19. Hydrology

Overview

The Project will result in changes to existing hydrology from land use changes and from changes to stream morphology. Hydrological and hydraulic modelling has been undertaken to inform the design and environmental assessment process. As a result of this closely integrated process, the majority of potential adverse hydrological affects have been avoided through refinement to the road and drainage design.

There is only one area (immediately upstream of Bridge 6) where localised protection might be required to mitigate potential increased flood risk in a Q100 event. All other increased flood risk is negligible and in fact, the Project results in a small reduction in downstream flood risk in many areas.

The stream realignments for the Project and the stream crossings (bridges and culverts) have been assessed and will result in negligible changes to hydraulic performance of the affected stream. This potential effect is largely able to be mitigated by constructing realigned streams as close as possible to their existing form. While this reconstruction is primarily being done for ecological reasons, it also minimises changes to hydraulic performance.

In summary, the majority of potential adverse hydrological effects have been avoided through design refinements. In a few areas specific measures (such as localised flood protection or the provision of upstream storage) are required to adequately mitigate the potential adverse effects.

19.1 Introduction

Hydrology refers to the movement and distribution of water across the earth. The hydrological system comprises the continuous movement of water on, above and below the surface of the earth. Hydraulics refers to the physical movement of water.

This chapter describes the potential hydrological effects of the Project in terms of:

- temporary stream crossings for construction access tracks;
- permanent changes to stream hydraulics resulting from;
    - channel diversions;
    - structures (culverts / bridges) across streams;
- stormwater runoff to existing urban stormwater systems; and
- changes to flood risk.

The assessment of hydrological effects has involved hydrological modelling which also informed the design of the proposed stormwater system. The modelling and how it relates to the assessment of hydrological effects is summarised in Section 19.3 and further details are contained in **Technical Report 14**.

Where hydrological effects have the potential to impact on other aspects of the environment, these effects are discussed in the relevant assessment chapters. In particular, this relates to potential effects on:

- water quality (Chapter 20);
- freshwater ecology (Chapter 22);
- cultural values associated with waterbodies (Chapter 24);
- recreational uses of waterbodies (Chapter 27);

19.2 Existing hydrological environment

The following parts of the hydrological environment are relevant:

- surface water (numerous permanent and ephemeral streams and tributaries in nine separate catchments); and
- groundwater.

The relevant marine environments (Porirua Harbour, the Wainui Stream mouth and the Whareroa Stream mouth) are described later in the chapters on water quality (Chapter 20) and marine ecology (Chapter 23).

19.2.1 Surface water

The Project traverses four separate watersheds (from north to south):

- the Whareroa watershed;
- the Wainui watershed;
- the Pauatahanui Inlet watershed; and
- the Onepoto Arm watershed.

The Whareroa watershed discharges to the Kapiti Coast at Whareroa Beach. This watershed has an area of 1,570ha (15.7km^2).

The Wainui watershed discharges to the Kapiti Coast north of Paekakariki. It is made up of the Wainui catchment (which contains the Te Puka sub-catchment). This watershed has a combined area of 830ha (8.3km^2).

The Pauatahanui watershed includes six catchments: Kakaho Stream, Horokiri Stream West Branch, Horokiri Stream East Branch, Ration Stream, Pauatahanui Stream, and Duck Creek, all of which discharge into Pauatahanui Inlet. Of these the Horokiri East Branch, Ration, Pauatahanui, and Duck catchments would be traversed by this Project. This watershed has a combined area of 10,640ha (106km²).

The Onepoto watershed includes Kenepuru Stream and its smaller tributary Cannons Creek which combine and flow into Porirua Stream a short distance upstream of where the stream discharges into the Onepoto Arm. Cannons Creek and several small tributaries of Porirua Stream are crossed by the Project. This watershed has a combined area of 5,325ha (53km²).

19.2.1.1 Whareroa Stream catchment

The Whareroa Stream is the northern most catchment, and is one of the smaller streams in the Project environment. The Stream is primarily influenced by the pastoral and scrub covered hills in which it passes through, before crossing the proposed Main Alignment and traversing through Queen Elizabeth Park out to the coast.

19.2.1.2 Wainui Stream catchment and Te Puka sub- catchment

The Wainui and Te Puka Streams are small catchments to the north of the route. The streams cross the proposed Main Alignment corridor and converge downstream from the Main Alignment and flow into the township of Paekakariki.

The topography traversed by these streams is typical of the Kapiti Coast district. Land use, which influences the water quality and hydrology of the streams, is a mixture of pasture, plantation pine and native bush. The steep upper catchment drops down onto an undulating dune environment. This change in grade between the hills and the coastal zone, combined with restrictions as the streams runs through the dunes, has resulted in historical flooding problems for the developed land surrounding the streams.

19.2.1.3 Horokiri Stream catchment

The Horokiri Stream catchment is one of the largest catchments within the Project area (approximately 3,300ha). It drains into the eastern side of the Pauatahanui Inlet. The stream has two main tributaries, one of which is crossed by the Main Alignment. Land use within this catchment is mostly pastoral with scrub and planted forest.

The main channel begins at the Wainui Saddle and drains south out into the Pauatahanui Inlet of the Porirua Harbour. In the upper catchment the steep sided valleys on the western catchment boundary are predominantly forested, whereas, on the eastern boundary the land use is predominantly pasture. As the lower catchment opens up onto the Horokiri Stream floodplain the major land use is rural pasture with pockets of residential dwellings. The majority of dwellings are located on the true left bank of the Horokiri Stream and have private access bridges crossing to Paekakariki Hill Road, which runs on the true right bank of the Stream. The upper Horokiri is mostly planted forest, while the downstream area is a combination of scrub, planted forest and pastoral land use.

19.2.1.4 Ration Stream catchment

The Ration Stream catchment is 680ha in area and is one of the smaller catchments in the Project area. The Stream has two tributaries, both of which are crossed by the Main Alignment. Land use within the catchment is mostly good quality pastoral, scrub and planted forest with an area of coastal wetlands at the stream mouth. The catchment also passes through the Pauatahanui Golf Course.

19.2.1.5 Collins Stream catchment

The Collins Stream catchment is small (0.64ha) and is almost entirely in pasture. Unlike most of the other catchments in the Project area it has relatively flat slopes.

19.2.1.6 Pauatahanui Stream catchment

The Pauatahanui Stream drains a catchment of approximately 4,200ha on the eastern side of the Pauatahanui Inlet. The upper catchment has numerous steep sided valleys which converge and drain northwest out onto the Pauatahanui floodplain. The upper catchment is predominately a mixture of rural pasture land and forestry.

As the lower catchment opens up the land use becomes a mixture of rural pasture land, residential and commercial. The residential suburb of Whitby lies on the western boundary and at the northern boundary is Pauatahanui Village. In the upper extent of the catchment the channel is located in a narrow steep sided gorge. The Stream is constrained as it runs adjacent to SH58 until the topography levels out downstream of the Bradey Road Bridge. Downstream of Bradey Road the grade of the stream flattens out as it skirts the western perimeter of the floodplain before passing beneath SH58 at Paremata Rd and the Paremata Rd bridge adjacent to Pauatahanui Village, and finally into Pauatahanui Inlet.

19.2.1.7 Duck Creek catchment

The Duck Creek catchment is 1,030ha in area and has a mixture of land uses. In the upper reaches of the catchment land use is primarily pastoral or recently harvested exotic forest slash. Further downstream the catchment is mostly urbanised with patches of scrub. The creek has three tributaries which are crossed by the Main Alignment, these converge downstream of the Project area and also pass under the proposed Whitby Link Road.

Upstream of the proposed Main Alignment, the creek is located in pastoral farmland, where stock has regular access to the Creek. The channel is typically small at approximately 1 metre wide. Downstream of the Main Alignment and the Link Road to Whitby, land use is mostly pastoral and planted forest, with some indigenous forest. The stream is wider and flatter than further upstream, with the channel varying between 2 and 3 metres in width.

The mouth of the Creek into the Pauatahanui Inlet is downstream of residential urban land use in the suburb of Whitby. At approximately 7 metres wide, the channel here is wider and flatter than upstream locations. It is surrounded by wetlands and scrub which are part of DOC land.

