MEMORANDUM

TO:	Waterfall Park Developments Ltd	Job No.:	Q000391
ATTENTION:	Lauren Christie	Date:	12 June 2018
FROM:	Fluent Solutions	Page 1 of 12	
SUBJECT:	Ayrburn Farm Flood Management Feasibility Assessment	Reference:	*M M -18-0 -21 Q000391 RevD*

1.0 Introduction

Fluent Solutions has been engaged by Waterfall Park Developments Ltd to assess the effects of flood flows in Mill Creek and the proposed Waterfall Park Hotel and Ayrburn Domain development on the proposed Ayrburn Farm area and provide advice on the feasibility of how any potential adverse effects could be managed and/or mitigated.

This feasibility assessment assumes that the proposed flood mitigation design for the main access road and Waterfall Park Hotel development (including the Ayrburn Domain) are implemented as presented in the previously issued Fluent Solutions flood management reports in October 2017 and April 2018 respectively (Waterfall Park Access Road RP-17-10-11 GMD Q000391-Rev2 and Waterfall Park Hotel Development RP-18-04-11 AOP Q000391). These reports are attached as Appendix 1 and 2 respectively.

The Otago Regional Council (ORC) consent for the proposed access road has been obtained and is included in Appendix 3.

2.0 ackground

2.1 Waterfall Park and Ayrburn Farm Locality

The proposed development area is located to the north of Lake Hayes and approximately 3km southwest of Arrowtown. Mill Creek drains a moderately large catchment that discharges to Lake Hayes that in turn discharges via Hayes Creek to the Kawarau River (see Figure 2.1). Ayrburn Farm lies in relatively rolling land, however, part of the Waterfall Park Hotel development area lies in a relatively incised valley. At the head of the valley, the floor of the valley rises steeply by approximately 40 metres (m), to form the well-known natural waterfall feature that the “Waterfall Park” development zone takes its name from.

At the transition from the rolling land form to the incised valley, the existing “Homestead Lot” is adjacent to some historic farm buildings located between the homestead and Mill Creek.

The proposed Ayrburn Farm area is located along the southern boundary of the Waterfall Park development area. The Ayrburn Farm area is located on a terrace that is part of the rolling land form. At the toe of the terrace, the Ayrburn Farm area transitions to a floodplain landform on either side of Mill Creek.

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Refer to Figure 2.1 below for the locality of the proposed Waterfall Park and Ayrburn Farm development areas.

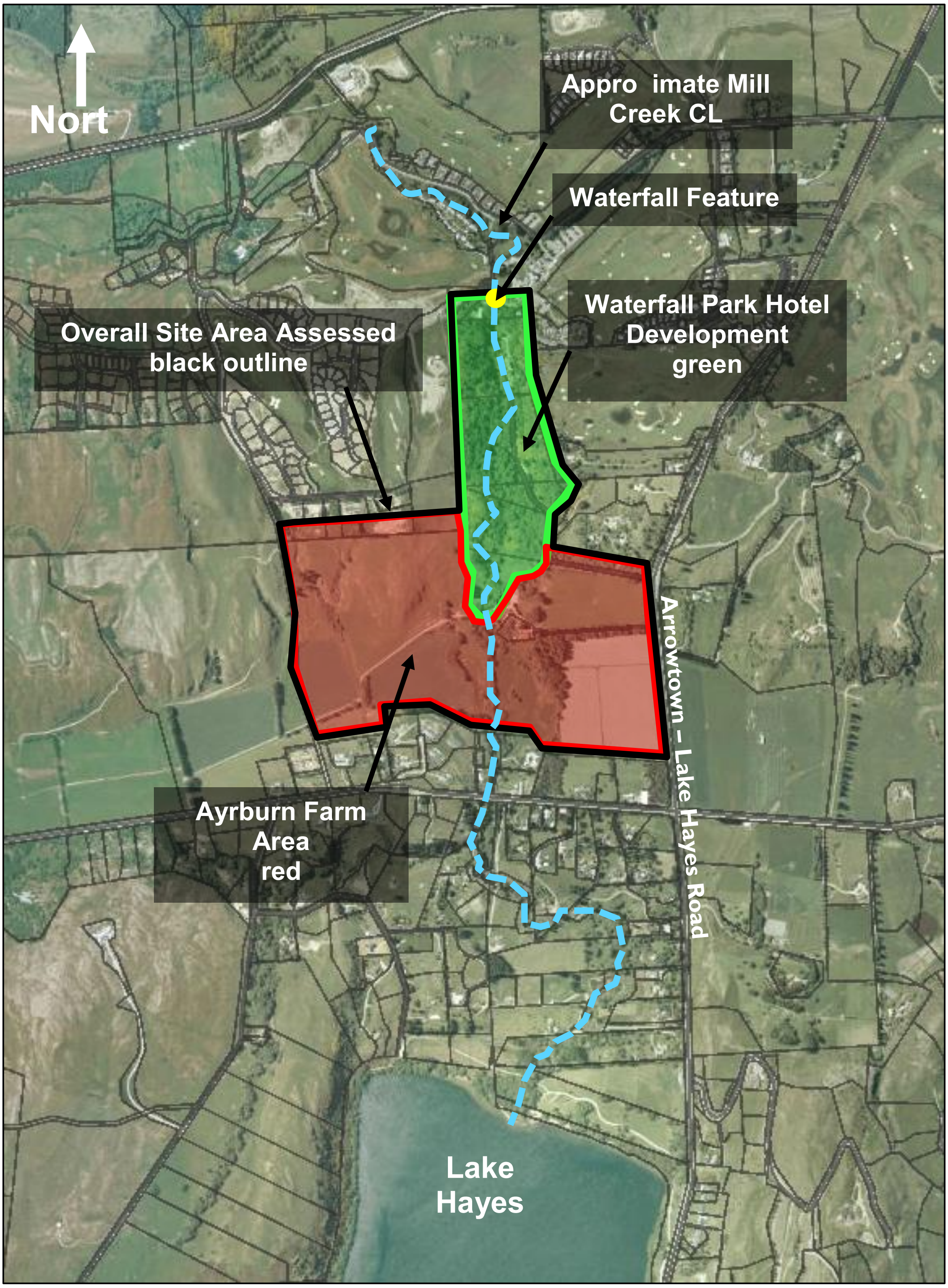

Figure 2.1 Waterfall Park and Ayrburn Farm Locality Plan

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2.2 Mill Creek C aracteristics

2.2.1 Flow Regime

The Mill Creek catchment upstream of Ayrburn Farm and 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 (km^2), which contributes to the downstream flows of Mill Creek in the vicinity of Waterfall Park.

Through the Waterfall Park Hotel development, the main channel of Mill Creek is confined and is relatively stable. The median dry weather flow is of the order of 350 litres per second (l/s). The stability of the flow regime creates an attractive habitat for fish and therefore Mill Creek is a valuable fish spawning area.

Design flows for the 10 year, 20 year, 50 year, and 100 year design ARI events have been estimated in an assessment of the Mill Creek flow regime and is included in the Fluent Solutions flood management report for the Waterfall Park Hotel development (April 2018).

The design input peak flows are shown in Table 2.1 below. For the purposes of this flood management feasibility study for the Ayrburn Farm area, the same design flows have been utilised. These flows were applied in the flood management feasibility study directly south of the waterfall feature.

Table 2.1 Peak Design Input Flows

Storm Event	Design Input Peak Flow m^3 s
10 Year ARI	7.6
20 Year ARI	8.5
50 Year ARI	9.6
100 Year ARI	10.4

2.2.2 Topography

The Mill Creek topography differs between the Upper Reach and Lower reach as shown in Figure 2.2 below. In the upper incised valley reach, the main channel of the stream is typically 3 to 5 metres (m) wide in the bottom and 10 to 15m wide at the top of the bank and is typically 1m to 2m deep. Where the channel is less than 1.5m deep there is a risk that flood flows would leave the main channel locally to the floodplain and return to the channel downstream.

At the southern end of the incised valley, Mill Creek then flows through a shallow terraced land form at the northern end of the east bank floodplain adjacent to the main channel.

The Creek in the rolling land area (Lower Reach) downstream of the incised valley is similar to that upstream in the incised valley except that bank heights are frequently less than 1.5m and therefore there are areas where during major flood events flood flows leave the main stream channel. Flows leave the Creek on the left bank of the channel downstream of the Historic Ayrburn Domain Buildings and follow a floodplain.

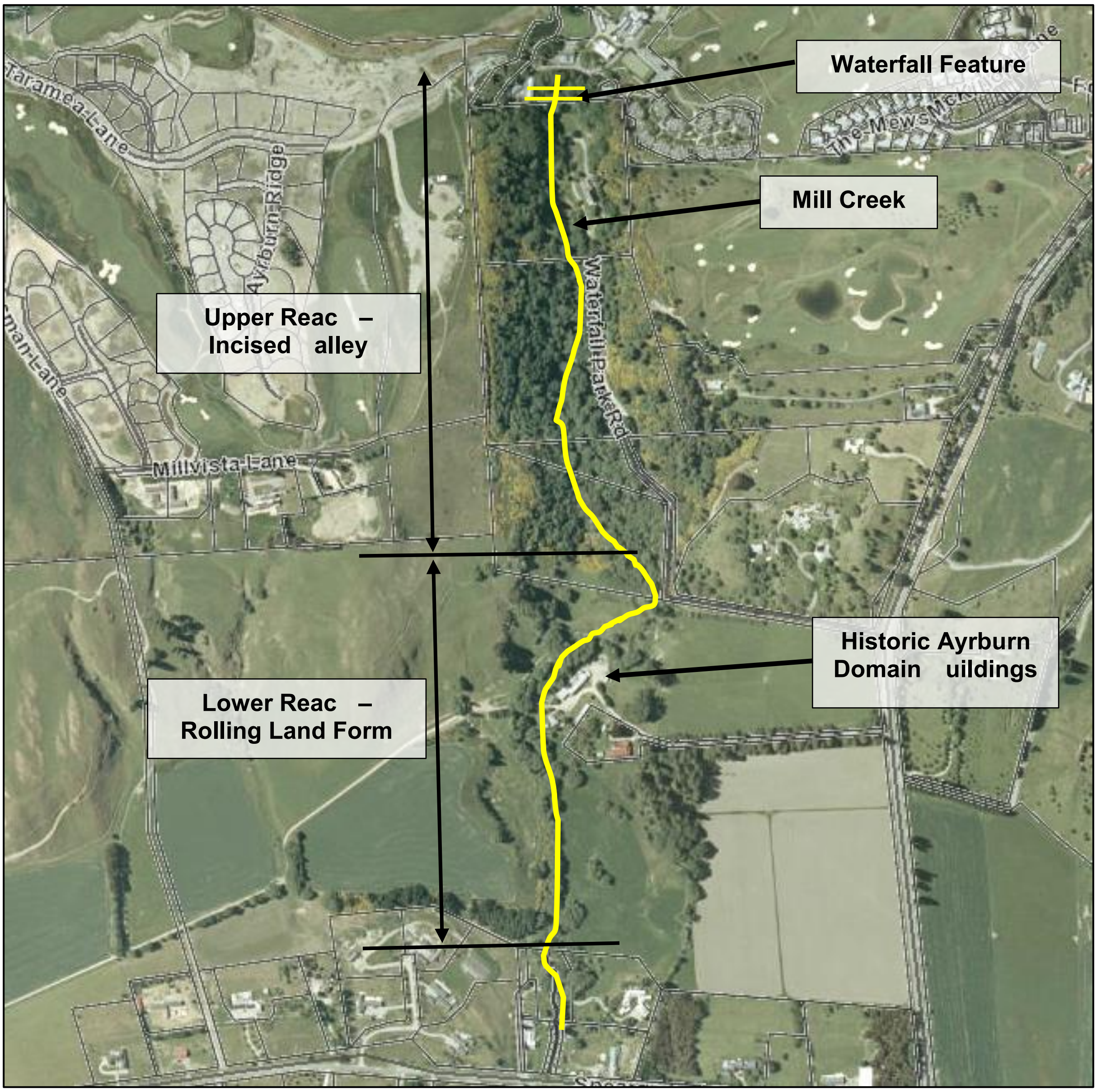

Figure 2.2 E isting Mill Creek Locality Prior to tree removal in Upper Reac

Figure 2.3 illustrates the spreading out of extreme (100 year Average Recurrence Interval (ARI)) flood flows on the Lower Reach outside the main Creek channel as part of the "pre-development" flow regime. Figure 2.4 represents the spreading out of a moderate event flood flow (20 year ARI) and provides a comparison to Figure 2.3. The flow on the floodplain is significant for moderate and extreme events.

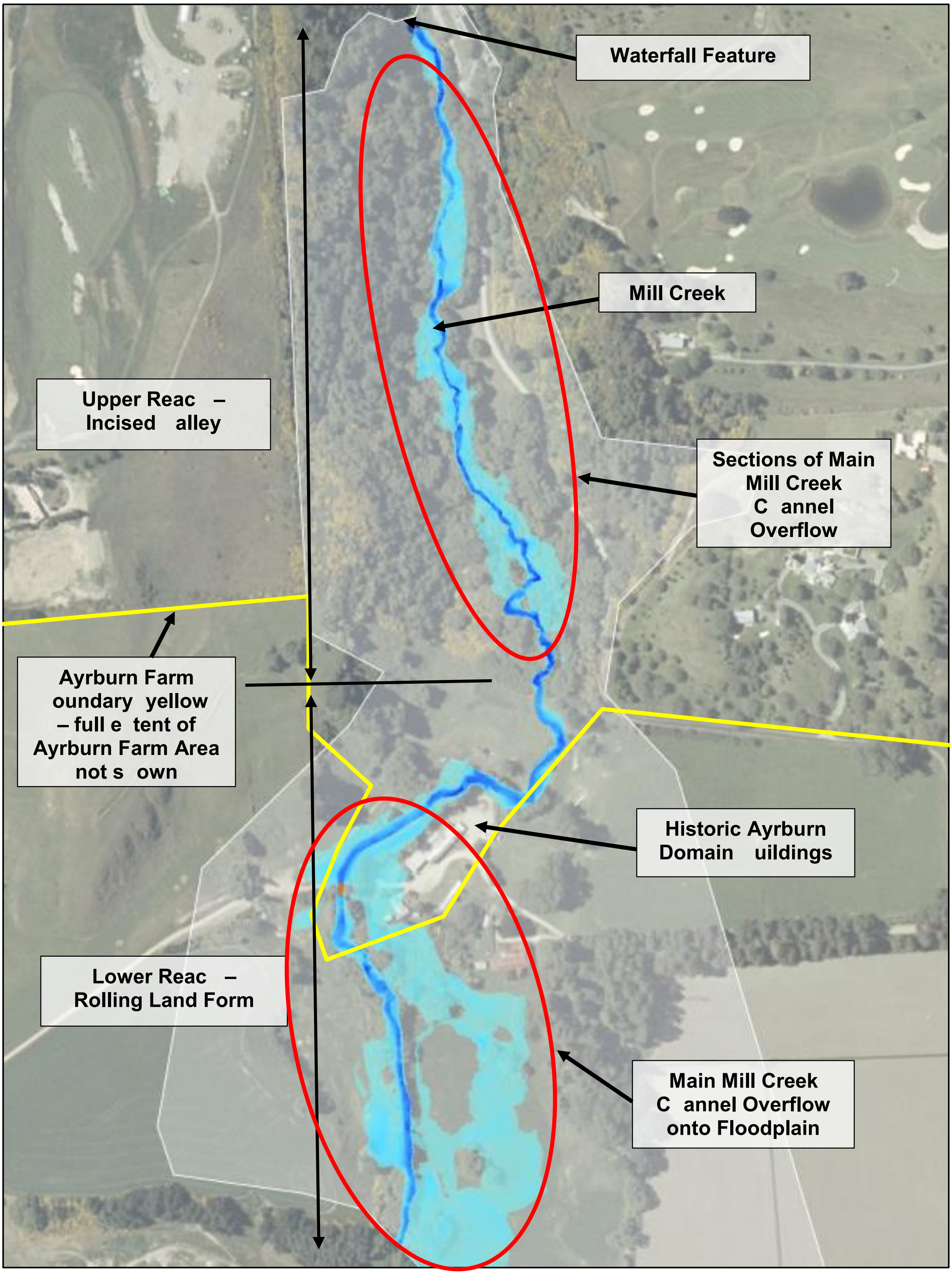

Figure 2.3 Mill Creek Lower Reac Main C annel Overflow – E isting Topograp y 100 ear ARI Flood Flow

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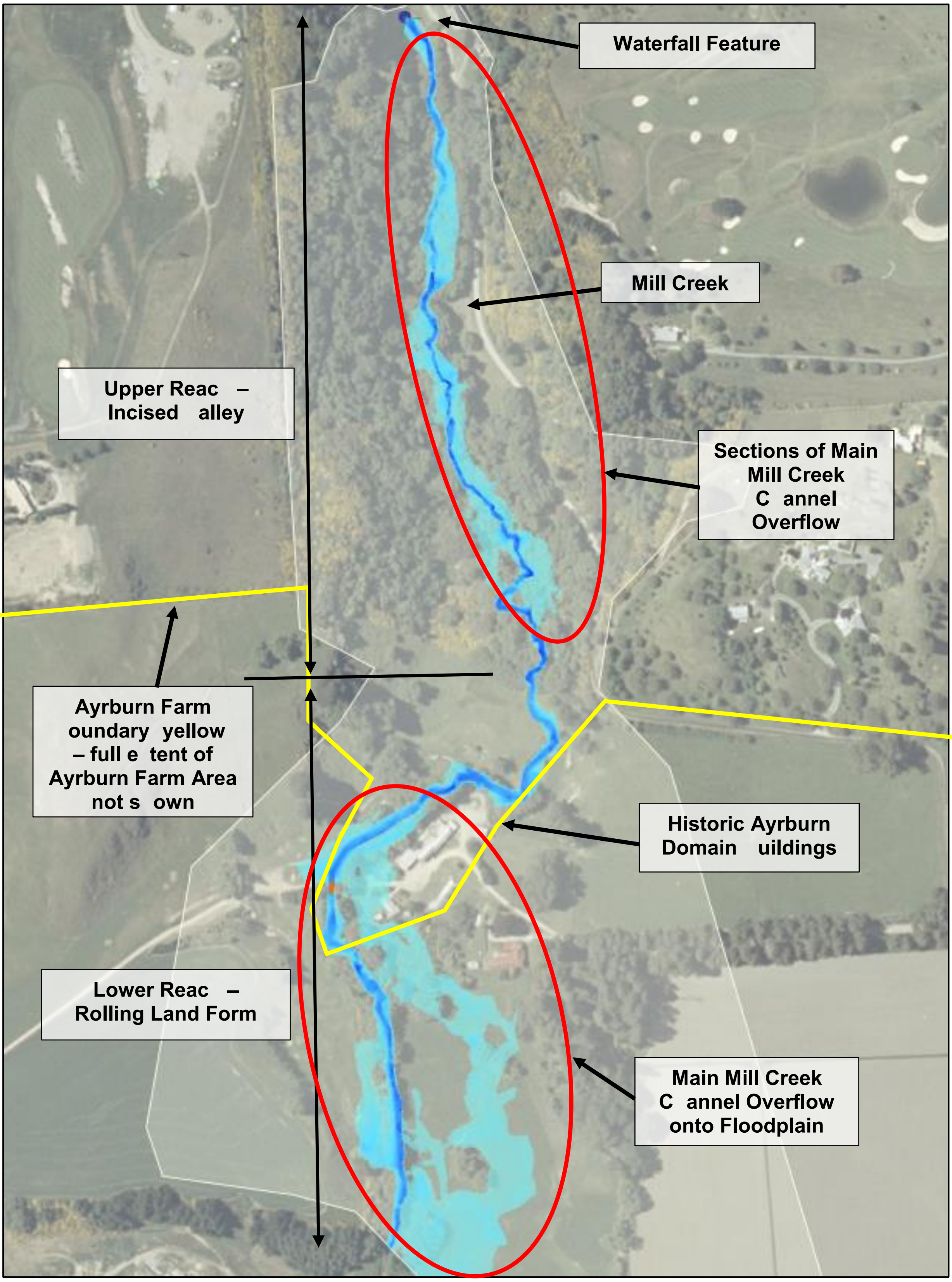

Figure 2.4 Mill Creek Lower Reac Main C annel Overflow – E isting Topograp y 20 ear ARI Flood Flow

3.0 Proposed Development

The Ayrburn Farm area is located downstream of the Waterfall Park hotel development and main access road. The Ayrburn Farm area is located along the southern boundary of the overall Waterfall Park development area as shown in Figure 3.1 below.

The proposed Ayrburn Farm development area is intended to contain a series of residential lots.

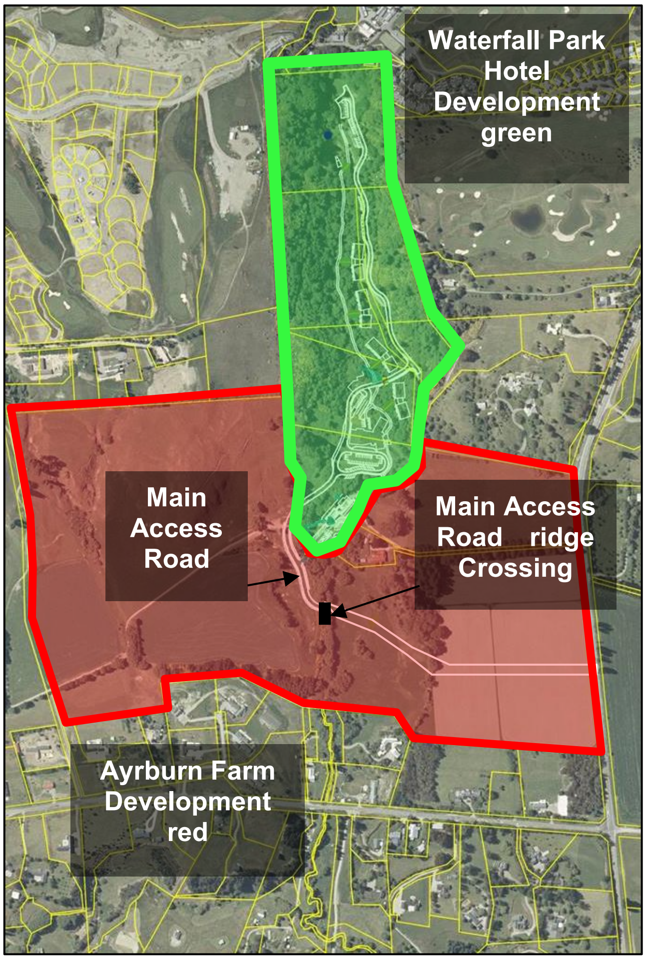

Figure 3.1 Proposed Ayrburn Farm Area

4.0 Proposed Flood Management Feasibility

The feasibility of flood management for the Ayrburn Farm area has been assessed for the 10 year, 20 year, 50 year, and 100 year ARI events. The basis for the feasibility study is to determine if flows and flooding extents can be managed to:

- Provide adequate freeboard from the 100 year ARI water level to the proposed residential dwellings, and
- Limit the post-development flows off the Ayrburn Farm and overall Waterfall Park development site to pre-development levels.

Note that flood management for the main access road and hotel development have been covered as part of Fluent Solutions flood management reports in October 2017 and April 2018 respectively (Waterfall Park Access Road RP-17-10-11 GMD Q000391-Rev2 and Waterfall Park Hotel Development RP-18-04-11 AOP Q000391). The proposed flood management infrastructure and design as indicated in the Fluent Solutions reports has been used as the basis for the Ayrburn Farm area flood management feasibility assessment.

Figures 4.1 and 4.2 below show the Mill Creek flow results for the 20 year and 100 year ARI storm events in the vicinity of the proposed Ayrburn Farm area. The overland flooding results shown below were developed using the hydraulic and hydrological modelling software Infoworks ICM (ICM), which utilises a 2D surface (based on 3D LiDAR and survey data) to estimate the overland flow depths within and adjacent to Mill Creek.

Note that the results presented below include the mitigation measures for the hotel and access road as per the Fluent Solutions flood management reports mentioned above. The area in the proposed Ayrburn Farm area (except for the main access road) is based on the existing 3D LiDAR data to give an estimate of the “pre-development” flow paths.

Figures 4.1 and 4.2 below show the following:

- The as-designed proposed detention area north of the main access road, which includes two discharge pipes to the floodplain to the south.
- To the south of the main access road, flows in Mill Creek break out of the creek banks and travel as overland flow through the floodplain (particularly on the true left bank).
- The Ayburn Farm site has two terraced areas which are more than 4m higher than the proposed Mill Creek floodplain area.
- On the higher ground to the west, there is an overland flow path which runs through the proposed residential area.

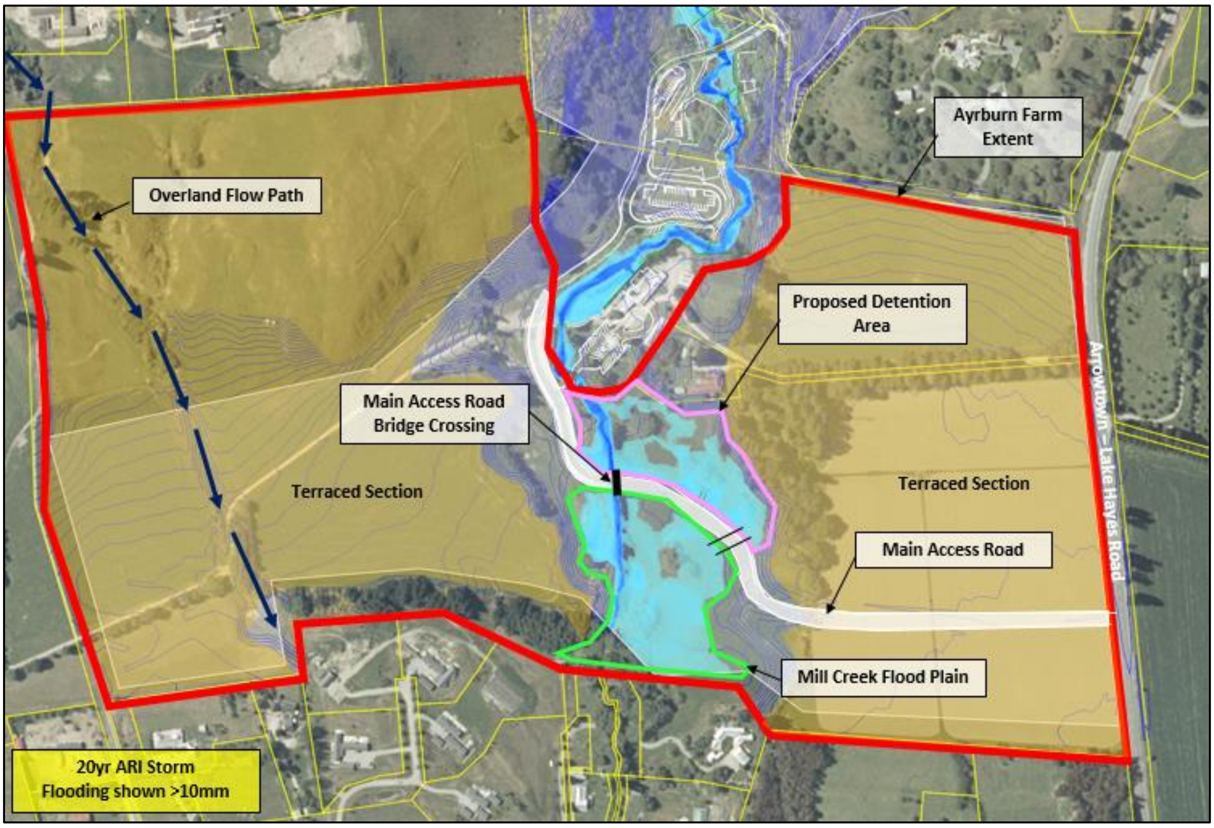

Figure 4.1 20 ear ARI – Preliminary "Pre development" Flood Flow Results

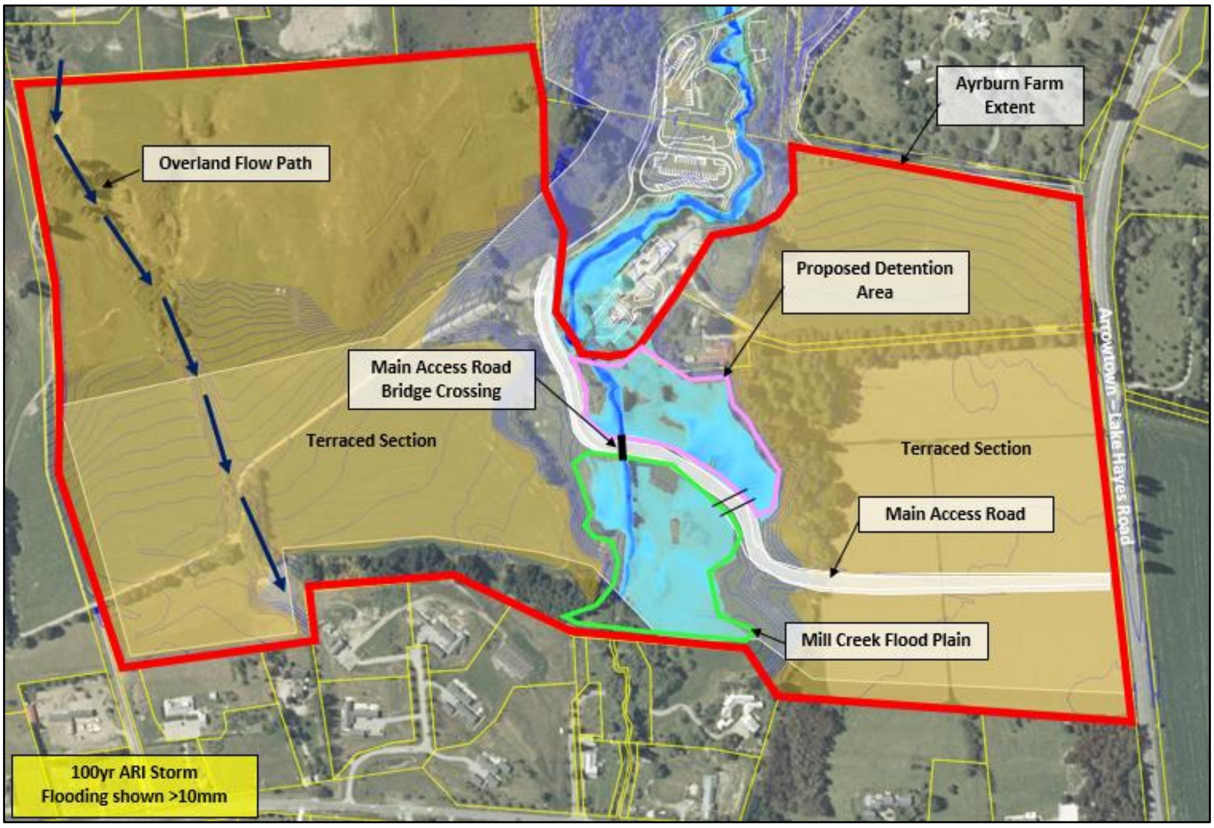

Figure 4.2 100 ear ARI – Preliminary "Pre development" Flood Flow Results

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Figure 4.3 shows a preliminary concept for flood management of Mill Creek in the Ayrburn Farm vicinity and includes the following:

- The main detention area north of the access road would be designated as a “no-build” area in order to maintain the effectiveness of the detention area in reducing post-development flows to pre-development levels. Outflow from the detention area would be transferred to Mill Creek via the two pipes under the main access road and downstream swale or pipe.
- All proposed houses / facilities building platform levels would need to be at least 0.5m above the 100 year ARI maximum flood level in order to ensure sufficient freeboard as per the QLDC Land Development and Subdivision Code of Practice (COP) Clause 4.3.5.2. Note that the COP indicates that *“the minimum freeboard shall be measured from the top water level to either the building platform level or underside of the floor joists or underside of the floor slab, whichever is applicable.”*
    - Those areas in the terraced section are generally more than 4m above the Mill Creek bed level and already has sufficient freeboard.
    - For low lying areas in the floodplain to the south of the main access road, additional design work would be necessary to ensure the required freeboard is achieved. This could be accomplished by creating a bund/wall along Mill Creek in order to contain the flows within the river banks and avoid overland flow through the floodway (indicated as green lines on the below).
- The Figure below shows an allowance for additional detention areas to help mitigate flows to pre-development levels. These areas would be designed and incorporated into the overall development plan.

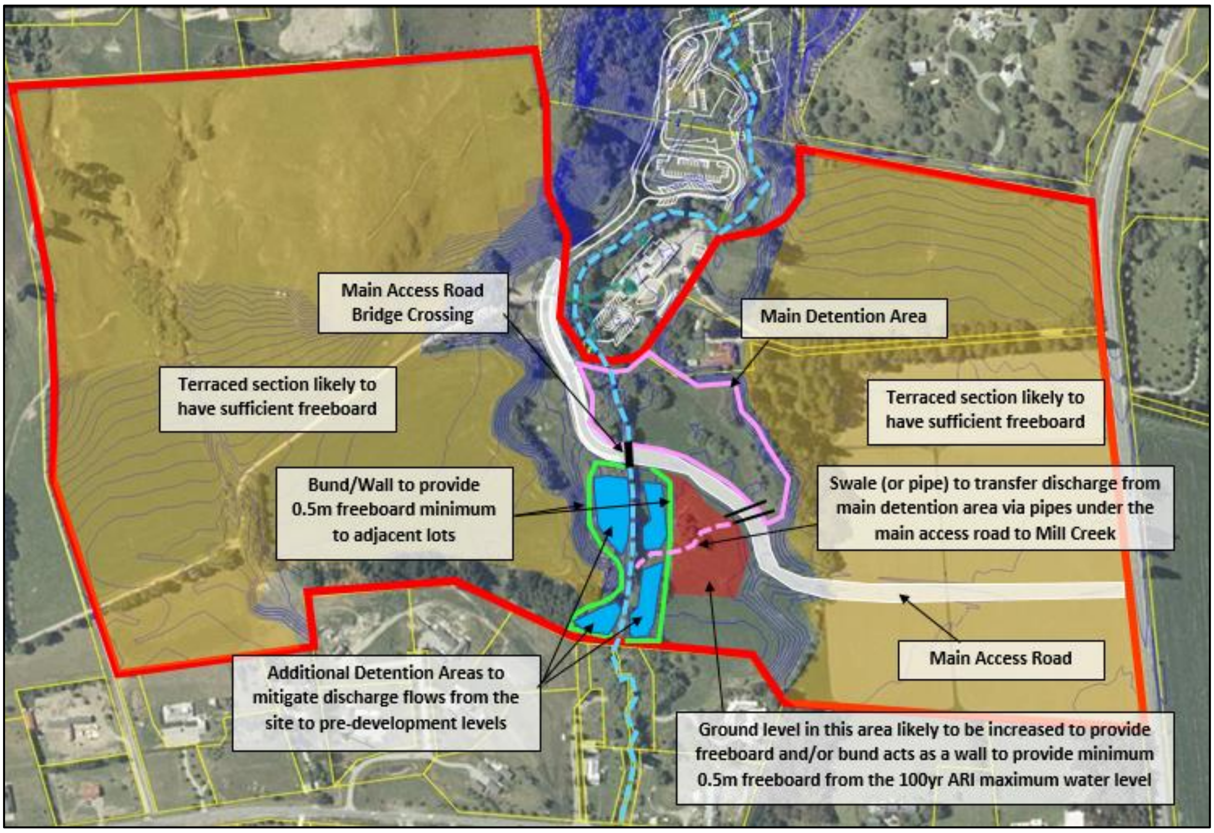

Figure 4.3 Preliminary Flood Management Concept

A preliminary model analysis using the preliminary concept as shown in Figure 4.3 above has been done to estimate pre- versus post-development outflows from the site. The preliminary results are shown in Table 4.1 below. Note that these values were used to help assess the feasibility of flood management in the Ayrburn Farm area and values and sizing of detention areas would need to be re-assessed as part of the design process.

Table 4.1 Summary Peak Flow Estimates

Storm Event	**Pre Development Mill Creek Peak Flow Estimate at 50m Upstream of Sout ern oundary m^3 s**	**PRELIMINAR Post Development Mill Creek Peak Flow Estimate at 50m Upstream of Sout ern oundary m^3 s**
10 Year ARI	7.7	7.1
20 Year ARI	8.5	8.0
50 Year ARI	9.9	9.4
100 Year ARI	10.9	10.2

The peak post-development flow for the design 10 year, 20 year, 50 year, and 100 year ARI storm events would be mitigated to less than the estimated preliminary peak pre-development flow and therefore the proposed works in Mill Creek associated with Ayrburn Farm would have no adverse flood effects on property downstream of Waterfall Park.

5.0 Summary

Based on the information presented above, it is feasible to provide flood management of Mill Creek for the Ayrburn Farm area in addition to the wider Waterfall Park development site.

The feasibility of flood management has been assessed for the 10 year, 20 year, 50 year, and 100 year ARI events. The proposed Ayrburn Farm works would:

- Provide adequate freeboard from the 100yr ARI water level to the proposed residential dwellings, and
- Limit the post-development flows off the Ayrburn Farm and overall Waterfall Park development site to pre-development levels.

Sizing and further assessment of discharge flows would be undertaken as part of the future detailed design processes.

Enclosures

- Appendix 1 – Waterfall Park Access Road Flood Management Report (Fluent Solutions) – Ref: RP-17-10-11 GMD Q000391-Rev2.pdf
- Appendix 2 – Waterfall Park Hotel Development Flood Management Report (Fluent Solutions) – Ref: RP-18-04-11 AOP Q000391 FINAL.pdf
- Appendix 3 – Access Road Consent (Otago Regional Council)

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Waterfall Park Developments Limited

Waterfall Park Access Road

Flood and Stormwater Management Proposal and Effects Assessment

13 October 2017

Fluent SOLUTIONS

Waterfall Park Developments Limited

Waterfall Park Access Road - Flood and Stormwater Management Proposal and Effects Assessment

13 October 2017

Task	Responsibility	Signature
Project Manager:	Jayne Richards	
Prepared By:	Alexis Patrylak / Jayne Richards	
Reviewed By:	Gary Dent	
Approved For Issue By:	Gary Dent	

Issue Date	Revision No.	Author	Checked	Approved
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Prepared By:
Fluent Infrastructure Solutions Ltd
Suite 2, First Floor
23-27 Beach Street
PO Box 1204
Queenstown 9348
Telephone: + 64 3 974 4586
Email: office@fluentsolutions.co.nz
Web: www.fluentsolutions.co.nz

Job No.: Q000391
Date: 13 October 2017
Reference: RP-17-10-11 GMD Q000391-Rev2

Waterfall Park Developments Limited

Waterfall Park Access Road - Flood and Stormwater Management Proposal and Effects Assessment

1.0 Introduction

Fluent Solutions has been engaged by Waterfall Park Developments Ltd to prepare a report on how the flood flows affecting the proposed Waterfall Park access road would be managed and an assessment of the effects in the context of proposed mitigation measures.

The proposed flood mitigation measures primarily relate to the effects of the Waterfall Park access road that is proposed to be constructed on the left bank flood plain areas adjacent to Mill Creek and a vehicle bridge over Mill Creek.

This report also outlines the stormwater management concept for the full length of the proposed access road.

This report has been prepared to support an application for resource consents for works associated with managing stormwater and flood flows on the flood plain and in the main channel of Mill Creek in respect of the access road.

Note: This report does not address matters related to the ecology of Mill Creek.

2.0 Background

2.1 Waterfall Park Locality

The proposed Waterfall Park and Ayrburn Farm development area is located to the north of Lake Hayes and approximately 3km southwest of Arrowtown. Mill Creek drains a moderately large catchment that discharges to Lake Hayes that in turn discharges via Hayes Creek to the Kawarau River. Waterfall Park lies in relatively rolling land, however, part of the development area lies in a relatively incised valley. At the head of the valley, the floor of the valley rises steeply by approximately 40 metres (m), to form the well-known natural waterfall feature that the “Waterfall Park” development zone takes its name from. At the transition from the rolling land form to the incised valley, the existing “Homestead Lot” is adjacent to some historic farm buildings located between the homestead and Mill Creek. Refer to Figure 2.1 below for the locality of the proposed Waterfall Park and Ayrburn Farm development area.

Mill Creek is referred to as “Mill Creek” because that is what the stream between the waterfall and Lake Hayes is referred to by the Otago Regional Council (ORC). The stream through the Waterfall Park site is not named on the 1:50,000 scale topographical map series typically used for locality references.

