BEFORE THE QUEENSTOWN LAKES DISTRICT COUNCIL

IN THE MATTER of proposed private plan change 44 to the Queenstown Lakes District Plan pursuant to Part 2 of the First Schedule to the Resource Management Act 1991

BETWEEN

RCL Queenstown PTY Limited
Requestor

AND

Queenstown Lakes District Council
Consent Authority

EVIDENCE OF GARY MAURICE DENT

1 JULY 2015

INTRODUCTION

1. My name is Gary Dent. I have a Bachelor of Engineering (Civil) and a Diploma in Hydraulic Engineering and I am a member of the Institution of Professional Engineers of New Zealand. Currently I am a Director and Principal Water Resources Engineer for Fluent Infrastructure Solutions Limited in Dunedin.

2. My qualifications and professional associations are:

Qualifications

- Bachelor of Engineering (Civil), New Zealand
- Diploma in Hydraulic Engineering, Delft, The Netherlands
- CPEng and IntPE (pending approval December 2013)

Professional Memberships

- Member – Institution of Professional Engineers New Zealand
- Member - New Zealand Hydrological Society
- Member – Water New Zealand (NZ Water & Wastes Association Waiora Aotearoa).

3. I have practiced as a professional engineer since 1982 in the fields of irrigation engineering, flood hydrology, river engineering, urban stormwater and wastewater reticulation engineering, infrastructure asset management and environmental effects assessment.

BACKGROUND

4. I have been engaged by the Requestor to provide evidence in relation to the potential risk associated with the known alluvial fan hazard in the general locality of the "Hanley Downs Urban Areas" and potential stormwater management effects of the proposed plan change.

5. In this evidence the Hanley Downs Urban Areas (HDUA) is a term I use to cover all of the areas owned or controlled by RCL and parts of the area owned by "Henley Downs Farms". Specifically, my evidence relates to those parts of the Structure Plan proposed by RCL and Henley Downs Farms labelled as follows:

   - Residential (Hanley Downs)
   - Residential (Hanley Downs – State Highway)
   - The Education and Innovation Campus

6. Effects on parts of Hanley Downs beyond these areas will be discussed where appropriate, including on the wetland shown on the Structure Plan to the west of R(HD-E).

7. The Hanley Downs Urban Areas would provide for predominantly urban residential development with potentially some areas of commercial / town centre activity. The density of development varies from high and medium density in areas R(HD) – A to D, (PC44 Proposed amendment to Resort Zones Rules 12.2.5.1 –x (e) - Site Standards), high density for the R(HD) - E area and low residential land use in areas R(HD) – F and G. Therefore the predominantly urban residential development will be a mix of low medium and high density housing. Along with other services and facilities, the area would be served by roads, stormwater and flood hazard management infrastructure. This statement of evidence addresses the potential effects on urban development of the risk posed by the adjacent alluvial fans up gradient from the HDUA, the potential effects development would have on stormwater runoff quantities and quality and the proposed water supply.

LOCATION

8. The Hanley Downs Urban Areas are 8 kilometres (km) in a direct line southeast of the Central Business District of Queenstown (Queenstown Bay) and 4km south of Frankton. The proposed area within the Hanley Downs that would be developed as urban land use can be seen in the Structure Plan agreed by RCL and Henley Downs Farms and is also the area shown in Annex 3 of the statement of evidence presented by Dan Wells. It includes an existing wetland with an area of approximately 0.07 km^2. The HDUA has boundaries with the existing Jacks Point urban residential development and other associated amenities including a golf course.

GEOGRAPHY

9. The HDUA lies in the bottom of a valley between the “Remarkables” range to the east and the southern flanks of Peninsula Hill to the west. Double Cone in the Remarkables rises to 2320 metres above sea level, the flanks of Peninsula Hill rise to approximately 400m above the valley floor at 834m above sea level. Adjacent areas of both the Remarkables and the flanks of Peninsula Hill drain to the HDUA. The valley drains both north to the Kawarau River that flows out of Lake Wakatipu at Frankton and to the south to Lake Wakatipu. The north / south divide in the valley floor catchment lies across the southern third of the HDUA.

10. The HDUA is currently predominantly used for pastoral farming however small areas are used as a contractor’s yard and depot and buildings that serve as a residence for the farm and implement sheds.

11. Within the site, the western valley side slopes are rolling. The valley side slopes to the east within the HDUA are terraced with moderate terrace face slopes and gentle slopes to the west and north. On the valley floor, the land has a gentle slope from east to west such that the low point of the valley floor is along the base of Peninsula Hill. Just south of the valley floor divide, as referred to above, is the existing natural

wetland with willow trees and other wetland vegetation and limited areas of open water.

12. Above the site to the east, the west face of the Remarkables mountain range fall very steeply from over 2000m to 500m elevation and from that elevation, over approximately 1.5km, the land gradient decreases significantly from the base of the range to the eastern boundary of the HDUA. The lower slopes have collected sediments from the steep mountain slopes above and exhibit the natural physical geographical characteristics that define them as alluvial fans.

13. A report prepared for the ORC entitled "Otago Alluvial Fans Project: Supplementary maps and information on fans in selected areas of Otago" Report No. 2009/052 prepared by GNS Science Consultancy and dated April 2009 provides a "Summary Assessment" (pp 108-110) of the alluvial fans east of the HDUA. Relevant material from this assessment has been incorporated into this evidence.

