APPENDIX C

Waitarere Beach Road Curves Project
Stormwater Design Report

Prepared for The New Zealand Transport Agency

November 2015

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BUILDING A BETTER WORLD

QUALITY STATEMENT

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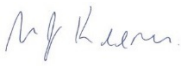
Nick Keenan		31/07/2015
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Executive Summary

This report describes the stormwater preliminary design for the Waitarere Beach Road Curves Project (the Project) which is part of the Otaki to north of Levin section of the Wellington Northern Corridor Roads of National Significance (RoNS) programme.

Stormwater management by road drainage, stream erosion control and stormwater quality management have been included in the Project generally in accordance with the New Zealand Transport Agency's (the Transport Agency) Environmental and Social Responsibility Standard (Z/19) for new project works. There may be opportunities for the use of soakage systems for stormwater management, once further specific soakage information is obtained and confirmation of this mechanism should be included within the final design investigations.

The main stormwater management solutions presented in this document relate to the characteristics of the receiving environment immediately downstream of the Project area. From a stormwater management perspective the receiving environment characteristics and the solutions are:

- The ecological assessment has confirmed that the majority of the Project site has low ecological values, however there are some areas of ecological value, including at risk species and threatened habitats, particularly the waterways.
- From consultation undertaken as part of the Project, there are no major existing flooding issues upstream or downstream of the project area and it is a rural catchment, therefore no specific flood flow detention is required.
- The four downstream receiving environments are considered high priority receiving systems regarding water quality in terms of the Transport Agency's *Stormwater Treatment Standard for State Highway Infrastructure*, therefore stormwater treatment is required.
- Three ponds are proposed to provide extended detention volume to two out of the four downstream receiving environments. This is to prevent channel erosion effects due to the increased water runoff from the proposed (increased) road surface area. Two downstream receiving environments are not considered to be at risk of channel erosion from the proposed works.
- Of the four downstream receiving environments, ecological assessment identifies three as having suitable mudfish habitat and mudfish have been trapped and sighted on site. (Reference MWH report, *Waitarere Beach Road Curves Project Ecological Assessment, November 2015*).
- The ecological assessment seeks to ensure that adverse impacts on aquatic ecology are kept to a practicable minimum. In terms of stormwater assessment, the ecological approach appears able to be incorporated within the bounds of normal best practice design and construction.
- Approximately 2,200 m length of environmental swale throughout the length of the highway realignment is the main water quality treatment mechanism.
- Cross drainage is provided by culverts sized to pass the 100 year flow and restricting flow depths to at least 500mm below the edge of the carriageway.

Following RMA approvals, further work and information will be required in order to finalise the detailed design. This includes:

- Detailed survey including of existing hydraulic structures
- Geotechnical soil assessment and soakage assessment
- Additional ecological advice
- Finalised road design
- Consideration of opportunities for soakage if primary drainage should be changed
- Inspection and maintenance considerations such as access and monitoring
- Finalised landscape/urban design.

The proposed design provides for enhanced water quality and improved ecological conditions in this part of the State Highway network, as well as opportunities for additional planting (including some swale and pond plantings) to increase ecological values in the immediate area.

New Zealand Transport Agency
Waitarere Beach Road Curves Project

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1 Introduction

1.1 Background and Objectives

The stormwater management provisions for mitigation of flood flows, stream erosion control and stormwater quality management have been included within the realignment design based on the New Zealand Transport Agency's (the Transport Agency) Environmental and Social Responsibility Standard (z/19) for new project works.

This report summarises the stormwater preliminary design for the project. The Waitarere Beach Road Curves Project (the Project) was conceived to improve vehicle safety at a curved section of SH1 in the vicinity of Waitarere Beach Road and Paeroa Road. The main objectives of the proposed preliminary design are to:

1. Provide a drainage design that meets the Transport Agency drainage and safety standards and local rules and policy provisions.
2. Prevent causing or exacerbating flooding.
3. Prevent causing or exacerbating stream erosion.
4. Managing the potential water quality impacts from the project.

2 Project Description

2.1 Description

The Project is part of the Otaki to north of Levin section of the Wellington Northern Corridor Roads of National Significance (RoNS) programme. The project area is approximately 7 km north of the centre of Levin.

It is proposed to improve the State Highway (SH1) defined between project chainage 5100 and 7820, by:

- Replacing the three existing curves with two curves;
- Increasing the radii of the curves to improve the alignment of the road;
- Widening the highway cross section to provide a median strip and wider shoulders (tapering in to connect to the sections of highway outside the project area);
- Providing a wire rope median barrier within the median strip;
- Providing wire rope barriers on the outer edge of the hard shoulder (this does not include across private accessways);
- Improving the layout of, and visibility at, the Waitarere Beach Road/SH1 intersection;
- Improving the layout of, and visibility at, the Clay Road/SH1 intersection; and
- Closing the Paeroa Road intersection with SH1, and providing a new connection which connects to SH1 at Hinaupiopio.

Minor road widening is also provided further north in the vicinity of Poroutawhao School[1].

The project will require significant earthworks in sections where there is undulating topography. Improvements to the stormwater management will also be made with new engineered swales and stormwater ponds at key locations, the installation of new culverts for the realigned sections and the upgrade of existing culverts where the existing SH1 alignment will be retained.

This report relates to the long term provision of the stormwater management for the Waitarere Beach Curves Project. The additional temporary drainage and sediment and erosion control during the construction stage is addressed separately (see the report in Appendix D, Volume II, of the Notice of Requirement documentation).

2.2 Project Inputs

Inputs for the drainage aspects of the design include:

1. LiDAR ground elevation data over a 200 m wide corridor along the project length provided by the Transport Agency.
2. LiDAR ground elevation data over a 3000 m wide corridor along the project length provided by Horizons Regional Council.
3. NIWA River Catalogue catchment information and 20m contour interval catchment topography.
4. Preliminary geometric road design indicating alignment, width, road cross fall, longitudinal grades and elevations, proposed swales and corridor widths (last version May 2015).
5. Site visit inspection information indicating existing drainage and land forms.
6. Preliminary Geotechnical assessment of the area.

In order to finalise the detailed design, detailed level survey and geotechnical soil assessment (soakage investigation) will be needed.

[1] Because of the small scale of works involved in this area, stormwater management will be addressed here as part of detailed design.

2.3 Existing land drainage

Close inspection of LiDAR data, current road alignment features and a site walkover have identified four main sections of the project – each section drains into a separate receiving environment. The Sections are labelled 1 to 4 and represent lengths of the project between proposed high points in the proposed design (see catchment plan Figure 2-3: Drainage paths and catchment areas):

- Section 1 chainage 5100 m to 5600 m (high point road alignment design)
- Section 2 chainage 5600 m to 6190 m (low point road alignment design)
- Section 3 chainage 6190 m to 7120 m (high point road alignment design)
- Section 4 chainage 7120 m to 7820 m (low point road alignment design).

The immediate area around the existing State Highway is relatively flat and historically was occupied by large areas of wetland. Today the existing highway includes a combination of road side drainage (refer to Figure 2-1), farm land drains through paddock swales (refer to Figure 2-2) and transverse culverts under the existing highway to accommodate the existing drainage paths in the area (refer to summary Table 2-1).