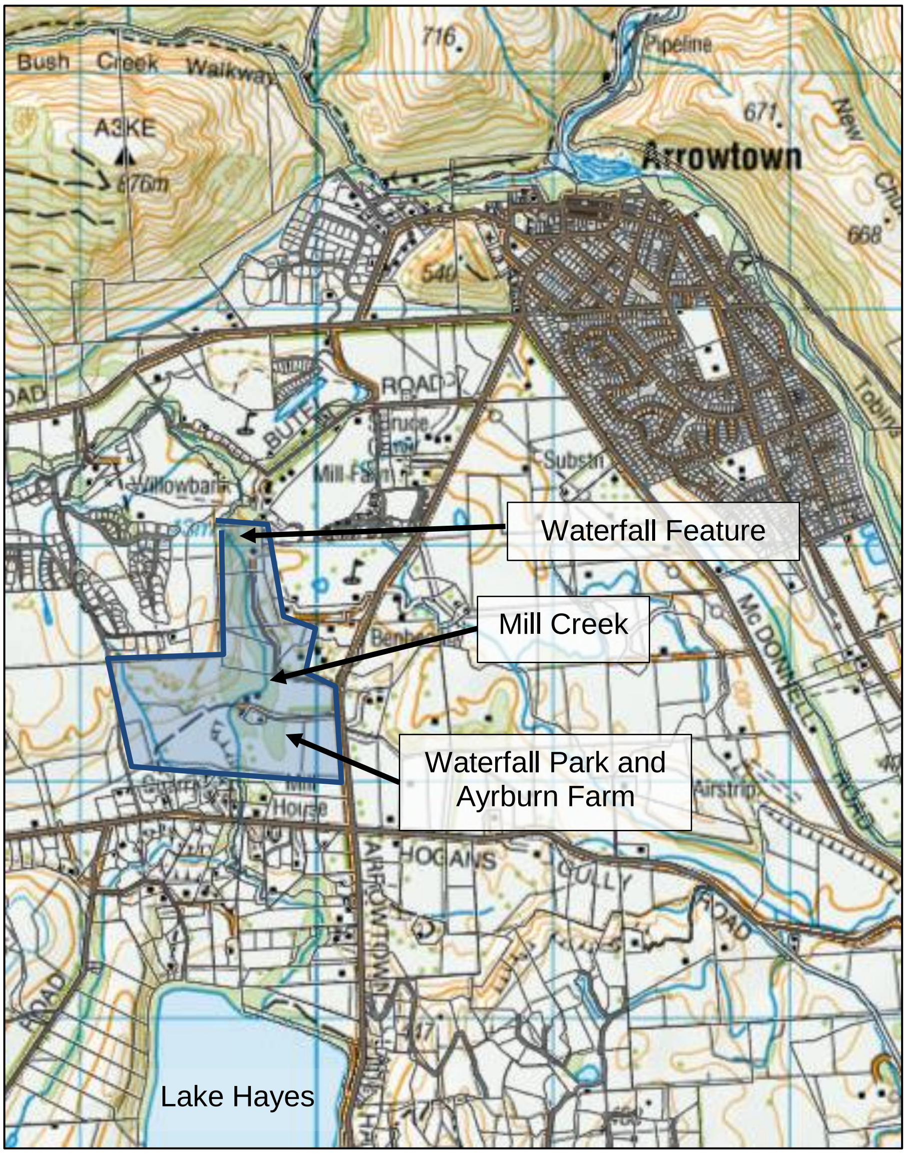


Figure 2.1: Locality Plan

2.2 Proposed Access Road

The layout of the proposed access road is included in the "Waterfall Park Developments Ltd Proposed Access Road Drawings" (Paterson Pitts Group, Q6388-15) in Appendix 1. A simplified layout of the Access Road Plan is provided in Figure 2.2 below.

The proposed access road provides access to the site from the Arrowtown-Lake Hayes Road. The proposed access road initially crosses the rolling land form containing terraces in the southern part of the site before crossing Mill Creek at a proposed vehicle bridge. The proposed access road then follows the true right bank of Mill Creek to provide access to the northern part of the site.

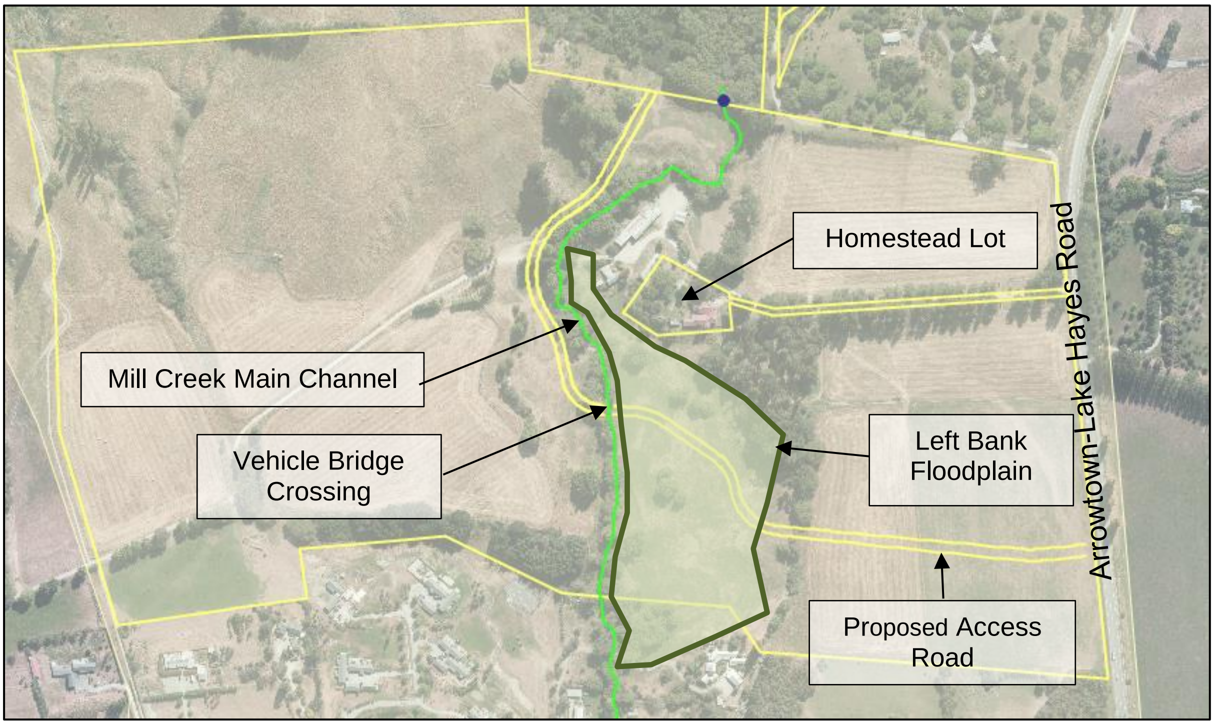


Figure 2.2: Waterfall Park Proposed Access Road Plan

2.3 Mill Creek Characteristics

2.3.1 Typical Flow Regime

The Mill Creek 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 (km^2). Upstream of the waterfall at the upstream and northern extent of Waterfall Park, the Mill Creek valley floor rises very gradually from 400m to 440m over a distance of 10km which is a very modest slope hence the valley floor is relatively flat and is typically 1km wide. Despite the significant catchment area and the steep valley sides, and hence the potential for significant flows, the wide valley floor has the ability to absorb and disperse large flows.

Through the Waterfall Park and Ayrburn Farm land, and elsewhere between Waterfall Park and Lake Hayes, the main channel of Mill Creek is confined and is relatively stable. The channel stability is indicative of a relatively stable flow regime typical of a stream downstream of a lake or wetland, in this case the wide flat valley floor upstream of Waterfall Park. The median dry weather flow is of the order of 350 litres per second (l/s). The stability of the flow regime creates an attractive habitat for fish and therefore Mill Creek is a valuable fish spawning area. The ecology of Mill Creek is the subject of a separate report by others.

Figure 2.3: Mill Creek Environment
(At the Homestead Lot (see Figure 2.2))

2.3.2 Upper Reach Stream Environment - Incised Valley

In the incised valley reach, the margins of the stream channel have recently been cleared of a dense willow thicket. See Figure 2.4 for the “Upper Reach”. The main channel of the stream is typically 3 to 5 metres (m) wide in the bottom and 10 to 15m wide at the top of the bank and is typically 1m to 2m deep. Where the channel is less than 1.5m deep there is a risk that flood flows would leave the main channel locally to the flood plain and return to the channel downstream.

At the southern end of the incised valley, Mill Creek then flows through a shallow terraced land form at the northern end of the east bank floodplain adjacent to the main channel.

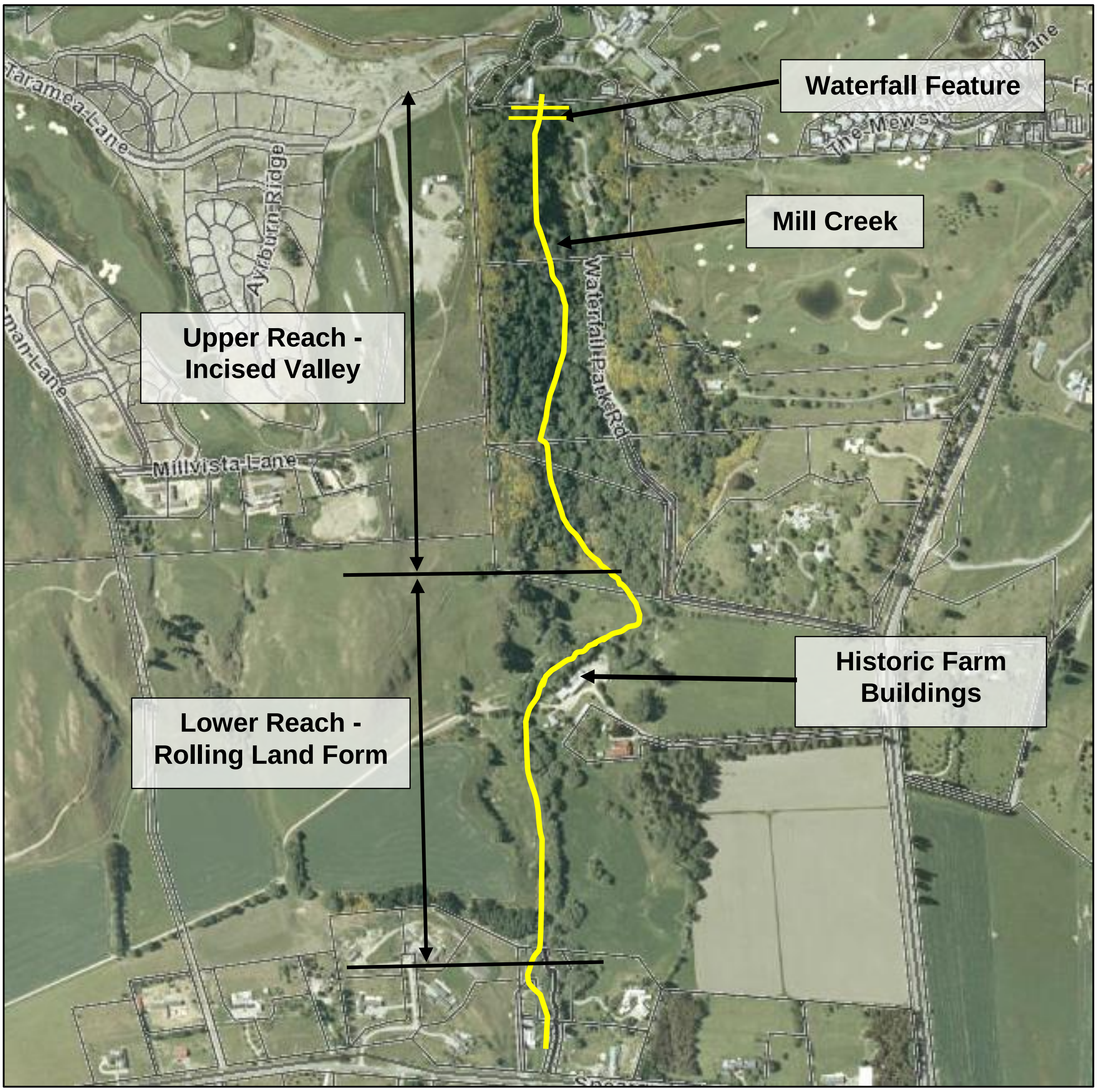


Figure 2.4: Existing Mill Creek Locality

2.3.3 Lower Reach Stream Environment - Rolling Land Form

The Creek in the rolling land area (Lower Reach) downstream of the incised valley is similar to that upstream in the incised valley except that bank heights are frequently less than 1.5m and therefore there are areas where during major flood events flood flows leave the main stream channel. Flows leave the Creek on the left bank of the channel downstream of the “Homestead Lot” and follow a flood plain. Figures 2.5 and 2.6 illustrate the spreading out of extreme (100 year Average Recurrence Interval (ARI)) flood flows on the Lower Reach outside the main Creek channel. Figure 2.5 also illustrates the flooding that would occur on the access road without raising the road above existing ground level. Figure 2.6 represents the spreading out of a moderate event flood flow (10 year ARI) and provides a comparison to Figure 2.5. The flow on the floodplain is significant for moderate and extreme events.

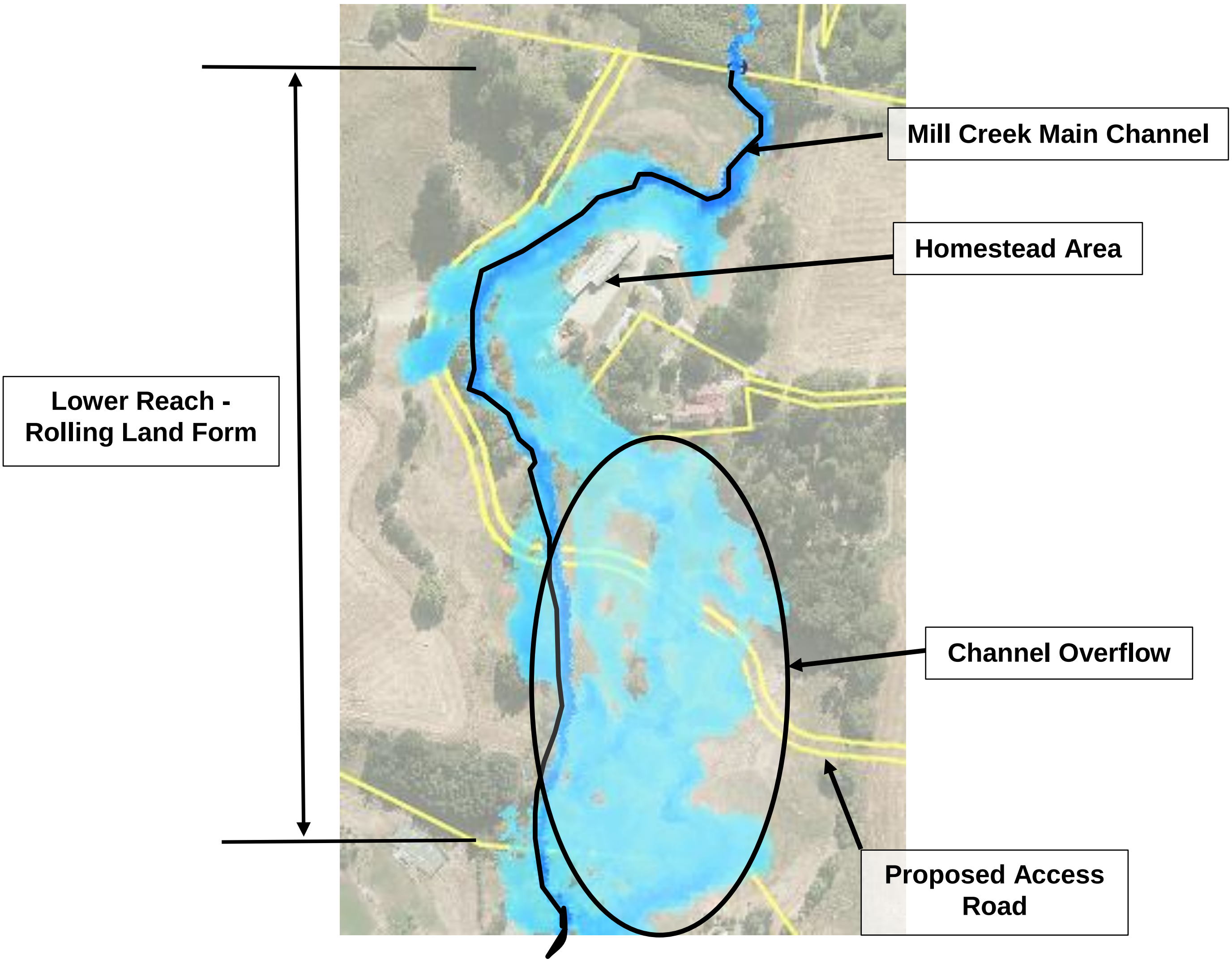


Figure 2.5: Mill Creek Lower Reach Main Channel Overflow (100 Year ARI Flood Flows)

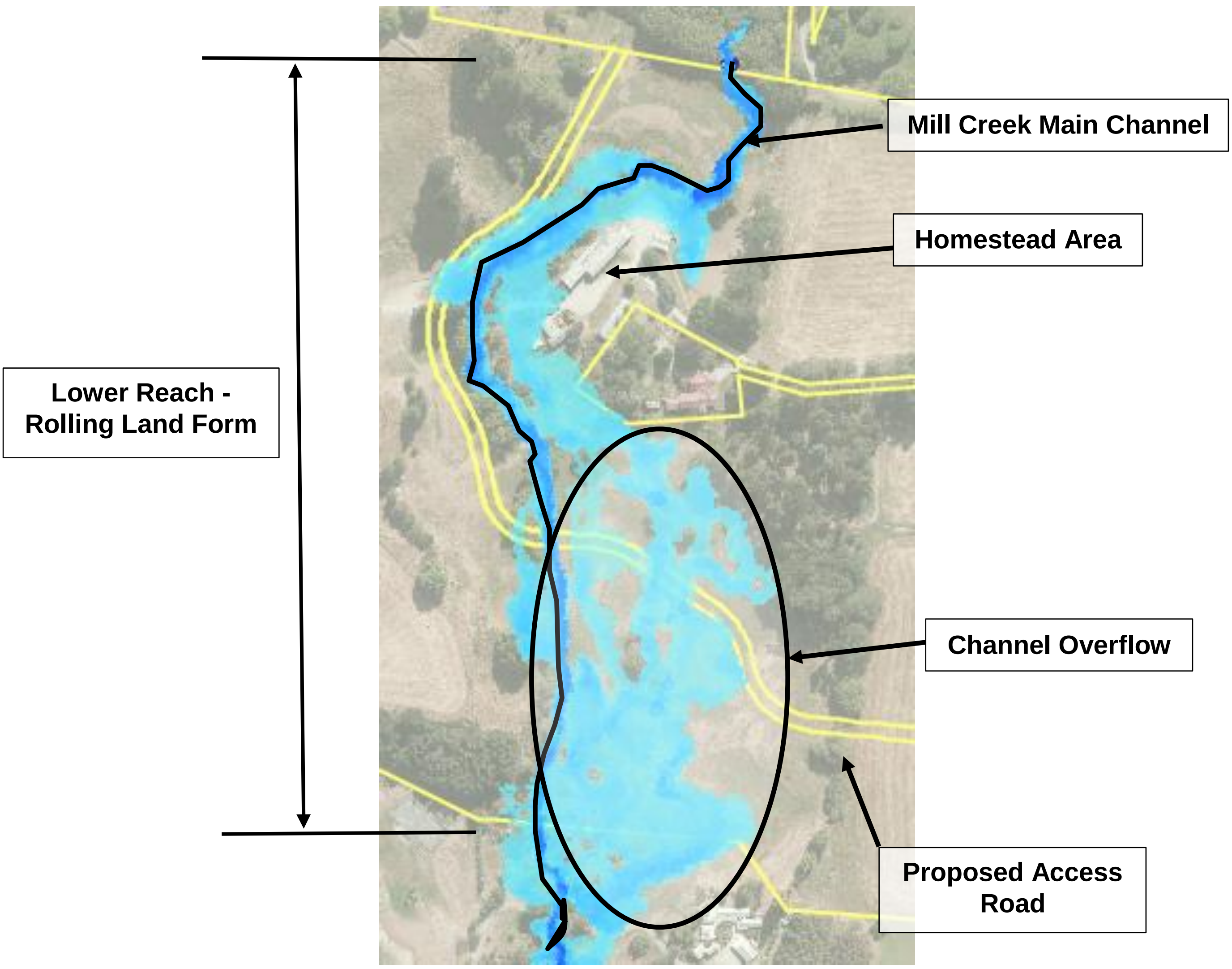


Figure 2.6: Mill Creek Lower Reach Main Channel Overflow (10 Year ARI Flood Flows)

2.3.4 Flood Effects Mitigation

The objectives followed for identifying flood mitigation measures have been as follows:

A. Construction of access road embankment above existing ground level.
To provide protection of the road during flood events the road would be constructed on a raised embankment across the flood plain typically up to 1m high. Noting that in the Lower Reach area, the flood flows have previously left the channel during moderate and extreme events, then, confining the flood flow within a smaller area due to the construction of the access road would have the effect of increasing the flood flow downstream of the Waterfall Park development area.

   To avoid any increase in downstream flow, culverts under the road would be sized to convey flood flow under the road formation to the flood plain south of the access road.

   The proposed access road formation would limit the flow at the southern boundary of the site to no more than the predevelopment flow for both the 10 year and 100 year Average Return Interval flood events.

B. The proposed bridge and road embankment works would have minimal effect on the main channel of the existing stream. The bridge would span the full width of the main channel. The finished road level would be approximately 2.1m above the main channel bed level.

C. Establish a Mill Creek flood path maintenance plan to maintain the flood flow path and address adverse vegetation and channel conditions that could result in increased flood levels within the floodway through the Waterfall Park development area.

Section 5 below provides the details of the methodology used to identify the effects and details of the mitigation proposal.

2.3.5 Stormwater Effects Mitigation

The objective for stormwater effects mitigation has been to collect stormwater that falls on the road or travels towards the road from within the catchment, removal of potential contaminants and return of water to Mill Creek, in compliance with ORC rules and QLDC Code of Practice.

3.0 Statutory Requirements

3.1 Code of Subdivision Requirements

The Queenstown Lakes District Council (QLDC) “Land Development and Subdivision Code of Practice” (dated 30/10/2015) (Cl 4.3.5) requires that a primary stormwater system be designed to convey, as a minimum, a 20 year Average Return Interval (ARI) (5% Average Exceedance Probability (AEP)) runoff flow taking into account climate change. Where a secondary flow path is available, the secondary flow path is required to convey the balance of a 100 year ARI (1% AEP) flow without damage to property and with freeboard. If a secondary flow path is not available, the primary system is required to convey a 100 year ARI flow with freeboard (Cl 4.3.5.2).

In relation to the Waterfall Park and Ayrburn Land, the Mill Creek and the associated flood plain is a primary stormwater flow path and therefore property potentially affected by Mill Creek is to be protected to 100 year ARI event standard with the appropriate freeboard.

The COP provides minimum standards for freeboard at bridges and culverts. The freeboard at the culvert is required to be 0.5m for a 50 year ARI event. For a bridge the freeboard required is 0.6m for a 50 year ARI event.

For a road in a secondary flow path flood waters up to 100mm deep may flow down / across a road. However, since the flow on the floodplain occurs for floods that occur more frequently than a 20 year ARI flood flow, the floodplain is a “primary flow path”. The minimum road level across the floodplain has been assumed to be the 100 year ARI flood level and higher at the culvert and the bridge sites as noted above.

3.2 Regional Plan: Water for Otago

3.2.1 Relevant Activities

The activities proposed in terms of the Regional Plan: Water for Otago (RPW) relating to the placement of a structure in, on, under or, over the bed of any lake or river and the discharge of stormwater are as follows:

1. Construction of a new bridge for vehicle and pedestrian use.
2. Construction of the road embankment (including culverts) across the flood plain to protect the road from flood events.
3. Construction of embankments along the right bank of the creek north of the bridge.
4. The discharge of treated stormwater from the access road into Mill Creek.

3.2.2 Bridge Construction

The relevant rules for the construction of the bridge are 13.2.1.7 and 13.5.1.1 in the RPW. Under Section 13.2.1.7 the construction of the new single span bridge is a permitted activity provided conditions (a) - (g) are met. Table 3.2 below lists each of these conditions and specifies how compliance with these conditions is achieved.

Table 3.2: Compliance with Rule 13.2.1.7

Rule 13.2.1.7 Conditions	Compliance with conditions
(a) The bridge or its erection or placement, does not cause any flooding, nor cause any erosion of the bed or banks of the lake or river, or Regionally Significant Wetland, or property damage; and	The bridge has been designed to ensure that it does not cause flooding, erosion or property damage. The bridge would have no adverse flood effect that is not mitigated by the proposed flood management work.
(b) No more than 20 metres of bridge occurs on any 250 metre stretch of any lake or river; and	There is an existing bridge within 250m of the new bridge. The existing bridge has a width of ~4m and the new bridge has a width of up to 11.2m. The combined width of these bridges along the creek is less than 20m within a 250m stretch of creek and therefore in compliance with this condition.
(c) There is no reduction in the flood conveyance of the lake, river or Regionally Significant Wetland; and	The new bridge has been designed to ensure that there is no reduction in flood conveyance. This is further discussed in sections 4 and 5 below.
(d) The bridge soffit is no lower than the top of the higher river bank; and	The bridge soffit would be no lower than the top of the higher river bank. A minimum freeboard of 600mm above the 50 year ARI flood level is provided to the soffit of the bridge. A minimum of 1.7m is provided from the bed to the bridge soffit.
(e) The bridge and its abutments are secured against bed erosion, flood water and debris loading; and	Concrete piles would be constructed to secure the bridge against bed erosion and flood water. A 600mm freeboard above the 50 year ARI would be provided to the bridge soffit. This is considered to be sufficient to secure against debris loading as the relatively small flows in the creek are not high enough to carry large trees downstream.
(f) Where the bridge is intended for use by stock, measures are taken to avoid animal waste entering the lake, river or Regionally Significant Wetland; and	The bridge is not intended to be used by stock.
(g) If the bridge is situated over or on public land, then public access over the public land is maintained.	The bridge is not situated on or over public land.

Under Section 13.5.1.1 the construction of the new single span bridge is a permitted activity provided conditions (a) - (k) are met. Table 3.3 below lists each of these conditions and specifies how compliance with these conditions is achieved, with the exception of condition (f), where compliance cannot be achieved.

Table 3.3: Compliance with Rule 13.5.1.1

Rule 13.5.1.1 Conditions	Compliance with conditions
(a) Except in the case of the demolition or removal of a structure, the structure is lawfully established; and	The bridge would be lawfully established, as outlined in Table 3.2 above.
(b) Except in the case of (i), there is no increase in the scale of the existing structure; and	N/A - this is a new bridge, not a replacement.
(c) If work is undertaken between 1 May and 30 September inclusive, the Department of Conservation and the relevant Fish and Game Council will be notified as soon as reasonably practicable in advance; and	The work would be undertaken outside the period of 1 May to 30 September.
(d) The bed or wetland disturbance is limited to the extent necessary to undertake the work; and	The bed disturbance would be limited to the extent necessary to construct the bridge. This would include the construction of concrete abutments and driving of piles into the bed. A coffer dam would be established to temporarily divert the creek in the vicinity of the bridge during the construction period, to ensure a dry creek bed and enable the construction to proceed.
(e) The bed or wetland disturbance does not cause any flooding or erosion; and	The disturbance of the bed would not cause flooding or erosion. During the construction period the creek would be diverted to a coffer dam. The size and details of this diversion and coffer dam would be determined during detailed design.
(f) The time necessary to carry out and complete the whole of the work within the wetted bed of the lake or river does not exceed 10 hours in duration; and	The time required to construct the bridge would be longer than 10 hours and is therefore non-compliant with this condition.
(g) All reasonable steps are taken to minimise the release of sediment to the lake or river during the disturbance, and there is no conspicuous change in the colour or visual clarity of the water body beyond a distance of 200 metres downstream of the disturbance; and	All reasonable steps would be taken to minimise sediment release during the construction of the bridge. An Earthworks Management Plan has been prepared to manage sediment loads during road construction.
(h) No lawful take of water is adversely affected as a result of the bed or wetland disturbance; and	The temporarily diverted water would be returned to Mill Creek and therefore no lawful water take would be adversely affected.
(i) The site is left tidy following completion of the activity; and	The site would be left tidy following completion of the bridge construction.
(j) Except for activities covered by Rules 13.2.1.5, 13.2.1.6, or 13.2.1.8, there is no change to the water level range or hydrological function of any Regionally Significant Wetland; and	The diverted water would be returned to Mill Creek and therefore the water level range and hydrological function of the Lake Hayes Margins (a Regionally Significant Wetland) would not be adversely affected.
(k) Except for activities covered by Rules 13.2.1.5, 13.2.1.6, or 13.2.1.8, there is no damage to fauna, or New Zealand native flora, in or on any Regionally Significant Wetland.	There would be no damage to fauna or New Zealand native flora, in or on any Regionally Significant Wetland.

3.2.3 Construction of the Road Embankment

As outlined in section 2.3.4, construction of the road on a raised embankment is required where the road crosses the flood plain to ensure that the road is protected against flooding. The effects associated with this activity and their mitigation are described in Section 5 below.

3.2.4 Bank Filling

Section 13.5.1 refers to the disturbance of the bed of a river for the purposes of "deposition of clean fill associated with works in the bed". In this case the deposition of material is required to lift ground levels along the banks of the lower reach to protect the proposed adjacent access road. The work would be at the top of bank level and above and therefore the deposition of material is outside the "bed" of Mill Creek.

3.2.5 Stormwater Discharge

Section 12.B.1.8 of the RPW provides rules relevant to the discharge of stormwater to water, or to land where it may enter water. The discharge of stormwater is a permitted activity provided that conditions (a) to (d) are met. Table 3.4 below lists each of these conditions and specifies how compliance with these conditions is achieved.

Table 3.4: Compliance with Rule 12.B.1.8:

Rule 12.B.1.8 Conditions	Compliance with Conditions
The discharge of stormwater from a reticulated stormwater system to water, or onto or into land in circumstances where it may enter water, is a permitted activity, providing:	
(a) Where the system is lawfully installed, or extended, after 28 February 1998: *(i) The discharge is not to any Regionally Significant Wetland; and* *(ii) Provision is made for the interception and removal of any contaminant which would give rise to the effects identified in Condition (d) of this rule; and*	(i) The discharge is not to a Regionally Significant Wetland. (ii) Detention basins are provided for the removal of suspended solids
(b) The discharge does not contain any human sewage; and	The stormwater is predominantly road runoff and would not contain human sewage.
(c) The discharge does not cause flooding of any other person's property, erosion, land instability, sedimentation or property damage; and	The design of the stormwater management system would ensure that the discharge does not cause flooding, erosion, land instability, sedimentation or property damage.
(d) The stormwater discharged, after reasonable mixing, does not give rise to all or any of the following effects in the receiving water: *(i) The production of any conspicuous oil or grease films, scums or foams, or floatable or suspended materials; or* *(ii) Any conspicuous change in the colour or visual clarity; or* *(iii) Any emission of objectionable odour; or* *(iv) The rendering of fresh water unsuitable for consumption by farm animals; or* *(v) Any significant adverse effects on aquatic life.*	The stormwater discharge would not give rise to these effects after reasonable mixing. This is further discussed in Section 6.

The conclusion of the stormwater discharge assessment of effects, see Section 5.5, demonstrates compliance with the permitted activity rules for RPW.

The sections of this report below address mitigating the effects of the proposed Waterfall Park development area access road.

4.0 Flood Hydrology of Mill Creek

4.1 Flood Effects Modelling

The hydraulic and hydrological modelling software Infoworks ICM (ICM) was used to estimate the peak flood flows in Mill Creek at the downstream end of the lower reach for the pre- and post-development scenarios for the 10 year, 20 year, 50 year, and 100 year design ARI events. The model utilises a 2D hydraulic calculation algorithms (built from 3D LiDAR information) to estimate flows.

The following section describes the hydrology, model input parameters, and peak flood flow results for Mill Creek.

4.2 Hydrology

4.2.1 Ground Model Data

LiDAR data supplied by the Otago Regional Council (ORC) was used to model the pathway of the flood flow through Mill Creek at Waterfall Park under the current “pre-development” condition.

4.2.2 Flow Estimate at Waterfall Park

The Mill Creek catchment area at Waterfall Park is approximately 35km^2 while the catchment area at the “Fish Trap” gauging station on Mill Creek is 55km^2. The additional catchment area is largely that of the Speargrass Flat area which includes Mooneys swamp. The Speargrass sub-catchment has a similar catchment shape but shorter time of concentration than Mill Creek at Waterfall Park and therefore the peak flow at the Fish Trap gauging station would generally be marginally higher than the peak flow at Waterfall Park. The flow estimates provided by the ORC using the Generalised Extreme Value (GEV) analysis of annual maximum flows from the Fish Trap flow record to provide ARI flow estimates have been used as the basis of the hydraulic analysis of conditions at Waterfall Park. Due to the contribution of the Speargrass sub-catchment use of the Fish Trap peak ARI flow estimates is a conservative approach.

From the gauging station record, the adopted 100 year ARI peak flow of 7.4m^3/s was adopted as the starting point. The 100 year ARI flow estimate based on the flow record summary for Mill Creek at the “Fish Trap” is included in the Appendix 2.

A 30% increase in the estimated 100 year ARI flow at the Fish Trap was added to account for climate change. Typically, an 11% increase in rainfall depth is added, which converts to approximately 30% increase in runoff with climate change. An additional 10% of the estimated flow at the Fish Trap was added as a contingency to allow for uncertainties including future local stormwater flows draining into the Mill Creek floodway at Waterfall Park. The additional allowances applied to the estimate of 7.4m^3/s at the Fish Trap provide a design total peak flow of 10.4m^3/s at Waterfall Park.

From these peak flow estimates, a 24 hour duration triangular flow hydrograph was created with the peak flow occurring at 0.7 times the duration each ARI storm event. The hydrograph was used to represent the storage routing.

The design model input peak flow was applied to the model upstream of the historic farm buildings, referred to as the “Flow Hydrograph Input Location” shown in Figure 4.1 below. A similar method was used to develop the peak 10 year, 20 year, and 50 year ARI flows. Design peak flows applied at the flow hydrograph input location are shown.

Discharge flows were estimated using the ICM model at the southern boundary of the Waterfall Park site for the pre- and post-development scenarios to ensure that discharges leaving the site are mitigated to at least pre-development levels. The peak design flows and the flows calculated at the southern boundary are presented in Table 4.1.

Table 4.1: Peak Design Input and Southern Boundary Result-line Flows

Storm Event	Design Input Peak Flow (m^3/s)	Southern Boundary Result-line Flow (m^3/s)
10 Year ARI	7.6	8.2
20 Year ARI	8.5	9.0
50 Year ARI	9.6	10.3
100 Year ARI	10.4	11.0

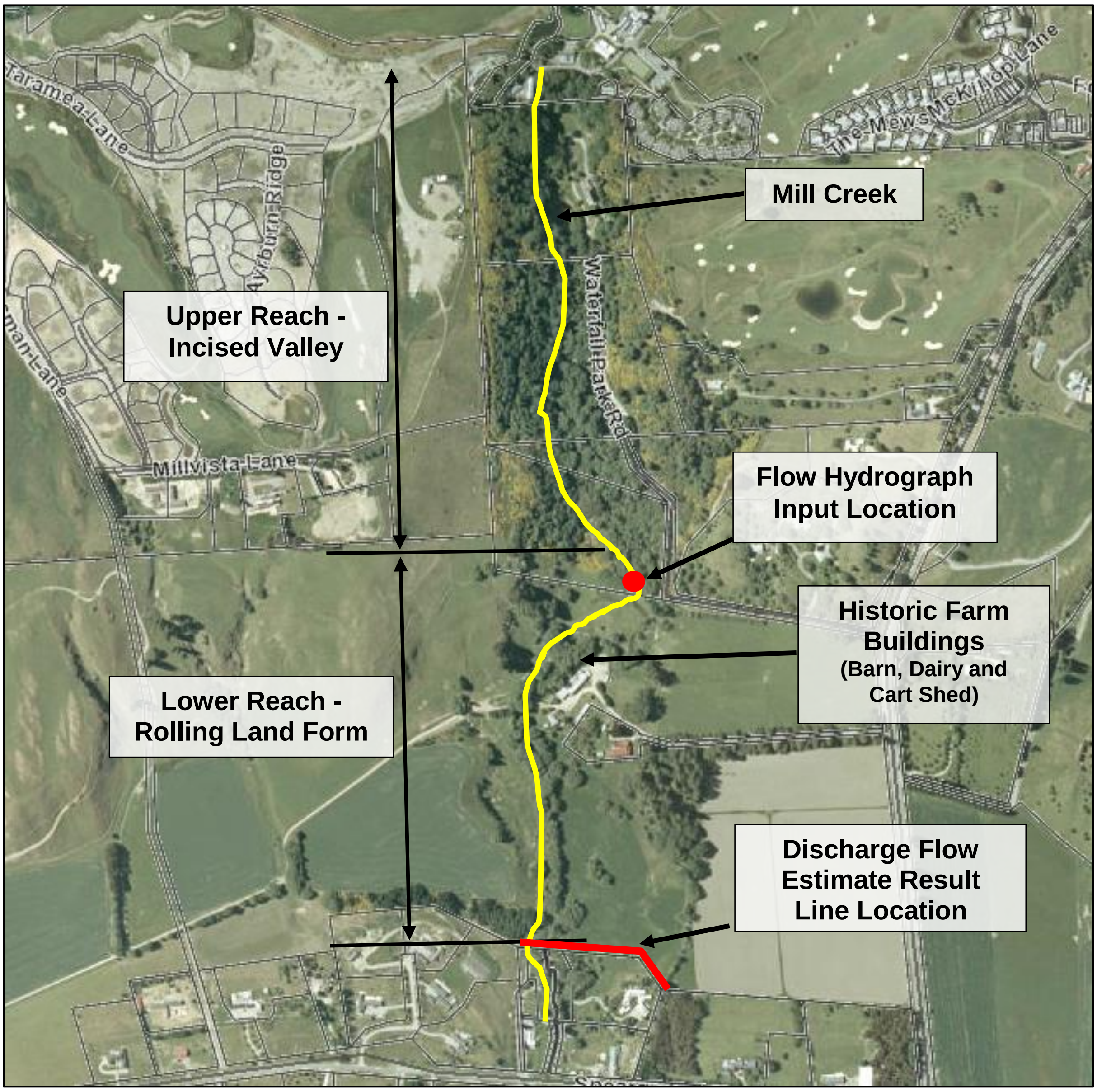


Figure 4.1: Flow Estimate Location

Note that the derivation of the flow input hydrographs is considered a conservative approach as explained above.

5.0 Proposed Flood and Stormwater Management System

5.1 Flood Management Concept

The proposed flood management system is designed to provide mitigation of flows in Mill Creek to pre-development levels for the 10 year, 20 year, 50 year, and 100 year ARI events by utilising storage in the area north of the access road on the flood plain, formed by the construction of the road embankment and natural river terrace.

The flood flow down Mill Creek and onto the flood plain with the road embankment in place during a major flood event is illustrated in Figure 5.1. The existing flow path in Mill Creek is generally contained within the Upper Reach, but a substantial flow leaves the main channel and flows down the floodplain on the left bank and spreads out in the Lower Reach section where a variety of overland flow paths are utilised, as demonstrated in Figure 2.5 above and 5.1 below.

Figure 5.1 is a representation of the proposed mitigated post-development flow path from the hydraulic model. The model estimates the effects of the access road embankment across the flood plain and the outlet pipe culverts to allow water to pass under the road to the lower flood plain, south of the access road.

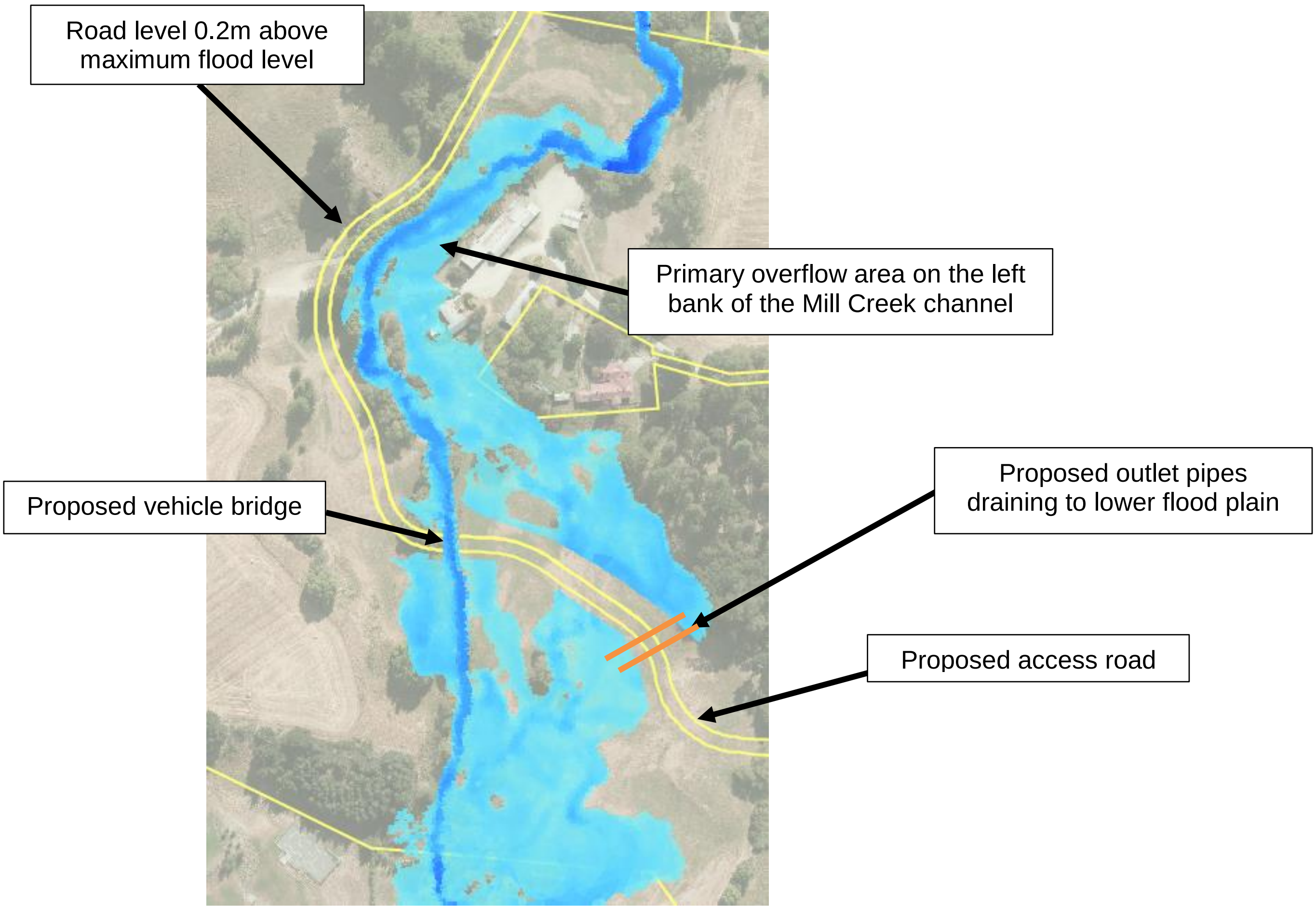


Figure 5.1: Post-Development Flow Path (100 Year ARI)

5.2 Pre- and Post-Development Flood Flow Results Summary

A summary of the peak pre- and post development Mill Creek flood flows from the southern boundary of Waterfall Park site are presented in Table 5.1 below.