CLIMATE

14. From Report No. 2009/052 the "Annual precipitation at the foot of The Remarkables of about 700 mm/yr increases with altitude to about 1,500mm/yr at the crest of the range (growOTAGO)." The climate is generally referred to as sub-humid.

GEOLOGICAL SETTING

15. As glaciers receded from the Wakatipu basin Lake Wakatipu was formed. Following the recession of the glaciers the water level in the lake was 50m above its current level and therefore beach ridge and lake bottom sediment formations are evident at lower levels within the HDUA. Later, the waters in Lake Wakatipu dropped as a result of water flowing eastwards down what is now known as the Kawarau River gorge. Before the diversion eastwards and the drop in the lake level the Shotover River likely flowed through the site into Lake Wakatipu. As a result of the outlet to the east areas of river terrace, stabilised beach ridge and abandoned lake bed materials exist within the HDUA.

16. During the post glacial period, that includes the period of time after the level of Lake Wakatipu dropped, erosion of the steep terrain of the west face of the Remarkables has resulted in alluvial fan activity below the steep slopes and this has extended as far west as the base of Peninsula Hill. Consequently major flood flows have deposited alluvial material over the former lake bottom and "river terrace" area just within, and to the north, of the HDUA.

PART 1 - ALLUVIAL FAN HAZARD ASSESSMENT

ALLUVIAL FAN DATA

17. Comprehensive data on the alluvial fan hazard associated with the HDUA is available from the Otago Regional Council "Otago Natural Hazards Database". The Database is available online and was provided in GIS format that enabled preparation of the "Hanley Downs Development Plan - Alluvial Fans Plan" in the appendices to this evidence. As noted above reference was also made to related information in Report No. 2009/052 prepared by GNS Science Consultancy and dated April 2009.

    As background on alluvial fan hazards, I have extracted the following text from the Executive Summary of Report No. 2009/052:

    "An alluvial fan is an accumulation of river or stream (alluvial) sediments that forms a sloping landform, shaped like an open fan or segment of a cone. Alluvial fans typically form where streams emerge from hill country onto a valley floor. Of the hazards associated with alluvial fans, the most serious are fast-moving sediment-laden floods and slurry-like flows of debris. Such floods and flows may commonly break out from existing stream channels and forge new, sometimes unexpected, paths. Fan sediment-laden floods or flows may be damaging or destructive to anything in their paths, and pose a threat of injury or death to people. Less serious hazards include sediment build-up, which may cause damage to productive land, crops or various types of infrastructure, such as water supplies or roads."

18. I have been involved with steep alluvial stream activity including bridge waterway work (Waterfall Creek) near Makarora, the Cardrona River valley and the Waiau River in Southland. I have maintained a keen personal interest in the general behaviour of streams and hydrology in the mountains of the South Island throughout my career. I have based my hazard assessment on the data available from the ORC and personal knowledge and experience as an engineering practitioner.

19. Definition:

    - **Apex**
      A point in a stream where the stream bed leaves a confining stream valley, or gulley, typically relatively steep, and becomes unconfined. Where the stream becomes unconfined it is able to flow laterally carrying sediment to form an "alluvial fan". The apex is therefore the highest point on an alluvial fan.

REMARKABLES CATCHMENTS DESCRIPTION

20. Three Remarkables range catchments were examined for their potential to affect the HDUA. The three catchments are illustrated in Sheet SW01. Catchments B and C have the potential to directly affect the site via two flood paths that flow through areas identified for potential medium density residential development in the north eastern corner of the HDUA.

21. Catchment A could have effects on an area identified for rural residential development at the northern extremity of the HDUA. The northern rural residential area (R(HD-SH)-2 could be affected because of the topography between the apex of the alluvial fan in

catchment A and the rural residential area and by overflows from Catchments B and C.

22. All three Remarkables catchments have their highest point at just above 2000m and fall to the upper and eastern boundary of the site at between 340m and 400m over a distance of between 3.5 kilometres (km) and 4.3km (including the distance along State Highway 6 (SH6) from Catchment C). Above the apex of the alluvial fans the stream bed slope is greater than 30% and as steep as 70% in the upper sub-catchments.

23. The upper catchments above the apex of the fan are largely bare rock with little or no soil cover. Accordingly, there is sparse vegetation on the lower slopes and minimal or no significant vegetation on the upper slopes. The steepness of the schist rock faces is a result of the repose of the primary shear plains dipping to the northeast and strike northwest southeast and hence the steep western slope of the Remarkables face is relatively stable.

24. The stability of the Remarkables west face means that the volume of sediment and rock debris available to the stream flows from time to time is limited. The magnitude of debris flows is therefore less than would be expected in catchments where large volumes of weathered debris is available to the stream from adjacent valley or gully slopes. Evidence of limited volume of debris issuing from the upper catchments is the relatively confined thread of the current stream flow path of Catchment B and the good vegetation cover in the vicinity of the apex of the fan.

25. The confined flow paths in the steep rocky gullies mean that the conditions exist, during extreme events in particular, to generate proportionately higher flows for the size of the catchment compared to flatter catchments with broader stream beds. The high flows from the steep confined catchments will, with whatever rock and debris that enters the stream bed above, be entrained in the flow and discharge at relatively high velocities at the apex of the alluvial.

