Before the Independent Hearing Panel
appointed by Environment Southland and
Gore District Council

Under	the Resource Management Act 1991
In the matter of	an application by Gore District Council for resource consent to establish the Longford Bridge across the Mataura River

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Statement of evidence of Eli George Maynard

2 December 2020

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Introduction

1 My full name is Eli George Maynard.

2 I am a Senior Geotechnical and Water Resources Engineer employed by RILEY Consultants Limited, an engineering consultancy specialising in Geotechnical, Environmental, Civil and Water Resource Engineering. I reside in Auckland.

3 I am a Chartered Professional Engineer and hold the following qualifications and memberships.

(a) Bachelor of Engineering with Honors BE(Hons) in Natural Resources, University of Canterbury.

(b) Master of Engineering in Management MEM, University of Canterbury.

(c) Chartered Member of Engineering New Zealand (CMEngNZ).

(d) Chartered Professional Engineer (CPEng).

(e) Member of the New Zealand Geotechnical Society, Rivers Group, and New Zealand Society of Large Dams.

4 My experience includes:

(a) July 2019 – present, Senior Geotechnical and Water Resources Engineer, Riley Consultants Ltd, Auckland

(b) October 2013 – July 2019, Geotechnical and Water Resources Engineer, GeoSolve Ltd, Dunedin

(c) October 2011 – October 2013, Student and later Graduate Geotechnical Engineer, Tonkin & Taylor Ltd, Christchurch

5 I have over 8 years' experience on bridge, dam, flood protection and land development projects across New Zealand. I was the lead geotechnical engineer for the 45m span Water of Leith Footbridge recently constructed in Dunedin, which is of a similar structural form and use to the proposed Longford Cable-stayed Footbridge. I also provided engineering input on the Pyramid Bridge replacement located 30km upstream, and three other bridge projects in Cambridge, Westport and Taranaki. Additionally, I have provided hydrological, hydraulic and geotechnical design inputs for several large dams and flood defence schemes in New Zealand, including several in Otago and Southland.

6 I am contracted by DC Structures Studio Ltd on behalf of Gore District Council (**GDC** or **Council**) as the geotechnical and hydrological engineer for the Longford Cable-stayed Footbridge.

7 I was the author of the following document attached to the application:

(a) *Geotechnical and Hydraulic Inputs* (Ref: 190376-B Rev 3, 9 July 2020), attached as Appendix D to the Application.

8 In preparing this statement of evidence I have considered the following documents:

(a) Submissions relevant to my evidence;

(b) The section 42A report;

(c) Evidence of Daniel Anthony Crocker.

Code of Conduct for Expert Witnesses

9 While this is not a hearing before the Environment Court, I have read the Code of Conduct for Expert Witnesses contained in the Environment Court Practice Note 2014. I have complied with it in preparing this evidence and I agree to comply with it in presenting evidence at this hearing. The evidence that I give is within my area of expertise except where I state that my evidence is given in reliance on another person's evidence. I have considered all material facts that are known to me that might alter or detract from the opinions that I express in this evidence.

Scope of evidence

10 This evidence addresses:

(a) Hydrological considerations for determining design flood levels.

(b) Hydraulic considerations for abutment scour protection, debris impact loading and back-stay anchorage protection.

(c) The geotechnical aspects with particular reference to foundation conditions, site stability, back-stay anchorages, and earthworks.

Executive summary

11 The following summary applies to the evidence in response to concerns raised during the notification phase of the consenting process related to the hydrological and geotechnical considerations of the Longford Cable-stay Bridge:

(a) The proposed bridge spans the Mataura River main channel and incorporates an approach embankment beyond the right bank within a wide floodplain. The single span design minimizes obstruction within the main channel and floodplain which ensure that any increased flooding due to the bridge construction is negligible

(b) The bridge level is above peak levels observed during the 5 February 2020 (flood of record) and is above the adjacent stopbanks which provide flood protection to central and east Gore. Design floods incorporate allowances for future climate change.

(c) Raising of the stopbanks in future will result in a greater proportion of the ULS flood being contained within the floodplain that would otherwise spill over the stopbanks. This results in a commensurate increase in hydraulic/debris loading on the bridge, which can be mitigated by either raising or strengthening of the bridge as outlined in Mr Crocker's evidence.

