Appendix N

Stormwater Design Philosophy

NZ TRANSPORT AGENCY
WAKA KOTAHI

Peka Peka to Otaki Expressway
Scheme Assessment Report Addendum
Stormwater Design Philosophy

Quality Assurance Statement

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NZ Transport Agency

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Abbreviations and definitions

Table 1 – Abbreviations

Abbreviation	Full Name
AEP	Annual Exceedance Probability[1]
ARC	Auckland Regional Council
BH	Bore hole
BPO	Best practicable option
CN	Curve number
DPS	Design philosophy statement
E&SC	Erosion and sediment control
GWRC	Greater Wellington Regional Council
KCDC	Kapiti Coast District Council
MBGL	Metre below ground level
M2PP	Mckays to Peka Peka
MfE	Ministry for the Environment
MPD	Maximum Probable Development
RoNS	Road of National significance
NIMT	North Island Main Trunk
NPS	Nation Policy Statement
NZTA	New Zealand Transport Agency
NZTA SWTS	New Zealand Transport Agency Stormwater Treatment Standard (for State Highway Infrastructure)
PP20	Peka Peka to Otaki
RMA	Resource Management Act
Toc	time of concentration
TP	Test pit

[1] Flood events are often expressed by their percentage Annual Exceedance Probability (AEP), which is the probability that a particular storm event will be equalled or exceeded in any one year. The same event may alternatively be described in terms of its Annual Recurrence Interval (ARI), the average statistical period between events greater than or equal to the design event. Thus the 1% AEP storm event can also be expressed as the 100 year ARI flood often shortened to the Q_{100} event.

1. Introduction

Opus has been commissioned by the New Zealand Transport Agency (NZTA) to develop the scheme design for the Wellington North Corridor Road of National significance (RoNS) from Peka Peka to Otaki North.

1.1 Report Purpose

The purpose of this report is to document the proposed design philosophy for stormwater elements of this project. Elements include:

- erosion and sediment control during construction
- collection and conveyance of road runoff
- treatment and attenuation of road runoff
- stream erosion protection, from increased surface runoff
- small to medium waterway crossings.

Although closely related, this report does not cover large waterway crossings, regional flooding issues or flood modelling. These are covered in the Flood Levels report[2] '*Design Flood Levels for Waterway Crossings*' Opus, 2011. Other than the flood levels report, this Stormwater report should also be read in conjunction with the Geotechnical Factual Report[3] and the Geotechnical Interpretative Report[4] (for ground water and ground investigation information), the Terrestrial Ecology report[5] and the Aquatic ecology report[6]. These will inform the design process to ensure that the stormwater treatment devices proposed in this report are fit of purpose.

While the design philosophy outlined in this report will form the basis of consent, and will therefore become progressively more fixed, actual design details will undergo significant further evolution through the design-and construction process.

1.2 Project Background

The planned upgrading of State Highway 1 (SH1) between Peka Peka and Otaki North is "*part of the Wellington Northern Corridor Road of National Significance (RoNS) – a planned four-lane expressway from Wellington Airport to Levin.*"

[2] Peka Peka to Otaki Expressway, Scheme Assessment Report Addendum, Design Flood Levels for Waterway Crossings, Opus, 2011.
[3] Peka Peka to North Otaki, Geotechnical Factual Report, AECOM, 2011
[4] Peka Peka to Otaki Expressway - Geotechnical Interpretative Report, Opus, 2011
[5] Pekapeka to Otaki SARA - Terrestrial Ecology Assessment, Opus, 2011
[6] Peka Peka to North Otaki expressway project: aquatic ecology report, NIWA, 2011

SH1 is the major route in and out of Wellington, linking the centres of Palmerston North, Wanganui and Levin with Wellington. By improving transport networks through the Kapiti Coast, this project will contribute to economic growth and productivity.

Currently the Peka Peka to North Otaki section of SH1 has a relatively poor and worsening safety record. It also experiences high levels of congestion during peak periods. This congestion is compounded by a high proportion of local traffic, and an increasing level of shopping-generated parking and pedestrian movements in the Otaki urban area. A bypass around Otaki, and the provision of a high-standard highway through the area will increase the efficiency of movements between Wellington and the North, will ease local congestion, and will facilitate economic development of the area.

The scope of this project is therefore to construct a high quality four-lane expressway bypassing the township of Otaki and the settlement of Te Horo. Together with the Mackays to Peka Peka section to the south, it forms the Kapiti Expressway and when both sections are completed will provide a superior transport corridor providing much improved, reliable and safer journeys through the Kapiti Coast.

1.3 Project Location

The project is located on the Kapiti Coast adjacent to the existing SH1, extending from the Peka Peka Beach junction to just north of Otaki.

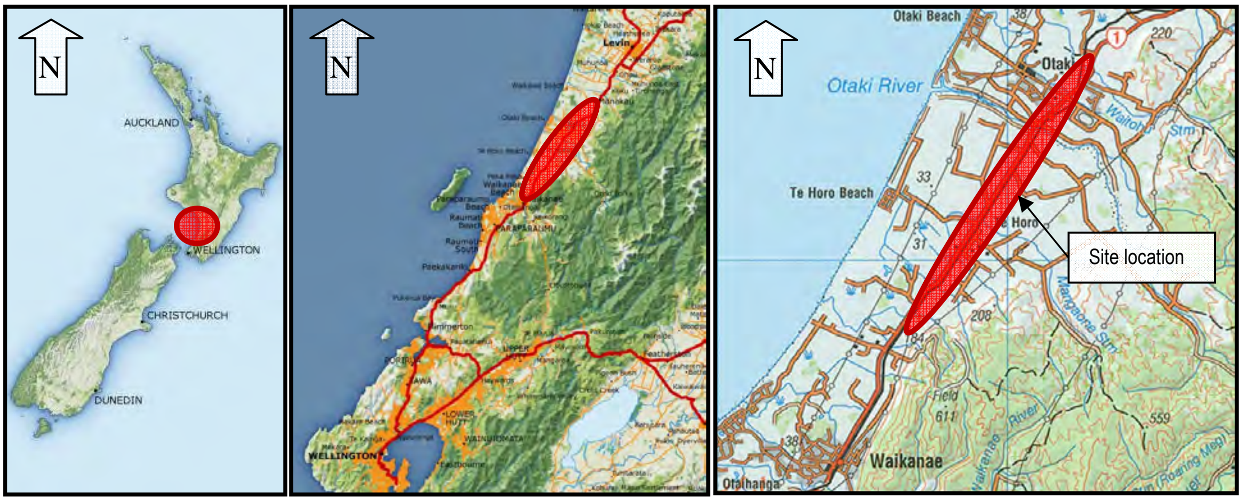

Figure 1 - Project Location Maps

1.4 Project Elements

This project is not just a new expressway but also includes new local roads. The project can be split in to five different elements:

- new sections of expressway (and junctions between expressway and local roads)
- new sections of local and connecting roads

- expressway upgraded from existing SH1
- local road converted from existing SH1 (and modified local road)
- realignment of the north island main trunk (NIMT) railway.

1.5 Existing Site Description

1.5.1 Topography

Land either side of the route generally consists of flat land to the west, and steep country to the east, with waterways flowing from east to west, towards the sea. Smaller waterways have defined flow paths to the east but some lose definition as they flow across the flat land to the west (possibly due to infiltration or artificial diversions to farm drainage channels).

The existing ground along most of the route alignment has low grades. The middle third has limited locations where stormwater can be discharged. The northern end (north of Otaki Township) rises into rolling country.

1.5.2 Geology

The landform of the project area is defined by a number of strong natural features including: the coastal edge, the coastal plain, the eastern foothills, and the rivers and streams.

The Southern two fifths of the road may be subject to debris flows, due to the small and steep nature of the catchments to the east.

Between Peka Peka Road and Te Horo Beach Road, there are underlying dune sand and inter-dune deposits, which are likely to contain peat deposits. North of Te Horo Beach Road, the underlying geology includes terrace alluvium and recent alluvium.

Generally, alluvium and inter-dune deposits are not good for stormwater disposal by infiltration. There may possibly be potential for infiltration in pockets of dune sand; however this should not be relied on as infiltration rates in dune sand can be disappointing. Soakage is expected to be better in the gravel deposits associated with the larger rivers.

1.5.3 Existing Man Made Features

The existing SH1 and NIMT rail embankments alter the natural drainage patterns of the area. In isolated places the culverts under the railway act as a restriction, reducing the downstream flooding risk.

Just north of the Otaki River is the Otaki stop bank. This alters the local drainage pattern particularly from the north.

1.5.4 Waterways of Significance

The three larger waterways noted below are cited in Greater Wellington Regional Council's (GWRC) Regional Freshwater Plan as having special significance.

The Otaki River is listed as:

- Containing 'Nationally Threatened Indigenous Fish' (species recorded are: short jawed kokopu, giant kokopu, banded kokopu, and koaro).
- Containing 'Important Trout Habitat'.
- Having 'Important Amenity and Recreational Values'.

The Waitohu Stream is listed as:

- Containing 'Nationally Threatened Indigenous Fish' (species recorded are: brown mudfish).

The Mangaone Stream is listed as:

- Containing 'Nationally Threatened Indigenous Fish' (species recorded are: short jawed kokopu, koaro, and banded kokopu).

1.6 Stormwater Catchment Maps

There are four main catchments that the existing state highway and proposed alignment cut through. These are the Waitohu, Otaki, Mangaone and Awatea (project assigned name) catchments as shown on Figure 2 below.

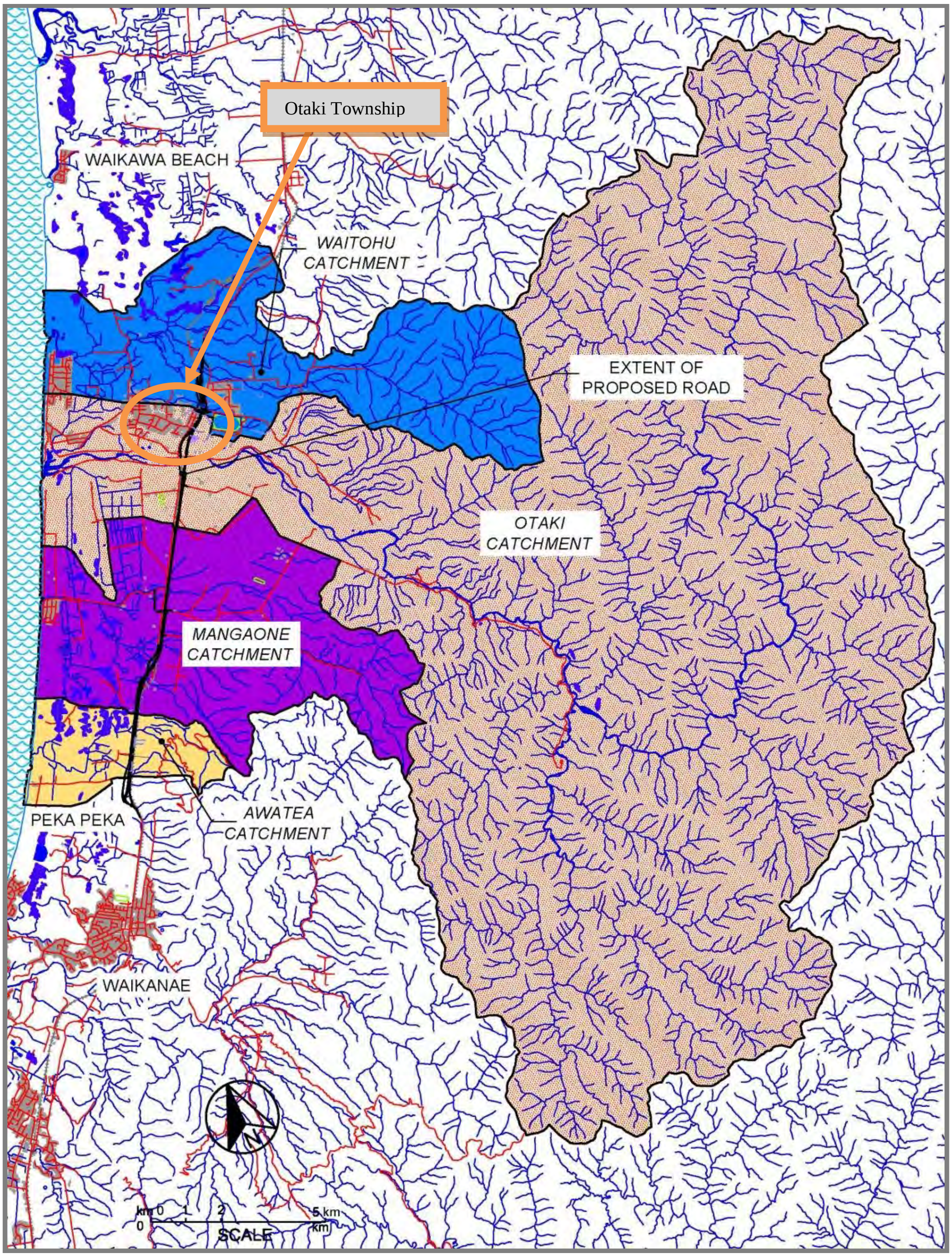

Figure 2 - The four major catchments that the project lies within

There are a further eight catchments in the range 100ha to 500ha, and over 10 catchments smaller than 100ha. There will be waterways (and waterway crossings and potential discharge points) associated with each of these catchments. See Figure 3 below.

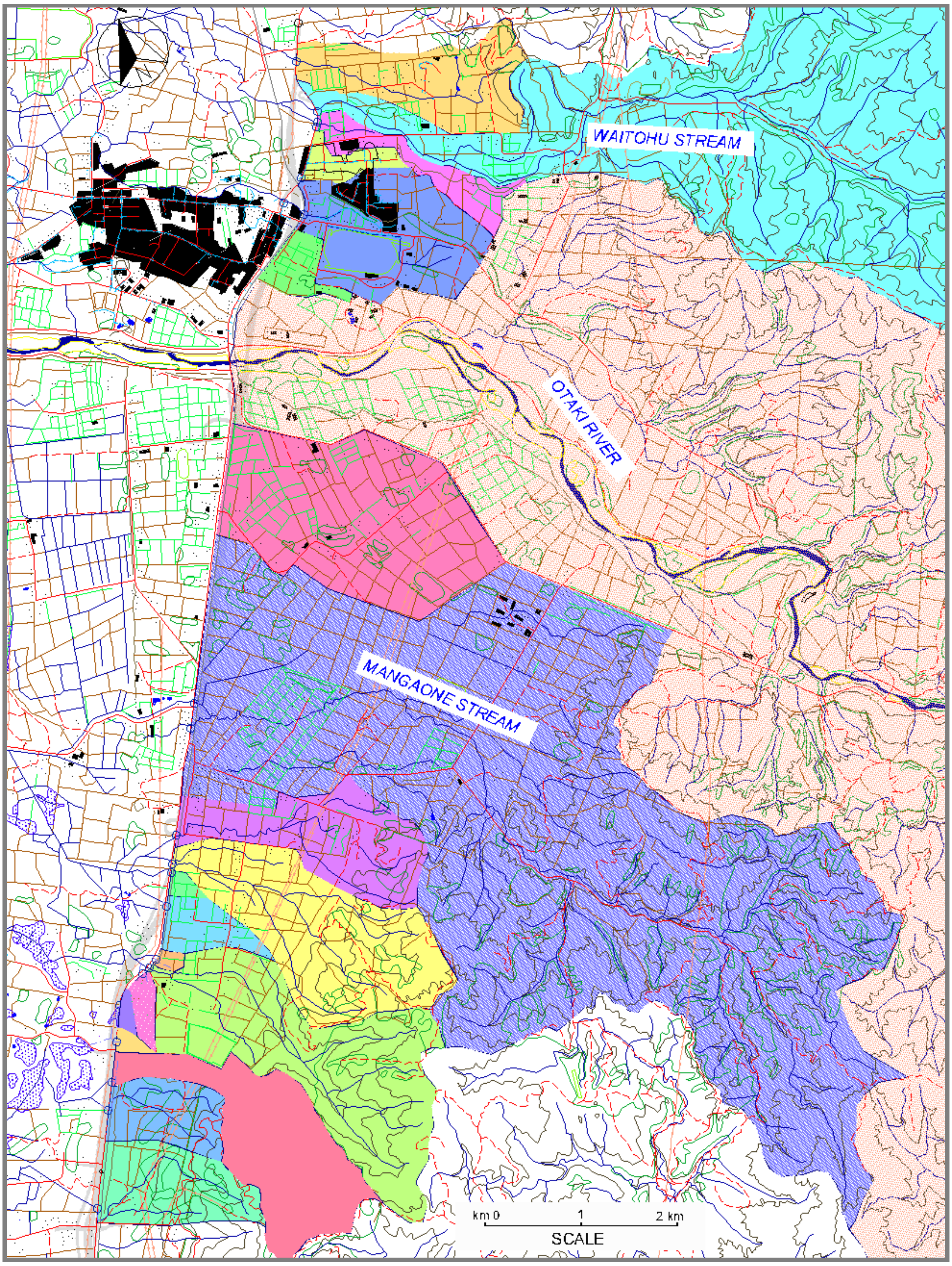

Figure 3 – Catchments associated with existing SH1 culverts

2. Legislation, Design Documents and Previous Reports

2.1 Legislation

The Freshwater Fisheries Regulations (1983) establishes the requirements for the protection of freshwater fish habitats and provision of fish passage (part 6).

The Resource Management Act promotes the sustainable management of natural and physical resources. This allows the development of natural resources whilst:

- RMA seciton5.2.b; 'safeguarding the life-supporting capacity of air, water, soil and ecosystem;
- RMA seciton5.2.c; 'avoiding, remedying, or mitigating any adverse effects of activities on the environment'.

Section 17 of the RMA also details the duty to 'avoid, remedy, or mitigate adverse effects'. The power to enforce this duty is passed to the consenting authority. A best practicable option approach can be used at the discretion of the consenting authority and is currently considered best practice stormwater management approach by in the industry. In determining the best practicable option, regard must be given to:

- The nature of the discharge and sensitivity of the receiving waterway.
- The financial implications (including maintenance) and effects on the environment when compared to other options.
- The current state of technical knowledge and the likelihood that the option can be successfully applied.

At a National level, the government has published Nation Policy Statement (NPS): Freshwater Management 2011. This NPS is a 'first step to improve freshwater management at a national level'; it identifies the values of freshwater and sets objectives and policy for both quality and quantity of water, integrated management and Tangata Whenua roles and interests.

To put this into practice: there are the NZTA stormwater standards[7&8] intended to be applied as minimum standards nationally (that address both quantity and quality effects) and local council guidelines that address stormwater quantity effects.

2.2 Design Documents

2.2.1 NZTA Documents

- Highway Surface Drainage, NZTA, 1977.
- Bridge Manual Second Edition, NZTA, 2003 (and amendments 2004, 2005).
- Climate Change Position Statement, NZTA, 2004.
- Stormwater Treatment Standard for State Highway Infrastructure, NZTA, May 2010.

[7] Stormwater Treatment Standard for State Highway Infrastructure, NZTA, May 2010
[8] Draft Erosion and Sediment Control Standard for State Highway Infrastructure, NZTA August 2010

- NZTA Environmental Policy Manual September 2010.
- Draft Erosion and Sediment Control Standard for State Highway Infrastructure, NZTA August 2010.

2.2.2 Kapiti Coast District Council (KCDC) Documents

- Subdivision and Development Principles and Requirements, KCDC, 2005.
- Isohyet Based Calculation of Design Peak Flow – Isohyet guidelines and charts, SKM (produced on behalf of KCDC), 2005.
- Update of Kapiti Coast Hydrometric Analyses – updated rainfall analysis, SKM, August 2008.
- Stormwater Management Strategy, KCDC, 2009.

2.2.3 Greater Wellington Regional Council (GWRC) Documents

- Otaki Flood Management Plan, GWRC, 1998
- Regional Freashwater Plan for the Wellington Region, GWRC, 1999[9]
- Erosion and Sediment Control Guidelines for the Wellington Region, GWRC, September 2002 (update pending).
- Fish-friendly culverts and rock ramps in small streams, GWRC, 2003[10].

2.2.4 Other Documents

- TP131 Fish Passage Guidelines for the Auckland Region, ARC, 2000.
- TP10, Stormwater Management Devices: Design Guidelines, ARC, 2003.
- Specification for the installation of pipelines on railway land, Ontrack, 2007.
- Draft Drainage Design Guidelines, Ontrack, January 2008.
- Track and civil design parameters summary, Opus/Ontrack, 2008.
- TP366 Culvert Barrel Design to Facilitate the Upstream Passage of Small Fish ARC, 2008.
- TR2009084 Fish Passage in the Auckland Region ARC, 2009.
- NZS4404:2010 Land Development and Subdivision Engineering, 2010.

[9] The Transmission Gully plan change to the Regional Freshwater Plan is currently being appealed and not currently in effect. This plan change would only be applicable to the Transmission Gully project and not any other project. The outcome of the appeal process would provide a reference point for further plan changes for other RoNS projects.

[10] Requirements for provision of fish passage are not currently addressed under the Regional Plans; however the Freshwater Fisheries Regulations still apply. Provision of fish passage is expected by GWRC and is routinely a condition of consent.

2.3 Previous project reports

- Scheme Assessment Report – Volume 1, North Otaki to Peka Peka Road, September 2002, Meritec Limited.
- Scheme Assessment Report – Volume 2, North Otaki to Peka Peka Road, July 2002, Meritec Limited.
- Scheme Assessment Report – Volume 3, North Otaki to Peka Peka Road, July 2002, Meritec Limited.
- Report of Stage 2 Consultation, SH 1 Otaki – Te Horo Expressway, May 2003, Meritec Limited.
- Assessment of Environmental Effects, Otaki – Te Horo Expressway, May 2003, Meritec Limited (see chapter 7.3 Effects on Flood Hazard).
- Peka Peka to North Otaki, Geotechnical Factual Report, Aprill 2011, AECOM.

It should be noted that stormwater issues are only briefly touched on in the above reports. This is to be expected since expectations around stormwater (especially water quality) have increased dramatically in the last 10 years.

3. Kapiti Coast Hydrology

As the project is completely located in the Kapiti Coast district, the hydrology outlined below will be used for this project.

3.1 Rainfall

Rainfall depth used for the purposes of determining culvert and road drainage catchment flows will be determined using the rainfall charts in KCDC's Subdivision requirements[11&12] (including the August 2008 updated rainfall analysis[13]).

The KCDC rainfall charts are used in preference to HIRDS V3.0 data. This is because the KCDC charts are based on a specific study for the Kapiti Coast region; whereas the HIRDS rainfall charts are based on a general nationwide study and only used where no better location-specific data exists.

3.2 Runoff

Runoff flow rates from the carriageway are to be determined using the rational formula for sizing of road drainage assets.

Change in flow rates for sizing culverts and attenuation devices are proposed to be determined using the U.S. Department of Natural Resources Soil Conservation Service method, used in accordance with KCDC's Subdivision requirements.

Consideration of the effect of future catchment development on curve number (CN) values is not necessary due to KCDC's requirement for hydrologic neutrality on all new developments.

3.3 Climate change

The Ministry for the Environment (MfE) has established guidelines when considering potential climate change effects[14]. SKM has incorporated the MfE's climate change recommendations (additional average rainfall of 16.8% for the 24 hour 1% AEP rainfall event see Appendix 1 – this assumes a temperature change of 2.1 degrees by 2090 and a 8% increase in rainfall per degree of change) into the regional rainfall model used in the hydrological methodology[12] and associated update[13] as included in the District's Subdivision Requirements[11]. As this hydrological methodology is being used, climate change is inherently included.

[11] Subdivision and Development Principles and Requirements, Kapiti Coast District Council, 2005
[12] Isohyet Based Calculation of Design Peak Flow – Isohyet guidelines and charts, SKM (produced on behalf of KCDC), 2005
[13] Update of Kapiti Coast Hydrometric Analyses – updated rainfall analysis, SKM, August 2008
[14] Ministry for the Environment. 2008. Climate change effects and impacts assessment: A guidance manual for local government in New Zealand. Wratt, D., Mullan, B., Salinger, J., Allen, S., Morgan, T., Kenny, G. with Ministry for the Environment. Ministry for the Environment, Wellington, 153p.

4. Stakeholder Stormwater Consultation

4.1 Consultation with KCDC

4.1.1 KCDC Stormwater Meeting 26 August 2010

Opus had a stormwater focused meeting with KCDC on 26 August 2010. The critical outcomes of the discussions with KCDC are summarised below.

- KCDC advised that GWRC are responsible for water quality.
- KCDC agreed that the general approach would be to: treat runoff from all new impervious areas, with no retrofit of existing roads, in general.
- KCDC are considering whether the NZTA stormwater Standard meets their expectations for stormwater treatment. They consider that some catchments may warrant a higher standard of treatment than provided by the NZTA Standard, but have not provided supporting evidence at this stage.
- KCDC advised that acceptable approaches for peak flow attenuation are to attenuate to pre-development levels or establish a case that effects are no more than minor.
- KCDC does not generally favour multi cell culverts on its road network due to the perceived maintenance requirement.
- The Mangapouri Stream is throttled by a culvert under the railway (possibly to 10 or 20 year flow). KCDC are keen to retain this throttle. Any new or re-configured throttle should have an easement over it in to allow KCDC access.

4.1.2 KCDC Stormwater Meeting 8 April 2011

Opus had a second stormwater focused meeting with KCDC on 8 April 2011. The critical outcomes of the discussions with KCDC are summarised below:

- KCDC (SKM) advised with regard to Racecourse Catchment, that there is a pipe under County Road and the NIMT but entry and exit points are very overgrown and are suspected to be completely choked. It is likely that the excess water ponds in Racecourse Catchment and soaks away.
- KCDC advised that their preferred approach would be for Opus to demonstrate that 5yr and 100yr storm runoff from the proposed road would be no worse than pre-development runoff, on the basis that the NZTA stormwater standard does not require attenuation.

- In regard to extended detention and stream erosion control, KCDC advised that they do not require detention of small storms but that Opus may choose to follow NZTA practice.

- KCDC advised that background testing may be required if the receiving environment is sensitive, in order to verify that post-development conditions are no worse. Opus confirmed that no testing was proposed.

4.1.3 KCDC Stormwater Meeting 15 June 2011

Opus' third stormwater-focused meeting with KCDC was on 15 June 2011. The critical outcomes of the discussions with KCDC are summarised below.

- KCDC advised that all developments are required to be hydraulically neutral in terms of peak runoff contribution to local watercourses, and confirmed that KCDC standard is to attenuate 1% AEP flows to 100% of pre development flow.

- KCDC advised that the Mary Crest area is main area of interest from a water quality/ecological perspective.

- KCDC agreed that there will need to be an agreement between NZTA and KCDC on maintenance of the swales that service both NZTA and NZTA roads.

- KCDC advised that the Alliance on the Mackay's to Peka Peka project are using 1.5 x (Q100+CC) as their extreme design event. Opus agreed to consider the same approach.

4.2 Consultation with GWRC

4.2.1 GWRC Stormwater Correspondence 2010

The outcomes of discussions with GWRC are summarised below:

- Flooding from the Waitohu Stream is frequent.

- The waterways that GWRC maintain in the Kapiti Coast that are relevant to this project are: Otaki River, Mangaone Stream, Mangaone Drains, Mangapouri Stream and the Waitohu Stream.

- The Regional Freshwater Plan (RFP) allows stormwater discharge as a permitted activity and there are currently no post-construction stormwater treatment guidelines. However the RFP is soon to be reviewed and GWRC see NZTA as a key stakeholder when it comes to the development of roading-related stormwater provisions [whilst the outcome of the review cannot be anticipated, it is prudent to assume that GWRC's stormwater discharge requirements will take a step towards the NZTA Standard approach].

- GWRC's expectations are that fish passage be maintained in any permanently flowing watercourses as a minimum. The RFP provides for river crossings in intermittently flowing streams as a permitted activity provided certain conditions are met; it does not require provision for fish passage[15]. Rule 25 specifies the maximum stream catchment size for crossings to be considered as intermittent streams (50ha in the project area); it does not dictate whether a stream is permanently or intermittently flowing, or the need to provide fish passage. Opus will need to assess each stream individually, and reporting provided with the resource consent application will need to clearly identify which watercourses are intermittent and which are permanent. Where there is uncertainty about the status of a watercourse and the need to provide fish passage, GWRC are happy to carry out an inspection with Opus and provide advice. GWRC also recommends that Opus seek the Department of Conservation's approval for the proposed crossings, particularly if fish passage cannot be provided.

4.2.2 GWRC Stormwater Meeting 15 June 2011

Opus had a stormwater focused meeting with GWRC on 15 June 2011. The critical outcomes of the discussions with GWRC are summarised below:

- GWRC advised Opus of the contact details for the GWRC person who has responsibility for water quality (subsequent discussions with Tim Park confirmed that the residual bush and associated wetland at Marycrest is the principal area of concern).

- GWRC agreed with the approach of using 1.5 x (Q100+CC) as the extreme design event.

- GWRC advised that if ponds volumes did not include for climate change, trigger levels may be needed to indicate when the attenuation ponds needed to be made bigger.

4.3 Consultation with KiwiRail

During 2010, Opus had discussions with Mark Gullery and Richard Justice of KiwiRail regarding stormwater standards/design parameters. The conclusion was that KiwiRail's latest stormwater standards are those as agreed on the Wellington Region Rail Programme (WRRP) MacKay's to Waikanae Double Tracking project (see Appendix 2).

[15] Requirements under The Freshwater Fisheries Regulations (1983) still applies.

5. Stakeholders' Stormwater Standards

There is no definitive and universally accepted document that encompasses the design standards for all aspects of stormwater design. As such we have collated the various stakeholders' requirements from a range of documents and then carried out interpretation as required. This process is captured in Appendix 3.

We have collated the main stormwater standards from NZTA, the Councils (GWRC and KCDC) and KiwiRail. These standards are summarised in Table 2 below.

Table 2 – Stakeholders' Stormwater Standards

	KCDC (from documents)	KCDC (from consultation)	NZTA	GWRC	KiwiRail
Primary drainage	10% AEP[16]	No further comment	20% AEP to edge of trafficked lane[17] 10% AEP catchpit and pipe capacity	Not specified	10% AEP with no surcharging[18]
Secondary drainage	1% AEP[16]	No further comment	In the 2% AEP storm event, at least half a traffic lane should have no more than 100mm of surface water depth[17]	Not specified	1% AEP with minimum 300mm freeboard from rail track[18]
Attenuation - (Storm peak discharge control)	10% AEP: no increase in flows or less than minor adverse efects[16]	either provide attenuation to pre-development level or establish a case that effects are no more than minor	1%AEP limited to 80% of predevelopment flow (where existing downstream problems exist)[19] (but no attenuation recommended where the project is in the bottom half of the catchment) 50% and 10% AEP flows to match pre development flows[19]	Not specified	Not specified
Stream channel erosion control	Not specified	No further comment	Three different approaches considering 50% AEP flows[19]: • Check the 50% AEP stream velocities to ensure that velocities are non-erosive • Implement extended detention or volume control • Conduct a shear stress analysis for a specific site NB: only applies where catchment imperviousness is expected to exceed 3% (including future foreseeable development) [19]	Not specified	Not specified

[16] Subdivision and Development Principles and Requirements, KCDC, 2005
[17] Highway surface Drainage, NZTA, 1977
[18] Draft Drainage Design Guidelines, Ontrack, January 2008
[19] Stormwater Treatment Standard for State Highway Infrastructure, NZTA, May 2010

	KCDC (from documents)	KCDC (from consultation)	NZTA	GWRC	KiwiRail
Treatment of road runoff	Best Practicable Option (BPO) approach[16 & 20]	KCDC are reviewing NZTA Stormwater minimum standard	BPO aproach[19]. Treat all new impermeable surfaces (or equivalent area).	Not specified	Not specified
Waterway crossings (at culverts)	10% AEP typically but 1% if appropriate (to be assessed on case by case basis)[16]	Existing level of service not to be reduced.	1% AEP, with 500mm freeboard[21]	Not specified	10% AEP or 1:10 year return with no surcharging and 1% AEP with min 600mm freeboard to rail tracks[18]
Climate change	Best practice (as MfE guidance)[22]	Use of MfE guidelines (or use of SKM rainfall charts also accepted)	Apply to assets lasting longer than 25 years19, or Apply to assets lasting longer than 50 years for pipe and culverts[23]	Best practice (as MfE guidance)	Not specified
Loss of floodplain storage	Not specified	establish effects are no more than minor by modelling or provide compensatory storage	Not specified	Not specified	Not specified
Sediment and Erosion control (during construction)	Not specified	No further comment	As per NZTA draft Standard [24]	As GWRC guidelines[25]	Not specified
Fish passage requirements	Not specified	No further comment	Not specified	As GWRC guidelines[26]	Not specified

From our assessment in Appendix 3 we conclude that:

- NZTA's Stormwater Treatment Standard (SWTS) does not require any attenuation on this project.
- NZTA's SWTS requires extended detention (for stream erosion control) for sections of the road discharging to the Waitohu and Awatea catchments but not the Mangaone or Otaki catchments.
- KCDC require peak flow attenuation up to the 1% AEP storm event for all locations where it cannot be shown that attenuation is not needed.