ALLUVIAL FAN SEDIMENT TRANSPORT PROCESSES

26. Once the discharge from the steep catchment above reaches the apex of the fan the flow becomes to some extent unconfined. Below the apex of the alluvial fan the surface of the fan flattens from of the order of 30% down to 5% at the boundary of the HDUA. At least initially, as the flow enters the fan, the flow will follow the existing channel and the flow velocity will decrease with decreasing slope and progressively the larger debris sizes entrained in the flow will come to rest.

27. As the high velocity flood flows enter the alluvial fan below the apex of the fan there is the potential for large flood flows to entrain and mobilise the sandy loam and stony loam soils on the fan. The potential for extreme debris flows however is expected to be moderated by the limited availability of material available from the upper slopes and by the likely "chunky" nature of material carried down from the relatively stable rock above. Small volumes of finer material will be carried down the alluvial fan. I have not been to the apex of the fan to observe the nature of the bed material, my opinion is based on general observations of steep mountain stream beds.

28. For large floods, the more extreme events, the existing channel capacity below the apex is likely to be exceeded, perhaps because debris is deposited in the stream bed or simply because of the magnitude of the flood is greater than the channel capacity. At this high flow stage of a rising flood the overflow may head in a lateral direction and if severe erosion occurs may divert the course of a main channel that has existed for some considerable time and create a new flow path that could discharge at a different location along 3km of SH6 the boundary of the Jacks Point development area and the HDUA. This stream direction change process is what is referred to as “avulsion”, this behaviour is what forms alluvial fans.

29. The majority of the topographical data available for the alluvial fans in Catchments A, B and C was at a vertical contour interval of 20m except for that near SH6 at a 2m contour interval. The 2m contour data indicates where flows from the upper catchments currently cross SH6 and also indicates future potential flow paths and marks what has occurred.

30. There is a significant eroded flow path on the northern side of the HDUA at Catchment 11, that is, between areas R(HD-SH)-1 and R(HD)-C) on the PC44 Structure Plan. The eroded flow path is referred to as the “Current primary flow path” on Sheet SW02 in the Appendix. This feature suggests that the alluvial fan has been built up and later eroded by a major flood flow or flows. Currently the major flow path is down through the HDUA between Catchments 3 and 11.

31. From observation of the 2m topographic data, and having been on site, it is possible that avulsion within Catchment C upstream of or at SH6 just north of the Jacks Point development area entrance could cause major floods to overflow to the north down the gully in Catchment 10 to the existing flow path between Catchments 3 and 11.

32. The opportunities for avulsion mean that predicting the magnitude of a flood flow at a location and its frequency of occurrence cannot be accurate – a possible order of magnitude of flow for a worst case scenario is a prudent approach.

33. The culverts under SH6 are of the order of 1.5m diameter or less and therefore the conveyance capacity of the culverts across SH6 to the HDUA will influence flow paths down the alluvial fan along SH6.

34. Equally, the identification of the effects of any mitigation works can only be indicative for the foreseeable future. Effects identified now may be overtaken by stream channel changes near the apex of the respective alluvial fans and at SH6. For these reasons a contingent rounded view of flood hazard management for the HDUA is required. Where the respective Remarkables catchments flow cross SH6 in future may change, the potential scenarios envisaged at present are as follows:

- As noted above Catchment C could overflow to Catchment B and flow either down through Catchment 10 or down SH6 to the flood flow path between Catchments 3 and 11, both scenarios affect the HDUA, or:
- Catchment C could potentially be diverted down SH6 and then join with the flow from Catchment B and continue to flow down SH6 to join the discharge from

Catchment A. The combined flows of the three catchments could discharge over SH6 and from SH6 down to Woolshed Road in at least 3 locations between Catchment 11 and the intersection of SH6 and Woolshed Road.

HYDROLOGY

35. The Remarkables Catchments A, B and C, as noted above, are short and steep and therefore the duration of peak flows is also typically short. The time of concentration for preliminary order of magnitude flow estimates was estimated to be of the order of 20minutes.

36. The upper slopes of the Remarkables are very steep and this means that the hydrological behaviour of the streams above the site are unique and therefore the magnitude of flood flows entering the top, or apex, of the alluvial fan are difficult to predict with any accuracy. Due to the hydraulic characteristics of steep narrow catchments actual flows have been known to significantly exceed the flow estimates derived from accepted hydrological estimation techniques.

37. Using a Regional Flood Estimation (McKerchar, & Pearson 1989) technique based on recorded flood histories of catchments in each region of New Zealand resulted in a 100year Average Return Interval flood estimate of the order of 23cubic metres per second (m3/s) including mean estimate plus standard error in recognition of the small size of the catchments B and C.

38. Applying a rainfall / runoff method using the US Soil Conservation Service (SCS) loss and unit hydrograph method, including an adjustment for climate change, resulted in an estimate of a 100year ARI flow of the order of 70 m3/s, 3 times greater than the regional flow estimate.

39. In comparing the results from the two methods reference was made to recent press reports as anecdotal evidence. On the 4 June 2013 the recorded rainfall depth for 24 hours in Queenstown was of the order of 72mm considered to be the highest since 2006. (Southland Times 4/06/2013). The report did not record a problem on SH6 at the Remarkables. Report No. 2009/052 prepared by GNS Science Consultancy refers however to "Historically, several of the larger streams have deposited gravelly sediment across the highway during floods, with aggradation upstream of the highway embankments." These observations indicate flood flows less than 50 m3/s for Catchment B for example.