Figure 2-1: Existing road side drainage, SH1

Figure 2-2: Upstream paddock swale

The proposed works will both improve the efficiency of the road side drainage in terms of flood capacity and also increase effectiveness of the water treatment benefits that the road side swales provide. The proposed culverts will also be larger and more fish friendly in terms of removing culvert drops and barriers that prevent fish migration upstream. Outlets will be more stable in the long term and will resist the development of scour holes.

Table 2-1: Summary of existing concrete pipe culverts

Section	Chainage	Fish Barrier ?	Description
1	5240		300 mm diameter culvert under the existing highway and proposed alignment
2	6160	No	450 mm diameter culvert under the existing highway alignment
3	6230	Yes	600 mm diameter culvert under the existing highway alignment
4	7800	Yes	2 x 225 mm (not confirmed diameter) diameter culvert under the existing highway and proposed alignment.

Note: Fish barrier assessment is based on MWH report, *Waitarere Beach Road Curves Project – Ecological Assessment, November 2015* (see Appendix G, Volume II, Notice of Requirement).

It has been assumed that the receiving drainage paths has some ecological value based on the presence of mudfish within the vicinity as determined by project-specific trapping and investigation

2.4 Receiving Environments

The Project area is located in the upper reaches of the Manawatu River catchment and is entirely outside the Horowhenua Lake catchment (see catchment plan Figure 2-3: Drainage paths and catchment areas). Catchment sizes for the design of cross-drainage are shown in Figure 2-3: Drainage paths and catchment areas and range from 13 hectares to 174 hectares.

Modified and natural drainage paths (watercourses, ditches and intermittent drainage paths) were identified from the site walkover and through ecological assessment within or near the project footprint. Four main receiving drainage paths are affected by runoff that drains away from the proposed highway alignment (refer to summary Table 2-2). The determination of what is, and is not, a stream in a planning context is made in MWH report, *Waitarere Beach Road Curves Project – Ecological Assessment, November 2015*, Section 3.2. The rainfall generated surface water from the project area flows into drainage paths at the road chainages shown.

Table 2-2: Summary of existing drainage paths

Drainage Path	Chainage	Flow Condition	Description
Drainage path 1	5240	Dry (ephemeral)	Dug drain. Small swale upstream (west) of SH1 widening to a 1-1.5m wide drain east of SH1 (refer to Figure 2-4). No evidence of natural stream morphology. Dry. Potential instability on bed and banks
Drainage path 2	6160	Dry U/S Flowing D/S (ephemeral)	Artificial dug drain upstream (west) of SH1. Natural stream downstream of SH1. Has natural morphology but no shade. Two perched pipes feed the start of the stream below SH1. (Refer to Figure 2-5). Potential instability on bed and banks. Potential mudfish environment.
Drainage path 3	6230	Flowing (perennial)	Modified natural stream with straightened and piped sections. Some shaded and open sections. Perched pipe downstream of SH1. Potential instability on bed and banks. Potential mudfish environment.
Drainage path 4	7800	Flowing (perennial)	Dug drain within kahikatea swamp forest at 463 State Highway 1. Well shaded by native vegetation. No fish passage barriers observed. Potential mudfish environment.

Figure 2-3: Drainage paths and catchment areas

Figure 2-4: Drainage path 1: downstream the road – Section 1 of the project

Figure 2-5: Drainage path 2: downstream of the road – Section 2 of the project

Figure 2-6: Drainage path 3: downstream of the road – Section 3 of the project

Figure 2-7: Drainage path 4: Wetland downstream of the road – Section 4 of the project (Outside the Project Area)

2.5 Ecological Summary

The ecological assessment described in MWH report, *Waitarere Beach Road Curves Project – Ecological Assessment,* November 2015, reached the following conclusion:

> *"The ecological assessment has confirmed that the majority of the Designation has low ecological values, however there are discrete areas of ecological value, including at risk species and threatened habitats. This report has addressed the actual or potential effects of Project design, construction and operation. Effects of the Project are considered to be minor or less than minor for native vegetation and avifauna. Effects are considered more than minor for stream piping and diversions, mudfish and herpetofauna. Appropriate mitigation is recommended to ensure that the Project has no more than minor adverse impacts on terrestrial and aquatic ecology."*

The ecological proposals have been assessed and found to be within the capacity of normal design and construction practice. The expectation is that if the Project is constructed to current best practice and meets the environmental and engineering obligations that are embodied within the NZ Transport Agency stormwater treatment guidelines then the Project will not adversely affect the surrounding ecology. It may result in some benefits.

3 Stormwater Preliminary Design

3.1 Stormwater Practice Selection

The project involves the modification of an existing highway alignment to reduce curvature and increase safety. The Transport Agency intends to follow internal protocol in this project which means developing an approach for stormwater management which is generally in accordance with the Transport Agency's Environmental and Social Responsibility Standard (Z/19). The Transport Agency Stormwater Treatment Standard for State Highway Infrastructure, on which this design report is based, is the most relevant document (reference: Forward (sic), Stormwater Treatment Standard for State Highway Infrastructure, May 2010.)

A flow chart for stormwater practice selection is part of the Stormwater Treatment Standard and is shown in Figure 3-1. Local rules and policy requirements from Horizons Regional Council (Horizons) have been assessed and are not clear on the definitions of contaminated water with regards to highway runoff. They give limited guidance on discharges to land and streams. Consents will be obtained as needed following further liaison with Horizons.

With reference to Figure 3-1, the project is assessed in the following way:

1. In the absence of specified local water quality requirements, the design of the proposed stormwater drainage and water quality management in this project is based on the Transport Agency *Stormwater Treatment Standard for State Highway Infrastructure, May 2010*. In particular, stormwater from the project will be disposed to drainage paths and not to land soakage. By following the Transport Agency standard, the design will achieve good practice and any standards that are specified in a regional consent (if required) will be able to be achieved.
2. Existing flooding problems in the catchment: none have been identified through the Project's consultation or desktop assessment[2]. The catchment is rural in nature, therefore no intermediate flooding controls are required. Horowhenua District Plan does not show this as an area which is flood prone[3], nor is it an area for future urban growth.
3. Stream erosion potential: catchment imperviousness is assessed as <3% for one catchment (no stream erosion provisions required) and >3% for three catchments (three catchments to be served by ponds as volume control mechanisms).
4. Water quality considerations: Based on Table 3-1 *Stormwater Treatment Standard for State Highway Infrastructure, May 2010,* assume high priority receiving drainage paths (stream and ground receiving systems); new highway; rural environment; therefore utilise new engineered swales[4] and existing roadside channels as water quality treatment mechanisms.

There are potentially opportunities over the length of the Project area to dispose of at least some stormwater runoff by soakage to ground. However, for this preliminary design stage, soakage information and detailed groundwater level information have not been available. For this reason, soakage has not been pursued in the preliminary design. Further soakage investigation and confirmation of feasibility will be considered in the detailed design.