(d) Erosion protection measures comprising deep piles socketed into the underlying bedrock, riprap, and reinforced grass have been adopted given the need for a robust solution.

(e) Geotechnical conditions at the bridge site are favorable.

Hydrological Considerations

12 The proposed Longford Cable-stayed Footbridge spans the Mataura River main channel, approximately 650m upstream of the existing State Highway 1 bridge in Gore. The Mataura River is the second largest in Southland, both in terms of catchment area and flow. Its headwaters originate in the Eyre Mountains to the south of Lake Wakatipu, with an estimated catchment area of 3,524km^2 at Gore.

13 At this location, the main channel trends close to the true left bank and incorporates a wide, shallow floodplain on the true right. Stopbanks are located either side of the river, providing flood protection to central and east Gore. The west abutment will be supported on an embankment up to 5.9m high, located on the main channel right bank within the floodplain. The east abutment will tie directly into the stopbank. The river channel is generally stable within this reach, with bedrock visible within the channel bed and near both banks. A small beach has formed by river aggradation at the inside bend, adjacent to the proposed west embankment.

14 Flood design is based on the New Zealand Transport Agency's Bridge Manual SP/M/022 3rd Edition (NZTA BM) which represents industry best-

practice in New Zealand. Two floods are considered, being the serviceability limit state **(SLS 2)** with an annual exceedance probability **(AEP)** of 1/50 and ultimate limit state **(ULS)** of 1/500 AEP. The SLS 2 flood establishes where the bridge soffit level should be set and any necessary clearances, and the ULS the maximum flood inundation that the structure must tolerate.

15 Design floods were estimated based on statistical flood frequency analysis of stream gauge recording for the Mataura River at Gore, using annual maxima from 1960 to 2020. The recorder location is less than 1 km from the bridge site with no significant tributary inflows in the intervening reach, meaning that the data can be applied directly for this purpose. This is the preferred method of flood estimation because it is based on observed flood data, compared to other methods which could be unreliable given the large catchment size. Specific consideration of climate variability was given to design flow estimates[1].

16 During the course of our analysis, the Mataura River experienced its largest recorded flood on 5 February 2020 which had a peak flow of 2,399m^3/s. Prior to this, the largest recorded flood was in October 1978 which had a peak flow of 2,108m^3/s. Our analysis was subsequently updated to incorporate this new information, slightly increasing earlier estimates. Peak flows for the SLS 2 and ULS were then confirmed as 2,622m^3/s and 4,802m^3/s respectively, including a 15% allowance for future climate change as discussed above. The SLS 2 event is 10% larger than the 5 February 2020 flood, meaning that the bridge deck would not have been inundated during this event with considerable freeboard remaining.

17 A two-dimensional hydraulic model of the river was developed, using industry-standard modelling software, to assess flood levels and peak velocities for the design events. A two-dimensional model was considered appropriate for this project in view of the different flow conditions expected within the main channel compared to the floodplain, which more simplified one-dimensional models do not consider. The model was calibrated[2] to the 5 Feb 2020 flood (flood of record) and then validated by the October 1978

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[1] Climate variability was assessed based on two methods: the first being the interdecadal pacific oscillation (IPO), which is a weather phenomenon known to affect the severity of floods in Southland across several decade phases; and the second using representative concentration pathway (RCP) scenario 6 which is based on a 2°C increase in annual mean temperature to 2100

[2] Calibration is a process whereby modelling parameters are adjusted to match observed flood levels. The model is then rerun with another flood to confirm these are also match an independent flood.

flood (previous flood of record) providing some confidence that the model outputs reflected historic flood observations.

18 Models run for the pre- and post-bridge construction indicate that the bridge structure and approach earthworks will have a negligible effect on flood levels, in the order of 100mm to 150mm, which is within the accuracy of the modelling itself. This is not surprising given the favourable alignment and teardrop shape of the west embankment, and the combined cross-sectional area only representing about 3% to 4% of the total floodplain area. Further, cable-stay designs such as that proposed offers advantages over conventional concrete and/or steel truss bridges which would require piers to be constructed within the main channel for support.