40. Given that the Regional Flood Estimation technique is based on recorded data the lower figure may reflect the following:

    a. The size of the Remarkables catchment is small and hence the runoff volume is relatively small and with the short duration of the peak flow the peak flow is dissipated relatively quickly as it overflows and spreads down the alluvial fan.

    b. The likely large size of the rock debris at the apex of the fan may be absorbing a significant portion of the peak flow.

c. The schist rock in the catchments may absorb more water than is assumed by the SCS loss method. Calibration of the SCS model was not possible.

d. The catchment above the gauging stations used to measure the regional flood estimation parameters are not applicable to the Remarkables catchments above the HDUA.

41. That the estimation parameters used for the Regional Flood Estimation method are not directly applicable is certainly the case but it would seem unlikely to account for the more than 3 times order of difference between the flow estimates.

42. The Alluvial Fan Hazard (AFH) data referred to below indicates significant "recent" alluvial fan activity in the vicinity of the HDUA. The AFH data is recorded on a geological time scale that is likely orders of magnitude greater than the life of future buildings. It is not appropriate however to ignore the likelihood of there being building cycles beyond those of an initial development and therefore, again, a conservative approach is appropriate to mitigation option assessment in this case.

43. The actual peak runoff estimate for a 100year ARI scale event is likely to lie between the Regional Flood Estimation and SCS Unit hydrograph method flow estimates. For the purposes of assessing risk mitigation options for the HDUA the SCS flow estimates and the combined catchment flow scenario have been assumed.

HISTORICAL ALLUVIAL FAN ACTIVITY

44. ORC alluvial fan hazard (AFH) data has been mapped over the HDUA – see Sheet SW03 in the Appendix – the primary zones of significance to the site are "fan recently active" (fra), "fan less recently active" (fla) and "fan active bed" (fna).

45. The areas referred to in the PC 44 Structure Plan that are affected by the AFH are the following areas:

a. R(HD-SH)- 2 – straddles less recently and a recently active flow paths (alluvial activity).

b. R(HD-SH)- 1– the greater part of area R(HD-SH)- 1is affected by recently active and less recently active alluvial fan activity. R(HD-SH)- 1 also borders on an alluvial stream path, referred to in Sheet SW02 as the "Current primary flow path", that has an area referred to as active bed and recently active fan areas. The Current primary flow path traverses down through the northern part of the HDUA from State Highway 6 to the base of Peninsula Hill.

c. EIC – all of the EIC area falls within a recently active area – it lies downstream of the stream path that flows down between areas R(HD) – A and C and areas R(HD-SH) 1 and 2.

d. R(HD)-C – there is a small part of the R(HD)-C area that falls within the fan active bed area on the AFH map..

e. R(HD)-A– part of the R(HD)-A area is affected by fan recently active area on the AFH map.

f. R(HD)-D – a short length of northern boundary of area R(HD)-D borders a fan recently active area at the lower end of the Current primary flow path through the northern part of the site.

g. R(HD)-E – part of this is an area in the southern most area of the HDUA is mapped as less recently active fan deposits. This less recently active area is isolated from a "recently active" fan deposit by road access and residential development in the neighbouring Jacks Point residential development area.

46. The "other" landform between State Highway 6 and the larger part of the HDUA has, at least in recent geological times, diverted any flood mobilised alluvial fan material generally through a narrow pathway in the northern part of the HDUA, to the north of the HDUA and to a smaller pathway descending through a narrow pathway within the Jacks Point development area.

47. While the northern HDUA sub-areas referred to above are affected by alluvial fan activity, 80% of the HDUA is not affected by either "recently", "less recently" or "active bed", alluvial fan activity.

HAZARD ASSESSMENT CONCLUSIONS

48. The potentially significant flows from the Remarkables catchments above the HDUA and the evidence of current and geologically recent stream channel activity on the alluvial fans below the Remarkables from the ORC hazard reports confirms that an alluvial fan flood hazard activity affects of the order of 20% of the HDUA at it's northern end.

49. In terms of the possible scope of future development within the HDUA the options available are to:

a. Avoid the alluvial fan flood hazard
This could conceivably be achieved by not proceeding with development in the vicinity of the recent and less recently active alluvial activity areas and the active stream beds. This would require further more detailed investigation to confirm the extent of the mapped areas and potential risks to peripheral areas to check that the risk is confined to those areas mapped to date.

b. Mitigate the alluvial fan hazard. The affected areas identified above have been examined to assess the feasibility of hazard mitigation. The conclusion is that by reinforcing and adding to the existing natural defences it is feasible at reasonable cost to mitigate the alluvial fan flood hazard to the extent that the risk of damage for a 100year ARI rainfall event is considerably less than 1% per annum.

HAZARD MITIGATION

50. The land form feature that currently diverts flood flows from the HDUA is elevated ground in Catchment 10 (Sheet SW02) adjacent to SH6. The elevated ground directs flood flows down grade parallel to SH6 to the point where flows can enter the Current Primary Flow Path (refer to Drawing SW02) between catchments 3 and 11 where flood

waters are conveyed through the northern HDUA to the base of Peninsula Hill. In extreme flood events flood waters potentially continue down gradient parallel to SH6 as referred to earlier. Comparing the topography of the Current Primary Flow Path with the "Alternative Existing Primary Flow Path" (See Sheet SW02) further down gradient on SH6, it appears that the current flow path is more recent and is developing. There is significant erosion evident in the middle reach of the current flow path through the HDUA.

