraulic Design of Energy Dissipators for Culverts and Channels,* US Department of Transportation, 3rd edition, 2006. It provides an overview of erosion hazards and available dissipator designs together with design procedures for energy dissipator designs for highway applications.

[19] Rock riprap aprons, reno mattress aprons, stilling basins are forms of energy dissipation design implemented to reduce downstream channel erosion.

(d) Erosion control matting where necessary (i.e. coconut matting or turf reinforcement).[20]

72. The selection of a rock riprap apron or stilling basin has been based on the Froude Number.[21] The overall dimensions and rock sizing and impact structures are based on HEC-14.

73. Where **Ms Justine Quinn**, in consultation with the Project iwi partners, has recommended fish passage be provided, this is incorporated into the outlet structure as follows:

(a) where required to maintain sufficient low flow depth for fish passage, riprap aprons will be designed to provide a low flow stream passage.

(b) a riprap stilling basin will be used where required to maintain sufficient low flow depth for fish passage, including a low flow channel for fish through the downstream apron.

Stream diversions

74. There are 39 stream diversions proposed as part of the Project. Stream diversions have been designed in collaboration with the Project ecology team and have been determined based on the following key considerations:

(a) the stream is a small tributary of the main stream which does not have significant ecological or flora and fauna value;

(b) the stream itself may be intermittent and does not contain large flows;

(c) creating culverts for each stream diversion is impractical due to the proximity to the next culvert either upstream or downstream.

75. The following features have been incorporated into the design of the stream diversions to mitigate adverse downstream effects:

(a) stormwater is retained within the same overall catchment (i.e. stormwater will not move between catchments);

(b) diversion converges to the same stream further down, therefore, the overall downstream impact remains unchanged or minimal; and

(c) channel stabilisation is provided to convey normal flow and prevent channel erosion.

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[20] Erosion control matting can comprise natural or man-made fibres and fabrics. They are used to line the channel and to promote plant growth, providing landscape erosion protection.

[21] A Froude number is a dimensionless value that describes different energy regimes in open channels. This helps determine the type of energy dissipation that is required to minimise the effect on the receiving environment.

76. The three following types of stream diversion are proposed:

(a) Type 1, which permanently diverts lowland streams;

(b) Type 2, which permanently diverts steep streams; and

(c) Type 3, which permanently diverts an intermittent stream.

Major waterway crossings

77. The Project crosses two main waterways via bridge structures, the Manawatū River in the west (BR02) and the Mangamanaia Stream (BR07) in the East. In addition to these bridges, the Project includes an Eco Viaduct Bridge (BR03) that spans over an existing wetland area and Stream 7, a tributary of the Manawatū River.

78. The Project also includes crossings of two significant streams at CH7850 and CH13630, which are being conveyed under the main alignment by multi-cell culverts CU-08 and CU-18 respectively.

Cut-off drains, channels and subsoil drains

79. Approximately 9km of cut-off drainage channels are proposed along the Project. Overland flow (predominantly sheet flow) that approaches the State highway corridor is proposed to be managed by cut-off drains. Cut-off drains are open channels designed to intercept and convey overland flow naturally flowing towards the Project area. The following factors have been incorporated into the design of the cut-off drains:

(a) The drains will be constructed as grassed or rocklined trapezoidal open channels, as this type of channel profile maximises hydraulic capacity for a given width and mitigates erosion potential.

(b) The drains have been sized (on a preliminary basis) to capture and convey the 100-year ARI event without overtopping.

(c) The drains are designed to mimic the existing hydrological regime as much as possible to minimise impacts of cross-catchment flows by discharging to the nearest State highway cross-culvert. This is an important element of the proposed stormwater management system as the drains mitigate adverse flooding effects on adjacent property associated with overland flow entering or running alongside the State highway.

80. Preliminary cut-off drainage provisions proposed for the Project (including location, size and form) are shown on the stormwater design drawings TAT-3-DG-H-1401 to 1421 in **Volume III**.

81. Sealed debris channels will be provided along much of the alignment at the bottom of cut slopes to allow for conveyance of runoff from cut slopes and benches. The following allowances have been incorporated into the design:

    (a) debris can accumulate without impeding flow;

    (b) debris channels are separated from the adjacent drainage channels, which are designed to convey runoff from the road surface, to the downstream treatment wetlands; and

    (c) treatment is provided through sediment basins or dual forebay wetlands. These will capture and allow settlement of sediment from runoff and prevent large sediment loads from entering the sensitive receiving environment.

82. A comprehensive pavement subsoil drainage network (including herringbone drainage where longitudinal grades are greater than 4%) is proposed for the Project in accordance with the Transport Agency requirements, listed in **Appendix B.1**, to ensure pavement base layers remain dry and are adequately drained.

CONSTRUCTION EFFECTS

83. Constructability considerations have been incorporated in the proposed stormwater design through input from experienced drainage contractors who are skilled in construction of stormwater systems in sensitive environments. For full details of the construction methodology and considerations for the installation of the drainage components of the Project, refer to the DCR.

84. The key aspects of the design which will minimise sediment and erosion impacts on the environment during construction include:

    (a) Selection of concrete canvas as the hard-surfacing treatments on cut benches. This is the most practical and cost-effective solution which has been favoured over concrete lined or rock lined channels due to simpler and safer construction techniques and improved performance during operation in terms of erosion mitigation and reduced ongoing maintenance requirements.

    (b) Hard surfacing for debris zone and swale treatments in cuttings. This will enable trafficking of the swale and debris areas behind barriers in cutting whilst providing protection against erosion. Options considered for this surface included concrete, asphalt or chipseal over a granular base. Chipseal over a granular base was selected because it provides constructability and programme benefits by using the same construction techniques as the adjacent maintenance berm. The use of consistent construction techniques and plant will allow for faster and simpler construction.

(c) Construction of localised compacted fill with light plant to provide sufficient cover to protect the pipe, prior to trafficking with large equipment. This will reduce the risk of pipes being damaged after installation and the need to open up established areas to repair defective works.

85. Construction-specific erosion and sediment control is covered in **Mr Stewart's** technical assessment report.

86. The key aspects of the design which minimise construction effects on and around existing streams include:

(a) The location of culverts; where site constraints have allowed, culverts have been positioned off the alignment of the original stream to reduce impact on natural flow paths and stream ecology (and limit the amount of temporary stream diversions required) during construction. Cross culvert grades have also been flattened rather than following the steep natural gully profile which has allowed for culvert lengths to be shortened and for culverts to be more easily constructed, without culverts on steep grades.

(b) The proposed use of open channels for collection and conveyance of runoff from the carriageway and cut slopes wherever possible, to provide improved resilience and safety during operation and maintenance. Open channels can also reduce construction impacts associated with the alternative design option of underground piped systems, by reducing the volume of earthworks.

(c) Selection of pipe materials. For both network drainage and culverts, pipes of 450mm in diameter or less have been proposed as flexible civil boss (polypropylene construction) type pipes. These pipes are significantly lighter than the concrete alternative which mean that they can be transported and placed more easily, particularly in places where access is difficult.