[2] Some consulted have asked if the design provides adequately for stormwater management (e.g. Whare Rongopai).
[3] Although Planning Map 4 shows that it is adjacent to such an area, but does not extend into the area.
[4] Sometimes referred to as environmental swales.

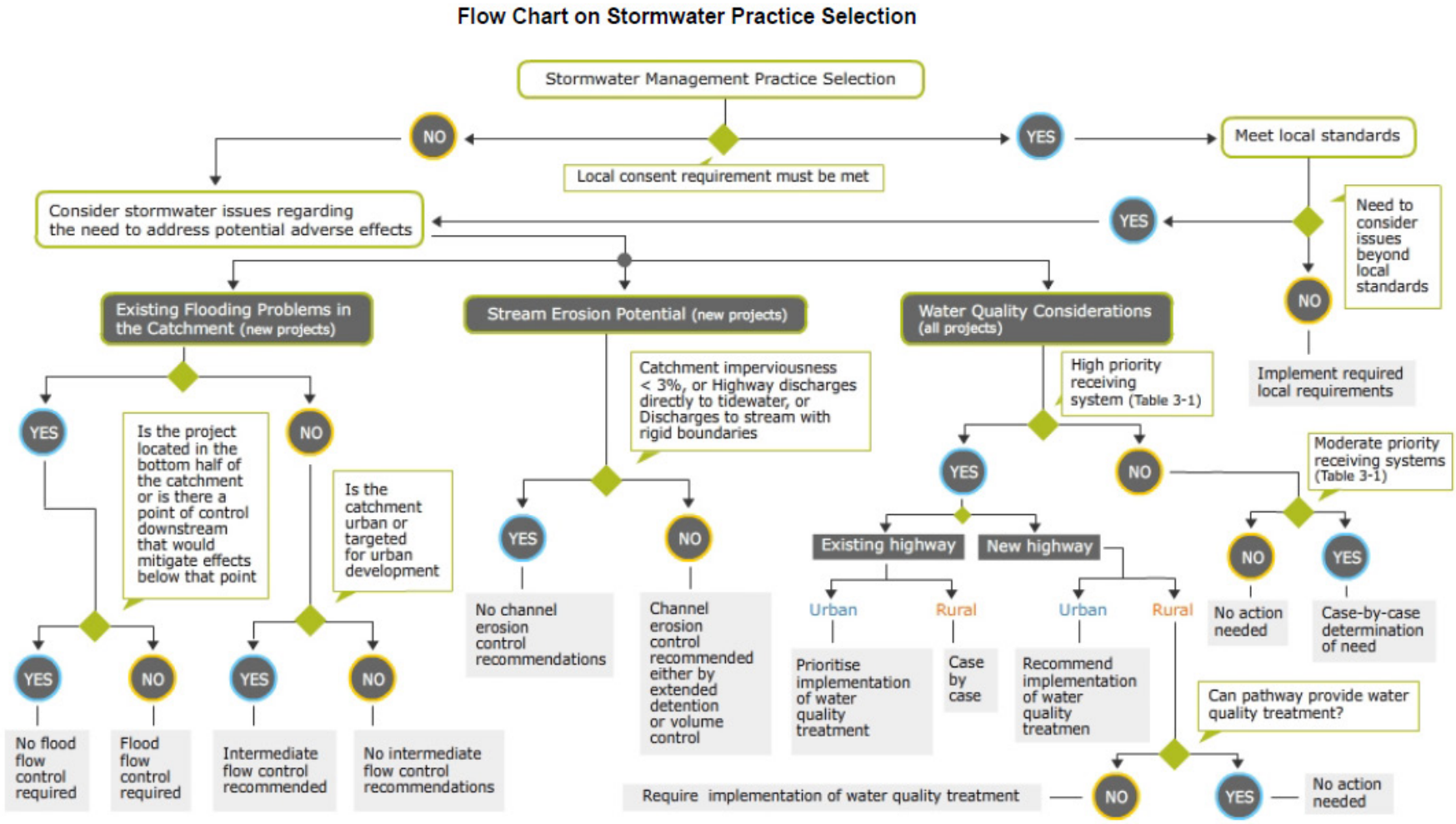

Figure 3-1: The Transport Agency flow chart on stormwater practice selection

**(reference Fig 7-3, Stormwater Treatment Standard for State Highway Infrastructure, New Zealand Transport Agency, May 2010)*

3.2 Assumptions and Limitations

The following assumptions and limitations are incorporated into the design:

- It is assumed that the road surface within the project area is a source of contaminants and treatment practices will be designed to mitigate the source as per the Transport Agency Environment and Social Responsibility Standard (Z/19);
- For preliminary design, the proposed highway formation is conservatively compared against a greenfields environment to determine design parameters. This is in line with the Transport Agency Z/19 whereby new projects seek to redress historical impacts where financially feasible, practical and environmentally appropriate.
- Stormwater preliminary design have been based on the assumption that soakage is not available as no detailed geotechnical field information was able to be gathered during the preliminary design phase.
- Stormwater preliminary design solutions will be updated during detailed design with more detailed geotechnical and survey information.
- It has been assumed that the receiving drainage paths has some ecological value based on the presence of mudfish within the vicinity as determined by project-specific trapping and investigation.
- Three of the four downstream drainage paths are considered potentially to be non-stable based on site photographs and field observations (Drainage Paths 1, 2 and 3). Erosion protection measures are considered in this project for these drainage paths where the impervious surface increases to 3% of the catchment area (reference: Figure 3-1 Stream Erosion Potential). Drainage Path 4 is a remnant wetland system which appears to be a stable receiving environment in terms of stormwater runoff from the project area.
- No widespread or serious flooding issues have been identified.
- As stated before, this report relates to the long term provision of the stormwater management for the Project. The temporary drainage and sediment and erosion control during the construction stage is addressed in another report (see Appendix D, Volume II of the Notice of Requirement documentation). Additional temporary drainage and sediment control ponds will be needed during construction, but they will not be required in the long term.
- Control and capture of contaminants from the road surface will be achieved through engineered environmental swales and informal roadside drains which impart a measure of vegetation biofiltering.
- There will be vegetation clearance.
- For the purposes of this assessment, drainage paths will be diverted only within the project footprint where the new road formation and alignment will change the drainage path locally between fixed points upstream and downstream of the Project area.