19.2.1.8 Kenepuru Stream catchment

The Kenepuru Stream catchment is located adjacent to the Duck Creek and Porirua Stream catchments. The Stream has several tributaries, one of which is crossed by the Main Alignment. At the lower end of the Kenepuru Stream it flows into the Porirua Stream. The catchment is mostly urbanised, flowing through the Waitangirua residential area. Above the Waitangirua residential area the stream flows through pastoral and scrub areas in the upper reaches of the catchment.

Figure 19.1: Like many of the waterways in the Kenepuru Stream catchment, parts of Cannons Creek have been highly modified

19.2.1.9 Porirua Stream catchment

The Porirua Stream catchment is of comparable size to the Pauatahanui catchment at around 4,100ha in area. A large proportion of the area surrounding the channel in this catchment is urban. Upstream areas are mostly pastoral and scrub. There are several tributaries to the main channel, which drain the surrounding hill catchments.

19.2.2 Groundwater

Within the slopes above the main valleys, groundwater levels are typically about 10m to 20m below ground level, but depths of 35m, or greater, have been found during testing on some, but not all, of the higher slopes of Sections 3 and 4 of the Main Alignment. Springs are evident along the Ohariu Fault and its active splinter on the western flank of Horokiri Stream, south of the Wainui Saddle, in Section 4.

Artesian pressures were noted in Section 7 (adjacent to the Pauatahanui Stream), with a head of at least 2m above ground level encountered in a borehole at a depth of 22m below ground level. Artesian pressures were also noted in Section 1 at a depth of 7m below ground level, adjacent to the Te Puka stream. KCDC extracts potable water from a bore located adjacent to the Wainui Stream and in close proximity to the Main Alignment.

19.3 Hydrological modelling and drainage design

The assessment of hydrological and stormwater effects was based on hydrological modelling. This modelling was also used in the drainage design for the Project. The key aspects of the model were:

- a soil water balance model;
- a hydrological model of rainfall runoff; and
- a hydraulic model of the characteristics of critical catchments.

19.3.1.1 Soil water balance model

The soil water balance model (SWBM) was developed to provide daily timeseries streamflow data for catchments that feed into the Porirua Harbour (i.e. every catchment except the Te Puka / Wainui and the Whareroa). This is required as an input into the hydrological and hydraulic models. The SWBM ultimately provides an estimate for the surface runoff and groundwater discharge from each catchment.

Further information about the SWBM is contained in **Appendix 15.K** of **Technical Report 15.**

19.3.1.2 Hydrological model

Hydrological modelling was undertaken to determine the runoff caused by the Project during both the construction of the Project and its operation. This modelling provided information for the development of the proposed hydraulic scheme (including culverts and erosion control protection etc.) and as a basis for further modelling of stormwater runoff during construction and operation. This modelling was based on information such as:

- meteorological information;
- morphology of the existing hydrological system, including channel characteristics and land use patterns;
- predicted land use changes as a result of the Project; and
- other predicted land use changes within each catchment over the duration of the model (to 2031).

This modelling also incorporated the predicted impacts of climate change, which includes a predicted 16% increase in heavy rainfall events by 2090[99]. The hydrological modelling was used, in conjunction with the relevant design guides[100], to size the culverts and bridges for the stream crossings.

As discussed previously, the drainage scheme has been developed around a number of performance criteria, including:

- Culverts should be capable of conveying the critical duration Q10 rainfall storm event without water levels rising above the pipe soffit.
- The road surface level should be at least 500mm above design stormwater levels for a Q100 event.
- Fish passage should be provided where required[101].
- Culvert inlets should be designed to minimise debris accumulation immediately upstream of inlets, which can lead to blockages. This is typically achieved through the use of stilling basins and debris screens.
- Culvert outlets and downstream channels need to be protected from erosion. Erosion typically creates sediment and can also undermine the structural integrity of culverts. This is important for all culverts, but particularly so for those culverts with steep hydraulic gradients where water velocities are likely to be higher. Outlet protection will typically be provided by construction of either a rip rap stilling basin and apron, or a baffle apron. A rip rap stilling basin and apron provides a more natural appearance as well as a resting place for migrating fish and is therefore the preferred option in culverts where fish passage is required.
- Piers in stream beds should be avoided, wherever possible.

For culverts the above criteria equates to a minimum diameter of 600mm and a freeboard depth of 0.5m. For bridges a freeboard of 0.6m is provided in normal circumstances but this has been doubled to 1.2m where upstream debris from large trees is possible. Culverts and bridges will also include erosion protections, including inlet and outlet protection for culverts. Fish passage will be provided in culverts when required for ecological reasons (discussed further in Chapter 22).

For many of the crossings, particularly those in ephemeral streams, the design of bridges and culverts is relatively simple and presents no particular issues in terms of appropriate sizing of structures or changes to existing hydrological conditions. Streamworks in these catchments present very little risk (and consequently negligible potential hydrological effects) and hence no further assessment was undertaken. Table 19.1 summarises the hydrological risk assessment undertaken for each catchment.

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99. Ministry for the Environment. 2008. *Preparing for climate change: A guide for local government in New Zealand*. Ministry for the Environment. Wellington. 40pp.

100. Transit NZ Bridge Manual, 2003; Austroads, 1994; Transit NZ F/3 Specification of pipe culvert construction, 2000.

101. As determined by the Project ecologists. See Chapter 22 for further details on fish passage.

Table 19.1: Summary of hydrological risk assessment

Catchment	Major diversions	Major constraints (stream or floodplain)	Significant downstream flood risk	Freshwater habitat value[102]	Detailed hydraulic modelling required?
Whareroa Stream	No	No	No (little downstream development)	Mostly high	No (no stream works)
Wainui / Te Puka Stream	Yes	Yes	Residential property (Tilley Road)	Mostly high	Yes
Horokiri Stream	Yes	Yes	Flood prone rural properties / dwellings	High	Yes
Pauatahanui Stream	Yes	Yes	Yes	Some high	Yes
Ration Stream	No	Yes	No	Mostly low	No
Collins Stream	No	No	No	Not assessed	No
Duck Creek	No	Yes	Yes	Mostly high	Yes
Kenepuru Stream	No	No	Yes	Low – moderate	Yes
Porirua Stream	No	No	Yes	Low	Yes

For the six catchments identified where further more detailed hydraulic modelling was considered necessary, modelling was undertaken to refine the design and provide a more detailed assessment of hydrological effects. For the Wainui, Horokiri, Pauatahanui and Duck catchment this is in relation to major diversions and / or flood risk. For the Kenepuru and Porirua catchments this relates to the effects of road runoff into existing urban stormwater systems.

19.3.1.3 Detailed hydraulic modelling

The methodology for the hydraulic modelling is described in **Technical Report 14**. However, in general, the modelling incorporated the following information:

- the geometry and roughness of existing streams;
- the gradient and runoff co-efficient of land within the catchment;
- key aspects of the proposed works, namely:
    - structures, such as bridges and culverts;
    - channel diversions;
    - earthworks (cut and fill);
    - vegetation clearance; and
    - road pavement formation.

102. Based on the assessment undertaken by the Project ecologists (refer to Technical Report 9).

In general, two aspects were modelled:

- the existing pre-construction situation (i.e. without the Project); and
- the post-construction scenario (i.e. with the Project).

For some catchments, multiple post-construction scenarios were modelled to inform the design and assessment process.

Specifically, in terms of land use change the modelling of the post-construction scenarios took into account the land use change as a direct result of the Project (conversion to paved road surface and retirement and revegetation of some areas of pasture) and other land use change predicted within the catchment over the next 20 years[103].

Based on this information, avoidance of adverse effects through design modification was the preferred solution but where this was not practicable, mitigation measures were developed.

The hydraulic modelling enabled the following effects to be assessed for each of the six critical catchments:

- hydraulic effects on runoff and overland flow paths;
- hydraulic effects of new stream crossings (culverts and bridges);
- hydraulic effects of realigned waterways;
- stream velocity effects and associated scour and erosion, particularly associated with channel realignment; and
- effects on flood risk, include loss of floodplain storage.

The hydraulic effects in each of the six critical catchments are discussed in Section 19.5.

