Chapter 18

Part G

VOLUME 2

Stormwater

Overview

Construction of the Project involves approximately 800,000m^3 of cut-to-fill and 45,000m^3 of imported fill across four construction sections. During earthwork activities, soil particles become detached from the ground surface making them easier to transport via stormwater to the downstream receiving environment. During construction of the Project, best practice Erosion and Sediment Control measures and principles, outlined in the GWRC and NZTA draft standard, will be adopted to minimise sediment yields and achieve compliance with effective measurable standards enshrined in conditions. These measures are outlined in the draft ESCP included in Volume 4 of the AEE.

The potential operational stormwater-related effects arising from the Project include increased run-off containing contaminants and effects arising from the disruption to small and medium-sized waterways from new culverts, bridges and crossings.

Potential stormwater effects of the Project have been identified through assessment and consultation. Site conditions and constraints have been identified and considered through site visits, geo-technical investigations, hydrological assessments, and topographical assessments. The potential stormwater effects of the Project have largely been mitigated through careful design.

Through the use of treatment and/or attenuation swales and attenuation basins, the potential effects of run-off will be appropriately mitigated to achieve appropriate measurable standards. This is in compliance with industry best practice. The Project will have a net positive effect on contaminant levels entering the environment, due to the transfer of most traffic from the existing SH1, which has no formal stormwater treatment, to the Expressway, which will treat all run-off.

The culverts proposed as part of the Project have been designed using methods developed and accepted by GWRC and NZTA. Culverts have been designed so that they have minimal impact on flood levels (both upstream and downstream) and allow for fish passage, where applicable.

The residual stormwater effects of the Expressway, after application of the mitigation measures described, will be less than minor. The sole exception to this relates to increased flood risk to a farm storage building at Gear Road, for which the residual effects are likely to be minor-moderate. This matter is proposed to be resolved through direct negotiation with the property owner.

18 Stormwater

18.1 Introduction

Stormwater is water that originates during rain and storm events and runs off impervious surfaces such as roads, drives, footpaths and rooftops. Stormwater either flows directly into surface waterways or is channelled into stormwater drains that then discharge into surface water or to ground.

This Chapter describes and summarises the actual and potential effects of stormwater arising from the construction and the operation of the Project, and the actions that are proposed to be taken to mitigate these effects.

The potential effects of erosion and transportation of sediment from areas disturbed by earthworks can have a significant adverse effect on downstream receiving environments. Adverse effects arising from the Project will be mitigated by applying best practice erosion and sediment control principles and practices.

The possible stormwater-related environmental effects of building a new road, re-aligned railway, and connecting roads can be considered in three groups:

- The first group includes effects arising during the course of construction activities.
- The second group are associated with the impermeable nature of the road pavement and the pollutants that are generated on it.
- The final group of effects are due to the road/railway crossings of waterways, which can disrupt natural flow patterns and habitat.

The potential for flood effects in the major waterways that the Expressway crosses is described in Chapter 17 (Hydrology) of this AEE report.

The information contained in this Chapter is based on the following Technical Reports:

- Peka Peka to Ōtaki Expressway: Assessment of Stormwater Effects, Technical Report 10.

Other, related reports are:

- Peka Peka to Ōtaki Expressway: Geotechnical Report, Technical Report 4;
- Peka Peka to Ōtaki Expressway: Construction Methodology Report, Technical Report 5;
- Peka Peka to Ōtaki Expressway: Assessment of Hydrology Effects, Technical Report 9;
- Peka Peka to Ōtaki Expressway: Aquatic Ecology Assessment, Technical Report 12; and
- Draft Erosion and Sediment Control Plan.

These reports are included in Volume 3 of this AEE report and the Draft Erosion and Sediment Control Plan is included in Volume 4.

18.2 Existing Environment

The existing environment as it relates to stormwater is as set out in Chapter 17, in relation to Hydrology effects of the Project.

