FLOOD HAZARD REVIEW

3

APPENDICES

EXPRESSION OF INTEREST

JUNE 2016

WATERFALL PARK

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14 June 2016

The Directors
Winton Partners Investments Ltd
Email: andrew.cavill@wintonpartners.com.au

Attention: Andrew Cavill

Dear Andrew

Waterfall Park Residential Development Proposal – Flood Hazard Mitigation Plan

1.0 Introduction

The purpose of this report is to provide a flood hazard assessment for the proposed Waterfall Park Residential Development.

The development area is traversed by Mill Stream that flows from north to south through the proposed site development plan – refer to Figure 1.1 below.

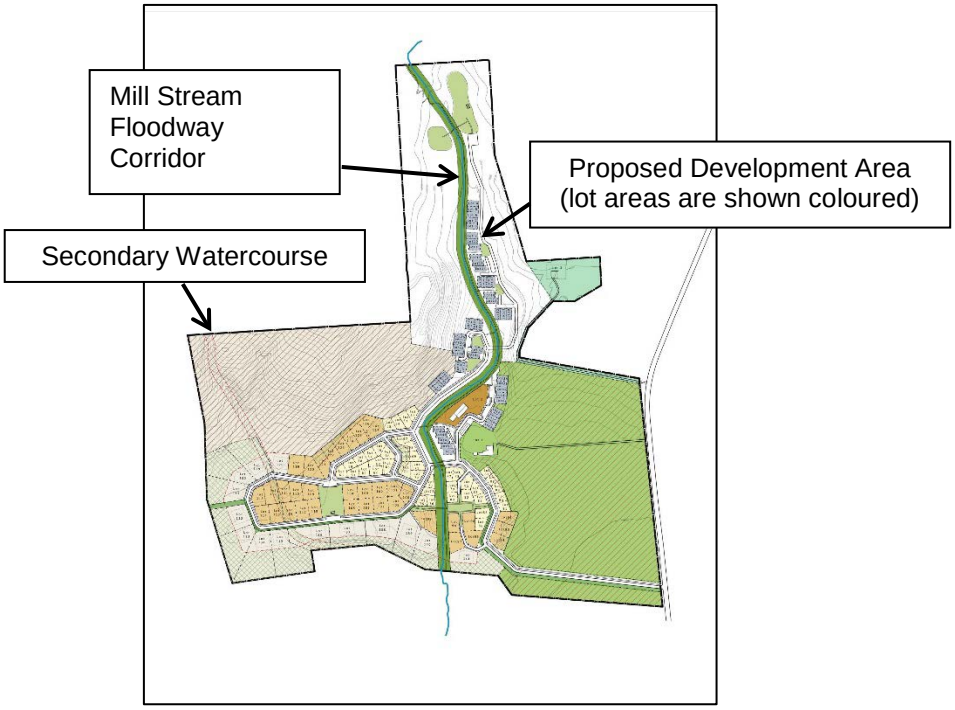


Figure 1.1: Site Development Plan

This report presents an interpretation of the flooding (due to rainfall) and alluvial fan hazard information from the Otago Regional Council Hazard Register in relation to the proposed residential and related development areas set out in the site development plan. Accordingly, this report identifies flood mitigation measures, where required, to manage flood risks for the respective development areas.

2.0 Flood Hazard Register Information

Refer to Figure 2.1 below for the natural hazard areas identified from the Otago Regional Council GIS based Hazard Register data.