19.4 Assessment of hydrological effects during construction

The construction access track will require 61 temporary stream crossings, as shown on plans **AC01-21**.

Some of these crossings will be new while others will be an upgrade of existing fords or culverts. It is necessary to upgrade some of the existing crossings to keep vehicles out of the stream channel (i.e. fords) and the unsuitably of some existing culverts for heavy vehicles. Culverts will be about 10m long (4m of road width, and 3m either side to allow for 500 – 600mm of road build up).

103. As discussed in Chapter 14, the Project will not result in widespread land development. Land use change within modelled catchments was determined from subdivision potential etc. in district plans. See **Technical Reports 14** and **15** for further information about the modelling.

Temporary culverts will be used for up to two years. While the construction period of the Project is longer than two years, it is anticipated that, once formed, sections of the Main Alignment itself will be used for construction access.

All temporary culverts have been sized for a Q2 event and this can be achieved in all cases. This equates to a minimum culvert size of 600mm. Flow in larger events will overflow the construction road and may cause some damage to the temporary culverts (as well as the access tracks potentially). After a large event, all culverts and access roads would be checked and repaired prior to use, if necessary.

All temporary culverts will be constructed at grade and within the existing (natural) channel, and hence will not involve any diversion of streams. As with the permanent culverts, erosion protection will be provided. Where necessary, fish passage will also be provided by widening and countersinking culverts by 300mm to form a continuous wetted perimeter, passable to native fish species.

Once culverts are no longer required for construction access, they will be removed and any damage to the streambed or riparian planting will be remediated.

The small scale and temporary nature of the crossings required for the construction access tracks means that any hydrological effects will be negligible.

19.5 Assessment of hydrological effects during operation

As discussed, potential hydrological effects associated with the operation of the Project (including the increase in impervious surface, permanent stream crossing and permanent stream diversions) can include:

- hydraulic effects on runoff and overland flow paths;
- hydraulic effects of new stream crossings (culverts and bridges);
- hydraulic effects of realigned waterways;
- stream velocity effects and associated scour and erosion, particularly associated with channel realignment; and
- effects on flood risk, including loss of floodplain storage.

For catchments where detailed hydraulic modelling was not considered necessary (refer Table 19.1), potential hydrological effects are considered to be negligible.

A summary of the modelling and assessment of hydrological effects for the other six catchments is as follows. The location of the proposed structures (bridges and culverts) and diversions is shown in the drainage plans (**DR01- 21**). Key hydraulic modelling scenario results are shown in plans in **Appendix 14.H** of **Technical Report 14**. The following effects summaries should be read in conjunction with these plans.

19.5.1 Wainui / Te Puka Stream catchment

Works in the Te Puka Stream involve major stream realignment (approximately 45% of the existing stream) as well as a number of structures for stream crossings. The Te Puka Stream valley is a relatively constrained and steep.

There are already flood risks associated with the Wainui / Te Puka catchment. The modelling predicted that an existing triple box culvert conveying the Te Puka Stream under SH1 would overtop in a Q100 event causing shallow (up to 150mm) inundation of pastureland immediately downstream. Existing culverts taking the Wainui Stream under SH1 and the NIMT are both insufficient for Q10 and Q100 events resulting in inundation. For the Q10 event this pond (in excess of 1m) is predicted to occur in an area between SH1 and the NIMT. For the Q100 event, flooding could threaten residential properties along Tilley Road in Paekakariki.

The initial post-construction modelling indicated that there would be minimal loss of storage and additional runoff would be less than1%. From this, two potential effects were considered further:

- flood risk at the foothills of the Te Puka Stream valley (i.e. Paekakariki); and
- water velocity changes on Te Puka Stream.

19.5.1.1 Flood risk

The model showed that in a Q100 event the twin box culvert (W3) will result in localised increase in flood levels of greater than 1m immediately upstream of the culvert (Figure 19.2). This increase is relatively contained due to the topography and the affected area is within the area the NZTA is designating for the Project. Options were assessed to reduce this increase but even a doubling of the size of W3 did not result in any real change to the area affected. Furthermore, the low return period of the event (Q100) means that the increase in flood levels is negligible. Protection can be provided for the road to prevent inundation.

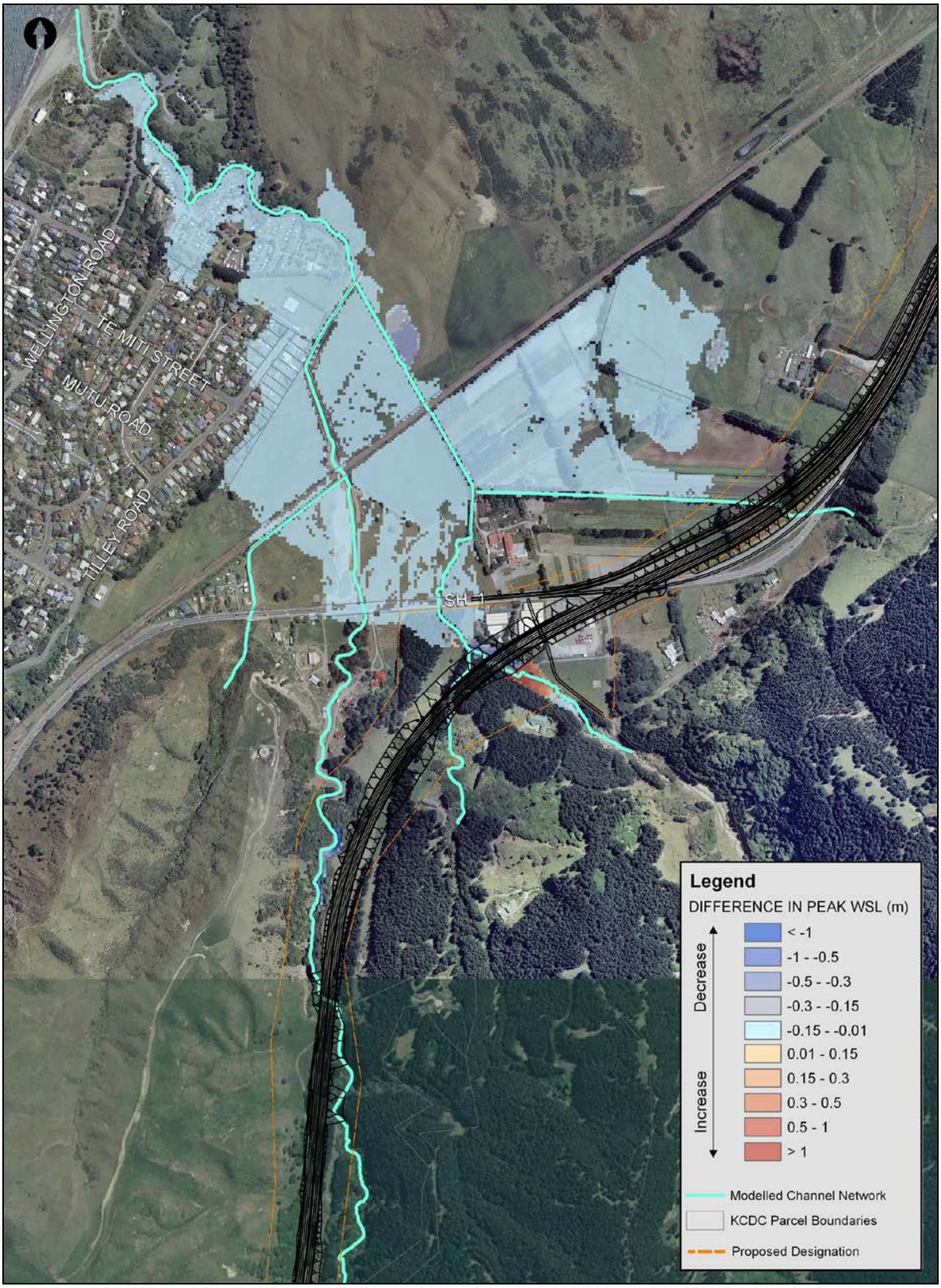

Figure 19.2: Difference in peak water levels with and without the Project for a Q100 event

19.5.1.2 Water velocities in Wainui and Te Puka Streams

The Wainui and Te Puka Streams are both in relatively steep catchments and alterations to the stream have the potential to increase existing stream velocities. Increased stream velocities can lead to increased scour which can undermine stream banks and / or structures in stream beds. Increased stream velocities can also have adverse ecological effects (discussed in Chapter 22).