Table 5.1: Summary Peak Flow Estimates

Storm Event	Pre-Development Mill Creek Peak Flow Estimate at Southern Boundary (m^3/s)	Post-Development Mill Creek Peak Flow Estimate at Southern Boundary (m^3/s)
10 Year ARI	8.2	7.6
20 Year ARI	9.0	8.5
50 Year ARI	10.3	9.7
100 Year ARI	11.0	10.4

From the hydraulic design for the culverts and road embankment, the peak post-development flow in the 10 year, 20 year, 50 year, and 100 year ARI storm events would be mitigated to no more than the estimated peak pre-development flow. The results of the ICM 2D modelling estimates that the post development flow at the southern boundary is between 93% and 95% of the pre-development flood flow and therefore there would be no adverse flood effects for flood events with an ARI between 10 years and 100 years.

5.3 Mill Creek Floodway Maintenance Plan

A Mill Creek Floodway Maintenance Plan is proposed to monitor the condition of the Mill Creek flood flow path and provide a mechanism for addressing channel conditions that could adversely affect flood levels and channel stability. Routine maintenance work would include inspections of the Mill Creek channel and bridge and culvert structures after major storm events and annual inspections in March to monitor stream condition. Where trigger conditions occur, such as the potential for debris deposition upstream of the vehicle bridge, maintenance requirements would be flagged in the course of the inspections and corrective action planned and implemented as a result.

5.4 Effects Assessment Summary

The access road flood mitigation strategy is implementation of a flood detention basin formed by the road embankment and culverts under the road to limit flows downstream. The flood detention basin offsets the loss of flood storage in the flood plain area south of the road embankment.

The proposed mitigation work achieves the following:

a. The proposed access road is protected from flooding by its proposed construction on an embankment across the flood plain and setting minimum road levels.

b. Modest earthworks to ensure the access road north of the vehicle bridge is at a minimum level that provides adequate flood protection for the road.

c. The Mill Creek Floodway Maintenance Plan would be important in ensuring that the flood carrying capacity of the Mill Creek flow path is maintained for the protection of property within and downstream of Waterfall Park.

d. The change in flow regime due to the flood mitigation measures ensures no increase above pre-development peak flood flows at the southern boundary.

6.0 Stormwater Management Plan

6.1 Scope

This stormwater management plan is for the access road from the Arrowtown - Lake Hayes Road to a location on the right bank of Mill Creek as shown in Figure 6.1 below. From a stormwater perspective, the access road has three distinct sections as indicated in Figure 6.1.

The access road crosses a relatively flat terrace, the ‘Entrance Section’, and then descends down the face of the river terrace above the left bank (eastern) edge of the Mill Creek flood plain, to the ‘Floodplain Section’, and then crosses the flood plain. Mill Creek is on the right bank (western) edge of the floodplain section where the access road crosses the Creek at a vehicle and pedestrian bridge before winding north on the true right bank of Mill Creek referred to as the ‘Western Section’.

The stormwater management approach for each section of the road is described in Section 6.2 below. Sizing and specific location of the stormwater management elements described below would be confirmed during detailed design.

As described in Section 2.3, the Mill Creek flow path above Waterfall Park is a wide, flat valley that absorbs runoff from the surrounding catchment areas and delays and moderates the flood response at Waterfall Creek. The stormwater runoff from the access road into Mill Creek would be immediate compared to the flood response from the greater Mill Creek catchment and therefore peak stormwater runoff to Mill Creek typically would occur hours before the peak flood flow from the upper Mill Creek catchment occurs. The stormwater and flood peak flows would not be coincident.

The layout of the stormwater management components for all of the access road sections is shown on Paterson Pitts Partners drawings in Appendix 1.

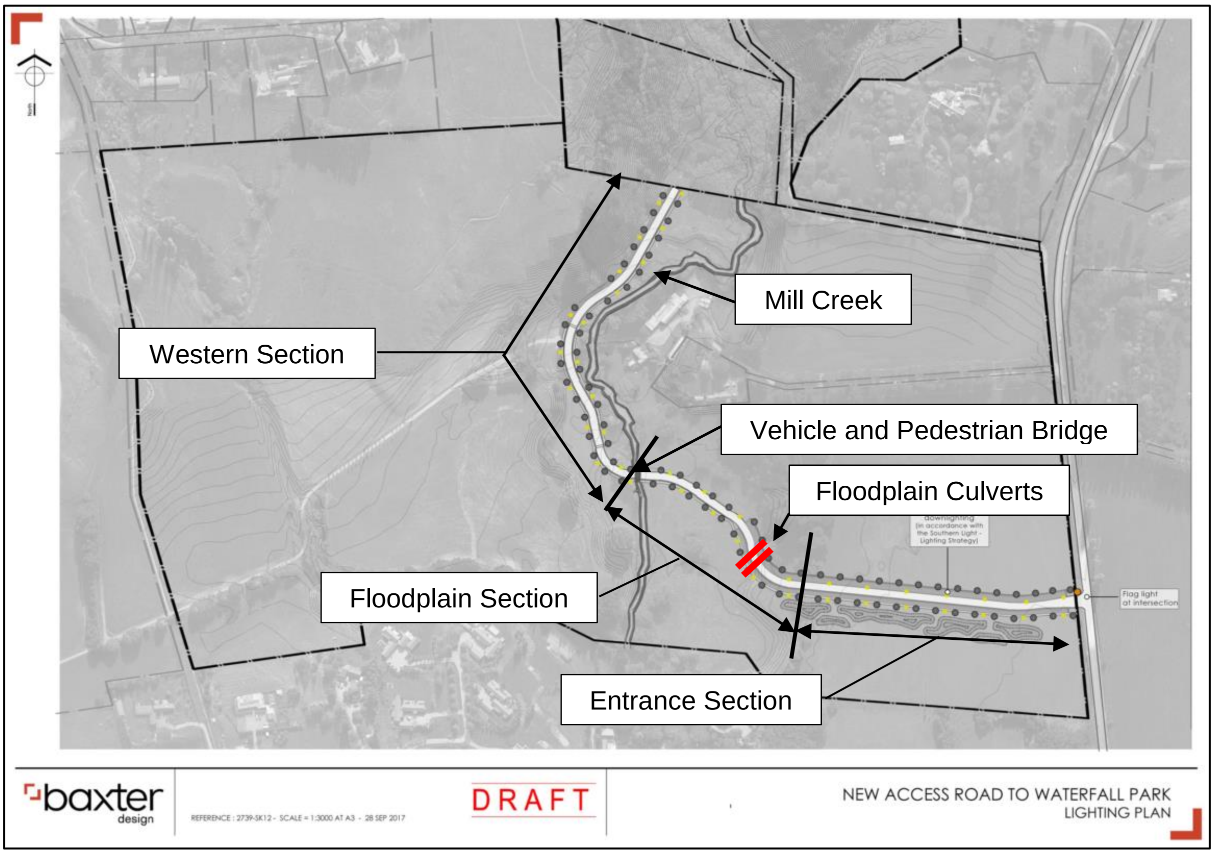


Figure 6.1: Waterfall Park Access Road

6.2 Stormwater Design

6.2.1 Entrance Section

There is a high point on the access road located at the boundary between Entrance and the Floodplain sections of the road. East of the high point, stormwater would be managed via grassed swales on both the northern and southern sides of the access road. The land falls north to southeast but very gently on both sides of the access road. Consequently, the swale on the northern side of the road would collect stormwater from farmland to the north and would be located outside the footpath and would have regular soak pits located along the swale to dispose of overland flow. The swale on the southern side of the road would receive runoff from the road only and therefore would be a shallow swale with a single soak pit at the intersection of the access road with the Arrowtown - Lake Hayes Road to take any runoff that is not absorbed in the swale.

The soil profile for the land on the river terrace is typically up to 1m topsoil and loess on gravels with reasonable permeability for infiltration. The soil permeability would be assessed to qualify the size and location of the soak pits at the detailed design stage.

6.2.2 Flood Plain Section

In the area west of the high point at the western end of the Entrance Section, stormwater would be managed via grassed swales and rock lined water table in the steeper areas. The swales and water tables would be located on both the northern and southern side of the road. The grassed swales would drain the flood plain along the road embankment and would discharge to the culverts under the access road at the toe of the river terrace.

From the floodplain culverts to the northern end of the access road, the road would have kerb and channel on both sides of the carriageway. Sumps in the carriageway channel would intercept stormwater runoff from the road and direct runoff to roadside water tables, a detention area in the Western Section for disposal to the floodplain culverts. All water from the carriageway would be detained in ponds, swales for small road area catchments or in the floodplain to intercept contaminants before entering Mill Creek.

In the Floodplain Section, the access road would be constructed on a raised embankment to provide protection from flooding. Culverts would be installed to allow the flood water to flow under the road to the southern flood plain area.

In the Floodplain Section, the kerb and channel would direct stormwater to two sumps located in a sag point just west of the culverts and discharge to the culverts under the road.

6.2.3 Western Section

Grassed swales and water table drains would be constructed along the western side of the road collecting water that runs off the steep face located to the west of the road and also collecting water that falls on the road via sumps. During a 20 year ARI storm event, the total flows of up to ~200 litres per second (l/s) are expected off the steep face. The swales would be constructed to a depth of ~0.5m and are expected to flow to a depth of ~0.3m deep during a 20 year ARI storm event, and with 0.2m freeboard, have sufficient capacity to carry the 100 year ARI event.

Except for a small road area catchment that drains the road at Chainage (CH) 730m, sumps in the road that discharge to the grassed swales would feed into two stormwater detention basins in which sediment and other contaminants would be removed before discharge to Mill Creek. For chainages refer to the PPG drawings in Appendix 1.

Stormwater collected in the northern-most detention basin (CH660m) would be directed to Mill Creek through a scruffy dome and a culvert beneath the road. The scruffy dome would have a high level outlet providing further sediment removal and ensuring that only clear water would be discharged to Mill Creek.

There would be a sag point in the road west of the vehicle bridge and two mud tanks would be provided at this sag point to discharge road runoff to the swale.

Stormwater collected in the southern detention basin would be directed to Mill Creek via a shallow weir at bank top to the Mill Creek main stream channel. Settling of sediment would be achieved behind the weir and a shallow flow would then be distributed down the grassed right bank of Mill Creek to the water in the Creek. The bank slope to the stream would be less than 3H:1V to prevent erosion and provide any carry-over sediment removal to ensure that clear water would be discharged to Mill Creek.

6.3 Stormwater Quality Management

The stormwater management approach for the proposed access road provides for comprehensive management of stormwater that falls on the road and is intercepted by the road alignment from the catchments above the road.

The primary potential contaminant of concern anticipated to be present in the stormwater is elevated suspended solids. The proposed stormwater treatment approach includes suspended solids removal primarily using settlement in detention basins. The use of scruffy domes with high level outlets would allow for suspended solids removal prior to discharge to Mill Creek. The proposed mitigation measures are considered to be adequate to ensure that only clear water is discharged to Mill Creek and that the effects on Mill Creek would be less than minor.

Oil and grease from vehicles would be present at low levels in the stormwater generated from the Waterfall Park access road. Excepting a significant spill, any oil and grease would be removed as the first flush of stormwater travels through the grassed swales. The risk of generating conspicuous oil and grease films in Mill Creek is considered to be very low and as such a dedicated stormwater hydrocarbon interception system is not considered to be required.

Lead, zinc and copper metal contaminants are typically associated with road runoff. Any road contaminants would combine with suspended sediments and would be settled out in the swales, the flood plain and the detention basins in the Western Section.

Nutrients (Nitrogen and Phosphorus) are not generated by the road activity and are therefore not of concern.

During the construction period there would be an increased risk of erosion, increased suspended solids load and increased hydrocarbon spill risk. An Earthworks Management Plan (Patterson Pitts Group, 2017) has been developed for the construction period and details specific measures for sediment and erosion control during earthworks. The Earthworks Management Plan also specifies dedicated areas for refueling and storage of contaminants to mitigate the potential risk of hydrocarbon spills reaching Mill Creek. Implementation of the Earthworks Management Plan would ensure compliance with rule 12.B.1.8 of the RPW during the earthworks period.

The stormwater quality mitigation measures are considered to be adequate to ensure that stormwater discharge from the road would be in compliance with rule 12.B.1.8 of the RPW and the effects on Mill Creek would be less than minor.

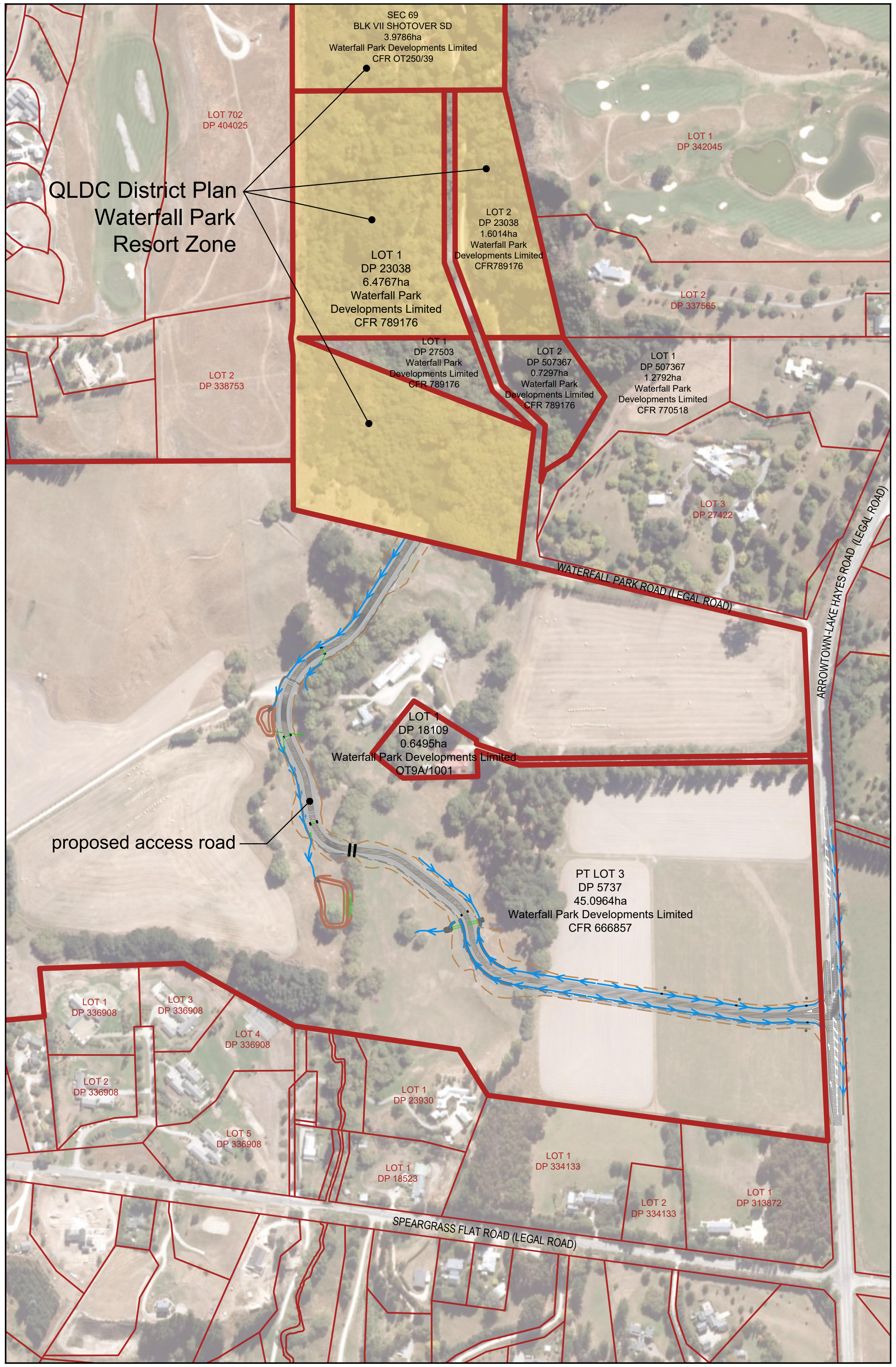
7.0 Conclusion

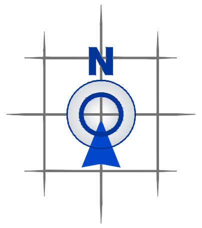
It is considered that the proposed activity, with its proposed mitigation measures, is consistent with, and has appropriate regard to the objectives and policies of the ORC Regional Plan: Water for Otago and addresses the requirements of the QLDC Code of Subdivision and Development requirements with regard to flood management and stormwater management.

APPENDIX 1

Waterfall Park Developments Ltd Proposed Access Road Drawings

Paterson Pitts Group Drawings: Q6388-15





SHEET	CONTENTS	REV	DATE
1	Plan Sheet Index	B	9/10/2017
2	Overview Sheet Layout	B	9/10/2017
3	Intersection	B	9/10/2017
4	Access Road CH45.0 - CH205.0	B	9/10/2017
5	Access Road CH195.0 - CH405.0 and Earthworks Quantities	B	9/10/2017
6	Access Road CH380.0 - CH580.0	B	9/10/2017
7	Access Road CH595.0 - CH715.0	B	9/10/2017
8	Access Road CH700.0 - CH868.5	B	9/10/2017
9	Longsection CH0.0 - CH260.0	B	9/10/2017
10	Longsection CH250.0 - CH510.0	B	9/10/2017
11	Longsection CH500.0 - CH760.0	B	9/10/2017
12	Longsection CH750.0 - CH868.52	B	9/10/2017
13	Typical Cross Sections	B	9/10/2017
14	Typical Cross Sections	B	9/10/2017

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   - Service connections to utility services
2. This plan includes information from site surveys undertaken by Paterson Pitts Group (Sep 2017) and CFM (2016/2017)
3. Coordinates and bearings are in terms of Geodetic Datum 2000, Mount Nicholas Circuit grid projection
4. Levels are in terms of MSL (Dunedin Vertical Datum 1958)
5. The origin of levels is C1PV (IT IX DP 12678) RL: 348.66m
6. Existing contours shown - 0.5m contour interval
7. Refer to the relevant CFRs and title plans for registered easements, covenants and interests

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QUEENSTOWN:
Terrace Junction,
1092 Frankton Road.
PO Box 2645,
Queenstown 9349.
T 03 441 4715
E queenstown@ppgroup.co.nz

Client/Location:
Waterfall Park Developments Ltd
Sec 69 Blk VII Shotover SD, Lots 1 & 2 DP 23038, Lot 1 DP 27503, Lots 1 & 2 DP 507367, Pt Lot 3 DP 5737 and Lot 1 DP 18109

Purpose/Drawing Title:
Proposed Access Road
Sheet Index

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Approved by:			
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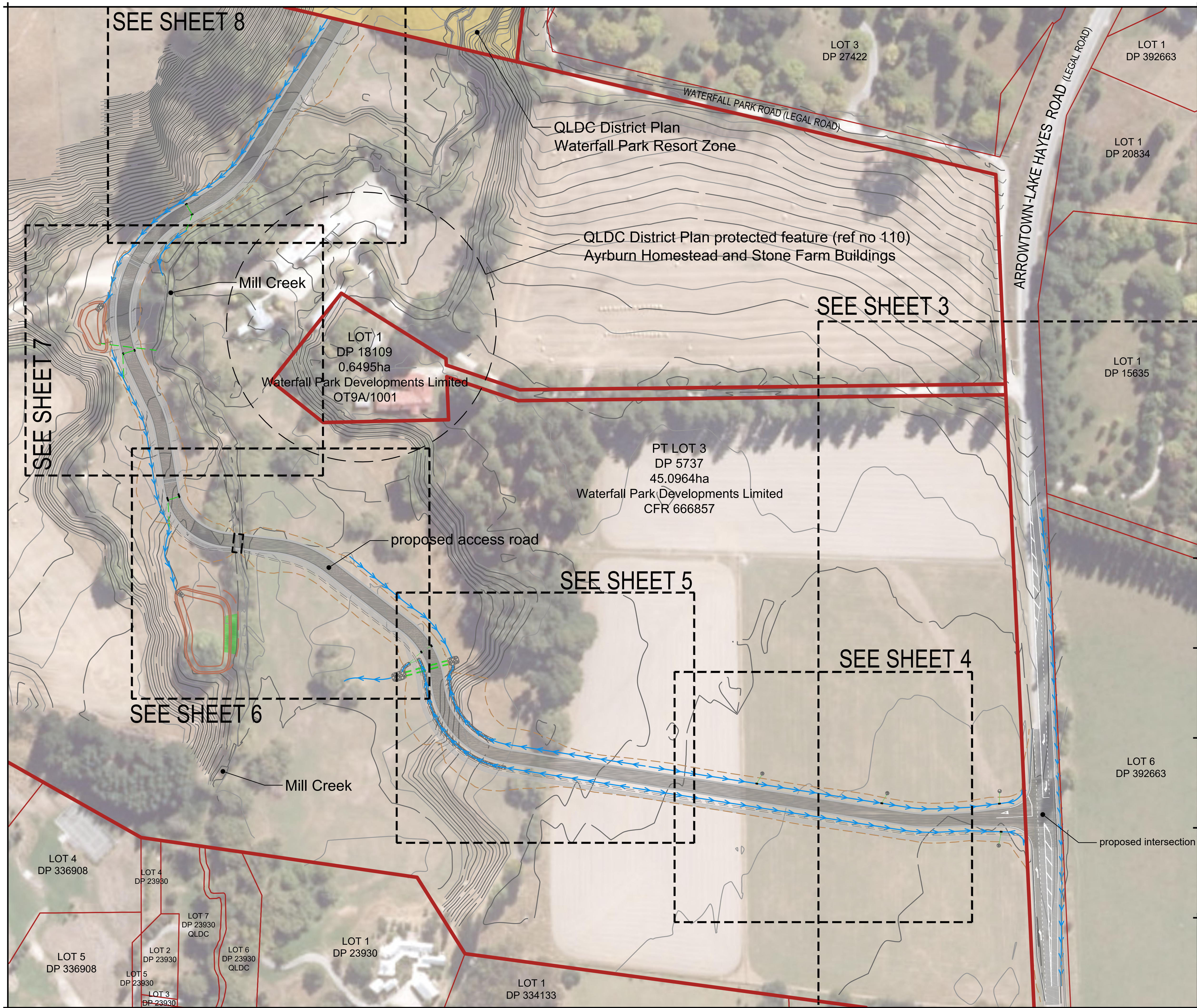

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1092 Frankton Road.
PO Box 2645,
Queenstown 9349.
T 03 441 4715
E queenstown@ppgroup.co.nz

Client/Location:
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Proposed Access Road Overview Sheet Layout

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Approved by:			DO NOT SCALE
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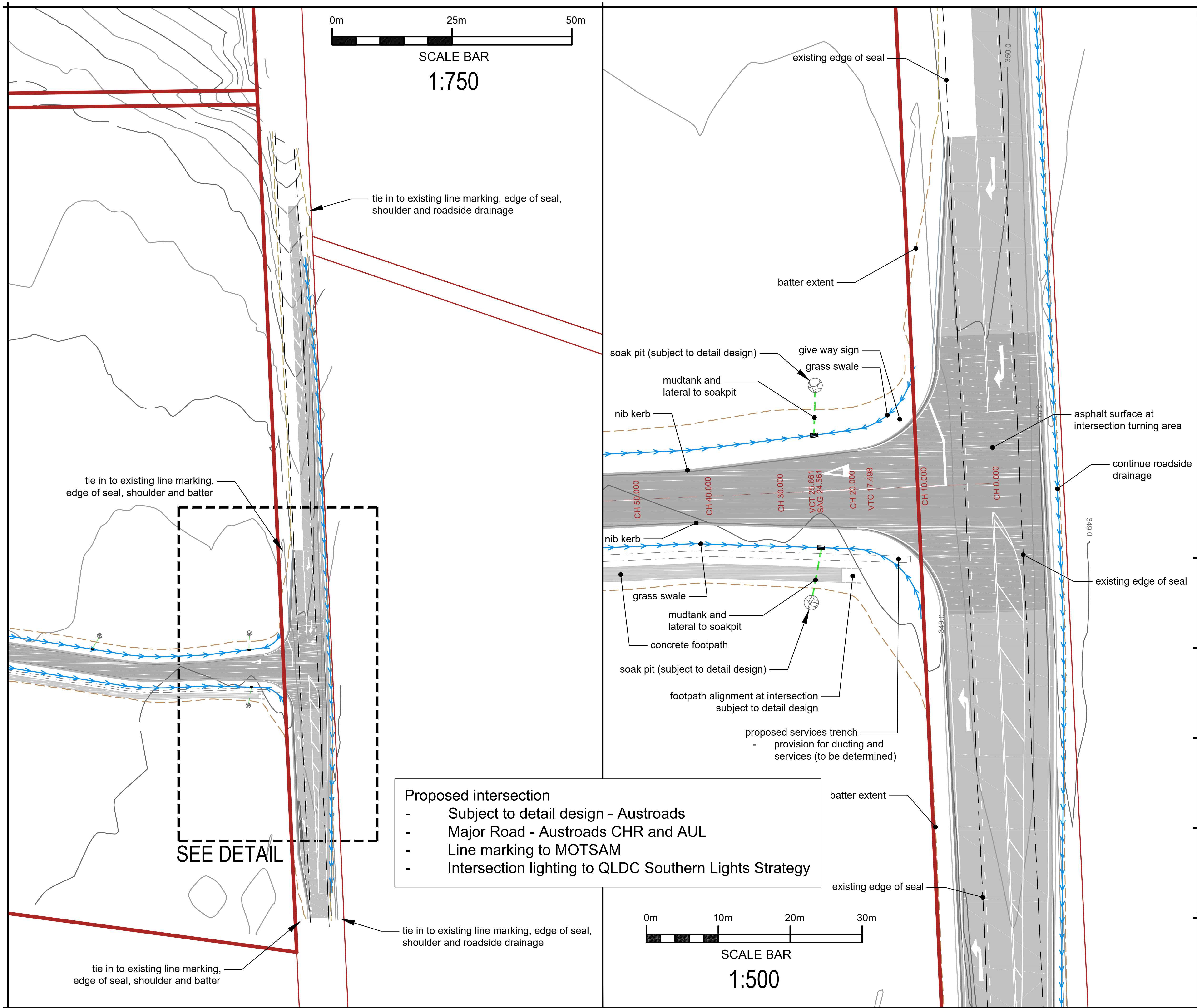

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Terrace Junction,
1092 Frankton Road.
PO Box 2645,
Queenstown 9349.
T 03 441 4715
E queenstown@ppgroup.co.nz

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Proposed Access Road Intersection Detail

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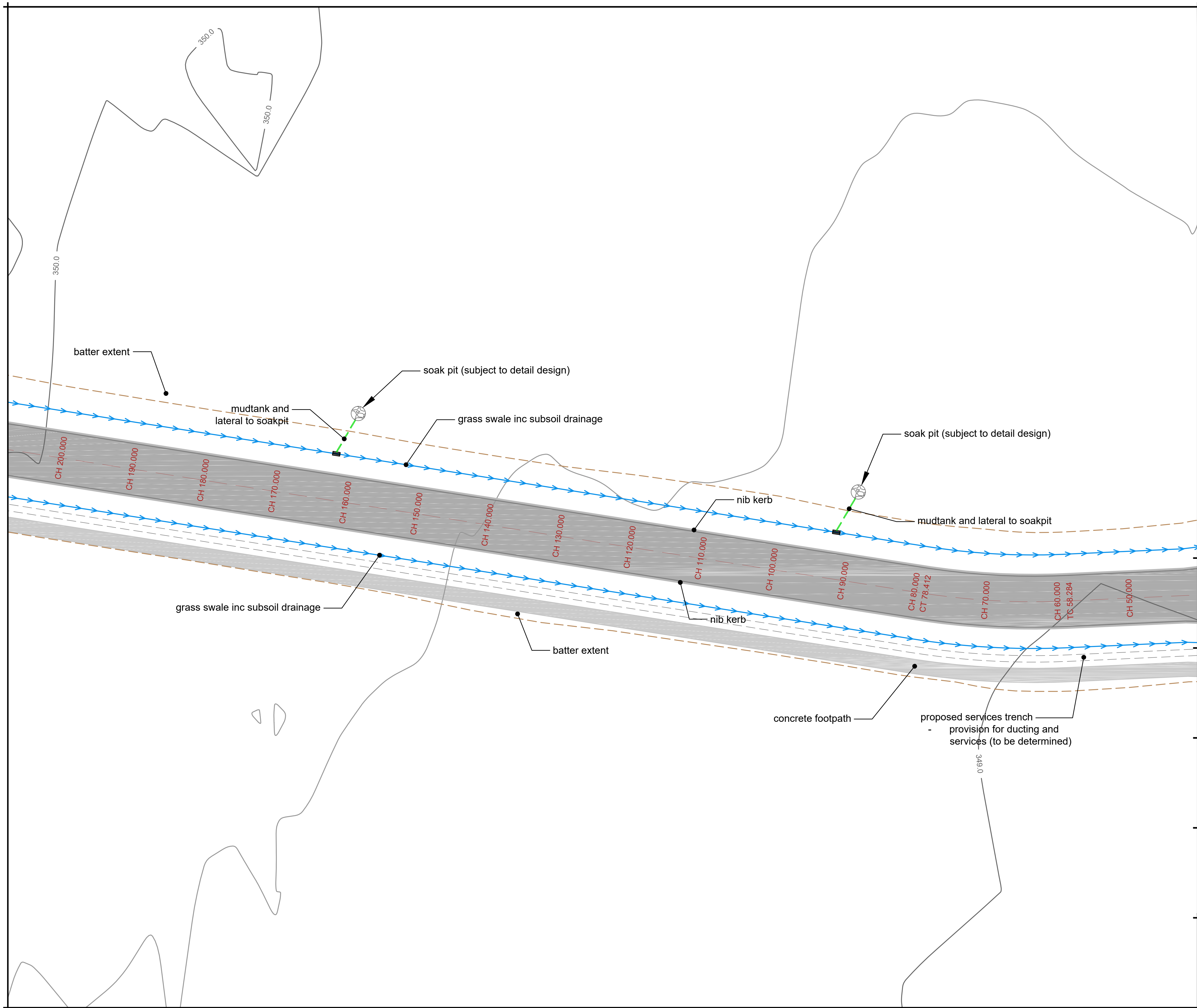

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1092 Frankton Road.
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Purpose/Drawing Title:

Proposed Access Road CH45.0 - CH205.0

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Approved by:			DO NOT SCALE
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EARTHWORKS QUANTITIES

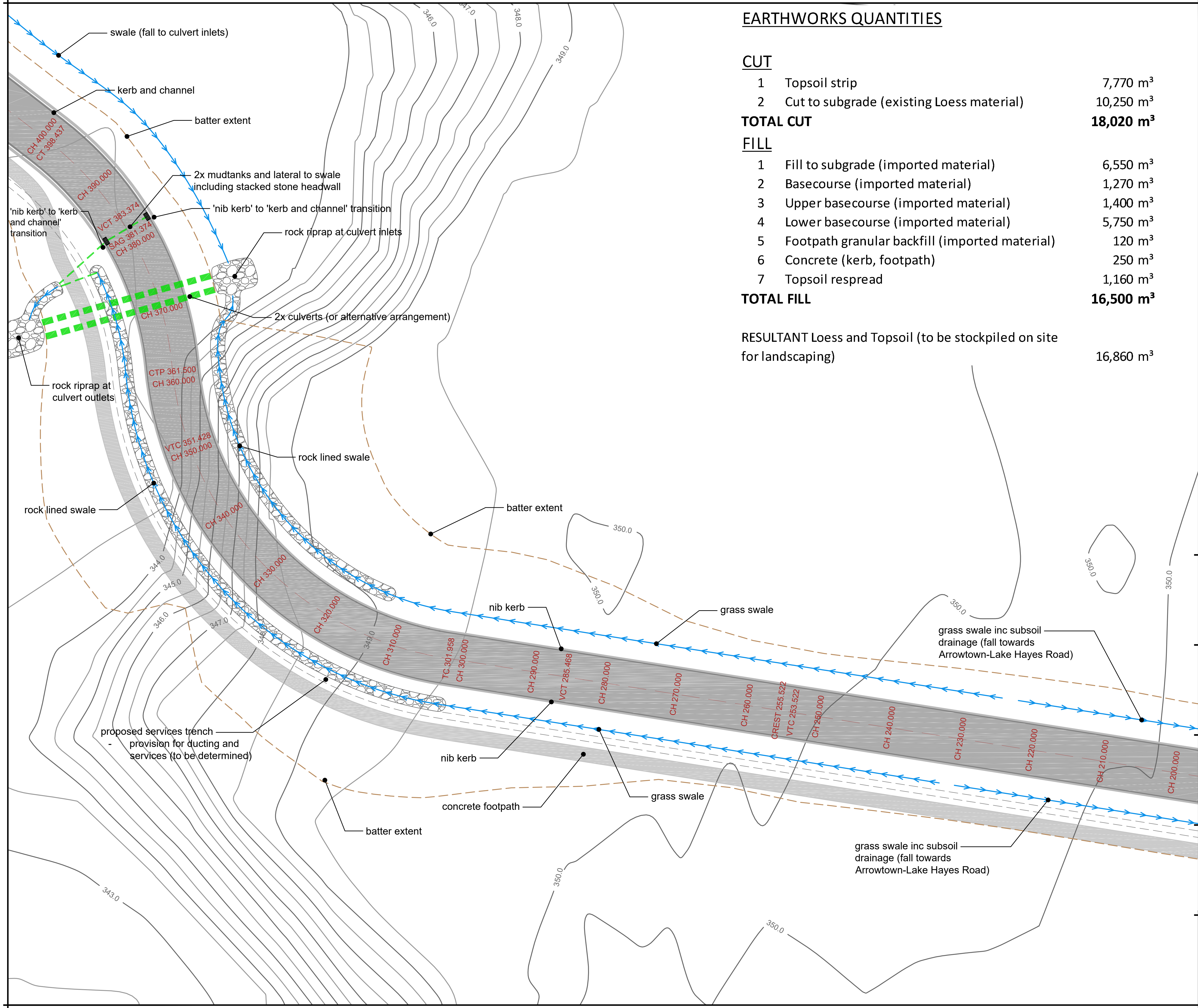
CUT

1	Topsoil strip	7,770 m³
2	Cut to subgrade (existing Loess material)	10,250 m³
TOTAL CUT		**18,020 m³**

FILL

1	Fill to subgrade (imported material)	6,550 m³
2	Basecourse (imported material)	1,270 m³
3	Upper basecourse (imported material)	1,400 m³
4	Lower basecourse (imported material)	5,750 m³
5	Footpath granular backfill (imported material)	120 m³
6	Concrete (kerb, footpath)	250 m³
7	Topsoil respread	1,160 m³
TOTAL FILL		**16,500 m³**

RESULTANT Loess and Topsoil (to be stockpiled on site for landscaping) 16,860 m³



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   - Service connections to utility services
2. This plan includes information from site surveys undertaken by Paterson Pitts Group (Sep 2017) and CFM (2016/2017)
3. Coordinates and bearings are in terms of Geodetic Datum 2000, Mount Nicholas Circuit grid projection
4. Levels are in terms of MSL (Dunedin Vertical Datum 1958)
5. The origin of levels is C1PV (IT IX DP 12678) RL: 348.66m
6. Existing contours shown - 0.5m contour interval
7. Refer to the relevant CFRs and title plans for registered easements, covenants and interests

0m 10m 20m 30m

SCALE BAR

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Client/Location:

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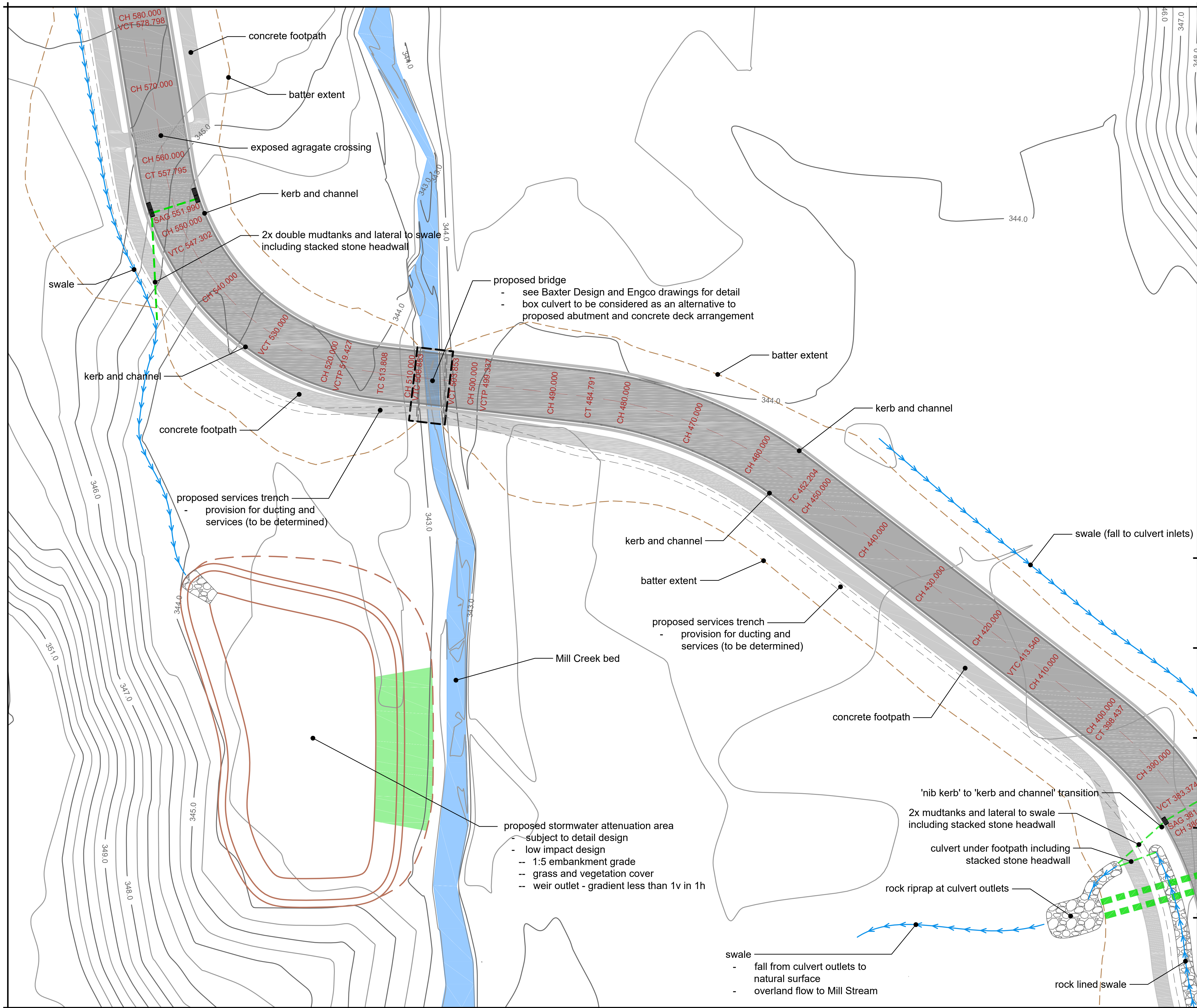
Sec 69 Blk VII Shotover SD, Lots 1 & 2 DP 23038, Lot 1 DP 27503, Lots 1 & 2 DP 507367, Pt Lot 3 DP 5737 and Lot 1 DP 18109

Purpose/Drawing Title:

Proposed Access Road CH195.0 - CH405.0 and Earthworks Quantities

Surveyed by:	PPG	Original Size: A3	Scale: 1:500
Designed by:	SJP		
Drawn by:	SJP		
Checked by:	SJW		
Approved by:			DO NOT SCALE
Job Ref: Q6388 - 15	Sheet No: 5	Revision No: B	Date Created: 09/10/2017



NOTES:

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DP 507367, Pt Lot 3 DP 5737 and Lot 1 DP 18109

Purpose/Drawing Title:

Proposed Access Road CH380.0 - CH580.0

Surveyed by: PPG	Original Size: A3	Scale: 1:500	
Designed by: SJP			
Drawn by: SJP			
Checked by: SJW			
Approved by:		DO NOT SCALE	
Job Ref: Q6388 - 15	Sheet No: 6	Revision No: B	Date Created: 09/10/2017

PLOT DATE: 09 October, 2017 - 4:32 PM BY: Stephen Popenhagen

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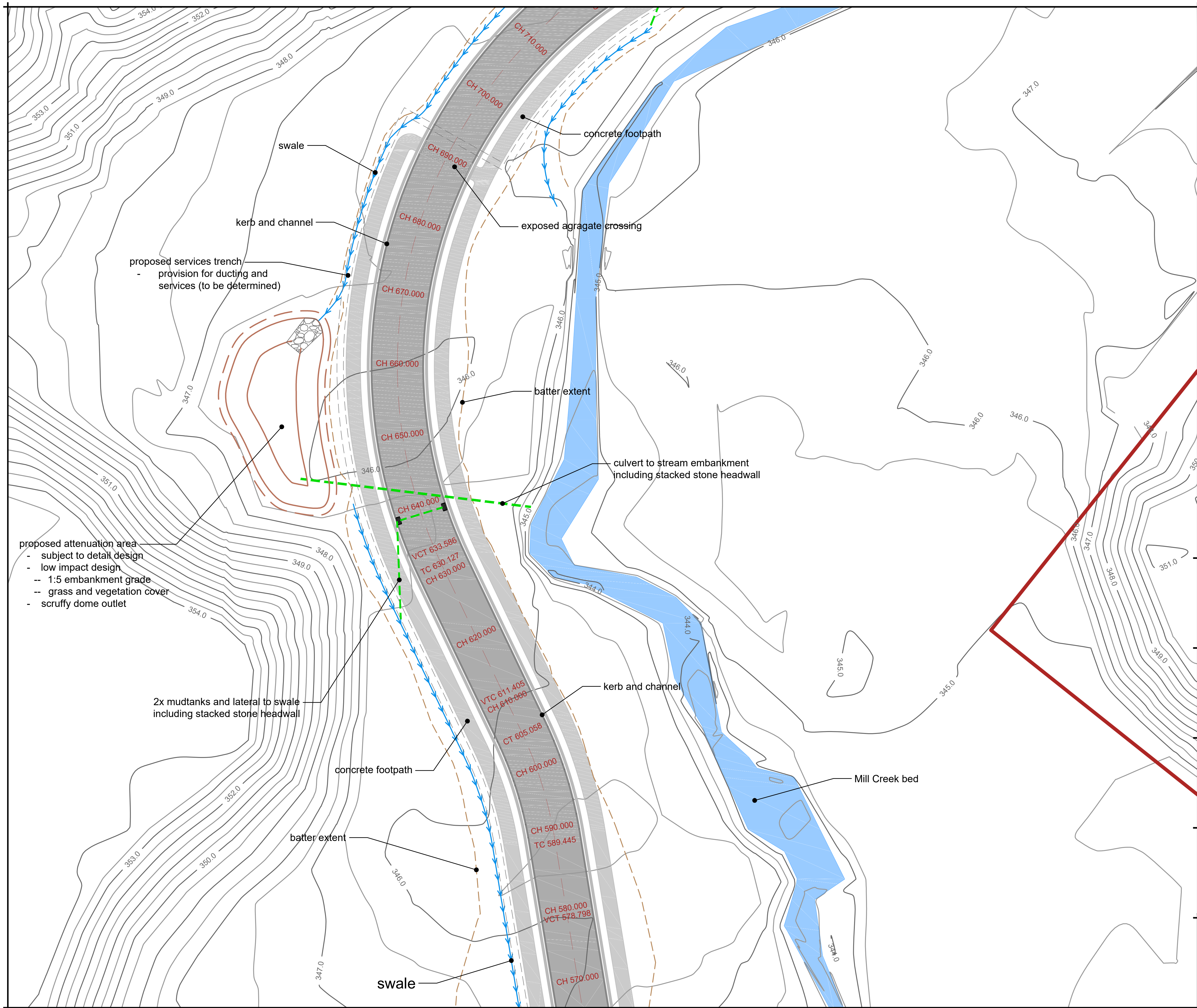

