Before a Board of Inquiry
Transmission Gully
Notices of Requirement and Consents

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under: the Resource Management Act 1991

in the matter of: Notices of requirement for designations and resource consent applications by the NZ Transport Agency, Porirua City Council and Transpower New Zealand Limited for the Transmission Gully Proposal

between: **NZ Transport Agency**
Requiring Authority and Applicant

and: **Porirua City Council**
Local Authority and Applicant

and: **Transpower New Zealand Limited**
Applicant

Statement of evidence of Craig Murray Martell (Hydrology) for the NZ Transport Agency and Porirua City Council

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Dated: 17 November 2011

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CHAPMAN TRIPP

STATEMENT OF EVIDENCE OF CRAIG MURRAY MARTELL FOR THE NZ TRANSPORT AGENCY AND PORIRUA CITY COUNCIL

QUALIFICATIONS AND EXPERIENCE

1 My full name is Craig Murray Martell.

2 I am a senior associate with Sinclair Knight Merz (*SKM*) New Zealand. My qualifications are BSc (Hons), MSc (hydrology) from Victoria University of Wellington. I am a member of the New Zealand Water and Waste Association.

3 I have 15 years experience in the analysis of peak flows (hydrological modelling) and assessing hydraulic impacts (hydraulic modelling) with a specific focus on flood risk and low impact stormwater solutions.

4 My work over this time has included a number of research projects largely focused on rainfall runoff characteristics in the Wellington region. This has included:

4.1 A masters degree that assessed rainfall runoff characteristics for Wellington catchments;

4.2 A Transfund research project looking at the application of rainfall runoff methodologies in low lying coastal zones based on research in Kapiti and Tauranga;

4.3 The development of a rainfall runoff standard for Kapiti Coast District Council which now forms part of its code of practice for land development;

4.4 Rainfall runoff assessments and hydraulic modelling of a number of waterways along the alignment including:

(a) The Porirua Stream for Wellington City Council and Greater Wellington Regional Council (*GWRC*);

(b) The lower Pauatahanui Stream for Transit NZ in the late 1990s when SH58 was realigned and a new bridge constructed;

(c) The lower Te Puka Stream including consenting of gravel extraction.

4.5 Numerous flood studies and hydraulic models in the wider Wellington region including for Upper Hutt City, Lower Hutt City, Wellington City and Kapiti Coast District Councils. In addition, flood studies in the Porirua Stream, Mangaroa River and lower Awamutu Stream have been undertaken for GWRC;

4.6 I have developed stormwater solutions for other major roading projects including the recently completed SH20-1 and East Taupo Arterial;

4.7 I have also been involved in numerous peer reviews of projects for subdivision consent including Clearwater estate (Waimakariri floodplain, Christchurch); Colorado estate (Styx/Krusses catchment, Christchurch); Leith-Lindsay flood upgrade (Dunedin); and Peka Peka rural hamlet flood mitigation (Kapiti).

5 On 15 August 2011 the NZ Transport Agency (*NZTA)*, Porirua City Council (*PCC)* and Transpower NZ Limited *(Transpower)* lodged Notices of Requirement (*NoRs)* and applications for resource consent with the Environmental Protection Authority (*EPA)* in relation to the Transmission Gully Proposal (*the Proposal)*.

6 The Proposal comprises three individual projects, being:

6.1 The 'NZTA Project', which refers to the construction, operation and maintenance of the Main Alignment and the Kenepuru Link Road by the NZTA;

6.2 The 'PCC Project' which refers to the construction, operation and maintenance of the Porirua Link Roads by PCC[1]; and

6.3 The 'Transpower Project' which refers to the relocation of parts of the PKK-TKR A 110kV electricity transmission line between MacKays Crossing and Pauatahanui Substation by Transpower.

My evidence relates to the NZTA and PCC Projects (together the *TGP* or the *Project*). It does not relate to the Transpower Project.

7 I am familiar with the area, streams and key stormwater networks that the Proposal covers and the State highway and local roading network in the vicinity of the Proposal. I carried out site visits in 2010 and 2011 along the route of the proposed road.

8 I am the senior advisor, contributing author and reviewer of the Assessment of Hydrology and Stormwater Effects report (Technical Report 14) which formed part of the Assessment of Environmental Effects (*AEE)* lodged in support of the Project.

9 I have read the Code of Conduct for Expert Witnesses as contained in the Environment Court Consolidated Practice Note (2011), and I agree to comply with it as if this Inquiry were before the Environment Court. My qualifications as an expert are set out above. I confirm that the issues addressed in this brief of evidence

[1] The Porirua Link Roads are the Whitby Link Road and the Waitangirua Link Road.

are within my area of expertise. I have not omitted to consider material facts known to me that might alter or detract from the opinions expressed.

SCOPE OF EVIDENCE

10 My evidence will:

10.1 Set out my background and role;

10.2 Explain how predicted rainfall runoff was calculated;

10.3 Explain how culverts, bridges, stormwater treatment devices and diversions were designed to accommodate predicted rainfall runoff (during both construction and operation);

10.4 Explain the effects of the above structures on flood risk, and how the effects can be managed (during both construction and operation);

10.5 Respond to submissions;

10.6 Respond to issues raised in the GWRC Key Issues Report;

10.7 Describe proposed conditions relevant to the issues discussed in my evidence; and

10.8 Provide brief conclusions.

Links to other evidence

11 The work in Technical Report 14 and summarised in my evidence was required as an input to other technical reports[2] and evidence by expert witnesses. The interaction between my evidence and the potential effects caused by changes to the hydrology and stormwater is summarised in the flowchart in **Figure 1**. The hydrology[3] and hydraulic[4] based potential effects have been grouped into four areas:

(a) Effects on Flood risk – how the long-term operation of the road will alter flood levels and the extent of flooding;

(b) Hydraulic effects – how changes to catchment runoff may impact on the natural stream channel and flow paths;

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[2] Technical report 11 and technical report 15.

[3] Catchment processes and runoff estimates including peak flow, volume and stormwater runoff.

[4] The impact of catchment runoff on the channel and floodplain.

(c) Water quality effects – the impact of increased runoff on sediment concentration and contaminants discharged to the receiving streams and coastal environment;

(d) Ecological effects – the impact on fish passage and habitat, and the water quality of the receiving streams and coastal environment.

12 Results of the hydrology and hydraulic modelling were used as inputs into the conceptual mitigation design of:

(i) Erosion and sediment control devices;

(ii) Requirements for bridges and culverts;

(iii) Stream realignment/diversions; and

(iv) Flood risk.

13 The flood risk assessment of environmental effects and the hydraulic assessment of environmental effects are addressed in Technical Report 14, and summarised in my evidence.

14 The water quality assessment of environmental effects is addressed in **Ms Malcolm's** evidence. This incorporates peak flow and runoff results from my modelling to assess the sediment yield and sediment transport in fresh water. **Mr Gough's** evidence describes the proposed erosion and sediment control measures (including treatment ponds). **Ms Malcolm's** evidence regarding water quality assumes water is treated using the erosion and sediment control methods discussed by **Mr Gough**.

15 The ecological assessment of effects incorporates results from my hydraulic assessment of effects to consider the impact of the Project on the ecology of the receiving streams and the coastal environments. The effects are addressed in **Dr Keesing's** evidence.

16 The conceptual mitigation design discussed in my evidence and in **Mr Gough's** evidence was revised and adjusted where possible and as necessary based on feedback from **Ms Malcolm, Dr Keesing** and **Dr De Luca**, to minimise the adverse effects to within acceptable levels.