[20] TP10, Stormwater Management Devices: Design Guideline Manual, Auckland Regional Council (ARC), 2003
[21] Bridge Manual Second Edition NZTA, 2003
[22] Stormwater Management Strategy, KCDC, 2009
[23] Climate Change Position Statement, NZTA, 2004
[24] Draft Erosion and Sediment Control Guidelines for State Highway Infrastructure, NZTA August 2010.
[25] Erosion and Sediment Control Guidelines for the Wellington Region, GWRC, September 2002
[26] Fish-friendly culverts and rock ramps in small streams, GWRC, 2003

- KCDC do not require extended detention for erosion control purposes.
- KCDC's stormwater treatment requirements will generally be met by following NZTA's SWTS.

The next section details the Stormwater Standards we propoes for this project see Table 3 on page 18.

6. Project Stormwater Standards Proposal

In section 5, and our assessments in Appendix 3, we established KCDC's aspirations; KiwiRail's and GWRC's requirements; worked through NZTA's standards, and have identified other considerations. In this section we will develop a set of stormwater objectives that we propose to apply to this project. In general we have proposed the highest reasonable stakeholder standard applicable to each area (in line with a BPO approach).

Our assessment of the NZTA's requirements (see detail of assessment in Appendix 3) showed that no attenuation is required, as the cumulative effects of ongoing catchment development are expected to be minor. Despite this we have adopted the KCDC standard and will be providing 1% AEP peak attenuation to 100% of the predevelopment flow in the locations where required.

As the 2010 NZTA SWTS was prepared by an acknowledged industry expert (and underwent implementation testing and formal industry consultation), we believe (and this was provisionally accepted by KCDC in initial consultation) that the 2010 NZTA SWTS reflects the latest in stormwater treatment research and thinking. As such, compliance with the NZTA SWTS has been adopted as the base-line standard which will also comply with the spirit of the KCDC's own stormwater treatment requirements.

6.1 Temporary Stormwater Management

Sediment and erosion control activities carried out during construction will comply with GWRC and NZTA requirements. A sample Erosion and Sediment Control Plan is expected to be developed as part of the resource consent application.

This erosion and sediment control (E&SC) plan is intended to be a live document. It will be prepared to demonstrate a concept solution (i.e. indicative design) for use in the design development and consenting stages and will then be updated by the Contractor to become part of the Contractor's Environmental Management Plan (CEMP). Any changes to the E&SC plans (which are likely to be necessary to meet the specific staging of the works proposed by the Contractor) are intended to be agreed with and approved by GWRC prior to any work commencing.

The Contractor undertaking the works will be responsible for the overall environmental management of the site. Regular compliance meetings and audits will also be undertaken to ensure compliance with resource consent conditions and the CEMP

For setting the designation, at a high level assessment will be undertaken to identify possible sediment pond locations for the purpose of setting the designation and informing land entry requirements.

6.2 New Sections of Road

The two types of new road in the project serve different purposes and are of different strategic importance. The table below gives our proposed level of service for the new roads in this project. Consideration has been given to the purpose of the section of road and also the current level of service experienced by the road user.

Table 3 defines the minimum stormwater management level of service that we propose for new sections of road.

Table 3 - Proposed Level of service for new sections of road

	New sections of local and connecting roads	New sections of expressway and Junctions
Climate change	As the midrange of the MfE guidance to the year 2090. This is an additional 16.8% of rainfall for the 1%AEP stormevent. This has already been incorporated into the KCDC rainfall charts	
Primary road drainage	Designed to convey the 10% AEP[27], 10 minute storm event flows	Designed to convey the 10% AEP, 10 minute, storm event and to keep the 50% AEP, 10 minute, storm event flows a maximum of 4mm deep at the edge of trafficked lane[28]
Secondary road drainage	Assuming no median barrier exists: Minimum of 2m width in centre of road to be passable[29] in a 1% AEP[27] storm event	Assuming a median barrier exists: Minimum of one lane in each direction to be passable[29] in a 1% AEP[28] storm event
Treatment of road runoff	We propose to treat a road surface area, equivalent to the increase in impermeable road surface. However where the opportunity exists, we will treat all road surfaces where practicable Treatment to NZTA requirements (which are an evolution of the TP10[30] treatment requirements as referred to in KCDC's subdivision requirements[27]). This is a Best Practicable Option approach. NZTA treatment requirements are defined in their Stormwater standard[31] From the NZTA Stormwater standard, the water quality event is defined as 19mm[32] over 24hours (before allowing for climate change)	
Stream channel erosion control	Not required	Provision of extended detention volumes where the 50% AEP velocities are erosive for catchment with foreseeable imperviousness of greater than 3%

[27] Subdivision and Development Principles and Requirements, KCDC, 2005
[28] Highway surface Drainage, NZTA, 1977
[29] "Passable" is defined as 100mm of water depth (NZTA 1977) with a velocity not exceeding 2m/s.
[30] TP10, Stormwater Management Devices: Design Guidelines, Auckland Regional Council (ARC), 2003
[31] Stormwater Treatment Standard for State Highway Infrastructure, NZTA, May 2010
[32] The NZTA stormwater guidance document defines the Water quality event as the 90th percentile rainfall event. From Appendix A of the NZTA stormwater guidance document the 90th percentile rainfall event along the project length varies between 17.5 and 20mm over 24 hours; we have adopted 19mm throughout (not including climate change)

	New sections of local and connecting roads	New sections of expressway and Junctions
Attenuation (storm peak discharge control)	For the critical duration storm event for the whole catchment: post road construction 50%, 10% and 1% flows will generally be attenuated to 100% of pre road construction flows. Climate change provision to be incorporated in past construction flow estimates There is the opportunity to establish the case that increases in flow are no more than minor for several of the larger catchments. These catchments are the Otaki River, the Mangaone Stream, the Waitohu Stream and the Mangapouri stream	
Minor Waterway crossings[33]	To convey 10% AEP storm flows, typically but 1% if appropriate (to be assessed on case by case basis) [27] with 300mm freeboard from road white edge line	To convey 1% AEP storm flows, with a minimum 500mm freeboard from road white edge line and a maximum of 2m heading up from the culvert soffit
	Hydraulic exceptions are culverts providing a throttling action and flood protection to downstream properties. Design flows to include an allowance for climate change. Fish passage provided to GWRC guidelines[34]	

Following on from Table 3 where basic levels of service are defined, Table 4 below seeks to define the hydraulic design parameters for the various stormwater elements that are envisioned to be included, where needed, in the project at this stage. The final stormwater management is not restricted to elements represented in the table and other devices (including proprietary devices) may be used.

Table 4 – Proposed parameters for stormwater elements in new road sections

Stormwater element	New KCDC local roads	New NZTA expressway
Road surface (Road drainage)	Hydraulic parameters: • No specific objective	Hydraulic parameters: • Maximum pavement water depth 4mm in a 10 minute, 50% AEP storm event
Kerb and channel with catchpits (Road drainage)	Assumption: • Local roads will have shoulders less than 2.5m wide Hydraulic parameters: • No specific objective to keep channel flow out of trafficked lanes • In a 10 minute 1% AEP storm event, at least 2m of carriageway is to remain passable[35]	Assumption: • The expressway will have shoulders of minimum width 2.5m Hydraulic parameters: • Keep water channel flow, to a maximum of 4mm at the edge of the trafficked lanes in a 10% AEP storm event • In a 10 minute 1% AEP event, at least one lane is to remain passable[35]

[33] Minor waterway crossings refer to all waterway crossings with the exception of the four major crossings (Otaki, Waitohu, Mangaone, Mangapouri). For information on the major crossings refer to 'Design Flood Levels for Waterway Crossings' Opus, 2011.
[34] Fish-friendly culverts and rock ramps in small streams, GWRC, 2003
[35] "Passable" is defined as 100mm of water depth (NZTA 1977) with a velocity not exceed 2m/s.

<table>
<tr><th>Stormwater element</th><th>New KCDC local roads</th><th>New NZTA expressway</th></tr>
<tr><td></td><td colspan="2">• Catchpit capacity designed for the 10 minute, 10% AEP storm event flows (allowing for 50% blockage for catchpits on grade and 70% blockage for catchpits in a low point)
• Catchpit capacity to be designed for the 10 minute, 1% AEP storm event flows (allowing for 50% blockage for catchpits on grade and 70% blockage for catchpits in a low point) where no secondary overflow path exists
• Climate change to be applied to all flows
Physical parameters:
• Sump leads to be lower than incoming Sub soil drains
• Catchpit sumps to be minimum 0.6m below invert of sump lead
• Catchpit grates to be minimum size of 450mm by 650mm and to be high capacity (such as Manning grates) - cycle friendly grates only required where sholders are less than 1.5m (such as the humes 675mm x 450mm Cycle friendly grate)
• Catchpits to have a back entry lintel minimum 2.4m long</td></tr>
<tr><td>Median
(Road drainage)</td><td colspan="2">Assumption:
• Required where a four lane road in super elevation
• Median drains provide conveyance only (is no formal treatment or detention).
Hydraulic parameters:
• As Kerb and channel above
Physical parameters:
• Expected to be a grassed v-drain with catchpits (catchpit parameters as above except no back entry lintel)
• Catchpits to discharge to adjacent swales at the edge of the road.</td></tr>
<tr><td rowspan="3">Pipework
(Road drainage)</td><td colspan="2">Hydraulic parameters:
• Catchpit leads and mainline pipework designed for the 10 minute, 10% AEP storm event flows
• Pipe work to be designed for the 10 minute, 1% AEP storm event flows where no secondary overflow path exists
• Climate change to be applied to all flows</td></tr>
<tr><td>Physical parameters:
• Minimum size of catchpit leads and pipe, 225mm diameter</td><td>Physical parameters:
• Minimum size of catchpit leads and pipe, 300mm diameter</td></tr>
<tr><td colspan="2">• Pipework to have a design life of 100 years and designed to HN-HO-72 loadings
• Manholes to be located outside of trafficked lane where practicable
• Typical minimum pipe cover 900mm in non trafficed areas and 1200mm under pavements
• HS2 is the maximum bedding suport to be assumed (unless flowable fill is used)
• Pipe Class selection to have minimum of 10% reserve capacity strength
• Typicaly minimum pipe angle to road to be 45 degrees</td></tr>
</table>

Stormwater element	New KCDC local roads	New NZTA expressway
Sub soil drains **(Road drainage)**	**Physical parameters:** • Located 1m below base course, preferably discharging to manholes (or to catchpits if no manhole locally available) • Sub soil pipe surrounded by 20mm to 40mm crushed rock or pea gravel surround • Geotextile rap around gravel, to stop fines from surounding ground migrating in to drainage material	
Swales **(Road drainage and Treatment)**	**Hydraulic parameters:** • 50% AEP storm flow level to be below base course level • Swales to contain the 10% AEP storm event flows • Swales to contain the 1% AEP storm event flows where no secondary overflow path exists • Stormwater runoff to be treated in the swale • Climate change to be applied to all flows **Physical parameters:** • Side slopes to be a maximum slope of 1 vertical to 4 horizontal • Swales to be planted with species that have a maximum mature height of 1m (where adjacent to the carriageway) and do not seasonally drop significant leaf litter (native species are preferred such as Oioi, Wiwi and possibly Isolepis)	
	• Local road pavement construction is assumed to have a feathered edge and base course thickness of 500mm • Swale base is assumed to be 1.5m wide	• expressway pavement construction is assumed to have a feathered edge and base course thickness of 700mm • Swale base is assumed to be 2m wide
Swale underdrains **(Road drainage and Treatment)**	**Physical parameters:** • Swale underdrains to be provided where longitudinal grade of the swale is less than 2% • Swale underdrains to fulfil function of (and replace) sub soil drains (where needed), in which case they will need to be 1m below base course level • Access chamber every 100m required for inspection and maintenance of swale underdrains	
Dry ponds **(Attenuation)**	**Hydraulic parameters:** • Dry pond provides attenuation to Post road construction 50%, 10% and 1% flows to pre read construction levels • Climate change allowance incorporated in to pond sizing **Assumption:** • Dry ponds are preceded by a swale (which provides stormwater treatment) • Dry ponds to blend in with surrounding land use (typically grassed)	

<table>
<tr><th>Stormwater element</th><th>New KCDC local roads</th><th>New NZTA expressway</th></tr>
<tr><td>Attenuation swales (Road drainage, treatment and attenuation)</td><td colspan="2">Hydraulic parameters:
• Swales to contain the 1% AEP attenuation volume with 300mm of freeboard to the road edge line
• Climate change included in attenuation volumes
Physical parameters:
• Side slopes to be a maximum slope of 1 vertical to 3 horizontal, typically 1 vertical to 4 horizontal
• Swales to be planted with species that have a maximum mature height of 1m (where adjacent to the carriageway) and do not seasonally drop significant leaf litter (native species are preferred such as OiOi and Wiwi)
• Bund spacing assumed to be 50 to 100m
• base width assumed to be 4m wide
• initially sized to hold full 1% AEP (including climate change) runoff (due to limited hydraulic controls)
• carrier pipe may be needed under the swale
• Under drain also assumed to be needed
• Hydraulic controls to be provided by a single pipe sized to discharge the total water stored in the swale over 48 hours</td></tr>
<tr><td>Culverts (Minor Waterway crossings[36])</td><td>Culverts will typically take the form of a single cell culvert with headwalls
Hydraulic parameters:
• Culverts to convey the 10% AEP storm flows without heading up more than 2m above the culvert soffit or within 0.3m of the white edge line
• Culverts to convey the 20% AEP storm flows without heading up above the culvert soffit
• Culverts to convey 1% AEP storm flows where the secondary overflow path would flow through buildings</td><td>Culverts will typically take the form of a single or multiple cell culverts with headwalls
Hydraulic parameters:
• Culverts to convey 1% AEP storm flows without heading up more than 2m above the culvert soffit or within 0.5m of the white edge line
• Culverts to convey the 10% AEP storm flows without heading up above the culvert soffit</td></tr>
</table>

[36] Minor waterway crossings refer to all waterway crossings with the exception of the four major crossings (Otaki, Waitohu, Mangaone, Mangapouri). For information on the major crossings refer to the hydraulics and modelling report.

Stormwater element	New KCDC local roads	New NZTA expressway
	• Back water effects to be kept within the designation where practicable. • Exceptions to hydraulic sizing are culverts that provide intentional throttling and flood protection to downstream properties (Mangapouri and Racecourse) Physical parameters: • The culvert design life will be 100 years and designed to HN-HO-72 loadings and NZTA F3: 2010 • Fish passage is expected to include a combination of: depressed culvert inverts, fish ramps, continuation of stream substrate through culverts and artificial features to provide resistance and variation to the flow • Erosion protection to be provided both upstream and downstream of culverts • Where practicable, culvert orientation will be perpendicular to the centre line of the road, and constructed off line (of the existing waterway)	

6.3 Existing Road Surfaces

Where existing SH1 is converted to a local road, we intend that there should be no worsening of the existing runoff quality or peak flows. We propose that this is achievable by not modifying the existing situation. In some cases, the paved surface is expected to reduce, as the road is converted from four lane State Highway to a two lane local road.

Where local road is modified but remains a local road, we also propose to leave the existing situation as it is.

Where existing SH1 is modified and becomes the new expressway, we intend that there should be no worsening of the existing situation. In general this will be achievable by treating and attenuating the equivalent increase in road area only, however we will evaluate opportunities to retrofit existing pavement areas on a case-by-case basis. For road drainage and minor waterway crossings we propose the existing situation needs to be upgraded to provide safe passage of emergency vehicles in a flood event.

6.4 New Sections of Rail

Design parameters for new sections of rail are detailed in the KiwiRail Basis of Design report. These are based on the design parameter summarised in Appendix 2, (which are from the 2008 WRRP MacKay's to Waikanae Double Tracking project). We note that the final extent of the rail track foot print will be similar to present.

6.5 Existing Rail

We are proposing to leave the existing drainage situation as it currently exists.

6.6 Differences from MacKays to Peka Peka Project

We have met and discussed standards, levels of service, and how these manifest with the Mackays to Peka Peka (M2PP) stormwater engineers. The purpose of this was to ensure consistence of approach.

At high level, the two designs teams are in broad agreement regarding standards and levels of service. Given the different project circumstances (such as topography, flood risk and development density) these standards manifest themselves in different ways, as is appropriate for each project locations.

Table 5 below highlights the differences between the M2PP Stormwater draft DPS (March 2011) and this report (PP2O stormwater DPS).

Table 5 - Differences between M2PP and PP2O

	M2PP	PP2O	Comment
Rainfall depth information	HIRDS V3 (2010)	KCDC rainfall data from the report, *Update of Kapiti Coast Hydrometric Analyses 2008*	HIRDS V3 gives about 5% more conservative results than the KCDC rainfall data, however the KCDC rainfall data is specific (and therefore more accurate) for the Kapiti Coast.
Peak flow Attenuation Standard	NZTA SWTS or KCDC standard (whichever is higher)	NZTA SWTS or KCDC standard (whichever is higher)	Both projects have the same high level philosophy, but due to different project circumstances this manifests differently.
Peak flow Attenuation Level of service	Attenuating the 1% AEP storm flow to 80% of predevelopment flows	Attenuating the 1% AEP storm flow to 100% of predevelopment flows	The M2PP assessment determined that NZTA SWTS required the stated attenuation, so this was deemed the highest requirements. The PP2O assessment determined that (due to different project circumstances) the NZTA SWTS did not require attenuation (see Appendix 3 for full assessment). Thus the KCDC requirements were deemed to be the highest required.

7. Project Stormwater Management Proposal

In section 6 we discussed stormwater standards and also hydraulic and physical parameters of stormwater devices that are expected to be used on this project. In this section, we will describe the recommended devices in more detail and discuss why they have been chosen for this project.

7.1 General Approach

The general approach we propose on this project is to treat and attenuate (where required) all new impervious areas. Opportunities for retrofit treatment of existing pavements will be assessed on a case-by-case basis. In some cases where it is difficult to treat or attenuate new pavement we may opt to use offset mitigation by treating an equivalent area of existing road with similar traffic volumes.

7.2 Stormwater Management Challenges

A number of situations along the route will present challenges for the development of a successful, best practice stormwater management system, including*:*

- Areas with existing localised or regional flooding.
- Geological constraints such as areas of subsoil with high organic content, high ground water, etc., may preclude certain forms of treatment device (e.g. infiltration practices).
- Topographical constraints may result in hydraulic head limitations.
- Existing development, and its proximity to the road alignment may restrict options in terms of available space.
- Cultural considerations (Iwi objectives).
- Maintenance and operational considerations, with a view to creating a positive long term legacy.

7.3 Stormwater Management Options

The various individual stormwater management devices are not listed here. This report assumes that these are well known by the reader (if not, see NZTA stormwater minimum standard document, ARC's TP10 and proprietary systems from Stormwater 360, Humes, Hynds and others).

7.4 Stormwater Treatment Trains

We have identified and listed a selection of possible treatment train approaches that have been considered for this project. They are described in Table 6 below.

Table 6 - Treatment Train Options

	Collection	Conveyance	Treatment	Attenuation
Treatment train 1	Attenuation Swales			
Treatment train 2	Swales			N/A
Treatment train 3	Swales			Dry Pond
Treatment train 4	Swales		Wet pond	
Treatment train 5	Swales		Wetland	
Treatment train 6	Kerb and Channel	Swales		N/A
Treatment train 7	Kerb and Channel	Attenuation Swales		
Treatment train 8	Kerb and Channel	Reticulation or open drain	Gross pollutant trap and Wet Pond	
Treatment train 9	Kerb and Channel	Reticulation or open drain	Gross pollutant trap and Wetland	
Treatment train 10	Kerb and Channel	Reticulation	Proprietary device	Dry Pond
Treatment train 11	Kerb and Channel	Reticulation	Proprietary device	Underground Tank

Limiting the number of permutations is desirable particularly to simplify future operation and maintenance; however a single treatment train is unlikely to be suitable for the entire length of the project.

Having carried out a rough order of cost, whole life cost analysis, we concluded that, in general, attenuation swales with simple hydraulic controls would be the most cost effective in situations where the longitudinal grade was less than 1.5% and that swales together with dry ponds would be cost effective in situations where the longitudinal grade was greater than 2.5%. However site constraints can often be expected to over-ride this choice.

Our whole life cost analysis, considered land costs, construction costs, maintenance costs and refurbishment costs. We considered two different situations (both applicable but non-specific, to this project): one a section of road at 0.5% longitudinal grade, and one section at 2% longitudinal grade. Consideration was then given to the elements and costs of having attenuation swales verses swales and attenuation ponds in each of the two situations.

The whole of life cost analysis assumes attenuation swales as described in Section 7.4.1 below. Interestingly, the analysis showed greatest costs associated with land cost and disposal of contaminated topsoil during refurbishment. Our whole life cost analysis is included in Appendix 4.

With the results of our whole life cost analysis (attenuation swales being more cost effective where the grade is less than 1.5%) and with the principle of providing a consistence solution in mind, we worked through the length of the project, allocating specific treatment devices. Four different treatment trains were needed: treatment trains 1, 2, 3 and 6 (as highlighted in Table 6 above). As the project develops, this selection may change.

There are some new local connecting roads and possibly bridge sections that will not be treated; however this will be offset by treating or reducing existing carriageway area elsewhere.

7.4.1 Description of Attenuation Swales

Attenuation swales deserve a special mention as they are a relatively new concept and the detail can be very different from one design to the next.

Previous attenuation swale variations have included:

- Swales with a bio-retention component, where the primary discharge is through the bio-media in the base of the swale and then collected by a perforated pipe under the drain. This is similar to a rain garden design, and rain gardens are generally not considered appropriate for high capacity roads due to the high suspended solid loads blinding the bio-media.

- Swales with a precise hydraulic control, consisting of a 20mm hole drilled in to the capped end of a 100mm diameter PVC pipe, where each bay discharges to a concrete carrier pipe running the length of the swale. In this arrangement, the small primary outlet is susceptible to frequent blockage, and the end cap is at risk of not being replaced during unblocking. Thus the precise hydraulic control could easily be lost.

On this project we propose a more robust hydraulic detail through each bund in the attenuation swales. This consists of a single PVC pipe (possibly a 100mm or 225mm diameter) with a mass concrete bed and surround at the upstream end (to act as a stop collar and as a headwall for ease of location), and as with most attenuation swales an underdrain will be needed. The negative side of this design is that we will need to store more water in the swale.

The positive side of this design is that: we can store an additional 55% to 70% water (by having twice as many bunds); do not need a carrier pipe running the length of the swale, and would have a much bigger hydraulic control that would be much less likely to block (as the hydraulic control would be sized to release the extended volume of the whole swale length over 24 hours as opposed to the extended volume of each swale cell over 24 hours). This concept for the attenuation swale detail is shown in Figure 4 and Figure 5.

Where the bunds in the attenuation swales encroach into the clear zone, the batters of the bunds (in the direction of travel) will need to be a maximum of 1 in 6. The 1 in 6 slope is taken from the NZTA approved mountable wingwall design. Figure 4 and Figure 5 are not drawn to scale.

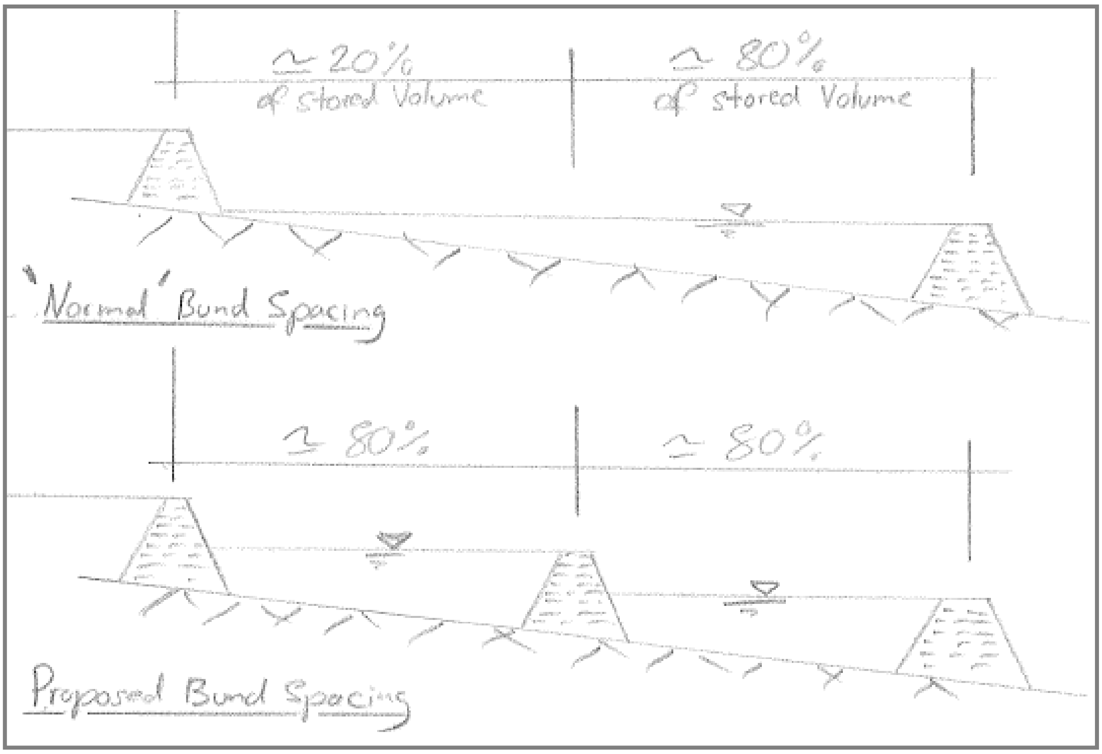

Figure 4 - Attenuation swale bund spacing and storage concept

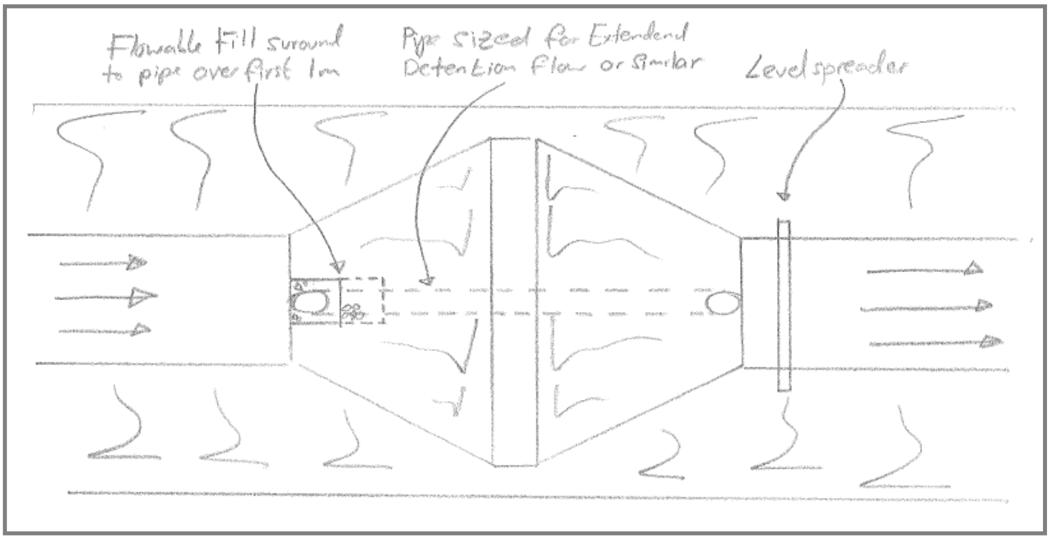

Figure 5 - Attenuation swale hydraulic control concept

To summarise: we are proposing a simple, relatively cheap and robust hydraulic control; proposing to provide 1% AEP 24 hour total capture storage volume; and providing twice as many bunds as 'normal' to increase the storage capacity of the swale by about 60%.

The hydraulic control is proposed to be the same for all bunds in a given swale, with the pipe sized for the extended detention flow for the whole swale catchment.

The size of the attenuation swales and the internal bund spacing will depend on the width of carriageway draining to it and the longitudinal grade. The depth of the attenuation swales is expected to range between 1.1m and 1.7m, with a corresponding top width (assuming flat ground) of 13m to 18m. The bund spacing is expected to range between 20m and 110m (see Appendix 6 for examples of attenuation sizing and bund spacing). Attenuation swales that are located directly adjacent to the expressway could be grassed or planted as there is easy maintenance access to them, however attenuation swales that are located at the bottom of fill slopes should be planted so regular access is not needed for mowing.

The attenuation swales will require maintenance. This could include: grass mowing, litter picking, inspection and clearing of swale bunds hydraulic controls, and eventually surface rehabilitation to remove the build-up of contaminates that the swales is designed to capture.

7.4.2 Description of Swales (treatment only)

Swales are a well-known concept. Essentially they are an approximately trapezoidal channel that are grassed or planted. They provide stormwater treatment but no significant attenuation. As with the attenuation swales, the swales that are at the bottom of fill slopes (not immediately adjacent to the expressway) are recommended to be planted, so that frequent maintenance (in the medium to long term) is reduced.

On this project, the size of the swales ranges. Typically the base of the swale is 200 to 300mm below the pavement construction. Assuming a 700m pavement construction, swales with 1 in 4 side slopes and a 2m wide base would have a top width of 10m (assuming flat ground). In addition to this, the swales must be able to drain so are not always able to be the same depth from the road surface.

The swales will require maintenance. This could include: grass mowing, litter picking and eventually surface rehabilitation to remove the build-up of contaminates that the swales is designed to capture.

7.4.3 Description of Ponds (Attenuation only)

Ponds are a well-known concept and in this project the ponds are proposed to provide attenuation only (as the swales provide treatment; if we had a piped system we would look to the ponds to provide treatment). As such the ponds are likely to be dry during periods of no rain. As with the swales, the pond could be grassed or plants as appropriate to fit in with the local project landscape theme.

The size of the ponds is bespoke and specific to the size and change in catchment characteristics that is draining to the particular pond.

The ponds will require maintenance. This could include: grass mowing, litter picking, inspection and clearing of pond hydraulic controls, and eventually surface rehabilitation to remove the build-up of contaminates that will accumulate in the pond base.

7.5 Stormwater Devices Proposal

The drawings in Appendix 5 show our proposal for stormwater treatment and attenuation devices. Preliminary sizing calculations for the stormwater devices are included in Appendix 6.

On the drawings the individual elements of the treatment trains are shown (swales, attenuation swales, ponds) and also culverts and other relevant features. Table 7 below gives a high-level view of where each treatment train is being used.

Table 7 - Treatment train locations

Expressway distance	Treatment train	*Collection*	*Conveyance*	*Treatment*	*Attenuation*
500 to 1100	Treatment train 1	Attenuation Swales			
1100 to 2000	Treatment train 3	Swales			Dry Pond
2000 to 2600	Treatment train 1	Attenuation Swales			
2600 to 3300	Treatment train 2	Swales			N/A
3300 to 3900	Treatment train 6	Kerb and Channel	Swales		N/A
3900 to 5200	Treatment train 2	Swales			N/A
5200 to 9700	Treatment train 1	Attenuation Swales			
9700 to 10300	Treatment train 3	Swales			Dry Pond
10300 to 12300	Treatment train 1	Attenuation Swales			

7.6 Minor Waterway Crossings Proposal

The drawings in Appendix 5 show the locations of culverts at the minor waterway crossings. Flow calculations and preliminary sizing's are for the culverts and are included in Appendix 7, and a draft plan of catchment areas is included in Appendix 8.

For calculating flows at minor waterway crossings we used HEC-HMS following the methodology described in KCDC's development guidelines[37]. For calculating preliminary culvert sizes, we initially assumed the culverts were inlet controlled and then increased the culvert size by one (e.g. from a 1050mm diameter to a 1200mm diameter), where we judged the culvert may be outlet controlled.

These culvert sizing calculations will need to be redone at the preliminary design stage, once survey information regarding downstream channel section and grades (and in some cases existing culverts), is

[37] Subdivision and Development Principles and Requirements, KCDC, 2005

available. Our intention is to use HY-8 (which allows modelling of downstream conditions) to size the culverts before consent lodgement.

We will also consider what happens in an extreme design event (defined with GWRC as the 2090, 1% AEP storm event plus 50%) at significant culvert locations.

7.7 Comments at Specific Locations

There are several specific areas that warrant further consideration. These locations and their associated complications are recorded in the following sections.

7.7.1 Natural Depression north of Otaki

There is an existing depression in the land located north of Otaki, just north of where the rail crosses under SH1 (see Figure 6 below). The piped stormwater from the residential areas to the east is discharging into this area. The water collected in this area is drained down by a small channel running south, adjacent to the rail, leading under SH1. The channel is then culverted under the railway from east to west, the channel then runs along the west side of the railway, in a southerly direction, until it discharges in to the Mangapouri Stream.