(d) Timing of trenching activities. Generally, pipe design across site has not relied on trench embedment conditions. This has allowed the pipe installation activities to be programmed within the earthworks as the embankment fills come up and has reduced the need for deep trench excavations for pipe installation. Limiting the need for deep trench excavation across the site will enhance construction safety and speed of pipe installation, while reducing impacts on the environment associated with large cuttings and working platform areas for deep pipe excavations. An exception to this approach to trenching activities is culvert installation.

Horizons' One Plan

Rare, threatened or at-risk habitats

87. Five culverts (CU-07, CU-08A, CU-09, CU-14, CU-15), one treatment device (Wetland 03), and one stream diversion (SD-EC05-01) and six cut-off drains are located within rare or threatened Schedule F habitats.

88. These activities will require earthworks and vegetation clearance of these habitats, therefore a land use consent pursuant to s9(2), s13 and s14 of the RMA and Rule 13-9 of the One Plan is required.

89. The effects of the stormwater drainage works and associated earthworks footprint on the at-risk, rare or threatened habitat are addressed in **Mr Babers** Terrestrial Ecology Assessment.

Stormwater discharges

90. Stormwater discharges are considered under Chapter 14 (Discharges to Land and Water) of the One Plan. As noted above, the design of stormwater management devices (treatment and detention systems) has been undertaken in accordance with the Transport Agency Treatment Standard 2010.

91. Except for discharges within a rare, threatened, or at-risk habitat, all stormwater discharges from the treatment devices can comply with the permitted activity standards of Rule 14-18. Specifically:

    (a) Wetlands and wetland swales have been designed to provide peak flow attenuation, as noted in **Dr McConchie's** technical assessment report.

    (b) All wetland, wetland swale and TS05 outlets include rock riprap aprons in accordance with HEC-14 to protect the receiving environment from erosion.

    (c) The network drainage system has been designed to capture and convey runoff from the road surface during all events up to the 100-year ARI storm event without overtopping.

(d) All treatment devices meet the Transport Agency Treatment Standard 2010 (table 5-7 Stormwater Management Practices and Water Quantity/Quality Control) with a water quality capability rating of moderate or better.

92. Further detail on the effects of stormwater discharge on water quality is provided in **Mr Hamill's** technical assessment report.

Drainage and diversions

93. Apart from within a rare, threatened, or at-risk habitat, stream diversions and drainage activities are considered under Chapter 16 (Takes, Uses and Diversions of Water) of the One Plan.

94. There are approximately 390m of proposed drainage (as described in paragraphs 44 to 48) within rare and threatened Schedule F habitats and which therefore require an assessment under Rule 13-9. The remaining proposed drainage can comply with the permitted activity standards of Rule 16-11. All network drainage carrying runoff from the road will discharge to a treatment device and be treated before finally discharging to the environment.

95. There are 39 stream diversions which require assessment under Rule 16-12 of the One Plan. The stream diversions which do not comply with the permitted activity standards require resource consent pursuant to Rule 16-13. All stream diversions are more than 20m in length and unlikely to comply with condition (a)(iv) of Rule 16-12. In addition, the majority of diversions (36 of the 38) have culverts either upstream or downstream and therefore do not comply with condition (i) of Rule 16-12. Four of the stream diversions cannot comply with condition (b) of Rule 16-12 as they transport wetland swale discharge, which contains stormwater from new drainage. However, the effect downstream is minimal due to highway runoff being treated before being discharged.

96. The effects of stream diversions on freshwater ecology are covered in **Ms Quinn's** report.

Structures in streams

97. Apart from the five culverts (CU-07, CU-08A, CU-09, CU-14, CU-15) within a rare, threatened, or at-risk habitat, structures within watercourses require consideration under Chapter 17 (Activities in Beds of Rivers and Lakes) of the One Plan.

98. There are 20 cross culverts and 8 access culverts which require assessment under Rule 17-10 of the One Plan. Due to the length of the culverts, none of the culverts can comply with the permitted activity standards of Rule 17-10 and therefore require resource consents pursuant to Rule 17-23 as a discretionary activity. However, scour protection is provided for all culverts.

99. Fish passage is also provided for in all but nine culverts, being culverts CU-01, CU-02, CU-05, CU-06, CU-11, CU-14, CU-16, ACU-04 and ACU-08, which were found to contain no permanent upstream fish habitat or habitat of a sufficient quality to support fish populations. Refer to **Ms Quinn's** technical assessment report for details on how fish passage through culverts has been provided for, and the effects of the culverts and stream diversions on freshwater ecology.

PROJECT SHAPING AND AVOIDING AND MINIMISING EFFECTS

100. The proposed stormwater management for the Project have targeted avoidance and mitigation of the potential effects identified above.

101. Treatment and detention of stormwater runoff has been proposed in accordance with Horizons' Guidelines and the Transport Agency Treatment Standard 2010 to minimise adverse effects caused by runoff from existing and new impervious surfaces over the Project.

102. The management of stormwater throughout the Project is primarily achieved by a treatment train approach through the use of piped networks with sumps, conveyance channels, and treatment wetland and swales.

103. Discharge of stormwater through infiltration has been found to be largely unachievable on this Project due to local soil conditions having low permeability and a relatively high groundwater level in some areas. However, the use of longitudinal planted swales and stormwater wetlands to capture and manage runoff from impervious areas achieves an element of retention and groundwater recharge through infiltration.

104. Peak flow attenuation / detention has been provided for all state highway sub-catchments in accordance with Transport Agency Treatment Standard 2010, to minimise the effects of flooding and erosion downstream. In sub-catchments that drain directly to the Manawatū River, no peak flow attenuation is proposed, as these catchments' contribution to flooding in such a large river will be negligible.

105. In summary, the proposed stormwater management scheme for the Project includes:

(a) improving the current situation by treating 100% of the proposed State highway impervious area in accordance with the Transport Agency Treatment Standard 2010;

(b) providing for attenuation of peak flows for various storm events to manage flood impact on upstream and downstream environments;

(c) using planted wetlands and treatment swales for providing stormwater treatment, detention and attenuation for the Project;

(d) using wetlands as the primary type of stormwater management device, which along with appropriate planting can also buffer discharge water temperature;

(e) providing for the extended detention of stormwater runoff in all sub-catchments, and the provision of erosion protection measures (including rip-rap aprons and basins) at all new and modified stormwater outlets to manage stream channel erosion downstream;

(f) using planted swales where practicable to provide conveyance of stormwater flows and informal pre-treatment; and

(g) maintaining natural drainage paths and discharge points from the proposed State highway network drainage system where possible to minimise impacts associated with changes to the flow regime of the downstream natural environment.

106. Fish passage within culverts and proposed stream diversions has been designed in collaboration with the Project ecology team. Consideration has been given to the existing and future upstream habitat, site topography, fish species and flow velocity.