18.3 Stormwater Design

The stormwater design for the Project was developed through consideration of key design documents (detailed in Technical Report 10 – Volume 3) and in consultation with KCDC and GWRC to develop an appropriate design philosophy, and stormwater standards. A set of proposed levels of service for the Project were agreed with KCDC and GWRC.

18.4 Construction Related Effects

During construction large areas of earth will be exposed as part of earthworks activities. This raises the potential for erosion of bare soil and contamination of water bodies with sediment. This is a particular risk during the course of bridge/culvert construction, stream diversions, and any other work in close proximity to streams. Similarly dust can be mobilised by earthworks and spread by wind where it creates both human nuisance and potential environmental effects.

If best practice erosion and sediment controls (E&SCs) are not established to mitigate the increase in sediment runoff, a range of adverse environmental effects may occur to the downstream receiving environment, such as smothering of aquatic life by build-up of sediment in the stream bed, increased turbidity, accumulation of contaminants transported by sediments and effects on consumable water for irrigation and stock (e.g. clogging of pumps).

The implementation of the ESCP will limit the effects of erosion and suspended solids on the downstream receiving environment.

Four key principles have been adopted in relation to the provision of E&SCs during the construction of the Project. These are:

- Minimise disturbance (both time and extent);
- Protect land surface from erosion;

- Prevent sediment from leaving the construction site; and
- Engage appropriate personnel.

Site-specific environmental factors such as topography, geology, soil composition, particle sizes and permeability have also been considered in the development of the draft ESCP (Volume 4 of this AEE report).

The soil composition throughout the Project length is predominantly composed of sands and gravels and so soil particle sizes are generally large and heavy when compared to that of silt and clay soils. On this basis retention practices such as decanting earth bunds and sediment retention ponds are expected to perform well.

To gain a rough indication of the proposed scale of environmental effects, the estimated sediment yield within each catchment due to construction, calculated using the Universal Soil Loss Equation (USLE), has been compared to the estimated sediment yield from the entire catchment (estimated using Water Resources Explorer New Zealand (WRENZ) model). When the percentage increase of sediment due to construction is assessed against that of the whole catchment, the percentage increase for the three waterways of significance is in the order of:

- 0.2% for the Waitohu catchment;
- 0.003% for the Ōtaki River catchment; and
- 0.1% for the Mangaone catchment.

Based on these findings, and providing that best practice is followed, the short term effects of land disturbance due to construction on the three waterways of significance is expected to be minor.

The USLE evaluation does, however, identify catchments that are much more sensitive to the effects of construction. In such locations particular attention will be required to limit sediment reaching the watercourses. The catchment areas sensitive to the effects of construction are summarised below:

- Te Manuao: Estimated 46% above baseline
- Andrews 1: Estimated 22% above baseline
- Andrews 2: Estimated 37% above baseline
- Cavallo: Estimated 80% above baseline

There are three main cuts on the Project and the Te Manuao and Cavallo catchments are both sensitive to construction because they each contain one of these large cuts. The Andrews catchments are sensitive to the effects of construction because the upstream catchment is very small and the disturbed areas account for 73% of the total catchment.

Of these, the Cavallo catchment in the Mary Crest area has been identified as being the most sensitive area to the effects of construction. For this reason this site has been selected as the subject of one of the SSEMPs (in Volume 4 of the AEE report). The SSEMP documents demonstrate the application of the methodologies and principles outlined in the ESCP, and provide confidence that the works can be constructed to ensure that environmental matters are appropriately managed.

The proposed Expressway will increase the volume of rainwater run-off from the new impervious surfaces. The potential effects, if not mitigated effectively, are an increase in stream erosion due to a permanent small percentage increase in stream flow and increases in downstream flood levels in large rainfall events.

These effects will be mitigated through the design of swales or attenuation ponds which will provide detention of the stormwater where appropriate.