N

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7. Refer to the relevant CFRs and title plans for registered easements, covenants and interests

0m 10m 20m 30m

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DP 23038, Lot 1 DP 27503, Lots 1 & 2
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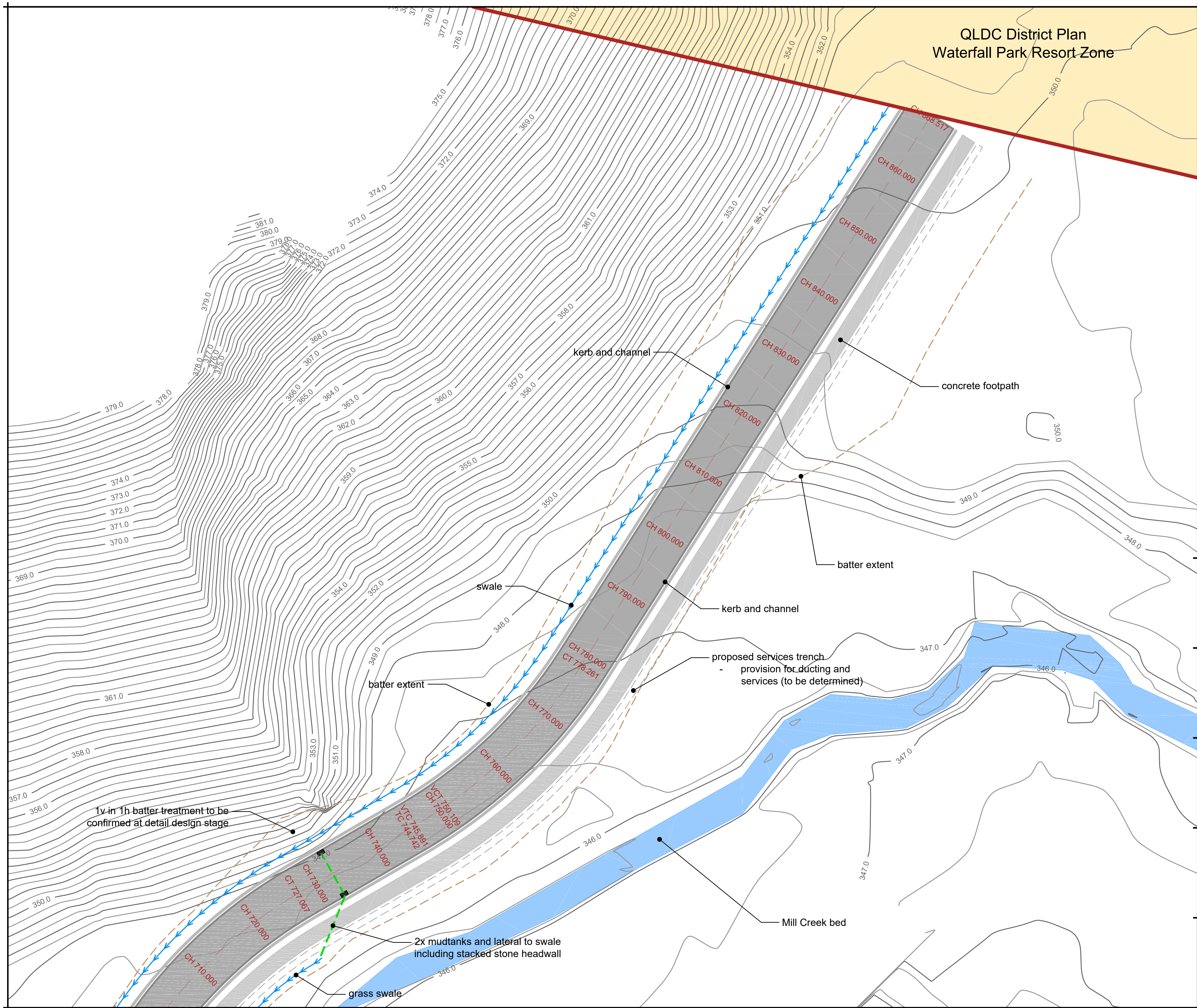
Purpose/Drawing Title:

Proposed Access Road CH565.0 - CH715.0

Surveyed by:	PPG	Original Size: A3	Scale: 1:500
Designed by:	SJP		
Drawn by:	SJP		
Checked by:	SJW		
Approved by:			DO NOT SCALE
Job Ref: Q6388 - 15	Sheet No: 7	Revision No: B	Date Created: 09/10/2017



N

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0m 10m 20m 30m

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Purpose/Drawing Title:

Proposed Access Road CH700.0 - CH868.5

Surveyed by:	PPG	Original Size:	Scale: 1:500
Designed by:	SJP	A3	
Drawn by:	SJP		
Checked by:	SJW		
Approved by:			DO NOT SCALE
Job Ref: Q6388 - 15	Sheet No: 8	Revision No: B	Date Created: 09/10/2017

PLOT DATE: 09 October, 2017 - 4:32 PM BY: Stephen Popenhagen

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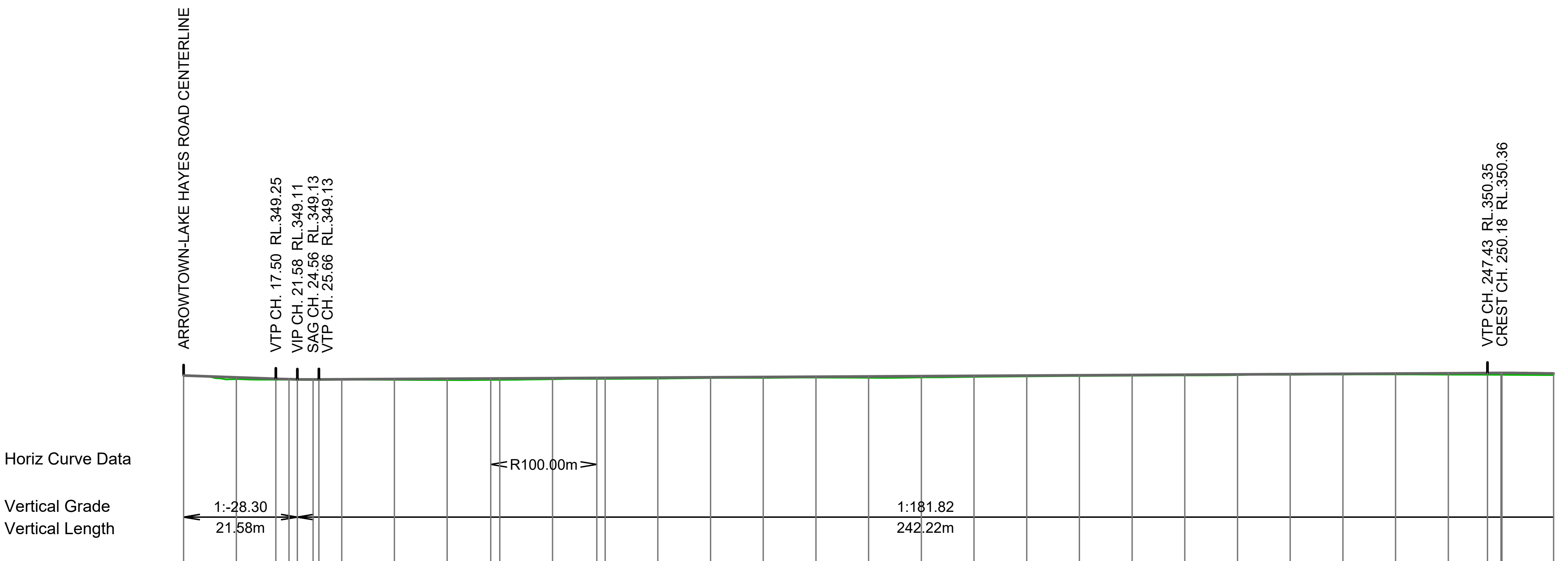

DATUM R.L.298.00

Existing ground level at centreline	349.87	349.18	349.06	349.06	349.04	349.03	349.04	349.07	349.03	348.99	349.02	349.03	349.16	349.22	349.22	349.28	349.39	349.42	349.46	349.43	349.50	349.60	349.70	349.77	349.83	349.87	349.95	350.01	350.04	350.06	350.03	350.01	350.00	350.00	349.95
+ Fill depth - Cut depth	-0.00	0.34	0.19	0.12	0.11	0.10	0.09	0.08	0.18	0.27	0.29	0.29	0.21	0.21	0.21	0.21	0.15	0.18	0.19	0.28	0.26	0.21	0.17	0.15	0.15	0.16	0.14	0.14	0.16	0.19	0.28	0.34	0.36	0.36	0.32
Finished level at centreline	349.87	349.52	349.25	349.18	349.15	349.13	349.13	349.16	349.21	349.26	349.31	349.32	349.38	349.42	349.43	349.49	349.54	349.60	349.65	349.70	349.76	349.82	349.87	349.93	349.98	350.04	350.09	350.14	350.20	350.26	350.31	350.35	350.36	350.36	350.26
Chainage	0.00	10.00	17.50	20.00	21.58	24.56	25.66	30.00	40.00	50.00	58.28	60.00	70.00	78.41	80.00	90.00	100.00	110.00	120.00	130.00	140.00	150.00	160.00	170.00	180.00	190.00	200.00	210.00	220.00	230.00	240.00	247.43	250.00	250.18	260.00

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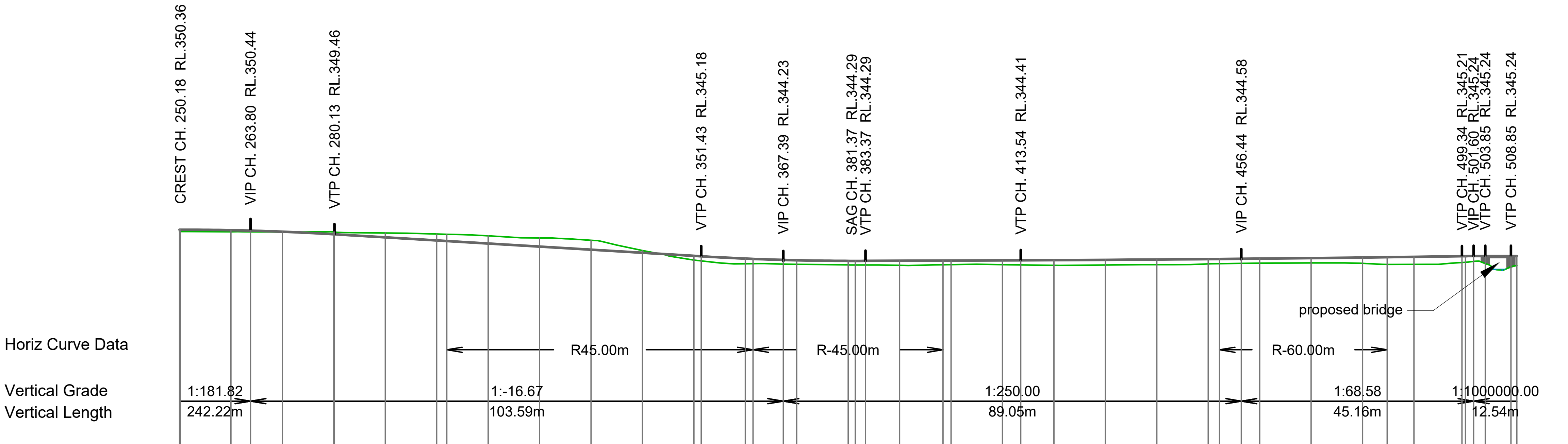
Purpose/Drawing Title:
Proposed Access Road Longsection CH0 - CH260

Surveyed by: PPG	Original Size: A3	Scale: 1:1000	
Designed by: SJP			
Drawn by: SJP			
Checked by: SJW			
Approved by:		DO NOT SCALE	
Job Ref: Q6388 - 15	Sheet No: 9	Revision No: B	Date Created: 09/10/2017



DATUM R.L.292.00

Chainage	Existing ground level at centreline	+ Fill depth - Cut depth	Finished level at centreline
250.00	350.00	0.36	350.36
250.18	350.00	0.36	350.36
260.00	349.95	0.32	350.26
263.80	349.93	0.24	350.17
270.00	349.90	0.06	349.97
280.00	349.92	-0.45	349.47
280.13	349.90	-0.44	349.46
290.00	349.72	-0.85	348.87
300.00	349.52	-1.25	348.27
301.96	349.47	-1.32	348.15
310.00	349.16	-1.49	347.67
320.00	348.77	-1.70	347.07
330.00	348.30	-1.83	346.47
340.00	346.30	-0.43	345.87
350.00	344.46	0.81	345.27
351.43	344.27	0.91	345.18
360.00	343.73	1.01	344.74
361.50	343.76	0.92	344.68
367.39	343.67	0.81	344.48
370.00	343.63	0.78	344.41
380.00	343.51	0.78	344.29
381.37	343.50	0.79	344.29
383.37	343.50	0.79	344.29
390.00	343.42	0.89	344.32
398.44	343.54	0.81	344.35
400.00	343.56	0.79	344.36
410.00	343.55	0.85	344.40
413.54	343.50	0.91	344.41
420.00	343.43	1.01	344.44
430.00	343.49	1.00	344.49
440.00	343.56	1.00	344.56
450.00	343.70	0.94	344.64
452.20	343.74	0.91	344.66
456.44	343.80	0.89	344.70
460.00	343.84	0.88	344.73
470.00	343.89	0.94	344.83
480.00	343.82	1.13	344.95
484.79	343.61	1.40	345.01
490.00	343.61	1.47	345.08
499.34	343.97	1.23	345.21
500.00	344.01	1.20	345.22
501.60	344.19	1.04	345.23
503.85	343.79	1.45	345.24
508.85	343.15	2.09	345.24
510.00	343.39	1.85	345.24

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DP 507367, Pt Lot 3 DP 5737 and Lot 1 DP 18109

Purpose/Drawing Title:
Proposed Access Road Longsection CH250 - CH510

Surveyed by:	PPG	Original Size:	Scale:
Designed by:	SJP	A3	1:1000
Drawn by:	SJP		
Checked by:	SJW		
Approved by:			DO NOT SCALE
Job Ref: Q6388 - 15		Sheet No: 10	Revision No: B / Date Created: 09/10/2017

DATUM R.L.292.00

Existing ground level at centreline	344.01	344.19	343.79	343.15	343.39	343.90	343.94	343.97	343.95	343.89	343.95	344.06	344.43
+ Fill depth - Cut depth	1.20	1.04	1.45	2.09	1.85	1.31	1.26	1.11	1.11	1.07	0.95	0.79	0.39
Finished level at centreline	345.22	345.23	345.24	345.24	345.24	345.21	345.20	345.08	345.07	344.96	344.90	344.85	344.82
Chainage	500.00	501.60	503.85	508.85	510.00	513.81	514.14	519.43	520.00	524.71	530.00	540.00	547.30

Existing ground level at centreline	344.67	344.83	345.22	345.39	345.73	346.04	345.94	345.83	345.42	345.45	345.81	345.87	346.02
+ Fill depth - Cut depth	0.14	-0.02	-0.39	-0.55	-0.86	-1.07	-0.77	-0.63	0.03	0.02	-0.08	-0.00	-0.02
Finished level at centreline	344.81	344.81	344.82	344.84	344.87	344.97	345.17	345.20	345.45	345.47	345.74	345.87	346.00
Chainage	550.00	551.99	557.79	560.00	563.05	570.00	578.80	580.00	589.45	590.00	600.00	605.06	610.00

Existing ground level at centreline	346.09	346.31	346.37	346.41	346.41	346.50	346.58	345.81	346.03	346.38	346.38	346.17
+ Fill depth - Cut depth	-0.05	-0.08	-0.09	-0.04	-0.04	-0.11	-0.16	0.66	0.48	0.17	0.22	0.48
Finished level at centreline	346.04	346.24	346.28	346.37	346.37	346.39	346.42	346.47	346.51	346.56	346.61	346.65
Chainage	611.41	620.00	622.49	630.00	630.13	633.59	640.00	650.00	660.00	670.00	680.00	690.00

Existing ground level at centreline	346.25	346.44	346.59	346.56	346.54	346.58	346.54	346.58	346.58	346.58	346.58	346.61
+ Fill depth - Cut depth	0.45	0.30	0.20	0.26	0.30	0.30	0.36	0.33	0.34	0.36	0.36	0.42
Finished level at centreline	346.70	346.74	346.79	346.82	346.84	346.88	346.90	346.91	346.92	346.94	346.94	347.03
Chainage	700.00	710.00	720.00	727.07	730.00	740.00	744.74	745.89	748.00	750.00	750.11	760.00

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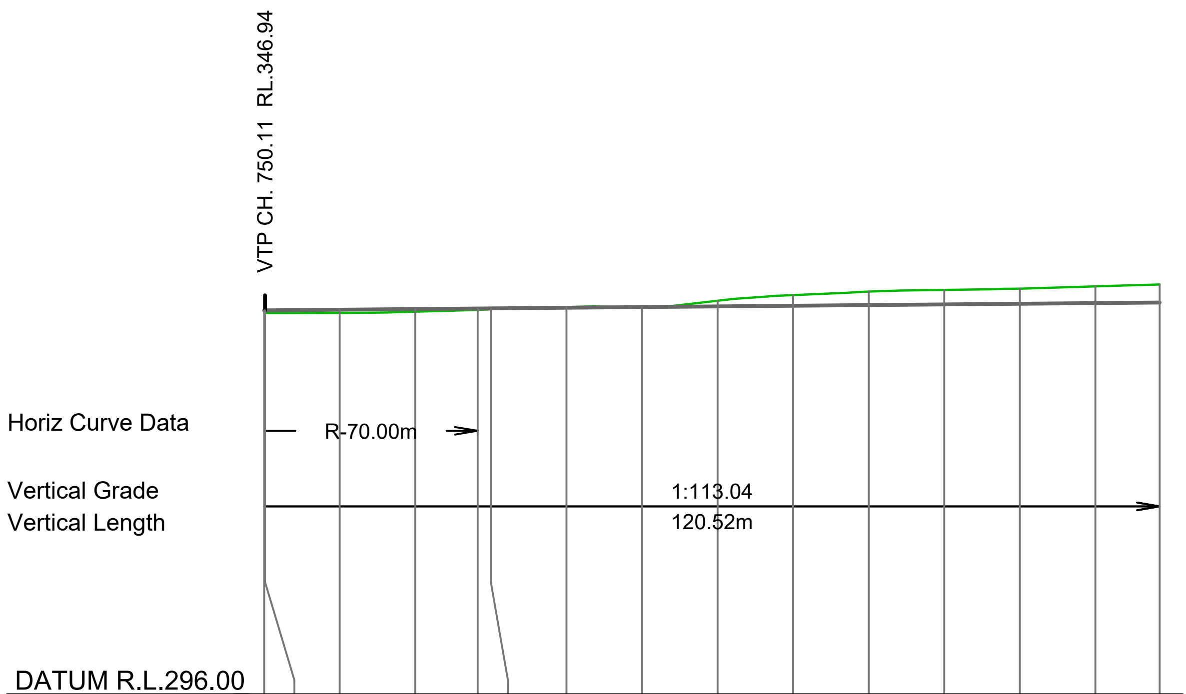
Purpose/Drawing Title:
Proposed Access Road Longsection CH500 - CH760

Surveyed by:	PPG	Original Size:	Scale:
Designed by:	SJP	A3	1:1000
Drawn by:	SJP		
Checked by:	SJW		
Approved by:			DO NOT SCALE
Job Ref: Q6388 - 15		Sheet No: 11	Revision No: B / Date Created: 09/10/2017



DATUM R.L.296.00

Existing ground level at centreline	346.58	346.58	346.61	346.77	347.02	347.09	347.38	347.34	348.23	348.97	349.44	349.66	349.83	350.13	350.37
+ Fill depth - Cut depth	0.36	0.36	0.42	0.34	0.17	0.11	-0.09	0.04	-0.76	-1.41	-1.79	-1.92	-2.00	-2.22	-2.39
Finished level at centreline	346.94	346.94	347.03	347.11	347.19	347.20	347.29	347.38	347.47	347.56	347.65	347.73	347.82	347.91	347.99
Chainage	750.00	750.11	760.00	770.00	778.26	780.00	790.00	800.00	810.00	820.00	830.00	840.00	850.00	860.00	868.52

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Client/Location:

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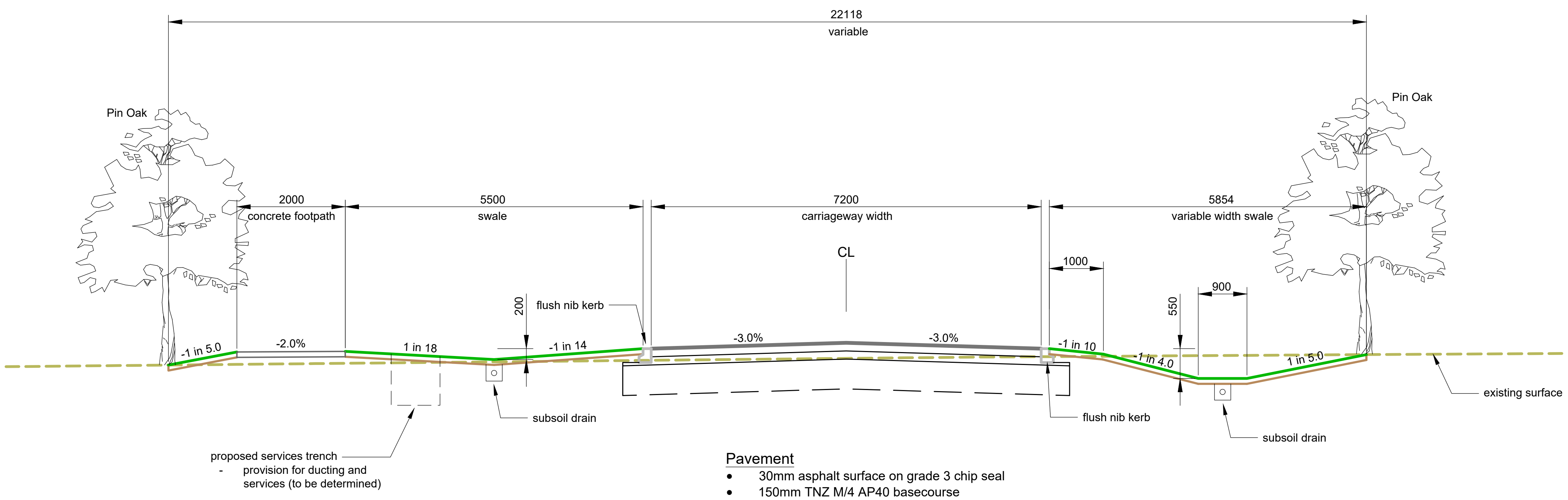
Purpose/Drawing Title:

Proposed Access Road Longsection CH750 - CH868.52

Surveyed by:	PPG	Original Size: A3	Scale: 1:1000
Designed by:	SJP		
Drawn by:	SJP		
Checked by:	SJW		
Approved by:			DO NOT SCALE
Job Ref: Q6388 - 15		Sheet No: 12	Revision No: B / Date Created: 09/10/2017

CH60.0

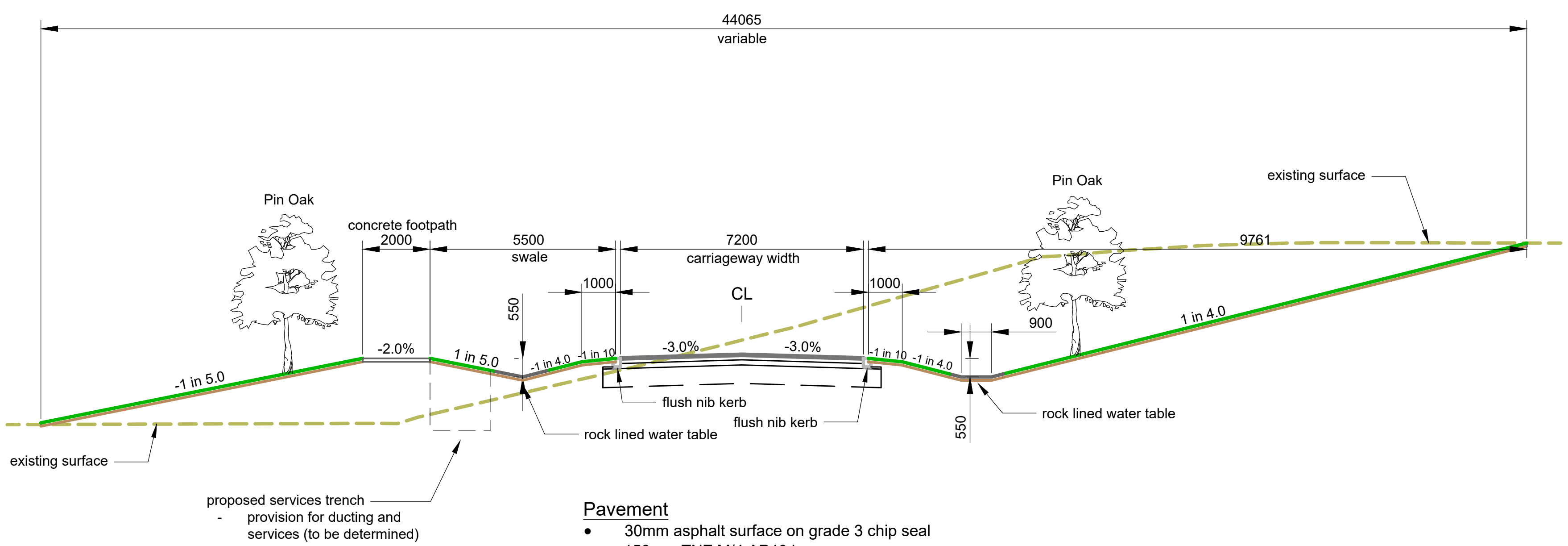
Scale 1:100



Pavement
- 30mm asphalt surface on grade 3 chip seal
- 150mm TNZ M/4 AP40 basecourse
- 150mm AP65 subbase
- 0mm - 550mm subgrade improvement layer

CH340.0

Scale 1:200



Pavement
- 30mm asphalt surface on grade 3 chip seal
- 150mm TNZ M/4 AP40 basecourse
- 150mm AP65 subbase
- 0mm - 550mm subgrade improvement layer

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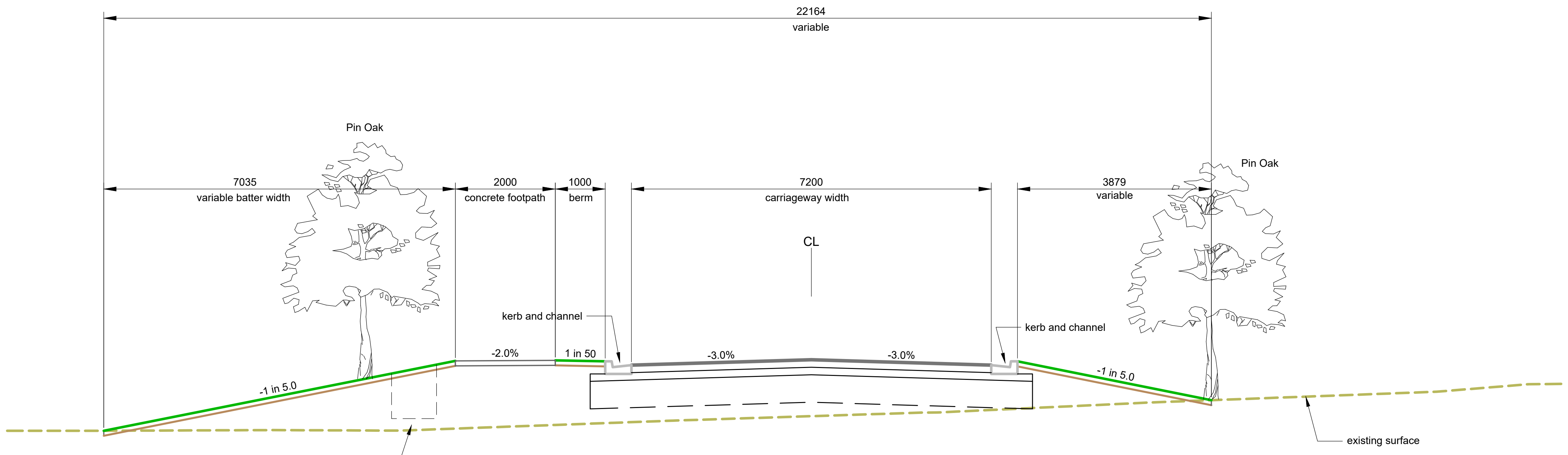
Purpose/Drawing Title:
Proposed Access Road
Typical Cross Sections

Surveyed by:	PPG	Original Size: A3	Scale: as shown
Designed by:	SJP		
Drawn by:	SJP		
Checked by:	SJW		
Approved by:			DO NOT SCALE
Job Ref: Q6388 - 15		Sheet No: 13	Revision No: B / Date Created: 09/10/2017

CH480.0

Scale 1:100

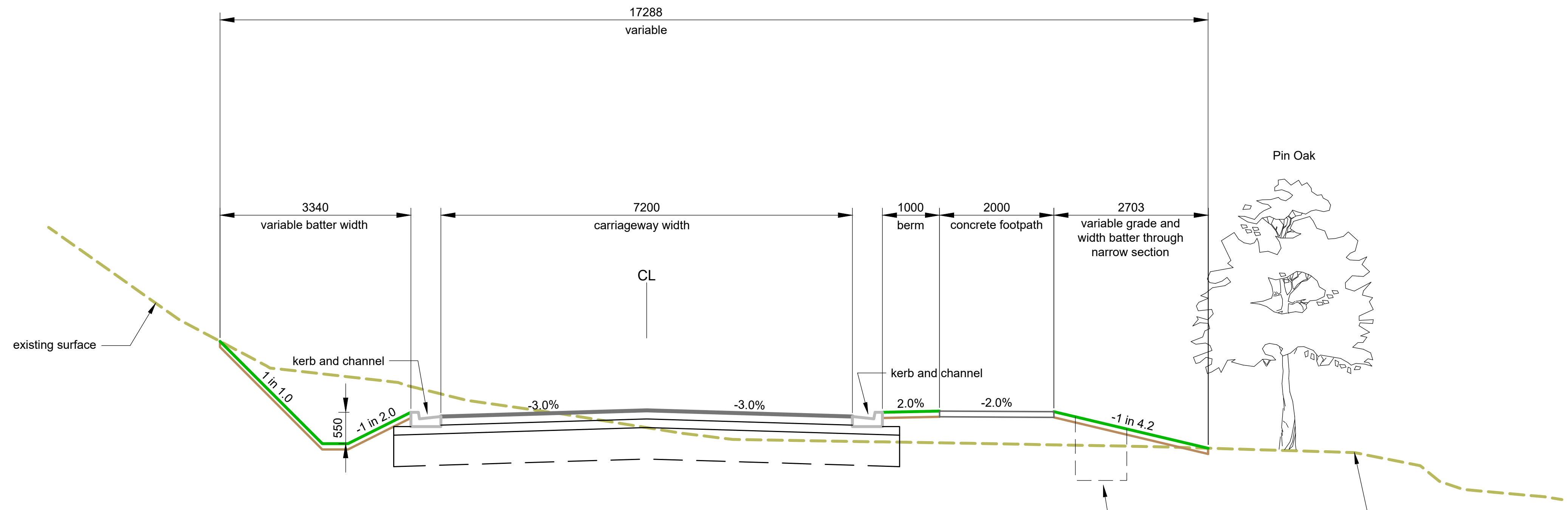


proposed services trench
- provision for ducting and services (to be determined)

Pavement
- 30mm asphalt surface on grade 3 chip seal
- 150mm TNZ M/4 AP40 basecourse
- 150mm AP65 subbase
- 0mm - 550mm subgrade improvement layer

CH740.0

Scale 1:100



proposed services trench
- provision for ducting and services (to be determined)

existing surface

Pavement
- 30mm asphalt surface on grade 3 chip seal
- 150mm TNZ M/4 AP40 basecourse
- 150mm AP65 subbase
- 0mm - 550mm subgrade improvement layer

NOTES:
1. This plan and its contents should not be used for any reason other than its intended purpose. This plan and surveyed information does not include assessment or representations concerning:
   - 'Ground level' as defined by the QLDC District Plan
2. This plan includes information from site surveys undertaken by Paterson Pitts Group (Sep 2017) and CFM (2016/2017)
3. Levels are in terms of MSL (Dunedin Vertical Datum 1958)
4. The origin of levels is C1PV (IT IX DP 12678) RL: 348.66m

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QUEENSTOWN:
Terrace Junction,
1092 Frankton Road.
PO Box 2645,
Queenstown 9349.
T 03 441 4715
E queenstown@ppgroup.co.nz

Client/Location:
Waterfall Park Developments Ltd
Sec 69 Blk VII Shotover SD, Lots 1 & 2
DP 23038, Lot 1 DP 27503, Lots 1 & 2
DP 507367, Pt Lot 3 DP 5737 and Lot 1 DP 18109

Purpose/Drawing Title:
Proposed Access Road
Typical Cross Sections

Surveyed by:	PPG	Original Size: A3	Scale: as shown
Designed by:	SJP		
Drawn by:	SJP		
Checked by:	SJW		
Approved by:			DO NOT SCALE
Job Ref: Q6388 - 15		Sheet No: 14	Revision No: B / Date Created: 09/10/2017

APPENDIX 2

Mill Creek Flood Frequency Estimate

Reference:
ORC - Flow Recording Station Record - Mill Creek at Fish Trap - GEV Estimate

Data provided by the Otago Regional Council

Reference: Pete Stevenson (Team Leader Environmental Monitoring, ORC) email dated 8 July 2016.

Hilltop Hydro Version 6.47 7-Jul-2016

~~~ FRED ~~~

Source is U:\Global Data.hts

Flow (cumecs) at Mill Creek at Fish Trap

From 31-Mar-1983 09:07:00 to 1-Jul-2016 18:00:00

GEV exponent 0.14144 has magnitude greater than 0.08675 and so GEV fits better than Gumbel

Moments L1= 3.313 L2= 0.868 T3= 0.082 T4= 0.069

Location = 2.68 Scale = 1.41 Shape = 0.141 100yr/2.33yr = 2.150

12 mth partition starts	Recorded value at	maximum measured	-- GEV	1.96 std. dev.	Distribution -- ann. prob. 1/y	return period y
			8.871		0.001	1000
			8.486		0.002	500
			7.914		0.005	200
			7.428		0.010	100
			6.890		0.020	50
			6.084		0.050	20
01-Jan-1999	17-Nov-1999 16:30:00	6.030 A	6.030		0.053	18.9
01-Jan-1983	26-Jun-1983 22:35:00	6.002 B	6.002		0.055	18.3
01-Jan-1991	14-Aug-1991 21:00:00	5.857 C	5.857		0.063	15.8
01-Jan-1996	07-Oct-1996 13:15:00	5.666 D	5.666		0.077	13.1
01-Jan-1994	14-Aug-1994 05:30:00	5.561 E	5.561		0.085	11.8
01-Jan-1995	01-Sep-1995 22:45:00	5.435 F	5.435		0.095	10.5
			5.385		0.100	10
			4.575		0.200	5
01-Jan-1988	12-Sep-1988 17:20:03	4.544 G	4.544		0.205	4.9
01-Jan-2002	18-Sep-2002 23:30:00	4.525 H	4.525		0.208	4.8
01-Jan-1984	17-Oct-1984 00:25:10	4.311 I	4.311		0.245	4.1
01-Jan-1993	19-Jul-1993 14:30:00	3.963 J	3.963		0.313	3.2
01-Jan-1992	26-Jul-1992 05:00:00	3.925 K	3.925		0.321	3.1
01-Jan-2013	02-Jun-2013 18:15:00	3.874 L	3.874		0.332	3.0
01-Jan-2000	02-Oct-2000 13:45:00	3.845 M	3.845		0.338	3.0
01-Jan-1997	10-Aug-1997 15:00:00	3.741 N	3.741		0.361	2.8
			3.455		0.430	2.33
01-Jan-1998	06-Aug-1998 12:30:00	3.292 O	3.292		0.471	2.1
01-Jan-2007	11-Aug-2007 20:30:00	3.168 P	3.168		0.503	2.0
01-Jan-2004	01-Sep-2004 11:30:00	3.142 Q	3.142		0.510	2.0
01-Jan-1987	13-Jun-1987 16:26:24	2.959 R	2.959		0.558	1.8
01-Jan-2006	30-Nov-2006 01:15:00	2.951 S	2.951		0.560	1.8
01-Jan-2014	11-Aug-2014 11:20:00	2.888 T	2.888		0.576	1.7
01-Jan-2015	18-Jun-2015 11:35:00	2.887 U	2.887		0.577	1.7
~~~

01-Jan-2009	23-Jul-2009 08:45:00		2.702	V	2.702	0.625	1.6
01-Jan-2012	15-Jul-2012 10:55:00		2.621	W	2.621	0.647	1.5
01-Jan-2001	02-Aug-2001 13:00:00		2.580	X	2.580	0.657	1.5
01-Jan-2003	16-Jul-2003 13:00:00		2.409	Y	2.409	0.701	1.4
01-Jan-1986	28-Jun-1986 14:19:02		2.140	Z	2.140	0.765	1.3
01-Jan-1985	19-Aug-1985 05:05:26		1.998	a	1.998	0.797	1.3
01-Jan-2008	27-Sep-2008 14:00:00		1.672	b	1.672	0.861	1.2
01-Jan-1989	08-Jul-1989 02:45:00		1.613	c	1.613	0.871	1.1
01-Jan-1990	18-Jun-1990 08:45:00		1.599	d	1.599	0.874	1.1
01-Jan-2010	29-Aug-2010 05:30:00		1.482	e	1.482	0.893	1.1
01-Jan-2005	08-Jan-2005 18:45:00		1.383	f	1.383	0.907	1.1
01-Jan-2011	26-Oct-2011 01:32:32		1.194	g	1.194	0.931	1.1
01-Jan-2016	23-May-2016 10:00:00		0.677	h	0.677	0.974	1.0
		Mean =	3.313				

Waterfall Park Developments Limited

Waterfall Park Hotel Development

Flood Assessment, Management Proposal, and Effects Assessment

April 2018

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Waterfall Park Developments Limited

Waterfall Park Hotel Development Flood Assessment Management Proposal and Effects Assessment

April 201

Task	Responsibility	Signature
Project Manager:	Jayne Richards	
Prepared By:	Alexis Patrylak	
Reviewed By:	Gary Dent	
Approved For Issue By:	Gary Dent	

Issue Date	Revision No.	Aut or	C ecked	Approved

Prepared By:
Fluent Infrastructure Solutions Ltd
Suite 2, First Floor
23-27 Beach Street
PO Box 1204
Queenstown 9348
Telephone: + 64 3 974 4586
Email: office@fluentsolutions.co.nz
Web: www.fluentsolutions.co.nz

Job No.: Q000391
Date: 12 April 2018
Reference: RP-18-04-11 AOP Q000391

Waterfall Park Developments Limited

Waterfall Park Hotel Development Flood Assessment Management Proposal and Effects Assessment

APPENDI 1

Waterfall Park Developments Ltd Hotel Roading and Carpark Design Overview and Earthworks Volumes

Paterson Pitts Group Drawings: Q6388-15, Sheet 1, Rev B

APPENDI 2

Mill Creek Flood Frequency Estimate

Reference: ORC - Flow Recording Station Record - Mill Creek at Fish Trap - GEV Estimate

APPENDI 3

ORC Correspondence and Hydrology Peer Review Comment

APPENDI 4

Mill Creek Proposed Widening

APPENDI 5

Proposed Freeboard Allowances

1.0 Introduction

Fluent Solutions has been engaged by Waterfall Park Developments Ltd to prepare a report on how the flood flows in Mill Creek would affect the proposed Waterfall Park Hotel (including the Ayrburn Domain) development and how any potential adverse effects would be managed and/or mitigated.

The proposed flood mitigation measures primarily relate to the effects of the proximity of the Waterfall Park Hotel buildings to Mill Creek, the accessways across Mill Creek, including two vehicle crossings, seven pedestrian bridges, and land form adjustments along Mill Creek as part of landscape planning.

This report has been prepared to support an application for resource consent for the flood mitigation works associated with the Hotel and Ayrburn Domain development.

Note: This report does not address the ecology of Mill Creek in relation to the proposed work. This is addressed in a separate report prepared by Ryder and Associates.

The flood assessment and associated mitigation design for the main access road and vehicle crossing proposed on the left bank flood plain areas adjacent to Mill Creek has been included in a previous resource consent application (RM17.302).