Figure 19.3 and Figure 19.4 show the comparison between the pre and post-construction stream velocities in Wainui Stream and Te Puka Stream, respectively[104].

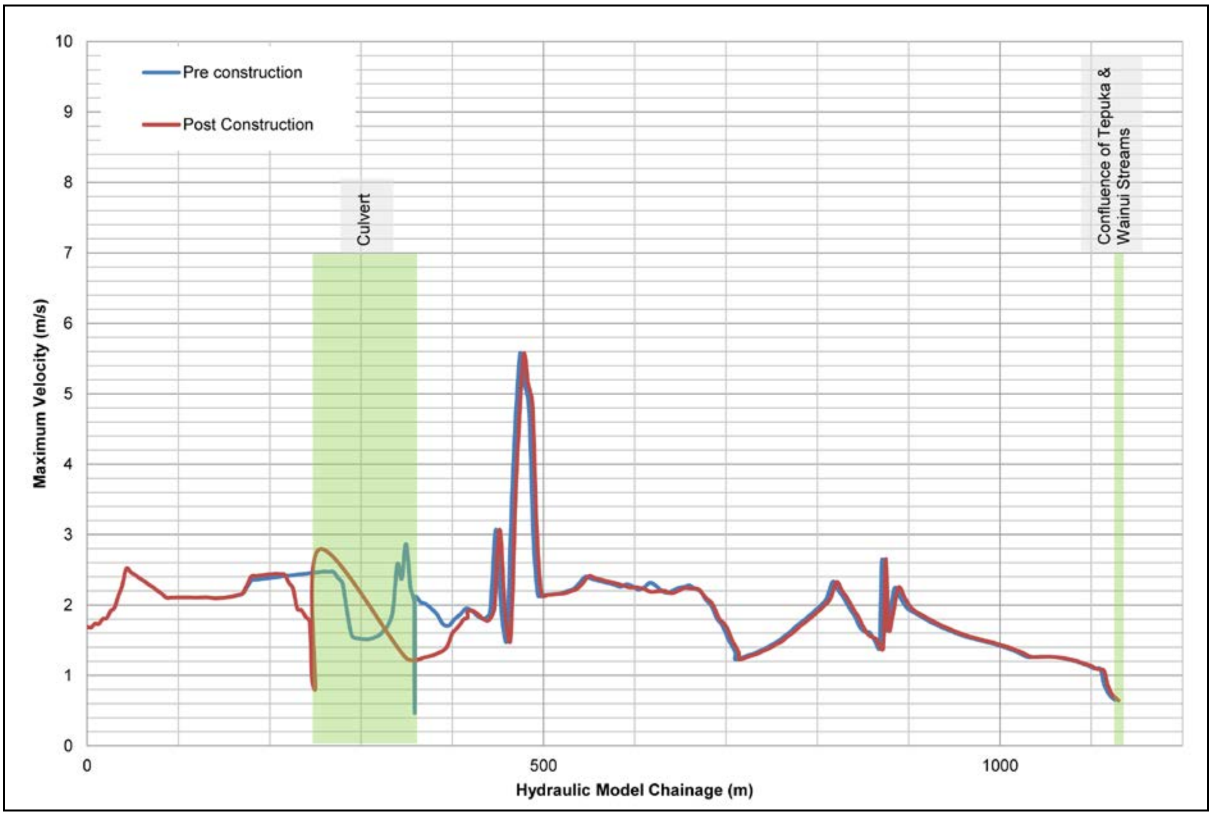

Figure 19.3: Comparison of peak water velocity in Wainui stream between pre and post construction scenarios for a Q10 event

104. The chainage values used in these figures relate to the hydraulic model, not the values used to describe positions along the Main Alignment.

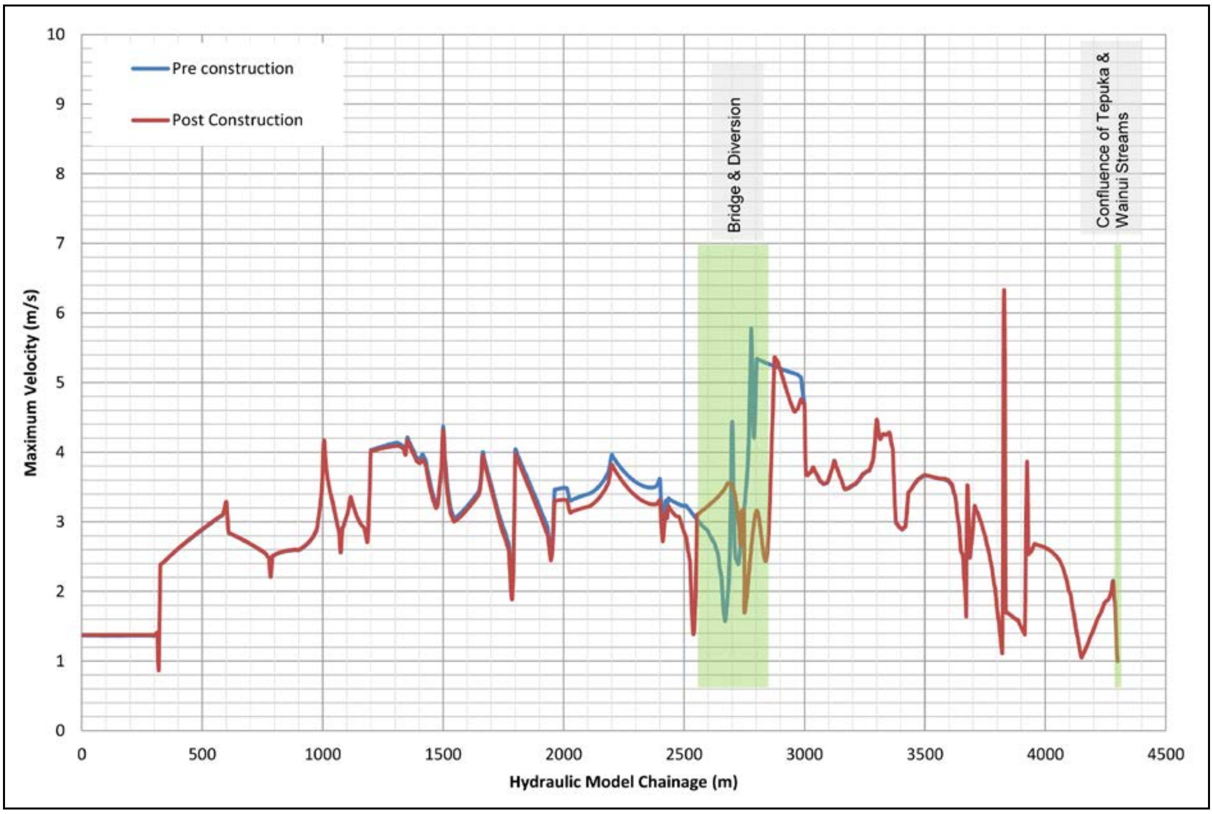

Figure 19.4: Comparison of peak water velocity in Te Puka stream between pre and post construction scenarios for a Q100 event

For the Wainui Stream, the only real change is around culvert W3 where the Project will result in a small decrease (0.5 – 1m/s) in flow velocities in a Q10 event. This will not have any adverse effects.

In the Te Puka Stream a localised increase of 0.5 – 2m/s is predicted around Bridge 3 (and the small upstream diversion) in a Q10 event. This predicted increased is not expected to cause additional scour of the stream bed. Protection as part of the bridge will mitigate any potential increased scour as a result of localised increases in stream velocity.

From Bridge 3 to the Wainui Saddle, parts of Te Puka Stream will be realigned, mainly to move the stream away from the base of the RSE walls used to support the carriage down the Te Puka valley. The re-aligned lengths of the stream will be as close in longitudinal and cross sectional profile as possible to the existing stream channel. There are not predicted to be any significant impediments to this and the hydraulic performance of the stream will remain relatively unchanged. As such, any changes to peak water velocities in Te Puka as a result of stream realignment will be negligible.