Figure 6 - Location of natural depression

The proposed Expressway is going to remove approximately half of the storage available in this depression. We propose to keep approximately the same drainage path as exists now but with the creation of new additional storage volume (and attenuation) further south (in-between the existing rail embankment and the new expressway) before discharging in to the Mangapouri Stream.

The purpose of doing this is to maintain a similar flow regime in small events (less than 50% AEP) to protect the Mangapouri Stream from erosion. The larger events are expected to be incorporated into the Mangapouri Stream flows and this will demonstrate that the flooding is no worse than present for the local residents.

7.7.2 Racecourse Catchment

Just to the west of 35 Rahui Road, there is a stream channel leading to a 1.2m by 1.2m box culvert leading under County Road and the railway. To the south east is Otaki race course (see Figure 7 below). It is not conclusive whether the Otaki race course drains to this culvert or drains to the Mangapouri.

Figure 7 - Location of existing box culvert

The proposed expressway will pass over the location of this 1.2m by 1.2m box culvert thus it will be replaced. As we are unsure what the catchment for this culvert is, we cannot be sure what size it needs to be to pass the 1% AEP storm flows. Downstream the stream channel is initially large but decreases in size to virtually nothing.

Having discussed this with Matt Aitchison (KCDC) and Ben Fountain (SKM) on 15 June 2011 we concluded that:

- Downstream of the culvert any water is primarily stored in the channel and soaks into the ground.
- If Otaki race course does drain to this culvert, the culvert is currently acting as a throttle.
- The project is not changing the flow paths from the Otaki race course.

- The new culvert should be no bigger than the existing culvert in order to maintain the flood protection to the downstream properties that the throttle is potentially providing.

As such a 1.2m by 1.2m box culvert (or equivalent) is the largest size we will provide at this location.

7.7.3 Soakage Area at Otaki Stop Bank

The area of land to the south-east of the railway, between Waerenga Road and the Otaki River, falls south (toward the river). However the drainage paths are blocked firstly by the Otaki stop bank and secondly by the land form at the quarry site (see Figure 8 below). As such the runoff from the land is currently contained and infiltrates into the ground by soakage.

Figure 8 - location of existing soakage areas

The geological maps, show that this area is Recent Alluvium (which are typically made up of gravels and silts). The GWRC bore log S25/5285, shows gravel to a depth of 4.5m (which is excellent for soakage), bore log S25/5283, shows the first 4.5m as gravel and clay but with gravels below that.

The *Peka Peka to North Otaki, Geotechnical Factual Report* prepared by AECOM, dated April 2011, shows these investigations in the area: BH106, BH107, TP109 and TP110.

BH106 shows silt to 1m followed by gravels and cobbles for the next 13m (very good for soakage under the silt). TP109 shown the first 0.5m as silty sandy clay followed by gravel, cobbles and boulders in a silty sand matrix to the bottom of the pit (the silty sand matrix limits the soakage but would still be expected to be satisfactory). TP110 show almost the same as

TP109 (so again the silty sand matrix will determine the soakage rate). BH107 shows clayey gravels to 0.2m, followed by gravels and cobbles to 14m.

On 31 March 2011, the ground water was recorded at BH106 and BH107 respectively as 4.7 and 4.8m below ground level (or elevation of 9.5m and 10m). Given that the NZTA SWTS prefers the ground water level to be 3.0m[38] below the infiltration level; this means that any infiltration device can be 1.2m deep. This should be sufficient to connect any infiltration device into the gravel layer. To ensure treatment, the swales need about 600mm of topsoil to capture pollutants (to prevent the pollutants entering the ground water).

Figure 9 – Location of BHs and TPs in soakage area

Clearly there is potential for good soakage in this area but specific investigation will need to be undertaken. Figure 10 below shows the underlying material in this area (from BH 106).

Figure 10 - BH 106, 4.3m to 7.8m

Our proposal in this area is that stormwater runoff is contained and infiltrated to ground. This mimics the existing situation.

[38] NZTA SWTS page 125

7.7.4 High Ground water

From the Peka *Peka to North Otaki, Geotechnical Factual Report* prepared by AECOM, dated April 2011, there is high ground water in several places. These are shown in the figures below.

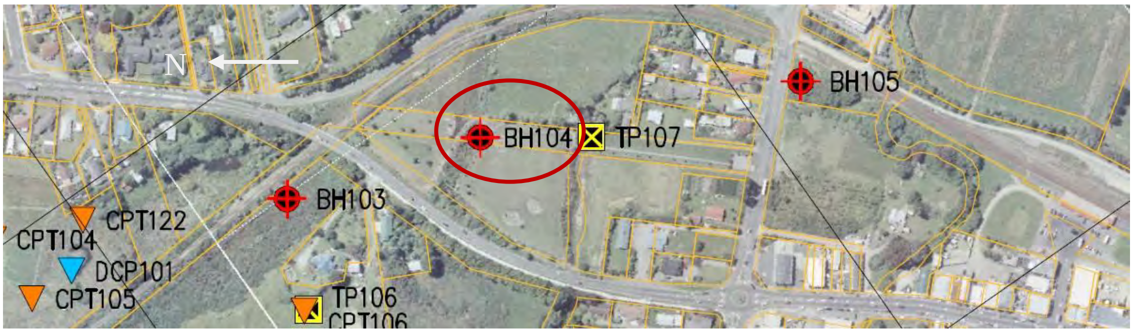

Figure 11 - BH104 (0.0mbgl) bottom of slope, north of Mangapouri Stream

Figure 12 – CTP114 (0.2mbgl), BH115 (0.4mbgl) north of Te Hapua Road

Figure 13 - BH112 (1.0mbgl)north of Te Hapua Road, CPT 117 (0.3mbgl).

These areas of high groundwater level need to be considered as the design progresses.

The only area where the current design concept is reliant on soakage is just north of the Otaki River. Fortunately the information we have suggests low ground water levels (4.5 to 5.0m deep) and very high infiltration rates in this area. This is the only area where moderate to high ground water would affect the fundamental choice of stormwater management mechanism.

In all other area of the Project, we have selected stormwater management devices that do not rely on infiltration of water into the ground. So where ground water is high, this will only affect the details of the device such as the slope stability angle, choice of surface treatment, plant species selection, and possibly construction methodology. It need not affect the fundamental choice of device.

We recommend NZTA continues to monitor the ground water level through at least one full winter to inform the future stages of design.

7.7.5 Drainage Tie in to the M2PP Project

The PP2O project currently stops at Te Kowhai Road where the M2PP project starts. There is a discharge point 600m north of Te Kowhai Road, however the road and drainage fall to the south. The next discharge point is 700m south of Te Kowhai Road (just south of Peka Peka Road).

If this was a single project, we would drain this 1300m section of road to the south, discharging to the waterway just south of Peka Peka Road. Even though this is two projects, it is still the sensible thing to do.

At this stage we are providing attenuation swales over the southernmost 600m of the PP2O project and have assumed that these can discharge into M2PP drainage. This detail needs to be confirmed with the designers of the M2PP project.

7.8 Identified Items Not Yet Considered

We intend to further develop details around the following points at the next stage of this project:

- What happens at culverts in the extreme event (Q100 +CC x 1.5).
- Confirm responsibilities for maintaining stormwater devices that service both NZTA and KCDC roads.
- Stormwater tie-in details for projects to north and south of PP2O.
- Possible enhanced stormwater treatment at specific locations where there is clear justification on environmental grounds.

Appendices

Appendix 1 – Climate change

Ministry for the Environment
Manatū Mō Te Taiao

Climate change effects and impacts assessment

A Guidance Manual for Local Government in New Zealand – 2nd Edition

May 2008

New Zealand Government

Table 2.2: Projected changes in seasonal and annual mean temperature (in °C) from 1990 to *2040*, by regional council area. The average change, and the lower and upper limits (in brackets), over the six illustrative scenarios are given.

	Summer	Autumn	Winter	Spring	Annual
Northland	1.1 [0.3, 2.7]	1.0 [0.2, 2.9]	0.9 [0.1, 2.4]	0.8 [0.1, 2.2]	0.9 [0.2, 2.6]
Auckland	1.1 [0.3, 2.6]	1.0 [0.2, 2.8]	0.9 [0.2, 2.4]	0.8 [0.1, 2.2]	0.9 [0.2, 2.5]
Waikato	1.1 [0.2, 2.5]	1.0 [0.3, 2.7]	0.9 [0.2, 2.2]	0.8 [0.0, 2.0]	0.9 [0.2, 2.4]
Bay of Plenty	1.0 [0.3, 2.5]	1.0 [0.3, 2.7]	0.9 [0.1, 2.2]	0.8 [0.0, 2.1]	0.9 [0.2, 2.4]
Taranaki	1.1 [0.2, 2.4]	1.0 [0.2, 2.6]	0.9 [0.1, 2.2]	0.8 [0.0, 2.0]	0.9 [0.2, 2.3]
Manawatu-Wanganui	1.1 [0.2, 2.3]	1.0 [0.2, 2.6]	0.9 [0.2, 2.2]	0.8 [0.0, 1.9]	0.9 [0.2, 2.2]
Hawke's Bay	1.0 [0.2, 2.5]	1.0 [0.3, 2.6]	0.9 [0.1, 2.2]	0.8 [0.0, 2.0]	0.9 [0.2, 2.3]
Gisborne	1.0 [0.2, 2.6]	1.0 [0.3, 2.7]	0.9 [0.1, 2.2]	0.8 [0.0, 2.1]	0.9 [0.2, 2.4]
Wellington	1.0 [0.2, 2.2]	1.0 [0.3, 2.5]	0.9 [0.2, 2.1]	0.8 [0.1, 1.9]	0.9 [0.3, 2.2]
Tasman-Nelson	1.0 [0.2, 2.2]	1.0 [0.2, 2.3]	0.9 [0.2, 2.0]	0.7 [0.1, 1.8]	0.9 [0.2, 2.0]
Marlborough	1.0 [0.2, 2.1]	1.0 [0.2, 2.4]	0.9 [0.2, 2.0]	0.8 [0.1, 1.8]	0.9 [0.2, 2.1]
West Coast	1.0 [0.2, 2.4]	1.0 [0.2, 2.1]	0.9 [0.2, 1.8]	0.7 [0.1, 1.7]	0.9 [0.2, 1.8]
Canterbury	0.9 [0.1, 2.2]	0.9 [0.2, 2.2]	1.0 [0.4, 2.0]	0.8 [0.2, 1.8]	0.9 [0.2, 1.9]
Otago	0.9 [0.0, 2.4]	0.9 [0.1, 1.9]	1.0 [0.3, 2.1]	0.7 [0.0, 1.8]	0.9 [0.1, 1.9]
Southland	0.9 [0.0, 2.4]	0.9 [0.1, 1.9]	0.9 [0.2, 2.0]	0.7 [-0.1, 1.7]	0.8 [0.1, 1.9]
Chatham Islands	0.8 [0.2, 1.9]	0.9 [0.2, 2.0]	0.9 [0.1, 2.3]	0.7 [0.1, 1.8]	0.8 [0.2, 1.9]

Note 1: This table covers the period from 1990 (1980–1999) to 2040 (2030–2049), based on downscaled temperature changes for 12 global climate models, re-scaled to match the IPCC global warming range for six illustrative emission scenarios (B1, A1T, B2, A1B, A2 and A1FI). Corresponding maps (Figures 2.3, 2.4) should be used to identify sub-regional spatial gradients.

Note 2: If the seasonal ranges are averaged, the resulting range is larger than the range shown in the annual column, because of cancellation effects when summing over the year.

Note 3: Projected changes for the 15 regional council regions were the result of the statistical downscaling over mainland New Zealand. For the Chatham Islands, the scenario changes come from direct interpolation of the General Circulation Model grid-point changes to the latitude and longitude associated with the Chathams.

Table 2.3: Projected changes in seasonal and annual mean temperature (in °C) from 1990 to *2090*, by regional council area. The average change, and the lower and upper limits (in brackets), over the six illustrative scenarios are given.

	Summer	Autumn	Winter	Spring	Annual
Northland	2.3 [0.8, 6.6]	2.1 [0.6, 6.0]	2.0 [0.5, 5.5]	1.9 [0.4, 5.5]	2.1 [0.6, 5.9]
Auckland	2.3 [0.8, 6.5]	2.1 [0.6, 5.9]	2.0 [0.5, 5.5]	1.9 [0.4, 5.4]	2.1 [0.6, 5.8]
Waikato	2.3 [0.9, 6.3]	2.2 [0.6, 5.6]	2.1 [0.5, 5.2]	1.8 [0.3, 5.1]	2.1 [0.6, 5.6]
Bay of Plenty	2.2 [0.8, 6.2]	2.2 [0.6, 5.6]	2.0 [0.5, 5.2]	1.8 [0.3, 5.1]	2.1 [0.6, 5.5]
Taranaki	2.3 [0.9, 6.1]	2.2 [0.6, 5.3]	2.1 [0.5, 5.1]	1.8 [0.3, 4.9]	2.1 [0.6, 5.3]
Manawatu-Wanganui	2.3 [0.9, 6.0]	2.2 [0.6, 5.3]	2.1 [0.5, 5.0]	1.8 [0.3, 4.9]	2.1 [0.6, 5.3]
Hawke's Bay	2.1 [0.8, 6.0]	2.1 [0.6, 5.3]	2.1 [0.5, 5.1]	1.9 [0.3, 5.1]	2.1 [0.6, 5.4]
Gisborne	2.2 [0.8, 6.2]	2.2 [0.6, 5.6]	2.0 [0.5, 5.2]	1.9 [0.3, 5.2]	2.1 [0.6, 5.5]
Wellington	2.2 [0.9, 5.7]	2.1 [0.6, 5.1]	2.1 [0.6, 5.0]	1.8 [0.3, 4.8]	2.1 [0.6, 5.2]
Tasman-Nelson	2.2 [0.9, 5.6]	2.1 [0.6, 5.1]	2.0 [0.5, 4.9]	1.7 [0.3, 4.6]	2.0 [0.6, 5.0]
Marlborough	2.1 [0.9, 5.6]	2.1 [0.6, 5.0]	2.1 [0.6, 5.0]	1.8 [0.3, 4.8]	2.0 [0.6, 5.1]
West Coast	2.2 [0.9, 5.3]	2.1 [0.7, 5.0]	2.1 [0.6, 4.9]	1.7 [0.4, 4.5]	2.0 [0.7, 4.9]
Canterbury	2.1 [0.8, 5.2]	2.1 [0.7, 4.9]	2.2 [0.8, 5.1]	1.8 [0.4, 4.7]	2.0 [0.7, 5.0]
Otago	2.0 [0.7, 4.8]	2.0 [0.8, 4.6]	2.2 [0.8, 4.8]	1.7 [0.5, 4.3]	2.0 [0.8, 4.6]
Southland	2.0 [0.7, 4.7]	2.0 [0.8, 4.6]	2.1 [0.8, 4.7]	1.6 [0.5, 4.1]	1.9 [0.8, 4.5]
Chatham Islands	1.9 [0.8, 4.6]	2.1 [0.6, 4.9]	2.0 [0.3, 4.5]	1.8 [0.3, 4.6]	2.0 [0.5, 4.7]

Note 1: This table covers the period from 1990 (1980–1999) to 2090 (2080–2099), based on downscaled temperature changes for 12 global climate models, re-scaled to match the IPCC global warming range for six illustrative emission scenarios. Corresponding maps (Figures 2.3, 2.5) should be used to identify sub-regional spatial gradients.

Note 2: If the seasonal ranges are averaged, the resulting range is larger than the range shown in the annual column, because of cancellation effects when summing over the year.

Note 3: Projected changes for the 15 regional council regions were the result of the statistical downscaling over mainland New Zealand. For the Chatham Islands, the scenario changes come from direct interpolation of the General Circulation Model grid-point changes to the latitude and longitude associated with the Chathams.

Table 5.2 shows recommended percentage adjustments per 1°C of warming to apply to extreme rainfalls when you are developing screening assessment scenarios. This is a new table and supersedes the corresponding table in the previous edition of this Manual. Note that preliminary analysis of NIWA regional climate model results indicates that increases substantially higher than the upper limit of 8% given in this table are possible in limited areas.

As indicated in Table 5.1, current extreme rainfall rates for selected locations, durations and average recurrence intervals (ARIs) can be obtained from analysis of historical rainfall datasets from particular sites, or from the HIRDS CD. For temperature, use the projected changes in annual mean temperature from the rightmost columns of Tables 2.2 and 2.3, or from Figure 2.3. At least two screening calculations should be undertaken – for low and high temperature change scenarios. A worked example of the application of this information is provided in Appendix 4. In carrying out such site-specific analyses, one should also bear in mind the uncertainties in return period estimates for the present climate. In many places, rainfall records cover a past period of only a few decades, so that design rainfall estimates for 50- or 100-year ARIs contain statistical assumptions and data-based uncertainties.

Table 5.2: Factors for use in deriving extreme rainfall information for screening assessments.

ARI (years) → Duration ↓	2	5	10	20	30	50	100
< 10 minutes	8.0	8.0	8.0	8.0	8.0	8.0	8.0
10 minutes	8.0	8.0	8.0	8.0	8.0	8.0	8.0
30 minutes	7.2	7.4	7.6	7.8	8.0	8.0	8.0
1 hour	6.7	7.1	7.4	7.7	8.0	8.0	8.0
2 hours	6.2	6.7	7.2	7.6	8.0	8.0	8.0
3 hours	5.9	6.5	7.0	7.5	8.0	8.0	8.0
6 hours	5.3	6.1	6.8	7.4	8.0	8.0	8.0
12 hours	4.8	5.8	6.5	7.3	8.0	8.0	8.0
24 hours	4.3	5.4	6.3	7.2	8.0	8.0	8.0
48 hours	3.8	5.0	6.1	7.1	7.8	8.0	8.0
72 hours	3.5	4.8	5.9	7.0	7.7	8.0	8.0

Note: This table recommends *percentage* adjustments to apply to extreme rainfall per 1°C of warming, for a range of average recurrence intervals (ARIs.). The percentage changes are mid-range estimates per 1°C and should be used only in a screening assessment. The entries in this table for a duration of 24 hours are based on results from a regional climate model driven for the A2 SRES emissions scenario. The entries for 10-minute duration are based on the theoretical increase in the amount of water held in the atmosphere for a 1°C increase in temperature (8%). Entries for other durations are based on logarithmic (in time) interpolation between the 10-minute and 24-hour rates. Refer to the discussion in section 2.2.4.

Applications of climate change scenarios for screening and more detailed assessments are shown in Figures 5.1 and 5.2. In these examples, changes in the area of land suitable for kiwifruit have been calculated. An initial screening assessment, using a mid-range scenario, indicated that the Bay of Plenty climate could become unsuitable for kiwifruit by the end of this century (Figure 5.1). A more in-depth study was then carried out (Figure 5.2), to evaluate incremental changes over the next 100 years and to identify the range of uncertainty associated

Appendix 2 – Summary of KiwiRail stormwater standards from the WRRP project

TRACK AND CIVIL DESIGN PARAMETERS SUMMARY				
Parameter	Desirable	Absolute	Source	Comment
Drainage Design life	50 years		ONTRACK DRAFT Drainage Design Guidelines January 2008	
Lateral Drainage	3% cross fall		ONTRACK DRAFT Drainage Design Guidelines January 2008	Cross stormwater only required to percolate through ballast of one set of tracks.
Stormwater outside of Rail Corridor				
Primary Systems	20% AEP or 1 in 5 year return with no surcharging		ONTRACK DRAFT Drainage Design Guidelines January 2008	Unless KCDC require higher levels of service.
Secondary Systems	1% AEP or 1:100 year return		ONTRACK DRAFT Drainage Design Guidelines January 2008	If flow is piped, KCDC approval is required **
Building	No inundation for 1% AEP		ONTRACK DRAFT Drainage Design Guidelines January 2008	
Stormwater inside of Rail Corridor				
Primary Systems	10% AEP or 1:10 year return with no surcharging		ONTRACK DRAFT Drainage Design Guidelines January 2008	Unless KCDC require higher levels of service.
Secondary Systems	1% AEP or 1:100 year return		ONTRACK DRAFT Drainage Design Guidelines January 2008	Piped flow only if no viable alternative.**
Longitudinal (outside underground)	1% AEP or 1:100 year return with minimum 300mm freeboard from rail track Match existing if already present.		ONTRACK DRAFT Drainage Design Guidelines January 2008	To be swale drains with catchpits or turnouts as appropriate. Swales to have side slopes < 1.5h:1.0v and may be flatter where insitu soil dictates**
Longitudinal (underground)	1% AEP or 1:100 year return with minimum 600mm freeboard from rail track - Match existing if already present.		ONTRACK DRAFT Drainage Design Guidelines January 2008	Unless KCDC requirements are more onerous.**
Manholes	60m centres		ONTRACK DRAFT Drainage Design Guidelines January 2008	At all changes in grade, horizontal alignment or max crs 60m
Cross Stormwater	10% AEP or 1:10 year return with no surcharging and 1% AEP with min 600mm freeboard to rail tracks		ONTRACK DRAFT Drainage Design Guidelines January 2008	Match existing waterways if in close proximity

Appendix 3 – Interpretation of stakeholders' stormwater standards

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TO	Warren Bird
COPY	
FROM	Richard Coles
DATE	22 July 2011
FILE	5-C1814.00 – PP2O - Stormwater
SUBJECT	Interpretation of stakeholders‟ stormwater standards

1 Stakeholders stormwater standards

There is no definitive and universally accepted document that encompasses the design standards for all aspects of stormwater design. As such we have collated the various stakeholders‟ requirements from a range of documents and then carried out interpretation as required. This process is captured below.

2 Conclusion

2.1 Peak flow attenuation

We conclude that the NZTA SWTS document, does not require peak flow attenuation in this situation. However KCDC does require attenuation upto and including the 1% AEP rainfall event.

2.2 Channel erosion control

We conclude that NZTA requires channel erosion control for project sections discharging in to the Major Waitohu and Awatea catchments (the Waitohu catchment includes the Te Manuao and the Mangapouri catchments). KCDC does not have this requirement.

3 High level summary of stakeholders stormwater standards

We have collated the main stormwater standards from NZTA, the Councils (GWRC and KCDC) and KiwiRail. These standards are summarised in Table 1 below.

Table 1 – Stakeholder's Stormwater Standards

	KCDC (from documents)	KCDC (from consultation)	NZTA	GWRC	KiwiRail
Primary drainage	10% AEP[1]	No further comment	20% AEP to edge of trafficked lane[2] 10% AEP catchpit and pipe capacity	Not specified	10% AEP with no surcharging[3]
Secondary drainage	1% AEP[1]	No further comment	2% AEP, with no more than 100mm depth on road [2]	Not specified	1% AEP with minimum 300mm freeboard from rail track[3]
Attenuation - (Storm peak discharge control)	10% AEP: no increase in flows or less than minor adverse efects[1]	either provide attenuation to pre-development level or establish a case that effects are no more than minor	1%AEP limited to 80% of predevelopment flow (where existing downstream problems exist)[4] 50% and 10% AEP flows to match pre development flows[4]	Not specified	Not specified
Stream channel erosion control	Not specified	No further comment	Three different approaches considering 50% AEP flows[4]: • Check the 50% AEP stream velocities to ensure that velocities are non-erosive • Implement extended detention or volume control • Conduct a shear stress analysis for a specific site NB: only applies where catchment imperviousness is expected to exceed 3% (including future foreseeable development) [4]	Not specified	Not specified
Treatment of road runoff	Best Practicable Option (BPO) approach [1 & 5]	KCDC are reviewing NZTA Stormwater Standard	Best Practicable Option (BPO) aproach[4]. Treat all new impermeable surfaces (or equivalent area).	Not specified	Not specified
Waterway crossings (at culverts)	10% AEP typically but 1% if appropriate (to be assessed on case by case basis) [1]	Existing level of service not to be reduced.	1% AEP, with 500mm freeboard[6]	Not specified	10% AEP or 1:10 year return with no surcharging and 1% AEP with min 600mm freeboard to rail tracks[3]
Climate change	Best practice (as MfE guidance)[7]	Use of MfE guidelines (or use of SKM rainfall charts also accepted)	Apply to assets lasting longer that 25 years [4], or Apply to assets lasting longer that 50 years for pipe and culverts[8]	Best practice (as MfE guidance)	Not specified

[1] Subdivision and Development Principles and Requirements, KCDC, 2005
[2] Highway surface Drainage, NZTA, 1977
[3] Draft Drainage Design Guidelines, Ontrack, January 2008
[4] Stormwater Treatment Standard for State Highway Infrastructure, NZTA, May 2010
[5] TP10, Stormwater Management Devices: Design Guideline Manual, Auckland Regional Council (ARC), 2003
[6] Bridge Manual Second Edition NZTA, 2003
[7] Stormwater Management Strategy, KCDC, 2009
[8] Climate Change Position Statement, NZTA, 2004

	KCDC (from documents)	KCDC (from consultation)	NZTA	GWRC	KiwiRail
Loss of floodplain storage	Not specified	establish effects are no more than minor by modelling or provide compensatory storage	Not specified	Not specified	Not specified
Sediment and Erosion control (during construction)	Not specified	No further comment	As per NZTA draft Standard [9]	As GWRC guidelines[10]	Not specified
Fish passage requirements	Not specified	No further comment	Not specified	As GWRC guidelines[11]	Not specified

[9] Draft Erosion and Sediment Control Standard for State Highway Infrastructure, NZTA August 2010.
[10] Erosion and Sediment Control Guidelines for the Wellington Region, GWRC, September 2002
[11] Fish-friendly culverts and rock ramps in small streams, GWRC, 2003

4 Interpretation of NZTA stormwater attenuation requirements

We have followed the rationale and process described in the NZTA SWTS for assessing stormwater attenuation requirements in different sections of the proposed road. The potential quantitative adverse effects and associated mitigation are split into 2 components. These are:

- Existing flooding problems in the catchment (addressed by peak flow attenuation)
- Stream erosion potential (addressed by extended detention)

Figure 1 below shows a flow chart extracted from the NZTA SWTS (page 84), which gives the process to follow for assessing what stormwater mitigation is appropriate in a given catchment.

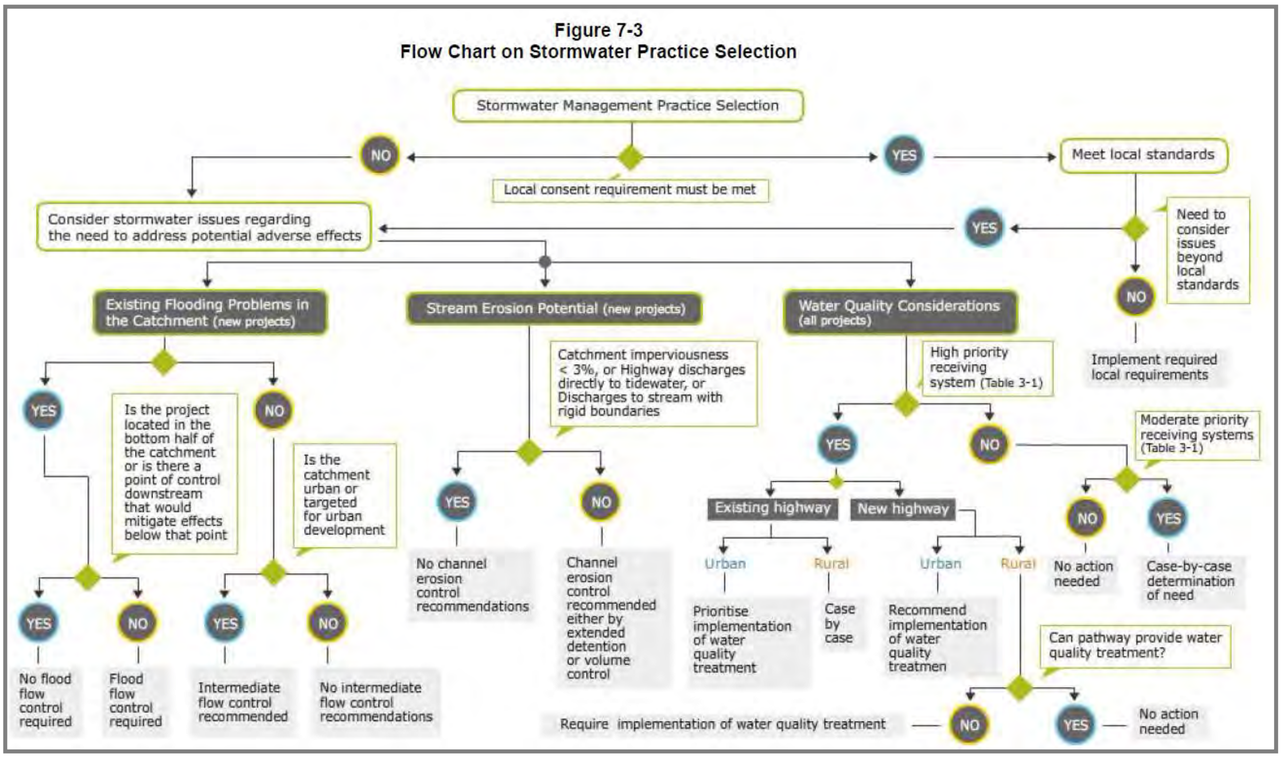


Figure 1 - Stormwater practice selection process chart (NZTA SWTG fig 7-3 pg 84)

The two quantity related components (Peak flow attenuation and Channel erosion control) are discussed in the following sections of this report.

4.1 Peak flow attenuation

The rationale and process described in the NZTA SWTS for used to assess the need for, and extent of peak flow attenuation. As shown in Figure 1 above, the NZTA selection process chart refers to the catchment, flood control and intermediate flow control. Clarification of these is given below:

- Intermediate flow control is defined as limiting the flows after road construction to the flows before the road was constructed, for the 50% and 10% AEP storm flows.

- Flood flow control is defined as limiting the post development flows to the 80% of the predevelopment flows for the 1% AEP storm flows.
- The catchment is referring to the whole or major catchment for a stream network (defined from the coastal outfall), not the catchments defined for waterway road crossings.

There are four major catchments that encompass the proposed road. We are referring to these four major catchments as:

- The major Waitohu catchment;
- The major Otaki catchment;
- The major Mangaone catchment; and
- The major Awatea catchment.

Figure 2 shows a plan of these four major catchments and the location of the proposed road within them.

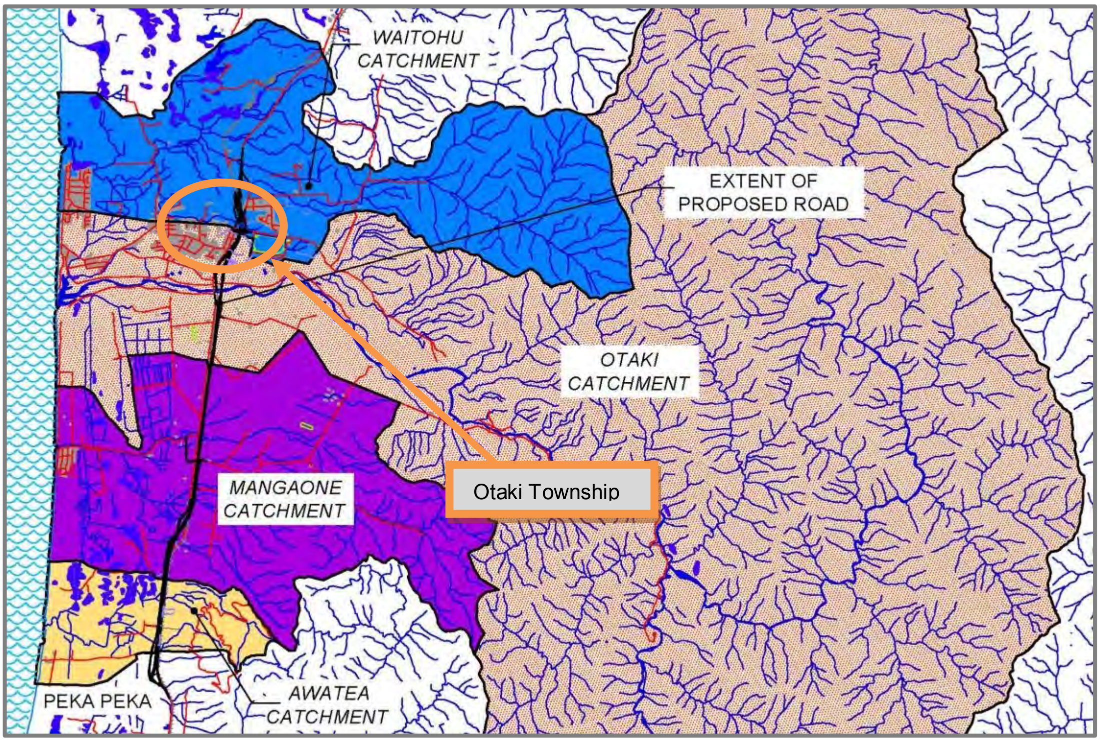


Figure 2 - The four major catchments that the proposed road lies within

4.1.1 Peak flow question 1 – Are there flooding problems in the catchment?

Following the attenuation selection process chart (shown in Figure 1 above), the first question is: are there flooding problems in the catchment?