The two locations where attenuation is not currently proposed are on the north and south banks of the Ōtaki River, where the discharge is to ground soakage and direct to the River respectively. The effect is considered to be insignificant as the increase in flow and volume of water to the Ōtaki River is negligible compared to the flow in the river.

18.5 Road Surface Generated Effects

18.5.1 Contaminants from Road Surface

Pollutants generated by vehicles will accumulate on the road surface and then get washed off by rain. With no intervention, the pollutants will be washed into the surrounding environment, which could be the surrounding land but is often streams. The effect of these contaminants on a stream is small but cumulative.

The commonly-accepted mitigation for this is to remove the majority of the contaminants from the rainwater before it discharges to streams or reaches ground water (the receiving environment).

The proposed Expressway increases the area of trafficked surface and will, long-term, convey increased traffic volume. All run-off from the Expressway and new roads will pass through treatment devices that will filter out contaminants. Although swales meeting the NZTA design standards should remove 70 to 80% of suspended solids and a proportion of other associated contaminants on a long term average basis, they are not able to remove 100% of the contaminants. Nonetheless, swales are considered the best practicable option (BPO) for mitigation.

The BPO E&SCs will be implemented, maintained and monitored throughout the Project. Site soil conditions suggest that best practical option for mitigation ESC practices are likely to be highly effective, however (as normally occurs on any earthworks site) there will still be some small residual release of sediment. This residual effect is likely to be less than minor, but will be further assured by consent conditions requiring device inspection and ecological monitoring.

There is currently no formal treatment of run-off from the existing SH1 over the Project length. As the Project will transfer the majority of traffic from the existing SH1 to the proposed Expressway, where all of the run-off is treated, the overall levels of contaminants discharged to the receiving environment from the two roads combined is expected to reduce.

It is therefore considered likely that the Project will have a net positive effect on the environment, in terms of contaminants from vehicles entering the environment, although this is difficult to quantify with any certainty.

18.5.2 Increased Road Surface Runoff During Rainfall Events

On a green-field development (as the Project is) the existing ground is often pasture. When it rains, some of the water soaks into the ground and some is lost through evapotranspiration (by plants), leaving only a portion to run off the land into streams. The natural form of the stream reflects the amount of runoff from the land that naturally occurs.

When a road is built, the rain that falls on the pavement is unable to soak into the ground or be lost through evapotranspiration and virtually all the rain turns into runoff. This means that more water reaches the streams that the road crosses, often faster as a result of efficient drainage systems. This in turn increases stream erosion and changes the stream characteristics.

The effects of this are small but incremental. If the total catchment of a stream has less than 3% impervious surface then the stream is likely to be able to absorb the increase in flow without significant negative effects. However once this 3% threshold is exceeded, mitigation is required.

The usual mitigation for this is to provide storage areas that, during small rainfall events, can hold back water and release it slowly once the rain has passed.

In large storm events there is likely to be flooding in the natural system. The increased road runoff is likely to make this flooding worse (i.e. increased downstream flood levels), depending on timing effects.

Once again the effects of this are small but incremental. The usual mitigation for this is to provide storage areas that, during large storm events, can hold back water and release it slowly once the peak of the storm has passed.

18.6 Effects Associated with Waterway Crossings

18.6.1 **Increases in Upstream Culvert Ponding Levels (at Stream Crossings)**

The Project has more than 25 crossing points over waterways ranging in size from the Ōtaki River to minor land drains.

When a road crosses a drain, stream or river the waterway can be diverted, culverted, or bridged. When the waterway is bridged there is relatively little stormwater environmental effect (assuming the bridge is sufficiently wide and the bed is not unduly disturbed during construction). Diverting a waterway is typically only done to low ecological value land drains or where the alignment unavoidably runs near / parallel with a watercourse (which is not the case for the Project except over short lengths). The most common way for a road to cross a waterway is to culvert the stream.

