BEFORE INDEPENDENT HEARING COMMISSIONERS

IN THE MATTER of the Resource Management Act 1991

AND

IN THE MATTER of the hearing of submissions on Proposed Variation 1 (Selwyn-Waihora) to the Proposed Canterbury Land and Water Regional Plan

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STATEMENT OF EVIDENCE OF IAN MCINDOE ON BEHALF OF IRRIGATION NEW ZEALAND INCORPORATED and DUNSANDEL GROUNDWATER USERS ASSOCIATION INCORPORATED

Dated: 29th August 2014

INTRODUCTION

1 My name is Ian McIndoe.

2 I am a Soil and Water Engineer, currently employed as Principal Engineer by Aqualinc Research Ltd, of which I am a director.

3 I have 37 years experience in water resources, hydrology and irrigation related work. I have specialised in water allocation for irrigation and the effect of water restrictions on irrigation reliability and performance.

4 I hold the qualifications of BE (Hons) from Canterbury University and Dip Bus Stud (Finance) from Massey University. I am a board member of Irrigation New Zealand and a member of the New Zealand Hydrological Society.

5 In preparing my evidence I have reviewed the following reports:

- Aqualinc (2007) Canterbury Groundwater Model 2 by Aqualinc Research Limited Report No. 07079/1 September 2007

- Clark, D.A., 2014. Technical report to support water quality and water quantity limit setting process in Selwyn Waihora catchment. Predicting consequences of future scenarios: Surface water quantity

- Environment Canterbury 2014 Proposed Variation 1 to the Proposed Canterbury Land and Water Regional Plan Section 32 Evaluation Report

- Hanson, C., 2014. Technical report to support water quality and water quantity limit setting process in Selwyn Waihora catchment. Predicting consequences of future scenarios. Groundwater quality, Environment Canterbury

- Robson M (2014) Technical report to support water quality and quantity limit setting in Selwyn Waihora catchment Predicting consequences of future scenarios: Overview Report.

- Scott, D. and Weir, J., 2014. Technical report to support water quality and water quantity limit setting process in Selwyn Waihora catchment. Predicting consequences of future scenarios. Groundwater quantity.

6 I have also read the relevant parts of the Officers section 42A Report.

SCOPE OF EVIDENCE

7 In my evidence I have been asked to provide comment on:

7.1 The appropriateness of the groundwater allocation limits proposed for the Selwyn-Waihora groundwater catchment.

7.2 My assessment of current allocation in the catchment.

7.3 The circumstances in which transfer of water occurs in the catchment.

8 Although this is a Council hearing, I have read the Expert Witness Code of Conduct set out in the Environment Court's Practice Note 2011. I have complied with the Code of Conduct in preparing this evidence and I agree to comply with it while giving oral evidence before the hearing committee. Except where I state that I am relying on the evidence of another person, this written evidence is within my area of expertise. I have not omitted to consider material facts known to me that might alter or detract from the opinions expressed in this evidence.

OVERVIEW OF THE HYDROLOGICAL SYSTEM

9 The conceptual model of how the catchment works is summarised in the S42A report (6.3, 6.4). I generally agree with the conceptual model.

10 It is widely accepted that the Selwyn Te Waihora hydrological system is highly dynamic, with inflows and outflows constantly changing as the system attempts to come to an equilibrium. It never reaches an equilibrium state as something is always changing.

11 The natural hydrological inputs into the system are river recharge, which varies according to river flows, and land surface recharge, which varies according to the influence of climate on the water balance. The natural hydrological outputs are lowland stream flows, discharges back to the main rivers, and outflows directly to the sea.

12 Scenario 0 (the simulated natural state) in Table 4 Council Report R14/16 provides the relative proportions of inflows and outflows. It shows that hydrological through-flow is in the order of 80 m^3/s (2,500 million m^3/year), bearing in mind that this figure includes the sum of losses and gains in the system and therefore will be overstating actual through-flow by 10- 20%.

13 Table 4 shows that lowland stream flow outflows are not more than 30% of the total outflow, recognising that some of the stream outflow shown in Table 4 is back to the Rakaia River or in losing/gaining reaches of individual streams.

14 Irrigation takes water out of the system – physical pumping but also results in additional recharge back into the system (rain falling on irrigated ground and application loses). The hydrological system responds to those changes by adjusting outflows to again try to bring the system back into equilibrium.