To assess the extent of flooding problems, we have used the information shown on the KCDC GIS system. These 1% AEP flood extent maps are included in Attachment 1, and give a very good indication of the flooding problems the area. A summary is given in Table 2 below.

Table 2 – Major catchment flooding issues

Catchment name	Are there flooding problems downstream from proposed road?
The major Waitohu catchment	Yes
The major Otaki catchment	Yes
The major Mangaone catchment	Yes
The major Awatea catchment	No

The 1% AEP flood extent (as shown on the KCDC GIS system) spans across the Waitohu Otaki and Mangaone catchments; the flood extent does not extend into the Awatea catchment.

4.1.2 Peak flow question 2 – Is the road located in the bottom half of the catchment?

Following the attenuation selection process chart (shown in Figure 1 above on page 4), where there are flooding problems in the catchment, the next question is: is the road located in the bottom half of the catchment?

From Figure 2 above, we can see where the proposed road is within each of the catchments. The NZTA SWTS is not explicit as to how the midpoint of the catchment is defined (by length, by area, or by time of concentration) so we have considered all three ways. By visual inspection we can see that the road is in the lower half of all the catchments (in all but the Awatea catchment) considering area and length. Considering time of concentration: by visual inspection we can conclude that the road is in the top half of the Awatea catchment and the bottom half of the Otaki catchment, but the Waitohu and Mangaone catchments require more analysis. See Attachment 2 for our time of concentration (Toc) analysis. The result of our ToC analysis is that the road is in the bottom half of both the Waitohu and Mangaone catchments (assuming that the Bransby-Williams method is used, as preferred by KCDC). Our assessment is summarised in Table 3 below.

Table 3 – Location of road within major catchment

Catchment name	Location of proposed road
The major Waitohu catchment	Bottom half
The major Otaki catchment	Bottom half
The major Mangaone catchment	Bottom half
The major Awatea catchment	Top half

4.1.3 Peak flow question 3 – Is the catchment urban or targeted for urban development?

Following the attenuation selection process chart (shown in Figure 1 above on page 4), - where there are no flooding problems in the catchment- the next question is: is the catchment urban or targeted for urban development?

We have assessed the maximum possible extent of urbanisation by referring to the KCDC district plan (Urban plan zone features maps are located in

Attachment 3). The result of this assessment is shown in Table 4 and Table 5 below.

Table 4 – Amount to urban zone in catchment

Catchment name	Catchment area (ha)	Urban Zone area (ha)	Urban Zone as percentage of Catchment area
The major Waitohu catchment	4852	235	4.8%
The major Otaki catchment	35700	311	0.9%
The major Mangaone catchment	5053	84	1.7%
The major Awatea catchment	1192	44	3.7%

The percentages shown are the percent of land in the catchment zoned as ether residential, commercial (retail) or industrial (services). This is not an assessment of catchment permeability (catchment permeability would be expected to be around half these figures shown).

From the percentage of land that has been zoned as urban, we have made a judgement as to whether the catchment is targeted for urban development. See Table 5 below.

Table 5 – Is the catchment urban or targeted for urban development?

Catchment name	Is the catchment urban or targeted for urban development?
The major Waitohu catchment	No
The major Otaki catchment	No
The major Mangaone catchment	No
The major Awatea catchment	No

4.1.4 Putting the Peak flow questions together

Table 6 below gives a summary of peak flow attenuation selection process chart (as shown in Figure 1 above on page 4).

Table 6 – What level of attenuation is required?

Catchment name	Are there flooding problems in the catchment?	Is the road located in the bottom half of the catchment?	Is the catchment urban or targeted for urban development?	What level of attenuation is required /recommended?
Waitohu	Yes	Yes	~~N/A~~	No flood flow control required
Otaki	Yes	Yes	~~N/A~~	No flood flow control required
Mangaone	Yes	Yes	~~N/A~~	No flood flow control required
Awatea	No	~~N/A~~	No	No intermediate flow control recommendations

So, having worked through the process attenuation decision chart in the NZTA SWTS document, we conclude that no peak flow attenuation is required for this project.

4.2 Channel erosion control

The rationale and process described in the NZTA SWTS was used to assess the need for erosion control of the receiving water body. Figure 3 below shows this process as an extract from the NZTA Stormwater practice selection process chart (this is shown in its entirety on page 4, Figure 1).

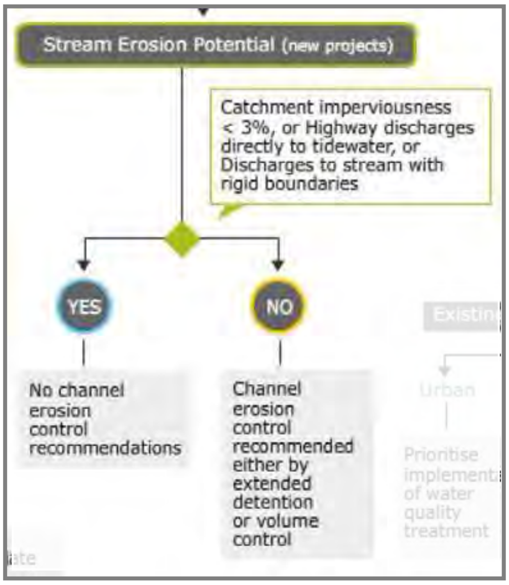


Figure 3 – Channel erosion control requirement selection process chart

The NZTA SWTS requires channel erosion control to protect the receiving environment (typically streams on this project) from increased flows (and associated increased erosion) from small and frequent storm events.

Although the above extract only refers to providing erosion control by either extended detention or volume control, section 6.2 of the NZTA SWTS covers this in more detail. If channel erosion control is recommended, then the NZTA SWTS describes three options. These are (see NZTA SWTS section 6.2.4.1):

- Check the 2-year stream velocities against Table 6-2 to ensure that post development velocities are non-erosive (assuming ultimate development of the catchment under the district plan land use). If this can be shown, no channel erosion control is needed;
- Implement extended detention/volume control. Capture and release over 24 hours of a volume equivalent to the water quality storm (volume multiplied by 1.2 for unstable stream receiving environments);
- Conduct a shear stress analysis for a specific site (requires specific catchment analysis and is not proposed for this project).

Unlike assessing the requirement for peak flow control (where we consider only the major catchment down to the coast), the channel erosion control assessment needs to consider both local and major catchments.

Our starting assumption is that we need channel erosion control everywhere. The following sections are a process to identify which receiving environments do not require channel erosion control.

4.2.1 Where can we eliminate the need for channel erosion control due to environment type?

The NZTA SWTS considers six types of receiving environment. These are shown in Figure 4 below.

Table 3-1 Receiving Environments and Stormwater Issues			
Receiving system	Flooding issues	Stream erosion issues	Water Quality
Streams	May be a priority depending on location within a catchment	High priority if the receiving stream is a natural, earth channel	High priority
Ground	Not an issue depending on overflow	Not an issue	High priority
Estuaries	Not an issue	Not an issue	High priority
Harbours	Not an issue	Not an issue	Moderate priority
Open Coast	Not an issue	Not an issue	Lower priority
Lakes	Not an issue	Not an issue	High priority

Figure 4 - Table of basic receiving environments (extract from (NZTA SWTS page 21)

All receiving environments in this project will be classified by the NZTA"s SWTS as streams (even the Otaki River). So no receiving environments can be eliminated at this stage.

4.2.2 Where can we eliminate the need for channel erosion control due to catchment imperviousness?

To answer this question we need to consider four things:

- What are the local and major catchments?
- What are the district plan zone areas in each catchment?
- What is the maximum allowable impermeability allowed in each District Plan zone?
- Is the maximum potential catchment imperviousness less than 3%?

We have considered both the major and the local catchment imperviousness. Assessing the major catchment allows for cumulative effects in the catchment and assessing the local catchment allows for any hot spots of development.

4.2.3 What are the local and major catchments?

The major catchments that the road is within are shown in Figure 2 above (on page 5), and a map showing the local catchments is included in as a separate appendix.

4.2.4 What are the District Plan zone areas in each catchment?

As can be seen from the KCDC District Plan maps (included in Attachment 3), the vast majority of this part of the Kapiti Coast has rural zonings, with urban zonings principally confined to a relatively small area around the Otaki township

The areas zoned as Conservation, Residential, Industrial and commercial (see maps in Attachment 3) have been measured and shown on Table 7. The five rural zonings (refer rural maps Attachment 4) have also been measures in each catchment and are shown in Table 7 also.

Table 7 – Zone areas within catchments*

Catchment name Zone	Local Te Manuao	Local Mangapouri	Local all others	Major Waitohu	Major Otaki	Major Mangaone	Major Awatea
Residential (Ha)	37	31	0	253	261	35	84
Industrial (Ha)	0	0	0	0	50	5	0
Commercial (Ha)	0	0	0	3	13	0	0
Rural (Ha)	0	218	(100%)[12]	4639	35560	5373	1333
Total (Ha)	**37**	**249**	**(100%)**	**4895**	**35884**	**5413**	**1417**
Rural zone is further split as follows:							
Rural residential (Ha)	0	0	-	84	0	0	150
Alluvial planes (Ha)	0	218	-	835	2392	1960	133
Hill country (Ha)	0	0	-	723	4866	2351	358
Costal/Dunes (Ha)	0	0	-	1341	827	1062	692
Conservation (Ha)	0	0	-	1656	27475	0	0

*Zone and catchment areas are approximate as zoning information was only available in PDF format

[12] The other catchments have not been measures as by inspection it can be seen that they have no urban zoning. From this we can conclude that the impervious percentage will be less than 3%.

4.2.5 What is the maximum impermeability allowed in each District Plan zone?

The KCDC District Plan does not define maximum imperviousness values for any zoning; only lot sizes, number of buildings per lot and maximum site coverage. These rules have been used in conjunction with an assessment of existing development examples, to estimate the expected imperviousness in each zone at full development. The key information is shown in Table 8 below.

Table 8 – Zone district plan rules and Zone importability

Zone	District Plan rules	Maximum Zone importability
Residential	The maximum area of any site covered by all buildings shall be 40% except that this standard shall not apply to network utilities on sites less than 200m^2.	Allow an additional 20% hard standing (driveways and roads), so zone impermeability 60%
Industrial		Assume 100% impermeable surfaces, so zone impermeability 100%
Commercial		
Rural (general)	One dwelling and one family flat per lot except on Kapiti Island	Allowing 500m^2 of impermeable surface per lot[13]
Rural zone is further split as follows:		
Rural residential (Ha)	Some areas: The minimum area for any lot shall be 1ha Other areas: average area of 1ha	Average lot area 1ha, lot impermeable surface 500m^2, so zone impermeability 5%
Alluvial plains	Lots must have: a minimum area of 4ha and an average size of 6ha	Average lot area 6ha, lot impermeable surface 500m^2, so zone impermeability 0.8%
Hill country[14]	Lots must have a: minimum area of 20ha.	Average lot area 20ha, lot impermeable surface 500m^2, so zone impermeability 0.25%
Coastal/Dunes	The average area of land for all lots within the subdivision shall be not less than 4ha.	Average lot area 4ha, lot impermeable surface 500m^2, so zone impermeability 1.25%
Conservation	The maximum floor area for any one building shall be 30m^2.	Average lot area 20ha (assumed as hill country), lot impermeable surface 30m^2, so zone impermeability 0.015%

4.2.6 What is the maximum potential catchment imperviousness?

Using our assessments of zone areas, District Plan rules and impermeable surface per lot; we have produced an estimate of the maximum potential catchment imperviousness at full development. A summary of the maximum potential catchment imperviousness is shown in Table 9 below.

[13] We have assessed the foot print of the houses and associated hard standing areas of the new sub-developments off Ludlan Way and Speranza Road (to the east of Otaki). We estimate that these typically have 350m^2 to 400m^2 of impermeable surface (drive and roof). We have also allowed 100m^2 local road surface, so in total we have allowed 500m^2 of impermeable surface for each lot in our assessment.
[14] Including water collection areas.

Table 9 – Impervious areas and Maximum Probable Development (MDP)

Catchment name Zone	Local Te Manuao	Local Mangapouri	Local all others	Major Waitohu	Major Otaki	Major Mangaone	Major Awatea
Residential (Ha)	22.2	18.6	0.0	151.8	156.6	21.0	50.4
Industrial (Ha)	0.0	0.0	0.0	0.0	50.0	5.0	0.0
Commercial (Ha)	0.0	0.0	0.0	3.0	13.0	0.0	0.0
Rural residential (Ha)	0.0	0.0	0.0	4.2	0.0	0.0	7.5
Alluvial planes (Ha)	0.0	1.7	-	6.7	19.1	15.7	1.1
Hill country (Ha)	0.0	0.0	-	1.8	12.2	5.9	0.9
Costal/Dunes (Ha)	0.0	0.0	-	16.8	10.3	13.3	8.7
Conservation (Ha)	0.0	0.0	-	0.2	4.1	0.0	0.0
Total Impervious area (Ha)	**22**	**20**	**-**	**184**	**265**	**61**	**69**
Total area (Ha)	37	249	-	4895	35884	5413	1417
Total potential impervious (MDP) %	**60%**	**8%**	**Less than 1%[15]**	**4%**	**1%**	**1%**	**5%**

4.2.7 Where can we eliminate the need for channel erosion control due to catchment impermeability?

From the NZTA SWTS, any catchment with less than 3% potential imperviousness (under the local District Plan rules) does not require channel erosion control (or extended detention).

From our assessment above, a large portion of the road is in a rural setting, and shown to have a Maximum Probable Development (MPD) of less than 3% (from the NZTA"s SWTS, extended detention is not required for catchments with a MPD of less than 3%).

Of the four major catchments, the sections of road within the Mangaone and the Otaki do not require channel erosion control (or extended detention).

4.2.8 Putting the channel erosion control questions together

Due to the receiving environment and the catchments" potential imperviousness; channel erosion control is required for sections of road discharging in to the Major Waitohu and Awatea catchments (the Waitohu catchment includes the Te Manuao and the Mangapouri catchments).

[15] All other minor catchments are zoned ether Alluvial or Hill country. From Table 8, we can see that the MDP will be between 0.25 and 0.8%.

5 Interpretation of KCDC stormwater standards and aspirations

Through consultation with KCDC, we have developed a better understanding of KCDC‟s expectations that build on the written standards given in their subdivision guidelines, 2005. The cornerstone of KCDC‟s stormwater philosophy is to "not make the existing situation worse"; how this is demonstrated is left up to an applicant.

5.1 Peak flow attenuation

5.1.1 KCDC's Subdivision Guidelines (2005) and Stormwater Management Strategy (2009)

The stormwater section of KCDC‟s subdivision guidelines require the post road construction flows to be attenuated to the equivalent pre construction level, for the 10% AEP storm event (page 44).

KCDC‟s Stormwater Management Strategy does not comment specifically on attenuation of stormwater flows but does detail that the stormwater network will continue to be updated so that primary systems can accommodate the 10% AEP storm event (page 36).

5.1.2 Through consultation

KCDC have indicated that peak flow attenuation requirement includes the 1% AEP storm event (that is post construction 1% AEP flow attenuated to the equivalent pre construction flows). Additionally, KCDC would also expect pre and post road construction peak rates to be matched for the 20% AEP storm event.

If less than 1% AEP peak flow attenuation is proposed for a project, then KCDC would like to see evidence (such as use of a model) that the existing situation is "not being made any worse" (or has a "less than minor effect" if using RMA terminology). In areas with habitable buildings, a water level change of less than 10mm has previously been used by KCDC to define a less than minor effect.

5.2 Channel erosion control (Extended detention)

5.2.1 KCDC's Subdivision Guidelines (2005) and Stormwater Management Strategy (2009)

The KCDC‟s documents do not comment on stream channel erosion control.

5.2.2 Through consultation

KCDC indicated that they have no requirements around controlling increased stream or channel erosion due to increases in flows of minor events (less than the 50% AEP storm event) due to urbanisation and increases in hard surface areas.

5.3 Stormwater Treatment

5.3.1 KCDC's Subdivision Guidelines (2005) and Stormwater Management Strategy (2009)

The stormwater section of KCDC"s subdivision guidelines direct the applicant to using Auckland Regional Council documents TP124 (Low Impact Design Manual) and TP10 (Stormwater Management Devices). These are both BPO documents and the applicant is "deemed to comply" with best practice if followed. Since 2005 KCDC have been accepting stormwater treatment devices designed according to TP10.

KCDC"s Stormwater Strategy does not comment on stormwater quality or treatment.

5.3.2 Through consultation

KCDC have indicated that designing treatment devices to TP10 or the NZTA SWTS will be generally sufficient for this project however they have indicated a desire for higher standard to be applied in catchments with high receiving environment values. To date the only specific location indicated as having „high value" is the reaming old bush and associated wetland at Marycrest.

KCDC have indicated that, for this project, base line assessments of stream quality are desired.

BPO solutions based on TP10[16] have been historically used and accepted by KCDC.

[16] TP10, Stormwater Management Devices: Design Guideline Manual, Auckland Regional Council (ARC), 2003

6 Interpretation of GWRC stormwater requirements

GWRC"s requirements (over and above those of KCDC and NZTA) revolve around sediment laden discharge during construction and maintaining ecological passage. Sediment laden discharge will be addressed by erosion and sediment controls on site during construction and fish passage will be provided at locations identified as requiring it. Generally GWRC consider all stormwater discharges as permitted activities[17], and have no requirement for stormwater treatment.

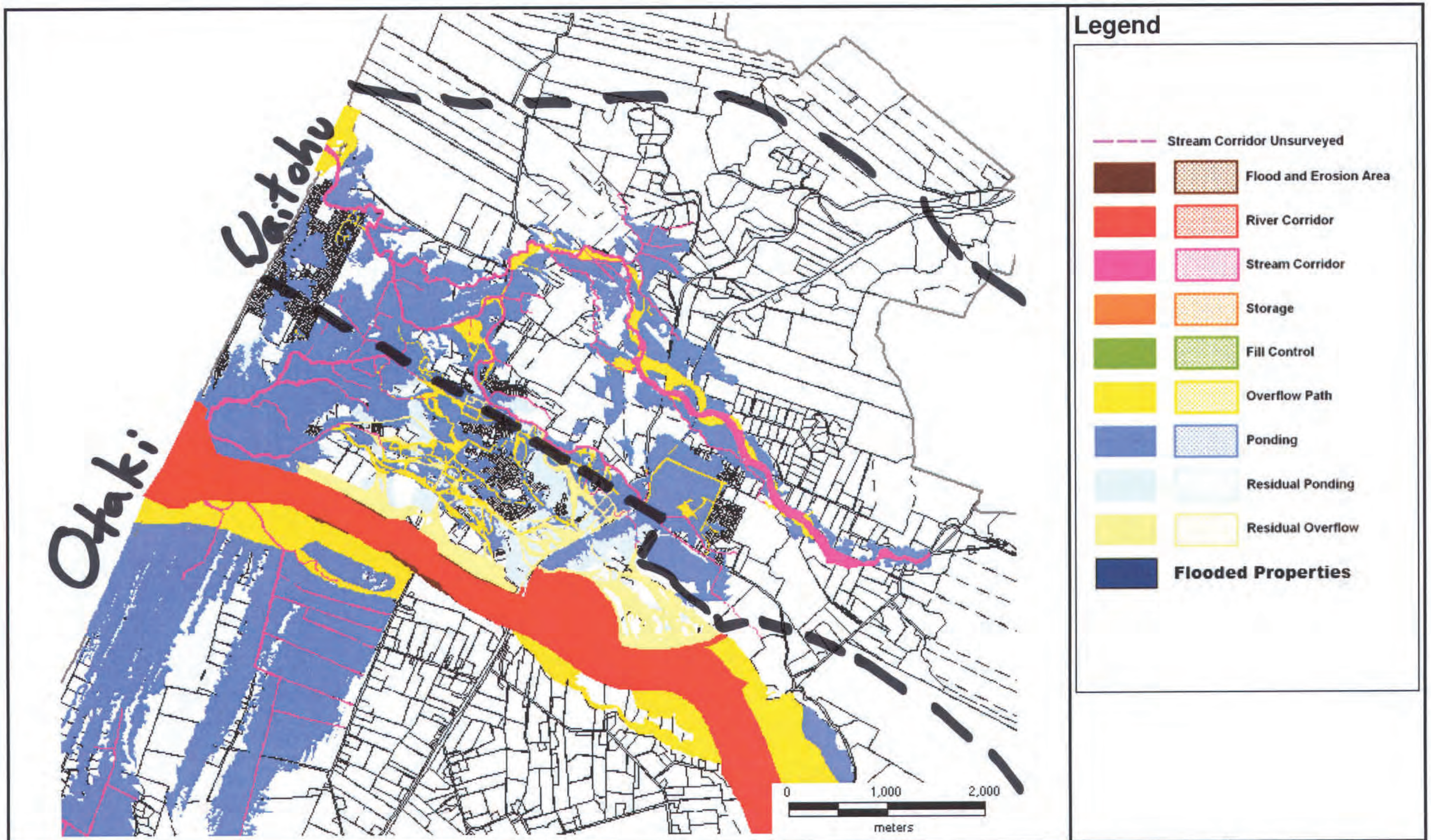
[17] Except discharges during construction which are not considered here

7 Interpretation of KiwiRail stormwater standards

KiwiRail stormwater standards are straight-forward and do not require discussion. Consultation with KiwiRail indicated no further expectations or requirements above those identified during the Wellington Region Rail Programme (WRRP) MacKay‟s to Waikanae Double Tracking project. A summary of these standards are included in Attachment 5.

Attachments

Attachment 1 - KCDC flood extent maps



KAPITI COAST DISTRICT COUNCIL

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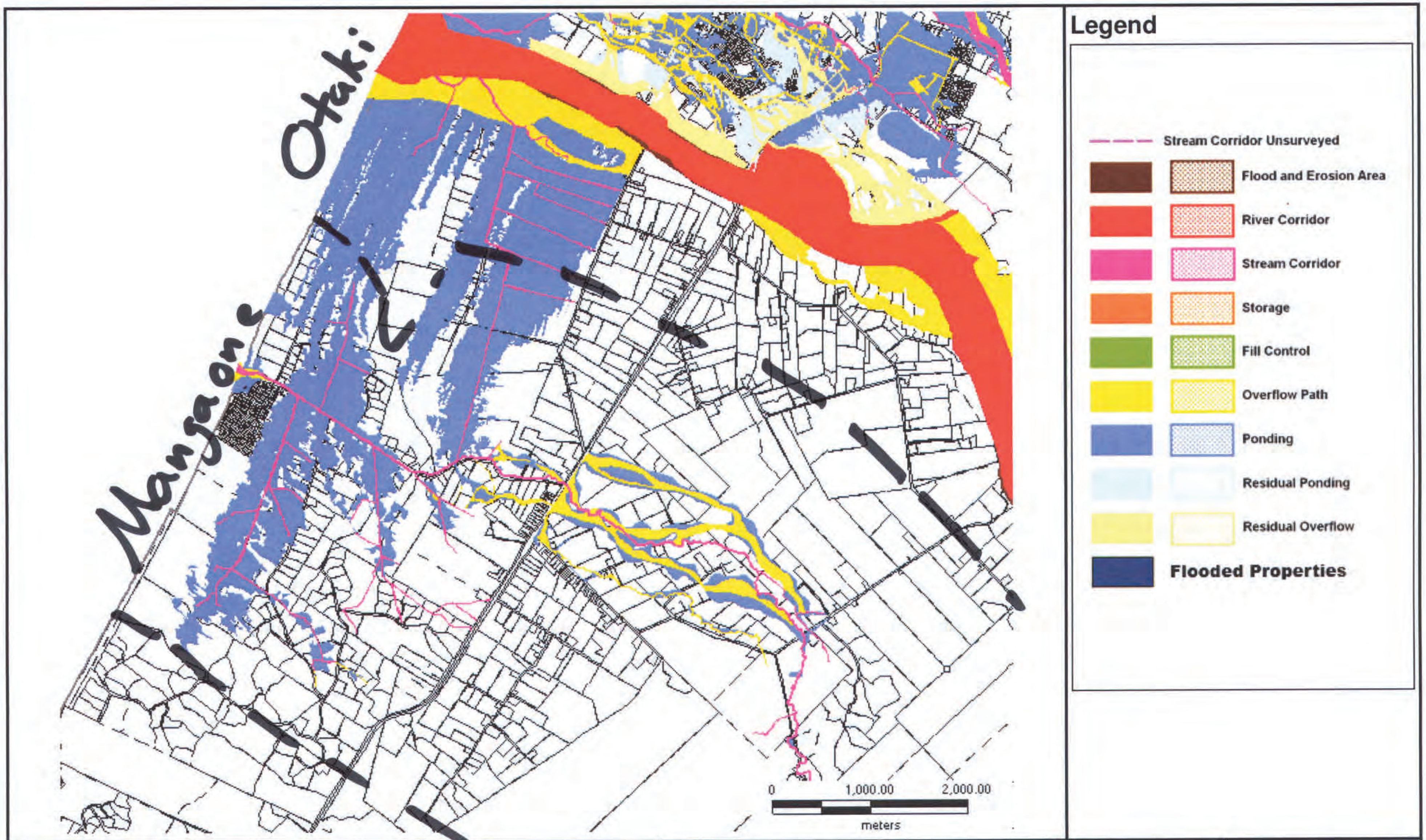
PP2O - Q100 flood extent, North end of project

Thursday, 31 March 2011

NORTH



KAPITI COAST DISTRICT COUNCIL

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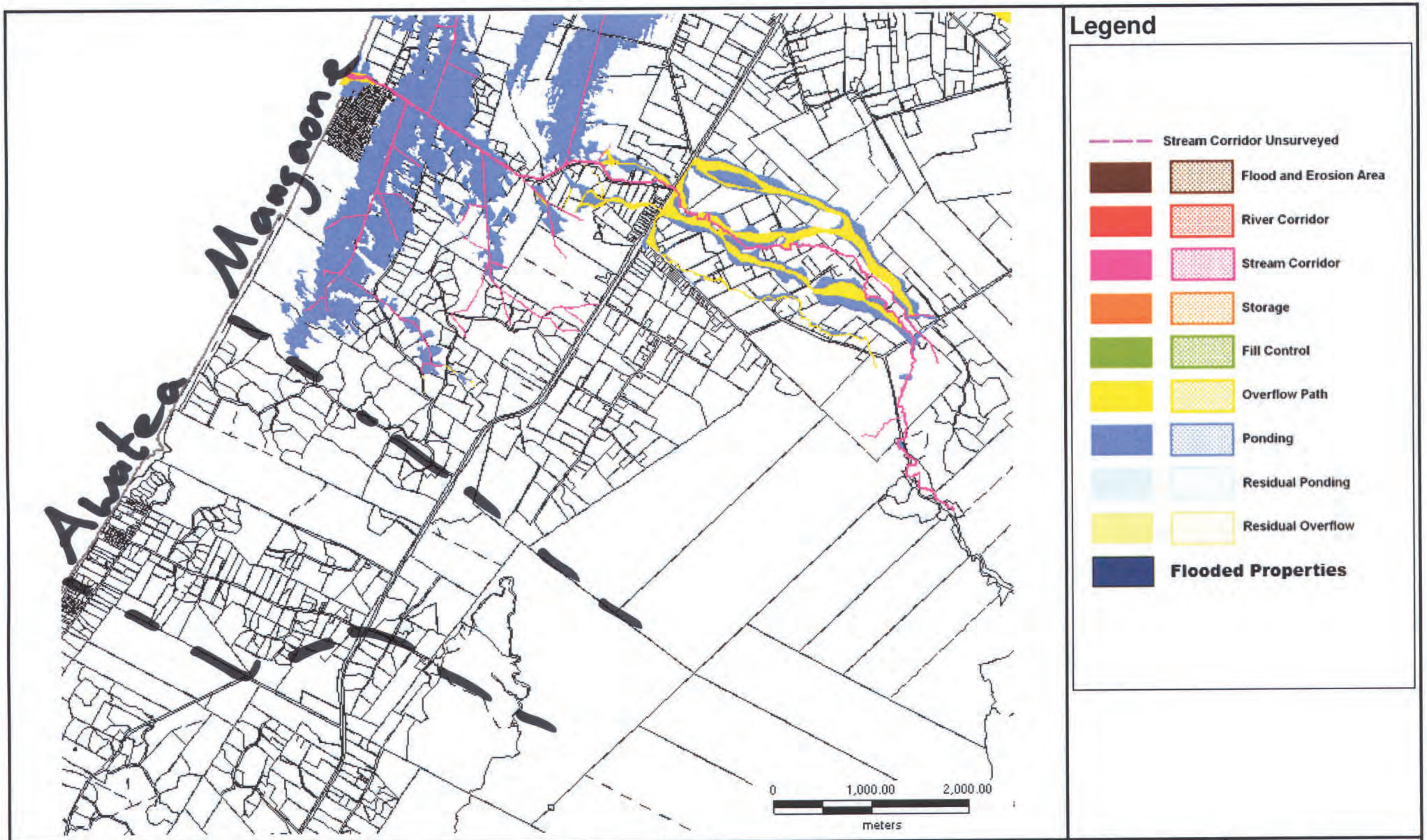
PP2O - Q100 flood extent, Mid section of project

Thursday, 31 March 2011

NORTH



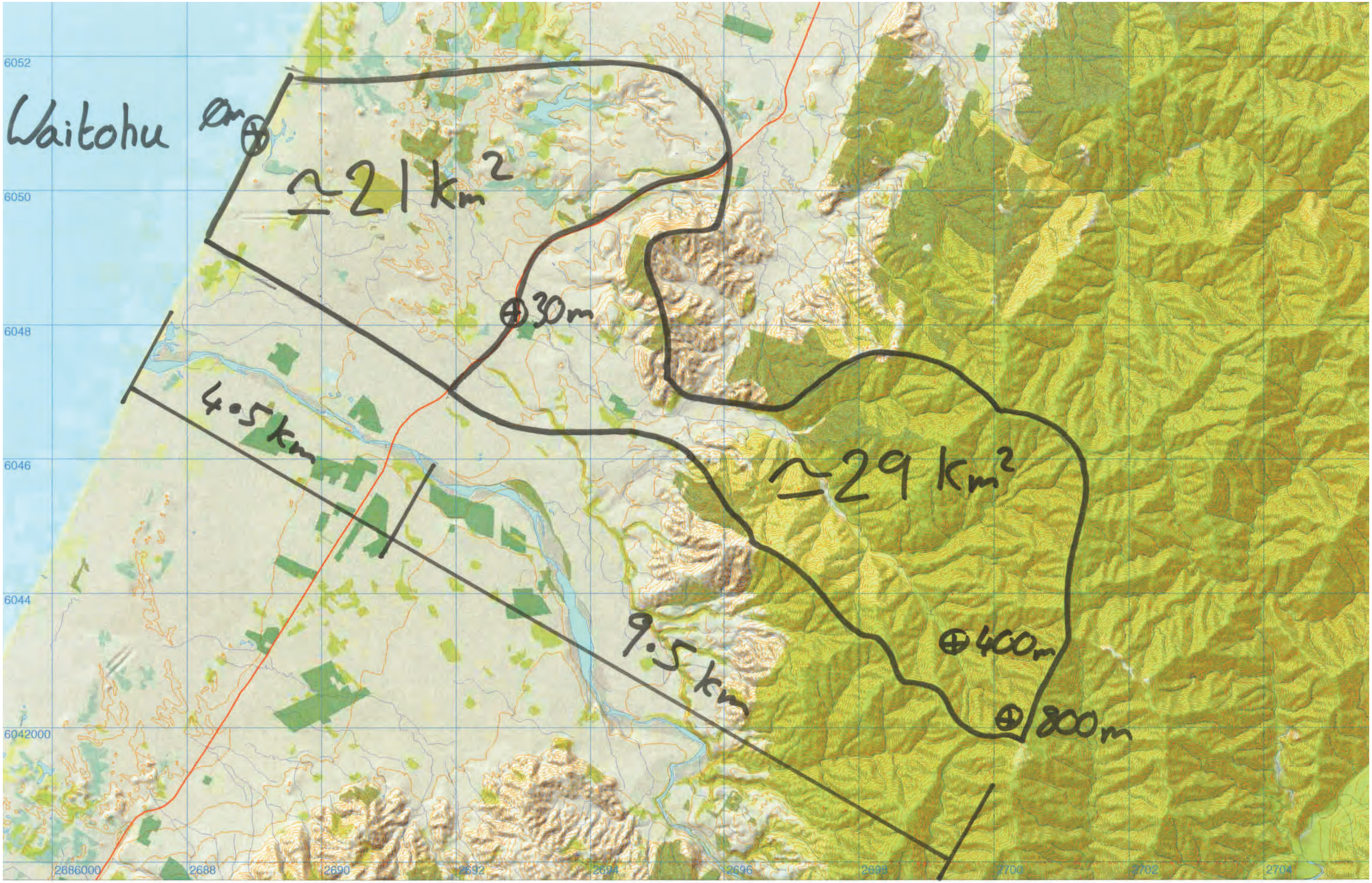
KAPITI COAST DISTRICT COUNCIL

PP2O - Q100 flood extent,
South end of project

Thursday, 31 March 2011

NORTH

Attachment 2 - Time of concentration above and below the road for Waitohu and Mangaone Catchments

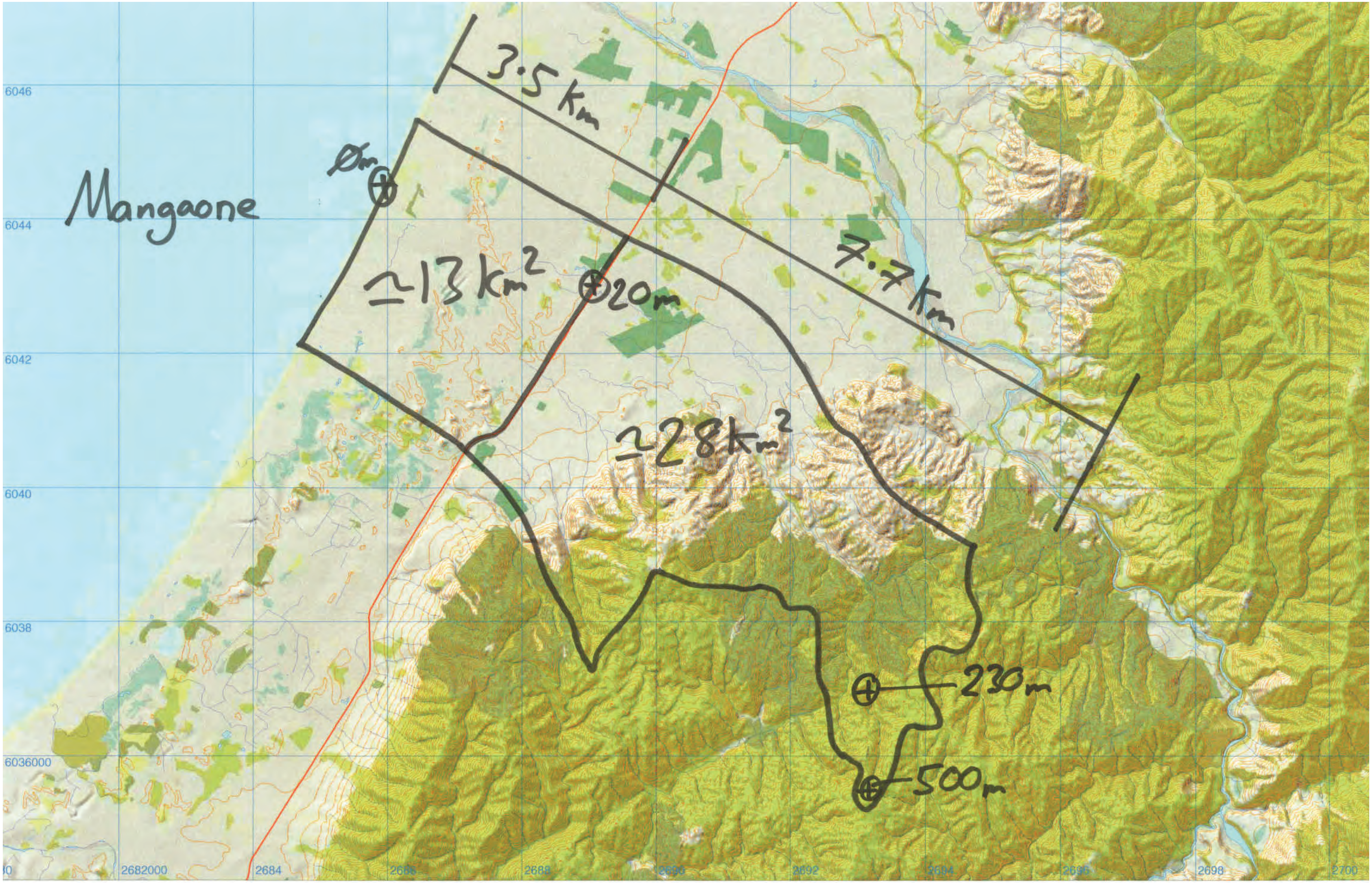


0 1000 2000 3000 4000 5000 6000 7000 8000 9000m

QuickMap
Custom Software Ltd

Any person wishing to rely on the information shown on this map must independently verify the information

@A4 Scale 1:70000 Topographical and Cadastral map derived from LINZ data. Printed: 9/06/2011 16:55.