2.0 ackground

2.1 Waterfall Park Locality

The proposed Waterfall Park development area is located to the north of Lake Hayes and approximately 3km southwest of Arrowtown. Mill Creek drains a moderately large catchment that discharges to Lake Hayes that in turn discharges via Hayes Creek to the Kawarau River. Waterfall Park lies in relatively rolling land, however, part of the development area lies in a relatively incised valley. At the head of the valley, the floor of the valley rises steeply by approximately 40 metres (m), to form the well-known natural waterfall feature that the “Waterfall Park” development zone takes its name from. At the transition from the rolling land form to the incised valley, the existing “Homestead Lot” is adjacent to some historic farm buildings located between the homestead and Mill Creek. Refer to Figure 2.1 below for the locality of the proposed Waterfall Park Hotel development area.

Mill Creek is referred to as “Mill Creek” because that is what the stream between the waterfall and Lake Hayes is referred to by the Otago Regional Council (ORC). The stream through the Waterfall Park site is not named on the 1:50,000 scale topographical map series typically used for locality references.

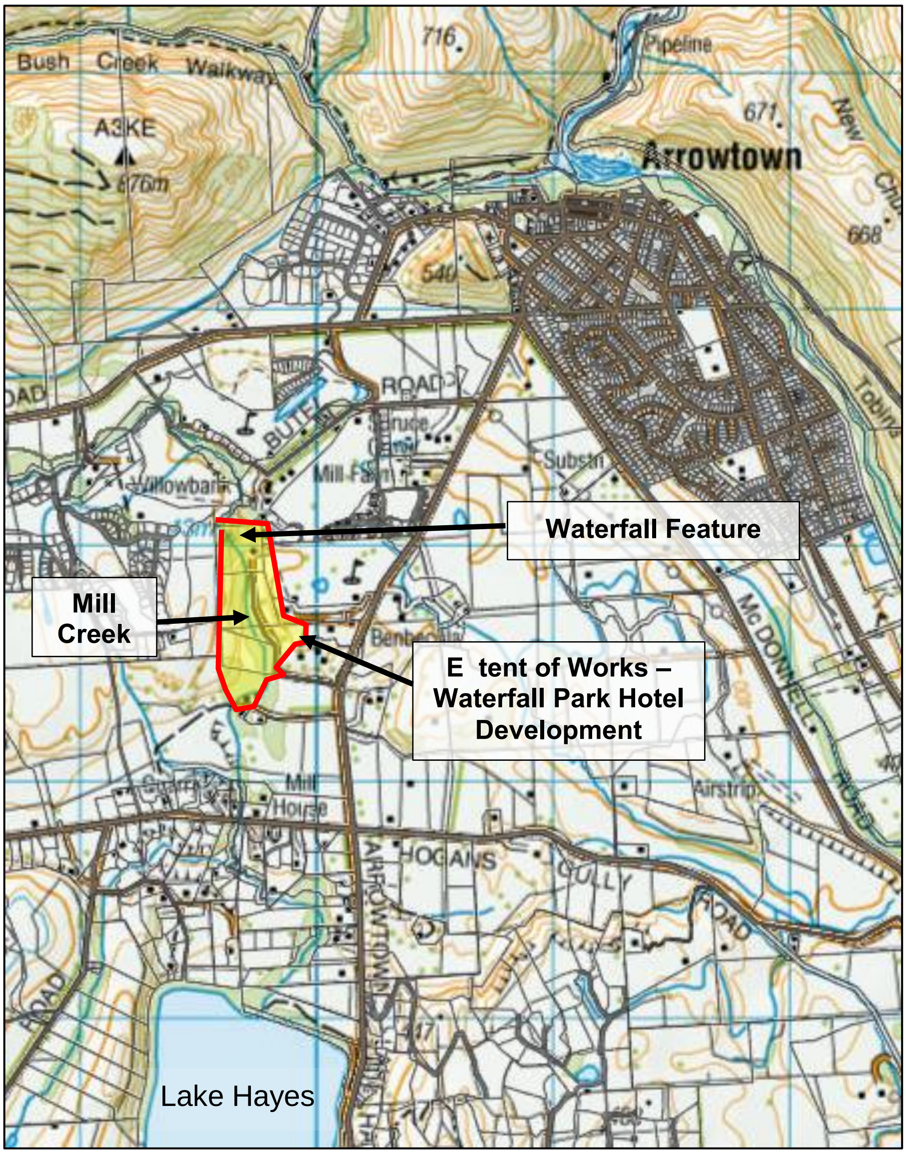


Figure 2.1 Locality Plan

2.2 Mill Creek C aracteristics

2.2.1 Typical Flow Regime

The Mill Creek 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 (km^2). Upstream of the waterfall at the upstream and northern extent of Waterfall Park, the Mill Creek valley floor rises very gradually from 400m to 440m over a distance of 10km which is a very modest slope hence the valley floor is relatively flat and is typically 1km wide. Despite the significant catchment area and the steep valley sides, the wide valley floor has the ability to absorb and disperse large flows in what is essentially a dry lake bed topographic feature.

Through the Waterfall Park and Ayrburn Domain land, and elsewhere between Waterfall Park and Lake Hayes, the main channel of Mill Creek is confined and is relatively stable.

The channel stability is indicative of a relatively stable flow regime typical of a stream downstream of a lake or wetland, in this case the lake bed topographic feature upstream of the Waterfall Park waterfall. The median dry weather flow is of the order of 350 litres per second (l/s). The stability of the flow regime creates an attractive habitat for fish and therefore Mill Creek is a valuable fish spawning area. The ecology of Mill Creek is the subject of a separate report by Ryder Environmental Ltd.

Figure 2.2 Mill Creek Environment Prior to Development
(At the Homestead Lot (see Figure 2.1))

2.2.2 Upper Reach Stream Environment - Incised Valley

In the incised valley reach, the margins of the stream channel have recently been cleared of a dense willow thicket and pine plantation. See Figure 2.3 for the "Upper Reach". The main channel of the stream is typically 3 to 5 metres (m) wide in the bottom and 10 to 15m wide at the top of the bank and is typically 1m to 2m deep. Where the channel is less than 1.5m deep there is a risk that flood flows would leave the main channel locally to the flood plain and return to the channel downstream.

At the southern end of the incised valley, Mill Creek then flows through a shallow terraced land form at the northern end of the east bank floodplain adjacent to the main channel.

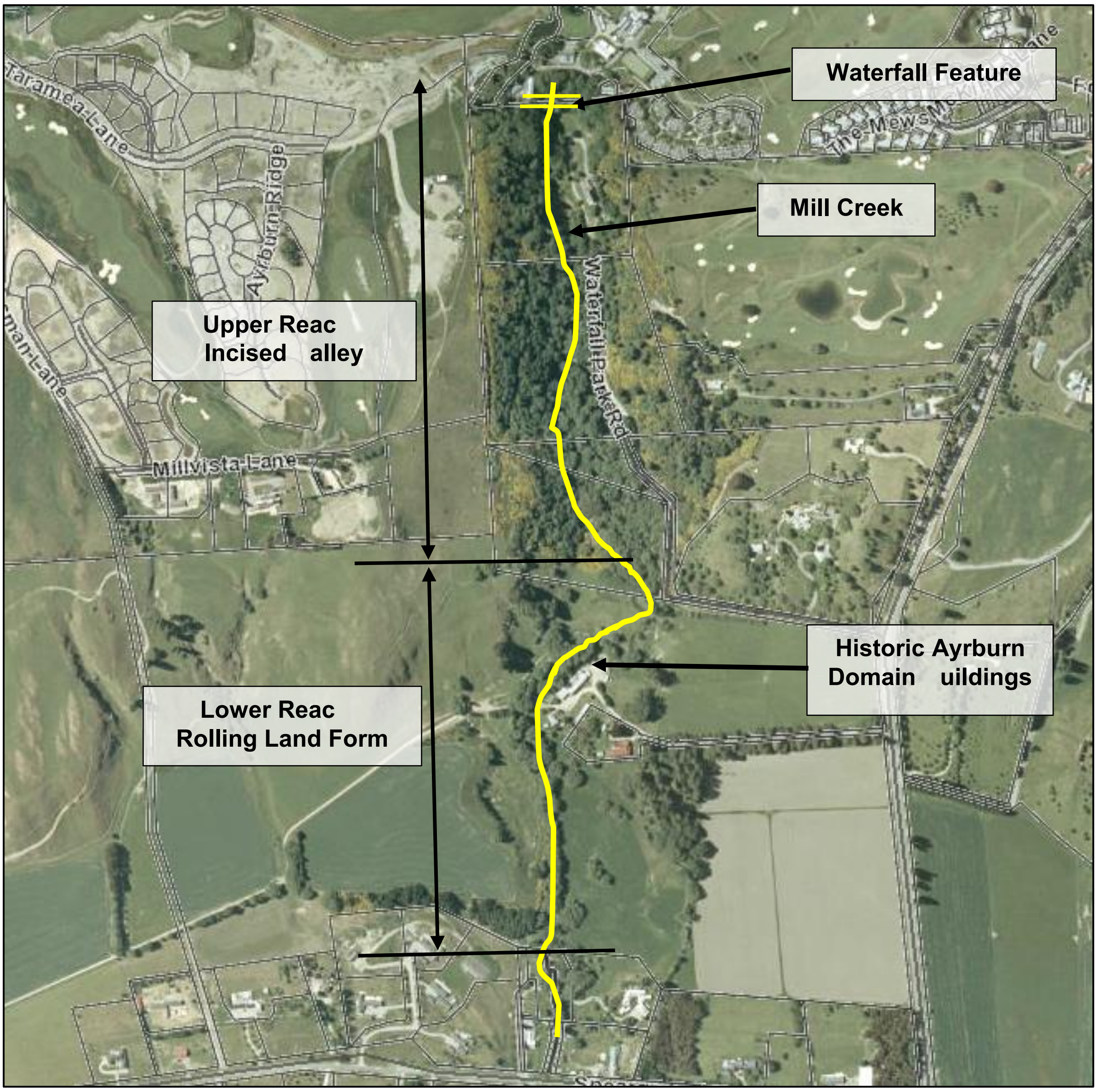


Figure 2.3 E isting Mill Creek Locality

2.2.3 Lower Reach Stream Environment - Rolling Land Form

The Creek in the rolling land area (Lower Reach) downstream of the incised valley is similar to that upstream in the incised valley except that bank heights are frequently less than 1.5m and therefore there are areas where during major flood events flood flows leave the main stream channel. Flows leave the Creek on the left bank of the channel downstream of the “Homestead Lot” and follow a flood plain. Figure 2.4 illustrates the spreading out of extreme (100 year Average Recurrence Interval (ARI)) flood flows on the Lower Reach outside the main Creek channel. Figure 2.4 also illustrates the flooding that would occur without management. Figure 2.5 represents the spreading out of a moderate event flood flow (20 year ARI) and provides a comparison to Figure 2.4. The flow on the floodplain is significant for moderate and extreme events.

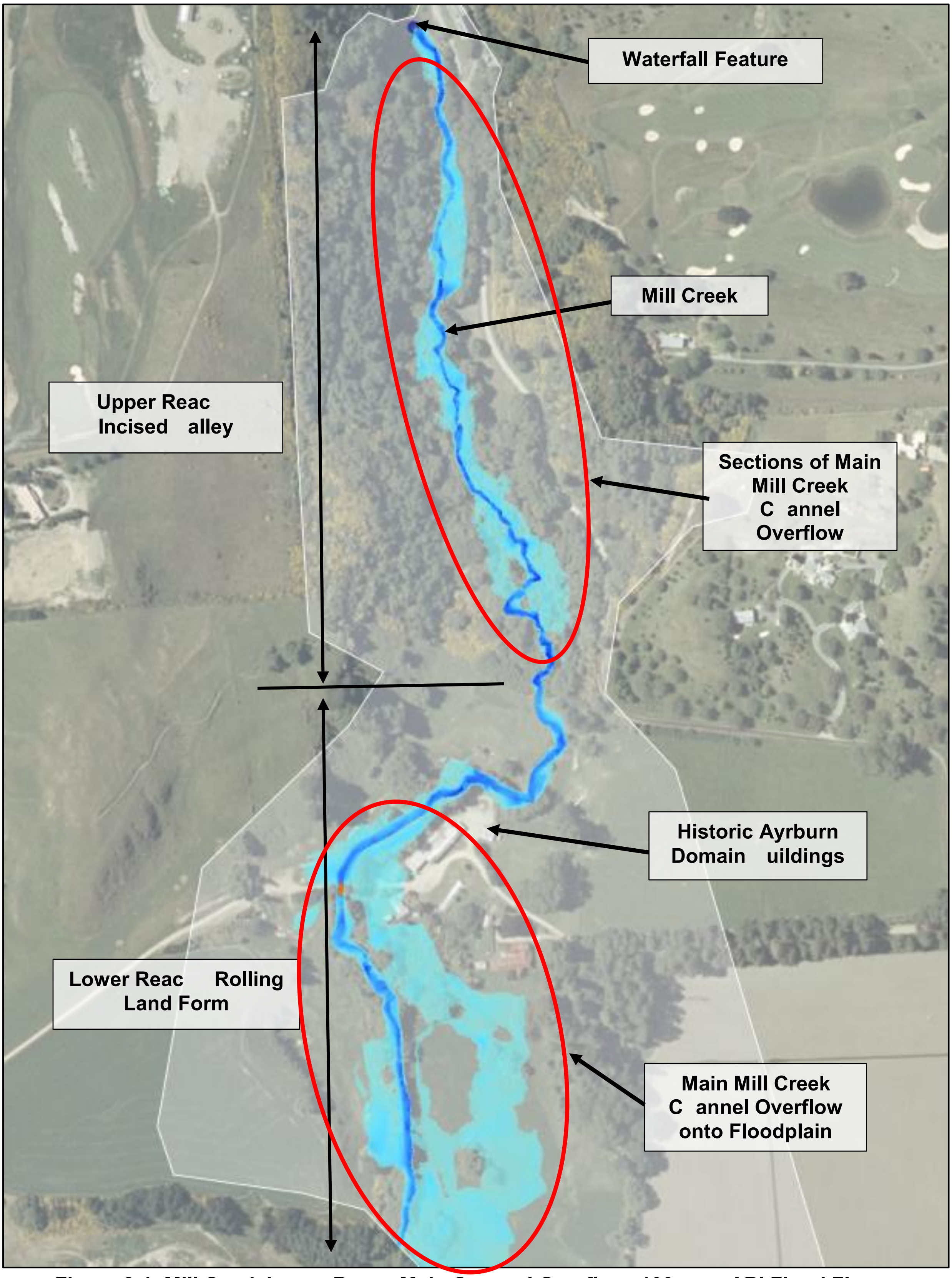


Figure 2.4 Mill Creek Lower Reac Main C annel Overflow 100 ear ARI Flood Flows

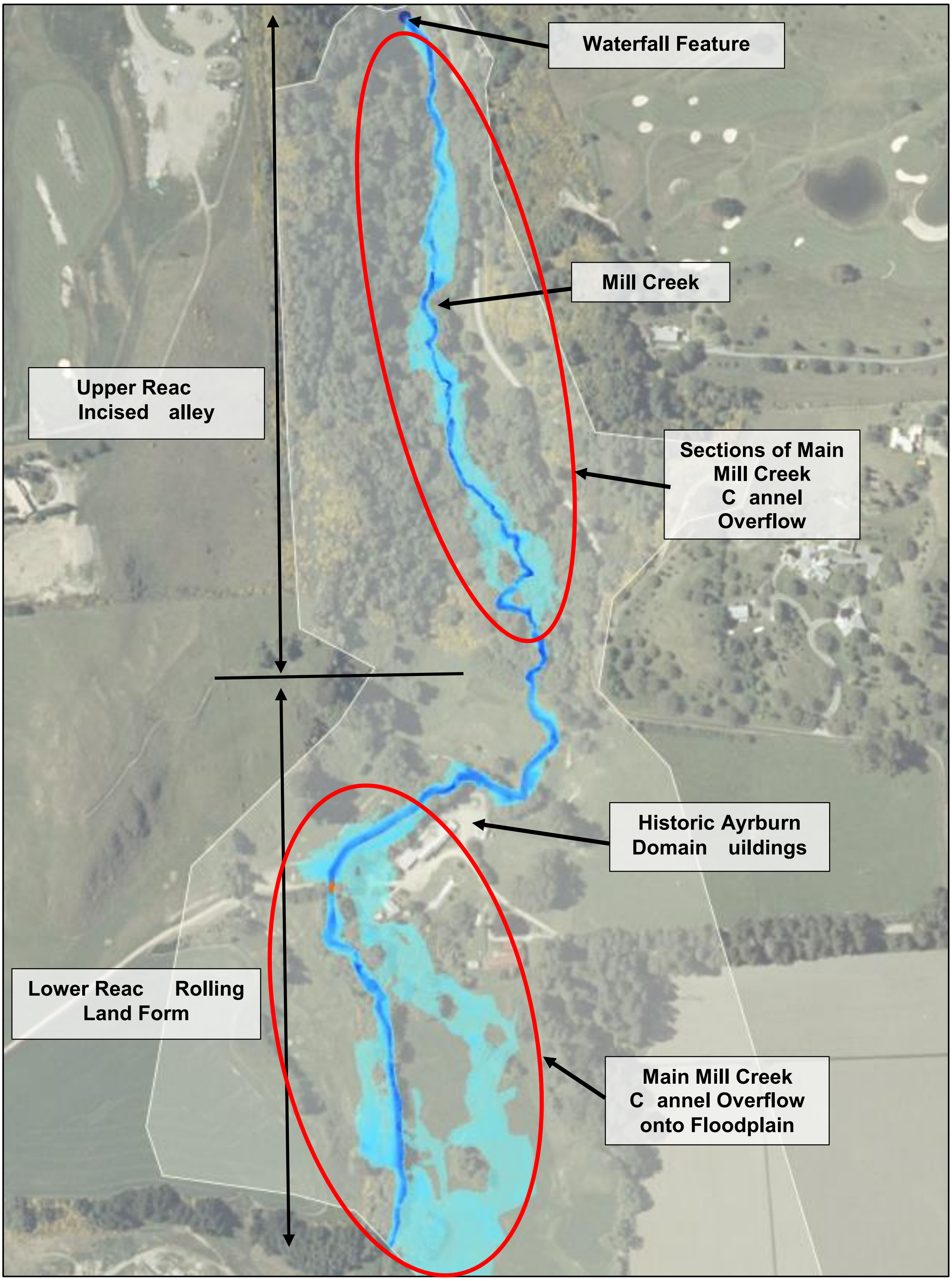


Figure 2.5 Mill Creek Lower Reac Main C annel Overflow 20 ear ARI Flood Flows

3.0 Proposed Development

The layout of the proposed development is included as part of the "Waterfall Park Developments Ltd Proposed Hotel Roading and Carpark Design Overview Drawings" (Paterson Pitts Group, Q6388-15) in Appendix 1. A simplified layout of the Hotel site plan is provided in Figure 3.1 below. The development includes a main reception building including a conference center and parking, hotel units accessible by vehicle and pedestrian bridges, wellness centre, chapel, pavilion structures, and the Ayrburn Domain which includes the main restaurant (accessible by vehicle and pedestrians bridges).

The development of these areas includes the following:

a. Widening of the stream bed throughout the development to create landscaped pools. Note that the ecological implications of this design element have been dealt to in a separate report (Ryder Environmental Ltd).

b. The proposed main pedestrian bridges (Buggy Bridges 01-06) would span the full width of the main channel and would have minimal effect on the main channel of the existing stream and stream flows. The finished bridge underside of deck would be approximately 0.6m above the 50 yr ARI maximum water level.

c. The proposed pedestrian path west of the Ayrburn Domain development (Pedestrian/Cycle Accessway 01) would constrict flows to the width of the main channel (approximately 4m width) for up to the 20 yr ARI event. For larger events, flows would overtop the path access.

d. The proposed vehicle access road to the hotel units (Road Culvert 01) would include a culvert to convey flows under the road. The top of the road would be 0.5m above the maximum estimated water level for a 50 yr ARI event. It is proposed to shape the main stream channel in the areas immediately upstream and downstream of the culverts to promote a smoother transition from the Creek bed to the culverts.

e. Floor levels for Buildings A to E, the Chapel, and Ayrburn Domain buildings are set with appropriate freeboard allowances above flood levels as required by the Queenstown Lakes District Council (QLDC) Land Development and Subdivision Code of Practice. Note that the Wellness Centre and Pavilion have not been included as part of this report, as they are more than 1m above the maximum 100 yr ARI flood level.

f. The vehicle access road to the Ayrburn Domain carpark (Road Culvert 02) and the Ayrburn Domain Carpark itself (Guest Parking 01) are designed to be serviceable for up to the 20 yr ARI event. For events larger than a 20 yr ARI event, flood waters would overtop the road and car park and continue downstream along the natural flow paths being the main channel and the left bank flood plain.

g. Pedestrian/Cycle/Buggy accessway along the true right of Mill Creek provides access for up to a 100 yr ARI flood event. The path is a combination of gravel and boardwalk pathway sections. Both the boardwalk and gravel path sections are designed to be above the 100 yr ARI flood level.

h. Viewing Platform 01 is located on the western side of Building A and is designed to be a deck which cantilevers over the Mill Creek waterway. In order to ensure adequate conveyance in a flood event, the platform is set above the 100 yr maximum water level.

i. The landscaped edge in front of the Ayrburn Domain restaurant allows closer access to Mill Creek. This area is designed to be serviceable for up to the 2 yr ARI event. In larger events, flood waters will flow over the landscaped area unimpeded.

j. The flood walls around the Ayrburn Domain are designed to protect the Ayrburn Buildings from flooding in the 100yr ARI event with 0.5m freeboard.

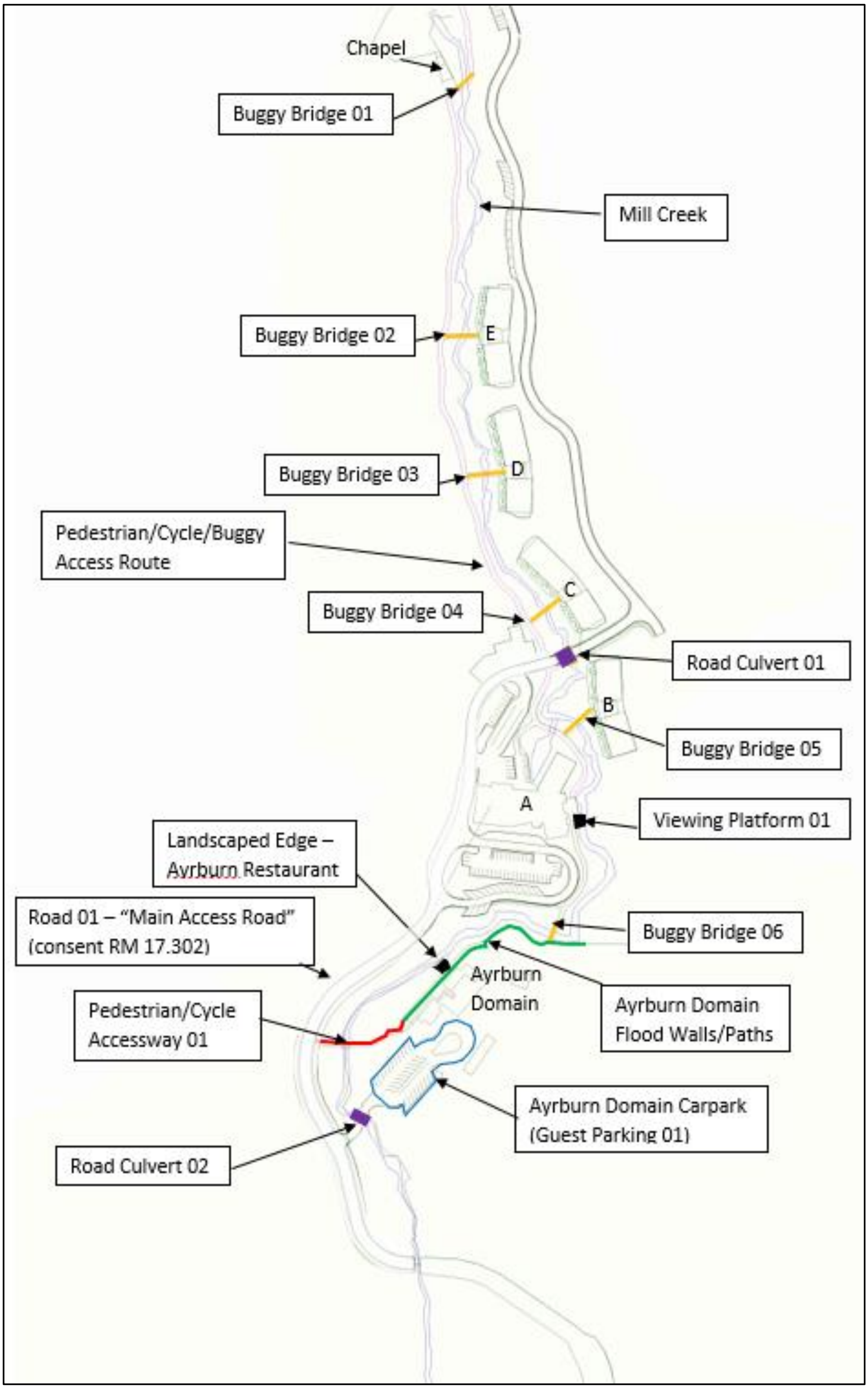


Figure 3.1 Waterfall Park Proposed Hotel and Ayrburn Domain Development Plan Mill Creek ridges and Structures

4.0 Flood Hydrology of Mill Creek

In order to evaluate the effects of the development and the necessary mitigation measures needed, a flood model was developed. The following sections describe the development of the model and peak flood flow estimations used in the design of the Waterfall Park Development.

4.1 Flood Effects Modelling

The hydraulic and hydrological modelling software Infoworks ICM (ICM) was used to estimate the peak flood flows in Mill Creek at the downstream end of the lower reach for the pre- and post-development scenarios for the 10 year, 20 year, 50 year, and 100 year design ARI events. The model utilises 2D hydraulic calculation algorithms (built from 3D LiDAR and survey information) and other parameters to estimate flows.

The following section describes the hydrology, model input parameters, and peak flood flow results for Mill Creek.

4.2 Hydrology

4.2.1 Ground Model Data

LiDAR data supplied by the Otago Regional Council (ORC) and survey data (Paterson Pitts Group) was used to model the pathway of the flood flow through Mill Creek at Waterfall Park under the current “pre-development” condition.

4.2.2 Flow Estimate at Waterfall Park

Under RM17.302 (Waterfall Park Main Access Road Resource Consent), an exercise was undertaken to review the 100 yr ARI design flow for Mill Creek within the Waterfall Park development area. This included correspondence with ORC and a hydrology peer review from Hank Stocker of Geosolve (see Fluent Solutions letter dated 13 February 2018, Appendix 3).

Based on this information, the Generalised Extreme Value (GEV) analysis, as is described below, was confirmed as an appropriate methodology for estimating flows.

4.2.3 Generalised Extreme Value (GEV) Flow Estimation Methodology

The Mill Creek catchment area at Waterfall Park is approximately 35km^2 while the catchment area at the “Fish Trap” gauging station on Mill Creek is 55km^2. The additional catchment area is largely that of the Speargrass Flat area which includes Mooneys swamp. The Speargrass sub-catchment has a similar catchment shape but shorter time of concentration than Mill Creek at Waterfall Park and therefore the peak flow at the Fish Trap gauging station would generally be marginally higher than the peak flow at Waterfall Park. The flow estimates provided by the ORC using the Generalised Extreme Value (GEV) analysis of annual maximum flows from the Fish Trap flow record provide ARI flow estimates and have been used as the basis of the hydraulic analysis of conditions at Waterfall Park. Due to the additional contribution of the Speargrass sub-catchment, use of the Fish Trap peak ARI flow estimates is considered a conservative approach for estimated flows for Waterfall Park.

From the gauging station record, the adopted 100 year ARI peak flow of $7.4m^3/s$ was adopted as the starting point. The 100 year ARI flow estimate based on the flow record summary for Mill Creek at the "Fish Trap" is included in the Appendix 2.

A 30% increase in the estimated 100 year ARI flow at the Fish Trap was added to account for climate change. Typically, an 11% increase in rainfall depth is added, which converts to approximately a 30% increase in runoff with climate change. An additional 10% of the estimated flow at the Fish Trap was added as a contingency to allow for uncertainties including future local stormwater flows draining into the Mill Creek floodway at Waterfall Park. The additional allowances applied to the estimate of $7.4m^3/s$ at the Fish Trap provide a design total peak flow of $10.4m^3/s$ at Waterfall Park.

From these peak flow estimates, a 24 hour duration triangular flow hydrograph was created with the peak flow occurring at 0.7 times the duration each ARI storm event. The hydrograph was used to represent the storage routing.

The design model input peak flow was applied to the model at the waterfall referred to as the "Flow Hydrograph Input Location" shown in Figure 5.1 below. A similar method was used to develop the peak 10 year, 20 year, and 50 year ARI flows. Design peak flows applied at the flow hydrograph input location are included in Table 5.1 below.

Discharge flows were estimated using the ICM model at the southern boundary of the Waterfall Park site for the pre- and post-development scenarios to ensure that discharges leaving the site are mitigated to at least pre-development levels. The peak design flows and the flows calculated at the southern boundary are presented in Table 5.1.

Table 5.1 Pre development Flows Peak Design Input and Sout ern oundary Result line Flows

Storm Event	Design Input Peak Flow m^3 s	50m Nort of Sout ern oundary Result line Flow m^3 s
10 Year ARI	7.6	7.7
20 Year ARI	8.5	8.5
50 Year ARI	9.6	9.9
100 Year ARI	10.4	10.9

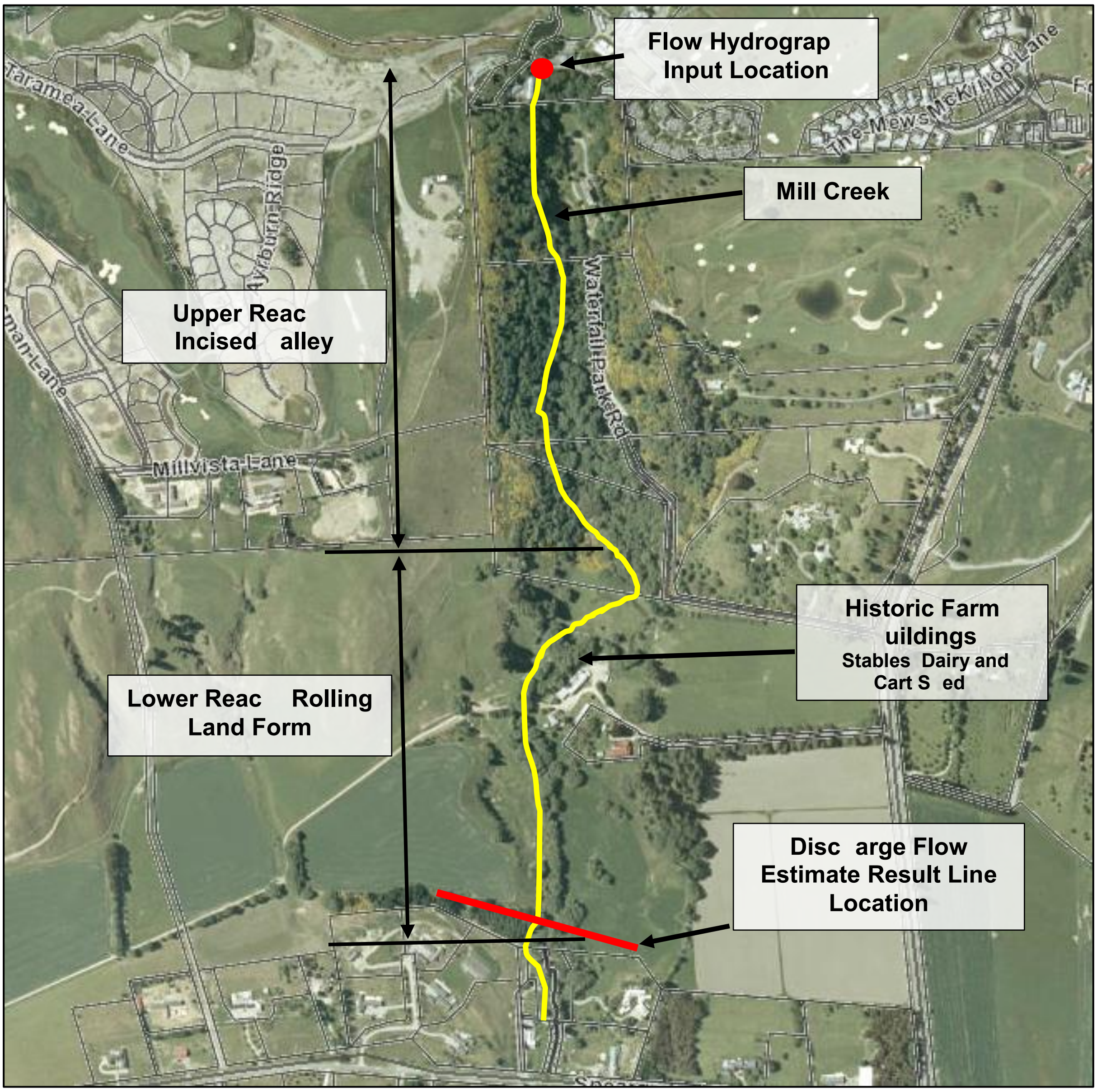


Figure 5.1 Flow Estimate Location

5.0 Proposed Flood Management System

5.1 Flood Management Concept

The proposed flood management system is designed to provide mitigation of flows in Mill Creek to pre-development levels for the 10 year, 20 year, 50 year, and 100 year ARI events and protect site features during the flood events.

The flood management strategy as part of this application includes:

a. Widening of the stream bed throughout the development to create aesthetically designed pools in the Mill Creek Floodway.

b. 6 Buggy Bridges across the floodway.

c. A pedestrian accessway west of the Ayrburn Domain development, serviceable for up to the 20 yr ARI event.

d. A road culvert crossing to provide road access to the eastern side of Mill Creek.

e. Vehicle access via a culvert crossing to the Ayrburn Domain carpark with serviceability up to a 20 yr ARI event.

f. Appropriate freeboard allowances for building floor levels based on the 100 yr maximum water levels.

g. Landscaped edge in Ayrburn Restaurant area to be serviceable for up to the 2 yr ARI event.

h. Flood walls/paths around Ayrburn Domain to protect buildings in the 100yr ARI event with 0.5m freeboard.

i. Combination boardwalk/gravel pedestrian/buggy path on true right of Mill Creek designed to be above the 100 yr ARI water level.

The effects of the development and flood management features are discussed in the following section.

5.2 Pre and Post Development Flood Flow Results Summary

Figures 6.1 and 6.2 below compare the flood flow results from the pre- and post-development scenario model runs for the 20 yr and 100 yr ARI events.

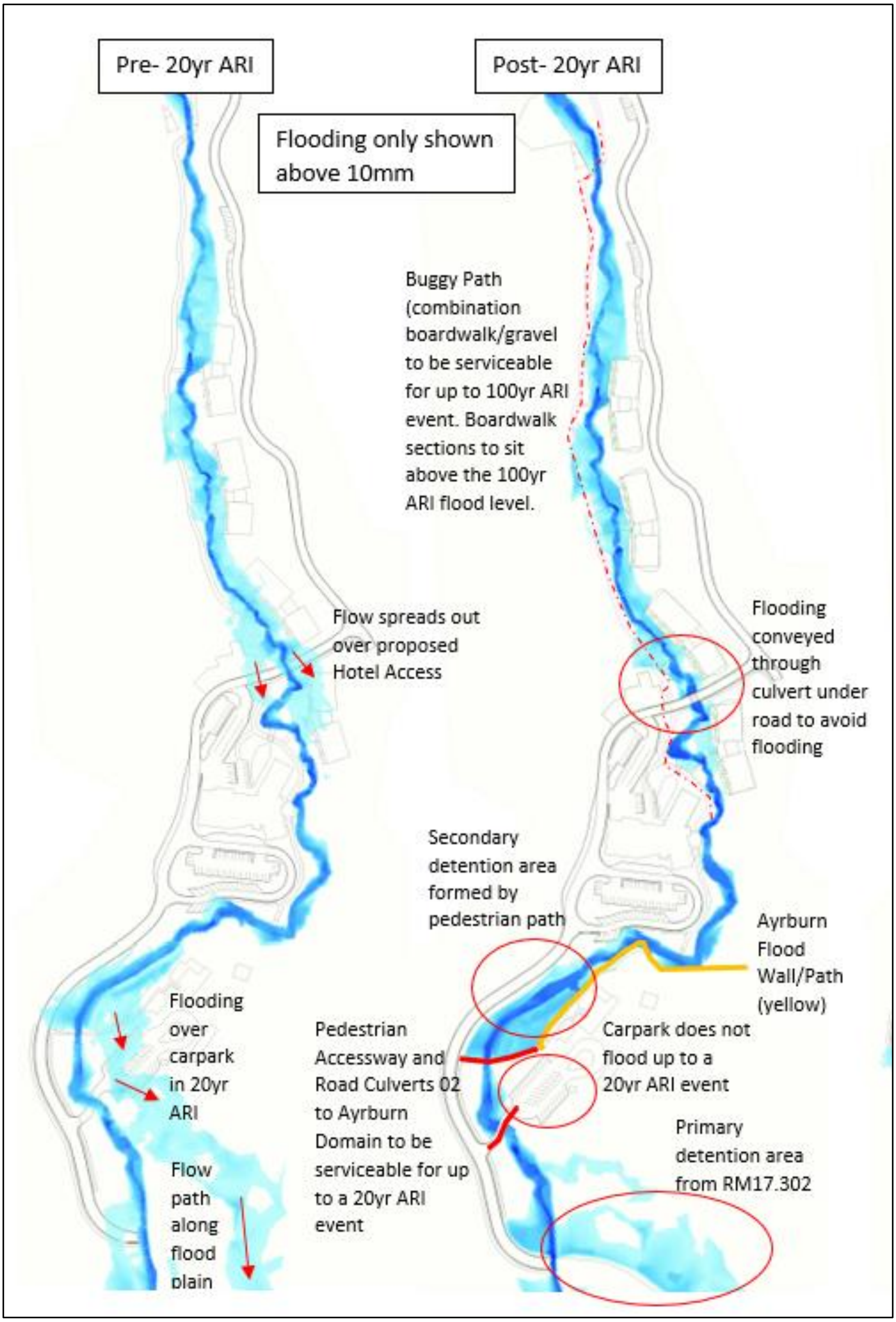


Figure .1 Comparison of Flood Flow Results 20 ear ARI

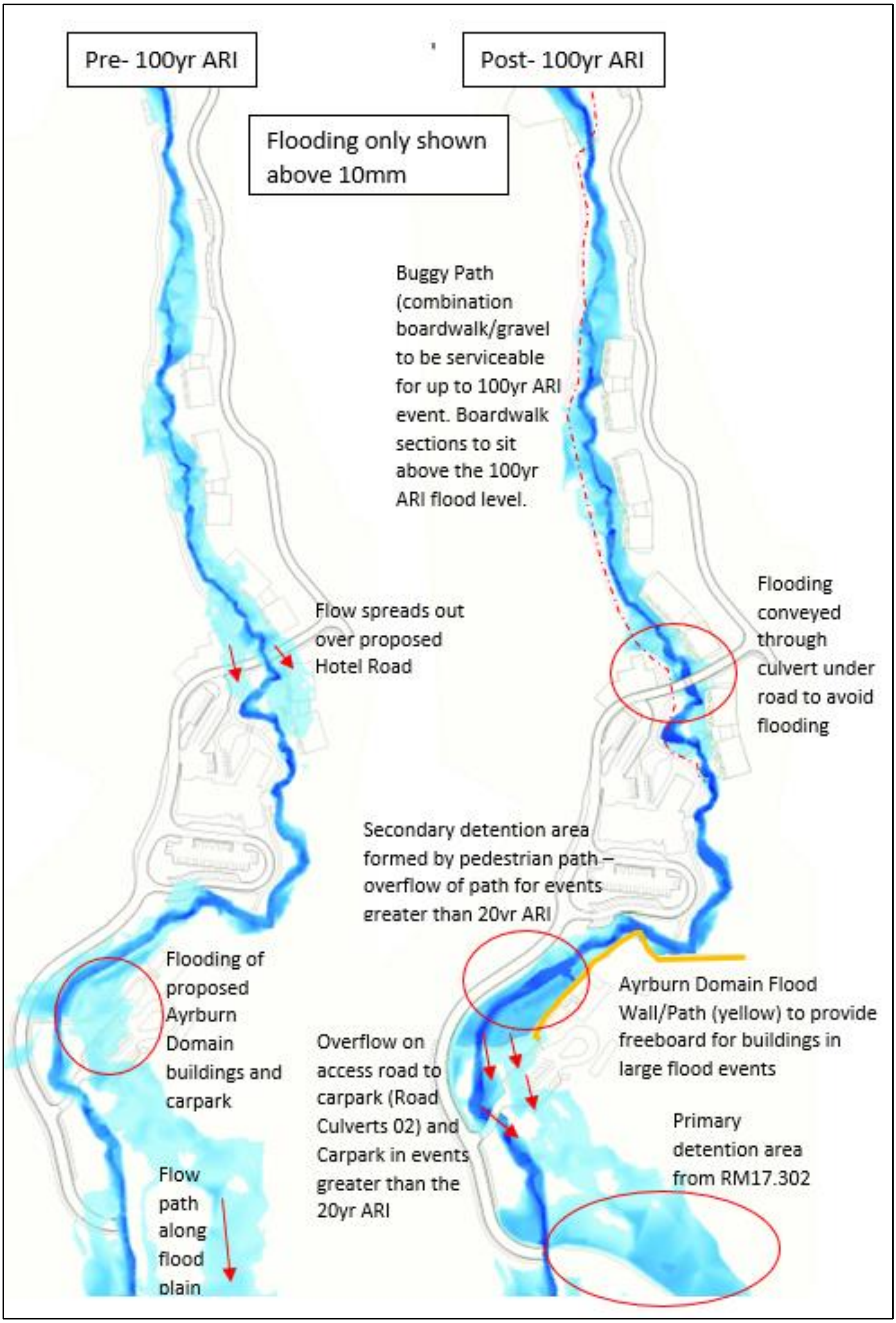


Figure .2 Comparison of Flood Flow Results 100 ear ARI

Based on Figures 6.1 and 6.2 above, observations are as follows:

- The sections of widening throughout Mill Creek in the site produce pools which would provide aesthetic value within the Hotel areas. In areas where the widening occurs, a weir is set on the downstream end of a short reach in order to ensure that the “pools” fill with water to create this aesthetic value. Typical cross sections and a plan showing the widening sections are included in Appendix 4. Note that the sections of proposed widening reduce flow depth and velocity and therefore reduces the potential for erosion. The Mill Creek waterway long section for the post-development scenario varies to a minor extent from the pre-development waterway - see Section 7.0 below and Appendix 4 for more information.
- The Buggy Bridges are designed to span the full width of the floodway and therefore offer little restriction on the flood flows.
- The proposed buildings are located on the margins of the Mill Creek waterway. A minimum freeboard of 0.5m above the 100 yr ARI maximum water level has been allowed for in order to provide flood mitigation (See Appendix 5).
- The viewing platform in the Ayrburn Restaurant area is designed to only be serviceable for up to a 2 yr ARI event and is therefore submerged in both the 20 yr and 100 yr ARI events shown in the figures above.
- The culvert crossing under the road leading to the hotel units constricts the flows upstream of the crossing and directs flood flows into the reach downstream. A freeboard to the top of the road of 0.5m above the 50 yr ARI maximum water level on the upstream side of the culvert has been allowed for in the design. Additionally, the proposed culverts have been staggered to promote a low flow channel.
- For the 20 yr ARI event, the western pedestrian access from the main access road to the Ayrburn Domain and the vehicle access culvert to the Ayrburn Carpark act as control weirs to limit flow through the bridges / culverts in the 20 yr ARI event.
- For events larger than the 20 yr ARI event, as can be seen in Figure 6.2 showing the 100 yr ARI event effects, flow overtops the Ayrburn pedestrian path and carpark access to allow additional flows to flow down the left bank floodplain. The use of the “control weirs” helps to limit downstream flows from the development site to levels below the pre-development flow regime and additionally reduces velocities and flows over the floodplain/carpark area.
- Downstream of the Ayrburn carpark, flows continue across the floodway in a similar path to the pre-development situation. The flow is collected in the floodplain detention storage area north of the access road and discharge via two outlet pipes draining under the main access road to the lower left bank flood plain that drains to the southern boundary (refer to consent RM17.302).