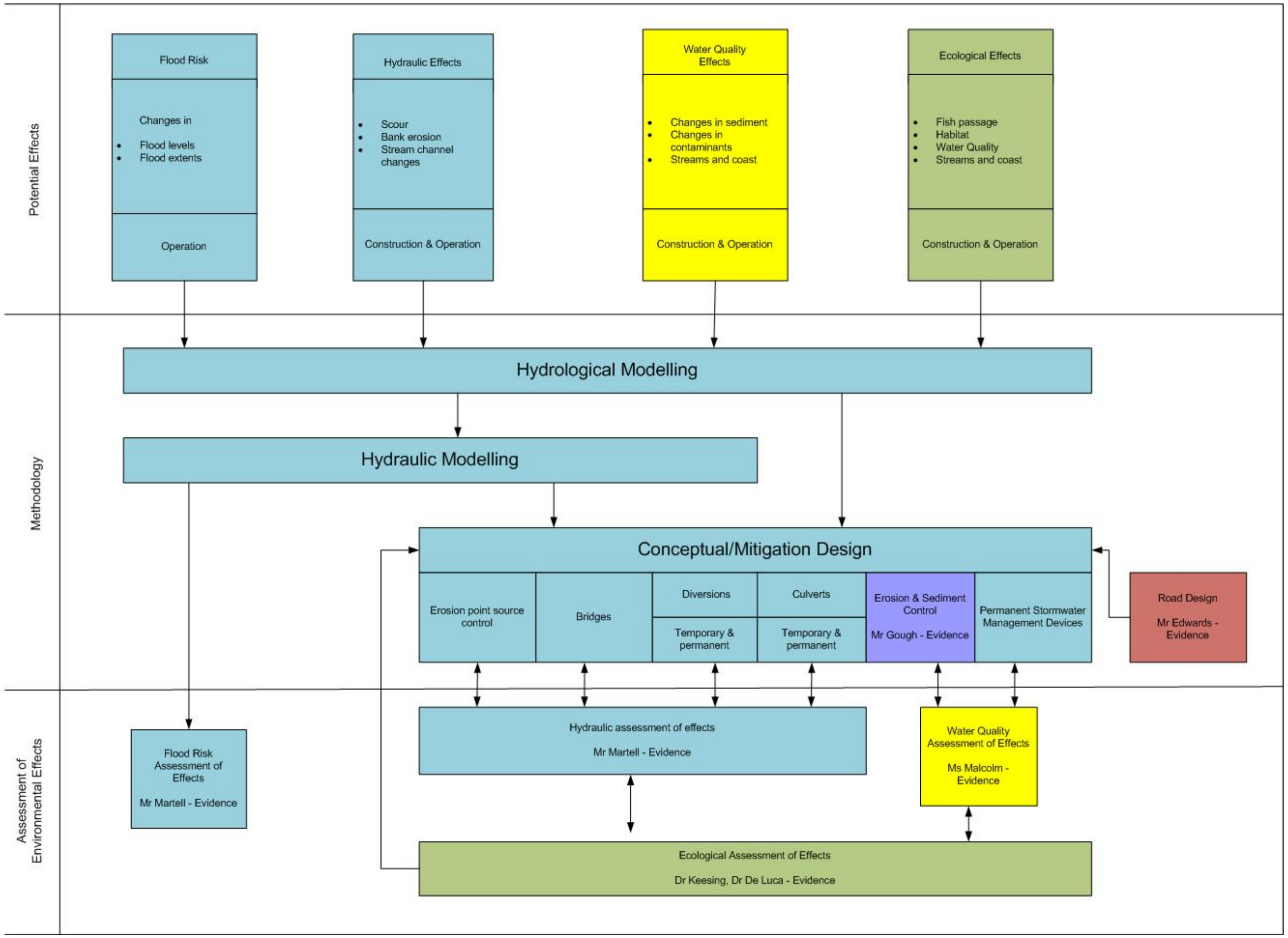

Figure 1: Potential effects and the interaction with the evidence of expert witnesses caused by changes to the hydrology and stormwater runoff during construction and operation of the Transmission Gully Project.

SUMMARY OF EVIDENCE

17 My evidence identifies and assesses issues associated with the quantity of water that is expected to run off the land and into the receiving environment. This includes construction and road runoff, stream flows and velocities, flood risk and point source erosion at culvert outlets.

18 I consider the receiving environment as being the streams, floodplains and any infrastructure potentially at risk from flooding within the catchments traversed by the Project. Modelling of potential effects on these receiving environments has been undertaken for both the during-construction and operational scenarios. The resulting information was then used to develop the design of cross culverts, bridges and stream diversions to test their ability to convey flows and minimise adverse effects. Rainfall, climate change and future planned development in the catchments were all factored into my assessments.

19 There are number of resulting effects of the Project, both positive and adverse. Positive effects are in the form of reduced flood risk to some areas, most notably the area around the Pauatahanui Substation.

20 Potential adverse effects can be caused by changes to the natural flow regime through culverts and bridges; stream diversion; and increases in the imperviousness of catchments increasing flood risk.

21 I consider these potential adverse effects can be managed through careful design and consent conditions, which will result in all effects being acceptably managed. Examples of these methods include:

21.1 Culverts and bridges have been sized to allow for predicted flows and velocities. They have been designed to allow for outlet erosion control and fish passage where required. The majority of the proposed culverts can be designed (during the detailed design phase) to comply with the relevant standards[5]. Kenepuru culverts K2 to K9 and Porirua culverts

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[5] The following standards are relevant to bridge and culvert design:

- Transit New Zealand's Bridge Manual (2003), supported by Austroads (1994). The Collection and Discharge of Stormwater from the Road Infrastructure. Research Report ARR 368, for design and best industry practice.
- NZTA's Stormwater Treatment Standard for State Highway Infrastructure (2010).
- Transit New Zealand's F/3 Specification for Pipe. The Construction (2000).
- OPUS International Consultants. (2008). Scheme Assessment Report (SAR). Report produced for the Transmission Gully Project.
- Guidance from Auckland Regional Council, (2000). Fish Passage Guidelines for the Auckland Region. Technical Report 131 (TP131); NIWA, (1999). Fish Passage at Culverts: A review, with possible solutions for New Zealand indigenous species; NIWA, (2003). Using ramps for fish passage past small barriers; NIWA, (2002), Successful fish passage past weirs.

PO2 to PO6 will not comply, because I recommend using storage behind the culverts to moderate peaks into the downstream stormwater network. I recommend the effects of these particular culverts are addressed by a specific consent condition discussed below.

21.2 Operational stormwater treatment can be implemented on site, largely as proprietary stormfilters, or as wetland treatment systems. These have been designed in accordance with NZTA and TP10 standards[6]. My team worked in consultation with **Ms Malcolm** to design and size operational stormwater treatment devices. The effect this has on the operational water quality is covered in **Ms Malcolm's** assessment of water quality effects.

22 The adverse effects from stream realignment relating to a change in stream form, and change to the flood risk, are potentially significant. However, with appropriate measures I consider these effects can be managed to an acceptable level:

22.1 Significant realignments are proposed in the Pauatahanui, Horokiri and Te Puka streams. My assessments conclude that without appropriate measures to manage effects, these could result in increased downstream velocities and flood risk. I recommend managing the effects by designing the new channels to replicate as closely as possible the existing channels, by allowing sufficient floodplain, meanders, and planting of stream banks – all of which are methods that will reduce water velocity (covered in proposed consent conditions WS.3). With these measures in place it is my opinion that the realignments will not have any significant hydraulic effects.

22.2 The Upper Te Puka Stream requires over 1km of realignment which will alter the natural form of the channel and the grade. This work will impact on stream velocities. I believe, based on a more detailed assessment of the stream works, and with the proposed consent condition WS.3[7], that a final solution to minimise effects in both the short and long term will be achieved.