A feature of culverts is that there needs to be a difference in water level between the upstream end and the downstream end for any water to flow through them. In large storm events this means that the level of the water in the stream has to build up to push water through the culvert. This increase in water level (and wetted area) can cause a negative effect on the adjacent upstream land or buildings. Ideally the culvert should be sized so that the increase in upstream water level will be kept within the road designation or within the natural banks of the stream. Sometimes this is not practicable and the increased water level is allowed to spread to rural land if the effect is deemed sufficiently minor.

18.6.2 **Removal of Existing Constrictions (at Stream Crossings)**

Existing roads and railways have existing culverts. When these roads are upgraded the culverts are often upgraded also. Typically the new culverts are bigger than the existing culverts (as levels of service rise and climate change is considered). This can mean that during large storm events water that was held back by the previously small culvert (acting as a constriction) is not held back by the new larger culvert.

This can mean that the peak flow in the waterway downstream of the upgraded culvert can be higher than it was previously. Depending on the magnitude of water that was previously impounded and the scale of the increase in peak flow, this can make existing downstream flooding worse.

One potential mitigation option is to keep the existing constriction in place. Alternatively, minor increases in flow may be tolerated if they are considered to have a minor effect.

Constrictions have been kept in place around the Ōtaki township, but not at the southern end of the Project area.

18.6.3 **Creating Barriers to Fish Migration (at Stream Crossings)**

If culverts are designed and constructed only considering the flood flow hydraulics, then barriers to fish passage can be inadvertently created. The potential effect of this is that fish will be cut off from their habitat, which leads to a decline in fish numbers.

The appropriate mitigation for this is to consider low flows and design the culvert such that native fish are able to swim into and through the culvert.

For all culverts, these effects have been fully mitigated by design. These culverts will feature rocky substrates in the culvert inverts, rock ramps or inverts depressed below stream bed levels so that native fish are able to swim into and through them.

18.6.4 **Reduction of Existing Flood Storage (at Stream Crossings)**

Where new roads (particularly roads on embankments) are built through existing flood areas, the embankment takes up volume that would previously be available for ponding of flood water. The effect is that the flood levels rise slightly. The amount the flood level rises by depends on the extent of the flood area and the volume that the road takes up below the water level. Generally speaking, the larger the flood area the smaller the effect.

One mitigation option is to excavate additional land within the flood area to offset the flood volume removed by the new road. Alternatively the effect on flood level may be shown to be insignificant by analysis (e.g. hydraulic modelling).

18.6.5 **Summary of Effects Associated with Waterway Crossings**

In summary the potential effects associated with waterway crossings are:

- Changes to the upstream flood levels outside of the designation;
- Changes to the peak flow that is discharged downstream;
- Changes in the waterway affecting the ability of fish to migrate; and
- Changes to overland flow paths in extreme events.

The 1% AEP (2090) flood flows (which include anticipated climate change effects) were established for all the small to medium-sized waterways, in accordance with KCDC requirements. Once characterised, the hydraulics of the existing situation were established using modelling software, and this data was used as constraints when modelling the future situation, to identify any upstream or downstream effects. Extreme 'super design' event flows (1.5 times the 1% AEP (2090) flood flow) were also modelled, to assess whether the road overtops and determine where the secondary overflow path would be. Provision for fish passage has been made at streams where there is a defined channel and a tributary network (consistent with the guidance in Technical Report 12 (Aquatic Ecology Assessment)). This has been achieved by embedding the culvert inverts below the stream bed level (to ensure the culvert contains water even at low flows) and providing for rock ramps or rocky substrate to be placed in the base of the culvert.