0 1000 2000 3000 4000 5000 6000 7000 8000 9000m

QuickMap
Custom Software Ltd

Any person wishing to rely on the information shown on this map must independently verify the information

Scale 1:70000 Topographical and Cadastral map derived from LINZ data. Printed: 9/06/2011 17:00.

This calculation is a further way to identify if the project is in the top or botton half of the catchment it is in. In this case the project is in four catchments.

See attached for catchment maps of the Waitohu and the Mangaone.

Catchment perameters table (for ToC)

Catchemnt name		Length (Km)	Area (km^2)	Slope (m/km)	Top Lvl (m)	Bottom Lvl (m)
Waitohu (top)	Hill crest to road	9.50	29	38.9	400	30
Waitohu (botton)	Road to coast	4.50	21	6.7	30	0
Mangaone (top)	Hill crest to road	7.70	28	27.3	230	20
Mangaone (botton)	Road to coast	3.50	13	5.7	20	0

NB: Top Level is taken from 90% of the main channel length

Time of concentratoin Table (verious methods)

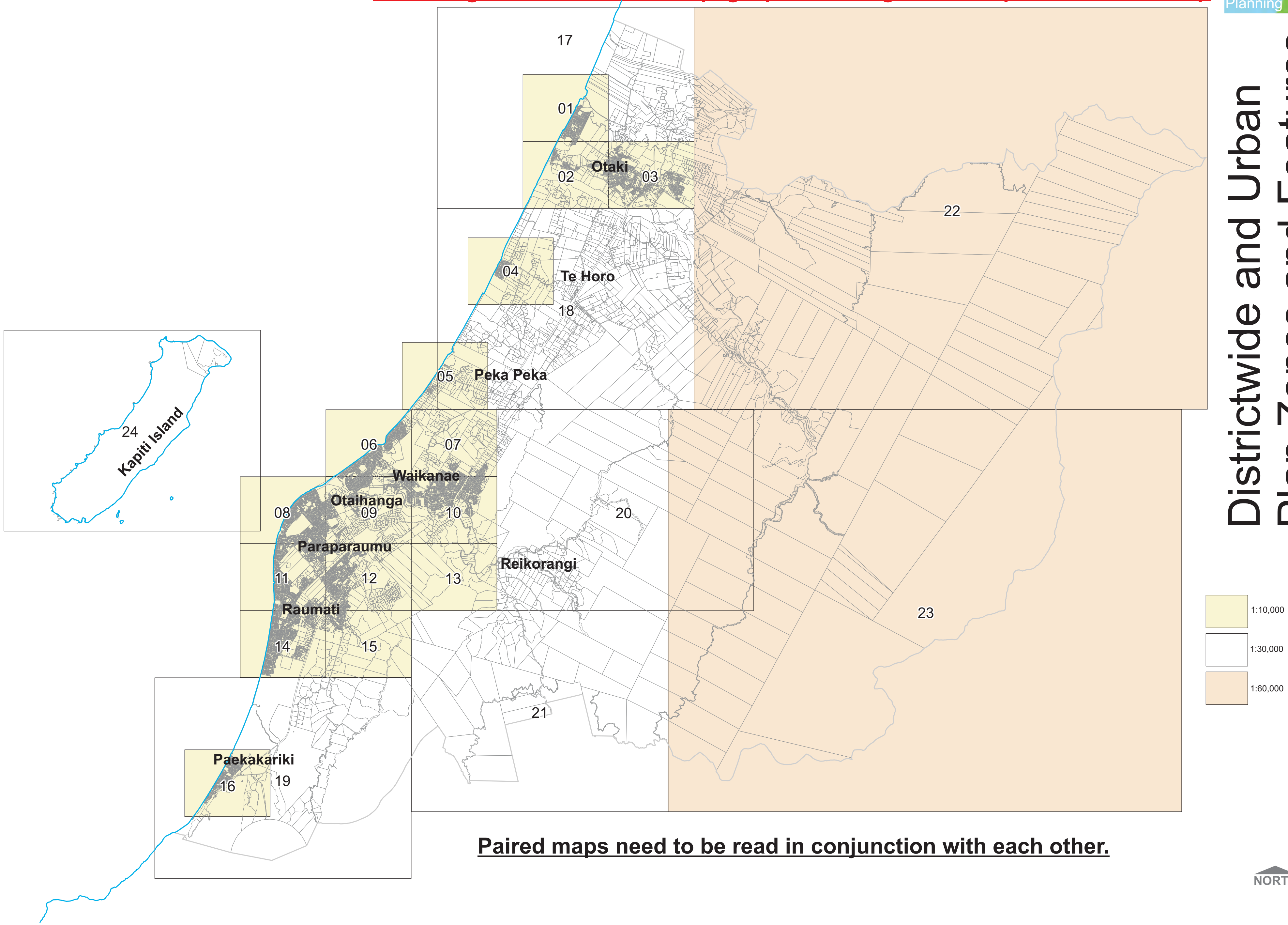
	Standard Method for	Ramser-Kirpich Method	Bransby-Williams Method	US Soil Conservation Service
Catchemnt name	$58 L / (A^{0.1} Se^{0.2})$	$3.98 L^{0.77} (Se^{-0.385})$	$57.18 L^{1.2} / (A^{0.1} H^{0.2})$	$56.868 (L^3 / H)^{0.385}$
Waitohu (top)	189	79	186	79
Waitohu (botton)	132	87	130	87
Mangaone (top)	165	77	163	77
Mangaone (botton)	111	76	109	76

Attachment 3 - KCDC District wide and Urban Plan Zone Features Maps (Measurements of urban zones)

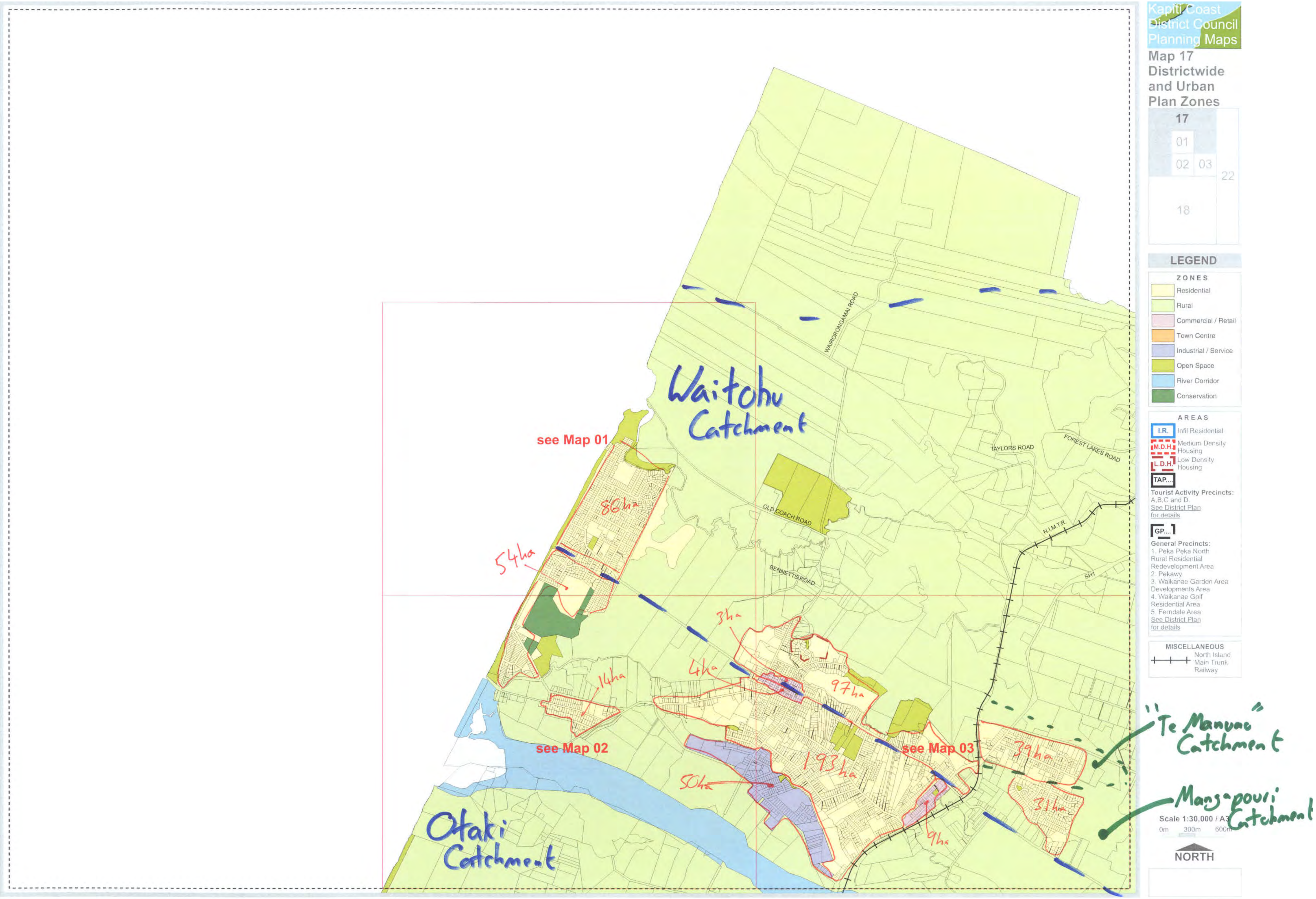
Kapiti Coast District Council Planning Maps

Districtwide and Urban Plan Zones and Features

Click on grid number to view 2 page .pdf showing Zones Map and Features Map



Paired maps need to be read in conjunction with each other.



Kapiti Coast District Council Planning Maps
Map 17 Districtwide and Urban Plan Zones
17
01
02
03
22
18
LEGEND
ZONES
Residential
Rural
Commercial / Retail
Town Centre
Industrial / Service
Open Space
River Corridor
Conservation
AREAS
I.R.
Infill Residential
M.D.H.
Medium Density Housing
L.D.H.
Low Density Housing
TAP...
Tourist Activity Precincts: A,B,C and D
See District Plan for details
GP...
General Precincts:
1. Peka Peka North Rural Residential Redevelopment Area
2. Pekaway
3. Waikanae Garden Area Developments Area
4. Waikanae Golf Residential Area
5. Ferndale Area
See District Plan for details
MISCELLANEOUS
North Island Main Trunk Railway
Scale 1:30,000 / A3
0m
300m
600m
NORTH
WAIRORONGAMAI ROAD
TAYLORS ROAD
FOREST LAKES ROAD
OLD COACH ROAD
BENNETTS ROAD
N.I.M.T.R.
SH1
see Map 01
see Map 02
see Map 03
Waitohu Catchment
Otaki Catchment
"Te Manuao" Catchment
Mangapouri Catchment
86ha
54ha
14ha
3ha
4ha
97ha
193ha
50ha
9ha
39ha
31ha


Kapiti Coast District Council Planning Maps
Map 18
Districtwide and Urban Plan Zones
17
02 03
22
04
18
05
07
20
23
LEGEND
ZONES
Residential
Rural
Commercial / Retail
Town Centre
Industrial / Service
Open Space
River Corridor
Conservation
AREAS
I.R.
Infill Residential
M.D.H.
Medium Density Housing
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Low Density Housing
TAP...
Tourist Activity Precincts:
A,B,C and D.
See District Plan for details
GP...
General Precincts:
1. Peka Peka North Rural Residential Redevelopment Area
2. Pekawy
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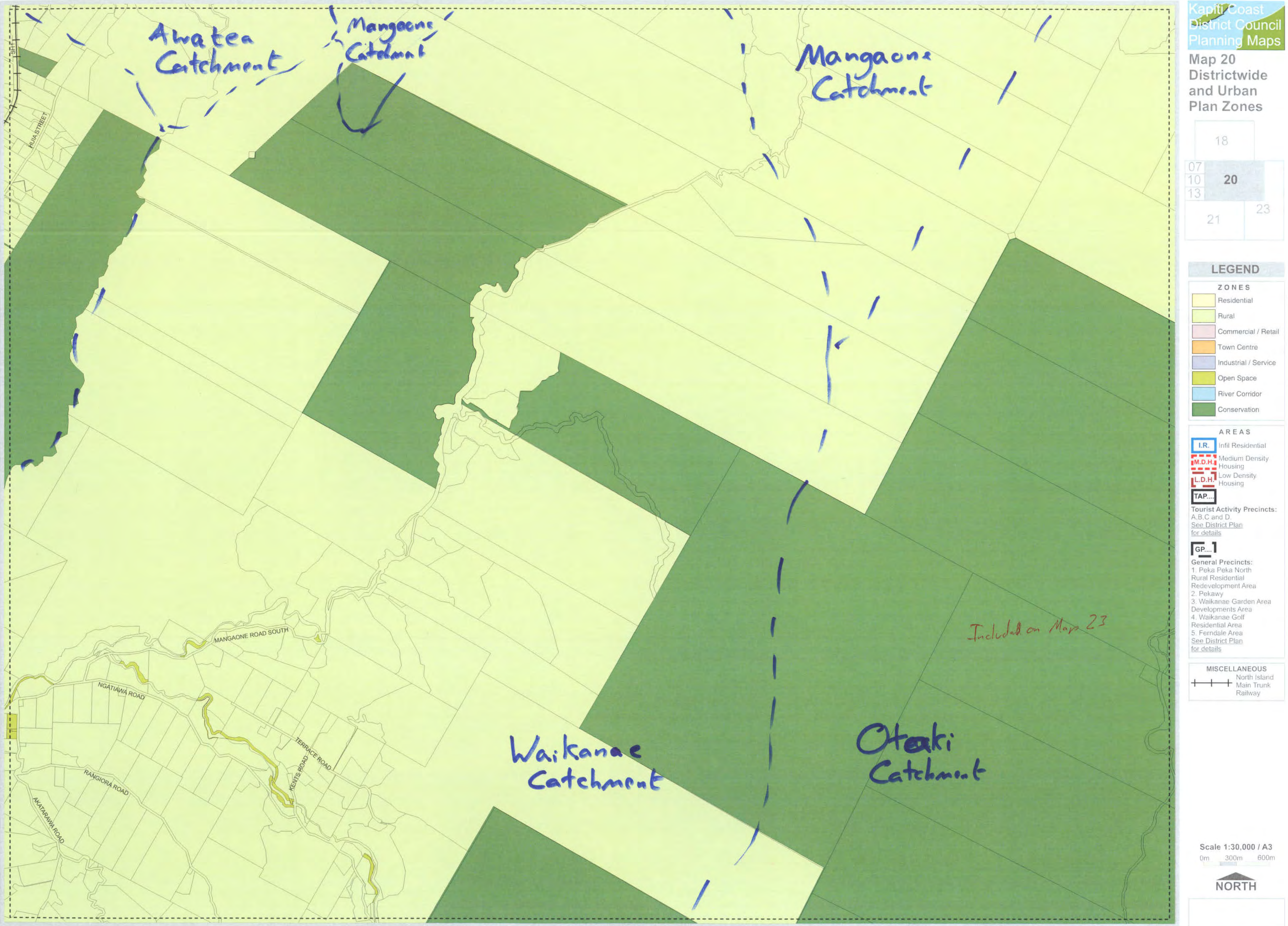
4. Waikanae Golf Residential Area
5. Ferndale Area
See District Plan for details
MISCELLANEOUS
North Island Main Trunk Railway
Scale 1:30,000 / A3
0m 300m 600m
NORTH
Otaki Catchment
Mangaone Catchment
Awatea Catchment
35 ha
see Map 04
5 ha
39 ha
see Map 05
45 ha
LETHBRIDGE
ADDINGTON RD
TE WAKA RD
SIMS ROAD
OTAKI GORGE RD
SWAMP RD
HARPER RD
SH1
OLD
HAUTERE
ROAD
TE HORO BEACH RD
TOTARANUI RD
ARCUS RD
CATLEY RD
SCHOOL ROAD
PUKENAMU
WAITAHEKE
MORRISON
GEAR ROAD
HAUTERE CROSS ROAD
MICKELL ROAD
MANGAONE NORTH ROAD
TE HAPUA ROAD
DERHAM ROAD
SUTTON RD
BEST RD
SETTLEMENT RD
TE KOWHAI ROAD
GARY ROAD
PEKA PEKA ROAD
HADFIELD ROAD
OCTAVIUS


Kapiti Coast District Council Planning Maps
Map 20
Districtwide and Urban Plan Zones
18
07
10
13
20
21
23
LEGEND
ZONES
Residential
Rural
Commercial / Retail
Town Centre
Industrial / Service
Open Space
River Corridor
Conservation
AREAS
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L.D.H. Low Density Housing
TAP...
Tourist Activity Precincts: A,B,C and D. See District Plan for details
GP...
General Precincts:
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2. Pekawy
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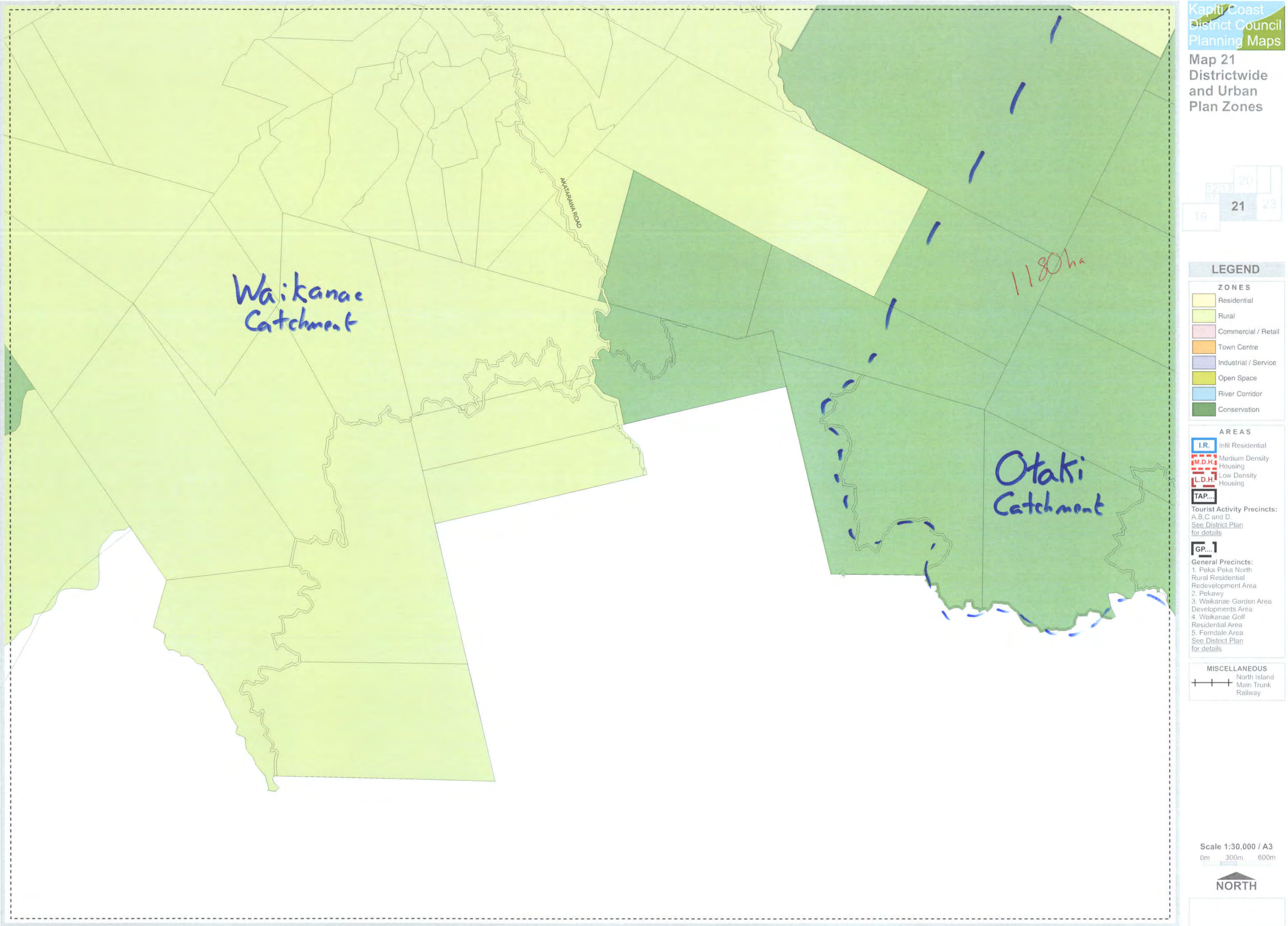
4. Waikanae Golf Residential Area
5. Ferndale Area
See District Plan for details
MISCELLANEOUS
North Island Main Trunk Railway
Scale 1:30,000 / A3
0m 300m 600m
NORTH
HUIA STREET
MANGAONE ROAD SOUTH
NGATIAWA ROAD
TERRACE ROAD
KENTS ROAD
RANGIORA ROAD
AKATARAWA ROAD
Awatea Catchment
Mangaone Catchment
Mangaone Catchment
Waikanae Catchment
Otaki Catchment
Included on Map 23


Kapiti Coast District Council Planning Maps
Map 21 Districtwide and Urban Plan Zones
21
AKATARAWA ROAD
Waikanae Catchment
Otaki Catchment
1180ha
LEGEND
ZONES
Residential
Rural
Commercial / Retail
Town Centre
Industrial / Service
Open Space
River Corridor
Conservation
AREAS
I.R. Infill Residential
M.D.H. Medium Density Housing
L.D.H. Low Density Housing
TAP... Tourist Activity Precincts: A,B,C and D. See District Plan for details
GP... General Precincts:
1. Peka Peka North Rural Residential Redevelopment Area
2. Pekawy
3. Waikanae Garden Area Developments Area
4. Waikanae Golf Residential Area
5. Ferndale Area
See District Plan for details
MISCELLANEOUS
North Island Main Trunk Railway
Scale 1:30,000 / A3
0m 300m 600m
NORTH

Kapiti Coast District Council Planning Maps

Map 22 Districtwide and Urban Plan Zones

08 14 11 22 20 23

LEGEND

ZONES
- Residential
- Rural
- Commercial / Retail
- Town Centre
- Industrial / Service
- Open Space
- River Corridor
- Conservation

AREAS
- I.R. Infill Residential
- M.D.H. Medium Density Housing
- L.D.H. Low Density Housing
- TAP... Tourist Activity Precincts: A,B,C and D. See District Plan for details
- GP... General Precincts: 1. Peka Peka North Rural Residential Redevelopment Area 2. Pekawy 3. Waikanae Garden Area Developments Area 4. Waikanae Golf Residential Area 5. Ferndale Area See District Plan for details

MISCELLANEOUS
- North Island Main Trunk Railway

Scale 1:60,000 / A3

0m 600m 1200m

NORTH

Kapiti Coast District Council Planning Maps

Map 23 Districtwide and Urban Plan Zones

22
18
20
23
21

LEGEND

ZONES

- Residential
- Rural
- Commercial / Retail
- Town Centre
- Industrial / Service
- Open Space
- River Corridor
- Conservation

AREAS

- I.R. Infill Residential
- M.D.H. Medium Density Housing
- L.D.H. Low Density Housing
- TAP....

Tourist Activity Precincts: A,B,C and D.
See District Plan for details

GP....

General Precincts:
1. Peka Peka North Rural Residential Redevelopment Area
2. Pekawy
3. Waikanae Garden Area Developments Area
4. Waikanae Golf Residential Area
5. Ferndale Area

See District Plan for details

MISCELLANEOUS

North Island Main Trunk Railway

Scale 1:60,000 / A3
0m 600m 1200m

NORTH

Kapiti Coast District Council Planning Maps

Map 01 Districtwide and Urban Plan Zones

	17	
	01	
	02	03

LEGEND

ZONES

- Residential
- Rural
- Commercial / Retail
- Town Centre
- Industrial / Service
- Open Space
- River Corridor
- Conservation

AREAS

- I.R. Infill Residential
- M.D.H. Medium Density Housing
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- TAP... Tourist Activity Precincts: A,B,C and D. See District Plan for details
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  4. Waikanae Golf Residential Area
  5. Ferndale Area

  See District Plan for details

MISCELLANEOUS

- North Island Main Trunk Railway

Scale 1:10,000 / A3

0m 100m 200m

NORTH

Kapiti Coast District Council Planning Maps

Map 02 Districtwide and Urban Plan Zones

17
01
02 03
18

LEGEND

ZONES

- Residential
- Rural
- Commercial / Retail
- Town Centre
- Industrial / Service
- Open Space
- River Corridor
- Conservation

AREAS

- I.R. Infill Residential
- M.D.H. Medium Density Housing
- L.D.H. Low Density Housing
- TAP... Tourist Activity Precincts: A,B,C and D. See District Plan for details
- GP... General Precincts: 1. Peka Peka North Rural Residential Redevelopment Area 2. Pekawy 3. Waikanae Garden Area Developments Area 4. Waikanae Golf Residential Area 5. Ferndale Area See District Plan for details

MISCELLANEOUS

- North Island Main Trunk Railway

Scale 1:10,000 / A3
0m 100m 200m
NORTH


Kapiti Coast District Council Planning Maps
Map 03
Districtwide and Urban Plan Zones
17
01
02
03
22
18
LEGEND
ZONES
Residential
Rural
Commercial / Retail
Town Centre
Industrial / Service
Open Space
River Corridor
Conservation
AREAS
I.R. Infil Residential
M.D.H. Medium Density Housing
L.D.H. Low Density Housing
TAP... Tourist Activity Precincts: A,B,C and D. See District Plan for details
GP... General Precincts:
1. Peka Peka North Rural Residential Redevelopment Area
2. Pekawy
3. Waikanae Garden Area Developments Area
4. Waikanae Golf Residential Area
5. Ferndale Area
See District Plan for details
MISCELLANEOUS
North Island Main Trunk Railway
Scale 1:10,000 / A3
0m 100m 200m
NORTH
L.D.H.
Lupin Road
CONVENT ROAD
TAYLORS ROAD
SH1
LUPIN ROAD
HADFIELD COURT
TE RAUPARAHA STREET
RAUKAWA STREET
MAIN STREET
KOTAKI STREET
MATENE STREET
MATENE PL
RANGATIRA STREET
ITI STREET
MILL ROAD
ALEXANDER
ANZAC ROAD
KAURI ST
KOTAKI STREET
WAERENGA ROAD
DOMAIN ROAD
KNIGHTS DRIVE
MILLHAVEN PL
KIRK STREET
LEMON STREET
ATMORE AVE
RIMU ST
TITOKI ST
MIRO ST
KIRK STREET
BELL STREET
WAERENGA ROAD
BENTLEY CT
DUNSTAN STREET
ARTHUR ST
JEAN KING PL
HARIATA ST
RAHUI ROAD
RIVERBANK ROAD
MAIRE STREET
TOTARA ST
TOTARA PL
COUNTY ROAD
TE ROTO ROAD
RAHUI ROAD
WAITOHU VALLEY ROAD
DITTMER STREET
TE MANUAO ROAD
COBB PL
ELPHICK ST
GREENWOOD BOULEVARD
ARATIKA CRES
TARARUA CRES
ORIWA CRES
RENATA ROAD
FREEMANS ROAD
LUDLAM WAY
ESPERANZA AVE
BRANDON ST
1370m
380m
3ha
4ha
80m
450m
80m
62-3=59ha
1100m
1380m
500m
68-4=64ha
310m
920m
29ha
630m
760m
700m
17ha
880m
89ha-9=80ha
40m
33ha
370m
550m
9ha
790m
170m
1100m
1370m
430m
8. 910m
39ha
230m
700m
31ha
640m

Kapiti Coast District Council Planning Maps

Map 04 Districtwide and Urban Plan Zones

04

18

LEGEND

ZONES

- Residential
- Rural
- Commercial / Retail
- Town Centre
- Industrial / Service
- Open Space
- River Corridor
- Conservation

AREAS

- I.R. Infil Residential
- M.D.H. Medium Density Housing
- L.D.H. Low Density Housing
- TAP...

Tourist Activity Precincts: A,B,C and D. See District Plan for details

GP...