3.3 Design Criteria

The fundamental design criteria used in the stormwater design, based on Stormwater Treatment for State Highway Infrastructure, are listed below:

- Hydrologic design method for the design will be rational method
- The 2-, 10- and 100- year rainfalls will be determined by use of the High Intensity Rainfall Design System (HIRDS) as developed by NIWA. Climate change of 2.1 degrees has been included.
- The ‘C’ runoff coefficient will be based on formula and Table 6-2 of *the Transport Agency Stormwater Treatment Standard for State Highway Infrastructure, May 2010.*
- Soil is considered as pervious sandy soil (2-7%) with a C =0.15.
- Time of concentration will be calculated for each catchment based on 6.1.3.1 *the Transport Agency Stormwater Treatment Standard for State Highway Infrastructure*

- For pond design, the storm duration will be considered as 1 hour for the calculation of runoff peak discharge and volumes – see 6.1.3.1 *the Transport Agency Stormwater Treatment Standard for State Highway Infrastructure*.
- Extended detention volume will be implemented as an erosion control measure when a receiving drainage path is considered to be non-stable. Extended detention volume will be calculated as the "water quality volume" multiplied by 1.2. That volume will be stored in a pond and then released over a 24-hour period (reference: *6.5.2, the Transport Agency Stormwater Treatment for State Highway Infrastructure).*
- 2m is considered the maximum depth of a pond.
- Water quality treatment devices and components are to meet the 90-percentile rainfall event (reference: *Appendix A, the Transport Agency Stormwater Treatment for State Highway Infrastructure)* which is taken as equivalent to the 2 year ARI[5]/1 hour rainfall event.
- Environmental swales will be designed for 100 year ARI rainfall event flow contained below the edge of the carriageway with 500 mm of freeboard, the 10 year ARI rainfall event velocity to be less than 1.5 m/s and the velocity during the Water Quality Storm will be less than 0.8 m/s (reference: *8.5.1 Swales the Transport Agency Stormwater Treatment for State Highway Infrastructure*).
- The base width in any environmental swales used as part of the stormwater treatment system will not exceed 2 m and maximum side slope will be 4H:1V.
- Cross drainage culverts are to meet the 100 year ARI design standard with 500mm freeboard to the edge of the carriageway.

3.4 Hydrological design

3.4.1 Catchment analysis

As identified in the receiving environment section, four main drainage paths are affected by runoff that drains through or off the proposed highway alignment. Each catchment area has been divided into sections describing upstream farmland and road area that drains to each of the drainage paths. Road area is considered to produce contaminated runoff that may require treatment measures to reduce impacts on the receiving environment, and farmland areas are considered to produce un-contaminated runoff.

Note that swales and culverts each have individual catchments draining into them or combinations of smaller catchments draining into them. These catchments are more-detailed descriptions of the four overall catchments described in Figure 2-3: Drainage paths and catchment areas.

Each of the four drainage paths and their local catchment areas are described in Figures 3-2, 3-3, 3-4 and 3-5. Figure 2-3: Drainage paths and catchment areas has described the wider catchments as they contribute to cross-drainage.

[5] Annual return interval.