ASSESSMENT OF EFFECTS

107. The stormwater infrastructure will be designed to mitigate flooding effects of the Project on the wider catchment. However, the Project may result in the following stormwater related effects on the receiving environment:

(a) Less than minor impacts on water quality in the receiving environment are expected because of the Project once operational. In some instances, water quality is expected to improve because:

(i) all existing and proposed State highway runoff within the Project area will go through a treatment train; and

(ii) treatment infrastructure will provide peak flow attenuation where appropriate and extended detention to ensure peak runoff after completion of the Project does not exceed current levels.

(b) Potentially increased or decreased flow in receiving watercourses due to diversion of flows along the State highway. This change in flow downstream of the state highway, and in particular the diversion of flows between sub-catchments, will be managed in the following ways:

(i) where the flow increases, the treatment infrastructure will provide peak-flow attenuation whereby the maximum discharge at a given point will not exceed pre-development conditions; and

(ii) where the flow decreases, the natural character and environment sensitivity will be checked against the change in flow.

(c) Increased erosion and changes to stream geomorphology in receiving environments associated with State highway discharges will be managed by all outlet structures and culverts being designed to have energy dissipating structures or riprap, based on the design criteria explained above.

(d) Rock riprap will be placed at all the outlets to dissipate discharge velocity and energy. In addition, geotextiles will be provided as required to stabilise vegetation and minimise adverse effects on existing and proposed riparian planting,

(e) Restriction of the passage of aquatic species associated with changes to cross drainage infrastructure (culverts); this effect will be mitigated because fish passage is provided for in all watercourses recommended by **Ms Quinn**, as described in her technical assessment report.

(f) Increased water temperature downstream of the state highway discharges associated with additional impervious areas is mitigated by detention of water in proposed well-vegetated wetlands.

108. Mitigation measures have been proposed to address the potential environmental effect created by the Project. The following table summarises potential effects considered, as well as the mitigation proposed and expected residual effects.

Table B.3: Summary of Stormwater Related Residual Effects Assessment

Stormwater Related Residual Effects Assessment				
Item	**Potential Effects**	**Mitigation through Design**	**Relevant Report sections**	**Residual Effects**
Sediment runoff from cut-slopes	Siltation of proposed channels, degradation of stream water quality, affecting aquatic life.	Provision of sediment basins and dual forebay wetlands to capture and settle sediment before release into the environment.	Sections 17(c)(iii) & 81	*Minor* The discharge water quality will be higher. However, there will be sediment collected which will need to be disposed of.
Blockage of overland flow paths	Embankments associated with the Project and the proposed design alignment may block overland flow paths and cause damming effects.	Cut-off drains and stream diversions have been designed upstream of fill embankments to provide flow paths to culverts which have been designed to convey water under the road embankment.	Sections 23, 75, 79 & 91(c)	*Less than minor* Flow paths have been designed to match the existing situation wherever possible, and an assessment has been undertaken to confirm any heading up upstream of culverts will not cause any adverse flooding.
Increased runoff leading to scour	Potential for scour at outfall locations and in the receiving watercourses.	Localised energy dissipation and scour protections will be provided at all outfalls. This will take the form of riprap basins or aprons.	Sections 17(c), 60(d) & 71	*Less than minor* Energy dissipation and scour protection designed in accordance with HEC-14.
Discharge of contaminants	Contaminants collect on the road surface and are washed into the stormwater system and have a potential to harm habitat in the receiving environment if not treated.	Wetland, wetland swales and treatment swales will be provided adjacent to the proposed highway. Further detail of the treatment performance of these devices is covered in **Mr Hamill's** technical assessment report.	Sections 17(c), 49, 51 & 54	*Less than minor* On the basis that stormwater runoff from the proposed road surface and sections of existing road will be treated, there will be less than minor effects associated with contaminants from the road discharging uncontrolled into the receiving environment.

Stormwater Related Residual Effects Assessment				
Item	**Potential Effects**	**Mitigation through Design**	**Relevant Report sections**	**Residual Effects**
Flood water displacement	Fills and the highway may displace flood water and affect upstream and/or downstream flood levels.	Culverts have been designed so the water is contained within the designated boundary as much as practicable. Water may back up past the designation but should not be substantially more than the existing (pre-development) 1% AEP floodplain.	Sections 66, 67, 69 & 71	*Minor*

109. The proposed stormwater design will, as far as practicable, avoid, minimise or mitigate any residual effects. Any remaining residual effects are considered less than minor and will be managed under the proposed resource conditions.

CONCLUSION AND RECOMMENDATIONS

110. In accordance with the proposed resource consent conditions, the stormwater quantity mitigation devices (including for example, proposed flow attenuation devices, cut-off drains, culvert works and erosion protection at outfalls) will be designed to appropriately mitigate the potential surface water effects of the Project on the wider catchment.

111. The key stormwater quality mitigations, include:

(a) a treatment train approach to manage stormwater runoff from new and existing impervious areas across the Project, including dedicated at-source catchpit devices and planted swales for capture and conveyance of stormwater runoff, and planted wetlands as the primary treatment means for treating stormwater runoff from the Project; and

(b) water quality treatment to 75% TSS removal on a long-term average basis is provided for all existing and new impervious areas within the Project area. This is a significant improvement from the treatment that is currently being provided over the existing state highway network within the Project area.

112. Overall the proposed stormwater design, which includes constructed wetlands and swales, is appropriate for managing the stormwater runoff from the Project; the devices are appropriate to the rural context, and consistent with the skills and resources of the maintenance personnel. The effects of the Project on water quality are assessed in **Mr. Hamill's** technical assessment report.

113. The proposed stormwater system will be operated, inspected and maintained by a competent network operator chosen by the Transport Agency to ensure best practice is being followed for maintenance in accordance with the Transport Agency Treatment Standard 2010. The details and frequency of inspection and maintenance activities required by the network operator will be clearly set out in a comprehensive stormwater drainage operation and maintenance plan, which will be completed by the Transport Agency prior to commissioning of any stormwater management assets.

114. While this assessment has focused narrowly on assessing effects within the Project area, it will bring about a wider benefit by transferring virtually all through traffic from a currently untreated road to a fully treated road.