Detailed and summary schedules of culvert design (for a total of 34 culverts, including some associated with the major waterways) are contained in Technical Report 10, section 7.2.1. In the majority of cases, potentially adverse effects have been eliminated through culvert design. The following have merited special consideration:

- Gear and Settlement Heights Culverts (near Gear Road, approximately two kilometres south of Mangaone Stream). The Gear and Settlement Heights streams are within 300m of each other and, in flood conditions, create a shared pond inland of the NIMT embankment. The proposed Expressway embankment goes through this ponded area, and will result in a 300mm increase in the 1% AEP (2090) headwater pond level. This is potentially significant for a farm building that is already in this flood zone, which will be subject to a greater depth and frequency of flooding. The effects on this farm storage building will be resolved through negotiations with the land-owner and may include raising or relocation of the building, bunding or compensation. If agreement cannot be reached the effect of the Expressway on this property is considered minor-moderate.

- Jewell and Cavallo Culverts (close to and south of Mary Crest). The Jewell culvert is significant as it will be downstream of existing SH1 and NIMT culverts. The proposed culvert needs to have sufficient capacity so as not to affect the flows through the existing upstream culverts (which could cause an increase in flood level). This has been achieved by limiting the water level on the upstream side of the culvert by design. In a super design event (1.5 times the 1% AEP (2090) flood flow) the height of the water will increase, encroaching onto the shoulder and first lane of the Expressway, as it flows overland into the adjacent Cavallo catchment. The flow rate is expected to be in the order of 1 to 4 m^3/s and last only in the order of 15-30 minutes.
- Kumutoto Culvert (at chainage 11600m). This culvert will replace an existing culvert under SH1. The culvert is being made larger, which will result in a reduction in the upstream flood level (of approximately 1m) and increased flows downstream (in the order of half a percent during the early part of a flood event.

18.7 Attenuation of Road Run-Off

The proposed Expressway will replace existing pervious surfaces. During rainfall events, the rain that falls on the pavement is unable to soak into the ground or be lost through evapotranspiration from plants, and virtually all the rain turns into run-off. This means that, in the absence of suitable mitigation measures, more water reaches the waterways that the road crosses, and the flows often arrives faster as a result of efficient drainage systems. This has the potential to increase stream erosion and change the character of the smaller waterways; in large storm events there is likely to be flooding in the natural system and increased road run-off may make this flooding worse.

Both NZTA and KCDC design standards require attenuation of peak stormwater flows prior to discharge in order to avoid downstream effects on flooding and channel morphology. KCDC refers to this as "hydraulic neutrality", meaning that areas outside the site of works should not experience any increased flood risk. The usual approach is to provide storage areas that can hold back water and release it slowly once the rain has passed. As the majority of the Project passes through a rural landscape, there is room to provide wide swales that serve as collection, conveyance, treatment and attenuation devices. Swales are vegetated areas designed to remove contaminants from stormwater run-off, with attenuation provided through the use of internal bunds.

Attenuation swales are proposed to be used along approximately 55% of the Project route to collect, convey, treat and attenuate the rain water that runs off the road surface. These swales are wider than conventional treatment swales, and contain plant species appropriate to a wet environment.

Attenuation swales have been designed to hold up to the full run-off arising over a 24 hour period from a Q_{100} storm event (including climate change). That is, the peak flow for a storm event with an average return interval of 100 years (also referred to as an event with 1% AEP (2090)).

There are three exceptions to this:

- Discharges to the Mangapouri Stream, immediately north of Ōtaki. At this location, there are a number of sources of stormwater in addition to the proposed Expressway, and there is insufficient space for attenuation swales. Therefore two attenuation areas are proposed being: the Railway and Kennedy Wetlands (operating together) and the Taylor Basin. The level of attenuation at this location has been designed to attenuate the resulting stream flows to their pre-existing levels. This system has been modelled to show that existing flooding is not made worse by the Project.
- Discharges in the vicinity of the Ōtaki River Bridge. Stormwater arising north of the Ōtaki River Bridge (behind the stopbank) will be discharged to ground soakage at an existing area between the rail embankment and the proposed Expressway. This

soakage area is relatively large and soakage conditions are considered to be favourable, but there is also the option to construct a shallow trench through the topsoil layer to improve the discharge of water to the extensive sand and gravel layers below if required. Stormwater arising south of the Ōtaki River Bridge will discharge directly to the River. No peak flow attenuation is required for either of these discharges. Stormwater arising from the road bridge will be conveyed by pipes either to the north or south banks, for treatment and discharge as described above.