19 Predicted flood levels for the SLS 2 event are RL 75.8m at the bridge site. A target freeboard of 1.2m above this level (RL 77.0m) was then adopted in accordance with the NZ Bridge Manual in view of the potential for large debris to be carried down the river in major floods. Debris loading from large trees was a primary contributor to the Pyramid Bridge failure which occurred in only a modest flood event. A design soffit level of RL 77.0m puts the bridge around 0.3m above the stopbank crest on the true left (RL 76.7m) and up to 1.0m above the true right stopbank crest (RL 76.0m). Through consultation with Environment Southland we understand the design standard adopted for the stopbanks was the 1978 flood level plus 0.5m freeboard (RL 76.7m). A slightly lower freeboard (0.6m appropriate under normal circumstances) is reasonable on the east abutment to enable the approach to tie in with the stopbank. It is worth noting that the bridge deck incorporates a gentle arch meaning that the weakest point of the bridge at mid-span has a freeboard in excess of 2m. Future raising of the stopbanks would not impact the SLS 2 levels as the flood is already contained within the stopbanks.

20 Predicted flood levels for the ULS event are RL 77.20m at the bridge site, representing overtopping of the stopbanks by between 0.5m and 1.2m. I anticipate stopbanks of this age and type could only sustain overtopping in the order of 0.2m and only for a few hours if in good condition. Recorded flood hydrographs suggest that floods can be sustained for several days, meaning that at their current level, the stopbanks are likely to fail in a 1/500 AEP flood, thereby reducing flood levels at the bridge.

21 However, we understand that Environment Southland has received 'shovel-ready' funding for raising of the stopbanks to increase the level of protection to Gore. Whilst the design standard for the raising is unconfirmed at this stage, I understand an increase of 0.5m is being considered which would contain in the order of a 1/100 AEP to 1/200 AEP flood event in keeping

with other flood protection schemes across New Zealand within built up areas. Any such raising would increase both the flood level and flow velocity affecting debris forces on the bridge in a ULS event only, because a greater proportion of the incoming flood is contained within the stopbanks (which was otherwise overtopped). Options to either strengthening or raise the bridge have been considered by the bridge designer, Mr Crocker, in his evidence.

22 The hydrology assessment was undertaken in conjunction with Environment Southland and was independently peer reviewed by GeoSolve Ltd.

Scour protection

23 The bridge abutments will be temporarily inundated during major floods which presents a risk of scour to the underlying fill. The foundation piles supporting the bridge superstructure will be embedded many metres below present ground level and into competent rock. They are, therefore, not considered to be at risk from scour.

24 The hydraulic model estimates both peak flow depths and velocities at key locations around the bridge. These have been used to design protection measures for the west embankment, and to estimate debris impact forces on the bridge structure and back-stay anchor surrounds. Depth and velocity estimates around the west embankment during a ULS event are in the order of 5m and 3.5m/s respectively but vary depending on specific location and with time. Velocities of up to 7m/s are estimated within the main channel but decrease on either side and across the right floodplain.

25 It is proposed to protect the west embankment from erosion by a combination of riprap and reinforced grass. Similarly, back-stay anchors are protected within a concrete housing and riprap. Riprap is a common method of protection for bridge abutments and has been used extensively to mitigate riverbank erosion across New Zealand. Riprap is provided at the toe of the west embankment as this is the most vulnerable area where flow turbulence could be concentrated. This extends into the right bank adjacent to the beach where riverbank erosion is possible in future large floods. Alternatives such as gabion baskets and concrete could also be considered. Reinforced grass is proposed in the upper sections of the embankment and locally around the east abutment where flow depths and velocities are less.

26 The S42A report and Mr Moore’s peer review report recommends that appropriate riparian plantings are included on the west embankment as part of landscape enhancement but also to enhance riverbank protection. Both

reports correctly note that this needs to be compatible with flood protection objectives and should not exacerbate natural hazards. Generally, larger structured vegetation is avoided within floodplains as these can induce local scour. Good grass cover offers advantages in this regard and is easier to maintain, hence its adoption on many flood defence schemes including the stopbanks here. Root structure, and the impacts on the reinforced grass elements, along with ensuring survival from prolonged inundation by high velocity water over several days, will also be design considerations. Overall, any such planting should only be considered in consultation with a specialist in flood protection and Environment Southland.