General Precincts:
1. Peka Peka North Rural Residential Redevelopment Area
2. Pekawy
3. Waikanae Garden Area Developments Area
4. Waikanae Golf Residential Area
5. Ferndale Area

See District Plan for details

MISCELLANEOUS

North Island Main Trunk Railway

Scale 1:10,000 / A3

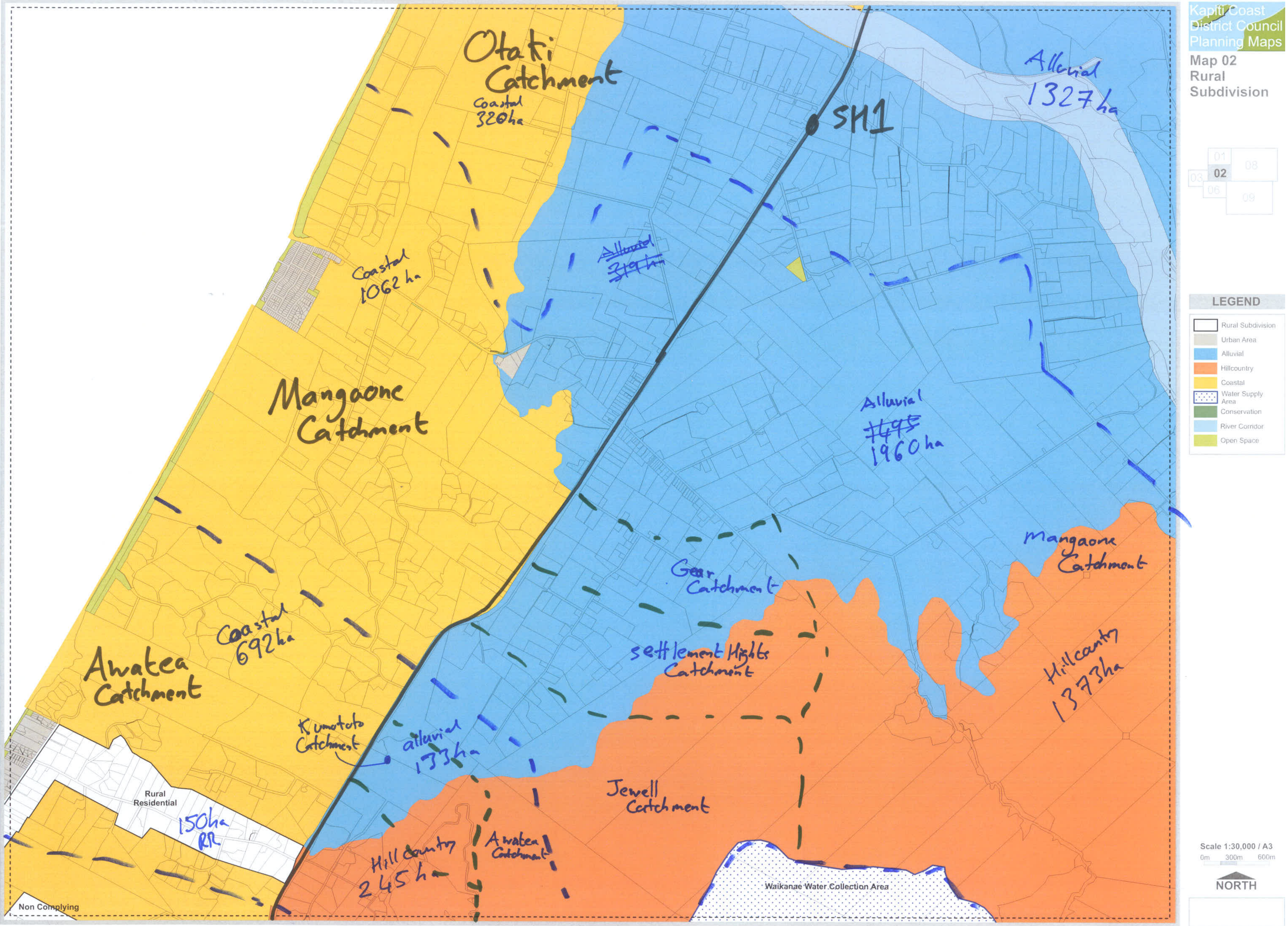
0m 100m 200m

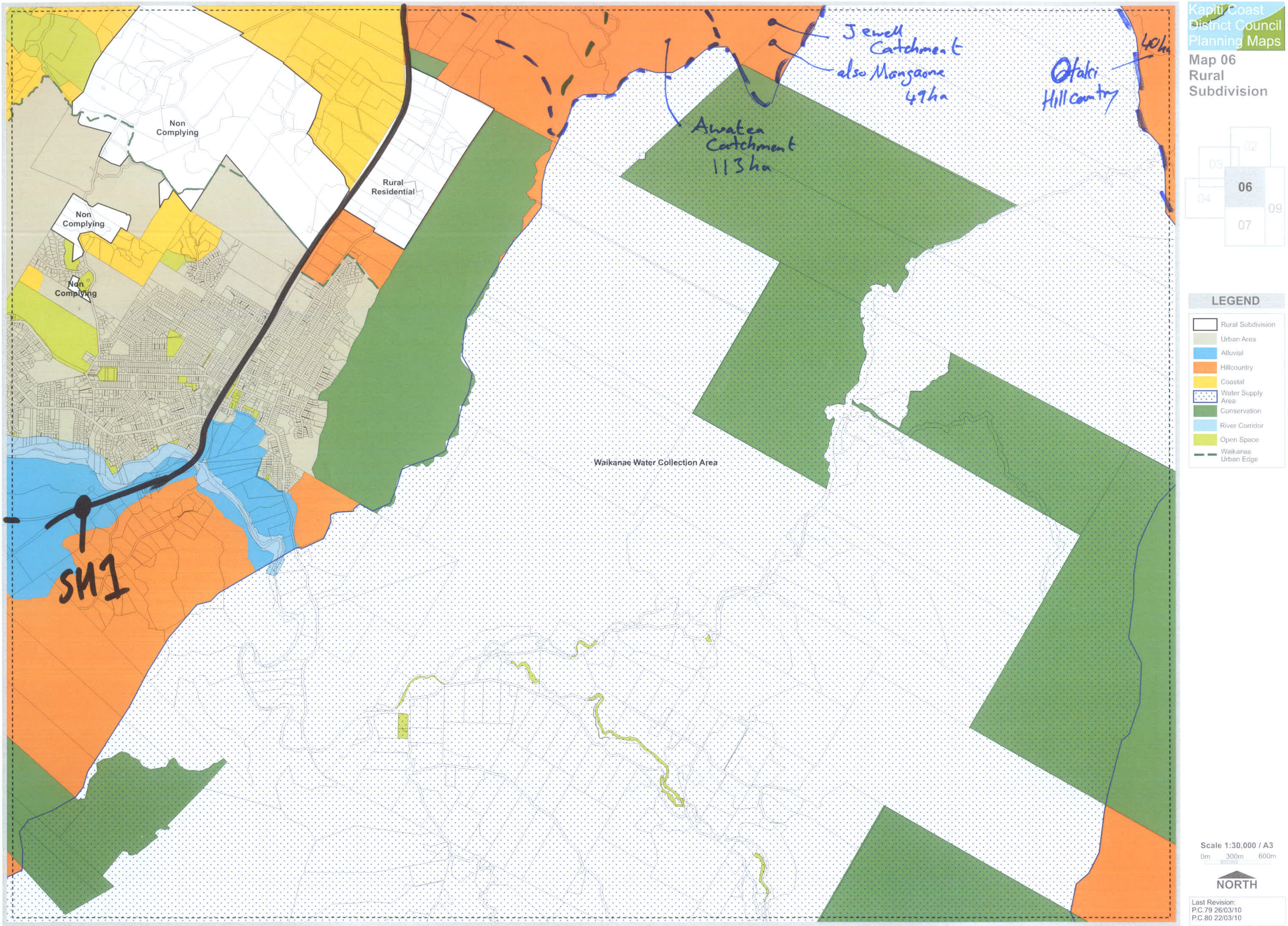
NORTH

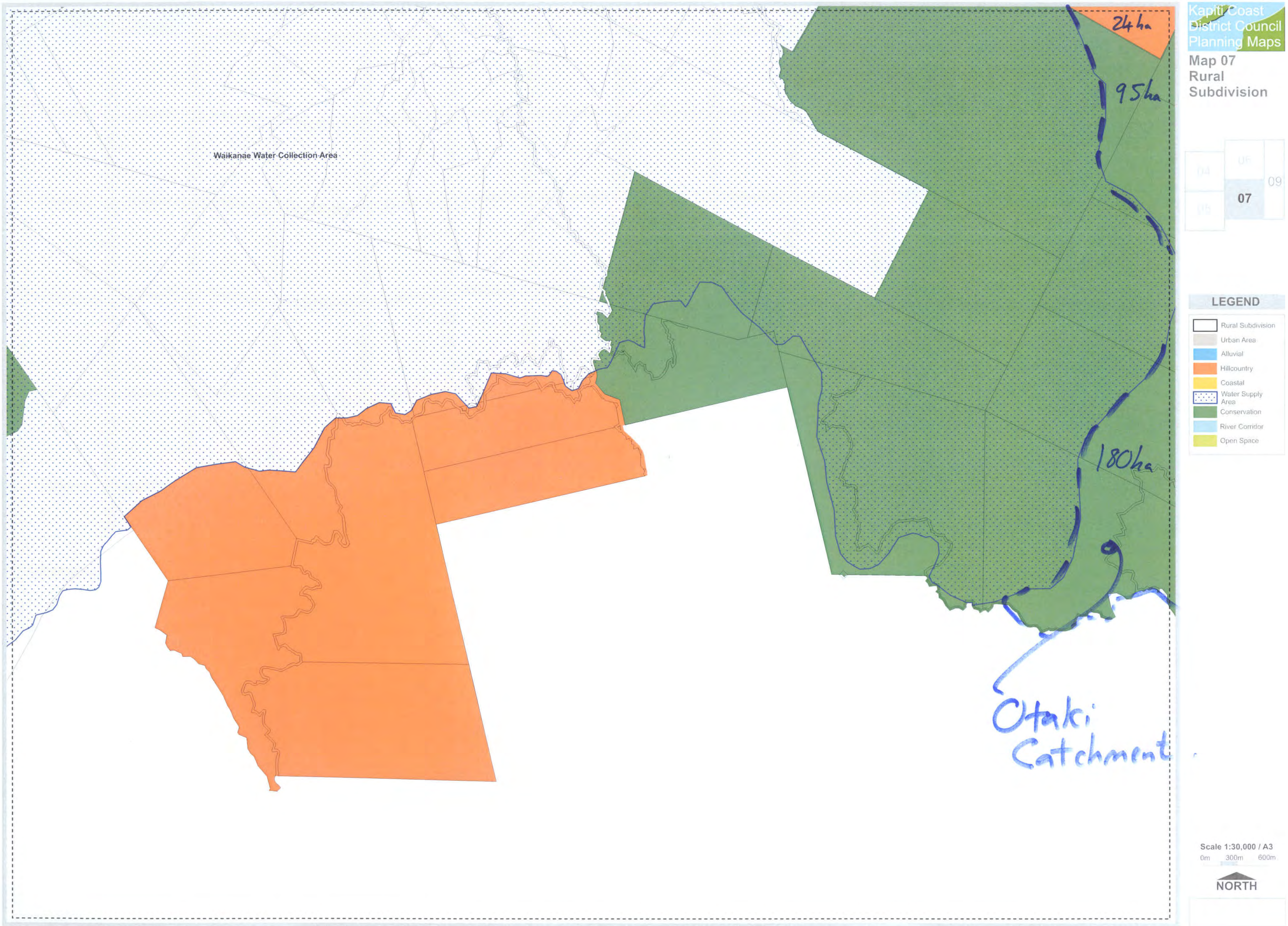

Kapiti Coast District Council Planning Maps
Map 05 Districtwide and Urban Plan Zones
04
18
05
06
07
LEGEND
ZONES
Residential
Rural
Commercial / Retail
Town Centre
Industrial / Service
Open Space
River Corridor
Conservation
AREAS
I.R.
Infil Residential
M.D.H.
Medium Density Housing
L.D.H.
Low Density Housing
TAP....
Tourist Activity Precincts:
A,B,C and D.
See District Plan for details
GP....
General Precincts:
1. Peka Peka North Rural Residential Redevelopment Area
2. Pekawy
3. Waikanae Garden Area Developments Area
4. Waikanae Golf Residential Area
5. Ferndale Area
See District Plan for details
MISCELLANEOUS
North Island Main Trunk Railway
Scale 1:10,000 / A3
0m
100m
200m
NORTH
GP.1
GP.2
PAETAWA ROAD
RUAKAWA ROAD
PEKA PEKA ROAD
GARY ROAD
KENSINGTON DRIVE
MARRAM WAY
780m
39ha
500m
300m
1500m
45ha

Attachment 4 - KCDC Rural Sub-division Maps (Measurements of different rural areas)


Kapiti Coast District Council Planning Maps
Map 01
Rural Subdivision
01
LEGEND
Rural Subdivision
Urban Area
Alluvial
Hillcountry
Coastal
Water Supply Area
Conservation
River Corridor
Open Space
Waitohu Catchment
Coastal Area = 1041ha
Otaki Catchment
Coastal 340ha
Non Complying
Alluvial 450ha
SH1
Greenwood Catchment
Waitohu Catchment
44ha
Rural Residential
Te Manuao Catchment
Mangapouri Catchment
Coastal 167ha
Alluvial 40ha
Alluvial 115ha
Alluvial 71ha
Scale 1:30,000 / A3
0m 300m 600m
NORTH


Kapiti Coast District Council Planning Maps
Map 02
Rural Subdivision
01
02
03
06
08
09
LEGEND
Rural Subdivision
Urban Area
Alluvial
Hillcountry
Coastal
Water Supply Area
Conservation
River Corridor
Open Space
Scale 1:30,000 / A3
0m
300m
600m
NORTH
Otaki Catchment
Coastal 320ha
SH1
Alluvial 1327ha
Coastal 1062 ha
~~Alluvial 319 ha~~
Mangaone Catchment
Alluvial
~~1495~~ 1960 ha
Gear Catchment
Mangaone Catchment
Awatea Catchment
Coastal 692ha
Settlement Hights Catchment
Hillcountry 1373ha
Kumototo Catchment
alluvial 133ha
Rural Residential
150ha RR
Jewell Catchment
Hill country 245 ha
Awatea Catchment
Waikanae Water Collection Area
Non Complying

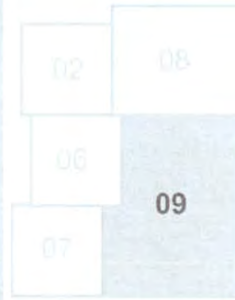

Kapiti Coast District Council Planning Maps
Map 06
Rural Subdivision
02
05
04
06
07
09
LEGEND
Rural Subdivision
Urban Area
Alluvial
Hillcountry
Coastal
Water Supply Area
Conservation
River Corridor
Open Space
Waikanae Urban Edge
Non Complying
Non Complying
Non Complying
Rural Residential
Waikanae Water Collection Area
Jewell Catchment
also Mangaone 49ha
Otaki Hill country
40ha
Awatea Catchment 113ha
SH1
Scale 1:30,000 / A3
0m 300m 600m
NORTH
Last Revision:
P.C.79 26/03/10
P.C.80 22/03/10


Kapiti Coast District Council Planning Maps
Map 07
Rural
Subdivision
07
09
Waikanae Water Collection Area
24 ha
95ha
180ha
Otaki Catchment
LEGEND
Rural Subdivision
Urban Area
Alluvial
Hillcountry
Coastal
Water Supply Area
Conservation
River Corridor
Open Space
Scale 1:30,000 / A3
0m 300m 600m
NORTH


Kapiti Coast District Council Planning Maps
Map 08
Rural Subdivision
08
LEGEND
Rural Subdivision
Urban Area
Alluvial
Hillcountry
Coastal
Water Supply Area
Conservation
River Corridor
Open Space
Scale 1:60,000 / A3
0m
300m
600m
NORTH
Coastal 300ha
SH1
Hillcountry 723ha
Greenwood Catchment.
40ha
Alluvial 320ha Waitohu
Waitohu Catchment (29km²)
Waitohu Water Collection Area
Conservation 1656ha
Alluvial Mangapouri 147ha
Mangapouri Catchment.
Alluvial 910ha
Hillcountry 2837ha
Mangaone Catchment
324ha
Otaki Catchment
Conservation area 10500ha

Kapiti Coast District Council Planning Maps

Map 09 Rural Subdivision



LEGEND

- Rural Subdivision
- Urban Area
- Alluvial
- Hillcountry
- Coastal
- Water Supply Area
- Conservation
- River Corridor
- Open Space

Scale 1:60,000 / A3

0m 300m 600m

NORTH

Attachment 5 - Summary of 2008 KiwiRail WRRP stormwater standards

TRACK AND CIVIL DESIGN PARAMETERS SUMMARY				
Parameter	Desirable	Absolute	Source	Comment
Drainage Design life	50 years		ONTRACK DRAFT Drainage Design Guidelines January 2008	
Lateral Drainage	3% cross fall		ONTRACK DRAFT Drainage Design Guidelines January 2008	Cross stormwater only required to percolate through ballast of one set of tracks.
Stormwater outside of Rail Corridor				
Primary Systems	20% AEP or 1 in 5 year return with no surcharging		ONTRACK DRAFT Drainage Design Guidelines January 2008	Unless KCDC require higher levels of service.
Secondary Systems	1% AEP or 1:100 year return		ONTRACK DRAFT Drainage Design Guidelines January 2008	If flow is piped, KCDC approval is required **
Building	No inundation for 1% AEP		ONTRACK DRAFT Drainage Design Guidelines January 2008	
Stormwater inside of Rail Corridor				
Primary Systems	10% AEP or 1:10 year return with no surcharging		ONTRACK DRAFT Drainage Design Guidelines January 2008	Unless KCDC require higher levels of service.
Secondary Systems	1% AEP or 1:100 year return		ONTRACK DRAFT Drainage Design Guidelines January 2008	Piped flow only if no viable alternative.**
Longitudinal (outside underground)	1% AEP or 1:100 year return with minimum 300mm freeboard from rail track Match existing if already present.		ONTRACK DRAFT Drainage Design Guidelines January 2008	To be swale drains with catchpits or turnouts as appropriate. Swales to have side slopes < 1.5h:1.0v and may be flatter where insitu soil dictates**
Longitudinal (underground)	1% AEP or 1:100 year return with minimum 600mm freeboard from rail track - Match existing if already present.		ONTRACK DRAFT Drainage Design Guidelines January 2008	Unless KCDC requirements are more onerous.**
Manholes	60m centres		ONTRACK DRAFT Drainage Design Guidelines January 2008	At all changes in grade, horizontal alignment or max crs 60m
Cross Stormwater	10% AEP or 1:10 year return with no surcharging and 1% AEP with min 600mm freeboard to rail tracks		ONTRACK DRAFT Drainage Design Guidelines January 2008	Match existing waterways if in close proximity

Appendix 4 – Whole life cost analysis of Attenuation swales v swales with ponds

Environmental
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PO Box 5848, Auckland 1141,
New Zealand

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Fax *+64 9 355 9584*

TO	Gareth McKay
COPY	Warren Bird
FROM	Ricki Coles
DATE	8 June 2011
FILE	5-C1814.36
SUBJECT	440PN: PP20: WLC of Attenuation swales v swales with ponds

Hi Gareth,

Introduction

This memo investigates the potential whole of life costs comparing different stormwater attenuation option, considering capital and maintenance costs.

Options

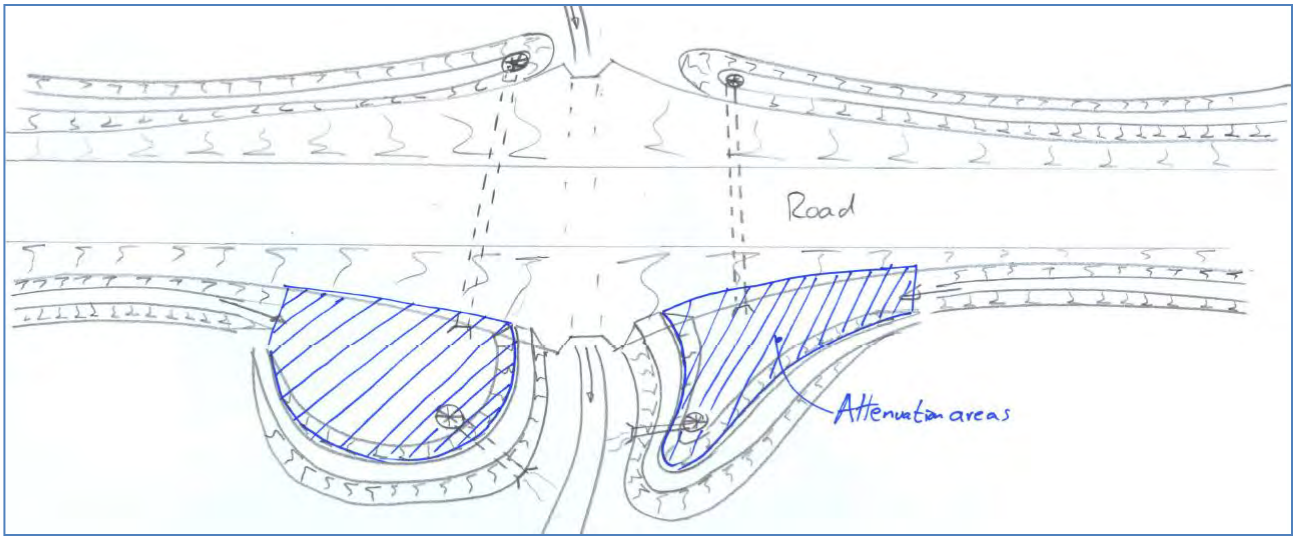
The two options considered are:

- Option 1 – Swales combined with dry ponds: or
- Option 2 – Attenuation swales.

In some area, such as section of road draining directly to the Otaki River, mo attenuation is expected to be required. In these areas swales or ponds will provide treatment only.

Description of Option 1 – Swales and Ponds

- The swales provide treatment. Nominal dimensions of the swales are assumed to be: 2m wide base, sides 1in4 to 1in6, depth 300mm below pavement (pavement 700mm thick), resulting in a top width of 10m, both sides of the road. Swales can be planted or grassed but are assumed to be grassed.
- The dry ponds provide attenuation by storing the water and releasing it slowly over time. The size and shape of these are location specific. Ponds are also assumed to be grassed.



Sketch of swales (providing treatment) leading to ponds (providing attenuation)

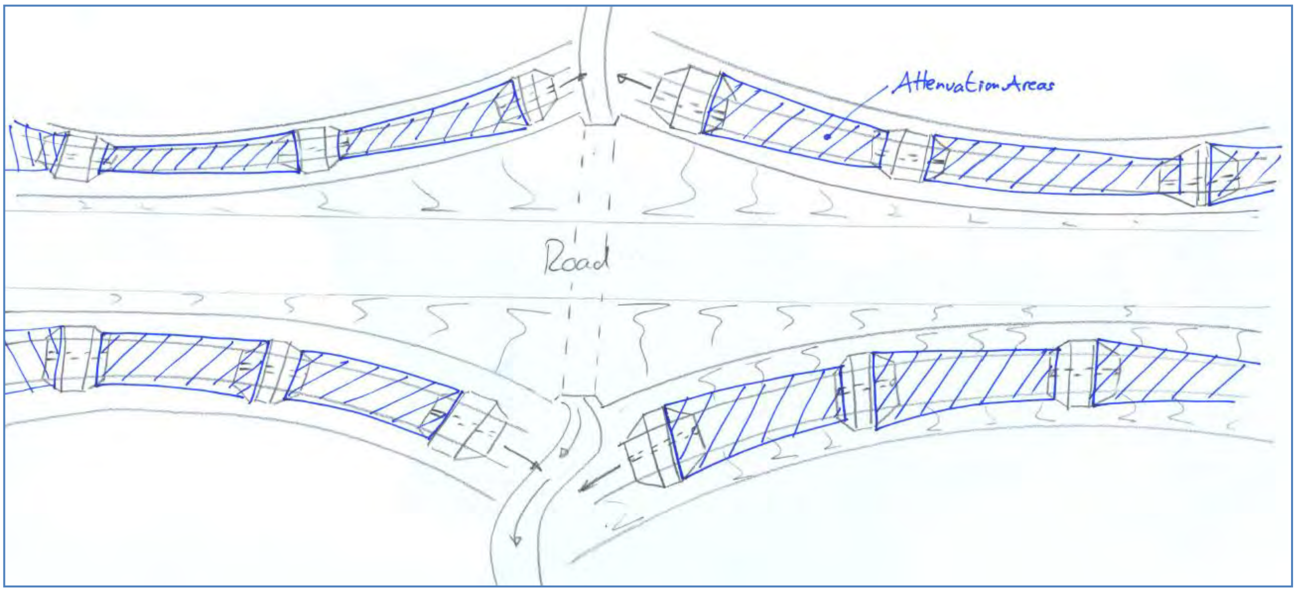
Constraints of Option 1 – Swales with Ponds

The swales with ponds option works best with moderate to high fall and where there are discreet square or round shaped parcels of land (located near low points in the topography prior to discharge points) that can be used as dry ponds.

This option works least well in flat areas with limited driving head, sections of road with no discrete areas for ponds or sections of road where there are multiple waterway crossings.

Description of Option 2 – Attenuation swales

- Attenuation swales provide both treatment and attenuation. The dimensions will change depending on longitudinal grade and area of road draining to them (single lane or 4 lanes). Attenuation swales require a bund every 20 to 300m (very depending on grade and bund height) with a hydraulic control to allow water to drain down. Attenuation swales can be planted or grassed but for consistency are also assumed to be grassed. Nominal dimensions: 4m wide base, sides 1in4 to 1in6, height of bund could range from 0.6m to 1.4m, with 100mm for overflow and 300mm freeboard. This gives a top width of 12m to 18m.



Sketch of attenuation swales (for treatment and attenuation)

Constraints of Option 2 – Attenuation swales

The attenuation swales option works best where there are low longitudinal grades, and there is generous width all along the road designation. Attenuation swales are also flexible enough to accommodate frequent water way crossings and the multiple discharge points associated with this.

This option is work least well in steep areas, or where the designation is consistently being kept as narrow as possible. In areas of extensive cut or fill, the volume of excavated material increases dramatically which has an effect of the cut/fill balance. If is also difficult to configure the hydraulic controls for more than one design flow profile.

Which option is more appropriate for this project?

The topography and constraints change along the project length. Some areas are flat, some are hilly, some have frequent waterway crossing, some have infrequent discharge points, some areas are constrained width-wise, and some are not. So unfortunately we cannot say that one of the options is more appropriate for this project. In some places one is more appropriate; in other places, the reverse is true.

Based on the alignment at concept stage, I split up the road into sections and commented on the appropriateness of each option for that particular section. As can be seen the option that is more appropriate changes along the alignment.

Table commenting on option appropriates for road section (preferred option is highlighted)		
Section of road	**Option 1 – Swales with Ponds**	**Option 2 – Attenuation swales**
Ch 00 to 400 – tie into existing	Opportunity to divert existing drainage to a pond adjacent to Taylors rd.	Opportunity on east side only
Ch 400 to 900 road in fill,	Possible – and opportunity to treat local road with pond	Possible – for main alignment
Ch 900 to 1500 road in cut	Possible	Tricky – makes cut wider, longitudinal grade 1.2% so possibly getting too steep
Ch 1500 to 1900 (to Mangapouri stream)	Possible – complicated, but in several discrete areas available for ponds.	Tricky – complicated, lots of roads crossing and in several places the width is constrained
Ch 1900 to 2600 (to Toro culvert)	Possible – but waterway crossings close together so need multiple ponds (there are limited number of discreet location available)	Possible –would help if more space between road and rail
Ch 2600 to 3400 (to Otaki River - Probably don't need attenuation here)	Possible – need pond device to treat bridge	Possible – could work for main alignment up to bridge.
Ch 3400 to 3800 (Otaki bridge Probably don't need attenuation here)	Possible	Tricky – may still need small pond or bridge runoff
Ch 3800 to 4600 (with 2 off/on ramps Probably don't need attenuation here)	Possible – but maybe K&C is wanted here anyway?	Tricky – not much room between ramps and main alignment.
Ch 4600 to 7800 (rural, flat, space available, to school road)	Possible	Possible – could work well here; need enough land between road and existing rail.
Ch 7800 to 9000 (to Mary Crest)	Possible: but frequent stream crossings, makes this area difficult for ponds.	Possible – could work well here; need enough land between road and existing SH1, and road and new Gear Road.
Ch 9000 to 11000 (through Mary Crest)	Not assessed as subject to large amount of change.	
Ch 11000 to 12200 (end of works	Possible but hydraulic head required to drive water through pond makes pond footprint big	Flat and mutable waterway crossings. Strip of land between existing and new and local roads are possible areas to use if made a bit wider.

Whole of life cost comparison – Capital Expenditure

For the proposed of a Whole of life cost comparisons, we have assessed two situations.

Table of different situation characteristics		
Variables identified	**Situation 1**	**Situation 2**
Longitudinal grade of road	0.5%	2%
Number of waterway crossings	3	1
Land availability	Generally unconstrained	Generally unconstrained
Road Section length	2000m	2000m
Road curvature	Straight	Straight

Table of assumptions for Option 1 – Swales with Ponds		
	Situation 1	**Situation 2**
Swale top width	10m	10m
Swale foot print (as swale both sides of road)	40000m^2	40000m^2
Swale excavation volume (base width 2m sides 1 in 4, depth 1m)	Swale section = 6m^2 Swale volume = 24000m^3	Swale section = 6m^2 Swale volume = 24000m^3
Number of ponds and pond discharge structures	5	2
Pond volume needed (based on: road 30m wide and rain fall depth of 160mm)	Total volume 9600m^3 Each pond volume = 1920m^3	Total volume 9600m^3 Each pond volume = 4800m^3
Pond area needed (assuming 1 in 4 batters, and plan aspect ratio of 1:2, pond depth of 1m, bund area = circumference x 9m wide, access track = 6m wide and pond circumference long)	Each pond: water area = 2200m^2 Each pond: water circumference = 200m Each pond: bund/access area = 3000m^2 Each pond: total area = 5200m^2 Cumulative ponds area = 26000m^2	Each pond: water area = 5350m^2 Each pond: water circumference = 310m Each pond: bund/access area = 4650m^2 Each pond: total area = 10000m^2 Cumulative ponds area = 20000m^2
Pond bund volume (2m top width, 1.3m high, side slopes 1 in 4, length half of pond circumference – assuming bunds on 2 sides)	Bund section area = 8m^2 Each pond: bund volume = 800m^3 Cumulative pond bund volume = 4000m^3	Bund section area = 8m^2 Each pond: bund volume = 1240m^3 Cumulative pond bund volume = 2480m^3
Pond excavation volume (if pond completely in cut the volume – depending on grade of the land – could be 3 times the water volume. We are assuming the pond is 50% in cut so 1.5 times pond water volume)	Excavation volume = 14400m^3	Excavation volume = 14400m^3

Table of assumptions for Option 2 – Attenuation swales		
	Situation 1	**Situation 2**
Swale top width	12m	14m
Swale foot print (swale both sides of road)	48000m^2	56000m^2
Swale excavation volume (base width 4m sides 1 in 4)	Swale depth 1.1m Swale section = 9.2m^2 Swale excavation volume = 36800m^3	Swale depth 1.2m Swale section = 10.6m^2 Swale excavation volume = 42400m^3
Bund height	0.65m	0.75m
Bund frequency (based on grade and bund height)	Every 67m	Every 21m
Number of bunds (half each side of road)	60	190
Swale bund volume (0.5m top length, front and back slopes 1 in 3, swale base 4m wide)	Each bund about 9m^3 All bunds = 540m^3	ach bund about 12m^3 All bunds = 2280m^3

Table of capital cost assumptions						
Situation 1						
			Option 1 – Swales with Ponds		**Option 2 – Attenuation swales**	
		Rate	**Quantity**	**Cost**	**Quantity**	**Cost**
Excavations	(m^3)	$15	24000m^3 + 14400m^3	$573,000	36800m^3	$552,000
Bund construction (pond)	(m^3)	$20	4000m^3	$80,000	0	$0
Bund construction (swale)	(m^3)	$80	0	$0	540m^3	$43,200
Pond outlet structure (MH with scruffy dome, 10m of 450mm and 225mm pipe, headwall x2, erosion control,)	(item)	$25,000	5	$125,000	0	$0
Swale bund outlet structure (5m of 100dia. Pipe, level spreader, 1/8m^3 concrete)	(item)	$600	0	$0	60	$36,000
Top soil and Grass seeding	(m^2)	$5	40000m^2 + 26000m^2	$330,000	48000m^2	$240,000
Land cost	(m^2)	$40	40000m^2 + 26000m^2	$2,640,000	48000m^2	$1,920,000
Comparative Total				**$3.7M**		**$2.8M**
				(Additional 34%)		
Situation 2						
			Option 1 – Swales with Ponds		**Option 2 – Attenuation swales**	
		Rate	**Quantity**	**Cost**	**Quantity**	**Cost**
Excavations	(m^3)	$5	24000m^3 + 14400m^3	$576,000	42400m^3	$212,000
Bund construction (pond)	(m^3)	$20	4000m^3	$80,000	0	$0
Bund construction (swale)	(m^3)	$80	0	$0	$2,280	
Pond outlet structure (MH with scruffy dome, 10m of 450mm and 225mm pipe, headwall x2, erosion control,)	(item)	$25000	2	$50,000	0	$0
Swale bund outlet structure (5m of 100dia. Pipe, level spreader, 1/8m^3 concrete)	(item)	$600	0	$0	190	$114,000
Top soil and Grass seeding	(m^2)	$5	40000m^2 + 20000m^2	$300,000	56000m^2	$280,000
Land cost	(m^2)	$40	40000m^2 + 20000m^2	$2,400,000	56000m^2	$2,240,000
Comparative Total				**$3.4M**		**$3.5M**
						(Additional 1%)

As you can see:

- In situation 1 (0.5% grade), the swales with ponds option is shown as approximately a third more expensive than the attenuation swales option;
- In situation 2 (2% grade), the two options are approximately the same price.
- The land cost is by far the single biggest cost so any specific assessment needs to pay particular attention to this, foot print and location.