David Hughes

APPENDIX B.1: STORMWATER DESIGN STANDARDS AND GUIDELINES

The following documents and guidelines have been used in development of the stormwater design:

- Standard Specification P46 State Highway Stormwater Specification (NZTA, 2016)
- Stormwater Treatment Standard for State Highway Infrastructure (NZTA, 2010)
- Guide to Road Design (Part 5) (Austroads, 2017)
- Climate Change Projections for New Zealand: Atmosphere projections based on simulations from the IPCC Fifth Assessment, 2nd Edition. Wellington. Ministry for the Environment, 2018
- Fish passage guidance for state highways (NZTA, 2013)
- New Zealand Fish Passage Guidelines for Structures up to 4 metres (NIWA, 2018)
- Highway Surface Drainage A Design Guide for Highways with a Positive Collection System (NZTA, 1977)
- Technical Memorandum TM-2502: Preferred method for calculating road surface water run-off in New Zealand (NZTA, 2014)
- Part 630 Hydrology, National Engineering Handbook, Chapter 7 Hydrologic Soil Groups, Chapter 8 Treatment Classes, and Chapter 9 Hydrologic Soil-Cover Complexes (For use where NRCS (SCS) Curve Number Method is applied) (US NRCS)
- Part 654 Stream Restoration Design, National Engineering Handbook, Chapter 6 Stream Hydraulics, Chapter 7 Basic Principles of Channel Design, Chapter 8 Threshold Channel Design and Chapter 12 Channel Alignment and Variability (US NRCS, 2007)
- HEC-9, Debris Control Structures, Evaluation and Countermeasures (USDOT, 2005)
- HEC-11, Design of Riprap Revetment (Primarily Chapters 3 and 4 for riprap design options) (USDOT, 1989)
- HEC-14, Hydraulic Design of Energy Dissipaters for Culverts and Channels (USDOT, 2006)
- HEC-15, Design of Roadside Channels with Flexible Linings (USDOT, 2005)
- HEC-18, Evaluating Scour at Bridges (USDOT, 2012)
- HEC-20, Stream Stability at Highway Structures (USDOT, 2012)

- HEC-22, Urban Drainage Design Manual (USDOT, 2013)
- HEC-23, Bridge Scour and Stream Instability Countermeasures: Experience, Selection, and Design Guidance-Third Edition, Volumes 1 and 2 (USDOT, 2009)
- Bridge Scour (Melville and Coleman) (WRP, 2000)
- Various NZTA standard specifications for pipe culverts and subsoil drainage (NZTA)
- NCHRP 24-20, Estimation of Scour Depth at Bridge Abutments (NCHRP, 2010)
- Roughness Characteristics of New Zealand Rivers (NIWA / WRP, 1998)
- US Forest Service, TN102.2, Guidance for Stream Restoration and Rehabilitation (USDA, 2017)
- US Forest Service, R8-TP 16, Stream Habitat Improvement Handbook (Only to be used as a supplement to TN102.2) (USDA, 1992)
- Stream Habitat Restoration Guidelines (Washington State, 2012)
- Engineering Standards for Land Developments (3rd Edition) (PNCC, 2016)