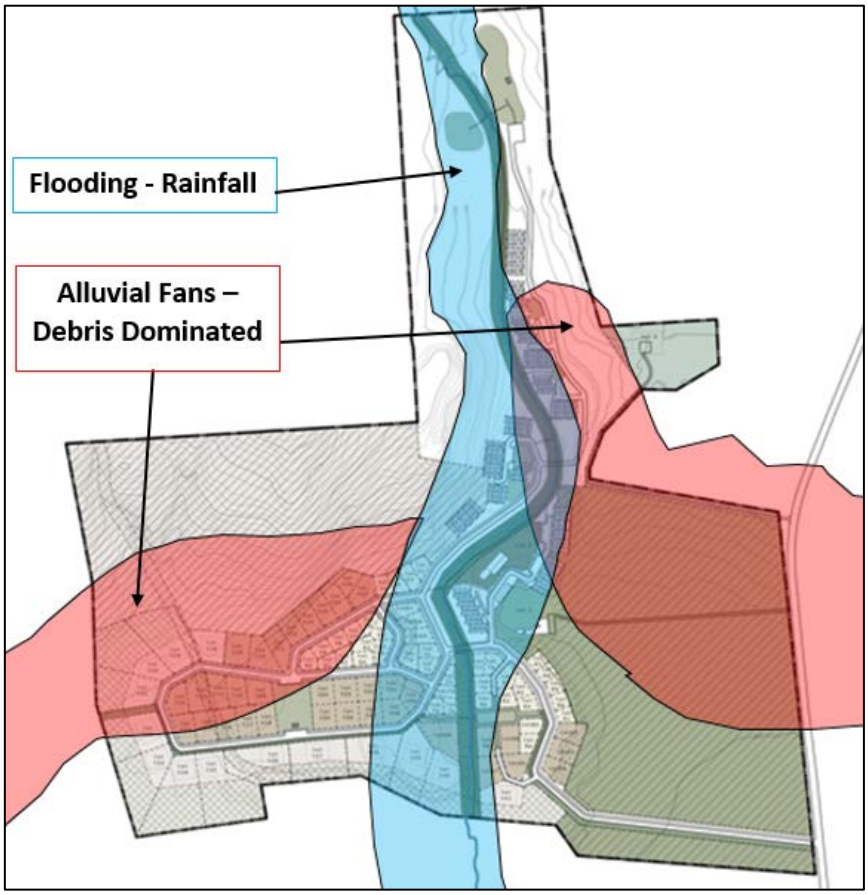


Figure 2.1: Hazard Identification at Waterfall Park Development

Two flood related natural hazards have been identified in the development site area. These are as follows:

1. "Flood hazard due to rainfall".
2. Alluvial fan hazard – "Active Debris Dominant Fan" areas.

3.0 Alluvial Fan Risks

3.1 Alluvial Fan Debris

The hazard map (Figure 2.1) illustrates two areas affecting the site that are subject to an "Active Debris Dominant Fan" hazard, one to the east of Mill Stream and the other to the west of the Stream.

Geotechnical investigations have highlighted that there is little risk in the area on the east side of the stream.

For the area on the west side of Mill Stream there is an active ephemeral watercourse with a small catchment area which is dry except during significant rainfall events resulting in runoff. From time to time runoff will flow through the development site and therefore there is a possibility that some alluvial debris could get carried into the site.

3.2 Alluvial Debris Mitigation Measure

To account for runoff and the possibility of debris entrainment a channel would be provided within a 15m wide "No Build Zone" through a development area with large 4000 and 1000 square metre lots. The flow path and the No Build Zone is illustrated in the attached "Flood Mitigation Concept Plan" and is expanded in more detail in Figure 3 below.