23 There is the potential for a change in flood risk through loss of floodplain storage, alteration of secondary flow paths, increased runoff from the change in land use, and increased velocities due to changes in stream form. Recommendations have been made to minimise each of these potential effects. These recommendations

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6 NZTA's Stormwater Treatment Standard for State Highway Infrastructure (2010); and Auckland Regional Council, 2003, *Design Guideline Manual Stormwater Treatment Devices*, Technical Report 10 (TP10).

7 Requires the diversion be designed in a manner that seeks to maintain stream flows in a similar state to its natural state at the time of commencement of Work.

are detailed in Technical Report 14[8] and address site specific minimum requirements (i.e. minimum bridge width, minimum culvert sizes, and diversion dimensions). It is considered that with these recommendations implemented the flooding effects will be acceptable. These recommendations have been incorporated into the proposed consent conditions discussed below.

24 The Kenepuru, Linden and Waitangirua urban stormwater networks do not have sufficient capacity for the increased runoff from the change in land use associated with the road (i.e. an increase in impervious surfaces). In order to manage capacity issues at Kenepuru and Linden it is recommended that flood storage is provided in the upper catchment. In Waitangirua it is recommended that the stormwater capacity is increased in co-ordination with Porirua City Council's planned upgrades for this area and I recommend new consent conditions to address this.

25 The estimation of runoff peaks and the sizing of structures and diversions have been modelled using a catchment based assessment. This modelling has been used to assess the magnitude and extent of adverse effects. This level of analysis enables sizing of culverts and bridges with some conceptual mitigation design.

26 To determine the extent of effects at specific sensitive areas, Site Specific Environmental Management Plans (*SSEMPs*) were developed. These plans are detailed studies looking at effects on a subcatchment basis.

27 The SSEMPs have been developed as case studies. As part of the consent conditions, I am proposing that all works will require an Erosion and Sediment Control plan as part of the Construction Environmental Management Plan(s), to be approved by GWRC prior to construction occuring in the relevant part of the site (proposed consent conditions G.13 and E.4 to E.6).

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8 Sinclair Knight Merz, 2011. *Transmission Gully Project: Assessment of Stormwater Effects, Technical Report 14.*

BACKGROUND AND ROLE

28 I have been actively involved with the Transmission Gully Project Assessment of Hydrology and Stormwater Effects report (Technical Report 14) from the initial scoping phase and development of Project methodology. My role in the Project team has been as technical lead and lead reviewer for hydrology. I have also acted as the key liaison between the Project specialist consultants, NZTA/PCC and other interested parties. As the key liaison person, I have attended Project workshops, site visits and had a leading role in preparing the SSEMPs.

29 I was the technical lead for the development of hydrological and hydraulic models that were used for the calculation of stream flows and for the design of culverts and bridges, diversions, erosion outlet control, stormwater treatment devices and flood risk assessments.

30 I was involved in the development of the design philosophy and was the lead reviewer for the design of the erosion and sediment control devices, including the performance assumptions and the design included in the SSEMPs. The design philosophy and performance assumptions are discussed in Technical Report 15[9] and in **Mr Gough's** evidence.

31 I was the technical lead for the design of the operational stormwater management devices, including the design philosophy and conceptual design. The design philosophy and conceptual design are discussed in Technical Report 15.

32 I have been involved with scoping the concept design of bridges, culverts and diversions. I worked closely with the authors of the Ecological Impact Assessment report (Technical Report 11[10]) to achieve an integrated design solution that considers the desired objectives for both technical disciplines (Technical Report 11 and Technical Report 15). Freshwater ecological effects will be discussed in the evidence of **Dr Keesing**.

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[9] Sinclair Knight Merz, 2011. *Transmission Gully Project: Assessment of Water Quality Effects, Technical Report 15.*

[10] Boffa Miskell, 2011. *Transmission Gully Project: Ecological Impact Assessment, Technical Report 11.*

METHODOLOGY — HOW RAINFALL RUNOFF WAS CALCULATED

33 This section discusses the hydrological modelling methodology. This modelling was required to provide inputs into the hydraulic methodology and conceptual mitigation design. The hydrological assessment is derived from a rainfall runoff model. This section discusses:

(a) The purpose for developing a rainfall runoff model;

(b) The need to include climate change in design to manage adverse effects for the foreseeable life of the asset; and

(c) Rainfall runoff modelling scenarios to model the effects and compare the effectiveness of mitigation measures.

34 To quantify the volume of water that is expected to run off the land as a result of construction and operation of the Project, and to manage adverse effects, a number of models were developed. The base model was developed to estimate runoff over the catchment without the Project. This was compared to the estimated runoff over the catchment with the Project. Any changes in peak[11] and volume of runoff can have a number of other effects including: hydrological and hydraulic impacts to flood flows and the sizing of bridges and culverts; water quality impacts to colour, clarity and suspended sediment; and ecological impacts to fish and sedimentation in streams and the receiving estuarine environment.

35 By quantifying runoff from the catchments, it is possible to:

35.1 Size the permanent and temporary culverts including allowance for fish passage;

35.2 Design culverts to minimise blockage at the inlet and manage erosion at the outlet;

35.3 Model proposed stream diversions;

35.4 Model the change in flood risk to the natural receiving environment;

35.5 Model the change in flood risk to downstream urban areas.

36 The process followed to quantify runoff and assess the effects is detailed in **Figure 2**.

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[11] Peak is defined as the maximum instantaneous flow to run off the catchment. Volume is the total amount of water to run off the catchment.