Given that the assessment is comparative and has an accuracy of plus or minus 30%, the small difference in cost between the two options (in situation 2) should not be the deciding factor. Site constraints, cut/fill balances and other project considerations will also influence the decision process.

Whole of life cost comparison – Operation and Maintenance

Table of maintenance cost assumptions								
Situation 1								
			Option 1 – Swales with Ponds			**Option 2 – Attenuation swales**		
Activity		**Rate**	**Quantity**	**Cost/ activity**	**Cost over 50 years**	**Quantity**	**Cost/ activity**	**Cost over 50 years**
Grass mowing	4 times per year	One person 1ha per hour = $70/ha	40000m² + 26000m²	$462	$92,400	48000m²	$336	$67,200
Litter picking	Once a year	One person 500m² per hour = $150/ha	40000m² + 26000m²	$990	$49,500	48000m²	$720	$36,000
Inspection of Pond outlet	Once a year	One person one pond per hour = $70/pond	5	$350	$17,500	0	$0	$0
Inspection of swale bunds	Once a year	Included in litter picking	0	$0	$0	25	$0	$0
Unblocking of pond outlets	5 yearly	two people two hours per outlet = $280/outlets	5	$1,400	$14,000	0	$0	$0
Unblocking of swale outlets	5 yearly	one people half hour per outlet = $35/outlets	0	$0	$0	25	$875	$8,750
Surface rehabilitation	50 yearly	Remove top soil (contaminated waste disposal cost at $180/Tonne, or $360/m³, if 100m thick then $36/m²), Top soil (imported at $60/m³ or $6/m²) and Grass seeding ($2/m²), total $44/m²	40000m² + 26000m²	$2,904,000	$2,904,000	48000m²	$2,112,000	$2,112,000
Comparative Total					**$3.1M**			**$2.2M**
Situation 2								
			Option 1 – Swales with Ponds			**Option 2 – Attenuation swales**		
Activity		**Rate**	**Quantity**	**Cost/ activity**	**Cost over 50 years**	**Quantity**	**Cost/ activity**	**Cost over 50 years**
Grass mowing	4 times per year	One person 1ha per hour = $70/ha	40000m² + 20000m²	$420	$84,000	56000m²	$392	$78,400
Litter picking	Once a year	One person 500m² per hour = $150/ha	40000m² + 20000m²	$900	$44,000	56000m²	$840	$42,000
Inspection of Pond outlet	Once a year	One person one pond per hour = $70/pond	2	$140	$7,000	0	$0	$0
Inspection of swale bunds	Once a year	Included in litter picking	0	$0	$0	190	$0	$0
Unblocking of pond outlets	5 yearly	two people two hours per outlet = $280/outlets	2	$560	$5,600	0	$0	$0
Unblocking of swale outlets	5 yearly	one people half hour per outlet = $35/outlets	0	$0	$0	190	$6,650	$66,500
Surface rehabilitation	50 yearly	Remove top soil (contaminated waste disposal cost at $180/Tonne, or $360/m³, if 100m thick then $36/m²), Top soil (imported at $60/m³ or $6/m²) and Grass seeding ($2/m²), total $44/m²	40000m² + 20000m²	$2,640,000	$2,640,000	56000m²	$2,464,000	$2,464,000
Comparative Total					**$2.8M**			**$2.7M**

As you can see the big ticket items are proportional to the foot print. Overall the results for maintenance costs are very similar to the results for construction costs.

Conclusion

- The outcome of the whole of live cost comparison is highly dependent on the site specific conditions.
- The choice of stormwater device cannot be made solely on a project wide whole of life cost comparison, the specific site constraints can have an overriding influence;
- As expected the attenuation swales assess favourably in flat situations, and the swales leading to dry ponds assess favourably in steeper situations. The switchover point will depend on the individual circumstances.

Summary Table of maintenance cost assumptions		
Situation 1 – 0.5% grade, 2000m of straight road (3 waterway crossings)		
	Option 1 – Swales with Ponds	**Option 2 – Attenuation swales**
Capital cost	$3.7M	$2.8M
Maintenance cost (over 50 years)	$3.1M	$2.2M
Total Cost (over 50 years)	**$6.8M**	**$5.0M**
Situation 2 – 2.0% grade, 2000m of straight road (1 waterway crossings)		
	Option 1 – Swales with Ponds	**Option 2 – Attenuation swales**
Capital cost	$3.4M	$3.5M
Maintenance cost (over 50 years)	$2.8M	$2.7M
Total Cost (over 50 years)	**$6.2M**	**$6.2M**

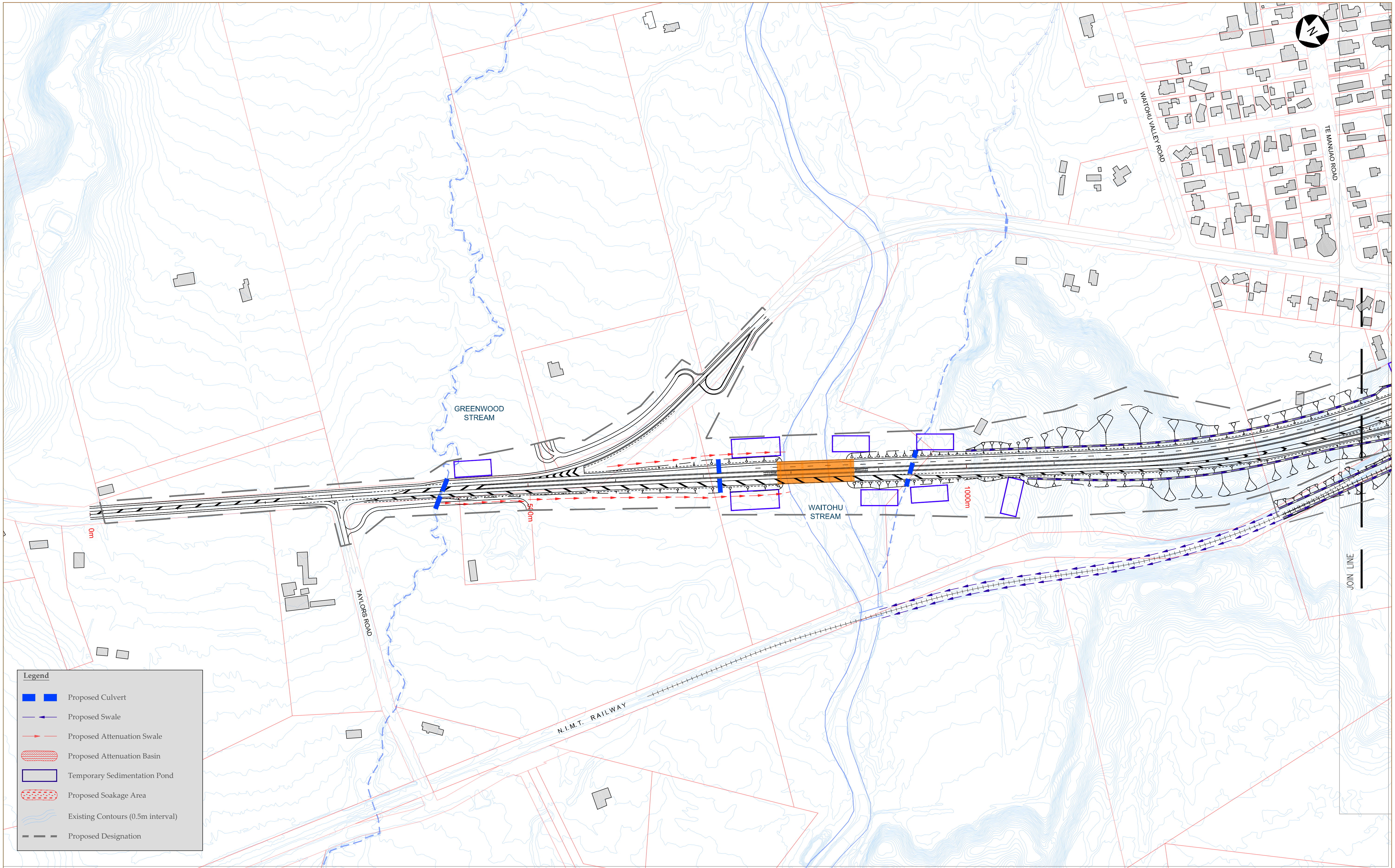
Recommendations

As a general guide:

- Use attenuation swales where the longitudinal grade is less than 1.5% and the site constraints permits;
- Use swales and ponds where the longitudinal grade is greater than 2.5% and the site constraints permits;
- For longitudinal grade between 1.5% and 2.5%, judgement will need to be used (in fact judgement will need to be used in all cases).

Due to the varied topography and many challenging site constraints, it is likely that a range of stormwater solutions will be used on the Peka Peka to Otaki project (including kerbs and possibly proprietary devices).

Appendix 5 – Scheme drawing - Stormwater device locations



0 40 80 120 160 200 (m)

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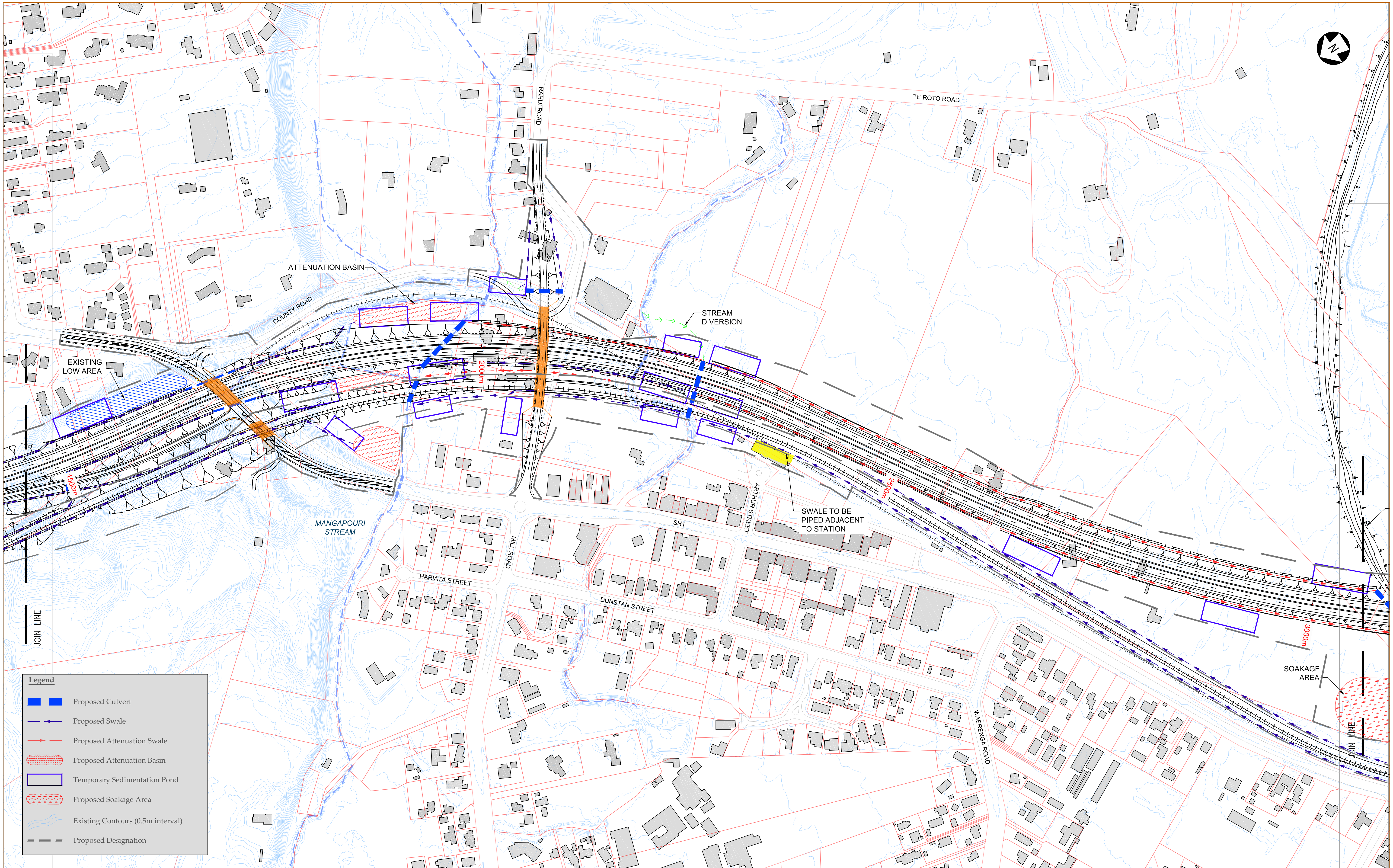

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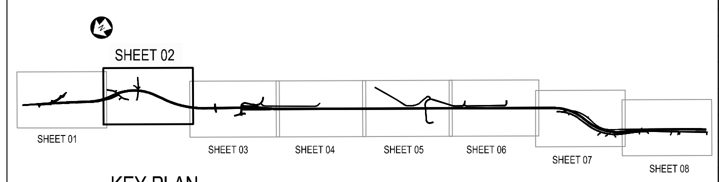

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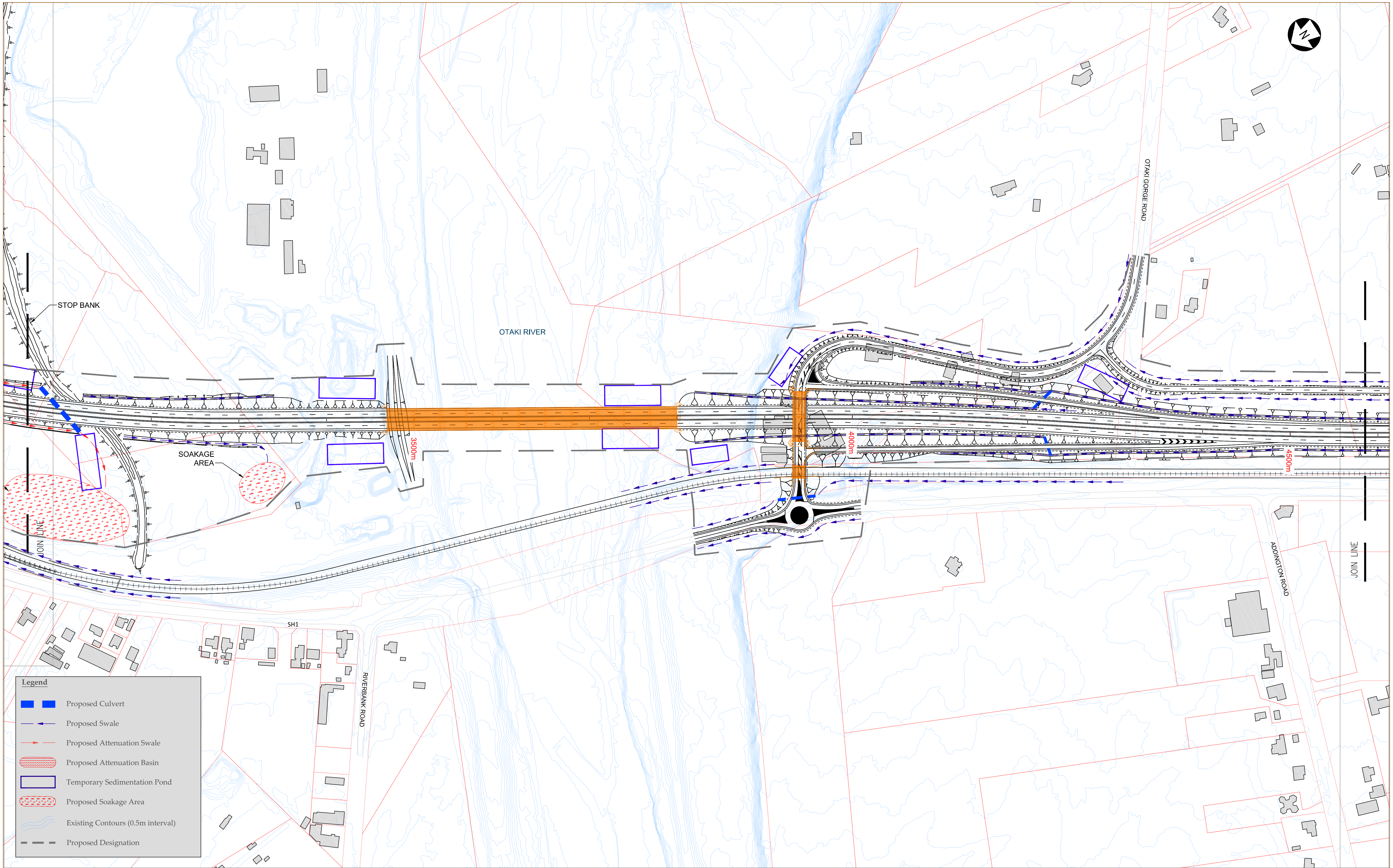

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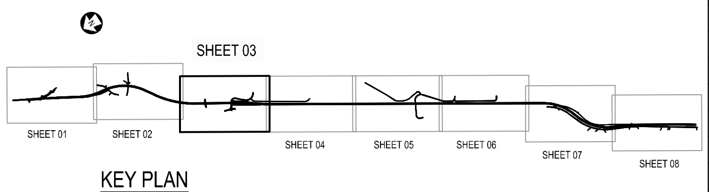

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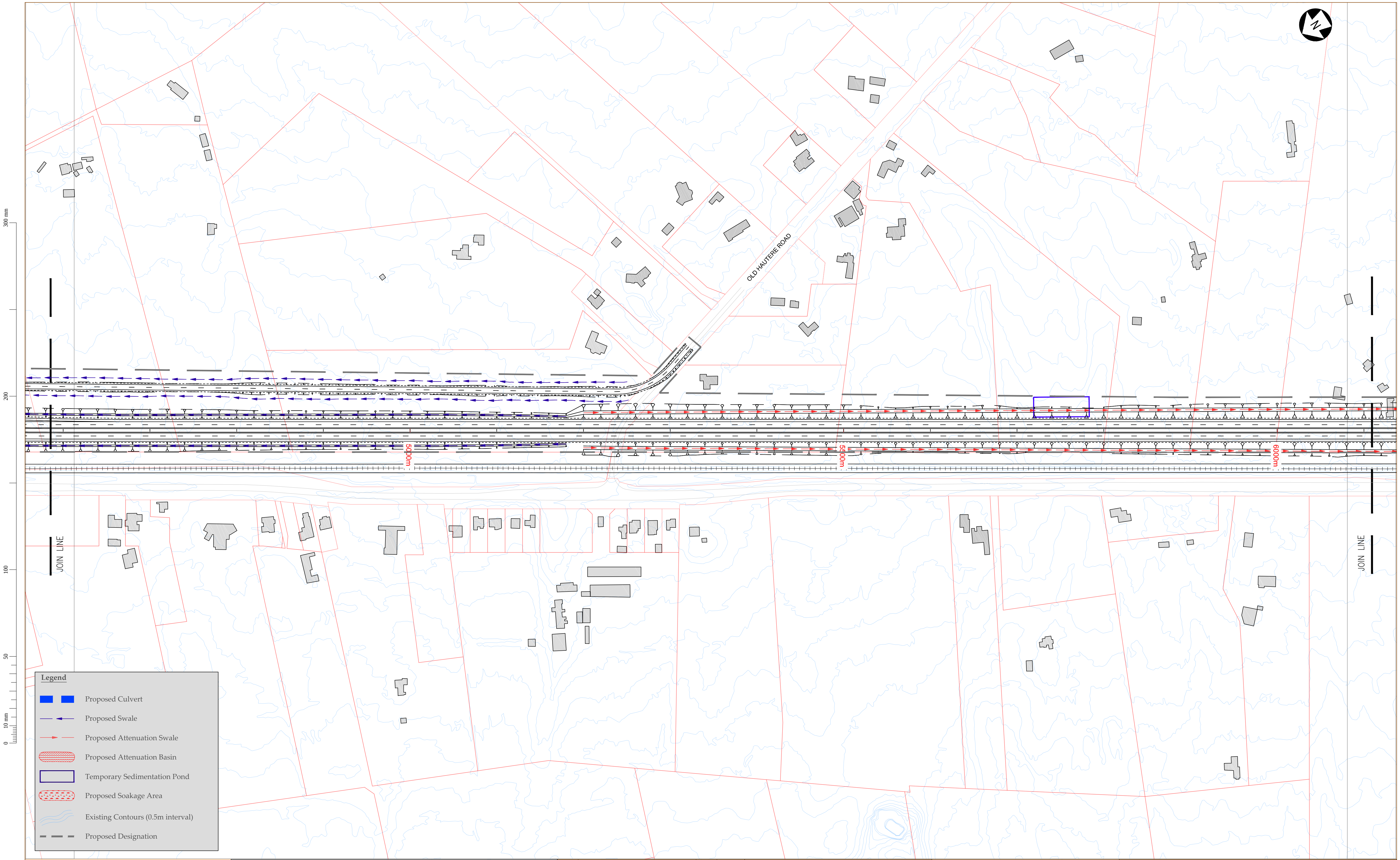

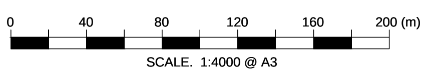

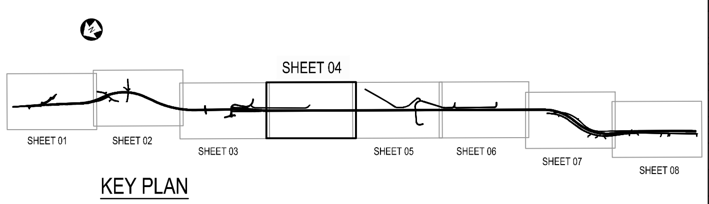

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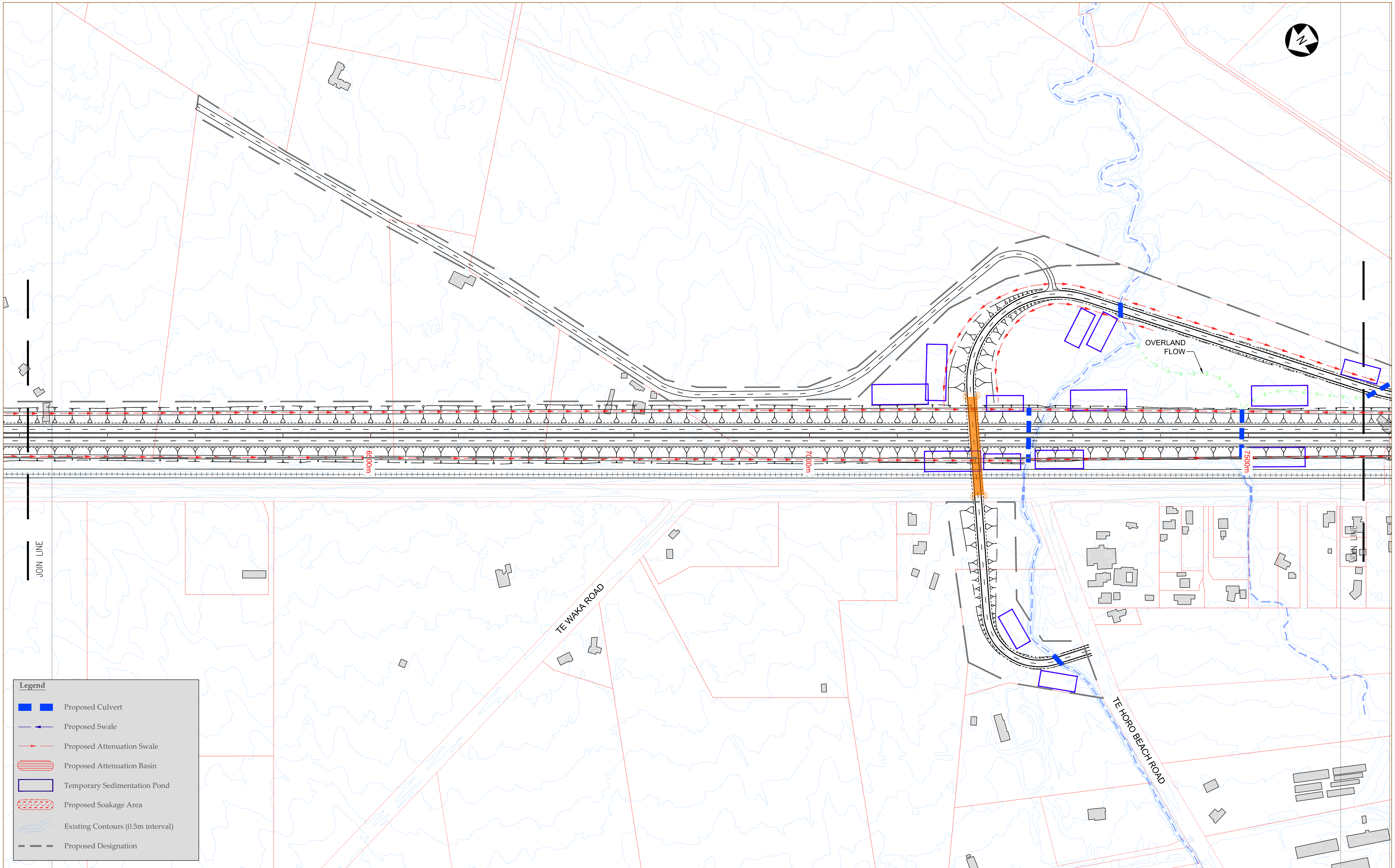

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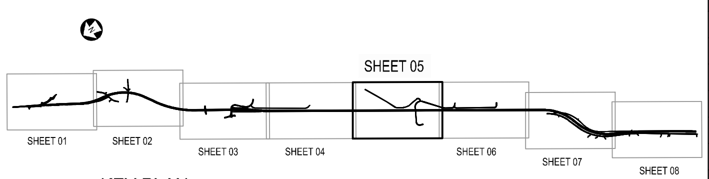

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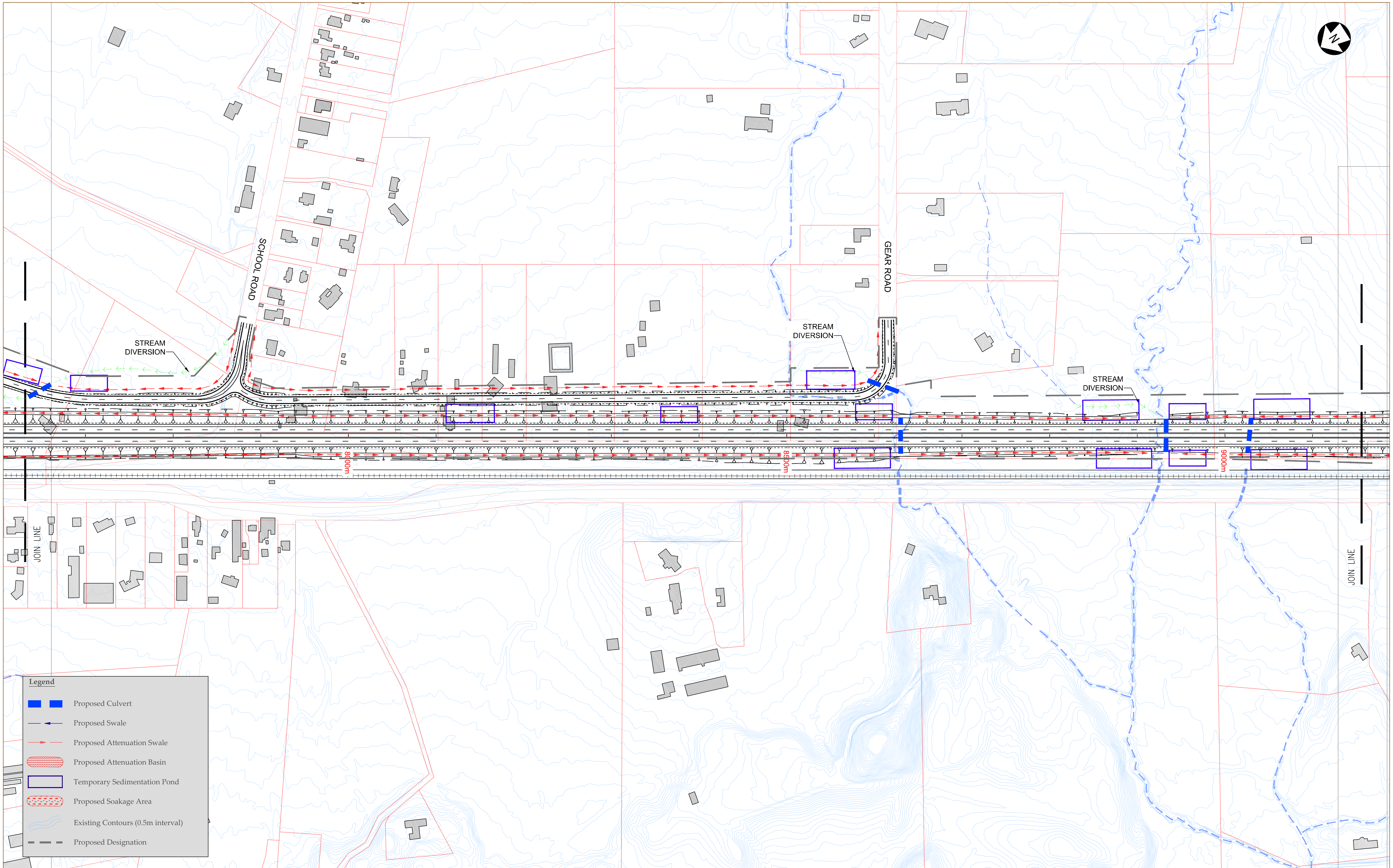

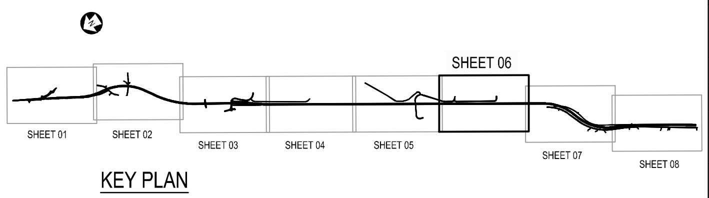

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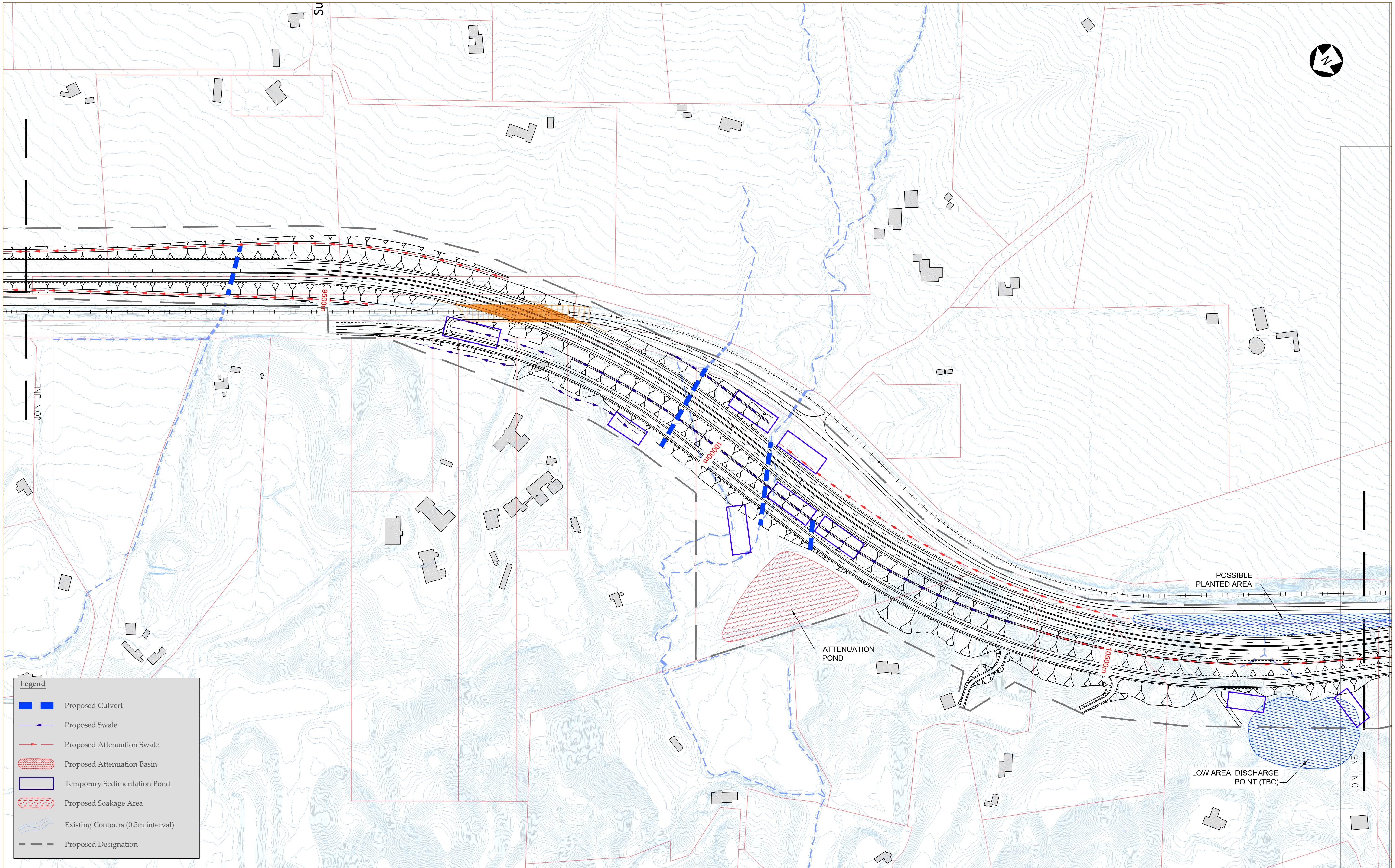