APPENDIX B.2: CULVERT CATCHMENTS AND DESIGN CALCULATIONS SCHEDULE

MANAWATŪ TARARUA HIGHWAY CULVERTS

CULVERT ID	CHAINAGE (m)	CATCHMENT AREA (ha)	DESIGN FLOWS AND FREEBOARD					CULVERT CHARACTERISTICS									OUTLET AND ENERGY DISSIPATION			STREAM CATCHMENT
			10% AEP FLOW (m3/s)	1% AEP FLOW (m3/s)	1% AEP HEADWATER LEVEL (mRL)	MIN ROAD LEVEL AT INLET (mRL)	FREEBOARD (1% AEP)	SIZE (mm)	NO. OF BARRELS	LENGTH (m)	GRADIENT (%)	MAXIMUM COVER FROM SOFFIT (m)	PIPE MATERIAL	FISH SPECIES	FISH PASSAGE TREATMENT REQUIRED	INLET CONFIGURATION	OUTLET STRUCTURE	STRUCTURE LENGTH (m)	D50 (mm)	
CU-01	3390	6.7	0.6	1.4	77.3	78.2	0.9	900Ø	1	74	7.0%	3.1	RCRRJ PIPE HS2 SUPPORT, CLASS 4	NO FISH PASSAGE REQUIRED	N/A	HEADWALL (WW1050), SECONDARY INLET AND DEBRIS RACK	RIPRAP APRON	5	250	8A
CU-02	SH3 (NAPIER ROAD)	8.5	0.8	1.7	70.0	71.0	1.1	900Ø	1	59	13.7%	8.0	RCRRJ PIPE HS2 SUPPORT, CLASS 4	NO FISH PASSAGE REQUIRED	N/A	SCRUFFY DOME	RIPRAP APRON	5	350	8A
CU-03	4680	15.1	1.4	3.0	110.3	111.6	1.3	1200Ø	1	69	6.8%	5.6	RCRRJ PIPE HS2 SUPPORT, CLASS 6	CLIMBERS	EMBEDMENT (25% OF PIPE DIAMETER)	HEADWALL (WW1350) AND SECONDARY INLET	RIPRAP APRON	7	350	7B
CU-04	4530	6.7	0.6	1.4	285.0	289.4	4.3	1200Ø	1	86	0.9%	4.4	RCRRJ PIPE HS2 SUPPORT, CLASS 4	CLIMBERS	EMBEDMENT (25% OF PIPE DIAMETER)	HEADWALL (WW1350)	RIPRAP APRON	5	125	5B
CU-05	6800	16.9	1.6	3.4	285.4	288.9	3.5	1600Ø	1	90	9.0%	8.3	RCRRJ PIPE HS3 SUPPORT, CLASS 8	NO FISH PASSAGE REQUIRED	N/A	HEADWALL (WW1800) AND SECONDARY INLET	RIPRAP APRON	7	125	5B
CU-06	7100	1.4	0.1	0.3	284.6	288.9	4.3	750Ø	1	88	6.8%	8.9	RCRRJ PIPE HS3 SUPPORT, CLASS 6	NO FISH PASSAGE REQUIRED	N/A	HEADWALL (WW1050)	RIPRAP APRON	3	125	5B
CU-07	7330	20.4	1.9	4.1	269.7	287.3	17.6	1600Ø	1	179	7.2%	23.7	RCRRJ PIPE HS3 SUPPORT, CLASS 8	CLIMBERS	EMBEDMENT (25% OF PIPE DIAMETER)	HEADWALL (WW1800) AND DEBRIS RACK	RIPRAP APRON	7.2	150	5A
CU-08	7850	320.0	14.3	26.3	284.1	285.6	1.6	2000W X 2000H BOX CULVERT	3	71	1.9%	3.7	BOX CULVERT BEDDING IN ACCORDANCE WITH AS1597.1 2010	SWIMMERS	EMBEDMENT (25% OF PIPE DIAMETER)	HEADWALL AND DEBRIS RACK	RIPRAP APRON	16	550	4A
CU-08A	8670	3.8	0.2	0.5	297.8	300.6	2.8	900Ø	1	101	5.7%	5.4	RCRRJ PIPE HS2 SUPPORT, CLASS 6	CLIMBERS	EMBEDMENT (25% OF PIPE DIAMETER)	HEADWALL (WW1050)	RIPRAP APRON	4	125	4A
CU-09	8740	10.7	1.0	2.2	296.8	302.6	5.8	1200Ø	1	106	3.0%	7.3	RCRRJ PIPE HS2 SUPPORT, CLASS 6	CLIMBERS	EMBEDMENT (25% OF PIPE DIAMETER)	HEADWALL (WW1350)	RIPRAP APRON	5	125	4C
CU-10	8980	16.6	1.0	2.2	300.5	306.0	5.5	1350Ø	1	98	0.9%	7.6	RCRRJ PIPE HS2 SUPPORT, CLASS 4	CLIMBERS	EMBEDMENT (25% OF PIPE DIAMETER)	HEADWALL (WW1350)	RIPRAP APRON	5.4	125	4D
CU-11	9140	1.8	0.2	0.4	308.2	309.1	0.8	900Ø	1	59	5.5%	2.8	RCRRJ PIPE HS2 SUPPORT, CLASS 4	NO FISH PASSAGE REQUIRED	N/A	HEADWALL (WW1050)	RIPRAP APRON	3.6	125	4A
CU-12	9270	8.9	0.8	1.8	309.7	311.4	1.7	1050Ø	1	86	3.0%	5.3	RCRRJ PIPE HS2 SUPPORT, CLASS 6	CLIMBERS	EMBEDMENT (25% OF PIPE DIAMETER)	HEADWALL (WW1050) AND SECONDARY INLET	RIPRAP APRON	4	125	4E
CU-13	9530	3.0	0.3	0.6	316.1	317.2	1.0	750Ø	1	76	6.3%	5.2	RCRRJ PIPE HS2 SUPPORT, CLASS 4	CLIMBERS	EMBEDMENT (25% OF PIPE DIAMETER)	HEADWALL (WW1050) AND SECONDARY INLET	RIPRAP APRON	3.0	125	4F
CU-14	9970	2.3	0.2	0.5	309.1	316.5	7.4	900Ø	1	112	11.6%	13.0	RCRRJ PIPE HS3 SUPPORT, CLASS 6	NO FISH PASSAGE REQUIRED	N/A	HEADWALL (WW1050) AND DEBRIS RACK	RIPRAP APRON	4	125	3A
CU-15	10200	5.2	0.5	1.0	287.9	306.0	18.1	1200Ø	1	127	2.9%	18.6	RCRRJ PIPE HS3 SUPPORT, CLASS 6	CLIMBERS	EMBEDMENT (25% OF PIPE DIAMETER)	HEADWALL (WW1350) AND DEBRIS RACK	RIPRAP APRON	5	125	3A
CU-16	10950	1.9	0.2	0.4	242.3	245.2	2.9	750Ø	1	88	7.0%	6.0	RCRRJ PIPE HS2 SUPPORT, CLASS 4	NO FISH PASSAGE REQUIRED	N/A	SCRUFFY DOME	RIPRAP APRON	3.0	125	3B
CU-17	11600	5.5	0.5	1.1	183.7	188.8	5.1	1200Ø	1	130	15.2%	11.5	RCRRJ PIPE HS2 SUPPORT, CLASS 6	CLIMBERS	EMBEDMENT (25% OF PIPE DIAMETER)	HEADWALL (WW1350)	RIPRAP BASIN	5	150	2C
CU-17A	13050	123.2	5.1	8.5	84.4	87.2	2.8	900Ø	1	56	0.9%	2.6	RCRRJ PIPE HS2 SUPPORT, CLASS 4	SWIMMERS	EMBEDMENT (25% OF PIPE DIAMETER)	HEADWALL (WW1050)	RIPRAP APRON	7.2	550	2B
CU-17B	13570	6.5	0.3	0.7	81.2	84.8	3.6	900Ø	1	44	1.0%	1.2	RCRRJ PIPE HS2 SUPPORT, CLASS 4	SWIMMERS	EMBEDMENT (25% OF PIPE DIAMETER)	HEADWALL (WW1050)	RIPRAP APRON	4	125	1B
CU-18	13750	55.0	3.2	5.8	82.5	84.0	1.5	1500Ø	2	52	0.5%	1.8	RCRRJ PIPE HS2 SUPPORT, CLASS 4	SWIMMERS	EMBEDMENT (25% OF PIPE DIAMETER)	HEADWALL (WW1800)	RIPRAP APRON	9.0	350	1B
CU-18A	WOODVILLE ROUNDABOUT	56.7	3.2	5.8	81.7	82.5	0.8	1500Ø	2	35	0.5%	1.2	RCRRJ PIPE HS2 SUPPORT, CLASS 4	SWIMMERS	EMBEDMENT (25% OF PIPE DIAMETER)	HEADWALL (WW1800)	RIPRAP APRON	9.0	350	1B
CU-18B	WOODVILLE ROUNDABOUT	10.3	0.5	1.1	80.9	81.6	0.7	1050Ø	1	25	0.4%	0.7	RCRRJ PIPE HS2 SUPPORT, CLASS 4	SWIMMERS	EMBEDMENT (25% OF PIPE DIAMETER)	HEADWALL (WW1050)	RIPRAP APRON	4.2	125	1A
CU-19	WOODVILLE ROUNDABOUT	9.4	0.5	1.0	81.7	83.1	1.4	1050Ø	1	31	0.6%	1.2	RCRRJ PIPE HS2 SUPPORT, CLASS 4	SWIMMERS	EMBEDMENT (25% OF PIPE DIAMETER)	HEADWALL (WW1050)	RIPRAP APRON	4.2	125	1A
CU-20	WOODVILLE ROUNDABOUT	35.8	1.0	2.2	83.4	84.4	1.0	1350Ø	1	30	0.8%	1.4	RCRRJ PIPE HS2 SUPPORT, CLASS 4	SWIMMERS	EMBEDMENT (25% OF PIPE DIAMETER)	HEADWALL (WW1350) AND DEBRIS RACK	RIPRAP APRON	5.4	150	1A