- Discharges around Mary Crest. At this location there is insufficient space for attenuation swales, therefore an attenuation basin (Valentine Basin) is proposed to attenuate the discharge to the Jewell Stream.

18.8 Treatment of Contaminants in Road Run-Off

Contaminants generated by vehicles, such as brake pad dust, rust, oil and coolant leaks, and exhaust discharges, will accumulate on the road surface and then get washed off by rain. With no intervention, the pollutants will be washed into the surrounding environment including surrounding land and streams. The effect of these contaminants on a stream is small but cumulative.

The BPO approach to managing road-derived contaminants in stormwater is to remove the majority of the contaminants from the rainwater before it discharges to streams or reaches groundwater. The water quality volume adopted (upon which devices are designed and sized) was the 90^{th} percentile storm, i.e. the storm for which 90% of all rainfall events will be smaller. This value varies along the length of the Project from 17.5mm to 20mm over 24 hours; a value of 19mm was adopted throughout the length of the Project, which was then increased to allow for climate change effects.

Swales were chosen as the appropriate devices to provide both treatment and attenuation as described previously. Treatment occurs as stormwater moves through the vegetation, where contaminants are removed by filtration, infiltration, absorption and biological uptake. The swales were designed to meet the design criteria (such as residence time, maximum flow velocity and maximum depth) that is expected to remove at least 70% of suspended solids (and the other contaminants bound to the solids) from the discharge.

As the majority of the swales designed for this Project are also attenuation swales, the water is likely to be in the swale for longer than the minimum required, and thus the percentage of solids (and contaminants) removed is likely to be higher.

18.9 Overall Summary of Effects

The Project will have a net positive effect on contaminant levels entering the environment, has minimal effects on flood levels and includes proposed culvert details that allow for fish passage.

The potential stormwater effects of the Project have been identified using a range of information sources including site conditions and constraints through site visits, geo-technical investigations, hydrological assessments, and topographical assessments.

Through the use of swales and attenuation basins the Project successfully minimises the potential adverse stormwater effects. This is in compliance with industry best practice. Where effects are not fully mitigated the residual effects have been assessed. All new roads will be treated, using principally swales or wetlands, however attenuation is proposed for only about 55% of the route length.

The following table gives a brief summary of effects, mitigation and residual effects.

Table 18-1: Summary of Effects, Mitigation and Residual Effects

Item	Potential effect	Mitigation through design	Residual effect
Contaminants	Contaminants (brake pad dust, tyres, paint, lubricating oils, exhaust fumes, coolant and oil leaks etc) collecting on the road and washing into the environment.	The proposed new roads are all designed to drain to swales[37] or other treatment devices. The swales filter out the majority of pollutants that the rainwater collects as it runs off the road.	Although the swales can meet the NZTA design standards, they will not remove 100% of the pollutants. This is not practically or economically achievable with current technology. If the Expressway and the existing SH1 are considered together, then this Project has a net positive effect on the amount of pollutants reaching the receiving environment. This is because the majority of existing traffic (associated with the contaminants' generation) will stop using the existing SH1, which has no formal road runoff treatment, and will use the Expressway, all of which will have formal road runoff treatment.
Increased runoff – stream bank erosion (in small frequent rainfall events)	An increased volume of rainwater runs off the new impervious surfaces, as none is lost via soakage or evapotranspiration. Potential increase in stream erosion due to a permanent small percentage increase in stream flow.	International research shows that this effect is only significant if the catchment imperviousness is over 3% (which is not the case for the majority of this Project[38]) However, because it is easy to achieve, the current design proposal provides for extended detention to be provided at all locations (except where discharging to the Ōtaki River or to ground)	None, fully mitigated. The relevant standard is exceeded.