Geotechnical Conditions

27 Geological maps indicate the site is underlain by an interbedded sequence of quaternary fluvial sediments eroded from the inland schist basement, overlying weakly metamorphosed sandstone (greywacke) and siltstone (argillite) of the North Range Group bedrock (Murihiku Terrane). The presence of these materials was confirmed during subsurface investigation as outlined below.

28 Geotechnical investigations were undertaken by Insight Engineering in August 2019. The investigation involved a site walkover, six machine drillholes with standard penetration tests, and supplementary Scala penetrometer tests. Bedrock was encountered at around 3m below present ground level, with the exception of BH06 that was drilled through the east stopbank. No active faults requiring specific consideration for design are mapped within 20km of the site. No other natural hazards have been identified that might impact the bridge site. Overall, geotechnical conditions are considered favourable for the bridge.

29 The bridge will be supported on a series of drilled 0.6m diameter bored concrete piles between 6m and 7m long. The piles will be socketed several meters into the underlying North Range Group bedrock at both abutments. Drilled piles are preferred over driven piles which may struggle to achieve the require embedment due to the hard nature of the rock. Geotechnical resistance is assumed to be provided by the bedrock alone with no contribution from skin friction in the soils above in case liquefaction were to occur during a large earthquake. The piles also provide the necessary lateral resistance to the bridge.

30 Slope stability calculations confirm that target factors of safety are met for the west embankment which will be constructed of free-draining granular fill. Foundation preparations for the embankment will address localised instability at the beach/right bank. Target factors of safety for the existing

stopbank on the east abutment are not achieved in their current condition. However, the east abutment wall and piles are seen to improve stability to exceed targets.

31 Anchorages for the mast backspan stay-cables are provided by six, 11m long, 0.15m diameter grouted bar anchors. These provide restraint/support to the bridge cables and comprise 46mm diameter steel anchors that are drilled into the underlying bedrock. During installation, these are methodically tested to provide a high level of confidence that design capacities are achieved. Anchors are double-corrosion protected, which ensures they continue to provide resistance for the full design life of the bridge structure (which could otherwise deteriorate with age).

32 The geotechnical assessment was independently peer reviewed by GeoSolve Ltd.

Alternatives

33 Alternative options to the proposed Longford Cable-stayed Footbridge include other bridge alignments either up or downstream of the present location, different structural forms such as a concrete, arch or truss bridge, and direction drilling of the pipeline beneath the riverbed (no bridge).

34 A single-span bridge is preferred from a flooding and construction risk perspective as it minimises obstructions within the floodplain. From a hydrological perspective, having several piers within the main channel would potentially exacerbate flood impacts, could induce local scour, and present obstructions for debris to accumulate on. Construction of the piers and drilling of foundation piles would also require progressive temporary diversion of the Mataura River around the work area and potentially dewatering. An alternative site upstream may require a second embankment on the east bank, of a similar order to the west embankment, because the stopbanks are located east of Woolwich St here resulting in a second floodplain. In my discussions with Environment Southland, their engineers expressed a strong preference for minimising the extent and frequency of obstructions within the channel and/or floodplain wherever possible. In is evidence, Mr Crocker discussed the design implications of alternative bridges capable of spanning the 90m across the main channel.

35 Whilst directional drilling has been utilised to install utilities beneath floodbanks across NZ, the method is typically only considered for soil conditions and preferably with smaller diameter pipes and shorter lengths. I have some reservations about the appropriateness of directional drilling on this site, both in terms of the hard bedrock likely to be encountered, but also potential variability in ground conditions across the floodplain.

Response to Submissions

36 Submissions made in opposition to the proposed bridge include concerns over increased flooding risk, scour, risk to and instability of the stopbanks, and debris impacts. Each of these aspects has been specifically considered in my evidence.

Conclusion

37 Hydrological and geotechnical aspects of the bridge were designed in accordance with NZ best practice and have been independently peer reviewed. The single span cable-stay minimises obstruction within the main channel and floodplain which ensure that any increased flooding is negligible. Design measures are proposed to ensure the bridge foundation design is robust and includes appropriately protected from scour and erosion.

Dated this 2nd day of December 2020

Eli Maynard.

Eli George Maynard