Figure 3-2: Section 1 Catchments areas

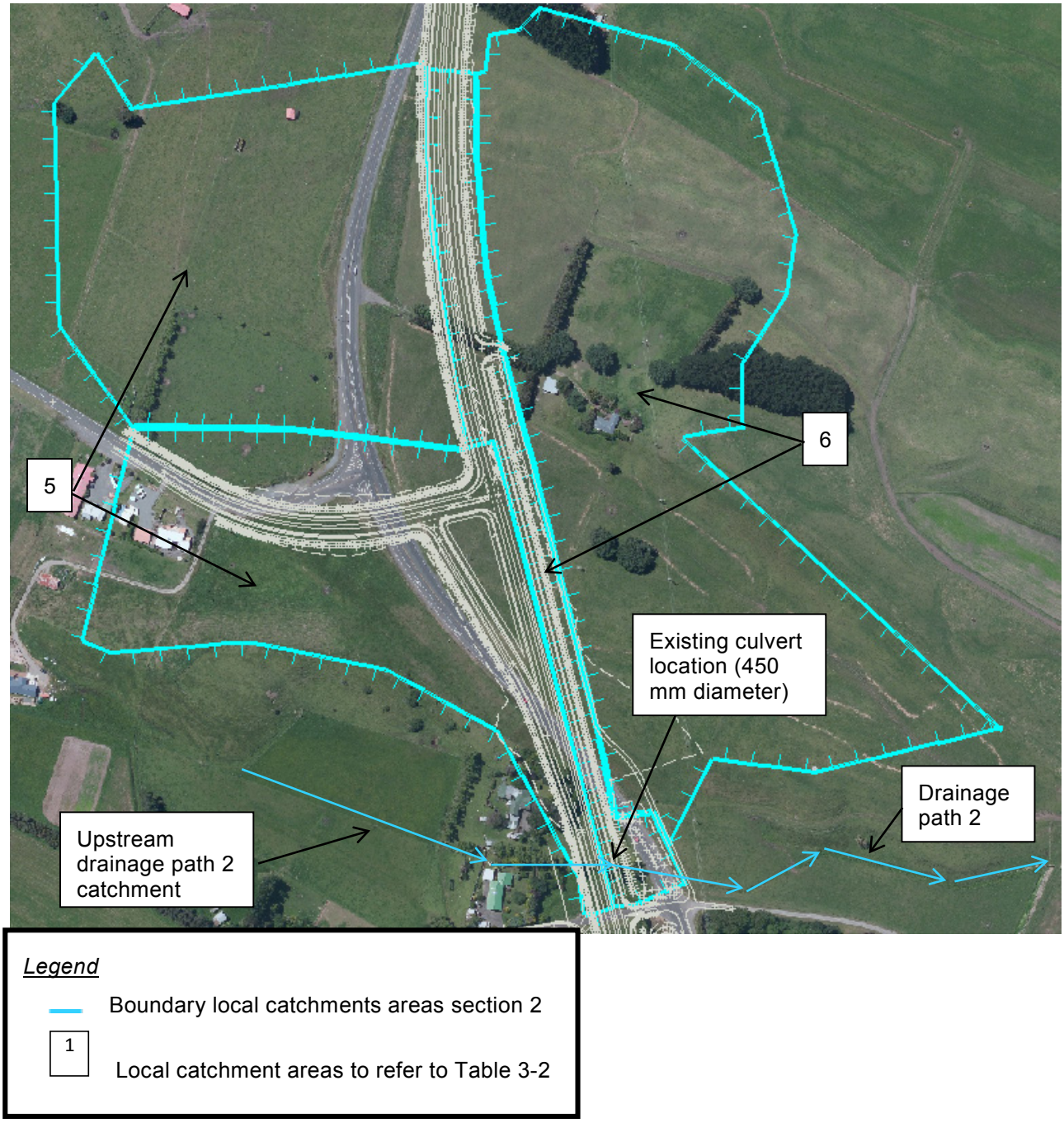

Figure 3-3: Section 2 Catchments areas

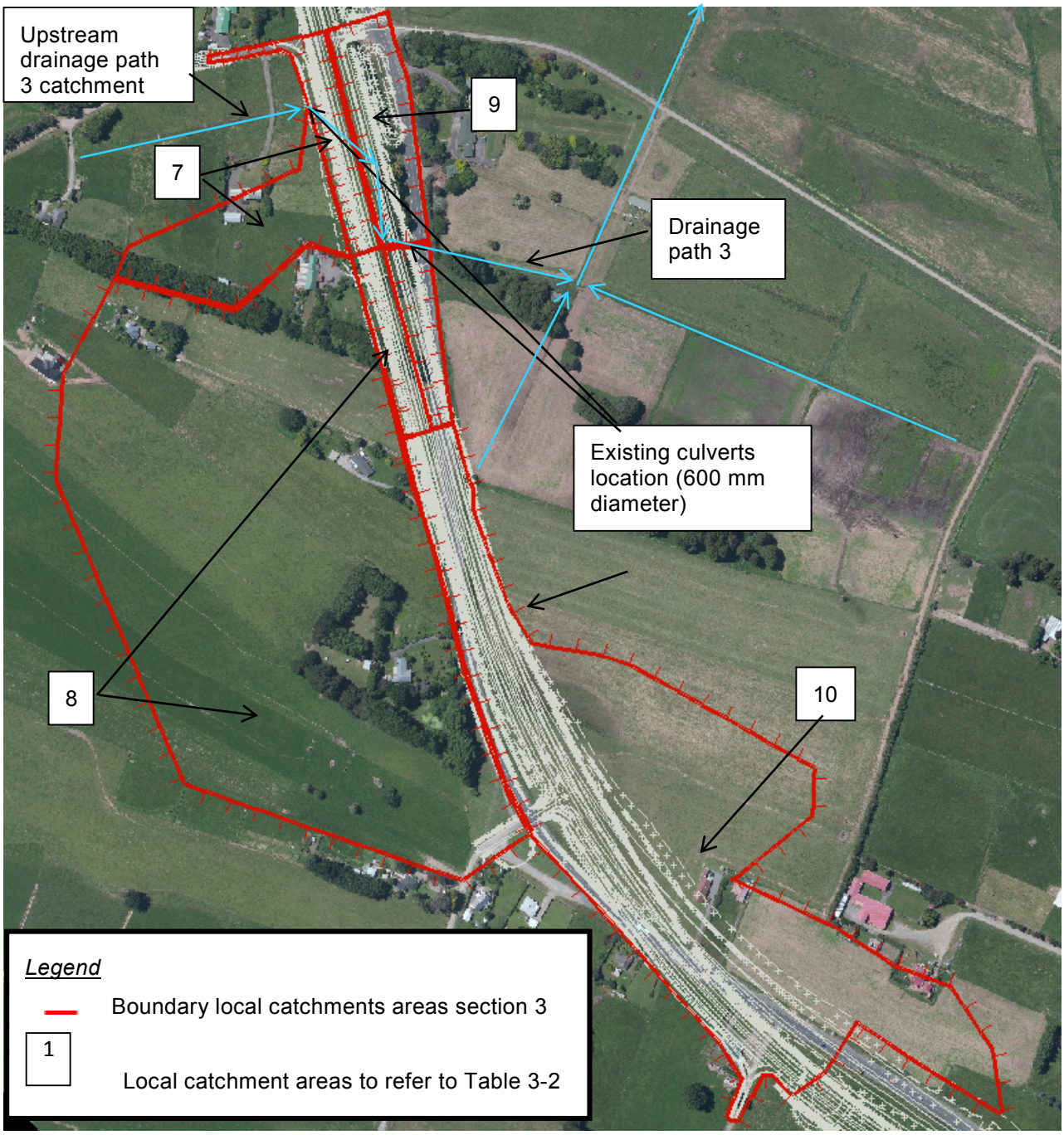

Figure 3-4: Section 3 Catchments areas

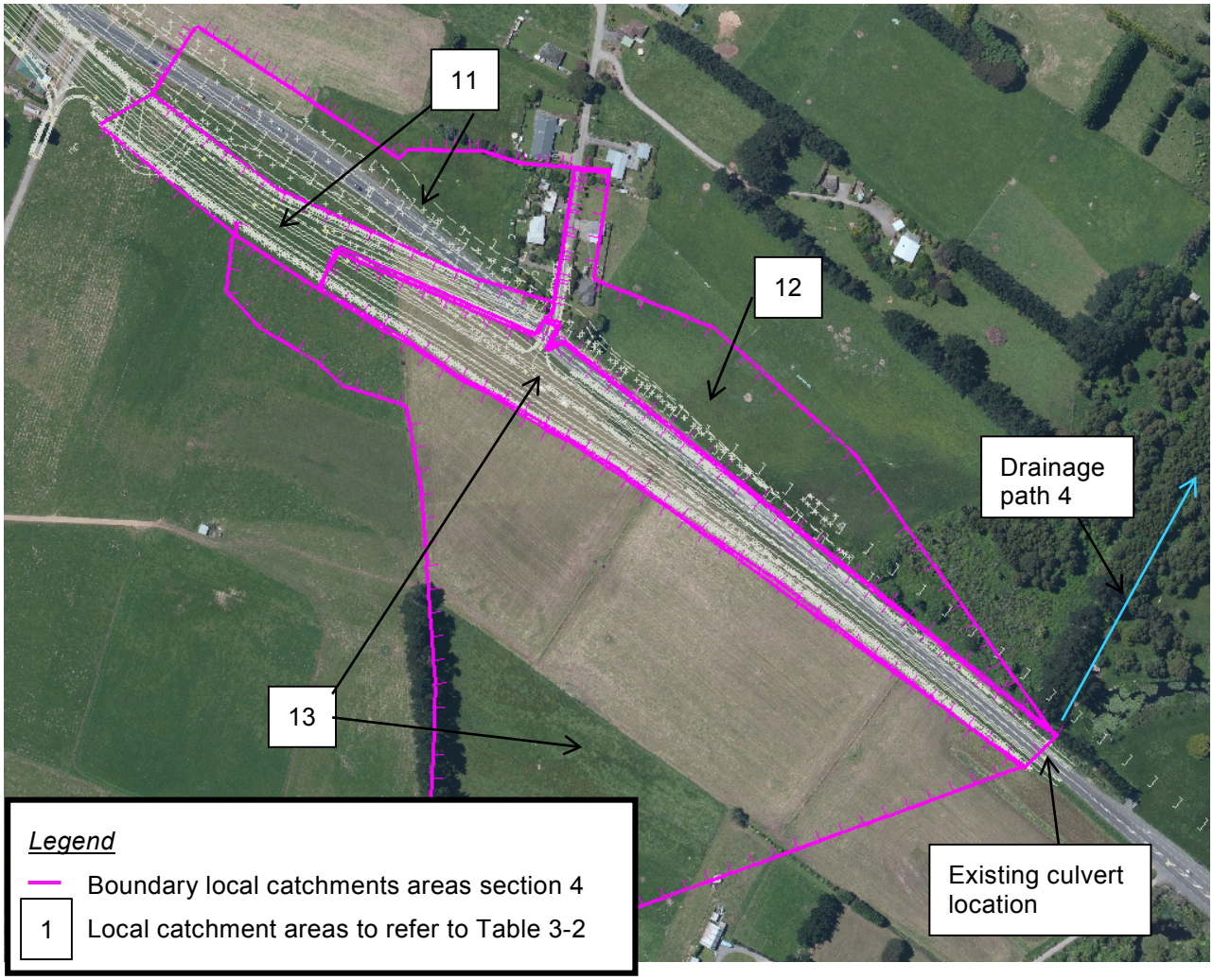

Figure 3-5: Section 4 Catchments areas

Table 3-1 summarises the change in impervious area due to the proposed Project compared to both a greenfields condition and to the existing state highway condition. The comparison with the greenfields condition provides parameters for the design. The comparison with the existing state highway condition informs the impacts (or benefits) caused by the proposed upgrade works.