15 Table 4, Scenario 1, shows how the water balance changes due to abstraction. It shows a reduction in both stream flows and discharge. I note that the assumed pumping in this scenario is 517 million m^3, which came from Mr Scott's water balance modelling and which I consider to be excessive because the modelling has not reproduced current irrigation practices, it has not included current on-farm allocation limits and has made several other assumptions that result in an overestimate of demand. I have given full details in the evidence I provide to Central Plains Water Limited on this point.

16 My view is that this is one of the reasons why the predicted effects of irrigation on lowland stream low flows appear to me to be excessive.

17 In terms of relative hydraulic responses in the natural system, variations in land surface recharge are the primary driver of variations in groundwater levels. Changes in river flows do affect groundwater levels, but at a much smaller magnitude. Groundwater levels drive lowland stream flows, particularly groundwater levels in the spring capture zones (essentially below SH1). They also drive outflow volumes to the sea.

18 Groundwater professionals generally accept that variations in abstraction volumes for irrigation (or any other use) cause further variations in groundwater levels. Taking water out of the system lowers groundwater levels and decreases discharge to the ocean and flows in lowland streams.

19 There is no disagreement around the fact that recharge to groundwater and abstraction from groundwater are the main drivers of groundwater levels and therefore lowland stream flows and that irrigation from groundwater causes a net lowering of groundwater levels. The issue is by how much, and whether that effect is acceptable.

20 Figure 1 below presents modelled irrigation demand, drainage under irrigated land and drainage under dry land for a location near Darfield. The figures are expressed in terms of depth (mm) and do not reflect the overall volumetric effect on the groundwater system.

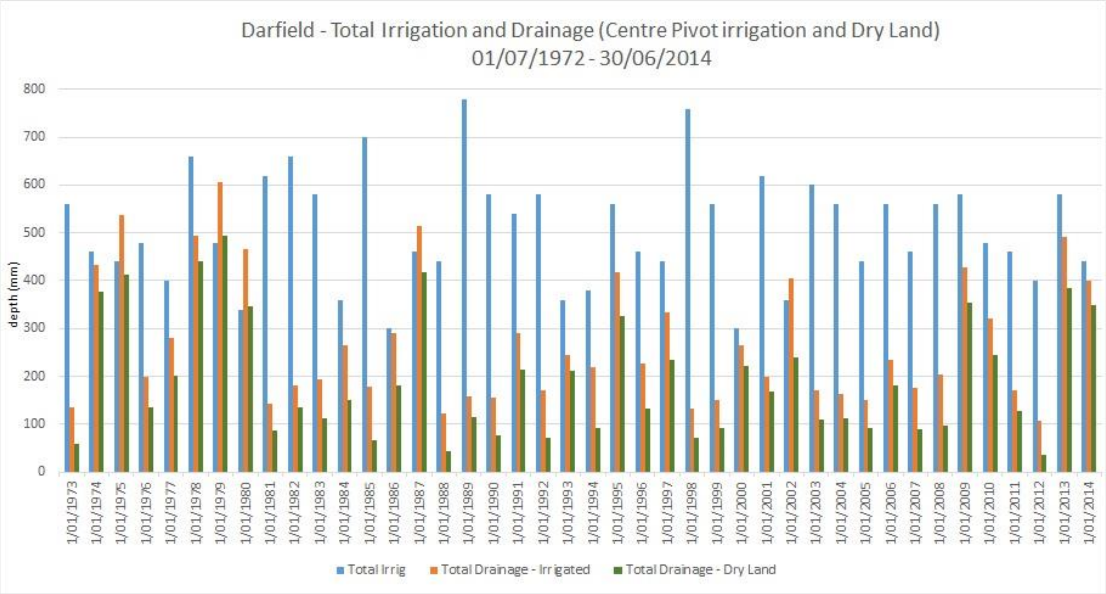


Figure 1: Example of irrigation and drainage (land surface recharge) in Central Canterbury.

21 On an annual basis, dryland recharge varies hugely, from next to nothing to up to 500 mm at this site. The annual sequences of low recharge periods have the greatest impact on groundwater levels and therefore stream flows.

22 Low recharge periods such as 1987-1989 and 2003-2005 have had a major impact. On the other hand, high recharge periods such as in the late 1970's, 1986 and 2012-2014 have produced high groundwater levels and stream flows.