51. Constructing approximately 400m of flood bank from the elevated ground in Catchment 10 down parallel to SH6 to the northeast boundary of Catchment 11 would divert flood flows to the alternative existing primary flow path between SH6 and Woolshed Road. The "high" flood bank would contain a culvert of similar capacity of the existing culverts under SH6 and therefore the Current primary flow path would continue to take the minor flood flows through the HDUA but the overflow for the extreme events would be diverted past the HDUA and mitigate the extreme flood flow risk to the HDUA.

52. As noted previously, there is the potential for flood overflows to avulse from Catchment C into Catchment 10 and ultimately down the current primary flow path between Catchments 3 and 11. Constructing approximately 400m of reinforced "low" flood bank would further reduce potential flood overflows within the HDUA. If this option were to be implemented any overflow from Catchment C would be diverted to the Alternative Existing Primary Flow Path and further down gradient to the north depending on flow conditions.

53. It is envisaged that the flood bank down the northeast boundary of R(HD-SH)-1 would be designed for the overflows from Catchments B & C to flow down SH6 in a channel formed between the flood bank and SH6. It has been conservatively assumed that the combined flood flow from Catchments B & C would flow against the flood bank and would be confined to a width of 25m in order to calculate an indicative depth and velocity for the typical gradient. On this basis, the flood bank would be nominally 2m high and reinforced with rock at least 1m thick on the flow side batter to 1.25m below natural ground level for protection against scour. The height of the flood bank allows for 1.2m freeboard for local sedimentation and dynamic flow effects. For landscape architectural reasons the rock could be filled with soil and planted with plant species that inhabit the local alluvial fans.

54. The low flood bank would be of the order of 1.5m nominal height and reinforced with rock if required to suit the local gradients.

55. The mitigation option above would mitigate the alluvial fan hazard in R(HD-SH)-1, R(HD)--C, R(HD)-A, R(HD)-D and the EIC areas.

56. With regard to development in R(HD-SH)-2, any siting of buildings and infrastructure in this rural residential area at the north-eastern extremity of the HDUA would need to be subject to specific approval considering the effects of the potential flow paths and the mitigation option outlined above if implemented. There is a small group existing

buildings on the margin of the alternative flow path that would need risk assessment and a potential a mitigation strategy if the flood banks are constructed.

57. The benefits of the mitigation options outlined above are as follows:

  c. The natural dry weather flow paths through the HDUA would be retained and provide amenity value but the magnitude of the flows would be limited to the natural runoff within the HDUA and adjacent Jacks Point catchments and the culvert capacity through the mitigation works flood bank.

  d. The existing flood risk to existing low lying lots within Jacks point adjacent to Catchment 3 would be reduced.

  e. Flood, and potentially debris flows, would have to cross SH6 first in order to flow within Hanley Downs area. There would be minimal, if any, additional impact on SH6 as a result of providing a flood bank and channel to direct flood waters and debris down the Hanley Downs boundary with SH6 to the existing flood path on the northern boundary of Catchment 11.

58. There is an initial cost for the mitigation works but the design should be such that minimal maintenance is required and the integrity of the flood banks is protected in perpetuity.

PART I CONCLUSIONS

59. The implementation of the mitigation option outlined above against flooding from the alluvial fan catchments above the Hanley Downs Urban Areas would provide a normally acceptable level of flood risk for future urban development.

60. Flood risk due to stormwater runoff from catchments within the HDUA is addressed separately in an indicative stormwater management plan.

PART 2 INDICATIVE STORMWATER MANAGEMENT PLAN

DEVELOPMENT OBJECTIVES

61. I have been asked to consider the feasibility of the performance standards sought by ORC in their submission to Plan Change 44 and to consider whether storm water effects on the wetland in Hanley Downs could be appropriately managed so as to ensure that development proposed in the vicinity would be appropriate.

    The proposed "PC44 Structure Plan" (appended) provides for what I would describe as medium density residential development in areas R(HD)-A to D and R(HD-SH)-1. Medium density residential in this case includes dwelling densities of between 12 and 26 dwellings per net hectare (i.e. excluding roads and open spaces), with the majority of these areas proposed to be developed to between 17 and 26 dwellings per net hectare. Area R(HD)-E at the southern end of the site and the EIC area at the northern end would be what I consider high density development areas. By this I assume 25 – 45 dwellings per net hectare could have an impervious area of up to 90% of the total area. Areas R(HD)-F and G provide for low density style development with a much lower proportion of impervious area.

62. For a preliminary analysis of stormwater effects I assumed the impervious area for stormwater runoff calculations account for 65% of the average lot area. Developed road reserve areas were assumed to have a similar impervious area percentage.

63. In the plan Sheet SW02 to this evidence I have included provision for two stormwater detention ponds within the urban residential areas that were designed to accommodate the type of development that can be achieved under the Hanley Downs Structure Plan. The process included consideration of a more detailed master planning exercise undertaken by RCL which included provisional road and open space layouts, an example of which was attached to the evidence of Mr Wells.

64. I should note that the R(HD)-E area of the Structure Plan now proposed by RCL and Henley Downs Farms differs in terms of likely impervious area percentage from that which was relied on for the work I was involved in. The size of the detention pond shown in R(HD)-E will depend on the final form of the Structure Plan and the densities of development but the pond shown in Sheet SW02 is indicative of the size of pond required.