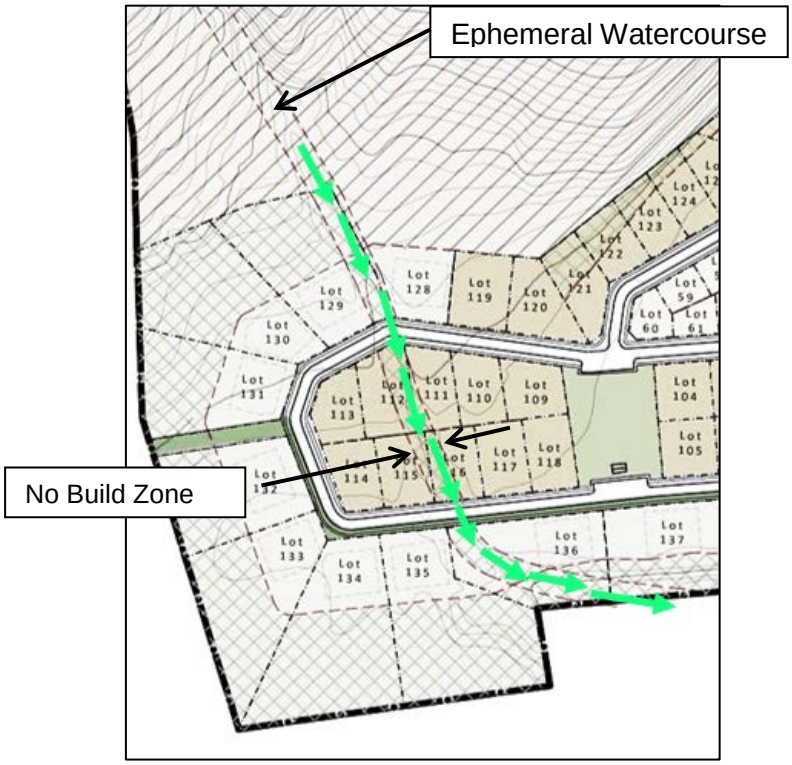


Figure 3.1: Active Debris Dominant Fan Hazard Mitigation – No Build Zone

4.0 Flood Risk and Mitigation

4.1 Mill Stream Flood Regime

The Mill Stream catchment above Waterfall Park extends northwest to Coronet Peak and westwards almost to Arthurs Point to include a total area of the order of 35 square kilometres.

The proposed Mill Stream floodway corridor follows the existing Mill Stream alignment. The existing Mill Stream channel is confined by a narrow valley in the northern half of the site development area. From the valley the land form broadens and during major flood events flood waters are able to spread laterally in the southern part of the site onto limited areas of floodplain that includes a secondary overland flow path. From the site, Mill Stream flows down gradient to Lake Hayes.

Since the proposed floodway corridor would convey all of the flood flow through the proposed development the floodway is the "primary flow path". Under the Queenstown Lakes District Council "Land Development and Subdivision Code of Practice" the floodway would be required to protect habitable floors against a 100 year ARI flood event with 0.5m freeboard.

A preliminary 100 year Average Return Interval (ARI) design flow estimate, based on a coarse catchment area assessment, was derived using the Pearson McKerchar regional flood estimation technique. The flood flow assessment suggests that a 100 year ARI event through Waterfall Park could, conservatively, be of the order of 100 cubic metres per second (m^3/s). The flood mitigation measures referred to below are related to the conservative flood flow estimate.

4.2 Mitigation Works Concept

The enclosed "Flood Mitigation Concept Plan" illustrates the respective Mill Stream floodway reaches referred to below.

From the northern end of the site and working downstream the flood mitigation works would be a combination of:

a. Widening of the existing channel and providing scour protection in the upstream reach of the floodway (Reach 1).

b. Retaining the existing flood plain in the upper middle reach (Reach 2).

c. In the lower middle reach within the residential area, the formation of flood protection banks on the left bank (looking downstream) to confine flood flows (Reach 3).

Upstream of Reach 1, the proposed building locations are above the river that is naturally confined and relatively stable. Any flood mitigation works of measures needed for the potential flood hazards above Reach 1 would be part of the detailed lot development planning to follow this stage of approvals. It is anticipated that the measures required would be to set minimum finished floor levels based on estimated flood levels.

Downstream of Reach 3, before the flows in Mill Stream leave the southern site boundary, the topography would remain unchanged to allow the flow to transition into the natural Mill Stream course as it does prior to development.

The remainder of this section below provides details of the works in each reach of the Mill Stream floodway.

4.3 Proposed Measures for the Respective Floodway Reaches

The attached Flood Mitigation Concept Plan shows the proposed mitigation works for the Mill Stream floodway corridor.