23 Figure 2 shows how groundwater levels fluctuate with varying recharge.

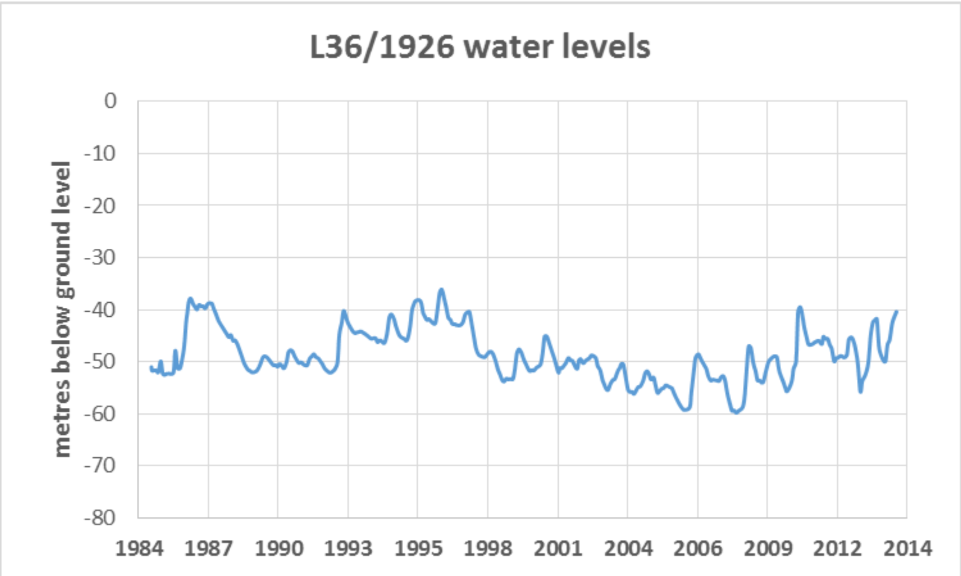


Figure 2: Measured bore water levels for L36/1926 – mid plains.

24 Fluctuations in bore water levels reflect the changing recharge patterns. As examples, low water levels were experienced in 2005 following the low recharge period of 2003-2005. High (near record) levels are now being experienced following two consecutive years of above average recharge, despite the fact that 2011/12 recharge was very low. Despite the fact that the water level record in Figure 2 does include the impacts of abstraction, water levels have been on an upward trend since 2007.

25 Lowland stream flows follow a similar pattern. I do not have a graph of historical stream flow (none of the CRC graphs presented in their reports include recent data), but the flow for Harts Creek over the last year (see Figure 3) is reflecting the impact of generally high groundwater levels and instances of quick flow due to direct or near direct runoff.

26 Despite there being many references to “declining trends” or “downward trends” in stream flows in the CRC reports, my view is that if recent data is included, the trends may not be so obvious, or there may be upward trends. Downward trends are not apparent in the measured levels in groundwater bores, which we agree generally drive stream flows, so if lowland stream flows are in fact still trending down, there may be other reasons.

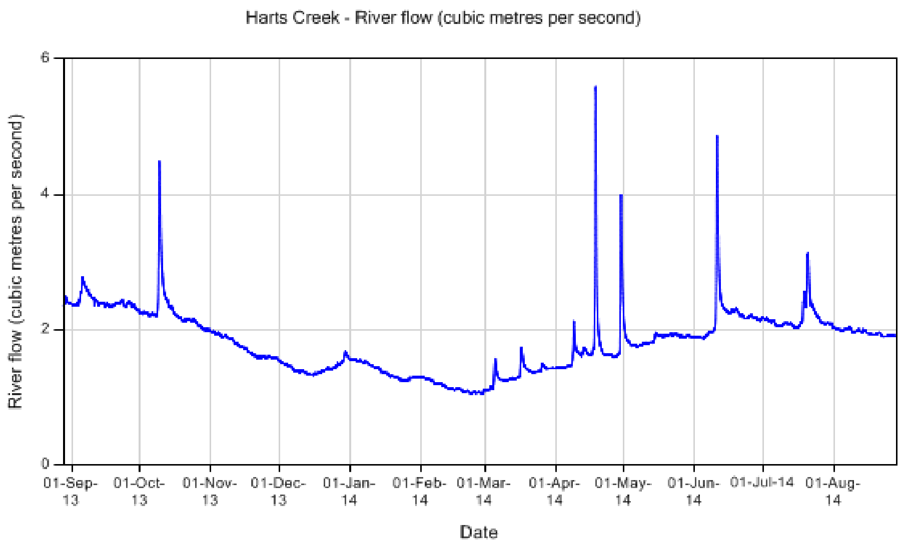


Figure 3: Measured flow in Harts Creek.