Additionally, Table 6.1 below provides a summary of the peak pre- and post-development Mill Creek flood flows. Note that due to constraints in the survey data, flood flows have been estimated at approximately 50m upstream of the southern boundary for the site. Given that the topography upstream of the southern boundary is very similar to that at the boundary, the flow result line 50m upstream of the boundary is representative of the flow at the site boundary.

Table .1 Summary Peak Flow Estimates

Storm Event	Pre Development Mill Creek Peak Flow Estimate at 50m Upstream of Sout ern oundary m^3 s	Post Development Mill Creek Peak Flow Estimate at 50m Upstream of Sout ern oundary m^3 s
10 Year ARI	7.7	6.3
20 Year ARI	8.5	6.5
50 Year ARI	9.9	8.9
100 Year ARI	10.9	9.6

The peak post-development flow for the design 10 year, 20 year, 50 year, and 100 year ARI storm events would be mitigated to significantly less that the estimated peak pre-development flow and therefore the proposed works in Mill Creek would have no adverse flood effects on property downstream of Waterfall Park.

6.0 Statutory Re uirements

The following sections set out the specific statutory requirements pertaining to proposed work around the Mill Creek waterway and how the design adheres to the statutory requirements. The sections below also identify any non-compliances and the mitigation measures taken to deal to these areas.

.1 Code of Subdivision Re uirements

6.1.1 General

The QLDC "Land Development and Subdivision Code of Practice" (dated 30/10/2015) (Cl 4.3.5) requires that a primary stormwater system be designed to convey, as a minimum, a 20 year Average Return Interval (ARI) (5% average Annual Exceedance Probability (AEP)) runoff flow taking into account climate change. Where a secondary flow path is available, the secondary flow path is required to convey the balance of a 100 year ARI (1% AEP) flow without damage to property and with freeboard. If a secondary flow path is not available, the primary system is required to convey a 100 year ARI flow with freeboard (Cl 4.3.5.2).

In relation to the Waterfall Park and Ayrburn Land, the Mill Creek and the associated flood plain is a primary stormwater flow path and therefore property potentially affected by Mill Creek is to be protected to 100 year ARI event standard with the appropriate freeboard.

6.1.2 Bridge and Culvert Crossings

The COP provides minimum standards for freeboard at bridges and culverts. The freeboard at the culvert is required to be 0.5m for a 50 year ARI event. For a bridge the freeboard required is 0.6m for a 50 year ARI event. A summary of the freeboard allowances are included in Appendix 5.

6.1.3 Minimum Building Freeboard Levels

The COP requires a minimum freeboard height above the maximum 100 yr ARI estimated water level to buildings (Cl 4.3.5.2). The minimum freeboard allowances are shown in the figure below. Note that the COP indicates that “the minimum freeboard shall be measured from the top water level to the building platform level or underside of the floor joists or underside of the floor slab, whichever is applicable.”

Freeboard	Minimum height
Habitable dwellings (including attached garages)	0.5 m
Commercial and industrial buildings	0.3 m
Non-habitable residential buildings and detached garages	0.2 m

For this application including the Hotel and Ayrburn Domain areas, all buildings were assumed to require a minimum freeboard height of 0.5m above the 100 yr ARI water level.

The COP freeboard requirement was still found to be appropriate in sensitivity analyses for a super design event flow.

A summary of the freeboard allowances are included in Appendix 5.

6.1.4 Exceptions

Within the Waterfall Park development, there are two areas where the freeboard requirements in the COP would not be provided. These two areas are the pedestrian / cycle accessway 01 on the west of the Ayrburn Domain development and the vehicle access culvert (Road Culvert 02) to the Ayrburn Domain Carpark - please see Figure 3.1 above.

These are not to be vested with Council and are only for use for by guests and staff. The design standard applied was that the culvert on the vehicle access to the carpark, the car park itself, and the pedestrian / cycle accessway would not be flooded for events up to the 20 yr ARI flood. Additionally, the pedestrian / cycle accessway, culvert, and car park provide flood water level control for the Mill Creek waterway.

During large flood events, appropriate management procedures would be in place to monitor and if necessary close off the vehicle access (Road Culvert 02) should water levels begin encroaching the road level (road closure to occur when maximum water level upstream of the culvert is approximately 0.2m below road level). In order for the carpark to withstand a higher frequency of flooding (i.e. being flooded above a 20 yr ARI event), the carpark material is likely to be concrete or stabilised gravel pavement.

In large events, Buggy Bridge 06 north of the Ayrburn Domain provides an alternative pedestrian accessway and also connects to another carpark located at Building A.

.2 Regional Plan Water for Otago

The Mill Creek waterway runs through the Waterfall Park Hotel and Ayrburn Domain development sites. This report does not include provision for stormwater reticulation and discharge from the developments into Mill Creek. This is subject to a separate report (Fluent Solutions Water, Wastewater, and Stormwater Infrastructure Assessment, April 2018).

From Section 8.2 of the Otago Regional Plan - Water (RPW), the issues to be addressed specific to "disturbance" of the bed and margins of a "river", being Mill Creek, are as follows:

Changes in the nature of the flow of water and sediment caused by activities in, on, under or over the bed or margin of a lake or river, can adversely affect:

a he stability and function of e isting structures
b he bedform of the lake or river
c ed and bank stability and
d Flood carrying capacity.

The design of the proposed flood mitigation works described below address each of the above issues. The proposed design protects the stability of the Mill Creek bed and bank, maintains a similar flow and velocity regime, as well as improves the flood capacity.

Pursuant to the RPW, consent is required from the Otago Regional Council (ORC) for the following activities:

a. Construction of new pedestrian bridges:
    - 6 new pedestrian / buggy bridges - Buggy Bridges 01-06.
b. Construction of box culvert crossings:
    - Box culvert for vehicle access to eastern side of Mill Creek - Road Culvert 01.
c. Disturbance of the bed of a river:
    - Reconstruction of the Mill Creek waterway within the site including selective widening of the Mill Creek channel berms.
    - Inclusion of a landscaped edge in front of the Ayrburn Domain restaurant allows closer access to Mill Creek.
    - Access to Guest Parking 01 - Road Culvert 02 vehicle access to be passable without flooding for up to a 20 yr ARI event.
    - Reshaping of the bed in areas immediately upstream and downstream of the Road Bridges 01 and 02.
    - Pedestrian path elevation to the Ayrburn Domain from the west - Pedestrian / Cycle Accessway 01.
    - Construction of the Ayrburn Domain carpark across the flood plain.
    - Sections of the Pedestrian / Cycle / Buggy Access Route along true right bank of Mill Creek.

d. Defence against Water

- Erection of flood walls in the vicinity of the Ayrburn Domain.

6.2.1 Bridge and Box Culvert Construction

Section 13 of the RPW sets out the rules for land use activities in the bed of a lake or river including construction of a bridge or culvert. In relation to the construction of the new box culverts and pedestrian bridges in the Waterfall Park Hotel area and Ayrburn Domain, under Rule 13.2.1.7 the RPW states the following. Comment is provided on the compliance with each condition.

Rule 13.2.1.7:
he erection or placement of any single span bridge including for pipes over the bed of a lake or river, or any Regionally ignificant Wetland, is a permitted activity, providing:

Table 3.2 Compliance wit Rule 13.2.1.7

Rule 13.2.1.7 Conditions	Compliance wit conditions
a he bridge or its erection or placement, does not cause any flooding, nor cause any erosion of the bed or banks of the lake or river, or Regionally ignificant Wetland, or property damage and	The bridges and culverts have been designed to ensure that they do not cause flooding, erosion or property damage. The bridges and culverts would have no adverse flood effect that is not mitigated by the proposed flood management work as a whole. Additionally, velocities in the areas of the bridges and culverts have been assessed to be low (<2.5m/s for a 100 yr ARI event).
b o more than 20 metres of bridge occurs on any 2 0 metre stretch of any lake or river and	There are more than 20m of bridge length over a 250m stretch of Mill Creek. Therefore, the development does not comply with (b).
c here is no reduction in the flood conveyance of the lake, river or Regionally ignificant Wetland and	The Buggy Bridges 01-06 and Hotel (Road Culvert 01) box culvert crossing have been designed to ensure that there is no reduction in flood conveyance.
d he bridge soffit is no lower than the top of the higher river bank and	The bridge soffit for Buggy Bridges 01-06 would be a minimum of 600mm above the 50 year ARI flood level and sits above the top bank level and therefore comply with Condition (d). The Hotel Access (Road Culvert 01) box culvert soffit would be submerged at peak design flood flow and therefore does not comply. The culvert confines the flows, creating an upstream head and increased flood level, therefore optimising the capacity of the proposed culverts.
e he bridge and its abutments are secured against bed erosion, flood water and debris loading and	Concrete piles would be constructed to secure the pedestrian bridges against bed erosion and flood water. A 600mm freeboard above the 50 year ARI would be provided to the bridge soffit. This is considered to be sufficient to secure against debris loading as the relatively small flows in Mill Creek are not high enough to carry large trees downstream.

Rule 13.2.1.7 Conditions	Compliance wit conditions
	For the box culverts at Road Bridge 01, a minimum freeboard of 500mm above the 50 year ARI flood level is provided to the road level. Should the culverts become blocked, flood levels would build up on the upstream side until the top of road height is reached, at which point water would flow over the road. Note that the FFL of Building C is approximately 1.76m above the road height. In the case of a blockage, there is sufficient freeboard to not cause backing up into Building C. Building B would be downstream of the road and flood levels would be lower.
f Where the bridge is intended for use by stock, measures are taken to avoid animal waste entering the lake, river or Regionally ignificant Wetland and	The bridges are not intended to be used by stock.
g If the bridge is situated over or on public land, then public access over the public land is maintained.	The bridges are not situated on or over public land.

The proposal does not comply with regard to Rule 13.2.1.7 (b) and (d) and therefore consent is required for a discretionary activity.

6.2.2 Disturbance of the River Bed

In relation to the re-shaping of Mill Creek, including selective widening throughout the site and in the areas immediately up and downstream of the box culvert crossings the design of the Mill Creek Floodway meets the following requirements:

1. There must be no adverse effects due to flood flows on property downstream and no adverse effects on adjacent land as a result of the proposed works.
2. The proposed mitigation measures are based on observations of the current waterway flow regime and are therefore consistent with the waterway's future use.
3. The waterway is designed to confine the design flood flows that could affect buildings proposed on the site.

The flood mitigation design includes the above requirements and is discussed further in the following sections. However, as provided by Rules 13.5.1.1 and 13.5.1.3, *"the time necessary to carry out and complete the whole of the work within the wetted bed of the lake or river"* is estimated to exceed 10 hrs in duration, and therefore a resource consent is required. The other conditions in Rules 13.5.1.1 and 13.5.1.3 including limiting sedimentation and erosion during construction would be included in the draft Earthworks Management Plan prepared by Paterson Pitts Group for sediment and erosion control during construction.

6.2.3 Defence against Water

The Ayrburn Domain includes flood walls to protect the buildings. The proposed Mill Creek flood walls in the landscape plan are to allow for flood conveyance through the waterway. As provided by Rule 13.2.3.1, "*the erection or placement of any structure fi ed in, on, under, or over the bed of any lake or river…is a discretionary activity.*" Therefore, a resource consent is required for the construction of the flood walls, acting as a defense against water.

7.0 Assessment of Effects

As noted in Section 6.0 above, consent is required for the changes to the bed of a river that is the existing Mill Creek waterway through the Waterfall Park Development site. This section sets out the proposed flood management measures for development of the site, designed to ensure effects due to development do not have a negative effect on the Mill Creek flow regime nor create any adverse effects downstream.

The following sections expand on proposed changes to the Mill Creek flow regime, maintenance measures, and how the effects of the proposed development are mitigated.

7.1 Mill Creek Flow Regime

As described above, the proposed work to the floodway alters the flow regime from a natural one to a constructed flow regime. Regular maintenance would be required to keep the shape of the constructed channel. If regular maintenance is not carried out, the channel would tend to return to a new flow regime where conditions along Mill Creek would be influenced largely by the road culverts in terms of invert level and the position of the stream waterway. Comparing the pre-development and post-development "long sections" in Appendix 4, the effects of the proposed road culverts would contribute to maintaining the Mill Creek waterway regime very similar to that existing prior to the work.

Appendix 4 also shows typical cross sections of the areas of the proposed widening. As noted above, for the reaches where widening is implemented these reaches require regular maintenance or a build-up of silt in these areas would likely re-confine the channel to its natural shape. The final cross sections for each reach remains to be confirmed at the final design stage.

Should maintenance not be carried out and the Mill Creek flow regime returns to its natural shape, the resulting flood levels would fall within the design freeboard allowed.

7.2 Mill Creek Floodway Maintenance Plan

7.2.1 Maintenance Measures

A Mill Creek Floodway Maintenance Plan is proposed to monitor the condition of the Mill Creek waterway and provide a mechanism for identifying channel conditions that could adversely affect flood levels and channel stability. Routine maintenance work would include inspections of the Mill Creek channel and bridge and culvert structures after major storm events and annual inspections in March of each year to monitor stream condition. Where trigger conditions occur, such as the invert levels that indicate significant debris deposition upstream of the bridges and culverts, maintenance requirements would be flagged in the course of the inspections and corrective action would be planned and implemented to reinstate the required channel state.

A Mill Creek Maintenance Plan is put forward by the applicant as a condition of consent and to be submitted for approval prior to waterway works.

It is recommended that the channel long section would be surveyed 5 years after the hotel becomes operational to monitor the waterway morphology.

7.2.2 Operational Activities

For flood events with an ARI greater than 20 years, both the Ayrburn Domain carpark and the accessway to the car park would be inundated (when climate change has occurred). Measures to avoid flood damage to vehicles in the car park would include closing the car park if the Mill Creek water level exceeds a threshold level at the bridge - closure of the access road would occur when water levels reach within 0.2m of road level.

7.3 Summary

The flood mitigation strategy for the works associated with the Ayrburn Domain and Hotel development areas focus on ensuring the downstream flows of Mill Creek are not increased by the development and the site buildings are protected against the adverse effects from the design flood events. Overall, the effects due to the development do not adversely affect the Mill Creek flow regime nor create an adverse effect downstream.

The proposed mitigation work achieves the following:

a. The buildings on site are protected from flooding by a combination of flood walls and setting appropriate freeboard levels.

b. Modest earthworks including the widening and proposed bridges ensure that the flooding is managed within the site.

c. The change in flow regime due to the flood mitigation measures ensures no increase above pre-development peak flood flows at the southern boundary.

d. The change in flow regime requires maintenance to maintain the proposed constructed Mill Creek waterway. Should maintenance not be carried out, the worst case is that the Creek returns to a shape similar to its natural flow regime. Should a new waterway regime be established the resulting flood levels would fall within the design freeboard allowed.

8.0 Conclusion

It is considered that the proposed activity, with its proposed mitigation measures, is consistent with, and has appropriate regard to the objectives and policies of the ORC Regional Plan: Water for Otago and addresses the flood management requirements of the QLDC Land Development Subdivision Code of Practice.

The proposed flood management concept for Mill Creek through the Waterfall Park development site ensures that the downstream flows are less than the pre-development flow for a 100 yr ARI event including allowance for climate change and allows for adequate freeboard and design robustness within the proposed development site while maintaining the flow regime of Mill Creek.

APPENDI 1

Waterfall Park Developments Ltd Hotel Roading and Carpark Design Overview and Earthworks Volumes

Paterson Pitts Group Drawings: Q6388-15, Sheet 1, Rev B

EARTHWORKS QUANTITIES

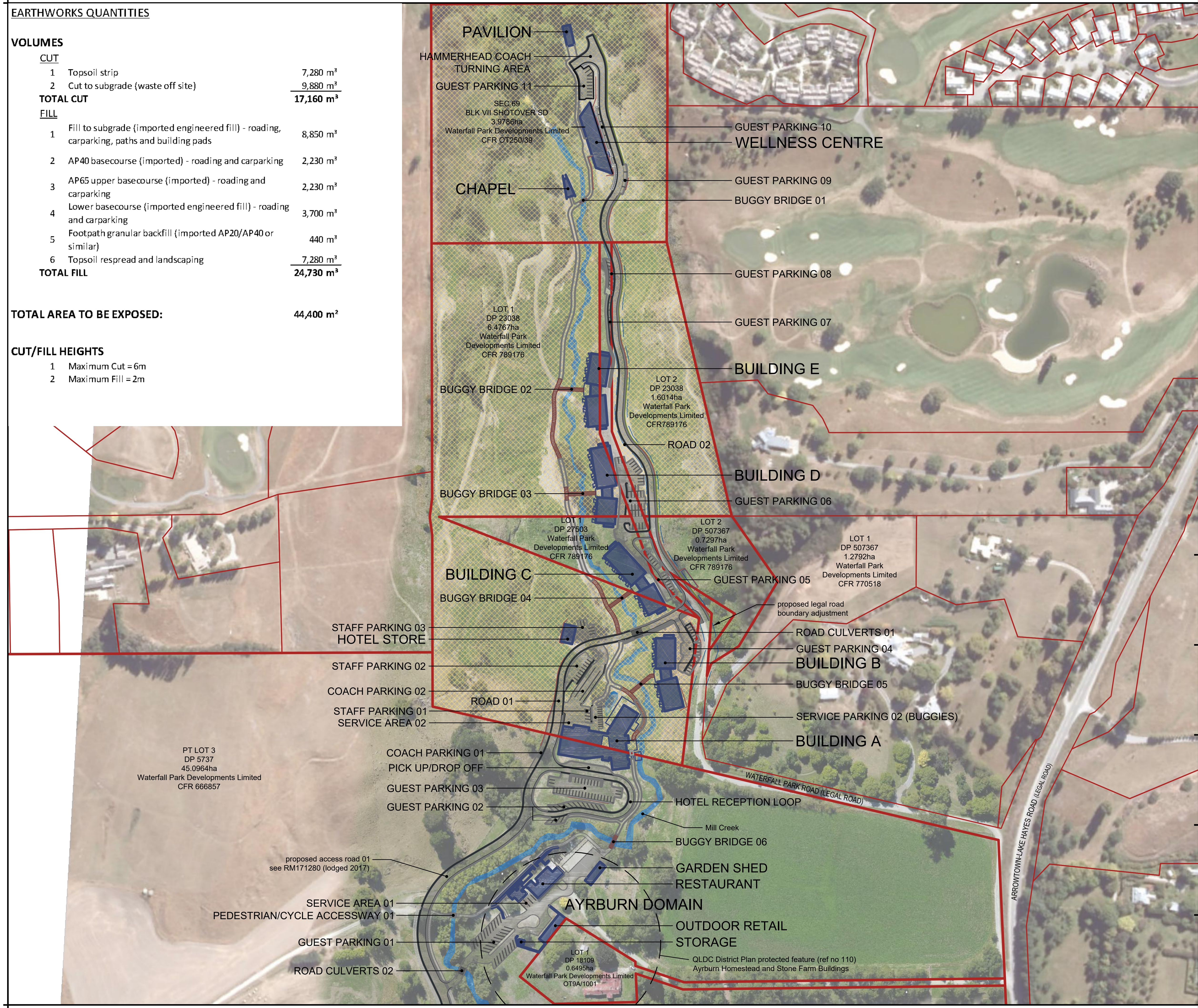
VOLUMES

CUT		
1	Topsoil strip	7,280 m³
2	Cut to subgrade (waste off site)	9,880 m³
TOTAL CUT		**17,160 m³**
FILL		
1	Fill to subgrade (imported engineered fill) - roading, carparking, paths and building pads	8,850 m³
2	AP40 basecourse (imported) - roading and carparking	2,230 m³
3	AP65 upper basecourse (imported) - roading and carparking	2,230 m³
4	Lower basecourse (imported engineered fill) - roading and carparking	3,700 m³
5	Footpath granular backfill (imported AP20/AP40 or similar)	440 m³
6	Topsoil respread and landscaping	7,280 m³
TOTAL FILL		**24,730 m³**

TOTAL AREA TO BE EXPOSED: **44,400 m²**

CUT/FILL HEIGHTS

1. Maximum Cut = 6m
2. Maximum Fill = 2m



NOTES:

1. This plan and its contents should not be used for any reason other than its intended purpose. This plan and surveyed information does not include assessment or representations concerning:
   - Hazard registers, ground conditions or suitability for development
   - 'Ground level' as defined by the QLDC District Plan
   - Service connections to utility services
2. This plan includes information from site surveys undertaken by Paterson Pitts Group (Sep 2017) and CFM (2016/2017)
3. Coordinates and bearings are in terms of Geodetic Datum 2000, Mount Nicholas Circuit grid projection
4. Levels are in terms of MSL (Dunedin Vertical Datum 1958)
5. The origin of levels is C1PV (IT IX DP 12678) RL: 348.66m
6. Existing contours shown - 0.5m contour interval
7. Refer to the relevant CFRs and title plans for registered easements, covenants and interests

QLDC District Plan
Waterfall Park Resort Zone (shaded)

0m 100m 200m
SCALE BAR

PATERSONPITTSGROUP
Surveying • Planning • Engineering
Your Land Professionals
www.ppgroup.co.nz
0800 PPGROUP

QUEENSTOWN:
Terrace Junction,
1092 Frankton Road.
PO Box 2645,
Queenstown 9349.
T 03 441 4715
E queenstown@ppgroup.co.nz

Client/Location:
Waterfall Park Developments Ltd
Sec 69 Blk VII Shotover SD, Lots 1 & 2
DP 23038, Lot 1 DP 27503, Lots 1 & 2
DP 507367, Pt Lot 3 DP 5737 and Lot 1 DP 18109

Purpose/Drawing Title:
Waterfall Park Hotel
Roading and Carpark Design
Overview and Earthworks Volumes

Surveyed by: PPG	Original Size:	Scale:	
Designed by: SJP	A3	1:3000	
Drawn by: SJP			
Checked by: SJW			
Approved by:		DO NOT SCALE	
Job Ref: Q6388 - 15	Sheet No: 1	Revision No: B	Date Created: 01/02/2018

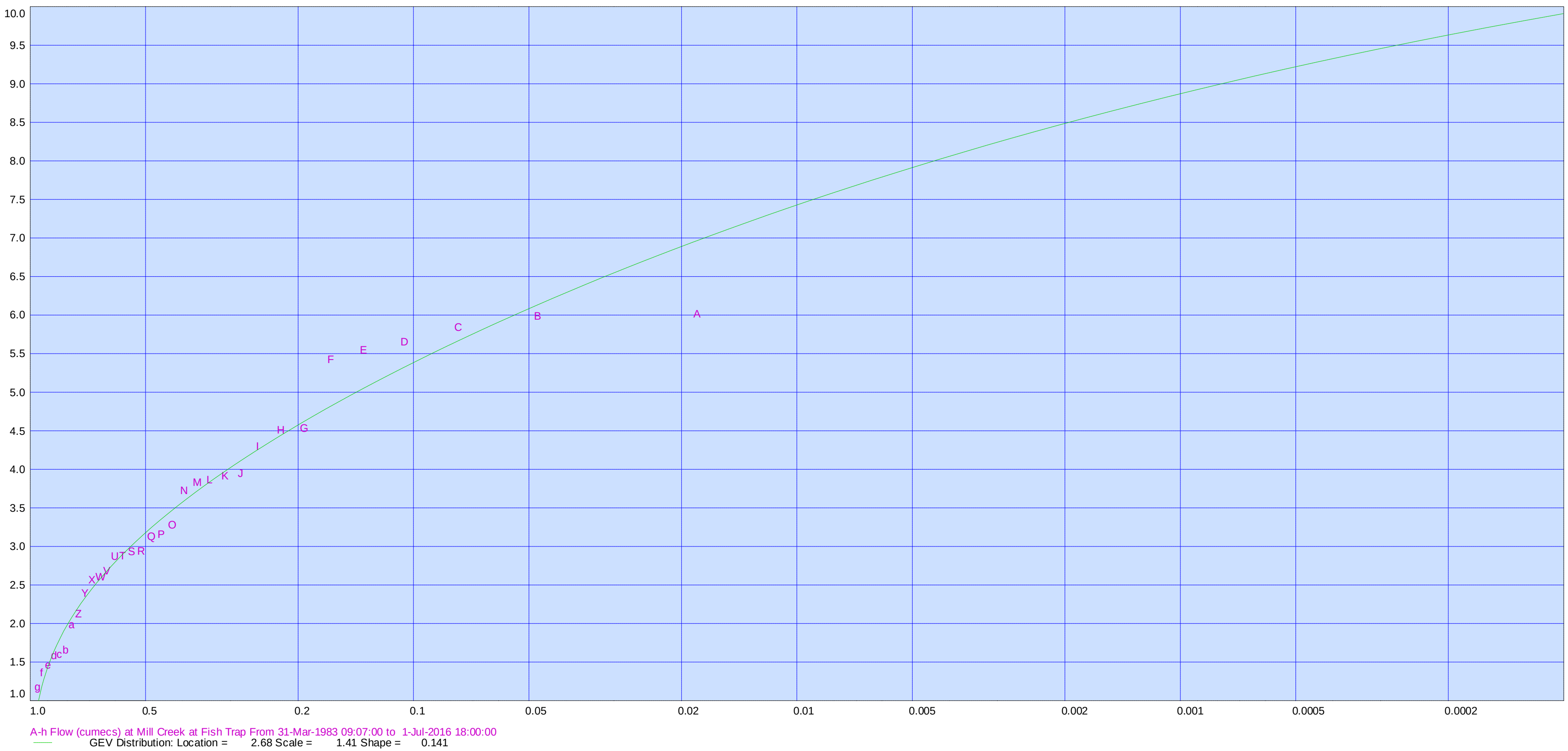
APPENDI 2

Mill Creek Flood Frequency Estimate

Reference:
ORC - Flow Recording Station Record - Mill Creek at Fish Trap - GEV Estimate

Data provided by the Otago Regional Council

Reference: Pete Stevenson (Team Leader Environmental Monitoring, ORC) email dated 8 July 2016.



Hilltop Hydro Version 6.47 7-Jul-2016

~~~ FRED ~~~

Source is U:\Global Data.hts

Flow (cumecs) at Mill Creek at Fish Trap

From 31-Mar-1983 09:07:00 to 1-Jul-2016 18:00:00

GEV exponent 0.14144 has magnitude greater than 0.08675 and so GEV fits better than Gumbel

Moments L1= 3.313 L2= 0.868 T3= 0.082 T4= 0.069

Location = 2.68 Scale = 1.41 Shape = 0.141 100yr/2.33yr = 2.150

12 mth partition starts	Recorded value at	maximum measured		-- GEV	1.96 std. dev.	Distribution -- ann. prob. 1/y	return period y
				8.871		0.001	1000
				8.486		0.002	500
				7.914		0.005	200
				7.428		0.010	100
				6.890		0.020	50
				6.084		0.050	20
01-Jan-1999	17-Nov-1999 16:30:00	6.030	A	6.030		0.053	18.9
01-Jan-1983	26-Jun-1983 22:35:00	6.002	B	6.002		0.055	18.3
01-Jan-1991	14-Aug-1991 21:00:00	5.857	C	5.857		0.063	15.8
01-Jan-1996	07-Oct-1996 13:15:00	5.666	D	5.666		0.077	13.1
01-Jan-1994	14-Aug-1994 05:30:00	5.561	E	5.561		0.085	11.8
01-Jan-1995	01-Sep-1995 22:45:00	5.435	F	5.435		0.095	10.5
				5.385		0.100	10
				4.575		0.200	5
01-Jan-1988	12-Sep-1988 17:20:03	4.544	G	4.544		0.205	4.9
01-Jan-2002	18-Sep-2002 23:30:00	4.525	H	4.525		0.208	4.8
01-Jan-1984	17-Oct-1984 00:25:10	4.311	I	4.311		0.245	4.1
01-Jan-1993	19-Jul-1993 14:30:00	3.963	J	3.963		0.313	3.2
01-Jan-1992	26-Jul-1992 05:00:00	3.925	K	3.925		0.321	3.1
01-Jan-2013	02-Jun-2013 18:15:00	3.874	L	3.874		0.332	3.0
01-Jan-2000	02-Oct-2000 13:45:00	3.845	M	3.845		0.338	3.0
01-Jan-1997	10-Aug-1997 15:00:00	3.741	N	3.741		0.361	2.8
				3.455		0.430	2.33
01-Jan-1998	06-Aug-1998 12:30:00	3.292	O	3.292		0.471	2.1
01-Jan-2007	11-Aug-2007 20:30:00	3.168	P	3.168		0.503	2.0
01-Jan-2004	01-Sep-2004 11:30:00	3.142	Q	3.142		0.510	2.0
01-Jan-1987	13-Jun-1987 16:26:24	2.959	R	2.959		0.558	1.8
01-Jan-2006	30-Nov-2006 01:15:00	2.951	S	2.951		0.560	1.8
01-Jan-2014	11-Aug-2014 11:20:00	2.888	T	2.888		0.576	1.7
01-Jan-2015	18-Jun-2015 11:35:00	2.887	U	2.887		0.577	1.7
~~~

01-Jan-2009	23-Jul-2009	08:45:00	2.702	V	2.702	0.625	1.6
01-Jan-2012	15-Jul-2012	10:55:00	2.621	W	2.621	0.647	1.5
01-Jan-2001	02-Aug-2001	13:00:00	2.580	X	2.580	0.657	1.5
01-Jan-2003	16-Jul-2003	13:00:00	2.409	Y	2.409	0.701	1.4
01-Jan-1986	28-Jun-1986	14:19:02	2.140	Z	2.140	0.765	1.3
01-Jan-1985	19-Aug-1985	05:05:26	1.998	a	1.998	0.797	1.3
01-Jan-2008	27-Sep-2008	14:00:00	1.672	b	1.672	0.861	1.2
01-Jan-1989	08-Jul-1989	02:45:00	1.613	c	1.613	0.871	1.1
01-Jan-1990	18-Jun-1990	08:45:00	1.599	d	1.599	0.874	1.1
01-Jan-2010	29-Aug-2010	05:30:00	1.482	e	1.482	0.893	1.1
01-Jan-2005	08-Jan-2005	18:45:00	1.383	f	1.383	0.907	1.1
01-Jan-2011	26-Oct-2011	01:32:32	1.194	g	1.194	0.931	1.1
01-Jan-2016	23-May-2016	10:00:00	0.677	h	0.677	0.974	1.0
		Mean =	3.313				

APPENDI 3

ORC Correspondence and Hydrology Peer Review Comment

Fluent SOLUTIONS
Infrastructure | Experience

Suite 2, First Floor
23-27 Beach Street
PO Box 1204
Queenstown 9348

Phone (03) 974 4586
Email office@fluentsolutions.co.nz
Website www.fluentsolutions.co.nz

Ref: GL-18-02-08 GMD Q000391

13 February 2018

Ralph Henderson
Senior Consents Officer
Otago Regional Council
70 Stafford Street
DUNEDIN 9054

Attention: Ralph Henderson

Dear Ralph

Waterfall Park Development RM17.302 – Mill Creek Flood Flow Estimate

This letter summarises the additional work undertaken to qualify the 100 year Average Recurrence Interval (ARI) design flow for Mill Creek within the Waterfall Park development area.

The additional work since the application for RM17.302 was lodged in mid-October 2017 has included:

a. **Fluent Solutions Letter dated 22 November 2017**
In response to questions from Ralph Henderson in an email dated 20 October 2017 we responded with our letter dated 22 November 2017. The letter included:
    i. Our review of the Pearson and McKerchar Regional Flood Estimation methodology results including additional information as to why the method was not providing a credible result in this case, namely due to the damping effects of the flat wide valley floor upstream of Waterfall Park.
    ii. The results from a site visit to the Fish Trap gauging site at Mill Creek to confirm the topography of the stream channel at the site against the gauged levels to determine if the site could be relied upon to measure water levels for major events ï at least large enough to extrapolate the gauged flows out to the design ARI. We concluded that the site has sufficient gauged results and an operating range to make an acceptable extrapolation out to a 100 year ARI event flow.

iii. Review of photos from a flood event that occurred in 1996 where a very minor flow outflanked the site but the associated water level was not recorded by the site that measures the water level every 15minutes. All the flow returned to below bank level in the stream channel downstream of the site and hence we concluded the high water level was due to a transient condition, being a temporary partial blockage of the culvert at the gauging site and was not an indication of the flood flow in the stream.

iv. Conclusion that the 100 year ARI flood flow is of the order of 8 cubic metres per second (m^3/s) not $80m^3/s$ predicted by the RFE method based on the catchment area at the Fish Trap gauging site.

v. Justification of the addition of a 30% flow increase for climate change compared to the 15% increase in rainfall depths for a 2°C increase in temperature.

b. Hydrology Peer Review

Hank Stocker of Geosolve undertook a peer review and responded with a letter dated 11 January 2018.

At the suggestion of the peer reviewer, Fluent Solutions used a detailed survey of the site to create a hydraulic model of the reach of Mill Creek at the Fish Trap and derive the flow for the measured water level at the gauge. The result of this work was that the Otago Regional Council rating curve used to derive the flood recurrence interval flood estimates was considered to be conservative.

The peer review contained in the Geosolve letter of 11 January 2018 concludes as follows:

“We consider that the Fluent analysis is comprehensive and based on the most suitable available methodology short of a comprehensive catchment model study. In the Mill Creek case, alternative flood estimation methods based on collated regional data are likely to yield over-estimated peak flows due to the atypical storage characteristics of this particular catchment.

We consider that the Fluent results are robust and credible, and a suitable basis for consenting and design of the proposed development.”

c. Post Peer Review Meeting

Following receipt of the peer review from Geosolve, there was a meeting with members of the ORC Hazards team. The following people were present at this meeting: Magdy Mohssen (ORC), Bikesh Shrestha (ORC), Hank Stocker (GeoSolve), and Gary Dent (Fluent). Tom Heller sat in the meeting as an interested observer and contributed to the discussion with observations about site conditions. The discussion lasted 2-hours and relevant matters were thoroughly traversed.

No further information was brought to light at this meeting to give any evidence-based reason to suggest that the 7.4m^3/s 100year ARI design flow including allowance for climate change proposed by Fluent Solutions should be increased.

Following the post peer review meeting we used the mean annual flood value from the gauge record (3.3m^3/s) and applied the Regional Flood Estimation scaling parameters (q_{100} multiplier and Q_T/Q of 2.75) which resulted in a 100yr ARI event estimate of 9.1m^3/s.

Comparing the GEV analysis with the RFE technique, the RFE technique is based on the catchment shapes and the hydraulic performance of the river systems upstream of the gauging stations used to derive the RFE method extrapolation parameters, that is, the mean annual flow and q100 the parameter used to extrapolate the annual flow out to a 100year ARI event.

The Mill Creek catchment above the Fish Trap site is a unique catchment due to the large hydraulic storage available in the dry lake valley topography between Millbrook and Arthurs Point relative to the size of the catchment. The catchments in the region used to derive RFE parameters used to arrive at the estimate of 9.1m3/s do not have the large storage relative to catchment area condition that Mill Creek has and therefore there is no justification for using the RFE approach with the recorded flow data from the Fish Trap site.

Summary

Given the length of the gauged flow record (34-years) and that the Fish Trap site recorder has had the capability to record all flood flows at the site over that time, the Generalised Extreme Value (GEV) analysis used to estimate the 100year ARI event magnitude is considered to be the appropriate flood estimation method.

The 100yr ARI event GEV estimate was extrapolated from the gauge record estimate of 7.4m3/s to 10.4 m3/s to account for climate change and estimation contingency. Please also note, that the 7.4m3/s figure was not reduced for the inflow from the Speargrass Road and Mooney's Flat catchment that flows into Mill Creek between Waterfall Park and the Fish Trap recorder site. The approach to deriving the 100year ARI design flow is therefore appropriately conservative.

Given the considerable additional analysis and checking that has been undertaken and the peer review provided by GeoSolve, we confirm that we still have no factual reason to recommend a revised estimate for the 10.4m^3/s 100year ARI design flow and that the analysis undertaken is robust and conservative.

Yours faithfully
FLUENT INFRASTRUCTURE SOLUTIONS LTD
Per:

Gary Dent
Environmental Engineer / Director

APPENDI 4

Mill Creek Proposed Widening

Mill Creek Widening
Waterfall Park Developments Limited

1.0 Introduction

This report provides an overview of the proposed alteration to the Mill Creek bed due to the proposed widening in the Waterfall Park development.

The proposed widening has been included in the ground model used as the base for the hydrological and hydraulic model developed to support the flood effects assessment for the Mill Creek floodway in Waterfall Park. The following sections in this report expands on the proposed widening concept for Mill Creek and also assesses the flood effects of the widening in support of the resource consent application.

2.0 Proposed Widening Concept

Figure 2.1 on the next page shows a plan of the proposed widening sections in Mill Creek.

There are two purposes for the proposed widening; it increases the aesthetic value of the stream and also helps with conveyance through the Mill Creek waterway including the main channel and berm areas outside the main channel.

2.1 Proposed Creek Widening for Aest etic alue

Increasing the aesthetic value of the Mill Creek waterway would be achieved by widening the waterway and the construction of rock weirs to locally raise the dry weather flow water level. The rock weir structures are shown in the long section in Section 5 below.

In the aesthetic widening the Creek bed would be excavated to create pools during normal flows, the substrate is to be reinstated with river gravels and small cobbles of suitable size to be a spawning medium (to be advised by ecologist).

2.2 Proposed Creek Widening for Culvert Transition

The proposed Hotel area and Ayrburn Domain development includes two box culverts to facilitate vehicle road crossings. The proposed widening would encourage a smooth transition from the creek bed to the box culverts. This would also help to reduce velocities and scour around the banks.

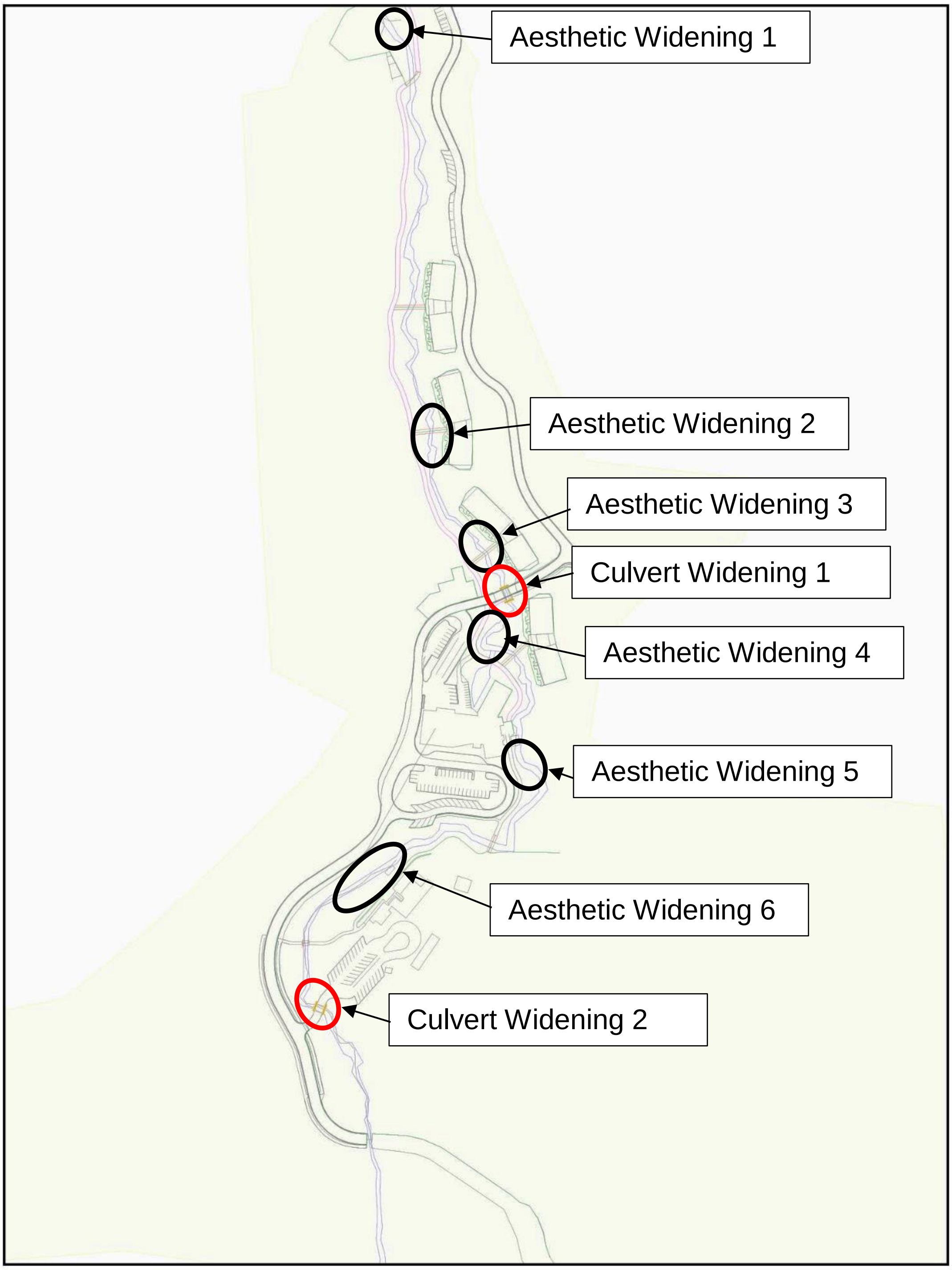


Figure 2.1 Proposed Mill Creek Widening Areas

3.0 Typical Cross Sections of Proposed Widening

3.1 Aest etic Widening Cross Sections

The figures below show typical cross sections for the proposed widening areas (detailed cross sections to be produced at the time of detailed design). Each widening section consists of a low weir which is intended to cause a backing up of the Creek flow into the widened section, creating a pool during normal dry weather flow periods.