Table 3-1: Summary of impervious catchment areas per drainage path

Drainage path	Total Area (ha)	Existing State Highway impervious area		Proposed realignment impervious area (ha)		Change in % impervious area
		Area (ha)	% Impervious	Area (ha)	% Impervious	
Drainage path 1	34.7	0.8	2.4%	1.4	4.0%	1.6%
Drainage path 2	27.6	1.3	4.6%	3.3	11.8%	7.2%
Drainage path 3	175.5	1.4	0.8%	5.2	2.9%	2.1%
Drainage path 4	13.9	0.8	6.0%	2.7	19.4%	13.4%

Table 3-2 summarises the design runoff draining to environmental swales (numbered) and through transverse road culverts.

Table 3-2: Summary of Catchment Areas Comparing to Greenfields

Section/ Receiving environment	Catchment	Total Area (ha)	Pervious Area (ha)	Impervious Area (ha)	% Impervious
Section 1/ Drainage path 1	1	0.2	0.0	0.2	
	2	0.7	0.5	0.2	
	3	6.9	6.7	0.2	
	4	1.3	0.5	0.8	
	Upstream stream 1 catchment	25.7	25.7	0.0	
	Upstream of culvert (1+3+Ups)	32.8	32.4	0.4	1.1 %
	Downstream of culvert (1+2+3+4+ Ups)	34.7	33.3	1.4	4.0 %
Section 2/ Drainage path 2	5	11.3	9.4	1.9	
	6	11.8	10.5	1.3	
	Upstream stream 2 catchment	4.4	4.4	0.0	
	Upstream of culvert (5+Ups)	15.7	13.8	1.9	12.2 %
	Downstream of culvert (5+6+ Ups)	27.5	24.3	3.2	11.8 %
Section 3/ Drainage path 3	7	1.5	1.2	0.3	
	8	11.7	11.3	0.4	
	9	0.9	0.3	0.6	
	10	7.5	3.8	3.7	
	Upstream Stream 3 catchment	153.9	153.9	0.1	
	Upstream of culvert (7+8+Ups)	167.1	166.3	0.8	0.50 %
	Downstream of culvert (7+8+9+10+Ups)	175.5	171.0	5.2	2.9 %
Section 4/ Drainage path 4	11	2.3	1.5	0.8	
	12	1.9	1.9	0.0	
	13	9.3	7.4	1.90	
	Upstream of culvert (13)	11.6	8.9	2.7	23.3 %
	Downstream of culvert (11+12+13)	13.9	10.8	2.7	19.4 %

3.4.2 Discussion

For roading projects that drain to streams, the main issues to be addressed with respect to stormwater discharges relate to both water quantity and water quality. Depending on the location of the project in a

catchment, peak flow control may also be an issue. The discussion below has been based on the assumption of a change from greenfield areas to proposed development. This assumption reflects the basics of design that the Transport Agency projects seek to account for historical effects (refer to the Transport Agency Environmental and Social Responsibility Standard (Z/19)). As the existing state highway has already modified the environment, this approach is intended to not only address the effects arising from the realignment project, but also to enhance the exiting environment in the area.

As identified in Figure 3-1 “Flow Chart on Stormwater Practise Selection”, stormwater issues for this project should be considered, having regards to the need to address potential adverse effects in three different areas:

- Existing flooding issues in the catchment – Flood flow control may be required
- No existing flooding issues have identified and it is a rural catchment, therefore no flood flow control is assessed as being required.
- Stream erosion potential – Channel erosion control measures may be recommended
    - Section 1: Catchment impervious is > 3% (refer to Table 3-2) and stream is considered not stable, therefore channel erosion control is recommended. Extended detention volume (EDV) is stored in Pond 1 and released over a 24-hour period.
    - Section 2: Catchment impervious is > 3% (refer to Table 3-2) and stream is considered not stable, therefore channel erosion control is recommended. Extended detention volume (EDV) is stored in Pond 2 and released over a 24-hour period.
    - Section 3: Catchment impervious is < 3% (refer to Table 3-2), therefore channel erosion control is not required.
    - Section 4: Catchment impervious is > 3% (refer to Table 3-2), however, stream is considered to be stable as a wetland area, therefore channel erosion control is not required.
- Water Quality considerations
- Receiving environments are considered high priority receiving systems, therefore implementation of water quality treatment is considered to be required. Environmental swale throughout the length of the highway alignment will provide effective water quality treatment.

3.4.3 Peak runoff calculations

Hydraulic design parameters for environmental swales, ponds and pipe concrete culverts have been calculated based on the method detailed in ‘*Stormwater Treatment Standards for State Highway Infrastructure*’. The results of the calculations are summarised in Appendix A.

Swale locations are shown in Figure 4-1.

3.5 Hydraulic Design

3.5.1 Swales

The swales' open channels have been designed to provide for water quality treatment for smaller and more frequent rainfall events (ie: the "first flush") and also to pass the 100 year ARI rainfall event flow with 500 mm freeboard to the edge of the carriageway (ie: the white edge line).

In order for the swales to be able to achieve water treatment, the following design criteria have been taken into consideration:

- Channel velocity 0.8 m/s for water quality storm
- The water quality design water depth should not exceed design height for grass. In all the swales design vegetation height used is 150 mm
- Maximum bottom width of 2 m
- Minimum hydraulic residence time of 9 minutes
- Maximum side slope of 4H:1V
- Channel velocity for 10-year storm < 1.5 m/s

The preliminary swale design is summarised in Table 3-3.

Table 3-3: Summary Swale Design (Preliminary)

Swale	Catchment	Base (m)	Maximum depth (m)	Side slope	Length minimum required (m)	Grade (%)	Vwq* (m/s) <0.8 m/s	V10** (m/s) <1.5 m/s
Swale 1	1 + upstream catchment from the drainage path that drains to the swale 1	2	0.35	4H:1V	145	0.4	0.30	0.51
Swale 2	2	1	0.25	4H:1V	26	0.4	0.05	0.30
Swale 3	3 + upstream catchment from the drainage path that drains to the swale 2	1.5	0.40	4H:1V	275	0.4	0.51	0.55
Swale 4	4	1	0.35	4H:1V	85	0.1	0.16	0.33
Swale 5	5	1	0.35	4H:1V	345	1.3	0.64	0.97
Swale 6	6	1	0.35	4H:1V	310	1.35	0.57	0.91

Swale	Catchment	Base (m)	Maximum depth (m)	Side slope	Length minimum required (m)	Grade (%)	Vwq* (m/s) <0.8 m/s	V10** (m/s) <1.5 m/s
Swale 7	7	1	0.15	4H:1V	50	1.8	0.12	Contained in the stream***
Swale 8	8	1	0.45	4H:1V	235	0.3	0.42	0.51
Swale 9	9	1	0.25	4H:1V	62	1.8	0.11	0.19
Swale 10	10	1	0.40	4H:1V	410	0.9	0.76	1.17
Swale 11	11	1	0.35	4H:1V	100	0.1	0.13	0.24
Swale 13	13	1	0.40	4H:1V	310	1.2	0.54	0.97

Notes:

* Vwq (water quality volume = 90% storm event rainfall depth x area of contributing catchment)

** V10 (water quality volume x area of contributing catchment)

*** Swale 7 will have Vwq separated from the main stream (drainage path 2), with greater events to flow over and then into the next adjacent channel (drainage path 3).