4.3.1 Floodway Reach 1: Channel Widening

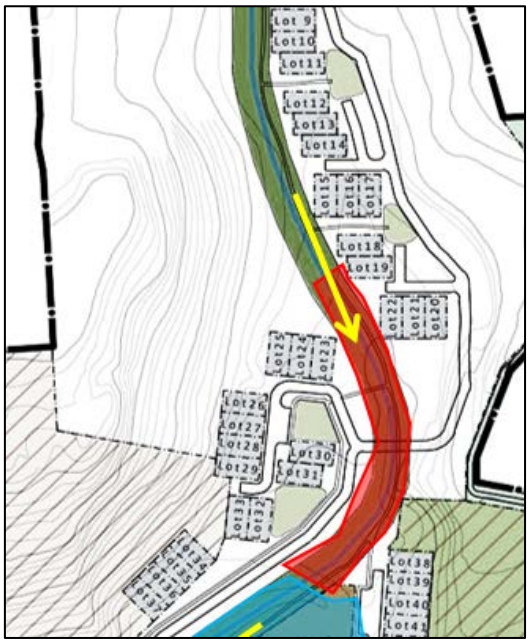


Figure 4.1: Reach 1 Locality

It is proposed that the stream bed be widened to contain the full potential maximum flow from the upstream catchment (100m^3/s).

In Reach 1, the existing channel is too narrow to contain the estimated maximum conveyance of Mill Stream – see Figure 4.2 below.

Figure 4.2: Existing Channel at Reach 1

The left bank is an area within Reach 1 that specifically requires strengthening. The strengthening is required to protect buildings proposed near the left bank of the channel and

to ensure the stability of existing scour protection on the outer left hand bend of the stream channel.

The depth of the flow in the widened floodway section would be of the order of 1.8m and based on the average gradient the velocity of flood flows would be of the order of 3 metres per second (m/s). The estimated flow velocity means that the channel design requires scour protection works to maintain a stable channel against erosion and sedimentation processes. The scour protection would be similar to that in the existing channel in Figure 4.4 below.

A proposed typical cross section is shown in Figure 4.3, shown with erosion protection on the side slopes.

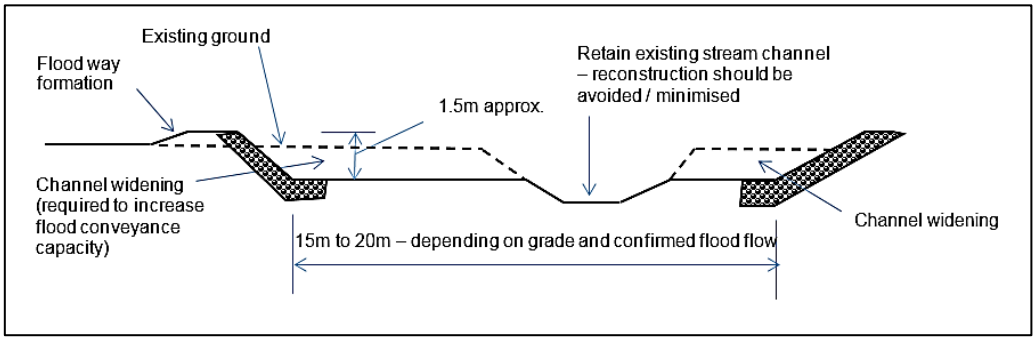


Figure 4.3: Typical Cross Section for Widening of Floodway in Reach 1

Figure 4.4: Scour Protection with Rock Structures

The floodway berms each side of the main channel would allow the floodway to be used as walkways except during times of flooding. The floodway provides an opportunity for grasses and occasional trees to be established for aesthetic appeal.

4.3.2 Reach 2: Existing Floodplain Reach

The floodplain area on the left bank is an existing landscape feature, including a woolshed that has historic place protection, which would be retained as open space. The use of the protected building in the flood plain would be reviewed subject to further analysis of the flood flows down Mill Stream.

Buildings on the outer banks would be set above the estimated flood level with at least the required freeboard.

4.3.3 Floodway Reach 3: Bridge Crossings

Since the proposed width of the floodway in Reach 3 is of the order of 25m, bridge crossings would be a significant cost. It is proposed that bridge crossings would be a combination of primary and secondary structures. A single primary bridge would ensure normal access across Mill Stream for flood events with an ARI of up to 100 years. Secondary bridges would provide pedestrian and possible light vehicle access at close to river level except during major flood events.