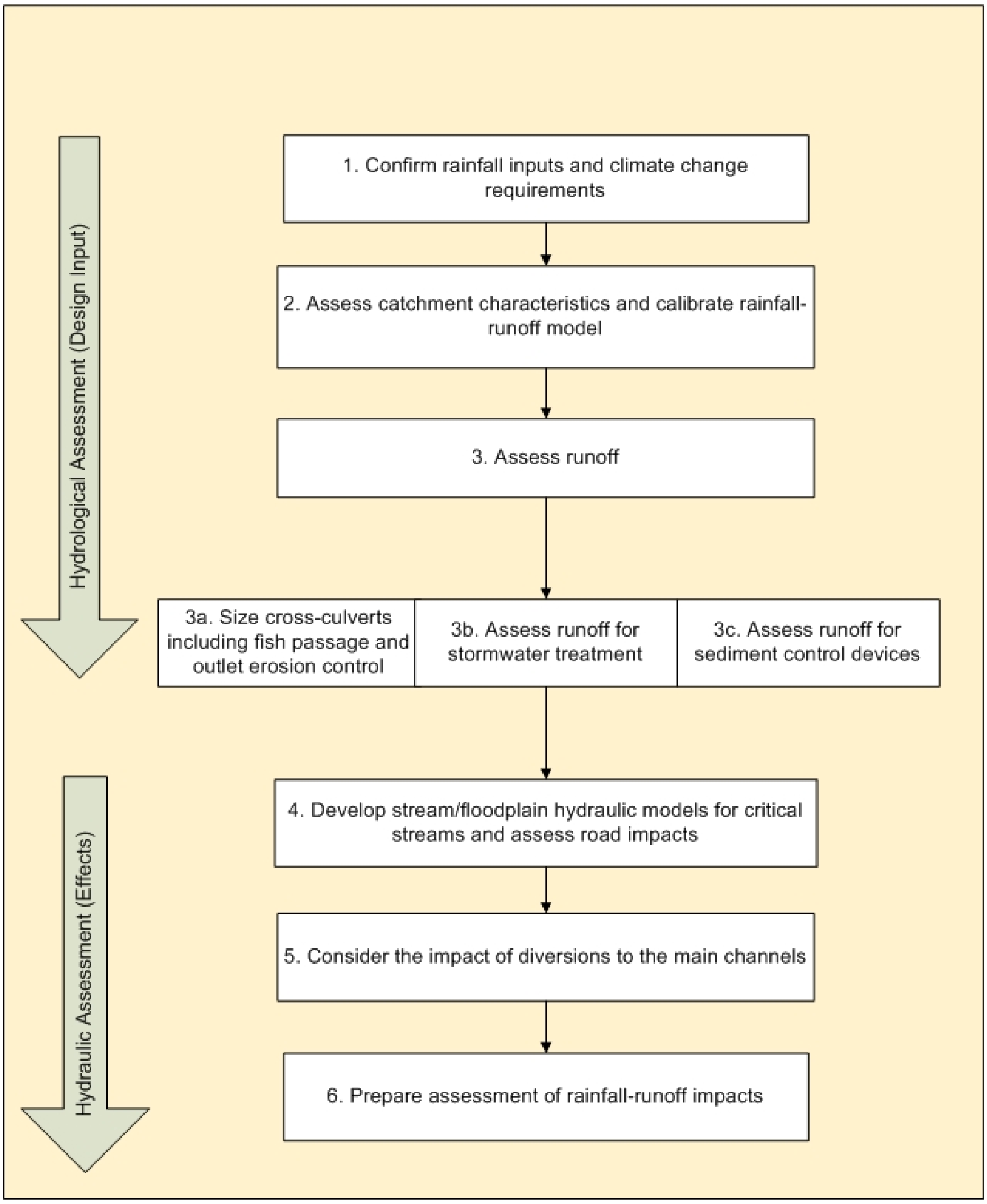

Figure 2: Rainfall runoff assessment process

37 A rainfall runoff model was developed to estimate runoff based on a detailed assessment of catchment characteristics, and design rainfall estimates derived for the local area. The model was calibrated to recorded events in gauged catchments within the Project area. Details of the rainfall runoff process and calibration are explained in Chapter 4 of Technical Report 14.

38 The predicted mid-range impacts of climate change were incorporated into the Project's design so that the assessment of effects would accommodate the foreseeable life of the asset being

constructed. The Ministry for the Environment report on climate change[12] estimates the change in rainfall intensities. For the Project area a 16% increase in heavy rainfall intensities by the year 2090 is estimated. A 16% increase in rainfall intensities has been applied to all operational assessments.

39 To assess the potential changes in runoff, three scenarios were modelled:

39.1 Without Project situation (baseline) – As the construction of the Project is scheduled to begin in 2014/15, assumptions about the nature of the pre-construction catchments were based on existing land use with the planned land use changes and likely development in the catchment in 2031 without the Project. These catchments were modelled for both the 10 year (10% AEP) and the 100 year (1% AEP) return period rainfall event[13], including the predicted mid-range impacts of climate change;

39.2 With Project situation – The same 2031 catchment characteristics were used, but the post-construction model also included any catchment changes directly associated with the Project. The catchments were modelled for both the 10 year and the 100 year return period rainfall event, including the predicted mid-range impacts of climate change. The 2031 year was selected for comparison to include any permanent operational effects from the Transmission Gully Project;

39.3 Ultimate-development situation – For the sizing of permanent culverts, an ultimate development land use layer was used to account for runoff over the expected life of the asset. This took into account proposed future land use zones and expected population growth, and included the mid-range impacts of climate change.

40 For each of the detailed stream investigations a combined 1D and 2D hydraulic model was constructed using the DHI software package MIKEFlood.

41 To quantify the hydraulic impacts of the Project, the base models of the existing streams and floodplains were altered to include the scheme design of the Project. Both the hydraulic and hydrological models were updated to reflect the changes to factors such as

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12 Ministry for the Environment, July 2008. *Preparing for Climate Change – A Guide for Local Government in New Zealand.*

13 This is the statistical probability (or the annual exceedence probability – AEP) of a storm of this magnitude occurring i.e. 10% AEP. The ARI (annual recurrence interval) is the statistical return period of an event of this magnitude occurring i.e. 10 year event.

topography and land use directly associated with the Project. Further details for the hydraulic modelling methodology are contained in Appendix 14.E of Technical Report 14.

DESIGN AND PERFORMANCE CRITERIA

Bridges and culverts

42 Culverted stream crossings have been assessed in accordance with the Scheme Assessment Report which required that; *Culverts along the route should be sized to convey the critical duration 10% annual exceedances probability rainfall storm event without heading up above the pipe soffit. The road surface level should be at least 500 mm above design stormwater levels for a 1% annual exceedances probability event*. (OPUS, 2008).

43 The culverts were sized assuming the mid-range climate change estimate of a 16% increase in rainfall intensities. I consider this to be an appropriate standard; that the road should not be flooded in a 100 year storm event and the majority of the culverted stream crossings should be sized so as not to constrain the flows expected in a 10 year storm event (the sizing of Linden and Kenepuru culverts and runoff attributed to the Waitangirua link road are addressed separately).

44 These requirements are consistent with the Transit New Zealand's *Bridge Manual* (2003) sections 2.3.2 (b) and 2.3.4 (a) for larger crossings as follows;

44.1 In the design of a stream crossing, the total waterway shall be designed to pass a 1% annual exceedance probability (AEP) flood without significant damage to the road and waterway structure(s);

44.2 When considering the level of serviceability to traffic the following freeboards[14] shall be used:

[14] Freeboard is an allowance added to modelled top water levels to account for a range of uncertainties and approximations that are made in the modelling.

Table 1: Transit New Zealand's Bridge Manual (2003)

Waterway structure	Situation	Freeboard	
		Measurement points	Depth (m)
Bridge	Normal circumstances	From the predicted flood stage to the underside of the superstructure	0.6
	Where the possibility that large trees may be carried down the waterway exists		1.2
Culvert	All situations	From the predicted flood stage to the road surface	0.5

45 Transit New Zealand's Bridge Manual and relevant material design codes[15] specify levels of durability that culverts, bridge structures, and their component members must comply with for this Project. Culverts and bridges have an expected design life of 100 years. This is the best practice level of service[16] and I consider this to be an appropriate standard for the asset life.

46 Fish passage design guidance is provided by the Auckland Regional Council TP131 *Fish Passage Guidelines for the Auckland Region* (2000) and NIWA publications *Fish Passage of Culverts: a Review with Possible Solutions for New Zealand Indigenous Species* (1999), *Successful Fish Passage Past Weirs* (2002), and *Using Ramps for Fish Passage Past Small Barriers* (2003). This is consistent with GWRC *Fish-friendly culverts and rock ramps in small streams* publication. The fish passage design was developed in consultation with **Dr Keesing**.

Flood risk

47 The performance criteria adopted to assess the flood risk throughout the majority of the alignment was a risk based approach assessment of effects.

Operational stormwater management

48 The level of service proposed to achieve the stormwater treatment philosophy is based on addressing the potential effects as recognised by **Dr Keesing** and the following rules and guidance:

48.1 Rules set out in the Greater Wellington Regional Council's *Regional Freshwater Plan (1999);*

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15 Transit New Zealand (2003) *Bridge Manual*; NZTA, (2010), *Specification for Pipe Culvert Construction*. NZTA F3:2010.

16 New Zealand Asset Management Support (NAMS); Wellington City Council (2006) *Code of Practice for Land Development*; Porirua City Council (2010) *Code of Land Development and Subdivision Engineering.*

48.2 NZ Transport Agency's *Stormwater Treatment Standard for State Highway Infrastructure (2010);*

48.3 Auckland Regional Council's (ARC) *Stormwater Treatment Devices: Design Guidelines Manual (2003)* (referred to as TP10).