65. The northern most detention pond location is also an indicative size and so in the subsequent design phases, if PC 44 is adopted, the northern pond location can be adjusted northward or southward to suit the preferred layout for development. For example, the detention pond in the EIC area may need to be slightly larger depending on whether it serves the EIC area or not. If the pond position is not altered to suit the EIC area a separate pond for the EIC area would be required.

66. The "Farm / Preserve" areas FP-1 and FP-2 are rural size lots with a low impervious percentage and therefore the effects of development on these areas would be minor.

67. The stormwater infrastructure for collection and disposal would be constructed according to the Queenstown Lakes District Council Development and Subdivision Engineering Standards that includes amendments and modifications to New Zealand standard NZS4404:2004.

68. Pursuant to the ORC submissions on Plan Change 44 the criteria used to identify the provisions in for the "indicative stormwater management plan" outlined below were as follows:

Provisions to be included in stormwater management plans:

Incorporate stormwater and sediment management options that minimise the impact of

stormwater generation and containment loadings through low impact design or sustainable urban drainage techniques and ensure that:

a) The rate of stormwater discharge remains equal to, or less than that of pre-development up to the 1 in 100 year average recurrence interval event; and

b) The quality of water in any discharge remains equal to or better than that of predevelopment; and

c) Stormwater management systems are designed to cater for the 1 in 100 year average recurrence interval event.

Stormwater management plan assessment matters include:

The extent to which:

a) natural flow paths have been used in the design of stormwater management systems;

b) techniques have been adopted to ensure that:

(i) the rate of stormwater discharge remains equal to, or less than that of pre-development up to the 1 in 100 year average recurrence interval event; and

(ii) The quality of water in any discharge remains equal to or better than that of predevelopment; and

(iii) Stormwater management systems are designed to cater for the 1 in 100 year average recurrence interval event.

INDICATIVE STORMWATER MANAGEMENT PLAN

69. The indicative stormwater planning I have undertaken and which is shown in Sheet SW02 in the appendices to my evidence provides for the following infrastructure:

- Flood hazard mitigation flood banks along SH6 are proposed to protect the HDUA from the Remarkables alluvial fan hazard. The flood banks proposed along SH6 would remove considerable risk from the HDUA catchments that drain north to the Kawarau River.

- The culvert through the flood bank adjacent to SH6 at area R(HD-SH)-1 would divert major flood overflow discharges past the existing Current Primary Flow Path to protect residential property in HDUA areas R(HD-SH)-1, R(HD)-C R(HD)-A, and the EIC area, the stormwater collection network and stormwater detention and treatment facilities within the HDUA.
- A conventional piped stormwater collection network with direct connection to individual properties and sumps for the collection of road runoff. The piped stormwater system would convey the 10year Average Return Interval (ARI) rainfall event to a detention pond and water treatment facilities.
- Secondary overland flow runoff from the HDUA residential areas, being runoff in excess of runoff contained in the pipe network, will be directed via the roadway network to existing natural flow paths. The primary natural flow paths are those that flow northwards along the base of Peninsula Hill (referred to further as the "northern stream") and the natural stream path from SH6 between HDUA areas R(HD)-A and C and R(HD-SH)-1.
- Secondary overland flow during extreme events from the southern area of the HDUA would discharge via roads and a detention pond serving most of the R(HD)-E area and then from the pond into the existing wetland to an existing ephemeral stream path to Lake Tewa adjacent to the golf course in the Jack's Point development area. A small part of area R(HD)-E would flow directly into the existing stream path and into Lake Tewa.
- First flush treatment for the first 25mm of runoff across the catchment area with release over 24 hours would be provided in the detention ponds for the northern and southern catchment areas.
- The detention pond for the northern area would have sufficient volume to detain and control the 10year and 100year ARI discharges within the pre-development peak discharges.
- The detention pond in the southern area catchment would detain a 10 year ARI rainfall event to within the predevelopment peak discharge. For an event with an ARI greater than 10 years there would be an overflow to the existing wetland where the existing wetland storage capacity would utilised to moderate the peak runoff to less than the predevelopment discharge.
- Jacks Point development area Catchments 2a and 2b (See Sheet SW02) that are south of HDUA areas R(HD)-B and C would be piped to the existing north stream natural flow path.
- At the detention pond for the northern catchments of the HDUA a culvert structure would divert the secondary overland flow from the residential areas and runoff for the total undeveloped catchment areas to the detention storage. Outflow would be controlled such that the culvert flow plus the controlled discharges from the detention pond do not exceed the pre-development flow.

- A flood channel would be constructed through the EIC to the northern extent of the HDUA. It would likely follow the edge of the northern detention pond to the northern boundary of the HDUA. The channel would convey the restricted flood flow from the culvert under the flood bank at SH6 and any runoff from the current primary flow path watercourse between SH6 and the northern detention pond.

ENVIRONMENTAL CONTEXT

70. The proposed residential activity is a change in land use that would result in a change in the nature of stormwater runoff discharges from the HDUA entering the northern and southern streams. The Otago Regional Plan – Water, pursuant to the Resource Management Act 1991, requires that in such instances the potential adverse effects of the changes need to be mitigated.

HDUA Water Quality Effects

71. The primary adverse effect of development in the HDUA, if not mitigated, would be the increase in runoff due to the increase in impervious areas as a result of residential roof and paving within lots and roadways. Increased runoff rates would increase the potential for erosion as the northern and southern streams as they descend to the Kawarau River and Lake Wakatipu respectively. The proposed detention ponds would mitigate the adverse effect of the increase in impervious area.