In the cross sections below, the orange line shows the proposed widening section whereas the green line shows the current (existing) Mill Creek configuration.

<u>Aesthetic Widening 1</u>
Existing width: Approx 5m
Proposed width: Approx 9m
Height of downstream weir: 0.5m

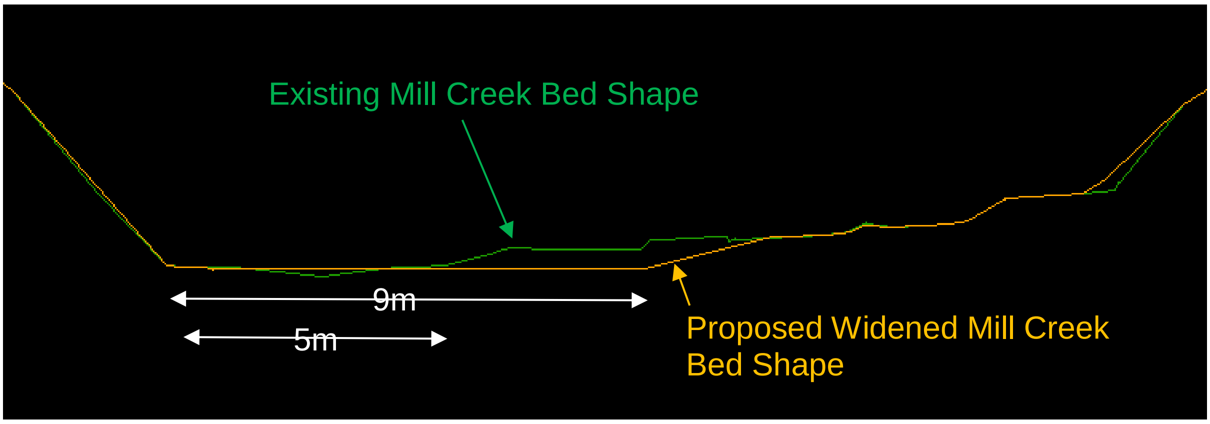


Figure 3.1 Aest etic Widening Cross Section 1

<u>Aesthetic Widening 2</u>
Existing width: Approx 2.2m
Proposed width: Approx 4m
Height of downstream weir: 0.4m

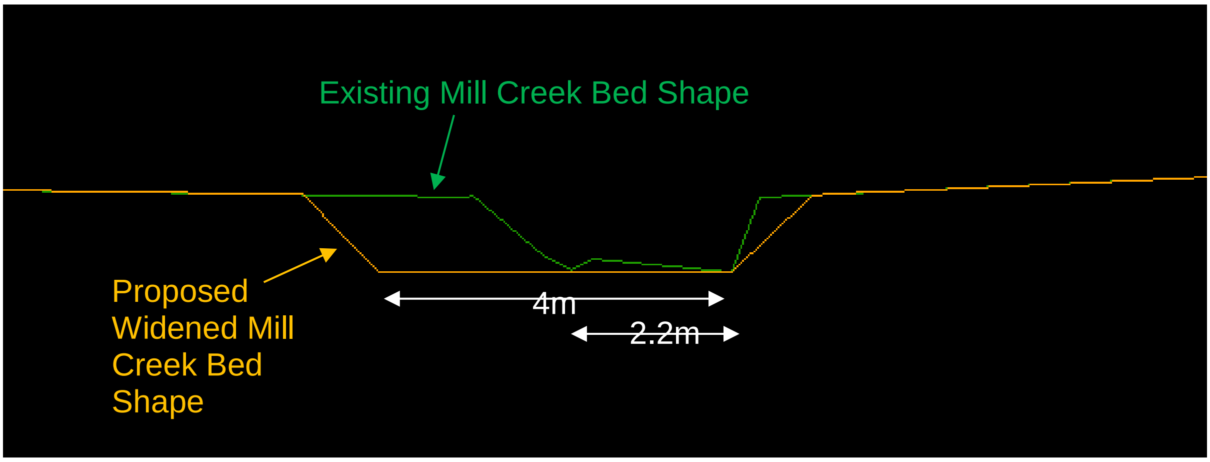


Figure 3.2 Aest etic Widening Cross Section 2

<u>Aesthetic Widening 3</u>
Existing width: Approx 3.6m
Proposed width: Approx 6.5m
Height of downstream weir: 0.4m

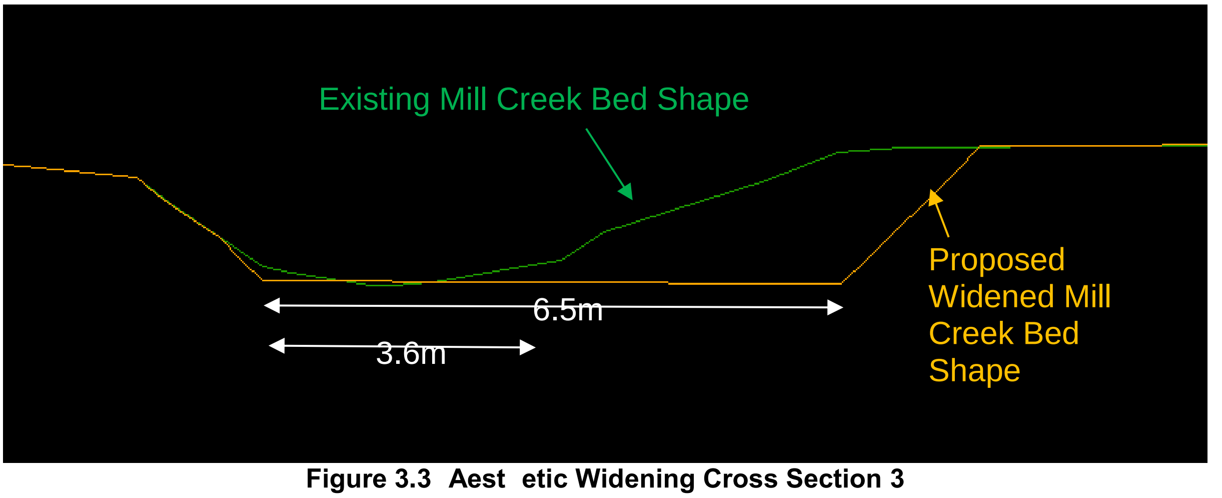


Figure 3.3 Aest etic Widening Cross Section 3

<u>Aesthetic Widening 4</u>
Existing width: Approx 5.2m
Proposed width: Approx 9.5m
Height of downstream weir: 0.4m

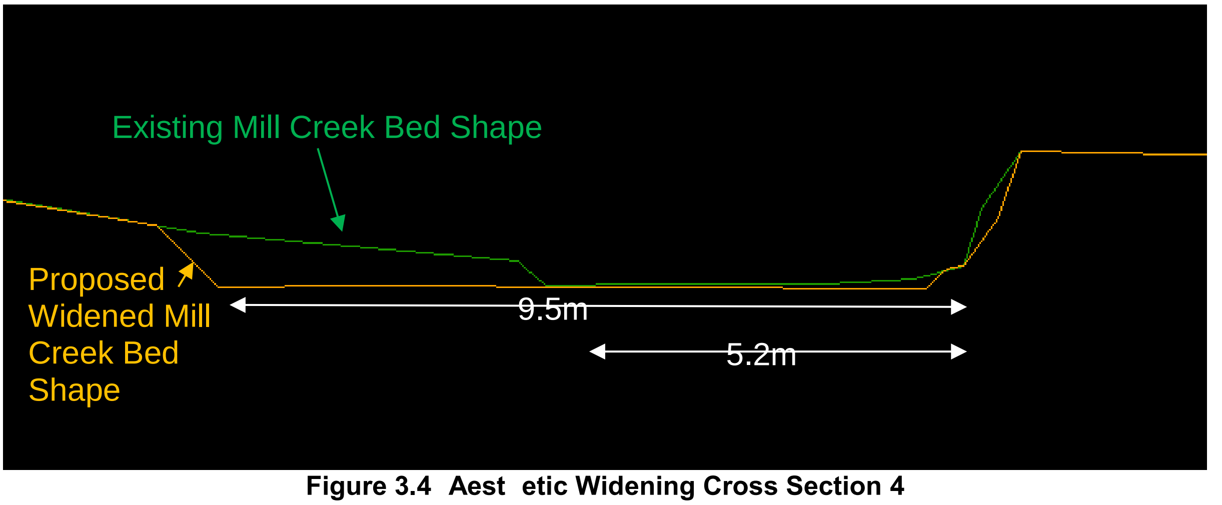


Figure 3.4 Aest etic Widening Cross Section 4

Aesthetic Widening 5
Existing width: Approx 4.1m
Proposed width: Approx 9.8m
Height of downstream weir: 0.4m

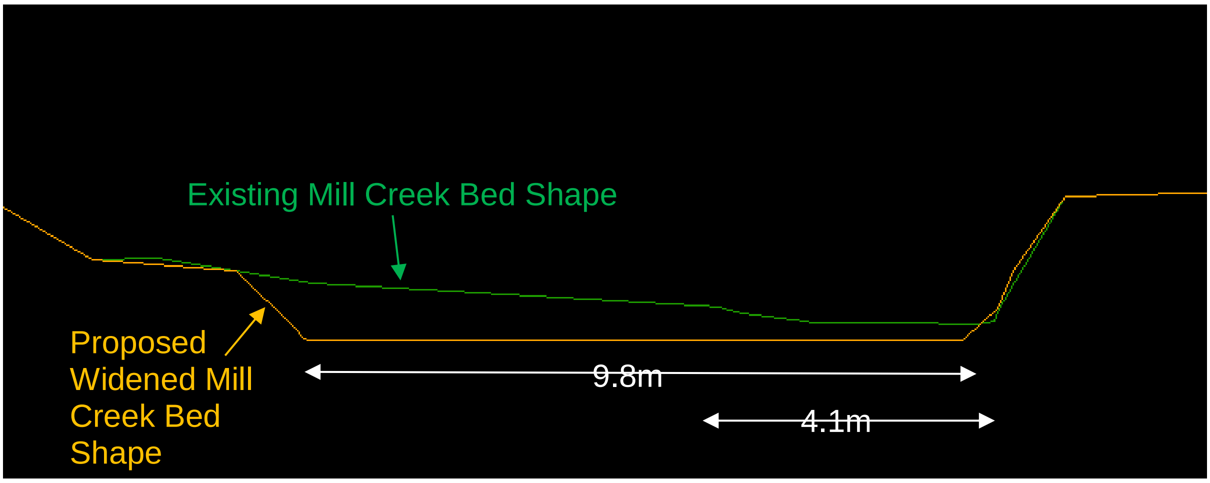


Figure 3.5 Aest etic Widening Cross Section 5

Aesthetic Widening 6
Existing width: Approx 3.9m
Proposed width: Approx 8.4m
Height of downstream weir: 0.3m

Figure 3. Aest etic Widening Cross Section

3.2 Culvert Widening Cross Sections

The widening sections upstream and downstream of the culvert crossings are intended to smooth the transition from the Creek bed into the culvert openings. In these cases, no weir will provide a "pool" effect. Instead, flood waters will back up on the upstream side of the culvert in high flow events, providing a head on the culvert to pass the design peak flood flow.

It is intended that a low flow channel be included in Culvert Widening 1 and Culvert Widening 2 in order to promote a low flow pathway through the floodway (approx. 0.25m deep to invert). The low flow channel is to be included at detailed design. The proposed box culvert inverts for Road Culverts 1 and 2 have been staggered to allow for a low flow channel. Figures 3.7 and 3.8 below show an example cross section on the upstream side for Culvert Widening 1 and 2, respectively. The green line represents the existing stream cross section. The widened cross section would be shaped to suit the proposed culvert alignment.

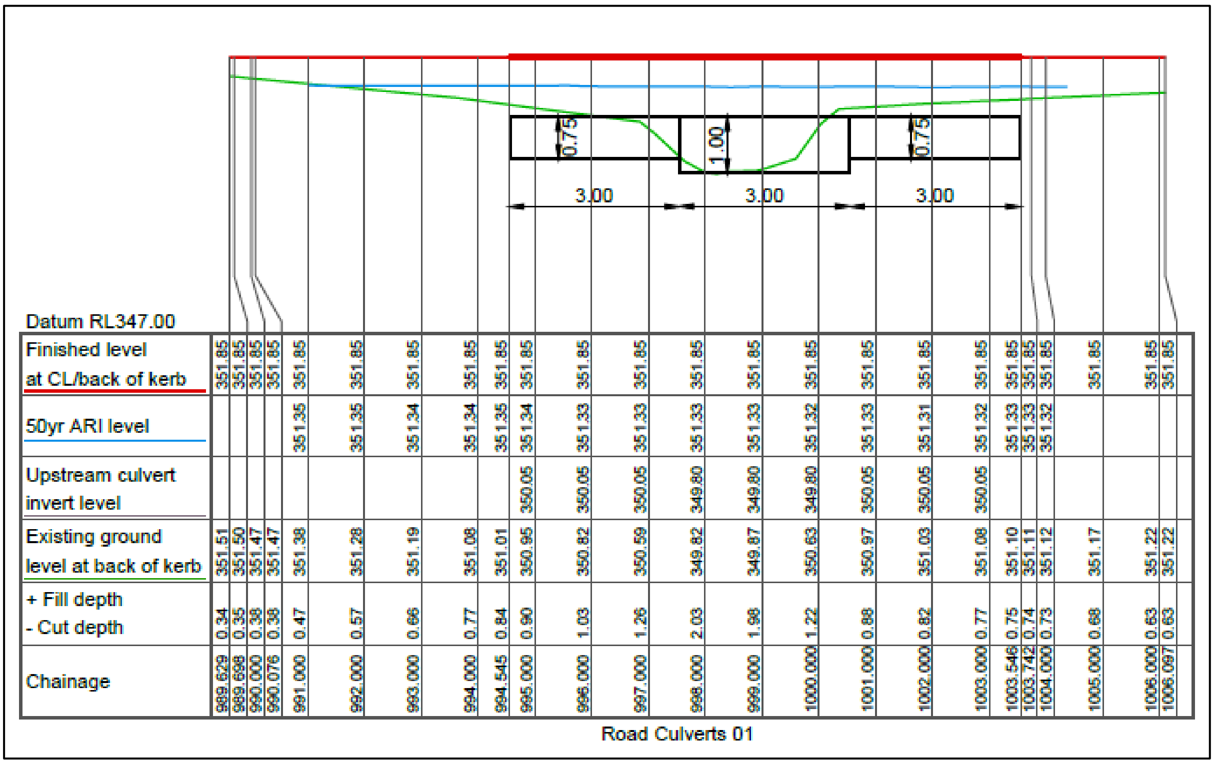
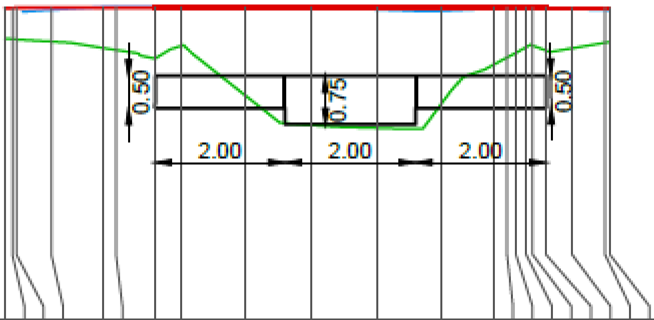


Figure 3.7 Culvert Widening 1 – Cross Section



Datum RL341.00

Finished level at nib kerb	345.79	345.79	345.79	345.80	345.80	345.80	345.80	345.80	345.80	345.80	345.80	345.80	345.80	345.80	345.80	345.80	345.80	345.80	345.80	345.80	345.80
20yr ARI level				345.76	345.80	345.80	345.80	345.80	345.80	345.80	345.77	345.75	345.78	345.78	345.78	345.79	345.79	345.78	345.78	345.76	345.76
Upstream culvert invert level								344.25	344.25	344.00	344.00	344.25	344.25	344.25	344.25	344.25	344.25	344.25			
Existing ground level at nib kerb	345.32	345.31	345.31	345.28	345.18	345.15	345.02	345.21	344.44	343.99	343.95	344.32	344.92	345.03	345.11	345.19	345.22	345.14	345.17	345.26	345.27
+ Fill depth - Cut depth	0.47	0.48	0.48	0.52	0.62	0.65	0.78	0.59	1.36	1.80	1.85	1.48	0.88	0.77	0.69	0.61	0.58	0.66	0.62	0.54	0.53
Chainage	20.287	20.403	20.465	21.000	21.798	22.000	22.600	23.000	24.000	25.000	26.000	27.000	27.798	28.000	28.138	28.298	28.397	28.600	29.000	29.506	29.582

Road Culverts 02

Figure 3. Culvert Widening 2 – Cross Section

4.0 Widening Sections Maintenance

As described above, the proposed work to the floodway alters the flow regime from a natural one to a constructed flow regime. Regular maintenance would be required to keep the shape of the constructed channel. If regular maintenance is not carried out, the channel would reclaim its natural flow regime. This would mean that sediment could build up to the top of the downstream weir, that is the invert level upstream of the weir could increase the upstream bed level by up to 0.5m. The weirs have been allowed for in the flood modelling. Stoplogs would be included in the weir design that would enable the upstream main channel to develop through the widened areas and allow the invert to be lowered to the invert level downstream of the weirs.

A Mill Creek Maintenance Plan is put forward by the applicant as a condition of consent and to be submitted for approval prior to waterway works.

5.0 Mill Creek Long Section

In addition to analysing the cross sections through the proposed widening areas, the long section through Mill Creek was also considered for the pre- and post-development scenarios for the Hotel and Ayrburn Domain areas (long section from downstream of the waterfall feature to the bridge on the main access road). The long section is shown attached to this document as part of the PPG Waterfall Hotel Mill Creek Longsection (Q6388-26-8).

Note that the pre- and post-development long sections look very similar. This means that if maintenance to the proposed widening sections was not performed on a regular basis, the natural flow regime would return and the long section through the Creek centre line would be similar to its current state and would have relatively minor effects on the Mill Creek flood flow regime.

.0 Mill Creek elocities

The velocities of the Mill Creek floodway have also been considered. Figures 6.1 and 6.2 below show the velocities for the 100yr ARI event. Velocities below 2.5 m/s are shown in greens and blues. Velocities from 2.5-3.0 m/s are shown in orange and velocities higher than 3.0 m/s are shown in red.

Where the 100yr ARI flow velocity exceeds 2.5m/s erosion protection would be specified at potential scour points as part of the final design. Velocities greater than 2.5m/s are restricted to limited local areas.

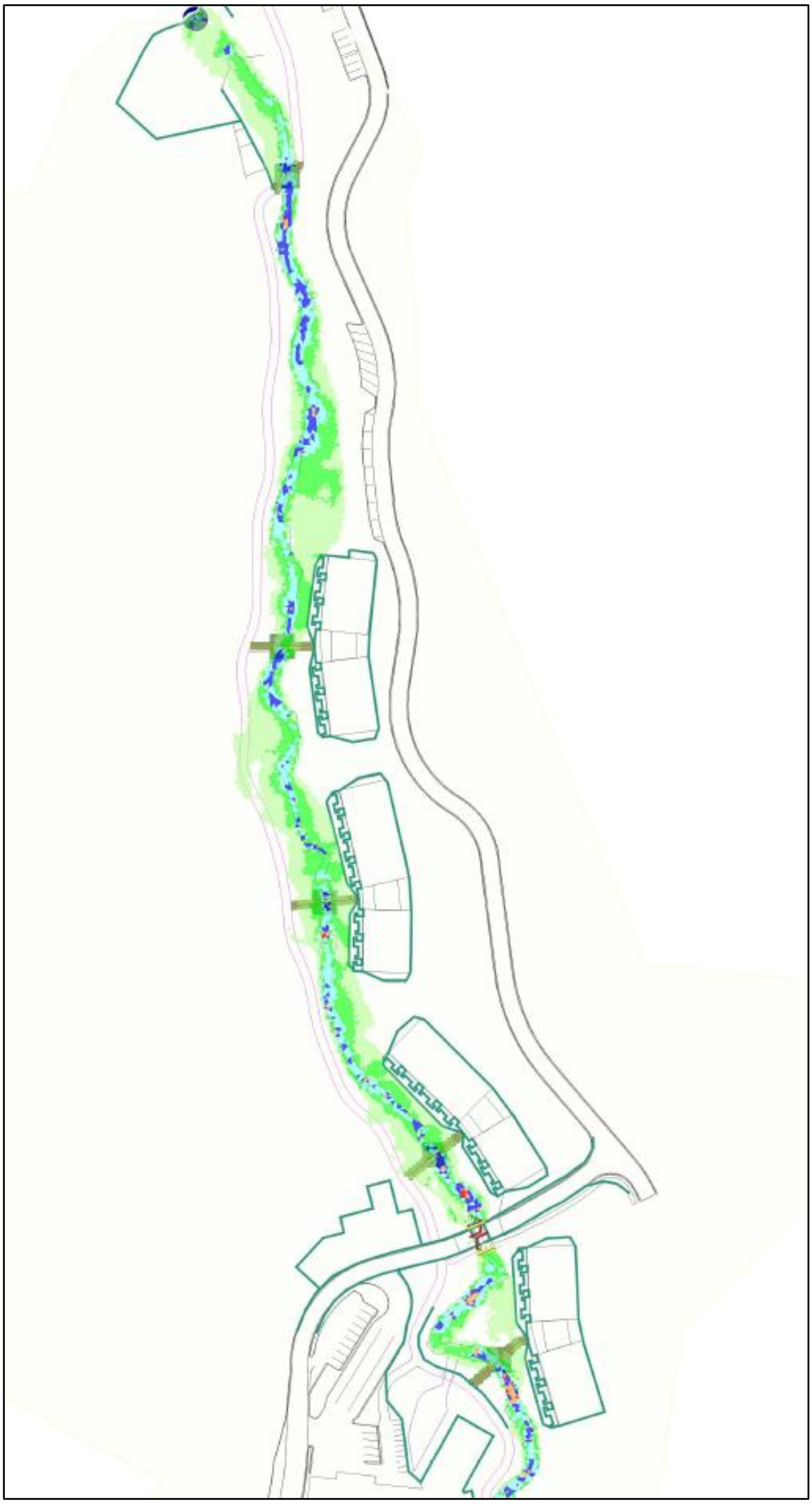


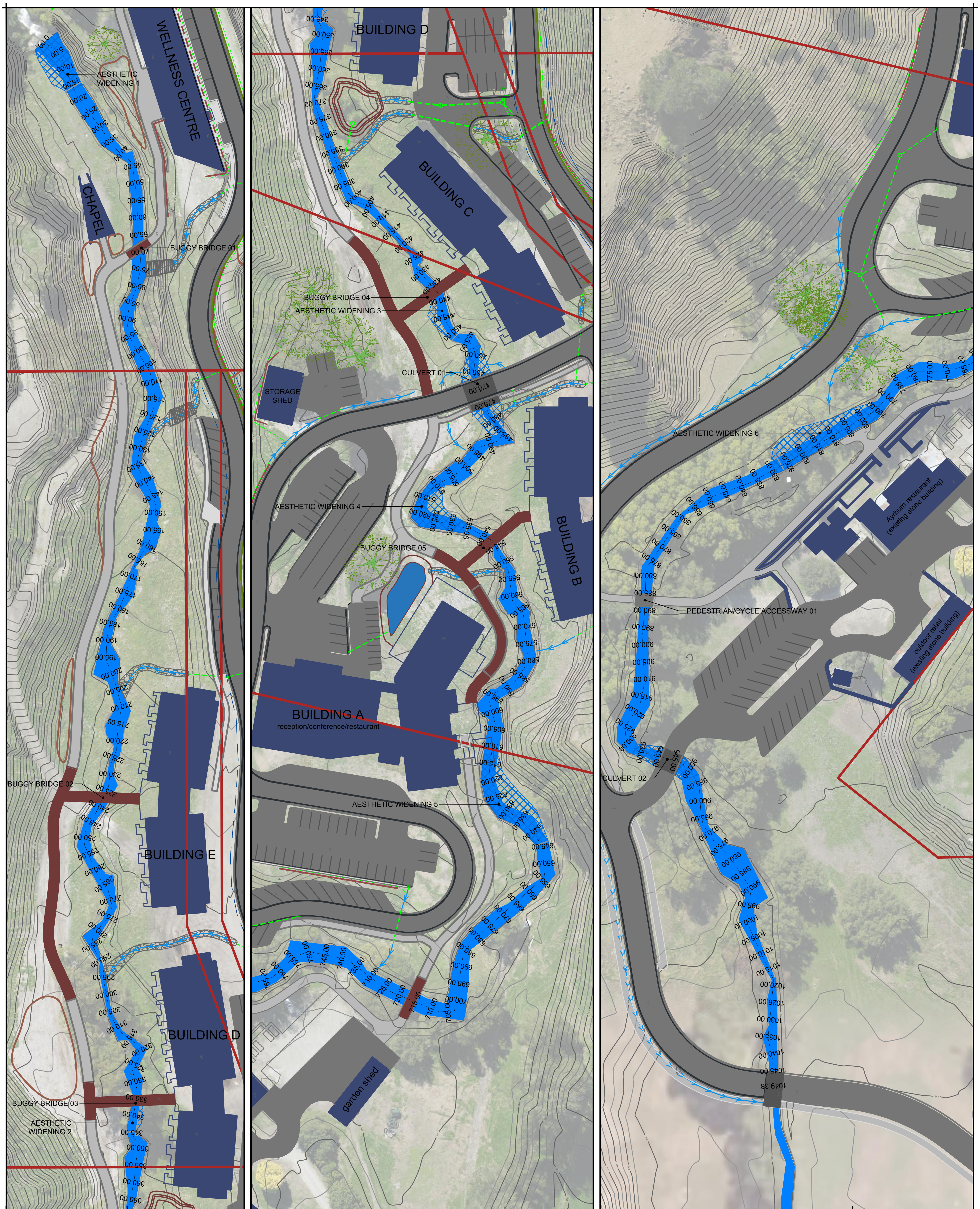
Figure .1 Mill Creek elocities 100yr ARI – Upstream Waterfall Park

Figure .2 Mill Creek elocities 100yr ARI – Downstream Waterfall Park

7.0 Conclusions

Based on the assumptions above, it is considered that the effects of the proposed widening of Mill Creek would not have adverse effects on the Mill Creek waterway or downstream environment. In the event that the proposed maintenance is not regularly kept up to date, then the floodway would return to a state similar to the existing flow regime and channel shape.

Enclosed:
Waterfall Park Hotel Mill Creek Longsection
Paterson Pitts Group Drawings: Q6388-26-8, Sheets 1-3



QUEENSTOWN:
Terrace Junction,
1092 Frankton Road.
PO Box 2645,
Queenstown 9349.
T 03 441 4715
E queenstown@ppgroup.co.nz

NOTES:
1. This plan includes information from site surveys undertaken by Paterson Pitts Group (Sep 2017) and CFM (2016/2017)
2. Coordinates and bearings are in terms of Geodetic Datum 2000, Mount Nicholas Circuit grid projection
3. Levels are in terms of MSL (Dunedin Vertical Datum 1958)
4. The origin of levels is C1PV (IT IX DP 12678) RL: 348.66m
5. Existing contours shown - 0.5m contour interval

N

0m 20m 40m 60m

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Client/Location:
Waterfall Park Developments Ltd
Sec 69 Blk VII Shotover SD, Lots 1 & 2
DP 23038, Lot 1 DP 27503, Lots 1 & 2
DP 507367, Pt Lot 3 DP 5737 and Lot 1 DP 18109

Purpose/Drawing Title:
Waterfall Park Hotel
Mill Creek Overview

Surveyed by:	PPG	Original Size: A3	Scale: 1:1000 hz
Designed by:	SJP		
Drawn by:	SJP		
Checked by:			
Approved by:			DO NOT SCALE
Job Ref: Q6388 - 26 - 8		Sheet No: 1	Revision No: A / Date Created: 04/04/2018

PLOT DATE: 13 April, 2018 - 4:45 PM BY: Stephen Popenhagen

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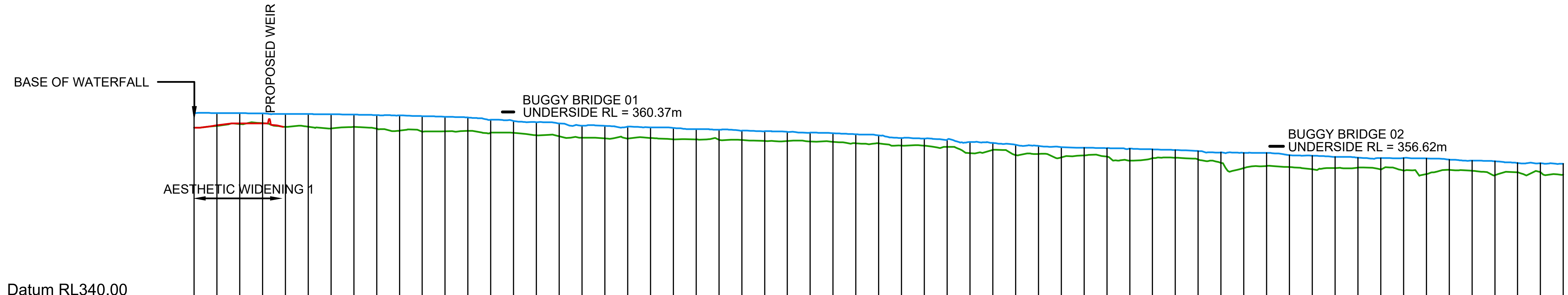
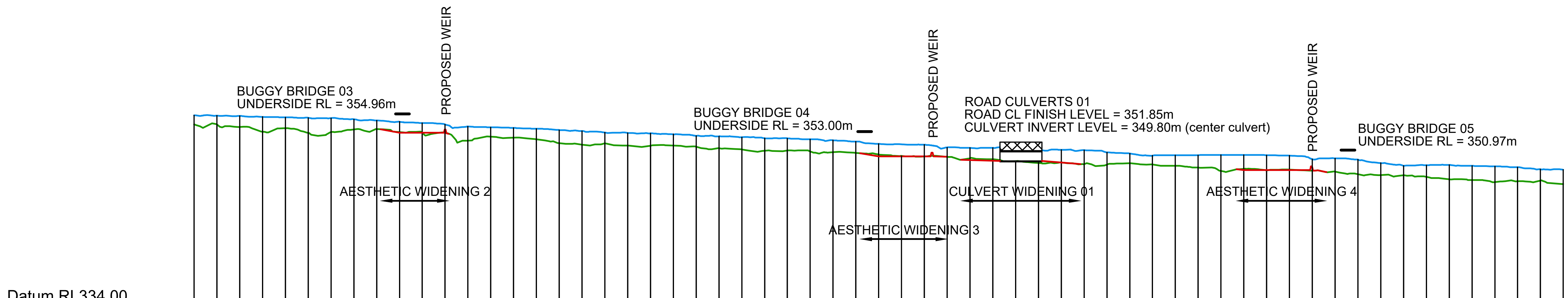


Datum RL340.00

Chainage	Proposed Bed Level	50yr ARI Event	Existing Bed Level	Height Difference
0.00	358.66	360.30	358.66	0.00
5.00	358.92	360.27	358.87	0.05
10.00	359.14	360.25	359.06	0.08
15.00	359.14	360.22	359.16	-0.02
20.00		360.18	358.76	
25.00		360.15	358.76	
30.00		360.13	358.59	
35.00		360.09	358.75	
40.00		360.04	358.55	
45.00		360.00	358.34	
50.00		359.93	358.24	
55.00		359.86	358.28	
60.00		359.77	358.31	
65.00		359.55	358.14	
70.00		359.41	358.10	
75.00		359.27	357.84	
80.00		359.13	357.72	
85.00		358.88	357.57	
90.00		358.87	357.48	
95.00		358.78	357.47	
100.00		358.69	357.55	
105.00		358.64	357.39	
110.00		358.51	357.37	
115.00		358.46	357.34	
120.00		358.33	357.31	
125.00		358.27	357.21	
130.00		358.20	357.23	
135.00		358.12	357.15	
140.00		358.06	357.13	
145.00		357.95	356.96	
150.00		357.83	356.96	
155.00		357.55	356.70	
160.00		357.48	356.68	
165.00		357.36	356.57	
170.00		357.10	355.88	
175.00		357.00	356.22	
180.00		356.79	355.69	
185.00		356.67	355.80	
190.00		356.55	355.43	
195.00		356.48	355.64	
200.00		356.42	355.51	
205.00		356.37	355.06	
210.00		356.30	355.33	
215.00		356.22	355.39	
220.00		356.10	355.18	
225.00		355.98	354.82	
230.00		355.92	354.25	
235.00		355.90	354.49	
240.00		355.67	354.36	
245.00		355.59	354.11	
250.00		355.48	354.27	
255.00		355.39	354.30	
260.00		355.34	354.11	
265.00		355.35	354.00	
270.00		355.31	353.60	
275.00		355.17	354.06	
280.00		355.07	353.96	
285.00		354.99	353.48	
290.00		354.81	353.79	
295.00		354.77	353.80	
300.00		354.73	353.52	



Datum RL334.00

Chainage	Proposed Bed Level	50yr ARI Event	Existing Bed Level	Height Difference
290.00		354.81	353.79	
295.00		354.77	353.80	
300.00		354.73	353.52	
305.00		354.63	352.99	
310.00		354.58	353.40	
315.00		354.52	352.87	
320.00		354.49	352.97	
325.00		354.36	353.25	
330.00		354.24	353.29	
335.00	352.88	354.10	352.96	-0.08
340.00	352.88	353.95	352.86	0.02
345.00		353.80	352.91	
350.00		353.57	352.03	
355.00		353.48	352.45	
360.00		353.42	352.34	
365.00		353.32	352.16	
370.00		353.18	351.75	
375.00		353.08	351.58	
380.00		352.91	351.74	
385.00		352.87	351.47	
390.00		352.82	351.46	
395.00		352.72	351.47	
400.00		352.54	351.36	
405.00		352.50	351.20	
410.00		352.40	351.05	
415.00		352.28	350.91	
420.00		352.27	350.94	
425.00		352.16	350.84	
430.00		352.07	350.76	
435.00		351.91	350.68	
440.00	350.28	351.67	350.49	-0.21
445.00	350.28	351.62	350.34	-0.06
450.00	350.28	351.57	350.29	-0.01
455.00	350.25	351.27	350.25	0.00
460.00	349.91	351.23	350.08	-0.17
465.00	349.84	351.22	349.98	-0.14
470.00			349.78	
475.00			349.56	
480.00	349.63	351.02	349.64	-0.01
485.00		350.97	349.44	
490.00		350.72	349.39	
495.00		350.62	349.54	
500.00		350.38	349.40	
505.00		350.43	349.26	
510.00		350.43	349.07	
515.00		350.44	348.70	
520.00	348.79	350.46	348.91	-0.12
525.00	348.79	350.43	348.76	0.03
530.00	348.79	350.37	348.84	-0.05
535.00		349.98	348.73	
540.00		350.08	348.62	
545.00		349.94	348.34	
550.00		349.56	348.23	
555.00		349.26	348.21	
560.00		349.32	348.04	
565.00		349.36	347.78	
570.00		349.25	347.69	
575.00		349.20	347.47	
580.00		349.09	347.58	
585.00		348.88	347.63	
590.00		348.84	347.27	

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QUEENSTOWN:
Terrace Junction,
1092 Frankton Road.
PO Box 2645,
Queenstown 9349.
T 03 441 4715
E queenstown@ppgroup.co.nz

Client/Location:
Waterfall Park Developments Ltd
Sec 69 Blk VII Shotover SD, Lots 1 & 2
DP 23038, Lot 1 DP 27503, Lots 1 & 2
DP 507367, Pt Lot 3 DP 5737 and Lot 1 DP 18109

Purpose/Drawing Title:
Waterfall Park Hotel
Mill Creek Longsection
CH0m - CH580m

Surveyed by:	PPG	Original Size: A3	Scale: 1:1000 hz 1:500 vt
Designed by:	SJP		
Drawn by:	SJP		
Checked by:			DO NOT SCALE
Approved by:			
Job Ref: Q6388 - 26 - 8	Sheet No: 2	Revision No: A	Date Created: 04/04/2018

PLOT DATE: 13 April, 2018 - 4:45 PM BY: Stephen Popenhagen

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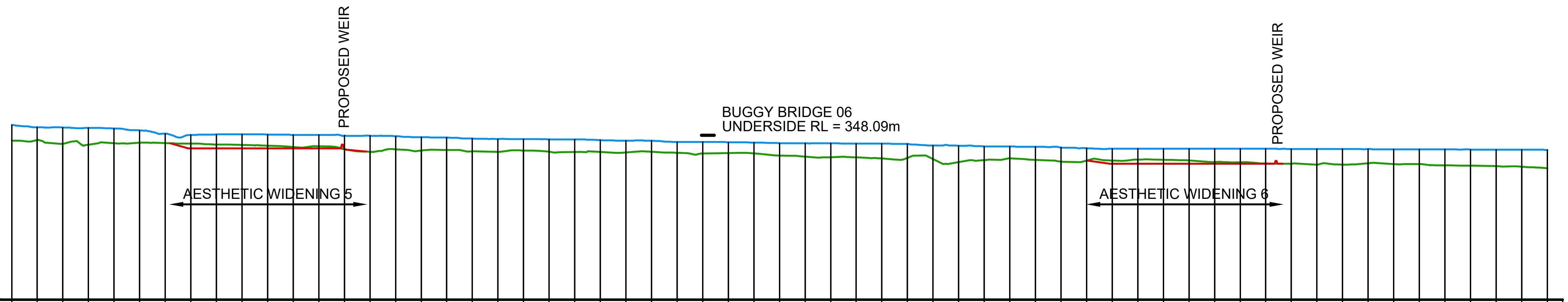
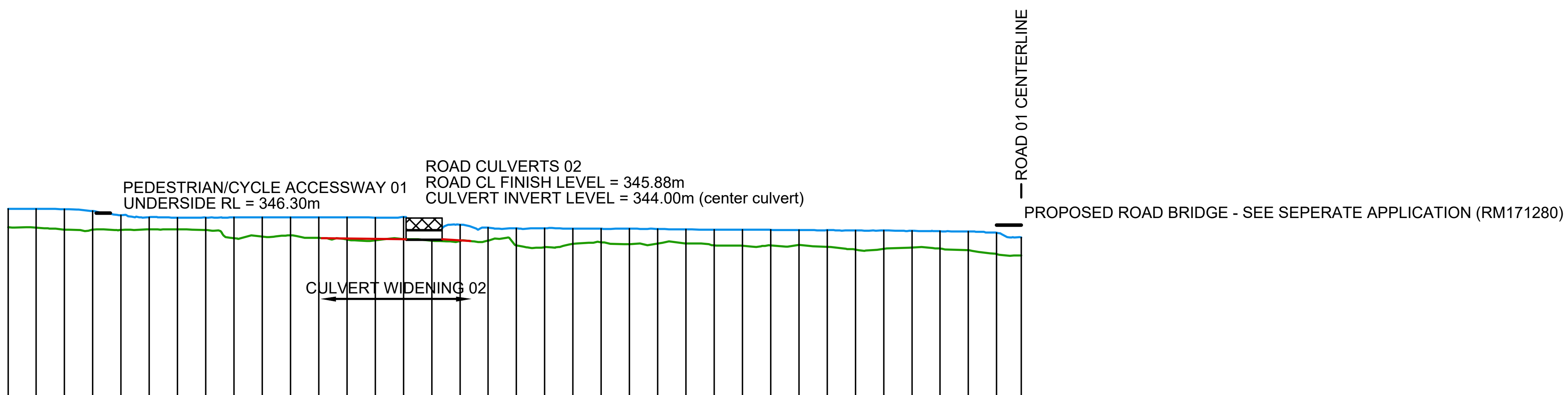


Datum RL332.00

Chainage	Proposed Bed Level	50yr ARI Event	Existing Bed Level	Height Difference
580.00		349.09	347.58	
585.00		348.88	347.63	
590.00		348.84	347.27	
595.00		348.82	347.17	
600.00		348.74	347.30	
605.00		348.57	347.37	
610.00		348.24	347.32	
615.00	346.81	348.12	347.27	-0.46
620.00	346.81	348.17	347.19	-0.38
625.00	346.81	348.18	347.13	-0.32
630.00	346.81	348.17	347.08	-0.27
635.00	346.81	348.14	346.94	-0.13
640.00	346.81	348.11	347.03	-0.22
645.00		348.05	346.74	
650.00		348.04	346.47	
655.00		348.00	346.71	
660.00		347.91	346.59	
665.00		347.87	346.65	
670.00		347.77	346.52	
675.00		347.72	346.48	
680.00		347.71	346.59	
685.00		347.70	346.47	
690.00		347.68	346.46	
695.00		347.61	346.45	
700.00		347.57	346.40	
705.00		347.56	346.49	
710.00		347.44	346.38	
715.00		347.45	346.31	
720.00		347.41	346.35	
725.00		347.38	346.32	
730.00		347.32	346.10	
735.00		347.30	346.01	
740.00		347.30	345.95	
745.00		347.28	345.93	
750.00		347.27	345.83	
755.00		347.25	345.88	
760.00		347.08	345.77	
765.00		347.05	345.47	
770.00		347.01	345.67	
775.00		347.00	345.82	
780.00		346.97	345.68	
785.00		346.90	345.52	
790.00		346.83	345.61	
795.00	345.30	346.78	345.62	-0.32
800.00	345.30	346.77	345.71	-0.41
805.00	345.30	346.78	345.71	-0.41
810.00	345.30	346.77	345.63	-0.33
815.00	345.30	346.77	345.49	-0.19
820.00	345.30	346.76	345.45	-0.15
825.00	345.30	346.77	345.33	-0.03
830.00		346.75	345.32	
835.00		346.75	345.23	
840.00		346.74	345.23	
845.00		346.73	345.36	
850.00		346.72	345.26	
855.00		346.72	345.28	
860.00		346.71	345.14	
865.00		346.70	345.12	
870.00		346.69	345.06	
875.00		346.68	345.02	
880.00		346.66	344.86	



Datum RL330.00

Chainage	Proposed Bed Level	50yr ARI Event	Existing Bed Level	Height Difference
870.00		346.69	345.06	
875.00		346.68	345.02	
880.00		346.66	344.86	
885.00		346.50	344.86	
890.00		346.11	344.82	
895.00		345.94	344.88	
900.00		345.91	344.87	
905.00		345.92	344.81	
910.00		345.93	344.08	
915.00		345.94	344.24	
920.00		345.93	344.33	
925.00		345.93	344.13	
930.00	344.07	345.93	343.98	0.09
935.00	344.04	345.91	343.91	0.13
940.00	344.01	345.98	344.02	-0.01
945.00			343.87	
950.00	343.92	345.29	343.85	0.07
955.00		345.03	343.86	
960.00		344.96	343.44	
965.00		344.98	343.29	
970.00		344.94	343.61	
975.00		344.92	343.73	
980.00		344.93	343.57	
985.00		344.92	343.61	
990.00		344.87	343.62	
995.00		344.84	343.45	
1000.00		344.85	343.42	
1005.00		344.83	343.45	
1010.00		344.81	343.51	
1015.00		344.80	343.32	
1020.00		344.78	343.09	
1025.00		344.77	343.16	
1030.00		344.74	343.26	
1035.00		344.72	343.17	
1040.00		344.68	343.02	
1045.00			342.68	
1049.38			342.57	

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T 03 441 4715
E queenstown@ppgroup.co.nz

Client/Location:
Waterfall Park Developments Ltd
Sec 69 Blk VII Shotover SD, Lots 1 & 2
DP 23038, Lot 1 DP 27503, Lots 1 & 2
DP 507367, Pt Lot 3 DP 5737 and Lot 1 DP 18109

Purpose/Drawing Title:
Waterfall Park Hotel
Mill Creek Longsection
CH580m - CH1049.38m

Surveyed by:	PPG	Original Size: A3	Scale: 1:1000 hz 1:500 vt
Designed by:	SJP		
Drawn by:	SJP		
Checked by:			
Approved by:			DO NOT SCALE
Job Ref: Q6388 - 26 - 8	Sheet No: 3	Revision No: A	Date Created: 04/04/2018

PLOT DATE: 13 April, 2018 - 4:45 PM BY: Stephen Popenhagen

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APPENDI 5

Proposed Freeboard Allowances

Freeboard Allowances
Waterfall Park Developments Limited

1.0 Introduction

This report provides an overview of the proposed freeboard allowances in the Waterfall Park development. The following sections expand on the freeboard requirements as per the QLDC Land Development and Subdivision Code of Practice (2015) (COP) and how these are achieved in the proposed development.