3.5.2 Ponds

Ponds have been designed for stream channel erosion control by way of an extended detention volume that will be stored and released over a 24 hour period. All ponds will discharge primarily through an orifice with allowance for larger flows to pass over spillways into the drainage path adjacent.

The pond design summary is presented in Table 3-4.

Table 3-4: Summary Pond Design (Preliminary)

Pond	Location	Base width (m)	Base Length (m)	Pond Side slope	Depth (m)	Volume (m3)	Design Q max (m3/s)	Proposed Q rate (m3/s)	Orifice dia (mm)
Pond 1	Drainage path 1	9	40	4H:1V	0.65	295	0.007	0.006	60
Pond 2a	Drainage path 2	17	55	3H:1V	1.25	898	0.021	0.019	90
Pond 2b	Drainage path 3	14	73	4H:1V	1.0	706	0.013	0.013	80

In order to minimise the land required, pond 2 was divided into two ponds (pond 2a and pond 2b). Pond 2a, the main pond will store runoff from the first pond of a storm and release of over 24-hours period to drainage path 2. Pond 2b will be used to store runoff in excess of the capacity of pond 2a and will discharge it over a 24-hour period to drainage path 3.

3.5.3 Culverts

In order for the drainage paths to be able to cross the SH1 and the swales to discharge to the proposed ponds, culverts are designed in accordance with the New Zealand Building Code. Culverts have been designed to pass 100 year ARI design standard with 500mm freeboard from the edge of the carriageway.

Table 3-5: Summary Pipe Concrete Culvert Design (Preliminary)

Culvert	Catchment	Chainage	Discharge point	Q100 (m3/s)	HW (m)	H (m)	Diameter (mm)	Length (m)	Grade (%)
1	1+3+ Upstream drainage path 1 catchment	5240	Drainage path 1	0.65	0.81	1.0	675	30	2
2	Upstream of Waitarere Beach road catchment	60 (Waitarere Beach Road)	Swale 5	0.36	0.60	0.4	600	25	0.7
3	5	6140	Pond 2a	0.65	0.65	0.5	1200	30	0.5
4	Upstream drainage path 2 catchment	6180	Drainage path 2	0.20	0.65	0.5	450	80	0.6
5	7+8+ Upstream drainage path 3 catchment	6370	Drainage path 3	3.23	1.3	0.6	1500	45	3.6
6	11+13	7820	Drainage path 4	1.12	1.1	1.0	750	30	3
7	11+12	7560	Swale 12	0.3	0.7	1.0	450	30	3

The proposed culverts have larger diameters than the existing culverts that they replace and will remove the existing blockages to fish passage that currently exist, such as perched outlets. The new larger culverts will be installed to allow fish passage in both directions through the careful setting of invert level and placement of outlet erosion protection measures. Given the flat terrain, the culvert gradients are expected to be shallow enough to allow fish passage along the culvert barrels during low flows and normal base flow conditions. Detailed design will include specifying culvert invert levels and pipe gradients to maximise fish passage conditions.

4 Summary of Stormwater Preliminary Design

The proposed preliminary design drainage works for the Waitarere Beach Road Curves project in the vicinity of Waitarere Beach Road and Paeroa Road are summarised in Figure 4-1 and the description below.

Section 1/ Drainage path 1

The proposed stormwater design for Section 1 will include:

- 180 m length of channel drains
- 530 m length of environmental swale.
- 30 m of 675 mm diameter pipe concrete culvert at chainage 5240
- Pond 1, providing extended detention volume (EDV).

Section 2/ Drainage path 2

The proposed stormwater design for Section 2 will include:

- 500 m length of channel drains
- 660 m length of environmental swale.
- 25 m of 600 mm diameter pipe concrete culvert at 60 chainage Waitarere Beach Road
- 30 m of 1200 mm diameter pipe concrete culvert at 6140 chainage.
- 80 m of 450 mm diameter pipe concrete culvert at 6180 chainage
- Pond 2a and Pond 2b, providing EDV.

Section 3/ Drainage path 3

The proposed stormwater design for Section 3 will include:

- 820 m length of channel drains
- 760 m length of environmental swale.
- 50 m of 1500 mm diameter pipe concrete culvert at chainage 6370.

Section 4/ Drainage path 4

Proposed stormwater design for Section 4 will include:

- 400 m length of channel drains
- 400 m length of environmental swale.
- 30 m of 750 mm diameter pipe concrete culvert at chainage 7820
- 30 m of 450 mm diameter pipe concrete culvert at chainage 7560.