ACCESS TRACK CULVERTS

CULVERT ID	CHAINAGE (m)	CATCHMENT AREA (ha)	DESIGN FLOWS AND FREEBOARD					CULVERT CHARACTERISTICS									OUTLET AND ENERGY DISSIPATION			STREAM CATCHMENT
			10% AEP FLOW (m3/s)	1% AEP FLOW (m3/s)	10% AEP HEADWATER LEVEL (mRL)	MIN ROAD LEVEL AT INLET (mRL)	FREEBOARD (10% AEP)	SIZE (mm)	NO. OF BARRELS	LENGTH (m)	GRADIENT (%)	MAXIMUM COVER FROM SOFFIT (m)	PIPE MATERIAL	FISH SPECIES	FISH PASSAGE TREATMENT REQUIRED	INLET CONFIGURATION	OUTLET STRUCTURE	STRUCTURE LENGTH (m)	D50 (mm)	
ACU-01	RHS 3220 (UNDERPASS ACCESS TRACK)	7.4	0.7	1.5	75.5	76.8	1.3	750Ø	1	12	7.3%	1.9	RCRRJ PIPE HS2 SUPPORT, CLASS 4	CLIMBERS	EMBEDMENT (25% OF PIPE DIAMETER)	HEADWALL (WW1050)	RIPRAP APRON	3.8	250	8A
ACU-03	RHS 6920 (MERIDIAN ACCESS TRACK)	31.3	2.9	6.3	247.3	255.2	7.9	1200Ø	1	89	5.1%	10.2	RCRRJ PIPE HS2 SUPPORT, CLASS 6	CLIMBERS	EMBEDMENT (25% OF PIPE DIAMETER)	HEADWALL (WW1350)	RIPRAP BASIN	9.2	150	5B
ACU-04	RHS 6980 (MERIDIAN ACCESS TRACK)	4.4	0.4	0.9	254.9	262.1	7.2	750Ø	1	80	5.6%	8.5	RCRRJ PIPE HS2 SUPPORT, CLASS 6	NO FISH PASSAGE REQUIRED	N/A	HEADWALL (WW1050)	RIPRAP APRON	3.0	125	5B
ACU-05	RHS 7750 (MERIDIAN ACCESS TRACK)	347.7	14.5	26.7	280.9	281.5	0.6	2000W X 2000H BOX CULVERT	2	26	0.4%	0.7	BOX CULVERT BEDDING IN ACCORDANCE WITH AS1597.1 2010	SWIMMERS	EMBEDMENT (25% OF PIPE DIAMETER)	HEADWALL	RIPRAP APRON	16.0	550	4A
ACU-05A	RHS 7990 (MERIDIAN ACCESS TRACK)	32.9	1.8	3.9	286.5	286.9	0.4	1050Ø	1	28	3.1%	1.3	RCRRJ PIPE HS2 SUPPORT, CLASS 4	CLIMBERS	EMBEDMENT (25% OF PIPE DIAMETER)	HEADWALL (WW1050)	RIPRAP APRON	5.3	250	4B
ACU-06	RHS 8230 (COOK ROAD ACCESS TRACK)	19.0	1.8	3.8	291.0	291.7	0.7	1050Ø	1	32	1.1%	0.6	RCRRJ PIPE HS2 SUPPORT, CLASS 4	CLIMBERS	EMBEDMENT (25% OF PIPE DIAMETER)	HEADWALL (WW1050)	RIPRAP APRON	5.3	250	4b
ACU-07	RHS 10230 (AG RESEARCH ACCESS TRACK)	19.2	1.2	2.5	285.7	288.5	2.8	1350Ø	1	27	5.5%	4.1	RCRRJ PIPE HS2 SUPPORT, CLASS 6	CLIMBERS	EMBEDMENT (25% OF PIPE DIAMETER)	HEADWALL (WW1350)	RIPRAP APRON	5.4	125	3A
ACU-08	LHS 10220 (AG RESEARCH ACCESS TRACK)	0.4	0.0	0.1	295.7	297.1	1.4	600Ø	1	13	13.2%	1.4	RCRRJ PIPE HS2 SUPPORT, CLASS 4	NO FISH PASSAGE REQUIRED	N/A	SCRUFFY DOME	USBR VI IMPACT BASIN	2.0	N/A	3A

NOTES

1. THE DETAILS AND DIMENSIONS SHOWN ARE INDICATIVE AND WILL BE REFINED AS THE DETAIL DESIGN IS DEVELOPED.
2. A MINIMUM PIPE CLASS OF 4 HAS BEEN ASSUMED FOR ALL RCRRJ PIPES.
3. A MINIMUM PIPE SIZE OF 750mm DIAMETER HAS BEEN ASSUMED FOR PIPE CULVERTS UNDER THE STATE HIGHWAY IN ACCORDANCE WITH AUSTROADS PART 5B. THIS IS TO MITIGATE POTENTIAL BLOCKAGE AND PROVIDE IMPROVED SAFETY FOR MAINTENANCE ACTIVITIES.
4. A MINIMUM BEDDING TYPE OF HS2 WILL BE PROVIDED FOR CIRCULAR PIPE CULVERTS, WHERE BEDDING CLASS HS3 WILL BE CONSIDERED FOR FILL HEIGHTS GREATER THAN 8m.
5. BEDDING FOR BOX CULVERTS WILL BE IN ACCORDANCE WITH AS1597.1 2010.
6. WHERE CULVERT LENGTHS EXCEED 120m AND FISH PASSAGE IS REQUIRED, A MINIMUM PIPE SIZE OF 1200mm DIAMETER HAS BEEN PROVIDED FOR IMPROVED ACCESS FOR MAINTENANCE ACTIVITIES.
7. WHERE CULVERTS REQUIRE EMBEDMENT FOR FISH PASSAGE, 25% OF CULVERT DIAMETER HAS BEEN ASSUMED TO BE EMBEDDED IN ACCORDANCE WITH NEW ZEALAND FISH PASSAGE GUIDELINES 2018.
8. ENERGY DISSIPATION STRUCTURES / OUTLETS HAVE BEEN SPECIFIED AND DESIGNED IN ACCORDANCE WITH HEC-14 FOR THE 1% AEP EVENT.
9. DEBRIS POTENTIAL OF CULVERTS ARE BASED ON HEC-9 GUIDELINES AND DEBRIS CONTROL MEASURES HAVE BEEN SIZED IN ACCORDANCE WITH HEC-9 FOR THE 1% AEP EVENT.
10. ALL ACCESS TRACK CULVERTS HAVE BEEN DESIGNED TO CONVEY THE 10% AEP STORM EVENT AND A PRELIMINARY ASSESSMENT HAS BEEN UNDERTAKEN TO ENSURE NO FLOODING UPSTREAM OR DOWNSTREAM OF THE CULVERTS WILL OCCUR IN ALL EVENTS, WHERE IT HAS BEEN DEEMED ACCEPTABLE FOR ACCESS TRACKS TO OVERTOP IN EVENTS EXCEEDING 10% AEP. MEASURES WILL BE PROVIDED TO MITIGATE POTENTIAL EROSION / PAVEMENT IMPACTS.
11. FISH SPECIES AND FISH PASSAGE TREATMENT INFORMATION HAS BEEN PROVIDED BY THE ECOLOGY TEAM, BASED ON THEIR ECOLOGICAL ASSESSMENT AND SURVEY.