49 Operational stormwater treatment is designed around the two key factors of water quality to be achieved, and the volume of water which can be treated:

49.1 The target standard adopted, and which I consider acceptable for long term water quality treatment, is removal of 75% of total suspended solids (*TSS*). This level of removal is considered best industry practice within existing standards, and is known to remove the great proportion of heavy metal solids;[17] and

49.2 The treatment volume for stormwater management devices is based on the volume of the 90th percentile storm (the probability that 90% of rainfall events in a given year are smaller than this storm)[18]. In the current climate in this area NZTA guidance[19] equates this to approximately 25mm of rainfall. However, because of the Project design life, it is more conservative to use the 2090 climate. The 90th percentile storm for 2090 has been calculated as an average of 27mm of rainfall across the Project catchments.

MANAGEMENT OF EFFECTS

Temporary works within watercourses during construction

50 Within each catchment there are a large number of small tributaries and some larger streams that require temporary crossings to be built to facilitate construction access.

51 The effects of temporary works within water bodies, both waterway diversions and crossings, have potential for erosion, discharges of sediment, changes in flood risk and general damage to the banks and bed of the watercourse itself. These effects are able to be managed to acceptable levels through appropriate design and construction methodologies.

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17 (Livingstone, E.H, (2001). *Protecting and Enhancing Urban Waters through Catchment Management: Using all of the tools in the BMP tool box successfully*. Bureau of Watershed Management, Florida Department of Environmental Protection, USA).

18 This is approximately equivalent to 1/3 of the 2 year return period storm.

19 NZTA, (2010), *Stormwater Treatment Standard for State Highway Infrastructure.*

Flood risk associated with temporary bridges and culverts during construction

52 Temporary culverts (to provide for construction access across the alignment) have been appropriately sized using the Rational Method[20]. The temporary bridges and culverts have been sized to convey peak flows in a 2 year flow (50% AEP). This design standard was considered appropriate as any temporary culvert will not be in use for more than 2 years. However it is expected that at some point during construction an event larger than the 2 year flood will occur. To manage the effects from larger flood events culverts will have a minimum depth of cover to allow overtopping to occur. I recommend a new condition be developed to address this.

53 Where fish passage has been considered by **Dr Keesing** to be necessary, culverts have been upgraded by 300mm and will be countersunk[21] to form a continuous wetted perimeter making the culvert passable to native fish species. Where this is not possible, or the grade and resulting velocities through the culvert are assumed too great for fish passage, an alternative fish passage solution has been used. The effects on fish passage are discussed in Technical Report 11 (section 9.2), and in **Dr Keesing's** evidence.

Bridges and culverts during construction and operation

54 Other than effects generated by temporary works in the bed of streams, there are other effects typically associated with the placement of culverts and bridges in waterways, including:

54.1 With open channel flows being directed through culverts, there is potential for scour to occur around the outlets. Also, the increase in flow velocities through culverts or stepped changes in the grade of the channel can impede fish passage. Scour can also be an issue around bridge abutments, if these are positioned within a waterway;

54.2 Culverts can provide a constraint to extreme event storm flows, including being blocked by debris. This can impact on the flood risk to the surrounding area.

55 Where the placement of these structures is permanent, there is more risk that scour and erosion may occur as the structures will be subject to continual significant events over the duration of the asset life.

56 A minimum culvert size of 600mm has been assumed for all catchments to reduce the risk of blockage. In addition, debris

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[20] The rational method is used to estimate peak flows. It has been adopted widely by many Councils (including GWRC) as a means to estimate peak flow on small catchments.

[21] Lowered below streambed level.

control devices and fish passage will be provided where required while maintaining flow.

57 To provide fish passage the same methodology described above for temporary crossings will be used. It is considered that the two proposed methods of fish passage (the standard countersunk method, and the alternative method where culverts are on a steep grade or longer than reasonable for fish passage) will be effective at providing fish passage to the upper reaches of the catchments.

58 Culverts have been sized to meet NZTA requirements (and additional standards detailed in paragraph 21.1). I believe these standards are appropriate for this Project. To size the culverts consideration was given to design flows, velocities, outlet erosion control, upstream storage, maintenance requirements, and debris control and freeboard. There are no significant issues associated with the sizing of culverts due to the hydraulically steep terrain and standards are being complied with in most situations.

59 For those that do not comply (namely Kenepuru culverts K2 to K9, and Porirua culverts PO2 to PO6), I recommend using storage behind the culverts to moderate peaks into the downstream stormwater network. I recommend new specific consent conditions are developed to address this.

60 Culvert velocities have been assessed and matched to those culverts that require fish passage from **Dr Keesing's** assessment of the freshwater environment. In general, low flow velocities in culverts can be maintained at levels that allow fish passage for the recorded species. Where the drop from the upstream side of the proposed road to the floodplain is substantial and does not easily allow for ongoing fish passage, stepped erosion control structures are proposed that will provide fish passage opportunities. The ecological effects of cross culvert design are covered in the Technical Report 11.

61 I have proposed that culvert outlet erosion control is provided at all culvert outlets. Two standard designs have been considered to manage specific Project risks. Debris aprons have been proposed for shorter culverts or those on a shallow grade, and cascade structures for longer culverts on a steep grade (section 5.4.6 of Technical Report 14). My analysis confirms that if erosion control is implemented as proposed the impacts will be less than minor.

Stream realignment/Diversions

62 The Pauatahanui, Horokiri and Te Puka Streams all have significant diversions associated with the construction of the Project. If not properly designed realignment can have an impact on the natural flow regime and ability to convey flood flows.

63 In general, the hydraulic modelling undertaken of these streams has demonstrated that, to minimise the impacts on the hydraulic character of the streams, the diversions will need to be constructed to meet the following scheme design criteria (which I recommend be included within proposed consent condition WS.3):

63.1 The existing channel shape and gradient should be duplicated as closely as possible;

63.2 Sufficient floodplain must be available to allow for flood flows to be conveyed without significant increases in velocities;

63.3 Where the diversions result in changes in length and gradient, the stream banks surrounding the diversions should be planted to help reduce increases in velocities in high flows.

64 Due to the significance and construction complexity of the Te Puka diversion, further work was undertaken to limit as far as possible the effects of this diversion and confirm how it would be constructed and staged whilst maintaining the ability to pass significant flows. I led a team to investigate the Project construction through this area. This formed the Te Puka SSEMP[22]. The work included a staged construction programme to test the constructability of the design.

65 The Te Puka Stream has a high natural value that needs to be maintained[23]. The Te Puka diversion requires 1.2km of stream to be realigned while working within this sensitive environment. The SSEMP showed that it was possible to undertake this diversion while reducing the effect on the receiving environment. Specifically:

65.1 The stream was raised in the upper reaches to remove cuts to the eastern side of the valley retaining native vegetation on one side of the constructed waterway;

65.2 It avoids ‘covering’ over of the waterway with extended culverts;

65.3 It manages higher velocities in short falls to meet ecologists’ requirements;

65.4 It confirms a method is available for the staging of construction that manages sediment and higher stream flows.

66 The Te Puka SSEMP confirmed that construction design could be staged in a manner to meet the performance standards, including

[22] NZTA, *Indicative Site Specific Environmental Management Plan (SSEMP): Te Puka Stream Focus Area,* Volume 5 of the AEE.

[23] NZTA, *Indicative Site Specific Environmental Management Plan (SSEMP): Te Puka Stream Focus Area,* Volume 5 of the AEE.

managing the higher velocities and stream flows to meet the ecologists' requirements; and erosion and sediment control devices could be constructed to meet the water quality requirements. Proposed condition E.20 requires the Te Puka SSEMP to be finalised, certified by the GWRC, and implemented.