19.5.2 Horokiri Stream catchment

The full length of the Horokiri Stream catchment was modelled. The majority of the main stream channel is constrained by the steep valley topography. South of the confluence of the Horokiri Stream with its main tributary (just upstream of the Paekakariki Hill Road bridge) the topography flattens out slightly and the channel is less constrained and in the last 1.5km it flows through the Pauatahanui floodplain. Most of the catchment has been highly modified and is in pasture or plantation forestry. There is some native bush, particularly in the upper parts of the catchment towards the Wainui saddle.

Modelling showed that the stream is currently constrained by an existing box culvert on the Paekakariki Hill Road that would cause localised flooding of this road in a Q100 event. Upstream of this culvert there is little existing flood risk due to the highly constrained channel. Downstream of the culvert some flooding is predicted in a Q10 event threatening four residential properties and seven properties in a Q100 event. Some inundation around the stream mouth is also predicted and this would include some inundation of Grays Road.

The model was then run for the post-construction scenario to assess the hydraulic effects of:

- three bridges across the Horokiri Stream (Bridges 4, 6 and 8); and
- channel diversions.

19.5.2.1 Bridge 4

Bridge 4 is located in the steep sided upper part of the catchment. A small (700mm) increase in flood level directly upstream of the bridge in the Q100 event is predicted. It is considered that the bridge can be sized to provide adequate freeboard and the inundation will have no effect on the road and only a negligible effect on the surrounding land, which does not contain any dwellings.

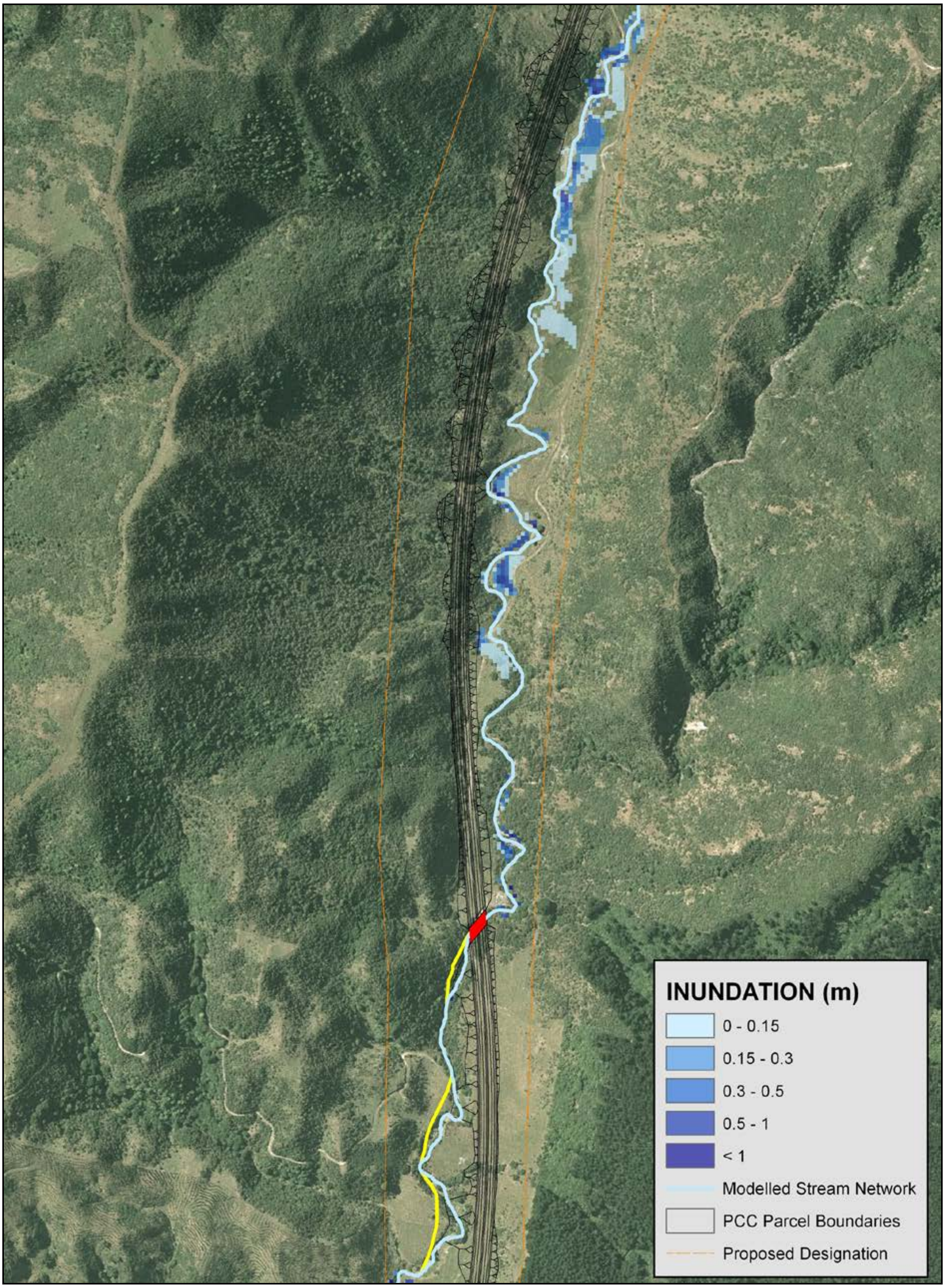

Figure 19.5: Peak inundation levels around Bridge 4, with Project in a Q100 event

Modelling showed that the 30m width for Bridge 4 is sufficient to avoid any adverse flooding effects for both Q10 and Q100 events and no mitigation is required.

19.5.2.2 Bridge 6

Bridge 6 is located at the upper end of the lower Horokiri Valley where the topography flattens out (towards the northern boundary of BHFFP). Modelling indicated that the 25m wide structure originally proposed would likely result in increased upstream water levels that could cover the carriageway. A 28m wide bridge (being the widest single span bridge possible for the crossing) was also modelled but this created unacceptable water level increases. Excavation of a wider stream channel was considered but was discounted due to the potential for a reduction in the depth of base flows, which would have undesirable ecological impacts. The solution chosen was to realign part of the stream channel immediately upstream of the crossing to create a hydraulically smoother approach to the bridge. The longitudinal and cross-sectional profile of the existing channel will be maintained as far as practicable. This realignment also assists with the reduction of flow velocities adjacent to fill areas which could cause erosion. Even with a maximum bridge width of 28m and channel realignment, the modelling indicated that the upstream surface water levels are predicted to increase by up to 1m, as shown in Figure 19.6.