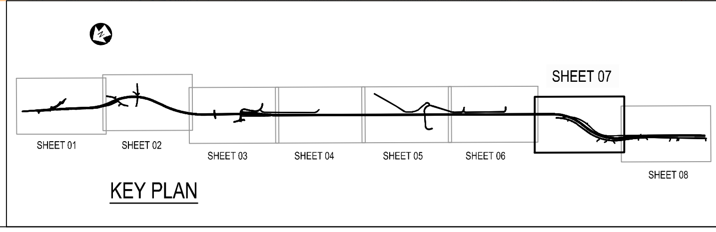

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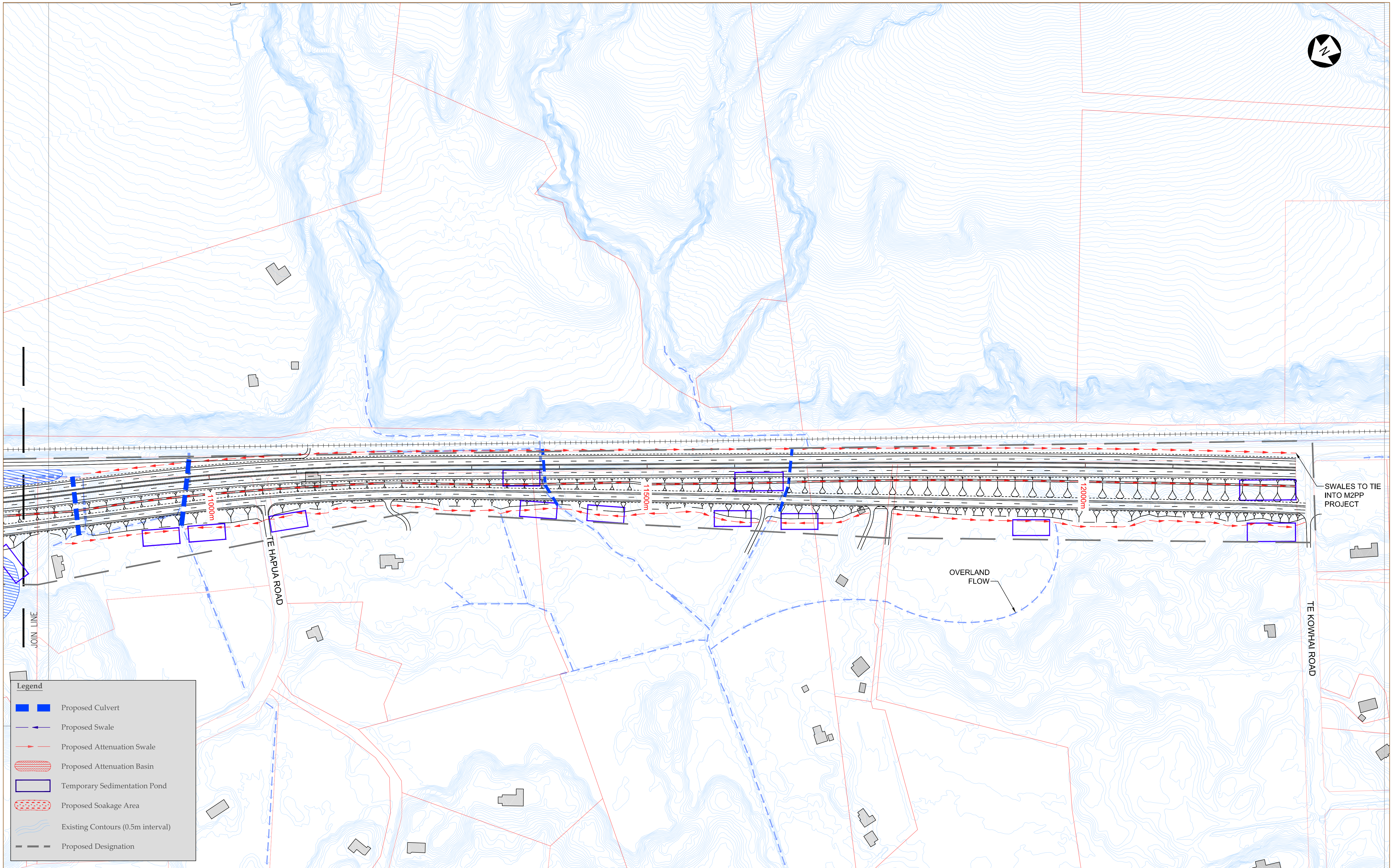

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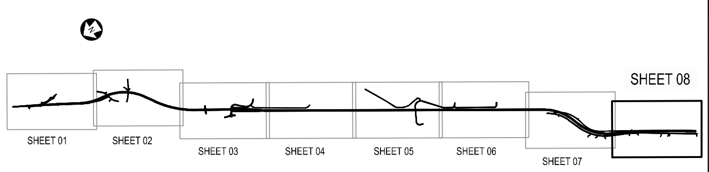

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Appendix 6 – Preliminary sizing calculations for stormwater device

Attenuation Swale Calculation - for use at Prelininary design

after fun off co-efficient); and how much water is stored between bunds in the swale. Initially the bund spacing is determined by the grade of the swale, but the user can "Override" the bund spacing in a cell further down. - Developed by R Coles

Other assumptions: trapizodal and constant swale section; Constand swale grade;

Cells to impute values to are in orange

Cells that have formulas in are in gray

Items in red are item you probably want to change often

			working example	
			inputs/calcs	Notes
Consider Volume runoff Change per meter of road (over 24 hours) - (very rough estimation of volume needed - consider 100% capture)				
Q100 24 hour rainfall depth	Rd	m	0.16	From SKM/KCDC 2090 Q100 rainfall depth
Road width	Rw	m	30	
Runoff C before (be conservative - say "0")	Cb		0	
Runoff C after (be conservative - say "1")	Ca		1	
Volume runoff Change per meter of road (over 24 hours)	Vro	m3/m	**4.8**	
Consider Volume stored behind each bund - approximate (does not allow for volume above bund toe or volume removed due to foliage)				
Swale Side slope	Ss	H : 1V	3	
Swale Base width	Sbw	m	4	
Swale Bund height (or water depth)	Bh	m	1.1	
Grade of swale	Sg	m/m	0.01	1.000%
Storage Length (internal space between bunds)	Sl	m	**110**	
volume stored behind each bund (For explanation of formula, see Storage volume tab)	Vstored	m3	**375.1**	
Consider bund dimensions				
Bund end slopes (longitudinal)	Bs	H : 1V	3	
Bund top length (longitudinal)	Btl	m	0.5	
Bund height (as above)	Bh	m	**1.1**	
bund base length (longitudinal)	Bbl	m	**7.1**	
Bund centre line spacing (longitudinal)	Bcl	m	**117.1**	
Consider moving bunds closer together				
Override Bund centre line spacing	Boverride	m	58.55	53%
Override Swale Side slope (as above)		H : 1V	**3**	
Override Swale base width (as above)		m	**4**	
Override Storage height "removed"		m	**0.5855**	
Override Storage length removed		m	**58.55**	
Override Storage volume removed		m3	**88.63**	
Override storage volume remaining		m3	**286.47**	
Consider if there is enough volume stored: does (bund spacing) x (change in runoff per meter of road) = (volume stored behind each bund)?				
Volume runoff Change between bunds (over 24 hours) (based on 'Override" bund centre line spacing)	Needed	m3	**281.04**	
is V stored greater than Needed			**YES**	
How much extra storage volume do we have?		m3	**5.43**	
Consider Flow over bund - assuming Broad Crested Weir, rectangle seciton, aproach velocity is Zero, see (http://www.jfccivilengineer.com/broad_crested_weir.htm)	$Q = 1.705 \times b \times (H_1 + \frac{V_1^2}{2g})^{\frac{3}{2}}$			
What % of stored volume is assumed will pass over weir in 3 hours?		%	100%	
Flow rate (this needs some more thought!)	FlowR	m3/s	**0.02602**	
top width of bund	Tbw	m	**10.600**	
Hight of water above weir crest (upstream of weir) - (assumeing V tends to 0)	Wfh	m	**0.01275**	
Consider Swale depth - (there needs to be some depth for flow over bund, and some freeboard)				
Swale Bund height (or water depth)	Bh	m	**1.1**	
Weir flow height (as above)	Wfh	m	**0.10000**	using min 100mm
Free board (be generous)	Fb	m	0.3	
Swale depth	Sd	m	**1.500000**	
Swale nomimal top width		m	**13**	

Perameters	Strate (both sides)	Strate (both sides)	Strate (both sides)	Strate (both sides)	Strate (both sides)	Strate (both sides)	Strate (both sides)	Strate (both sides)
Longitudanal Grade	0.20%	0.50%	0.75%	1.00%	1.20%	1.50%	1.75%	2.00%
pavement width	15	15	15	15	15	15	15	15
Bund hight (m)	0.65	0.65	0.65	0.65	0.7	0.7	0.7	0.75
Bund Spacing (m)	164.7	67.2	45.5	34.7	31.5	25.7	22.4	21.3
side slope ?h:1v	3	3	3	3	3	3	3	3
Bace width (m)	4	4	4	4	4	4	4	4
overall depth (m)	1.05	1.05	1.05	1.05	1.1	1.1	1.1	1.15
		12.4						

Perameters	Super (one side)	Super (one side)	Super (one side)	Super (one side)	Super (one side)	Super (one side)	Super (one side)	Super (one side)
Longitudanal Grade	0.20%	0.50%	0.75%	1.00%	1.20%	1.50%	1.75%	2.00%
pavement width	30	30	30	30	30	30	30	30
Bund hight (m)	1.05	1.05	1.1	1.1	1.15	1.15	1.15	1.2
Bund Spacing (m)	265.9	108.4	76.9	58.6	51.6	42.0	36.6	33.9
side slope ?h:1v	3	3	3	3	3	3	3	3
Bace width (m)	4	4	4	4	4	4	4	4
overall depth (m)	1.45	1.45	1.5	1.5	1.55	1.55	1.55	1.6

Perameters	Super and one rail	Super and one rail	Super and one rail	Super and one rail	Super and one rail	Super and one rail	Super and one rail	Super and one rail
Longitudanal Grade	0.20%	0.50%	0.75%	1.00%	1.20%	1.50%	1.75%	2.00%
pavement width	35	35	35	35	35	35	35	35
Bund hight (m)	1.15	1.2	1.2	1.25	1.25	1.3	1.3	1.3
Bund Spacing (m)	291.2	123.9	83.9	66.5	56.1	47.5	41.3	36.7
side slope ?h:1v	3	3	3	3	3	3	3	3
Bace width (m)	4	4	4	4	4	4	4	4
overall depth (m)	1.55	1.6	1.6	1.65	1.65	1.7	1.7	1.7

Pond footprint and volume calculation - for use at Prelininary design stage.

This calculation considers: how much water is needed to be stored (by input of before and after fun off co-efficient); how much land is needed for cuts and bund to contain water (partly govened by the general grade of the land); and an alowance for an acces track - Developed by R Coles

Other assumptions: Excavation volume is aproximat only: foot print will be the same for pond cut or with bunds (foot print based on pond with bunds)

Cells to impute values to are in orange

Cells that have formulas in are in gray

			Merry hill south - 380 of supper at 30m (or 760m or 15m), 300+160m of 15m wide	
			inputs/calcs	Notes
Consider Volume runoff stored in pond (over 24 hours) - (estimation of volume needed - consider 100% capture)				
Q100 24 hour rainfall depth	Rd	m	0.16	From SKM/KCDC 2090 Q100 rainfall depth
Road width	Rw	m	15	
Runoff C before (be conservative - say "0")	Cb		0	
Runoff C after (be conservative - say "1")	Ca		1	
Volume runoff Change per meter of road (over 24 hours)	Vro	m3/m	2.4	
Length of road we are considering	Lr	m	1220	
Volume of runoff stored	Vs	m3	2928	
Consider water surface of pond				
Level of inlet (consider level of invert of swale or pipe work)	Ii	m	1	assumed
Level of outlet (consider level of stream discharging to)	Io	m	0	assumed
depth of storage	Wd	m	1	
Nominal water surface area (assuming vertical sides)		m	2928	
Pond aspect ratio (assuming rectangular pond)	Ar	L : 1W	2	
Nominal length of the short side of the water surface		m	38	
Pond batters		H : 1V	3	
Length of the short side of the water surface		m	41	
Water surface area	WsA	m2	3405	
Water surface circumference	WsC	m	248	
Consider bund - if bunded				
Bund batters (probably the same as the pond batters above)		m	3	
Bund top width		m	2	
Free board		m	0.3	
Bund lenth as persentage of Water surface circumference (assumed 2 short sides and one long side)		decimal	0.7	
bund hight (assuming land is flat)		m	1.3	
Bund bace width (assuming land is flat)		m	9.8	
land grade		decimal	0.01	
Additional bund hight due to land grade		m	0.1	
Total bund hight		m	1.4	
Total bund base width		m	10.4	
Bund foot print		m2	1714.5	
bund cross-section area		m2	8.7	
Bund Volume		m3	1429	
Consider cut - if in cut				
internal top width of pond (at top of free board)		m	43	
excavatoin hight above low side of pond		m	0.4	
excavation volume above low side of pond (extimation)		m3	1597	
Excavation volume for free board		m3	1113	
Excavation volume for water		m3	2928	
Total excavation volume		m3	5638	
Consider access track				
access track width		m	3	
Access track length as persentage of Water surface circumference		decimal	1	
Access track foot print		m2	743	say 3m by 1400m
Summary				
Water surface area		m2	3405	say 100m by 100m
Bund food print		m2	1715	would be as excavating but areas still needed
Estimated total pond foot print		m2	5862	say 120m by 120m
Estimated bund volume (If pond is bunded)		m3	1429	3600
Estimated excavation volume (If pond in cut)		m3	5638	

Summary	Water surface area	Estimated total pond foot print
	m2	m2
Merry hill south - 380 of supper at 30m (or 760m or 15m), 300+160m of 15m wide	3400	5900
Mangaone south - 2050m of road at 15m wide	3500	5600
Mangaone north 2050m of road at 15m wide	5400	8700
Mangpouri pond area A - 200m of supper at 30m (or 400 at 15m), and 240m of road at 15m,	2700	4700

Appendix 7 – Preliminary sizing calculations for culverts (for minor waterways)

This is a first rough cut at sizing culverts, including assumptoin for fish pass alowance.
The need for fish passage needs to be assessed on a case by case basis. At this stage desktop assumptions have been made.

Catchmet name	waterway crossing location	Culvert hydrolic size	fish pass required and alowance	First cut Culvert size	Comment
Greenwood	Ch 0+394	twin 900mm dia. (extension)	Assumed needed - retro fit fish pass through one culvert.	Existing size = twin 1000mmdia.	see coments in table below and - risk that we will need to upgrade all of the cuvlert, with a box culvert? 4m wide and 2m high?
Waitohu overland flow	Ch 0+825	By DHI modeling	Assumed NOT needed	-	see coments in table below
Waitohu	Ch 0+825	By DHI modeling	Assumed needed	-	see coments in table below
Waitohu Tribuitory	Ch 0+925	By DHI modeling	Assumed needed	-	see coments in table below
Te Manuoa	± Ch1+650	1600mm dia.	Assumed NOT needed as leads to retic	1600mm dia.	see coments in table below
Mangapouri	Ch1+940	By DHI modeling	Assumed needed	-	see coments in table below
Racecourse	Ch 2+195	1.2m x 1.2m	Assumed needed	1350mm dia.	see coments in table below
Te Roto	Ch 2+620	750mm dia.	Assumed NOT needed	750mm dia.	see coments in table below
Andrews 1	Ch 2+880	750mm dia.	Assumed NOT needed	750mm dia.	see coments in table below
Andrews 2	Ch 3+020	750mm dia.	Assumed NOT needed	750mm dia.	see coments in table below
Otaki	Ch 6+600	By DHI modeling	Assumed needed	-	see coments in table below
Mangaone	Ch 7+250 & 7+430	By DHI modeling	Assumed needed	-	see coments in table below
School	Ch 7+550	1350mm dia.	Assumed needed	1600mm dia.	see coments in table below
Gear	Ch 8+610	3m x 2.1m	Assumed needed	3m x 2.5m or 3000mm dia	see coments in table below
Settlement Heights	Ch 8+910	4m x 2.7m	Assumed needed	4m x 3.0m	see coments in table below
Coolen	Ch 8+980	1200mm dia.	Assumed needed	1350mm dia.	see coments in table below
Avatar	Ch 9+370	2100mm dia.	Assumed needed	2700mm dia.	see coments in table below
Jewell a	Ch 10+020	1200mm dia.	Assumed needed	1350mm dia.	see coments in table below
Jewell main	Ch 10+020	4m by 2.8m	Assumed needed	4m by 3m	see coments in table below
Cavallo	Ch 10+590	-	-	-	see coments in table below
Cording A	Ch 10+930	1800mm dia.	Assumed needed	2400mm dia.	see coments in table below
Cording B	Ch 10+930	600mm dia.	Assumed needed	675mm dia.	see coments in table below
Awatea	Ch 11+335	3m by 2.6m	Assumed needed	3m by 3m	see coments in table below
Kumototo	Ch 11+630	3m by 2.1m	Assumed needed	3m by 2.5m	see coments in table below

This is a first rough cut at sizing culverts.
Warning – these culvert sizes are indicative only. They are assessed at an early stage of the project when the downstream conditions are unknown (location uncertainty and insufficient site data or tail water controls) for the purposes of setting minimum road levels. Nor do they include an allowance for fish passage. For the purposes of rough order of cost assessment, add 40% to diameter or 500mm to box hight.

1) no alowance for fish pass at this stage (not revevent as Soffit does not need to move)
2) assuming twin cuvlerts not allowed as in KCDC
3) Assuming max pipe size 2.1m dia. (not true but longer lead in times)
4) arch, cuvlert, box sizes all rounded up to nearest real size
5) sizes/hights include an nominal alowance for them being outlet controled (as Lidar info not avaliable to assess this at this time)

Catchmet name	waterway crossing location	Circular culvert soffet level above stream bed	Arch culvert soffet level above stream bed	Box cuvlert (3m wide) soffet level above stream bed	Box cuvlert (4m wide) soffet level above stream bed	Comments
Greenwood	Ch 0+394	2.70	2.30	2.2	1.75	Existing size = twin 1000mmdia. Avoid works in stream (no culvert extension as part of these works) other wise we are likely to be pushed into a full upgrade. A**llow for the existing to be extended.**
Waitohu overland flow	Ch 0+825	-	-	-	-	By DHI modeling
Waitohu	Ch 0+825	-	-	-	-	By DHI modeling
Waitohu Tribuitory	Ch 0+925	-	-	-	-	By DHI modeling
Te Manuoa	± Ch1+650	2.10	1.75	1.3	-	Connected to retic 450mmdia. Lifting road to need to alow of overland flow. Overland flow goes over road at several places. infomation from SKM shows overland flows of 1.3m3 at this location. **Sugest pipe under road is 1500mmdia. at this stage**. tail water conditions will depend on detail design.
Mangapouri	Ch1+940	-	-	-	-	By DHI modeling
Racecourse	Ch 2+195	1.60	1.40	-	-	Esisting culvert posiably a constricion. Max size of culvert to be 1.2m x 1.2m. Or equvelent. **Allow box culvert 1.2m x 1.2m.** (but will consider changing to a circular culvert)
Te Roto	Ch 2+620	1.20	0.97	-	-	If road is to be used as stopbank then no culvert in this section. If not then provide **3No 750mmdia. Culverts.** Ground is flat along the road in this area with no defined channals however there is some overland flow that colects and soaks away in this area.
Andrews 1	Ch 2+880	0.45	-	-	-	
Andrews 2	Ch 3+020	0.30	-	-	-	
Otaki	Ch 6+600	-	-	-	-	By DHI modeling
Mangaone	Ch 7+250 & 7+430	-	-	-	-	By DHI modeling
School	Ch 7+550	-	-	-	-	Allow a extra culvert here: say 1200mmdia. under local road
Gear	Ch 8+610	2.70	2.30	2.1	1.65	down stream culvert sizes/level unknown **Say a 3m wide by 2.1m**
Settlement Heights	Ch 8+910	3.60	3.07	3.3	2.70	down stream culvert sizes/level unknown. **Say 4m wide by 2.7m high box culvert**
Coolen	Ch 8+980	1.20	0.82	-	-	Alow 1200mm dia.
Avatar	Ch 9+370	2.00	1.88	1.4	-	Alow **2100mm dia**. (posiably too big - need to check catchment
Jewell a	Ch 10+020	-	-	-	-	Provisionaly **1200mm dia.**
Jewell main	Ch 10+020	3.60	3.07	3.4	2.80	Allow **4m wide by 2.8m high box**
Cavallo	Ch 10+590	1.60	1.26	-	-	drain to cording A culvert
Cording A	Ch 10+930	1.60	1.12	-	-	allow 1800mm dia. (catchment to be re-done)
Cording B	Ch 10+930	-	-	-	-	allow 600mm dia. (catchment to be re-done)
Awatea	Ch 11+335	3.00	2.69	2.6	2.05	allow **3m wide by 2.6 box** (might be able to go to round culvert
Kumototo	Ch 11+630	2.70	2.30	2.1	1.70	allow **3m wide by 2.1 box** (might be able to go to round culvert

Table of inlet controle nomograph inputs and out puts (for initial inlet controled hydrolic sizing)

Catchmet name	waterway crossing location	Q100 Peak flow (m3/s)*	HW/D (Head water depth/hight of culvert)	output Size from Inlet controled nomograph circular dia. (m)	output Size from Inlet controled nomograph arch hight (m)	Esimation of down stream chanel grade from KCDC GIS info and comments
Greenwood	Ch 0+394	12.9	1.0	2.55	2.3 (rounded)	1% down stream grade, might be inlet controled if lucky but stream very winding which sugests it is flat, thus outlet controled. (need to increce by one culvert size as flat)
Waitohu overland flow	Ch 0+825	-	-	-	-	By DHI modeling
Waitohu	Ch 0+825	Bridge	-	-	-	By DHI modeling
Waitohu Tribuitory	Ch 0+925	-	-	-	-	By DHI modeling
Te Manuoa	± Ch1+650	5.7	1.0	1.85	1.75 (rounded)	Piped system but also need to size a culvert for the overladn flows which (presumaly) goes over the SH1 at the momnet
Mangapouri	Ch1+940	13.7	1.0	2.60	1.3 (limit)	By DHI modeling
Racecourse	Ch 2+195	3.2	1.0	1.45	1.4 (rounded)	atchment area is under dispute. Also cuvlert posiably used as a constricion.
Te Roto	Ch 2+620	1.1	1.0	0.95	0.97 (rounded)	Flat and also, waterlevel down stream is probably controled by a culvert under the rail (size unknown). Defently outlet controled. (need to increce culvert size as flat)
Andrews 1	Ch 2+880	0.4	1.0	0.40	-	insignificant - posiably not needed, depending on flood bunds.
Andrews 2	Ch 3+020	0.2	1.0	0.30	-	
Otaki	Ch 6+600	Bridge	-	-	-	Grant doing
Mangaone	Ch 7+250 &	Bridge	-	-	-	Grant doing
Gear	Ch 8+610	12.3	1.0	2.50	2.3 (rounded)	HS1 and rail cuvlerts just down stream, need to assess them to know back water effects. (need survay) (need to increce culvert size as flat)
Settlement Heights	Ch 8+910	24.6	1.0	3.30	3.07 (rounded)	HS1 and rail cuvlerts just down stream, need to assess them to know back water effects. (need survay) (need to increce culvert
Coolen	Ch 8+980	1.1	1.0	0.95	0.82 (limit)	HS1 and rail cuvlerts just down stream, need to assess them to know back water effects. (need survay) (need to increce culvert
Avatar	Ch 9+370	6.9	1.0	2.00	1.88 (rounded)	2% down stream grade - probably inlet controled
Jewell	Ch 10+020	25.5	1.0	3.40	3.07 (rounded)	2% down stream grade - probably inlet controled
Cavallo	Ch 10+590	1.2	1.0	1.35	1.26 (rounded)	New road changing the down stream circumstances, flat. Assume outlet controled. - could be 2 culvert locations here (need to increce culvert size as flat)
Cording	Ch 10+930	1.7	1.0	1.15	1.12 (rounded)	D/S grade 1 in 500 so outlet contoled. Also could be 2 culvert locations here (need to increce culvert size as flat x2)
Awatea	Ch 11+335	16.7	1.0	2.80	2.69 (rounded)	D/s grade 1in 100 might be inlet controled if lucky
Kumototo	Ch 11+630	12.5	1.0	2.50	2.3 (rounded)	D/s grade 1in 150 might be inlet controled if lucky

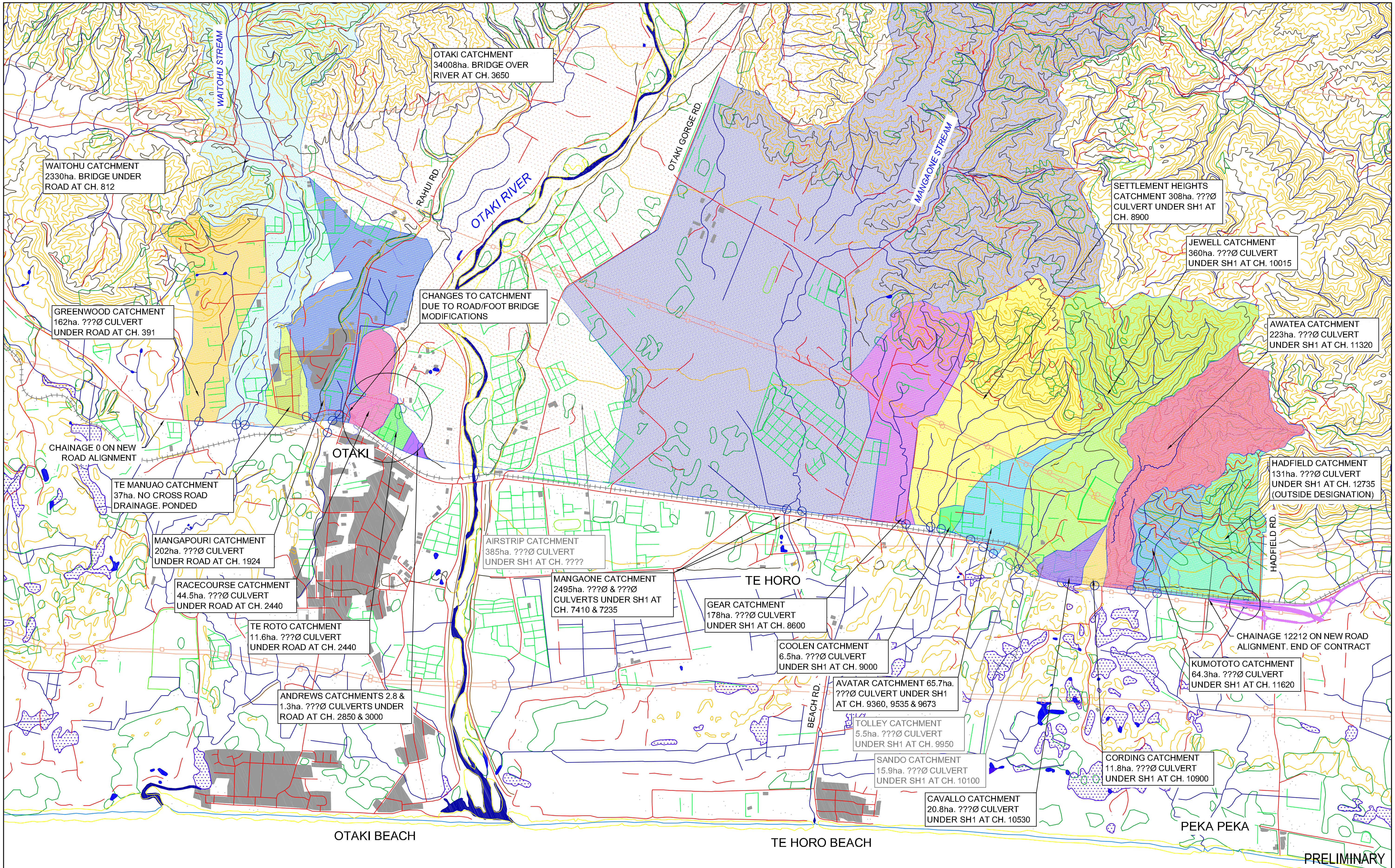
* Flows include Climit change to 2090

This is s summary of the outputs from HEC-HMS following the SCS method for flow assessment, as detailed in SKM's 'Isohyet Based Calculation of Design Peakflows' in appendix 1 of KCDC 's Subdivision and development principles and requirements 2005 (including the August 2008 updated rainfall analysis)

Summary table - Outputs from HEC-HMS for culvert flows, (Climate change inclusive to 2090 using mean MfE guidance)

Catchmet name	Culvert location	Q2 24 hour Rainfall (mm)	Q2 Peak flow (m3/s)	Q10 24 hour Rainfall (mm)	Q10 Peak flow (m3/s)	Q100 24 hour Rainfall (mm)	Q100 Peak flow (m3/s)	From DHI Model - Q100 No CC (or with CC at 16.8%)
Greenwood	Ch 0+394	-	-	125	8.3	175	12.9	-
Waitohu	Ch 0+825	Flows assessed by other means			-	-	-	-
Te Manuoa	± Ch1+650	-	-	125	4.0	175	5.7	-
Mangapouri	Ch1+940	-	-	125	8.9	175	13.7	11.5 (13.4)
Racecourse	Ch 2+195	-	-	125	2.0	175	3.2	-
Te Roto	Ch 2+620	-	-	125	0.7	175	1.1	-
Andrews 1	Ch 2+880	-	-	125	0.3	175	0.4	-
Andrews 2	Ch 3+020	-	-	125	0.1	175	0.2	-
Otaki	Ch 6+600	Flows assessed by other means			-	-	-	-
Mangaone	Ch 7+250 & 7+430	Flows assessed by other means			-	-	-	-
Gear	Ch 8+610	-	-	150	8.6	200	12.3	-
Settlement Heights	Ch 8+910	-	-	150	16.9	200	24.6	-
Coolen	Ch 8+980	-	-	150	0.8	200	1.1	-
Avatar	Ch 9+370	-	-	150	4.8	200	6.9	-
Jewell	Ch 10+020	-	-	150	17.6	200	25.5	-
Cavallo	Ch 10+590	-	-	150	1.8	200	2.6	-
Cording	Ch 10+930	-	-	150	1.2	200	1.7	-
Awatea	Ch 11+335	-	-	150	11.5	200	16.7	-
Kumototo	Ch 11+630	-	-	150	8.7	200	12.5	-
Hadfield*	Ch 12+640	-	-	150	10.0	200	14.5	-

Appendix 8 – Drawing showing local catchments as defined by waterway crossing



Revision	Amendment	Approved	Revision Date

NZ TRANSPORT AGENCY
WAKA KOTAHI

OPUS URS

Project
NEW ZEALAND TRANSPORT AGENCY
PEKA PEKA TO NORTH OTAKI EXPRESSWAY
DETAIL DESIGN

Sheet
Water Engineering
Catchment Area Plan to Proposed Road Alignment

Drawn	Designed	Approved	Revision Date
G.D.	R.C.	T. Coulman	Mar. 2011

Project No.	Scale	Drawing No.	Sheet No.	Revision
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Original Sheet Size A1 [841x594] Plot Date 23/03/11 @ 08:34 p:\projects\5-c1814.00 peka peka to north otaki 440pn\800 drawings\810 cad\stormwater (.32) concept plans\design updates march2011\5_2664_1_5504_301 rev1.dwg