Figure 4.5 shows a typical design for primary and secondary access way bridges in the floodway cross section.

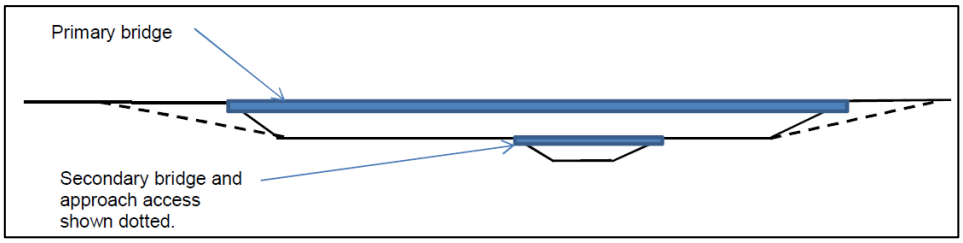


Figure 4.5: Proposed Primary/Secondary Bridge Crossings

4.4 Floodway Reach 3: Confined Stream Section – Left Bank Flood Bank

Initial investigations showed there was a potential for flood flows to break out of the main Mill Stream channel and follow an overland flow path through proposed residential lots in the southeast portion of the site as shown in Figure 4.6.

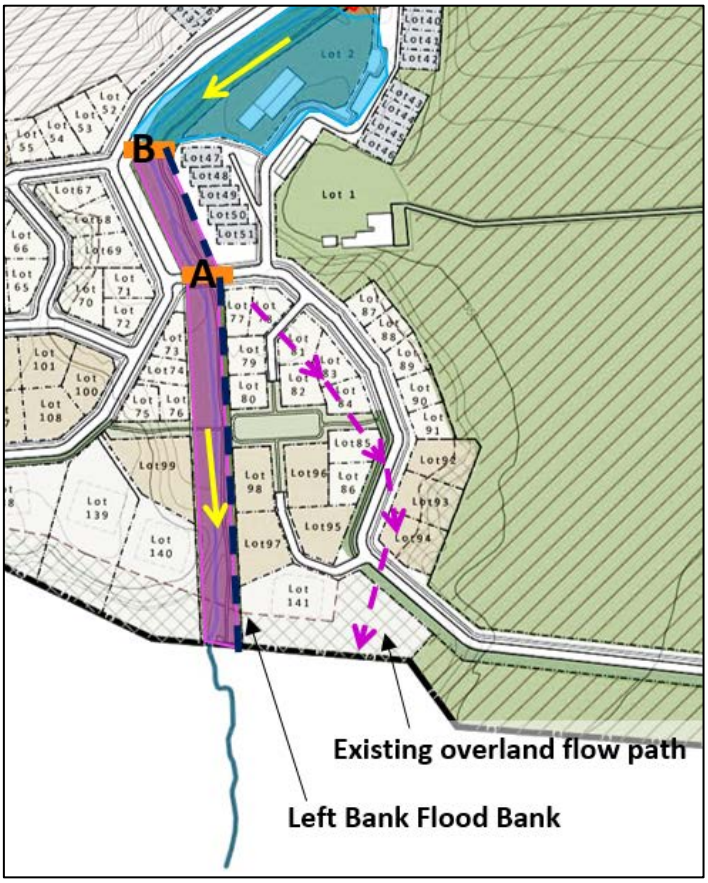


Figure 4.6: Reach 3 Locality

In order to prevent flows down the secondary flow path and to provide the freeboard requirement for the surrounding lots, it is proposed to construct a flood bank on the left bank of the Mill Stream floodway corridor.

The depth of the flow in the confined stream section would be of the order of 1.8m. Based on the average gradient, the velocity of flood flows would be of the order of 3 metres per second (m/s). The estimated flow velocity means that the channel design requires scour protection works to maintain a stable channel against erosion and sedimentation processes.

The estimated flow depth is of the order of that on the right bank of the existing stream channel and therefore transitions to the existing stream channel at the downstream end of the reach would be gradual.