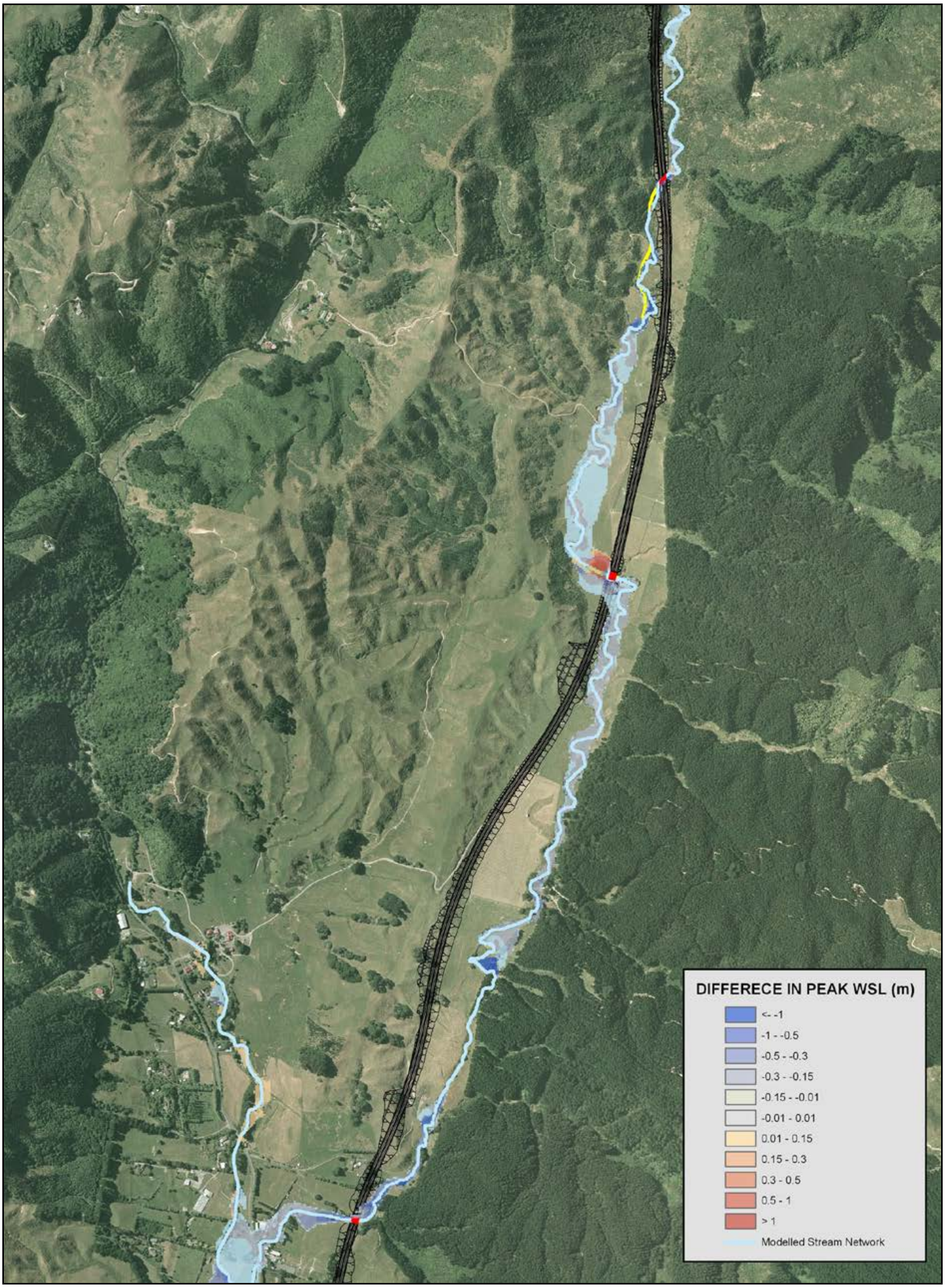

Figure 19.6: Peak inundation levels around Bridge 6, with Project in a Q100 event

Unless filled, the topographic depression south of the new bridge could fill with water during a flood and inundate the carriageway. Mitigation solutions include filling in the depression or by providing localised protection such as stop banks. Any mitigation to be adopted will be implemented in agreement with the adjacent property owner who would otherwise be affected by any flooding.

19.5.2.3 Bridge 8

The other main bridge across Horokiri Stream (Bridge 8) was sized as a 30m wide single span structure. Modelling showed that this would not cause any increase in flood risk upstream in either a Q10 or Q100 event.

19.5.2.4 Stream diversions and loss of storage

In addition to the stream diversion discussed earlier in relation to Bridge 6, there are a number of other diversions needed within the Horokiri Stream. These diversions are required because either Main Alignment cut or fill will impact on the existing stream channel. Due to the constrained nature of the upper part of the catchment, there were often limited options for the alignment of the road relative to the stream.

The modelling shows there is a negligible change in stream velocities in the stream, including around the three bridges. Even in these extreme events there is only a minimal, and localised, increase in inundation levels and these are immediately upstream of bridges. For most of the catchment, the Project will result in a small reduction in inundation levels during extreme events.

19.5.3 Pauatahanui Stream catchment

The reach of the Pauatahanui Stream model extends from the stream mouth to approximately 3.4km upstream. Upstream of the Bradey Road bridge the channel is relatively constrained within a narrow steep sided gorge. Downstream, however, the topography opens out to a natural floodplain.

Currently, for the area below the Bradey Road bridge the model predicts that under existing conditions during a Q10 event the floodwaters would cover much of the floodplain, but are shallow and generally less than 200mm. The model predicts that this shallow flooding could cross SH58 in places, which could result in deep ponding on the northern side of SH58 which is below the road level in a localised hollow. There are a number of residential properties and a substation in this low lying area. In a Q100 event, the floodplain is predicted to be inundated by over 500mm of water. The model predicts extensive and deep flooding across SH58 and in the localised hollow on the far side. In addition, the model indicated that the two existing bridges, near the roundabout that joins SH58 and Paekakariki Road, are constraints to high stream flows and contribute to the upstream flooding. In a Q100 event, the model predicts these constraints will increase upstream flooding by up to 1m. In the current situation during high rainfall events, the flooding upstream of these bridges is expected to inundate the lower back yards of four residential properties on Joseph Banks Drive[105].

The hydraulic modelling of the post-construction scenario indicates that changes to the stream associated with the new crossing (Bridge 15) and the reduction in storage on the floodplain could increase the flooding effects. Channel realignment is proposed in conjunction with the new crossing.

105. Pt Lot 2055 DP 74735, Lot 2056 DP 74735, Lot 2057 DP 74735 and Lot 2726 DP 85792.

In addition, the earthworks required in the area will result in a further loss of storage on the existing floodplain. Filling on the floodplain has the potential to restrict flood flows or to reduce the available flood storage resulting in increased flood levels.

The crossing of the Pauatahanui Stream by the Main Alignment was also closely analysed as it is subject to high flows. The use of a culvert for this crossing was discounted early on as the modelling indicated that a culvert would significantly increase flow velocities and would be likely to cause unacceptable scour and resulting erosion. It would also significantly increase flooding risk upstream of the crossing. For this reason a bridge was selected as the method of crossing. A bridge would also have fewer ecological effects as compared to a culvert.

The modelling also assisted with the sizing of this bridge. For ecological reasons it is desirable for the bridge to have a single span to ensure there were no piers in the stream bed. Within the topographical and road geometry constraints this meant that the maximum length the bridge could be is 28m. The modelling showed that even at this maximum width, there is an approximately 800mm increase in peak water surface levels upstream of the new bridge in a Q100 event, as shown in Figure 19.7.