STREAM DIVERSIONS											
STREAM DIVERSION ID	CATCHMENT AREA (ha)	AVERAGE CHANNEL SLOPE	50% AEP FLOW (m3/s)	1% AEP FLOW (m3/s)	CHANNEL LENGTH (m)	CHANNEL TYPE	CHANNEL DIMENSION				STREAM TRIBUTARY
							BASE WIDTH (m)	DEPTH (m)	SIDE SLOPE (1V:_H)	TOP WIDTH (m)	
SD-AC01-05	1.7	0.9%	0.1	0.4	60	TYPE 3	1	0.6	2	3.5	8A
SD-AC01-04	44	10%	1.6	6.8	805	TYPE 1	1.5	0.9	2	5.1	8A
SD-MC01-03	6.7	0.5%	0.4	2.1	130	TYPE 3	1.5	1.0	2	5.5	8A
SD-EC05-01	107	11%	3.1	11.5	55	TYPE 3	2	1.0	2	6.0	7C
SD-MC03-05	17	6%	0.9	3.4	625	TYPE 2	1.5	0.8	2	4.6	7B
SD-MC03-08	2.8	8%	0.1	0.6	520	TYPE 3	1	0.5	2	3.0	7B
SD-MC03-01	4.3	7%	0.2	0.6	195	TYPE 2	1.5	0.5	2	3.4	7B
SD-MC03-09	3.8	12%	0.2	0.8	165	TYPE 2	1.5	0.5	2	3.4	7B
SD-MC05-01	11	13%	0.6	2.3	475	TYPE 2	1.5	0.6	2	4.0	5B
SD-MC05-03	5.2	8%	0.3	1.1	340	TYPE 3	1	0.6	2	3.3	5B
SD-AC03-02	28	15%	1.5	5.6	280	TYPE 2	1.5	0.8	2	4.7	5B
SD-AC04-01	3.9	29%	0.2	0.8	95	TYPE 3	1	0.5	2	2.9	5B
SD-MC07-02	11	9%	0.6	2.2	40	TYPE 2	1.5	0.6	2	4.1	5A
SD-MC07-03	1.4	19%	0.1	0.3	95	TYPE 3	1	0.4	2	2.6	5A
SD-MC07-05	20	0.5%	1.1	4.1	25	TYPE 2	2	1.2	2	6.8	5A
SD-AC05A-01	41	2%	2.2	9.8	290	TYPE 1	2	1.2	2	6.9	4B
SD-AC05-01	45	2%	2.4	12.7	140	TYPE 1	2	1.4	2	7.8	4B
SD-AC05-02	46	1%	2.5	14.3	65	TYPE 1	2	1.7	2	8.7	4A
SD-AC06-02	15	0.9%	0.8	3.1	65	TYPE 2	1.5	1.0	2	5.7	4B
SD-MC09-03	11	2%	0.6	2.2	30	TYPE 2	1.5	0.8	2	4.7	4C
SD-MC10-03	59	4%	2.2	7.7	310	TYPE 2	2	1.0	2	6.1	4A
SD-MC11-03	1.8	4%	0.1	0.4	30	TYPE 3	1	0.5	2	3.0	4A
SD-MC10-04	16	9%	0.6	2.1	760	TYPE 2	1.5	0.6	2	4.0	4D
SD-MC13-02	2.9	16%	0.2	0.6	170	TYPE 3	1	0.5	2	2.9	4F
SD-MC13-05	3.5	0.8%	0.2	0.7	60	TYPE 3	1	0.7	2	3.8	4F
SD-MC16-04	2.3	12%	0.1	3.9	115	TYPE 3	1	0.8	2	4.2	3B
SD-MC17-05	7.5	21%	0.4	1.5	225	TYPE 2	1.5	0.5	2	3.6	2C
SD-MC17-01	4.5	24%	0.2	0.9	395	TYPE 2	1	0.5	2	3.0	2C
SD-DS20-01	4.3	7%	0.2	0.9	340	TYPE 2	1.5	0.5	2	3.6	2E
SD-MC17A-02	11	0.1%	0.3	1.1	165	TYPE 1	1.5	1.0	2	5.4	2B
SD-MC17B-02	6.5	1%	0.4	1.3	20	TYPE 3	1	0.8	2	4.3	1B
SD-MC18A-01	56	1%	3.0	11.5	95	TYPE 1	2	1.5	2	8.2	1B
SD-MC18-01	36	1%	2.0	7.5	145	TYPE 1	2	1.3	2	7.3	1B
SD-MC18-02	14	1%	0.8	3.1	190	TYPE 1	1.5	1.0	2	5.6	1A
SD-MC18-03	4.4	1%	0.2	0.6	110	TYPE 1	1.5	0.6	2	3.9	1A
SD-MC18B-01	4.5	1%	0.2	1.8	160	TYPE 3	1	0.9	2	4.7	1A
SD-MC19-01	4.1	1%	0.2	1.2	205	TYPE 3	1	0.8	2	4.3	1A
SD-MC20-01	1.5	1%	0.1	0.3	55	TYPE 3	1	0.6	2	3.2	1A
SD-MC20-02	6.9	1%	0.3	0.9	60	TYPE 1	1.5	0.7	2	4.2	1A