72. A change of land use from pastoral farming to residential development would result in some change in the potential contaminants in stormwater and the balance of contaminants that could, if not mitigated, potentially affect activities downstream of the discharge point.

73. With respect to a change in contaminants in stormwater runoff, there would be an increase in contaminants in stormwater runoff as a result of vehicle traffic associated with development in the HDUA. An increase in Copper (Cu), Zinc (Zn), oil and grease and total suspended solids (TSS) contaminants in stormwater runoff is anticipated. For this reason a wet pond area in the detention ponds is proposed as a suitable Best Management Practice response to managing contaminants generated by development.

Northern Stormwater Catchment

74. The northern part of the HDUA residential area would drain to the northern stream that joins with the water from the Remarkables Catchments B and C via the Current Primary Flow Path. The northern stream discharges to the Kawarau River 2.7km north of the HDUA.

75. The remainder of the catchments draining via the HDUA drain via what is referred to as the “southern stream” to the south to Lake Wakatipu. Refer to Sheet SW02.

76. The northern stream receives water from the west face of the Remarkables and the alluvial fans and the eastern faces of Peninsula Hill. Except for the Jack’s Point development area the alluvial fans and valley floor catchment areas are farmed.

77. The valley floor to the north of the HDUA is currently cropped and grazed, and therefore defined by fencing in a generally rectangular pattern. The northern stream is therefore not a natural flow path. For most of its 2.7km length from the HDUA to the Kawarau River the northern stream functions as a farm drain. The quality of the water in the northern stream is affected by farming operations and activities including grazing stock on the valley floor and alluvial fans.

78. From the northern stream crossing of SH6 near the Kawarau River, the final reach to the river drops steeply. From aerial imagery, erosion in this final reach to the river is currently reduced by heavy willow growth.

79. The water quality in the northern stream is affected by farming and the alluvial fan runoff and therefore with the proposed wetland and detention facilities an improvement in some water quality parameters downstream would be anticipated and the increase urban specific parameters would be limited by best management practice.

80. Since the wetland pond is proposed as part of the greater northern detention pond it could be a feature along the Public Access Route.

Southern Stormwater Catchment

81. Drainage to the south includes water from the existing natural wetland that joins a natural stream from the Remarkables that flows to Lake Tewa via the Jack's Point development area. The stream drains into Lake Tewa within a 100m of the HDUA and is effectively the southern stream discharge point for the HDUA. For a 100yr ARI event the HDUA peak runoff flow to the southern stream where it enters Lake Tewa would be of the order of 25% of the peak flow ignoring the positive buffering effect of the natural wetland that was not modelled. Indicative calculations for a 100yr ARI rainfall suggest that residential development could potentially result in an short duration, being 12 hours or perhaps a few days, increase in the level of the of the natural wetland of the order of 100mm to 200mm. The very infrequent short duration increases in wetland water level would depend on the wetland water level before the storm and the flow characteristics from the wetland outlet.

82. Downstream from Lake Tewa the modified south stream channel receives additional water from other Remarkables catchments and the combined flow is conveyed via an existing natural meandering stream pattern down to Lake Wakatipu. The meandering reach to Lake Wakatipu is steep and appears to be eroding and as a result the bed would logically be degrading on a geological time scale.

83. The quality of water in Lake Wakatipu is described as "near pristine" and therefore consideration was given to whether discharges from the HDUA to the southern stream via Lake Tewa to the south could potentially have localised effects in Lake Wakatipu.

84. Runoff to Lake Wakatipu from the southern stream during stormwater runoff events will be predominantly affected by the runoff from the Remarkables Catchments, the Jack's Point development area and farming activities in the lower parts of the Remarkables catchments and therefore Lake Wakatipu would not be affected by development in the HDUA.

85. The southern area detention pond would have wetland areas and detention volume capacity for up to a 10yr ARI event. Despite the existing wetland having the capacity to assimilate stormwater runoff contaminants the purpose of the southern detention pond would be to protect the existing wetland from the chemical and TSS contaminants and therefore minimise any adverse effect on the flora and fauna within the existing natural wetland and maintain its natural values.

86. I have discussed the stormwater detention and wetland treatment methodology with an ecologist involved in this project (Ms Dawn Palmer). Ms Palmer advised that avoiding an increase in water flow rates using a detention facility and stormwater treatment in a specifically designed wetland for the levels of contaminants derived from residential development would appropriately mitigate potential adverse effects on the biodiversity values of the wetland.

87. Given that runoff from the most of the southern part of the HDUA would drain via the detention pond containing wetland components for First Flush treatment and via the existing natural wetland, the quality of HDUA runoff water entering the southern stream any potential adverse effects would be minor.

88. The existing wetland would provide additional buffering of any effects of the HDUA and therefore any potential adverse effect on Jacks Point amenities would be minor.

INDICATIVE STORMWATER INFRASTRUCTURE CAPACITY

89. A preliminary analysis of the stormwater infrastructure requirements indicated that the following works would be required:

- Flood banks, 2.0m and 1.5m high have been identified to mitigate the flood hazard from the alluvial fans. The flood banks would be important to protecting some of the infrastructure envisaged within the northern part of the HDUA.
- A piped stormwater collection reticulation network with 19km of stormwater mains ranging in size from 300millimetres (mm) to 1050mm diameter.
- The northern stream detention pond would have a detention storage capacity of the order of 25,000cubic metres (m^3) for a 100yr ARI event. The storage volume for the southern area for the 10year ARI design event would be of the order of 9000 m^3 for area R(HD)-E.