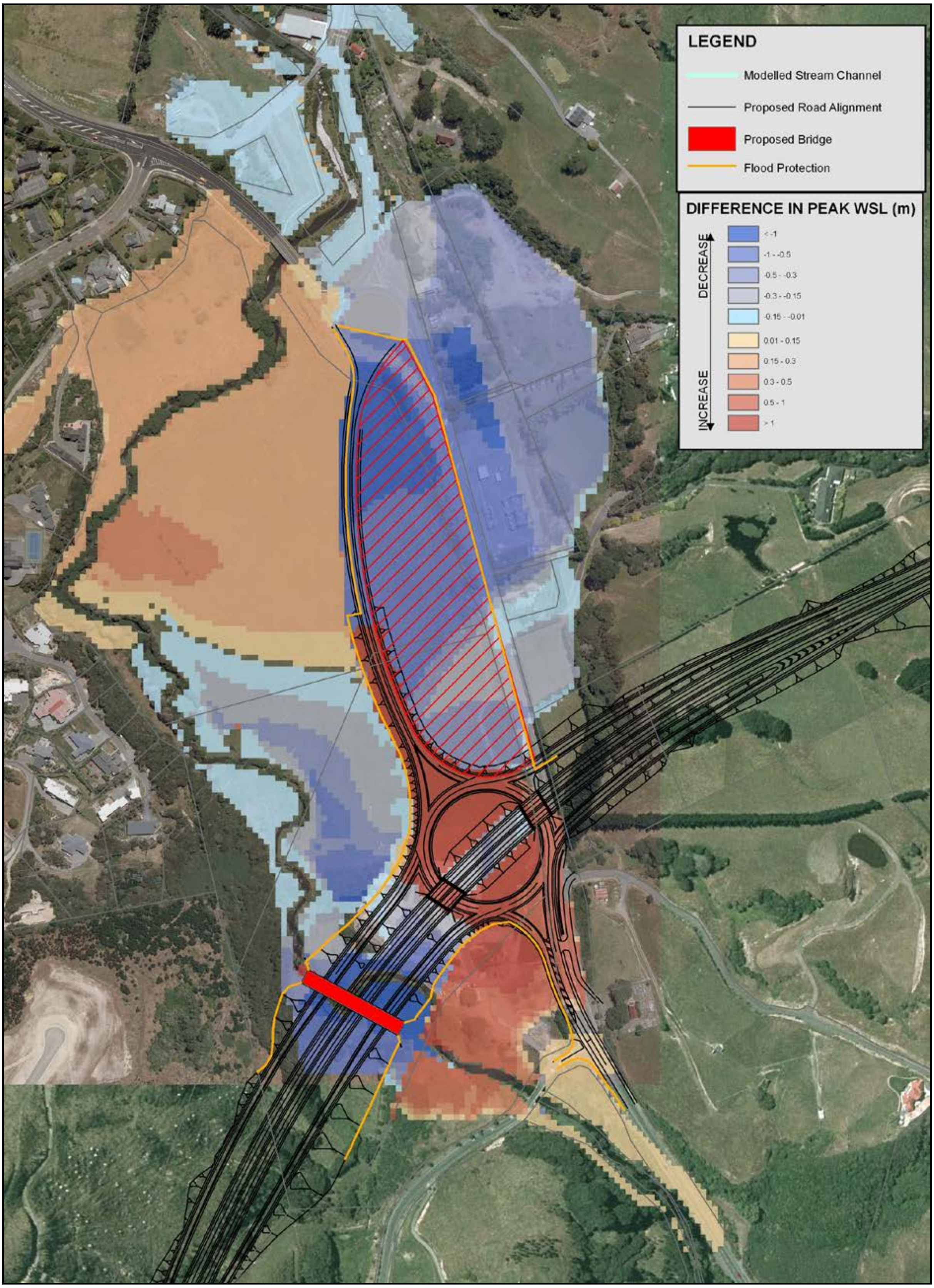

Figure 19.7: Comparison in a Q100 event of the peak water levels in the post and pre-construction situations with the inclusion of a new 28m span bridge across the Pauatahanui Stream

It was decided that an acceptable solution to this would be to allow the lower level of the interchange (i.e. the roundabout underneath the Main Alignment) to be used as a secondary flowpath in a Q100 event. This would see water depths of approximately 500mm across the lower level of the interchange in such an event. This will not make the road unusable (as the Main Alignment running over the interchange roundabout will not be affected) but will reduce the level of service temporarily for road users. Given the low frequency of such an extreme event, this is considered to be an acceptable compromise and it will ensure that flooding effects on land upstream of the interchange are reduced.

The modelling for a Q100 (Figure 19.7) showed changes to peak water levels downstream of the interchange. The peak water levels to the north of the re-aligned Paremata Road (existing SH58) are slightly reduced. This decreased flood risk includes the area where the Pauatahanui Substation is located. Inundation levels to the south of the realigned road will increase slightly (in the order of 0.01 – 0.3m) in a Q100 event. After construction of the Project is complete this area will be landscaped to create a wetland recreation area. It is not necessary to mitigate a small increase in inundation in this area during a rare Q100 event. The only other increased inundation predicted during a Q100 event is to the low lying areas on the four adjacent private properties on Joseph Banks Drive. This increase will be in the order of 100-200mm in a Q100 event and that the area of flooding will only be in the backyards of the properties. The dwellings are not at risk of flooding in this event. This is considered to be a very minor impact, not requiring any mitigation.

The hydraulic model was also used to assess the effects of the proposed stream realignment on peak flow velocities. This showed that there will likely be an approximately 1m/s increase in peak flow velocity immediately upstream of the new bridge. However, downstream of the bridge, there will be a reduction in velocity which is attributed to a reshaped stream channel and the inclusion of a secondary flowpath. It is not considered that the changes in flow velocity, upstream or downstream, will cause any adverse effects in terms of scour and erosion.

19.5.4 Duck Creek catchment

Duck Creek is a north-facing catchment of approximately 1,030ha. The upper part of the catchment is rural, while the lower part runs through the suburb of Whitby prior to discharging in the Pauatahanui Inlet.

The Main Alignment runs parallel to Duck Creek for approximately 3.5km, while the Whitby and Waitangirua Link Roads are also in the catchment. The physical effect on Duck Creek is minimal with only two crossings of the main channel (Bridge 19 on the Main Alignment and Bridge 29 (box culvert) on the Waitangirua Link Road). There are no other crossings proposed for the main stem of Duck Creek. The minor nature of the physical works in Duck Creek and its tributaries means that changes to stream velocities as a result of altered channel morphology are not expected.

The main potential hydrological effect in Duck Creek could be an increase in peak flow volumes as a result of increased runoff from road surfaces. The Project will result in an approximate 2% increase in connected impervious area in the catchment (this is the highest proportional land use change of any of the nine affected catchments). For a Q10 event, this will result in a corresponding 2% increase in peak flow volumes which is considered to be negligible.

For larger Q50 and Q100 events, however, the increase in peak flow volumes (and potential downstream flood risk) is higher and mitigation options required consideration. Mitigation for this potential increased flood risk is in the form of reducing the size of particular culverts so they store water upstream during these Q50 and Q100 events. To adequately mitigate the flood risk, peak flows for these two events should be maintained at existing (i.e. pre-construction) levels. Two culverts were identified as being possible options:

- the Waitangirua Link Road box culvert (Bridge 29); or
- culvert D7.

Hydraulic modelling showed that either one of these two culverts would be able to provide the required volume of upstream storage to mitigate the potential flood risk. The preferred option will be selected during the specimen design phase (Phase 4) from further hydraulic assessment. The NZTA and PCC are confident, however, that this potential effect can be adequately mitigated. Both upstream storage options would involve temporary inundation of parts of the Duck Creek valley on land owned by GWRC. The rarity of this magnitude of event (i.e. Q50 and above) and the temporary nature of the inundation means that it is acceptable.

19.5.5 Waitangirua stormwater network

Stormwater runoff from approximately 600m of the Waitangirua Link Road will drain into the existing Waitangirua stormwater network. Results from a localised hydraulic model showed that the existing network has insufficient capacity for both Q10 and Q100 events. The model was then re-run to determine the additional inundation as a result of runoff from the Waitangirua Link Road. Figure 19.8 shows the results for the Q10 event where most of the network experiences increases of 0.05 – 0.2m.