4.5 Stormwater Management

The time of concentration from the development area is a fraction of that from the Mill Stream catchment upstream and therefore the peak flow from the development area does not coincide with the peak flow in Mill Stream. The controlled discharge from the development area would therefore have no significant adverse capacity effect on the stream channel downstream.

5.0 Conclusions

The flood hazard assessment has not identified significant flood issues that cannot be resolved in a practical manner. Based on the conservative flood flow estimate for a 100year ARI flood event, the potential flood effects on the proposed development can be mitigated by the proposed mitigation works outlined in the attached "Flood Mitigation Concept Plan".

The potential alluvial fan debris hazard would be mitigated with a formed channel and provision of No Build Zone. There is no reason to believe that the alluvial fan debris poses any significant limitations on the proposed future use of the site.

Yours faithfully
FLUENT INFRASTRUCTURE SOLUTIONS LTD
Per:

Gary Dent
Senior Environmental Engineer
CPEng / IntPE

Enclosure:

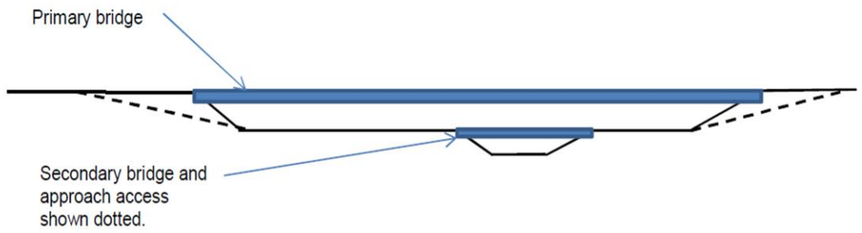
- Plan – "Flood Mitigation Concept Plan"

Flood Mitigation Concept Plan

Prepared by Fluent Solutions

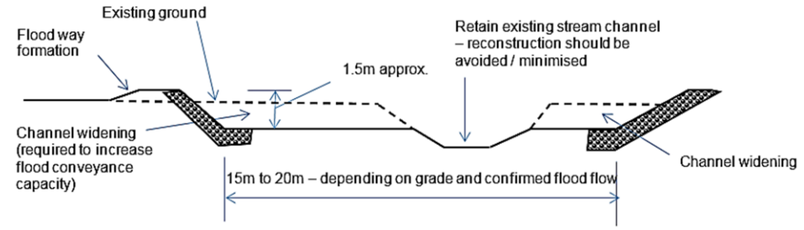
Bridge Crossings

- A. Primary Access – 20m long/2 lane bridge with deck level approx. 2.5m above stream invert and spanning the width of the floodway
- B. Secondary Access – low level bridges very similar to the existing bridges across the stream channel with the deck level at existing top of bank level



Floodway Reach 1: Widened Stream Section

The existing channel of Mill Stream is too narrow in this location to convey the potential of 100m3/s flow and requires a widening, in combination with a low bank to deflect water from flowing over the proposed lots.



Alluvial Fan Mitigation – No Build Zone

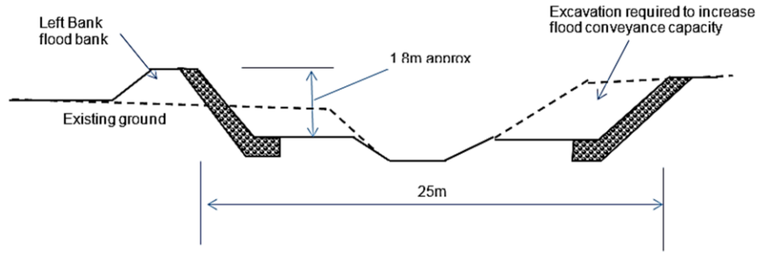
- 15m wide no build zone for active debris dominant alluvial fan hazard

Floodway Reach 2: Natural Floodplain

Minimal work required

Floodway Reach 3: Confined Stream Section

Flood bank required on left bank to confine the overland flow path to the Mill Stream floodway corridor



Existing overland flow path

Left Bank Flood Bank

Development Plan prepared by Baxter Design Group