  The detention volumes were calculated using a HEC-HMS SCS hydrological rainfall / runoff model of the HDUA potential development and the natural catchment areas.
- Detention ponds would include first flush retention volumes for the wetland pond component of the order of 60% of the water quality treatment volume. That is, 10,000m^3 for the northern pond, and 3500m^3 southern area pond.
- The volume of direct runoff will increase as a result medium residential development. Implementation of the first flush treatment volume that is detained for

release over a 24hour period for the majority of runoff events reduces the effects of the increased volume of runoff.

- The detention pond outflows from the northern detention pond would be controlled to ensure the post development discharge is less that the 100year ARI. For example, for the northern flow stream this means the flow is restricted to 210litres per second (l/s) for the first flush volume, up to 3200/s for the 10year ARI event and 18,000l/s for the 100year ARI event compared to a predevelopment flow estimate of 20,000l/s.
- Flow from Catchments 2a and 2b would be piped in a 900mm diameter pipe across the HDUA to near the existing wetland and from there directed to the northern stream flow path. Secondary overland flow would be via the street network as for the other residential development areas.

PART 2 CONCLUSION

90. Flood hazard mitigation and stormwater effects mitigation strategies as solutions specifically applicable to the Hanley Downs site have been described.
91. Utilising the piped stormwater collection network with capacity for a 10year ARI rainfall event within the medium residential development areas contains the primary contaminant load as a result of development. Using the piped network contains contaminants from their source through to the treatment facilities and thus provides protection for the aquatic, recreational and farm use environments downstream.
92. The stormwater flows from the development would represent approximately 30% of the total runoff flow in the northern stream immediately downstream of the HDUA. The stormwater detention and best management practice approach to water quality treatment would avoid any significant adverse effects on the aquatic environment downstream to the Kawarau River.
93. Compared to the runoff flow to the north, flows from the HDUA to the south are a smaller proportion of the total runoff flows. With treated runoff being directed through the existing wetland that would also moderate peak flows and polish the quality of runoff flows any potential adverse effects on the nearby Jack's Point development area amenities and natural stream values down to Lake Wakatipu would be insignificant.
94. The proposed approach to stormwater detention for events up to a 100year ARI rainfall event and delayed release of the first flush storage volume would avoid peak flow discharges and control recession flow for the more frequent events that could otherwise increase the rate of erosion and sedimentation processes.
95. The work done to identify infrastructure to mitigate alluvial fan hazards and the facilities for internal stormwater management confirm that the scale of effects and the appropriate mitigation works do not represent a limitation to development within the HDUA. I am therefore comfortable that the assessment matters sought by the ORC in their submission can be satisfactorily addressed by the form of the alluvial hazard

mitigation and stormwater infrastructure proposed for residential development at Hanley Downs.

PART 3 - WATER SUPPLY

96. It is proposed that the residential and EIC areas of the proposed HDUA would receive a water supply from the existing Jacks Point development area water supply network.

97. The Jacks Point development on the southern and eastern boundaries of the HDUA area was established with a water supply network that draws its water in the vicinity of the natural feature called Jacks Point on the shores of Lake Wakatipu. Water from the lake is pumped via a rising main up to a storage reservoir site on the high point above the natural feature referred to as Jacks Point in the lake and the residential area that is now also referred to as Jacks Point. From the reservoir site a falling main supplies water to the Jacks Point residential area. The rising and falling mains were constructed with sufficient capacity to supply an area significantly larger than the existing Jacks Point development area.

98. The existing falling main terminates approximately 500metres south of the residential area R(HD)-E. The residential area is identified on Drawing SW02 appended. It is proposed to connect a new trunk main onto the existing Jacks Point falling main network and extend the water supply reticulation throughout the Hanley Downs activity area including to the EIC area at the northern end.

99. To provide the capacity required to serve the fully developed HDUA it is anticipated that additional headworks capacity would be required in the form of an additional pump, or pumps, at the lake pump station, reservoir storage and water treatment capacity. It is anticipated that the additional reservoir and water treatment capacity would be provided at the reservoir storage site. From an initial appraisal, the total additional headworks capacity cost would be significantly less than the cost of the new reticulation pipework that would be needed to supply the HDUA.

100. A check on the elevations within the HDUA against the elevation of the reservoir confirms that there is likely to be sufficient pressure available to comply with the QLDC minimum supply pressure requirements. If there is a pressure shortfall then that could be remedied with local booster pumping and the appropriate sizing of the trunk mains..

101. Given the existence and capacity of the existing Jacks Point water supply network, future residential development in the HDUA has the option of utilising the existing water supply headworks infrastructure.

Gary Dent
Water Resources Engineer
Fluent Solutions
29 June 2015

APPENDICES

- Drawing - PC44 Structure plan – Drawing No. HD_14_1_MLP-00L – Date 10.03.15.
- Drawing - Hanley Downs Site Catchment Plan – Sheet SW01
- Drawing - Locality Catchment Plan Hanley Downs – Sheet SW02
- Drawing – Hanley Downs Development Plan - Alluvial Fans Plan – ORC Hazard Data – Sheet SW03.