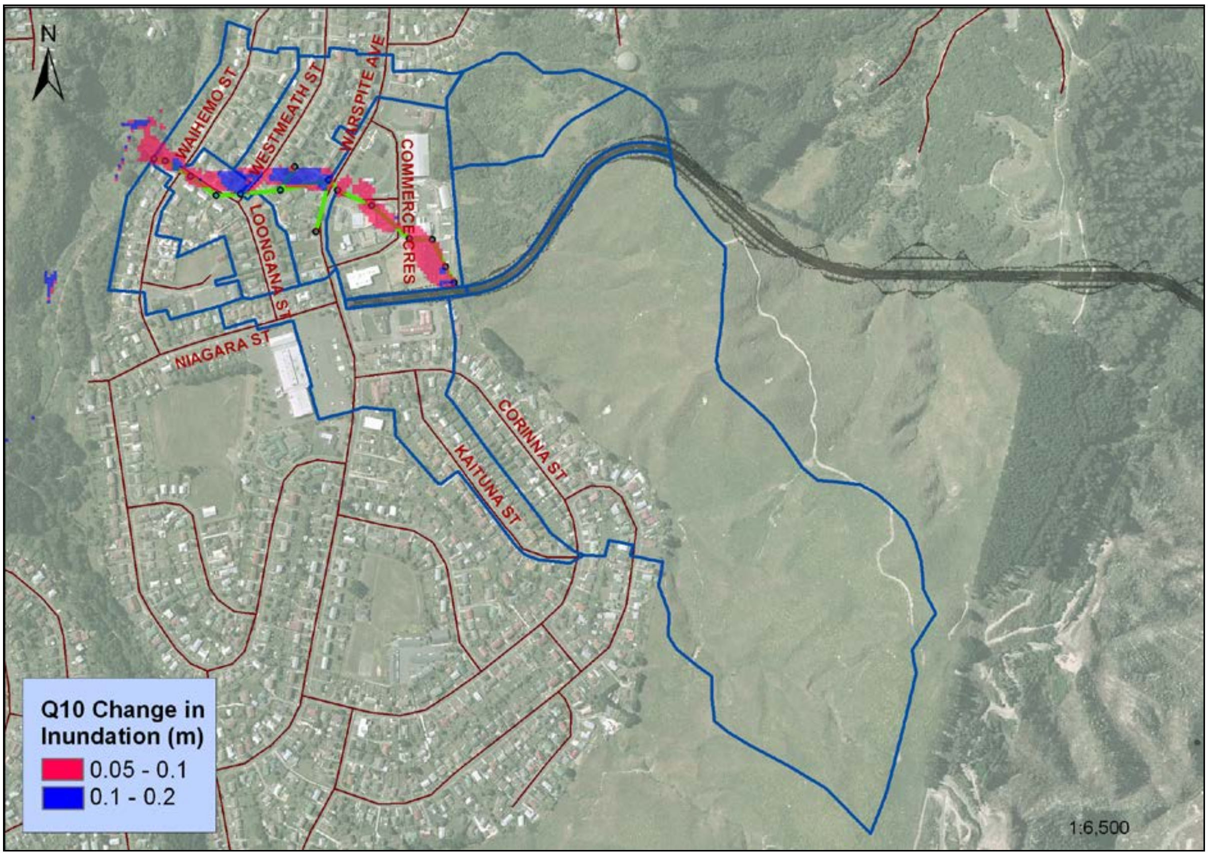

Figure 19.8: Comparison in a Q10 event of the peak water levels in the post and pre-construction on the Waitangirua stormwater network

For a Q100 event, there is virtually no difference in inundation levels because the additional volume from the Waitangirua Link Road is comparatively small in proportion to the flows that would be generated under the existing scenario.

The only real option to mitigate the potential adverse effect of increased stormwater runoff from the Waitangirua Link Road is to upgrade the existing Waitangirua stormwater network to convey a Q100 event. The use of secondary overflow paths is not recommended due to the suburban land use within the catchment.

Upgrading of the Waitangirua stormwater network will be undertaken by PCC prior to the commissioning of the Waitangirua Link Road.

19.5.6 Linden stormwater network

Part of the surface runoff from the Project will run into the existing Linden stormwater network, operated by WCC. Modelling showed that currently, the Linden stormwater network is undersized for a Q10 event and this would result in flooding towards the west of Anthony Street. In a Q100 event, two basins east of Coates Street and west of existing SH1 would be inundated.

Additional runoff to the Linden network was modelled. In a Q10 event, the maximum increase in inundation caused by additional runoff from the Project is 200mm. This occurs in a very limited area downstream of Bell Street, adjacent to the outlet. In the Q100 event, the maximum increase in inundation is 550mm. This occurs between the existing SH1 and Tremewan Street (Figure 19.9).

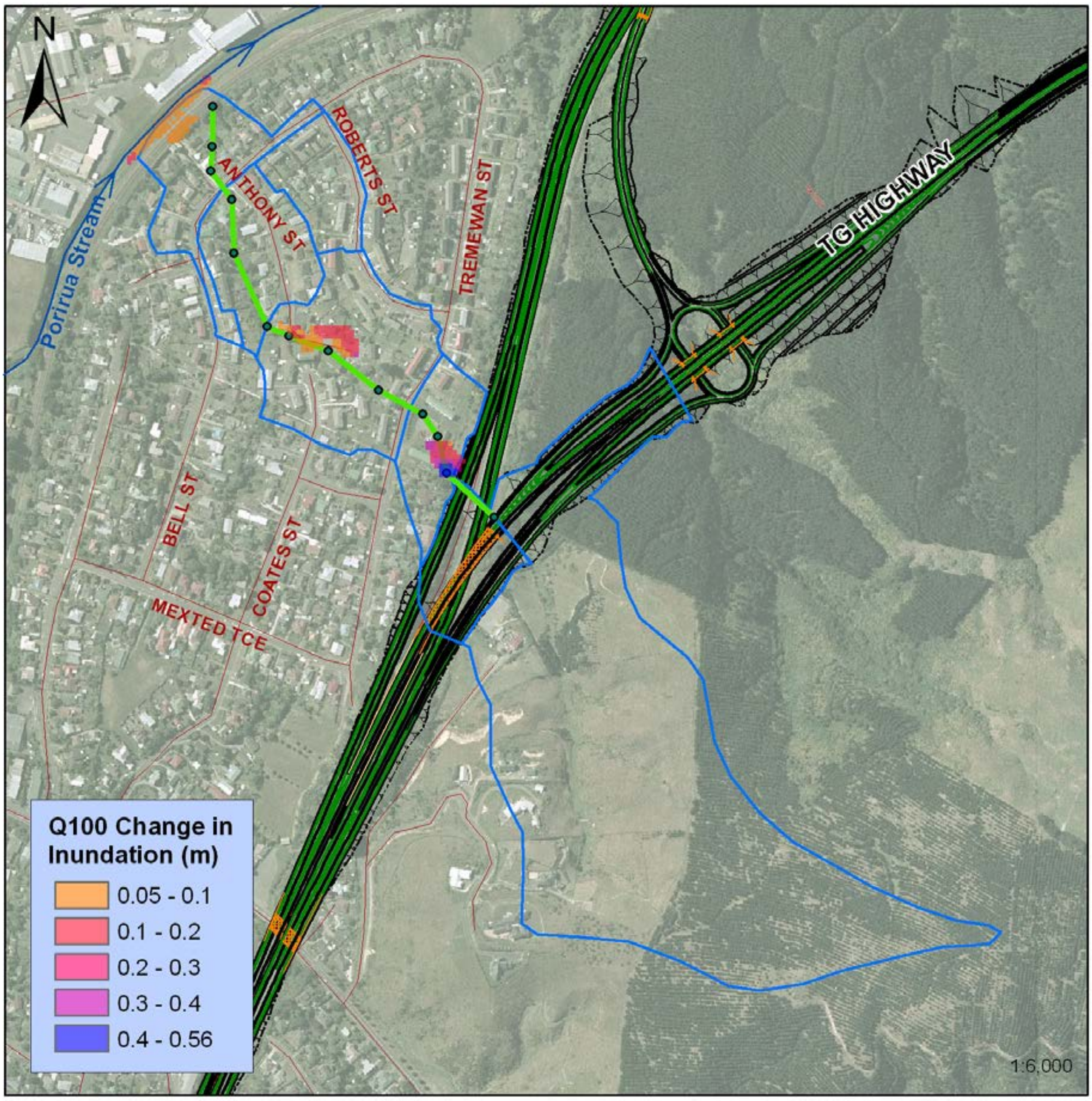

Figure 19.9: Comparison in a Q100 event of the peak water levels in the post and pre-construction on the Linden stormwater network

To mitigate the potential impacts of increased inundation from the Project, three options were considered:

- upgrade the existing stormwater network;
- divert runoff to secondary overflow paths; or
- store peak flows in the upper catchment.

The first two options are not preferred because upgrading the stormwater system through the suburban area is difficult and expensive and is not warranted as mitigation for the relatively minimal increase in inundation levels in Q10 and Q100 events caused by the Project. The suburban nature of the environment also means that diversion to secondary overflow paths is undesirable.

As such, upstream storage in high flow events is the preferred mitigation solution. This would be achieved by reducing the diameter of culvert Po6 so water is retained upstream (on the eastern side of the Main Alignment) during high flow events. Modelling indicates that this will be achievable but will result in a non-compliance with the NZTA's stormwater guidelines in terms of water clearance levels below the road surface. This non-compliance is considered acceptable in this case and it should be noted that the only risk it poses is to the NZTS's own asset (i.e. SH1).

19.6 Effects on groundwater hydraulics

Groundwater conditions within the Project were assessed as part of the geotechnical investigations used to inform the design of the Project.

While groundwater conditions are an aspect of the design, the construction and operation of the Project is expected to have minimal, if any, effects on groundwater movement or levels. As such, no mitigation is required.