[37] "Swales" are shallow channels (usually grass-lined) through which road runoff receives treatment as it percolates through foliage. "Attenuation swales" provide storage and peak-flow attenuation in addition to treatment.

[38] Refer to Appendix 3 for an assessment of catchment imperviousness.

Item	Potential effect	Mitigation through design	Residual effect
Increased runoff – flood mitigation (in large storm events)	As above, increased runoff due to increased impervious surfaces. Potential increase in downstream flood levels in large rainfall events.	The swales we have designed to provide treatment also provide attenuation for over half the Project length. For the rest of the Project: – the road catchments that discharge to the Ōtaki River or to ground are not attenuated, and – for the remainder, attenuation basins have been included.	No residual impact for all storms up to the Q_{100} event. Whilst no attenuation of storm flows is proposed for areas discharging to the Ōtaki River, the effect on the river is deemed to be insignificant.
Constrictions introduced	By culverting streams, constrictions to flows are introduced. The effect is that water can pond upstream of the culvert. This increase in water level can have a negative effect on adjacent land or buildings	The culverts are designed so that the upstream ponding does not affect upstream flooding levels outside of the designation. We have been able to do this in all cases with the exception of the Gear/Settlement Heights culverts.	Due to downstream constraints, we have not been able to eliminate the effects of increased ponding depth at the Gear/Settlement Heights culverts. The residual effect at those culverts is that the Q_{100} flooding level in the area will increase by approximately 300mm and potentially a farm building would be adversely affected to a greater level than currently.
Constrictions removed	By replacing existing culverts with larger new culverts. The potential effect of this is to allow a greater flow of water downstream in a storm event. This may make existing flood problems worse.	This is difficult to mitigate through design. The only thing that can be done is to keep the existing constriction in place. This might compromise levels of service. Constrictions have been kept in place around the Ōtaki township, but not at the southern end of the Project.	Of the two constrictions that have been removed: one has an additional existing constriction (which is not being removed) just upstream so there is no increase in flow; the other has been assessed to have only impounded a very small amount of water, so the increase in flow is deemed to have a negligible effect, if any, on downstream flood levels.
Extreme (i.e. super-design) event flows	In a storm event greater than the 100 year ARI design event, available Expressway culvert freeboard may be "used up" and the Expressway may overtop. Culvert headwater pond depth and extent may increase, and overland flowpaths may be diverted.	An extreme event (defined as 1.5 times the 100 year ARI storm flow plus climate change) was modelled for each culvert to ascertain whether the Expressway overtops, and the likely location of the overflow path.	Some short-term inundation of the Expressway; some increased depth and extent of culvert headwater ponding (depth increase generally limited to "consumption" of the 500mm culvert freeboard before overtopping occurs); and some diversion of overland flows. Note that this low-probability event lies outside the Project design brief, and therefore some level of effects must be expected. It has been evaluated to ensure that the potential effects are not catastrophic.

Item	Potential effect	Mitigation through design	Residual effect
Fish passage	Introducing culverts into streams can create barriers to fish migrating. The potential effect of this is that fish will be cut off from their habitat which leads to a decline in fish numbers.	We have designed the culverts such that native fish are able to swim into and through them. Fish passage features includes: introducing rocky substrate to culvert inverts, rock ramps, and very importantly, setting downstream inverts below low flow ponding levels.	None. Fully mitigated pending attention to detail during construction.
Loss of flood plain storage	By road embankment occupying volume in an existing flood plain. The potential effect is increased flood levels.	This can be designed out by altering the route of the road, or offset by creating new flood storage areas where there is land available in the appropriate location.	Altering the proposed road alignment or providing new flood areas has been deemed impracticable in this case. Instead at several locations the effect has been modelled and found to be minor (see Technical Report Nº 9)