27 Irrigation demand also fluctuates widely. Two years that stand out in Figure 2 are 1988/89, which was a 1:100 year drought in Central Canterbury, and 1997/1998, where the eruption of Mt Pinatubo drove temperatures to very high levels. Conversely, years such as 1999-2000 had very low irrigation demand.

28 Regardless of how much water is abstracted for irrigation, the risk of very high groundwater levels and stream flows or very low groundwater levels and stream flows will remain. Both groundwater levels and stream flows are very high at the moment. The risk is that the effect of low groundwater levels combined with high groundwater use will cause stream flows to go below an acceptable level.

29 According to the Council (S42a, 13.3), there are many groundwater takes distant from the lowland streams and individually they may not have a measurable effect on flows. But due to the large numbers (over 2000) there is a large cumulative effect on the lowland stream flows.

30 I have read the Council reports and I cannot find any specific information or measurements that support the comment that due to the large numbers (2000) there is a large cumulative effect on the lowland stream flows. I address this point in my evidence below.

THE PROPOSED GROUNDWATER ALLOCATION LIMITS

31 Table 11(e) in Variation 1 provides the relevant groundwater allocation limits for the area, as follows:

Zone	**Allocation limit** (million m^3/y)
Selwyn-Waimakariri (SW)	193
Rakaia-Selwyn (RS)	180
Little Rakaia (LR)	85.9

32 The zones are as shown in Figure 4.

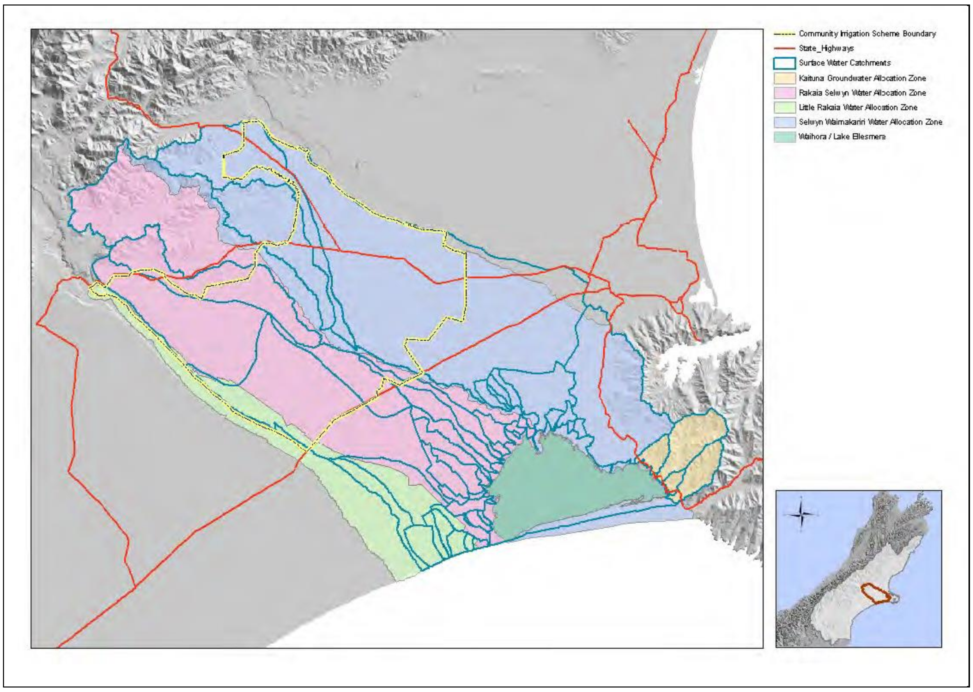


Figure 4: Groundwater allocation zones (from S32 p 129).

33 We have been told that the water allocation limits in Tables 11(e) 11(f) and 11(g) in Variation 1 are set at a level that would ensure low flows in rivers are protective of ecological and cultural values (S32 p143). Golders recommended target low flows of 90% of natural 7D MALF. Statements in various reports say that low flows of at least 80% of natural 7D MALF value have been targeted. However, I cannot find any technical data that specifically links the proposed allocation limits to a reduction in stream low flows.

34 An internal Council memorandum written by Clark in Nov 2012 describes a procedure for establishing limits, but does not include the numbers. An earlier memorandum on the same subject (Clark, Oct 2012) presents a range of numbers, but does not present the allocation numbers.

35 Eigen modelling has been used to estimate natural flows in five of the groundwater-fed streams, but that method of modelling is best used to indicate the general magnitude and timing of flow, not to produce accurate flows at specific times (Williams, 2011). That does not appear to have been used.