67 I believe that if the permanent stream diversions follow the above design criteria (paragraphs 63.1 to 63.3), then the effects on flood conveyance will be less than minor.

68 The ecological effects of stream diversions are discussed in **Dr Keesing's** evidence.

Operational stormwater runoff

69 Once the Project is operational the road will introduce additional contaminants into runoff that will discharge into the receiving environments. Left untreated this can have an adverse effect on the downstream water quality and ecology.

70 The devices proposed to treat rainfall runoff for the Project are detailed in **Table 2**. Other devices such as water quality ponds, sand filter boxes, infiltration trenches and rain gardens have not been considered due to the size and nature of the road making them unsuitable. Operational stormwater devices are designed to meet the performance standards as set out in paragraphs 48 and 49.

Table 2: Operational stormwater treatment devices

Device	Specific Use	Controlling Factors
Proprietary devices[24]	Small catchment area Allows for steep slopes Space constraints (cut/fill areas)	Runoff Volume
Wetland/Pond	Medium-large catchments	Available space Slope Soil Hydrology

71 Swales and filter strips were included in the preliminary design. However, swales require significant extra road width (if treating both sides of the road) as compared to using concrete channel drainage. The additional road width required to achieve effective treatment would be difficult to attain in the narrow sections of the

[24] This is a filtration system designed to remove fine solids, soluble heavy metals, oil and total nutrients from stormwater. It is a self-contained unit that is not dependant on the surrounding topography or soil type to effectively treat stormwater runoff.

road such as where the road alignment is in cut, and the greater cuts required would have had associated environmental effects. Thus, in later designs swales were not included.

72 Using wetlands as is proposed for the medium and larger catchments intersected by the Project, is preferred to using ponds as they have improved overall water quality treatment and do not have the safety concerns that deeper ponds have, as outlined in the NZTA stormwater guidelines[25].

73 Each treatment system has a certain range of applications which depend on site constraints. The method for designing and locating stormwater treatment devices, having regard to site constraints for the alignment, is described in section 16 of Technical Report 15.

74 Where proprietary devices are required it is proposed a Stormwater360 StormFilter with ZPG media be used. If in the subsequent detailed design an alternative technology is employed, the system will be required to be at least as effective as the Stormwater 360 StormFilter for removal of TSS, TPH and metals[26].

75 A Contaminant Load Model (see Chapter 17 of Technical Report 15), and discussed in **Ms Malcolm's** evidence), has been used to assess the effectiveness of the proposed devices in removing TSS and contaminants from the Project discharges, and is used to inform the assessment of effects of stormwater discharges on the receiving environment.

Open channel flood risk

76 A risk assessment of the streams crossed by the Transmission Gully Project[27] identified six streams/networks[28] where the construction of the road and stream diversions could potentially result in significant changes to the upstream or downstream risk of flooding.

77 Hydraulic models were constructed to assist in the analysis of these six streams/networks. The hydraulic models were used to assess the potential flooding impacts associated with:

77.1 Loss of storage on the floodplain due to earthworks;

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25 NZ Transport Agency. (2010). *Stormwater Treatment Standard for State Highway Infrastructure*.

26 The removal efficiencies of contaminants by using the StormFilter 360 are estimated in the Auckland Regional Council's Contaminant Load Model as being 75% for TSS, 55% for total zinc, 65% for total copper and 75% for TPH. See section 15.5 in Technical Report 15 for further details.

27 See section 3.3 (table 14.1) in Technical Report 14 for the risk assessment process.

28 The six streams/networks where hydraulic models were undertaken were Pauatahanui Stream, Horokiri Stream, Te Puka/Wainui Stream, Duck Creek and network, Linden stormwater network and Waitangirua stormwater network.

77.2 Alteration of secondary flowpaths by the proposed road alignment;

77.3 Increased runoff associated with the change in land use; and

77.4 Impacts of changes in stream alignment and shape.

Pauatahanui Stream

78 A major interchange is proposed on the Pauatahanui Floodplain. A range of options were tested to reduce the hydraulic impacts of the associated filling on the lower floodplain and the constraint caused by the stream crossing. The hydraulic model of the stream was used to size the crossing, locate overflow paths and allow for maintaining the existing stream channel shape under the bridge.

79 The modelling indicated that there was likely to be an increase in water levels upstream of the new bridge during extreme flooding events such as the 100-year average recurrence interval flood event. These effects are localised to the area immediately upstream and can be managed to avoid increasing the flood risk to the existing infrastructure.

80 The model also identified that the low lying sections of the back yards of four properties in Joseph Banks Drive are also likely to experience increases in flood levels as a result of the construction of the new highway[29]. The increase does not endanger any of the existing buildings and there are a range of options to mitigate these impacts. I understand the NZTA is consulting with the owners of the affected properties, to determine whether any mitigation works are required.

81 If the recommendations made in section 6.1 of Technical Report 14 and in the proposed consent conditions (including new conditions recommended in this evidence) are incorporated into the highway design, the adverse hydraulic effects can be largely mitigated. In some locations, such as the existing Pauatahanui Substation, there is a positive effect on flooding by a reduction in flood risk.

Horokiri Stream

82 The key potential impacts of the new highway in the Horokiri Stream catchment include the changes in flooding levels associated with the new bridges on the main channel and the alteration of the stream channel in the vicinity of the new diversions.

83 The additional runoff associated with the change in land use was found to increase peak discharge from the stream by less than 1%

[29] An increase of between 100 and 200mm is likely. See section 6.1 of Technical Report 14 for further details.

and therefore has almost no observable impact on the flood levels in the model.

84 Three bridges (bridge numbers 4, 6 and 8) are proposed for crossing of the main alignment in the upper reaches of the Horokiri catchment. The hydraulic model was used to test the adverse effects from construction, and to test the success of a range of mitigation options.

85 Based on the analysis of the model results, a number of recommendations have been documented in section 6.2 of Technical Report 14, including the dimensions of the diversions, bridge widths and localised protection measures. I suggest these recommendations also form new proposed consent conditions which relate specifically to the Horokiri Stream. I consider these recommendations limit the hydraulic effects to localised impacts around the new highway. I believe these effects will be able to be remedied, or mitigated to within the area of the proposed road designation.

Te Puka/Wainui Stream

86 The flood risk impacts to the Te Puka/Wainui Stream results from the Project crossing branches of the Te Puka/Wainui in four locations. To pass over the Te Puka stream, a stream diversion and bridge were modelled, and over the Wainui stream branches, culverts and a stream diversion were modelled. These structures and diversions will alter the natural stream channel and flood risk.

87 Limiting or mitigating the hydraulic effects of the new highway in the Te Puka/Wainui catchments will require careful design of new stream crossings and management of high stream velocities. The hydraulic model was used to identify the 'at risk' locations and resulted in recommendations for culvert sizes and scour protection. The modelling demonstrates that the new highway will increase flooding in the area directly upstream of the Wainui stream twin box culverts, though I believe this can be effectively mitigated by localised protection. The Project will largely result in a positive effect downstream of the road by reducing the flood depth. The key to the management of the flood risk for both the new highway and downstream properties is the appropriate sizing of the culverts to take the design flows, the modelled bridge, culverts and diversions layout. I recommend new conditions are developed to ensure these are appropriately taken into account in detailed design.

Duck Creek

88 The Waitangirua Link Road crosses Duck Creek. The predicted 2% change in peak flows resulting from the construction of the Project is assessed to be minor. Mitigation for increased flows in a Q100 event can be provided by creating storage upstream of the Waitangirua Link Road crossing (BSN 29). Here the peak flow in a

100-year flood event can be restricted to below the pre-construction situation, reducing any potential effects to negligible levels. The 10 year flow passes through the culvert without the water level increasing above the pipe soffit[30].