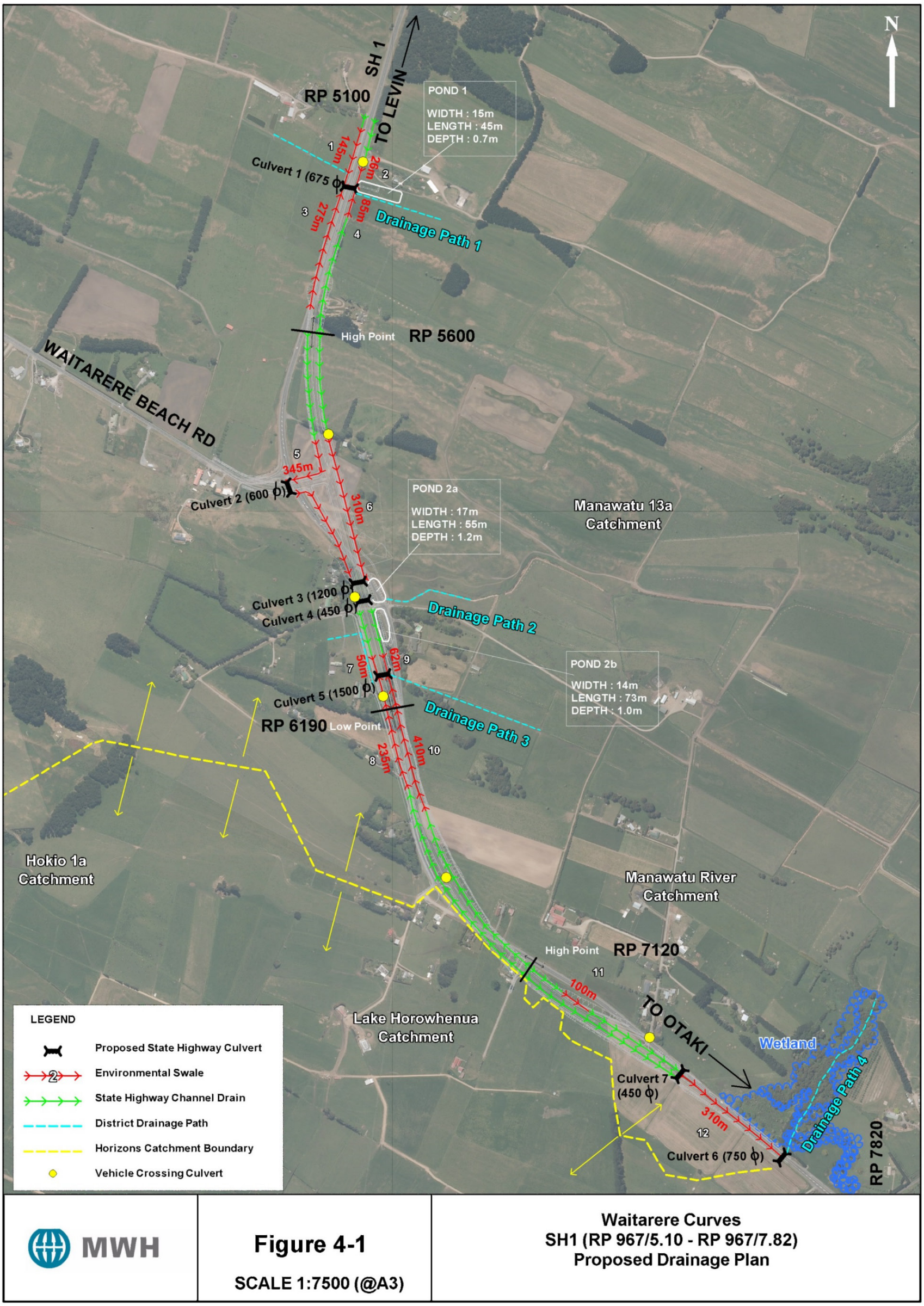

Figure 4-1: Summary of proposed drainage work

5 Conclusions

The proposed stormwater design for the Project will include approximately 2,000 m length of drain channel, 2,200 m length of environmental swale, 7 concrete pipe culverts and three detention ponds. This design meets the requirements of the Transport Agency Stormwater Treatment for State Highway Infrastructure and therefore the Transport Agency Environmental and Social Responsibility Standard (Z/19) to:

- Mitigate contaminant loads from the state highway
- Mitigate flows off the state highway to avoid erosion in downstream channels

The proposed design will provide for improved treatment of stormwater from the surface of SH1 within the Project area, and therefore for enhanced water quality. The design will also provide capacity to ensure there is no potential for flooding in the area as a result of the Project. It also ensures that all stormwater is directed into the catchment of the Manawatu River and away from Lake Horowhenua.

Swale and pond design and planting will provide a minor habitat benefit in the wider area, and existing perched culverts and pipes are to be replaced with designs that provide for fish passage. This will improve ecological conditions in this part of the state highway network, including benefits from additional planting (including some swale and pond plantings) to increase ecological values in the immediate area.

Following RMA approvals, and to finalise the detailed design, further work and information will be required. This includes:

- Detailed level survey including of hydraulic structures
- Geotechnical soil assessment and soakage assessment
- Ecological input
- Road design finalised
- Consideration of opportunities for soakage if primary drainage should be changed
- Inspection and maintenance considerations such as access and monitoring
- Finalised landscape/urban design.

6 Bibliography

MWH report, *Waitarere Curves Ecological Assessment November 2015*

New Zealand Transport Agency. (May 2010) *Stormwater Treatment Standard for State Highway Infrastructure*

New Zealand Building Code 2003 clause E1 Surface Water

Appendix A – Summary of Calculations for Swales, Ponds and Culvert Designs

Summary Environmental Swale Peak runoff discharge

Environ-mental Swale	Catchment	Total Area (ha)	Pervious Area (ha)	Impervious Area (ha)	Runoff coefficient 'C'	'Tc' (min)	Q2 post-development (m3/s)	Q10 post-development (m3/s)	Q100 post-development (m3/s)	Qwq (m3/s)
Swale 1	1 + upstream catchment stream that drains to the swale 1	12.5	12.3	0.2	0.16	20	0.187	0.273	0.443	0.1039
Swale 2	2	0.7	0.5	0.2	0.33	10	0.029	0.043	0.070	0.011
Swale 3	3 + upstream catchment stream that drains to the swale 3	19.8	19.6	0.2	0.16	30	0.292	0.341	0.558	0.160
Swale 4	4	1.3	0.5	0.8	0.57	20	0.068	0.100	0.162	0.038
Swale 5	5	11.3	9.4	1.9	0.26	20	0.276	0.404	0.655	0.154
Swale 6	6	11.8	10.5	1.3	0.22	20	0.247	0.362	0.586	0.137
Swale 7	7	1.5	1.2	0.3	0.27	10	0.055	0.082	0.132	0.022
Channel	7+ upstream catchment stream 3	155.5	155.0	0.5	0.15	60	1.229	1.828	2.998	N/A
Swale 8	8	11.7	11.3	0.4	0.17	20	0.230	0.359	0.599	0.104
Swale 9	9	0.9	0.3	0.6	0.60	10	0.069	0.104	0.167	0.027
Swale 10	10	7.5	3.8	3.7	0.47	20	0.462	0.691	1.112	0.182
Swale 11	11	2.3	1.5	0.8	0.38	10	0.114	0.170	0.275	0.045
Channel 12	12	1.90	1.90	0.00	0.15	10	0.037	0.055	0.089	N/A
Swale 13	13	9.3	7.4	1.90	0.28	10	0.348	0.520	0.836	0.137

Summary Ponds Peak runoff discharge and volume needs for storage

Pond	Catch	Perv Area (ha)	Imper Area (ha)	Runoff coeff 'C'	'Tc' (min)	Q2 pre-dev (m3/s)	Q10 pre-dev (m3/s)	Q100 pre-dev (m3/s)	Q2 post-dev (m3/s)	Q10 post-dev (m3/s)	Q100 post-dev (m3/s)	V2 (m3)	V10 (m3)	V100 (m3)	Vwq (m3)	EDV (m3)
Pond 1	2+4	1.7	1.0	0.34	60	0.013	0.019	0.032	0.034	0.051	0.083	185	275	451	245	294.1
Pond 2	5+6	19.9	3.3	0.24	60	0.158	0.233	0.377	0.291	0.432	0.709	1571	2335	3830	1217	1460

Summary cross-drainage - Peak runoff discharge

Culvert	Catchment	Total Area (ha)	Pervious Area (ha)	Impervious Area (ha)	Runoff coefficient 'C'	'Tc' (min)	Q2 post-development (m3/s)	Q10 post-development (m3/s)	Q100 post-development (m3/s)
Culvert 1	1+3+ Upstream stream 1 catchment	32.8	32.4	0.4	0.16	60	0.268	0.399	0.654
Culvert 2	Upstream of Waitarere Beach road catchment	7.7	7.00	0.7	0.21	20	0.150	0.178	0.363
Culvert 3	5	11.3	9.4	1.9	0.26	20	0.276	0.404	0.655
Culvert 4	Upstream stream 2 catchment	4.4	4.4	0.0	0.15	10	0.086	0.129	0.209
Culvert 5	7+8+ Upstream stream 3 catchment	167.4	166.9	0.5	0.152	60	1.322	1.973	3.236
Culvert 6	11+12+13	13.5	11.2	2.3	0.26	10	0.464	0.694	0.112
Culvert 7	11+12	4.2	3.5	0.6	0.25	10	0.137	0.204	0.330