APPENDIX B.3: STORMWATER MANAGEMENT DEVICE CATCHMENTS AND DESIGN CALCULATIONS

MANAWATŪ TARARUA HIGHWAY STORMWATER MANAGEMENT DEVICES																	
STORMWATER MANAGEMENT DEVICE REFERENCE	TYPE	LOCATION OR CHAINAGE(m)	STORMWATER MANAGEMENT PROPOSED			CONTRIBUTING CATCHMENT AREA (ha)	DESIGN VOLUME (m3)			DESIGN FLOW (m3/s)		VOLUME (m3) OR LENGTH (m)		100 YEAR ARI BYPASS PIPE PROVIDED	METHOD OF DISCHARGE: OUTFALL TYPE AND SIZE	EMERGENCY SPILLWAY PROVIDED	DISCHARGE LOCATION (STREAM ID)
			TREATMENT	EXTENDED DETENTION	10 YEAR ARI ATTENUATION		WQV	EDV	10% AEP	WQ FLOW	10% AEP FLOW	REQUIRED	PROVIDED				
WETLAND W01		2960 (LHS)	YES	YES	YES	2.2	331	397	1034	N/A	0.55	1366 m3	1640 m3	NO	975mm RCP WITH HEADWALL WITH RIPRAP	NO	PROPOSED TREATMENT SWALE TS02
WETLAND W02		3400 (LHS)	YES	NO	NO	2.2	341	N/A	N/A	N/A	0.56	341 m3	750 m3	YES	525mm RCP WITH HEADWALL WITH RIPRAP	YES	MANAWATŪ RIVER
WETLAND W03		3900 (LHS)	YES	YES	NO	1.2	190	228	N/A	N/A	0.31	418 m3	505 m3	YES	525mm RCP WITH HEADWALL WITH RIPRAP	YES	MANAWATŪ RIVER
WETLAND W04		4600 (RHS)	YES	YES	YES	4.1	623	747	1945	N/A	1.03	2568 m3	3085 m3	YES	825mm RCPWITH HEADWALL WITH RIPRAP	YES	PROPOSED STREAM DIVERSION TO 7B
WETLAND W05	WETLAND	5660 (RHS)	YES	YES	YES	6.8	1040	1248	3248	N/A	1.72	4288 m3	5150 m3	YES	900mm RCP WITH HEADWALL WITH RIPRAP	YES	7A
WETLAND W06		8300 (RHS)	YES	YES	NO	2.7	409	491	N/A	N/A	0.68	901 m3	1085 m3	YES	825mm RCP WITH HEADWALL WITH RIPRAP	YES	PROPOSED STREAM DIVERSION TO 4A
WETLAND W07		10900 (RHS)	YES	YES	YES	7.2	1094	1312	3417	N/A	1.81	4510 m3	5415 m3	YES	975mm RCP WITH HEADWALL WITH RIPRAP	YES	3B
WETLAND W08		12380 (RHS)	YES	YES	YES	5.3	805	966	2515	N/A	1.33	3319 m3	3985 m3	YES	975mm RCP WITH HEADWALL WITH RIPRAP	NO	2E
WETLAND W09		12800 (LHS)	YES	YES	NO	1.9	289	346	902	N/A	0.48	635 m3	765 m3	YES	675mm RCP WITH HEADWALL WITH RIPRAP	YES	2C
WETLAND SWALE WS01		3900 (RHS)	YES	YES	NO	3.4	512	614	N/A	N/A	0.85	1126 m3	1355 m3	NO	750mm RCP WITH HEADWALL WITH RIPRAP	NO	4A
WETLAND SWALE WS02		7860 - 8160 (LHS)	YES	YES	NO	1.6	247	296	N/A	N/A	0.41	543 m3	655 m3	NO	600mm RCP WITH HEADWALL WITH RIPRAP	NO	4A
WETLAND SWALE WS03		8780 - 8920 (LHS)	YES	YES	YES	3.7	557	668	1740	N/A	0.92	2297 m3	2760 m3	NO	600mm RCP WITH HEADWALL WITH RIPRAP	YES	4A
WETLAND SWALE WS04		12920 - 13060 (RHS)	YES	YES	NO	0.6	91	109	N/A	N/A	0.15	199 m3	240 m3	NO	375mm RCP WITH HEADWALL WITH RIPRAP	YES	2B
WETLAND SWALE WS05	WETLAND SWALE	13430 - 13560 (RHS)	YES	YES	YES	1.4	218	262	682	N/A	0.36	901 m3	1080 m3	NO	450mm RCP WITH HEADWALL WITH RIPRAP	YES	1B
WETLAND SWALE WS06		13600 - 13720 (LHS)	YES	YES	YES	0.3	50	60	156	N/A	0.08	205 m3	250 m3	NO	375mm RCP WITH HEADWALL WITH RIPRAP	YES	1B
WETLAND SWALE WS07		WOODVILLE ROUNDABOUT	YES	YES	YES	0.9	142	170	443	N/A	0.23	585 m3	705 m3	NO	375mm RCP WITH HEADWALL WITH RIPRAP	YES	1B
WETLAND SWALE WS08		WOODVILLE ROUNDABOUT	YES	YES	YES	0.8	150	180	469	N/A	0.25	477 m3	575 m3	NO	375mm RCP WITH HEADWALL WITH RIPRAP	YES	1A
WETLAND SWALE WS09		WOODVILLE ROUNDABOUT	YES	YES	YES	0.6	86	104	270	N/A	0.14	356 m3	430 m3	NO	375mm RCP WITH HEADWALL WITH RIPRAP	YES	1A
WETLAND SWALE WS10		WOODVILLE ROUNDABOUT	YES	YES	YES	0.8	126	152	394	N/A	0.21	521 m3	630 m3	NO	375mm RCP WITH HEADWALL WITH RIPRAP	YES	1B
TREATMENT SWALE TS01		ASHHURST	YES	NO	NO	0.22	N/A	N/A	N/A	0.009	N/A	30 m	30 m	N/A	ROCK RIPRAP	NO	EXISTING SMALL STREAM
TREATMENT SWALE TS02		ASHHURST ROUNDABOUT	YES	NO	NO	0.35	N/A	N/A	N/A	0.015	N/A	35 m	460 m	N/A	ROCK RIPRAP	NO	EXISTING SMALL STREAM
TREATMENT SWALE TS03		ASHHURST ROUNDABOUT	YES	NO	NO	0.35	N/A	N/A	N/A	0.015	N/A	35 m	122 m	N/A	ROCK RIPRAP	NO	EXISTING SMALL STREAM
TREATMENT SWALE TS04		ASHHURST ROUNDABOUT	YES	NO	NO	0.67	N/A	N/A	N/A	0.033	N/A	55 m	270 m	N/A	ROCK RIPRAP	NO	EXISTING SMALL STREAM
TREATMENT SWALE TS05	TREATMENT SWALE	4260 - 4600 (RHS)	YES	NO	NO	2.2	N/A	N/A	N/A	0.094	N/A	240 m	275 m	N/A	375mm RCP WITH HEADWALL WITH RIPRAP	NO	7A
TREATMENT SWALE TS06		13400 - 13560 (LHS)	YES	NO	NO	0.25	N/A	N/A	N/A	0.011	N/A	40 m	188 m	N/A	375mm RCP WITH HEADWALL WITH RIPRAP	NO	PROPOSED STREAM DIVERSION
TREATMENT SWALE TS07		13590 - 13680 (RHS)	YES	NO	NO	0.20	N/A	N/A	N/A	0.008	N/A	45 m	110 m	N/A	ROCK RIPRAP	NO	PROPOSED STREAM DIVERSION
TREATMENT SWALE TS08		3500 (LHS)	YES	NO	NO	0.15	N/A	N/A	N/A	0.006	N/A	35 m	54 m	N/A	375mm RCP TO CU-02	NO	MANAWATŪ RIVER
TREATMENT SWALE TS09		3500 (LHS)	YES	NO	NO	0.19	N/A	N/A	N/A	0.008	N/A	35 m	50 m	N/A	375mm RCP TO CU-02	NO	MANAWATŪ RIVER
TREATMENT SWALE TS10		3500 (LHS)	YES	NO	NO	0.12	N/A	N/A	N/A	0.005	N/A	31 m	35 m	N/A	375mm RCP TO CU-02	NO	MANAWATŪ RIVER

NOTES:

1. THE DETAILS AND SIZING SHOWN ARE INDICATIVE AND WILL BE REFINED AS THE DETAILED DESIGN IS DEVELOPED.
2. FOR STORMWATER TREATMENT DEVICE LOCATION REFER TO DRAWINGS TAT-3-DG-H-1401 TO 1421.
3. FOR STORMWATER TREATMENT DEVICE CONTRIBUTING CATCHMENT AREAS REFER TO DRAWINGS TAT-3-DG-H-1434 TO 1439.
4. WHERE NO EMERGENCY SPILLWAY IS PROVIDED, OVERSIZED SERVICE OUTLET IS PROVIDED TO ACCOMMODATE FOR ADDITIONAL FLOW.
5. CONTRIBUTING CATCHMENT AREA CONSISTS OF BOTH PERVIOUS AND IMPERVIOUS AREAS.
6. REINFORCED CONCRETE PIPE (RCP) IS USED FOR ALL OUTLET PIPES.
7. THE PEAK FLOW ATTENUATION FOR EVENTS UP TO 10% AEP STORM EVENT HAS BEEN CONSIDERED. THIS IS BASED ON THE ASSESSMENT UNDERTAKEN BY DR McCONCHIE, WHERE IN THE WIDER HYDROLOGICAL SETTING, ANY STORM EVENT GREATER THAN 10% AEP WILL BEHAVE IN THE SAME MANNER AS THE EXISTING SLOPES AND THE PROJECT WILL NOT CAUSE ANY INCREASED FLOOD RISK DOWNSTREAM.