89 In a Q100 event approximately 4000m^3 of water will back up above the pipe soffit. This volume of water will drain over approximately 2 hours. I believe the effect of storing water in the catchment for approximately 2 hours in infrequent large events, to be less than minor.

Local network flood risk

90 Localised hydraulic models of the Waitangirua and Linden stormwater networks were constructed to help better understand the existing flood risk and compare that against the potential flood risk if additional runoff from the Project is diverted through the existing stormwater network. Mitigation measures, such as detention storage and network upgrades, are proposed to manage the potential adverse effects.

Linden stormwater network

91 Modelling indicated that for the Linden stormwater system there is not capacity within the existing system in large (10% or 1% AEP) storm events to accept the additional runoff resulting from the Project. Several mitigation options have been considered, with attenuation of peak flows in the upper catchment the recommended option[31]. With this implemented the effect of the Project on downstream flooding is assessed to be less than minor.

Waitangirua stormwater network

92 The existing stormwater network beneath Waitangirua is undersized. The network currently does not have the capacity to convey a 10-year peak flow (including a mid-range climate change scenario), even without the road. It is recommended that when the Waitangirua Link Road is constructed the stormwater network is upgraded, which will remove any adverse effects from the construction of the Waitangirua Link Road.

Behind culvert flood risk

93 All of the culverts along the alignment will act as a constraint to flows above a 10% AEP storm (including climate change). In this situation water will pond behind culverts inundating farmland that would not previously have been affected by extreme flows. The affected areas are generally steep gullies, but in some cases flatland areas will be affected by increased ponding behind culverts. In general these increases in depth are small, infrequent and short in

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[30] NZTA (2003) *Bridge Manual* requirements.

[31] Storing of water in the upper catchment to reduce the flood peak and release the volume of water over a longer period of time.

duration and are all within the boundaries of the designation. This ponding is considered to be a minor issue.

RESPONSE TO SUBMISSIONS

Submitter 19 – Mr Eberhard Deuss

94 Submission 19 suggests a realignment of the road near the submitter's property.

95 Without a concept design it is difficult to visualise the impact this could have on the Horokiri stream crossing (BSN 8). The current alignment is constructible without a diversion of the waterway in this location. This may be more difficult to achieve under the proposed scenario, in that the road is likely to be closer to the stream, and may require more significant earth retention (retaining walls) to reduce the footprint of fill batters so that they do not impact on the waterway.

Submitter 23 – Kapiti Coast District Council

96 Submission 23 suggests that stormwater attenuation is required so that there is no increased stormwater runoff in the Te Puka Stream catchment.

97 Stormwater attenuation, to achieve hydraulic neutrality in events up to the 100 year flood including the mid-range climate change prediction, can be achieved in the Whareroa catchment by attenuating the change in peak runoff in the proposed Whareroa wetland.

98 Attenuation of peak flows in the Wainui/Te Puka catchment has been realised upstream of the road. Hydraulic modelling carried out for this Project indicates that the inundation depth downstream of the Project will be marginally reduced by construction of the road (Figure 14.25 in Technical Report 14).

Submitters 23, 28 – Kapiti Coast District Council, KCDC Grey Power Association

99 Submissions 23 and 28 raise concerns about an increased flooding risk on land where the Council intends to procure a new bore.

100 There will be an increase in peak water levels adjacent to the Wainui Stream upstream of the Project as a result of Bridge 2 constricting flood flows. The increase in peak water levels in a 100 year flood is isolated to the land directly adjacent to the Stream channel. The test bore for Paekakariki water supply is outside this area so the Project will not impact on flood levels in an event of this magnitude. This is shown in figure 14.25 in Technical Report 14.

Submitter 26 – Mr Jacob Shapleski

101 Submission 26 raises general concerns about the impacts of the Project on the region's hydrology.

102 Most major roading projects will result in a change to the hydrology as pervious areas (vegetation) are converted to impervious (road surface). The Transmission Gully Project is no exception, however many design measures have been put in place to avoid or mitigate the adverse effects on hydrology.

103 The change in the connected impervious area in each catchment attributed to the Project is minimal with the maximum change being 1.5% in the Duck Creek catchment. This is a relatively small catchment with approximately 5km of road running through it. **Table 3** below details the change to connected impervious area for each of the affected catchments. The resulting impact on the catchment peak flow is minimal.

Table 3: Change in connected impervious area attributed to the Project

Catchment	Change in Connected Impervious Area (%) attributed to the Project
Wainui/Te Puka	1.4
Whareroa	0.2
Horokiri	0.5
Ration	1.1
Pauatahanui	0.3
Duck	1.5
Kenepuru	0.5
Porirua	0.2

104 Figure 15.83 in Technical Report 15 discusses how increases in connected impervious areas can result in the degradation of stream habitat. Paraphrased from this document; t*wo thresholds exist: where catchment imperviousness exceeds 10% sensitive stream elements are lost; and where catchment imperviousness exceeds 25-30% and most stream quality indicators show poor health. The Kenepuru and Porirua catchments by 2031 (excluding Transmission Gully) will have high imperviousness (exceeding 22%) so fall into the heavily degraded classification. The Duck catchment in 2031 will have a connected impervious area of 11% (excluding Transmission Gully) so many sensitive stream elements will already be at risk. The remainder catchments are rural in natural and therefore*

construction of the road is unlikely to threaten the more sensitive elements.

105 Wetlands are included in the design where the catchment characteristics allow. These have been primarily designed to treat stormwater runoff, though the Whareroa wetland has sufficient available space to allow the attenuation of flow to pre-construction levels.

106 Native planting is planned throughout parts of the catchment, often replacing areas of pasture with forestry. Once the planting is established, this will help offset the increase in peak flow. The effect of planting on catchment runoff was not included in analyses as it will take an unknown number of years for the plants to establish.

107 Runoff that drains through urban stormwater networks will largely be attenuated in the catchment to ensure no adverse effects on the existing stormwater capacity. The Waitangirua link road is the exception to this rule as no storage is available in the upper catchment. The effects on the stormwater network will be mitigated through a new proposed consent condition discussed below.

Submitters 31, 36, 51, 52, 62, 63 – Sheriden C and Osborne A D, Gail and Murray Milner, Mr Jianfei Li, Mrs Judith Esther Gray, David and Janet Barnes, Sallie Binion Hill and Jon Sinclair Grace

108 These submitters raise concerns about the possibility of a disruption to their stormwater and sewer services, caused by a proposed construction compound and construction activities.

109 The formation of the site compound would consider existing sewer and stormwater services. This could be drawn into the conditions of consent if there is lasting concern.

110 Any planting (to provide a visual barrier) around PO6 should consider long term access needs for cleaning and maintenance of the culvert intake.

Submitter 43 – Department of Conservation

111 The submission by the Department of Conservation notes that the construction of culverts, and earthworks necessary for relocation of the transmission line, have not been assessed.

112 As stated in paragraph 6 above, my evidence does not relate to the Transpower Project. I understand that Transpower intend to lodge resource consent applications for any regional consents at a later time.

Submitter 60 – Whitby Coastal Estates Ltd

113 The submission by Whitby Coastal Estates Ltd suggests that various changes to bridges, culverts and dams within the Duck Creek catchment, on the basis that these would control flood flows.

114 Bridges 17 to 19 could be culverted and used as flood storage. Alternately small choker dams could provide a similar function. However, importantly, I believe the flood impacts of the Transmission Gully Project can be mitigated without either of these measures (which have other ecological impacts).