2.0 Minimum uilding Freeboard Levels

The COP requires a minimum freeboard height above the maximum 100 yr ARI estimated water level to buildings (Cl 4.3.5.2). For this application, all buildings were assumed to require a minimum freeboard height of 0.5m above the 100yr ARI water level to "*the building platform level or underside of the floor oists or underside of the floor slab, whichever is applicable*."

2.1 uildings A E and C apel

The following table shows the freeboard allowances for Buildings A-E and the Chapel.

Table 2.1 uildings A E and C apel Freeboard Allowances

Building Name	Max 100yr ARI WL (m)	Freeboard Allowance Measured To:	Freeboard Allowance (m)	FFL (m)
Building A	350.43	Underside of floor slab (100mm thick)	0.50	351.03
Building B	351.02	Underside of floor slab (100mm thick)	0.66	351.78
Building C	352.83	Underside of floor slab (100mm thick)	0.68	353.61
Building D	354.78	Underside of floor slab (100mm thick)	0.60	355.48
Building E	356.55	Underside of floor slab (100mm thick)	0.74	357.39
Chapel	360.05	Underside of floor joist (190mm thick)	0.50	360.74

2.2 Ayrburn Domain uildings

Freeboard allowances for the Ayrburn Domain buildings are achieved by utilising a flood wall to provide adequate freeboard above the 100yr ARI maximum water level. Figure 2.1 on the following page shows the proposed flood wall/path heights around the Ayrburn area and the corresponding 100yr ARI maximum water levels.

Note that at the southwestern end of the development there is no flood wall. Here, the FFL is more than 0.66m above the 100yr maximum flood level (160mm allowance for floor joists+0.5m above 100yr max WL=0.66m freeboard allowance).

The Dairy, Cart Shed, and Garden Shed are existing structures. There is at minimum 0.5m freeboard allowance from the 100yr ARI WL to the FFL.

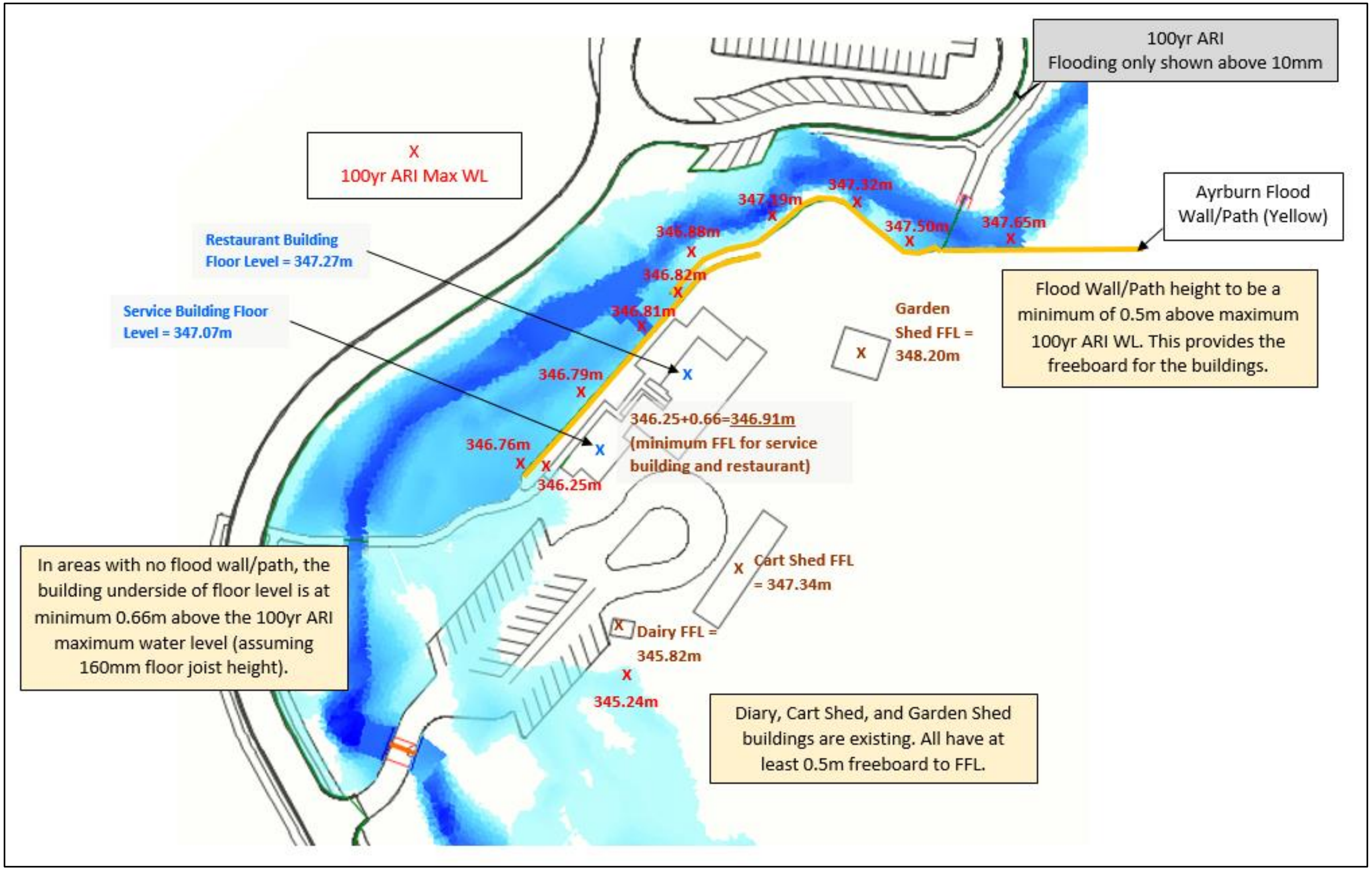


Figure 2.1 Ayrburn Domain uilding Freeboard Allowances

3.0 uggy ridges Freeboard Allowances

For bridges, the COP requires a minimum freeboard of 0.6m above the 50 yr ARI maximum water level to the underside of the bridge deck. Table 3.1 below shows a summary of the bridge heights and freeboard allowances. Note that Table 3.1 below also shows the 100 yr ARI water levels and corresponding freeboard allowances.

Table 3.1 uggy ridge Freeboard Allowances

Buggy Bridge Number	50yr ARI Max WL (m)	Freeboard from 50yr WL to underside of deck (m)	Underside of deck level (m)	100yr ARI Max WL (m)	Freeboard from 100yr WL to underside of deck (m)
1	359.77	0.6	360.37	359.82	0.55
2	355.95	0.6	356.55	356.02	0.53
3	354.22	0.6	354.82	354.27	0.55
4	352.11	0.6	352.71	352.15	0.56
5	350.25	0.6	350.85	350.31	0.54
6	347.49	0.6	348.09	347.53	0.56
Average		0.60			0.55

Figures 3.1-3.6 below show a cross sectional view of each buggy bridge crossing and the approximate maximum 50 yr ARI water level (from PPG Waterfall Park Hotel Roading and Carpark Design Bridge Cross Sections Drawings Q6388-15, Sheets 21-22).

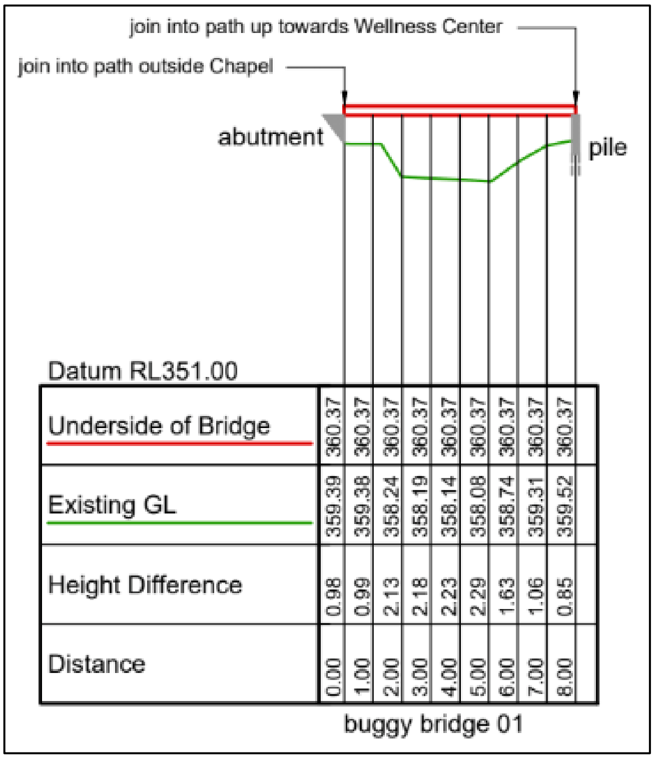
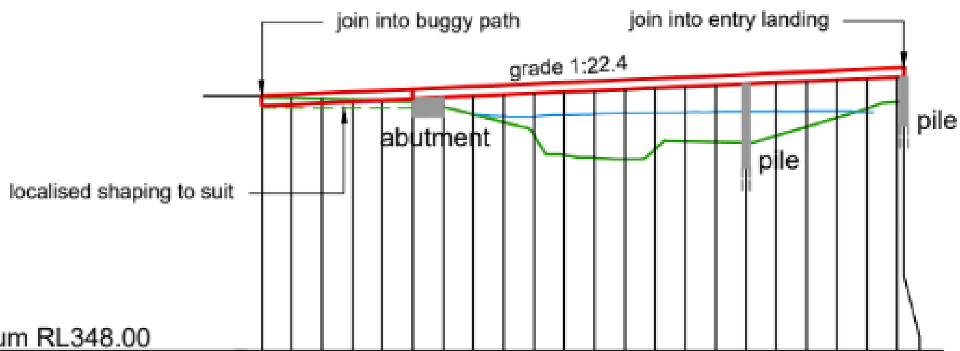


Figure 3.1 uggy ridge 01 Cross Section

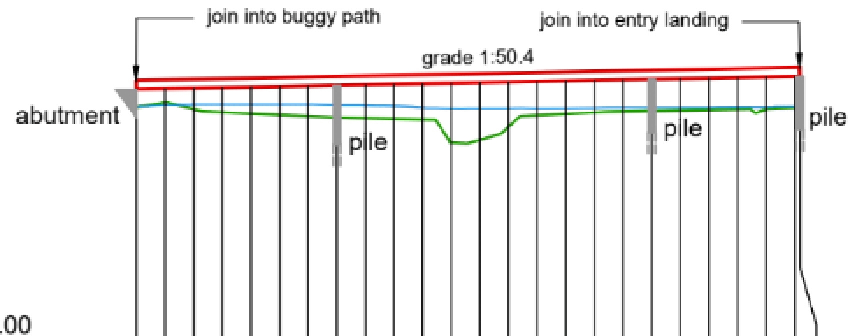


Datum RL348.00

Underside of Bridge	356.14	356.19	356.23	356.28	356.32	356.37	356.41	356.46	356.50	356.54	356.59	356.63	356.68	356.72	356.77	356.81	356.86	356.90	356.95	356.99	357.03	357.08	357.09
50yr ARI Flood Level									355.79	355.79	355.84	355.86	355.88	355.90	355.91	355.93	355.95	355.96	355.96	355.96	355.92		
Existing GL	356.41	356.41	356.38	356.34	356.31	356.27	356.11	355.85	355.60	355.16	354.51	354.43	354.37	354.71	354.96	354.94	354.92	355.14	355.44	355.74	356.04	356.27	356.26
Height Difference	-0.27	-0.22	-0.14	-0.07	0.01	0.09	0.30	0.60	0.90	1.38	2.08	2.21	2.31	2.01	1.81	1.87	1.94	1.76	1.51	1.25	1.00	0.81	0.83
Distance	0.00	1.00	2.00	3.00	4.00	5.00	6.00	7.00	8.00	9.00	10.00	11.00	12.00	13.00	14.00	15.00	16.00	17.00	18.00	19.00	20.00	21.00	21.23

buggy bridge 02

Figure 3.2 uggy ridge 02 Cross Section

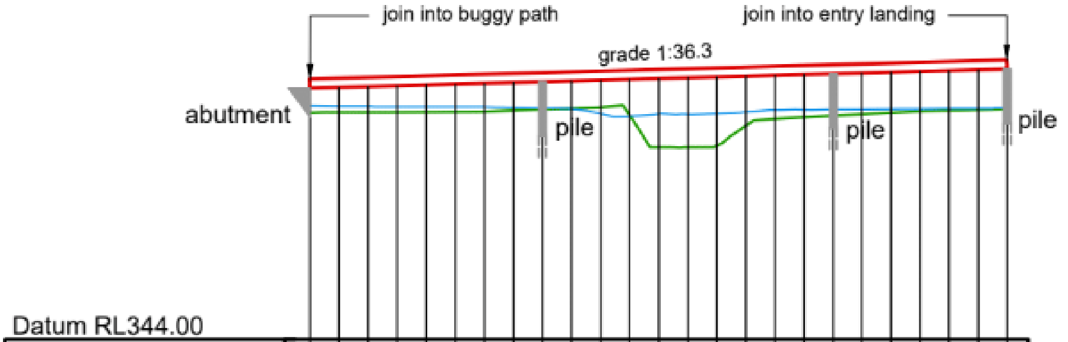


Datum RL346.00

Underside of Bridge	354.72	354.74	354.76	354.78	354.80	354.82	354.84	354.86	354.88	354.90	354.92	354.94	354.96	354.98	355.00	355.02	355.04	355.06	355.08	355.10	355.12	355.14	355.16	355.18	355.18
50yr ARI Flood Level	354.12	354.16	354.19	354.20	354.20	354.20	354.19	354.17	354.16	354.13	354.08	354.05	354.05	354.06	354.06	354.06	354.07	354.08	354.08	354.08	354.09	354.10	354.10	354.11	354.11
Existing GL	354.10	354.26	354.03	353.92	353.88	353.83	353.79	353.74	353.72	353.70	353.68	352.87	352.96	353.43	353.82	353.87	353.92	353.96	353.98	353.99	354.01	354.03	354.03	354.07	354.08
Height Difference	0.62	0.48	0.73	0.86	0.92	0.99	1.05	1.12	1.16	1.20	1.24	2.07	2.00	1.55	1.18	1.15	1.11	1.10	1.10	1.10	1.11	1.11	1.13	1.10	1.10
Distance	0.00	1.00	2.00	3.00	4.00	5.00	6.00	7.00	8.00	9.00	10.00	11.00	12.00	13.00	14.00	15.00	16.00	17.00	18.00	19.00	20.00	21.00	22.00	23.00	23.17

buggy bridge 03

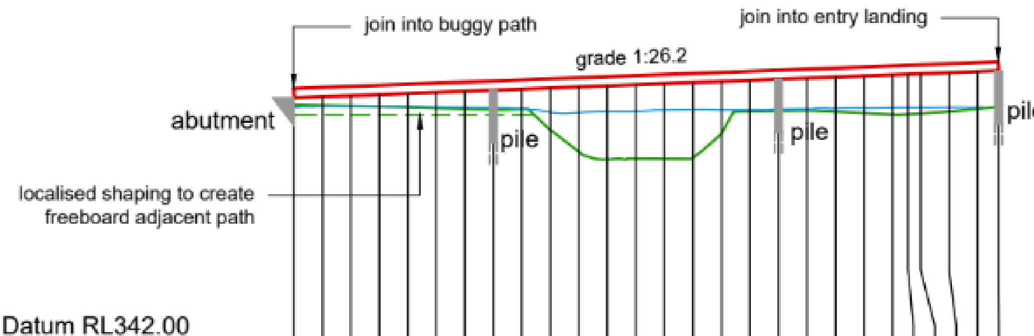
Figure 3.3 uggy ridge 03 Cross Section



Underside of Bridge	352.65	352.68	352.70	352.73	352.76	352.79	352.81	352.84	352.87	352.90	352.93	352.95	352.98	353.01	353.04	353.06	353.09	353.12	353.15	353.17	353.20	353.23	353.26	353.28	353.31
50yr ARI Flood Level	352.05	352.03	352.02	352.01	352.01	352.02	352.01	351.99	351.96	351.95	351.78	351.69	351.77	351.75	351.78	351.83	351.91	351.91	351.92	351.92	351.93	351.94	351.95	351.95	
Existing GL	351.81	351.82	351.82	351.83	351.83	351.84	351.84	351.89	351.93	351.96	351.99	351.72	350.62	350.62	350.68	351.36	351.59	351.65	351.70	351.75	351.81	351.86	351.89	351.91	351.94
Height Difference	0.84	0.86	0.88	0.90	0.93	0.95	0.97	0.95	0.94	0.94	0.94	1.23	2.36	2.39	2.36	1.70	1.50	1.47	1.45	1.42	1.39	1.37	1.37	1.37	1.37
Distance	0.00	1.00	2.00	3.00	4.00	5.00	6.00	7.00	8.00	9.00	10.00	11.00	12.00	13.00	14.00	15.00	16.00	17.00	18.00	19.00	20.00	21.00	22.00	23.00	23.99

buggy bridge 04

Figure 3.4 uggy ridge 04 Cross Section



Underside of Bridge	350.54	350.58	350.61	350.65	350.69	350.73	350.77	350.80	350.84	350.88	350.92	350.96	351.00	351.03	351.07	351.11	351.15	351.19	351.22	351.26	351.30	351.34	351.36	351.38	351.41	351.45	351.48
50yr ARI Flood Level	350.20	350.23	350.25	350.24	350.23	350.21	350.20	350.18	350.14	350.02	350.01	350.05	350.06	350.11	350.12	350.11	350.10	350.12	350.14	350.16	350.18	350.18	350.19	350.19	350.20	350.21	
Existing GL	350.28	350.26	350.24	350.23	350.21	350.18	350.15	350.12	350.13	349.41	348.63	348.36	348.39	348.38	348.42	349.26	350.05	350.07	350.10	350.05	350.00	349.94	349.96	349.98	350.04	350.15	350.21
Height Difference	0.26	0.31	0.37	0.42	0.48	0.55	0.61	0.68	0.71	1.47	2.29	2.60	2.61	2.65	2.66	1.85	1.10	1.11	1.13	1.21	1.30	1.40	1.40	1.39	1.37	1.31	1.27
Distance	0.00	1.00	2.00	3.00	4.00	5.00	6.00	7.00	8.00	9.00	10.00	11.00	12.00	13.00	14.00	15.00	16.00	17.00	18.00	19.00	20.00	21.00	21.56	22.00	23.00	24.00	24.73

buggy bridge 05

Figure 3.5 uggy ridge 05 Cross Section

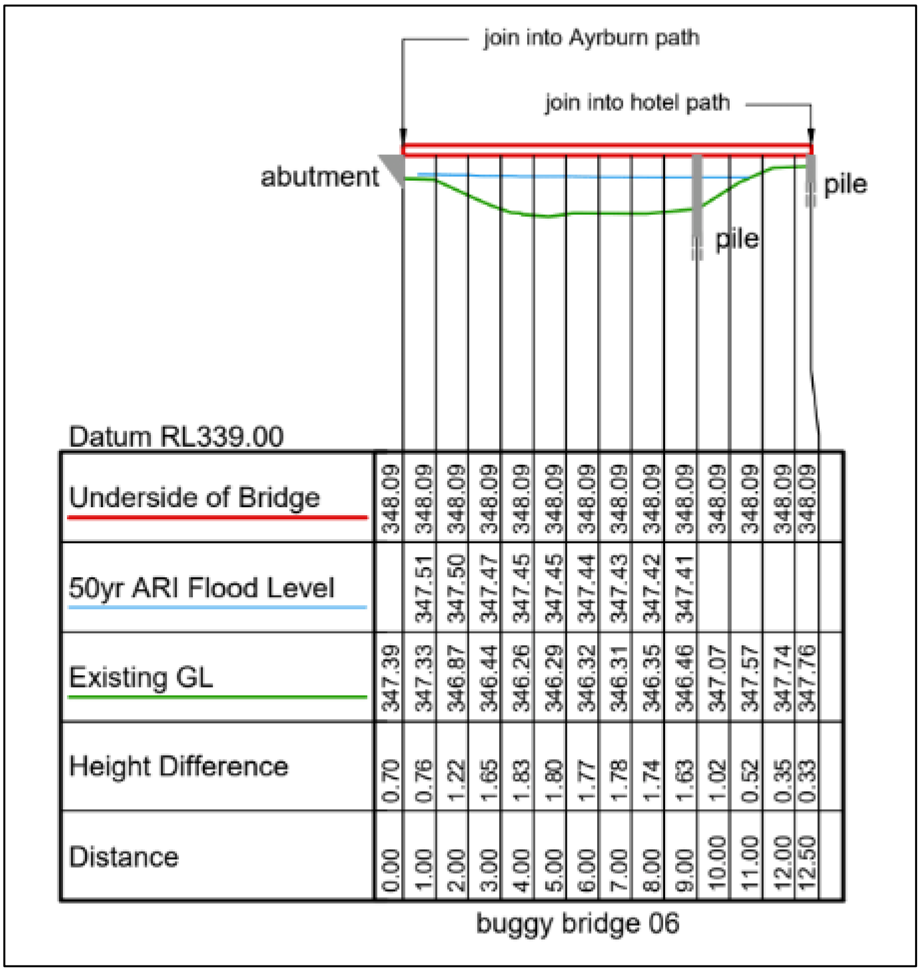


Figure 3. uggy ridge 0 Cross Section

4.0 Road Culvert 01 Freeboard Allowance

The COP provides a minimum of 0.5m freeboard above the maximum 50 yr ARI event water level to the road level for culverts.

Table 4.1 below shows the freeboard allowance at Road Culvert 01.

Table 4.1 Road Culvert 01 Freeboard Allowance

Culvert	50yr ARI Max WL (m)	Freeboard from 50yr WL to Road Level (m)	Road Level (m)	100yr ARI Max WL (m)	Freeboard from 100yr WL to Road Level (m)
Road Culvert 01	351.35	0.5	351.85	351.43	0.42

Otago Regional Council

Our reference: A1091352

Consent No. RM17.302.01

LAND USE CONSENT

Pursuant to Section 104B of the Resource Management Act 1991, the Otago Regional Council grants consent to:

Name: Waterfall Park Developments Limited

Address: Level 2 33 Shortland Street Auckland

To disturb and to divert Mill Creek for the purpose of constructing a bridge

For a term expiring 1 March 2023

Location of consent activity: Mill Creek, 583 metres north west of the intersection of Arrowtown - Lake Hayes Road and Speargrass Flat Road, Arrowtown

Legal description of consent location: Pt Lot 3 DP 5737

Map Reference: NZTM2000 E 1269672 N 5013172

Conditions

Specific

1. This consent shall be exercised in conjunction with Water Permit RM17.302.02.

2. The works shall be sized, constructed and located generally as described in the application for consent and the Earthworks Management Plan lodged with the Consent Authority on (13 October 2017), and as shown on the drawings 1-2 attached as Appendix 1 to this consent. If there are any inconsistencies between the application and this consent, the conditions of this consent shall prevail.

3. Works shall not be undertaken between 1 May and 7 January inclusive to avoid the disturbance of koaro and brown trout spawning habitat.

Performance Monitoring

4. The consent holder shall notify the Environmental Engineering and Natural Hazards Unit of the Consent Authority in writing at least five working days prior to the commencement of work authorised by this consent, and at the completion of work authorised by this consent.

5. Within three months of completion of the works the consent holder shall supply to the Consent Authority "as built" plans and photographs of:

Otago Regional Council

(a) the works outlined in Condition 1 of this consent, and
(b) the bridge over Mill Creek demonstrating compliance with the conditions of permitted activity rule 13.2.1.7.

General

6. All machinery and equipment that has been in watercourses shall be water blasted and treated with suitable chemicals or agents prior to being brought on site and following completion of the works, to reduce the potential for pest species being introduced to or taken from the watercourses, such as didymo. At no time during the exercise of this consent shall machinery be washed within the bed of a watercourse.

7. (a) Work shall be undertaken with the minimum time required in the wet bed of the watercourse and with the minimum necessary bed disturbance.
(b) Damage to riparian vegetation shall be minimised when exercising this consent.
(c) All reasonable steps shall be taken to minimise the release of sediment to water.
(d) At completion the works shall not result in any decrease of the upstream and downstream cross-sectional area of the streambed, as the streambed exists prior to commencement of the works authorised by this consent.
(e) At the completion of the works authorised by this consent, the consent holder shall ensure that all plant, equipment, chemicals, fencing, signage, debris, rubbish and any other material brought on site to give effect to this consent is removed from the site. The site shall be tidied to a degree at least equivalent to that prior to the works commencing.
(f) The consent holder shall ensure that existing fish passage is not impeded as a result of the placement of the structure.

8. Any rock/gravel to be used for the consented work, is clean and placed rather than dumped into position. Excess excavated material shall be re-used if suitable or disposed of appropriately.

9. The consent holder shall ensure that once completed the works authorised by this consent do not cause any flooding, erosion, scouring, land instability or property damage.

10. In the event that an unidentified archaeological site is located during works, the following applies;
(a) Work shall cease immediately at that place and within 20m around the site.
(b) The contractor must shut down all machinery, secure the area, and advise the Site Manager.
(c) The Site Manager shall secure the site and notify the Heritage New Zealand Regional Archaeologist and the Consent Authority. Further assessment by an archaeologist may be required.
(d) If the site is of Maori origin, the Site Manager shall notify the Heritage New Zealand Regional Archaeologist, the Consent Authority and the appropriate iwi groups or kaitiaki representative of the discovery and ensure site access to enable appropriate cultural procedures and tikanga to be undertaken, as long as all statutory requirements under legislation are met (Heritage New Zealand Pouhere Taonga Act 2014, Protected Objects Act 1975).
(e) If human remains (koiwi tangata) are uncovered the Site Manager shall advise the Heritage New Zealand Regional Archaeologist, NZ Police, the Consent Authority and the appropriate iwi groups or kaitiaki representative and the

above process under 4 shall apply. Remains are not to be moved until such time as iwi and Heritage New Zealand have responded.

(f) Works affecting the archaeological site and any human remains (koiwi tangata) shall not resume until Heritage New Zealand gives written approval for work to continue. Further assessment by an archaeologist may be required.

(g) Where iwi so request, any information recorded as the result of the find such as a description of location and content, is to be provided for their records.

Notes to Consent Holder

1. *The consent holder shall also comply with all notices and guidelines issued by Biosecurity New Zealand, in relations to avoiding spreading the pest organism Didymosphenia geminata known as "Didymo" (refer to www.biosecurity.govt.nz/didymo).*

2. *During the exercise of this consent, the consent holder should ensure that fuel storage tanks and machinery working and stored in the construction area shall be maintained at all times to prevent leakage of oil and other contaminants into the watercourse. No refuelling of machinery shall occur within the watercourse. In the event of contamination, the consent holder shall undertake remedial action and notify the Consent Authority within 5 working days.*

3. *The consent holder shall ensure that any contractors engaged to undertake work authorised by this consent abide by the conditions of this consent. A copy of this consent should be present on site at all times while the work is being undertaken.*

4. *Under the Heritage New Zealand Pouhere Taonga Act 2014 an archaeological site is defined as any place in New Zealand that was associated with human activity that occurred before 1900 and provides or may provide, through investigation by archaeological methods, evidence relating to the history of New Zealand (see Section 6). For pre-contact Maori sites this evidence may be in the form of Taonga (artefacts) such as toki (adzes) or flake tools as well as bones, shells, charcoal, stones etc. In later sites of European/Chinese origin, artefacts such as bottle glass, crockery etc. may be found, or evidence of old foundations, wells, drains or similar structures. Pre-1900 buildings are also considered archaeological sites. Burials/koiwi tangata may be found from any historic period. Archaeological sites are legally protected under Sections 42(1) & (2) of the Heritage New Zealand Pouhere Taonga Act 2014.*

5. *It is an offence under S87 of the Heritage New Zealand Pouhere Taonga Act 2014 to modify or destroy an archaeological site without an Authority from Heritage New Zealand irrespective of whether the works are permitted or a consent has been issued under the Resource Management Act or Building Act.*

Issued at Dunedin this 1st day of March 2018

Marian Weaver

Marian Weaver
Resource Manager Procedures & Protocols

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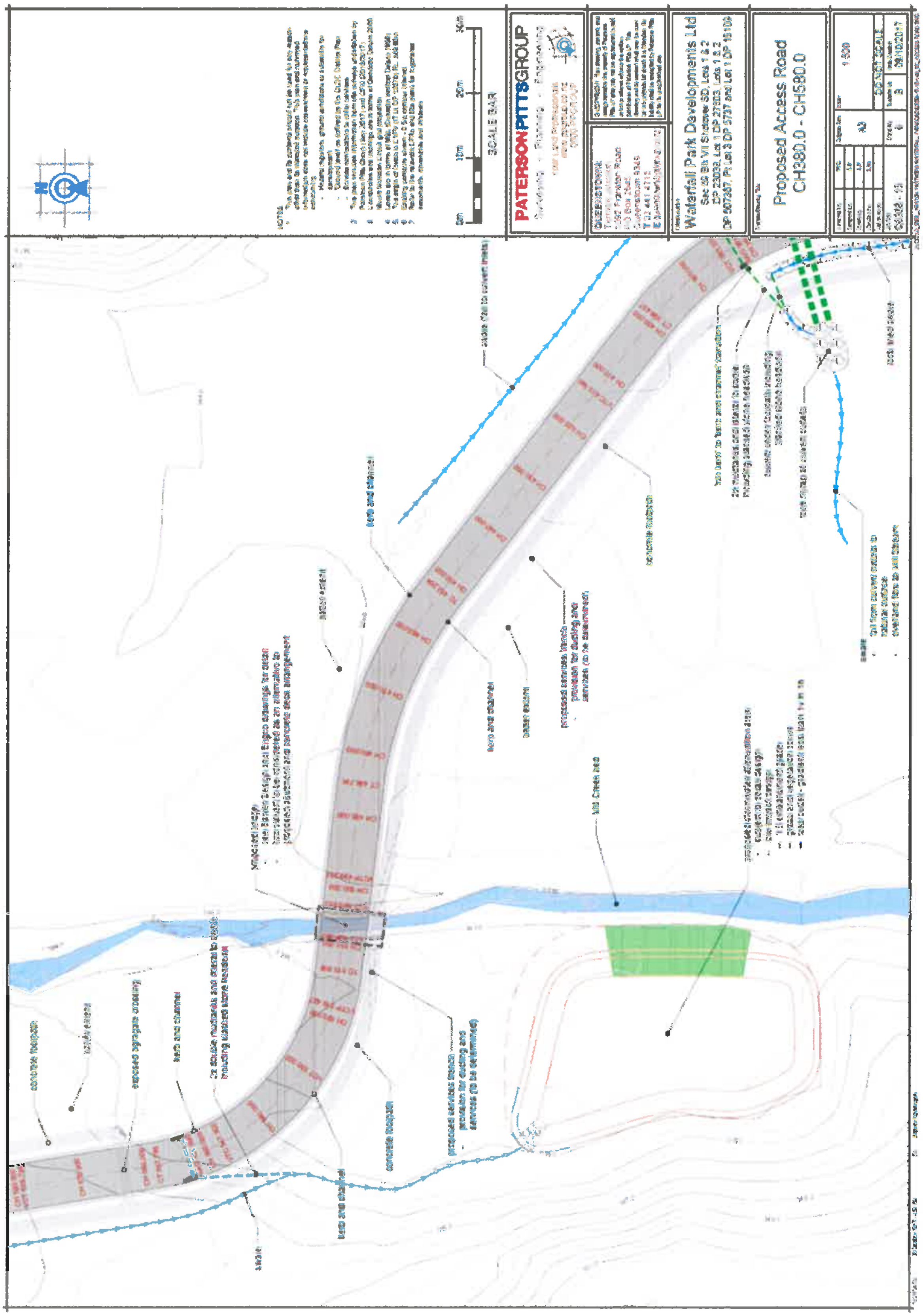
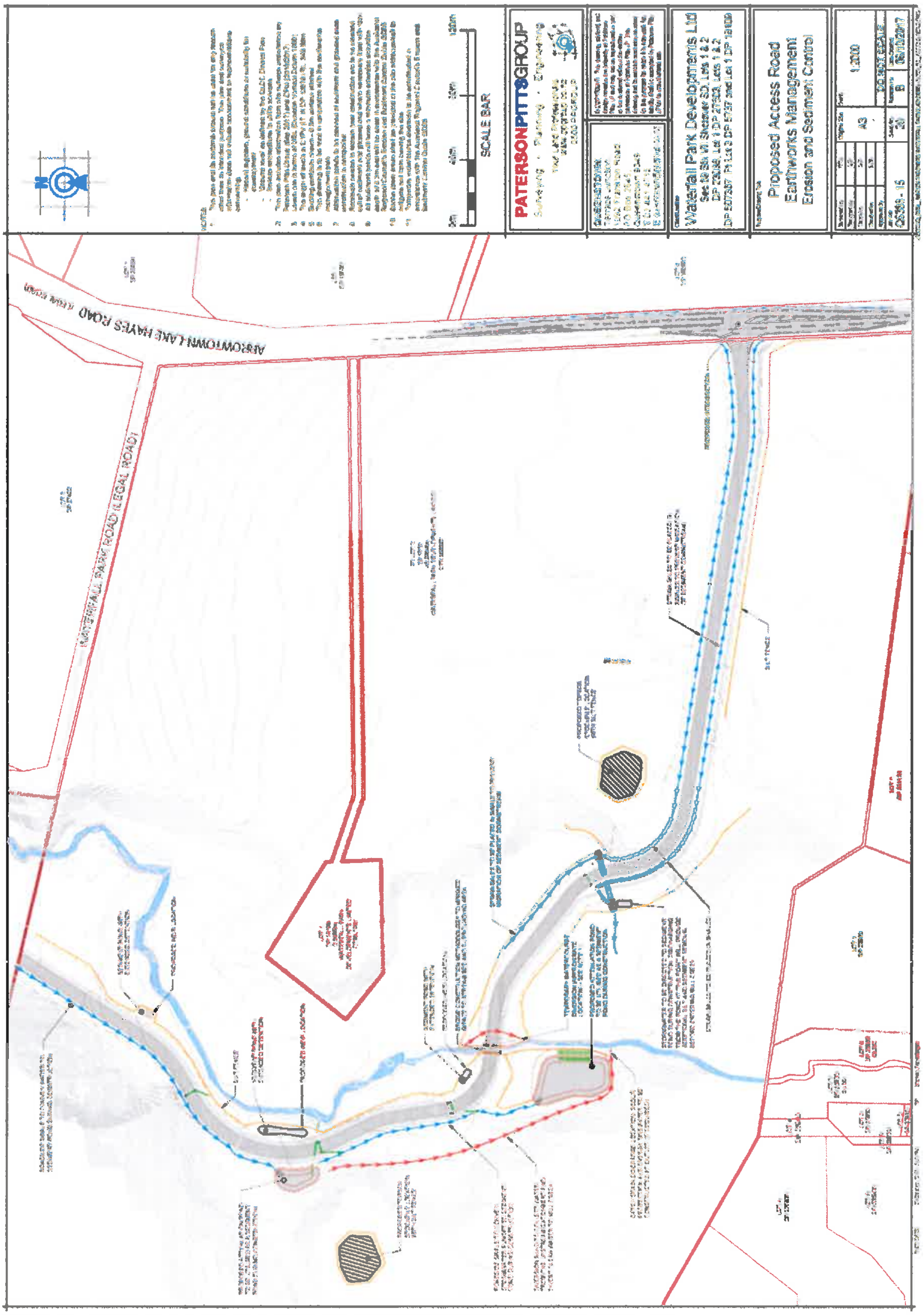
Appendix 1



Plan 1: Detailed plan of earthworks in area of bridge



Plan 2: Proposed Access Road and Earthworks Management

Our reference: A1091352

Consent No. RM17.302.02

WATER PERMIT

Pursuant to Section 104B of the Resource Management Act 1991, the Otago Regional Council grants consent to:

Name: Waterfall Park Developments Limited

Address: Level 2, 33 Shortland Street, Auckland

To temporarily divert water for the purposes of bridge construction

For a term expiring 1 March 2023

Location of consent activity: Mill Creek, 583 metres north west of the intersection of Arrowtown - Lake Hayes Road and Speargrass Flat Road, Arrowtown

Legal description of consent location: Pt Lot 3 DP 5737

Map Reference: NZTM 2000 E 1269672 N 5013172

Conditions

Specific

1. The diversion shall be undertaken as described in the application, including:
    (a) the diversion shall be constructed in accordance with Auckland Regional Council's Erosion and Sediment Control Guide GD05, 'Temporary watercourse diversions', section G4.2.3
    (b) the diversion shall be by open channel to maintain fish passage for all species
    (c) the diversion channel shall be designed to ensure the flow speed through the area of diversion is consistent with a run (e.g. relatively laminar flow, not a pool or riffle) of Mill Creek within 20m upstream of the proposed works.

2. The realigned portion of Mill Creek shall be constructed at an even gradient and with a similar cross-section to the existing stream bed.

3. The diversion of water from the Mill Creek shall only occur once the diversion channel has been fully excavated.

4. The diversion shall only remain in place while the works permitted by consent RM17.302.01 is being undertaken. On completion of the works the diversion shall cease and the site shall be returned to its natural state.

Otago Regional Council

5. The consent holder shall ensure that no fish become stranded, and fish passage is not impeded as a result of the diversion works.

6. When diverting water into the new diversion channel, all reasonable steps shall be taken to ensure that sediment and discolouration of water are kept to a minimum.

Performance Monitoring

7. The consent holder shall provide detailed plans of the proposed diversion channel and associated mitigation measures to the Resource Science Unit of the Consent Authority at least ten working days prior to the commencement of work authorised by this consent.

8. Representative photographs shall be taken of the site:
   (a) before works commence; and
   (b) immediately after the completion of works and rehabilitation of the site,
   These photographs shall be provided to the Consent Authority within one month of the final photographs being taken.

General

9. The consent holder shall undertake all reasonable measures to promote bank stability of the new channel as rapidly as possible.

10. There shall be no reduction in the surface flow of Mill Creek as a result of the diversion.

11. No lawful take of water shall be adversely affected as a result of the diversion.

12. The consent holder shall ensure the diversion does not cause any flooding, erosion, scouring, land instability or damage of any other person's property.

Notes to Consent Holder

1. *The consent holder shall ensure that any contractors engaged to undertake work authorised by this consent abide by the conditions of this consent. A copy of this consent shall be present on site at all times while the work is being undertaken.*

Issued at Dunedin this 1st day of March 2018.

Marian Weaver

Marian Weaver
Resource Manager Procedures & Protocols