RESPONSE TO KEY ISSUES REPORT

115 The Key Issues Report prepared by GWRC raised a number of issues relevant to my evidence.

116 In response to specific paragraphs:

116.1 Paragraph 5.4 addresses the damming/diversion of flood flows in the Duck Creek valley where it is proposed that flow in large infrequent events (greater than a 1 in 10 AEP flood) will be attenuated in the catchment. In a 1 in 100 year event flood levels are expected to peak at a maximum height of approximately 50m ASL[32]. This is approximately 1m above the box culvert soffit level with a maximum volume of water of 4000m^3 above the soffit level expected to pond for less than 2 hours. This does not represent any interference of peak flows in the stream during events equal to or less than a 1 in 10 year AEP and only partial interference, for a short period of time, in rare events of a greater magnitude than this. I believe the culvert should not be considered as a dam on this basis.

116.2 Paragraph 8.4.1 addresses the impact of increased flows in the Duck Creek culvert to downstream developers. Attenuating the flow in large flood events will reduce the runoff to pre construction levels. This will result in no change to the design peak flow assumptions for downstream developers. I recommend a new consent condition is developed which requires that the detailed design provides for flows from large flood events to be attenuated in the catchment.

32 Metres above sea level.

PROPOSED CONDITIONS

117 The critical aspects of the consent conditions revolve around maintaining the natural stream flow (peak and velocity) and channel form as closely as possible to mimic the natural system and limit potential adverse effects. The objectives of the consent conditions are to:

(a) Maintain as closely as possible the natural stream flow (peak and velocity) to retain, and in areas to enhance, fish passage.

(b) Duplicate the existing channel form (channel shape and gradient) as closely as possible so that the catchment and hydraulic processes remain largely unchanged.

(c) Plant the new channel banks to resemble the natural channel form so as to reduce peak velocities by providing a rougher floodplain surface and reducing the bank scour potential.

(d) Allow for adequate floodplain through bridges to manage peak velocities and scour around structures.

(e) Reduce inlet blockage and outlet erosion of culverts.

(f) Mitigate the flood risk to downstream users.

118 I was involved in the preparation and review of the hydrology and stormwater effects proposed consent conditions contained in chapter 30 of the Assessment of Environmental Effects. However, after considering the Key Issues Report by GWRC, and the comments from submitters, I recommend further conditions are included. I have described in my evidence what these conditions should address, and understand they will be included in a revised set of conditions to be provided with rebuttal evidence. In my opinion, the proposed conditions will appropriately control the constructional and operational stormwater effects of the Project to meet the above objectives.

119 Chapter 30 of the AEE includes proposed conditions on resource consent RC14. The conditions relate to global streamworks for construction and are general conditions associated with the effects of stormwater and channel hydraulics. These proposed conditions that relate to my work are summarised below:

119.1 S.2 requires detailed design plans and construction methodology be submitted to the Manager for approval, providing detail of the culvert inlet and outlet protection structures, and the appropriate sizing of culverts and allowance for secondary flow paths during high flows.

Condition S.2 was developed to make certain a minimum design standard for culvert inlet and outlet protection structures, culvert sizing and secondary flow paths is adhered to. Culvert sizing and secondary flow paths will be sized appropriately to minimise the flood risk.

119.2 S.5 requires the consent holder to prepare and implement a revegetation and mitigation strategy for stream modifications.

This condition requires stream bank planting using native plants consistent with the area to stabilise stream banks. This will help reduce peak velocities and provide stream bank protection in a timely manner.

119.3 S.8 requires all practicable steps to be taken to minimise sedimentation and disturbance of streams during construction.

This condition in part addresses temporary and permanent culverts, bridge crossings, and stream diversions as works are required to realign channels and construct structures. Disturbance of the stream should be avoided where possible, and minimised where works in the channel are unavoidable. S.8 specifically states performance objectives to minimise the risk of construction in and adjacent to waterways and potential adverse effects on water quality and ecology.

119.4 I believe that if all conditions on resource consent RC14 are adhered to then the potential adverse effects through design and construction of temporary and permanent in-stream structures will have minimal adverse effects on flood risk and point source erosion.

120 The "WS" set of conditions are proposed to apply to land use and water consents relating to each affected stream. Condition WS.3 provides directions as to how stream diversions should be designed and constructed. It requires all diversions and realignments to be designed in a manner that attempts to preserve the natural stream channel and hydraulic characteristics. Specifically, it requires the duplication of the channel shape and gradient as closely as possible; sufficient floodplain to reduce velocities (this will consequently reduce the erosion and scour potential through the main channel); and stream bank planting to increase stream bank roughness through straightened reaches reducing peak velocities and providing bank protection. Hydraulically, I consider this to be an important condition that will help maintain the natural character of the stream and minimise the potential flood risk and bank erosion.

121 I suggest new consent conditions apply specifically to works on the Pauatahanui, Horokiri and Te Puka streams, based on hydraulic modelling of the respective water courses. The specific conditions

will stipulate the minimum design levels and dimensions of bridges and diversions. These levels and dimensions have been set based on results from hydraulic modelling, and include an allowance for freeboard. The recommended design was set after iterations of various mitigation measures were run and the potential adverse effects assessed, until the effects were less than minor, or measures put in place to remedy the adverse effect.

122 I believe that if the minimum bridge and diversions dimensions are adopted, then the adverse effects will be less than minor.

123 I also suggest that new consent conditions are developed to limit the downstream flood risk in the Duck, Kenepuru/Porirua and Waitangirua networks in large storm events to pre-construction levels. Specific conditions are required because stormwater runoff from the Project drains into urban stormwater networks. These stormwater networks are largely undersized and do not have the capacity for additional flow. The new conditions will restrict peak flows in large flood events to pre-construction levels by utilising the storage in catchments upstream of the road to attenuate the flood peak.

124 Construction of the Waitangirua link road is one of the Porirua City Council's components of the TG Project. I recommend a new condition is developed which requires the stormwater infrastructure in which runoff from the Link Road is to drain gets upgraded when the link road is developed. This upgrade should meet the Council's code of practice for stormwater networks that do <u>not</u> have available secondary overflow paths.

125 I believe that if additional peak flow attributed to the Project is attenuated to pre-construction flow, or if the downstream stormwater network is upgraded, then the flood risk to the resulting urban stormwater network will be entirely acceptable.

126 For the proposed temporary culverts during the 6 year construction period of the Project it is likely that a flood event of a reasonable magnitude (exceeding a 2 year) occurs at least once. For this reason the culverts are to be designed to convey a minimum of a 2 year flow, and not be in situ for more than 2 years. In addition, I recommend a new condition is developed which requires the consent holder to put appropriate measures in place for a 10 year flood to pass with minimal disruption to the natural flow regime. To convey larger flows a minimum depth of cover over the culvert should be considered to allow overtopping of the culvert during larger flood events.

127 I believe that by managing for a 10 year flood, that the adverse effects on flood risk and point source erosion from temporary culverts during construction can be managed. Should a larger

unforeseeable event occur during construction then condition G.16 will come into effect. This condition requires improving erosion and sediment controls in catchments that drain to the Porirua Harbour, if a heavy rainfall event occurs or is forecast to occur.

CONCLUSIONS

128 Assuming the consent conditions are confirmed as proposed, and that the proposed management plan framework is implemented, it is my opinion that the adverse effects associated withflooding, culverts and bridge construction, diversions and operational stormwater can be avoided, remedied or mitigated along the length of the alignment.

129 The greatest challenge will be the staging and construction of the diversion on the Te Puka Stream. I led a team that undertook more detailed work in a number of areas that are covered by the SSEMPs to satisfy ourselves that these issues are resolveable prior to completion of the Assessment of Environmental Effects.

130 The water quality impacts associated with sediment control devices and operational stormwater treatment are covered in the evidence of **Ms Malcolm**.

Craig Murray Martell
17 November 2011