36 My assessment after reading several documents provided by the Council is that the allocation limits have been determined based on the 85th percentile of annual irrigation demand calculated by Mr Scott, and allowing for 30,000 ha of groundwater supplied irrigation in the CPWL Scheme area to be retired. It is also possible that adjustments have been made for

effective allocation (originally 85% of consented allocation when they were first calculated), but I cannot see how the actual allocation limits were obtained.

CURRENT ALLOCATION

37 Groundwater is by far the most exploited water resource in the catchment with total consented groundwater allocation, according to CRC being approximately 487 million m^3/year (S32 p 135). How accurate the allocation number is, I do not know but I believe it can be more accurately defined. The total in the allocation summary referred to in the S32 report and displayed on the ECan website is 453 million m^3/year.

38 Total allocation is the product of on-farm allocation per hectare and irrigated area. With respect to area, Aqualinc has accurately mapped actual irrigated area in the zone and found it to be about 90,000 ha with a 5% margin of error.

39 Consented irrigated area, based on the figure used by CRC in the analysis is 114,000 ha as far as I can tell. The extent of irrigation was derived from remote sensing data and the CRC consents database (Hill, 2012); drainage and nitrate losses are based on the Lookup Tables (Lilburne et al., 2010; Lilburne, 2013).(S42a section 6.26).

40 It is well known among groundwater professionals that it is a challenge to determine current allocation from the CRC consents database. The GIS analysis that we carried out at Aqualinc indicated that there may be some double-counting (land parcels with multiple consents) occurring in the CRC estimate.

41 The Zone Committee has identified healthy lowland stream and hill-fed rivers as priority outcomes while at the same time providing highly reliable water for irrigation and an increase in irrigated area of 30,000 ha to approximately 140,000 ha in total. (13.5). This implies that existing consented irrigated area was assumed to be 110,000 ha by the zone committee.

42 Although it is unclear as to exactly what current allocation is, my view is that the numbers being used by Council are likely to overestimate allocation, or put another way, they will certainly not understate current allocation.

43 Regardless of what the actual allocation is, it is correct to say that the zone is currently over-allocated if the proposed allocation limits are adopted. However, in the long term if zone allocation limits are to be met (whatever numbers are ultimately arrived at), it is important that the correct actual allocation is determined. At the moment, I consider this is a work in progress and it can be done. At the end of my evidence I also suggest that the amount allocated to the “adaptively managed” consents should be treated differently. The whole point of those consents is to effectively create a different allocation block.

CURRENT USE COMPARED WITH FUTURE RECHARGE

44 The amount of water permanently removed from the groundwater system by irrigation sourced from groundwater is the difference between irrigated evapotranspiration and dryland evapotranspiration. We refer to the difference as net use.

45 Net use on a per hectare basis varies according to rainfall, evapotranspiration, soil type and crop type. It can be easily calculated using soil water balance models. I have done so using the Irricalc model and found it to range on average from about 130 mm/year on the heavier soils/ higher rainfall areas near the foothills up to about 350 mm/year on the lighter soils/ low rainfall areas near the coast. My analysis indicates that it probably averages somewhere between 200 and 250 mm/year over the zone. The figure we used in the Canterbury Strategic Water Study (2002), where this analysis was first carried out, was 180 mm/year.

46 Using 250 mm and applying it over 90,000 ha of actual irrigated area shows that irrigation is removing about 225 million m^3/year from the groundwater system. Although the net use is less than half of the CRC current allocation estimate of 487 million m^3/year, that allocation is based on a 9/10 year demand and does not account for return water, so the two numbers should not be directly compared. Typically, allocation should be about twice net use.

47 I indicated earlier that the flow through the groundwater system is a little under 2500 million m^3/year. What these figures show is that the groundwater system easily has the capacity to support the current net use of 225 million m^3/year. The issue is what impact the current level of abstraction has on stream flows.

48 Putting that aside and looking forward, CPWL is presently building an irrigation scheme to irrigate 20,000 ha with alpine water. The intention is to expand that to 60,000 ha.

49 The Scheme will bring about 300 million m^3 of alpine water into the zone for irrigation. 30,000 ha of new area will be irrigated and 30,000 ha of groundwater supplied irrigation will be replaced.

50 The net use on 30,000 ha of new irrigation will be about 75 million m^3/year. The net use on the existing 30,000 ha of groundwater supplied irrigation will stay the same as it is now, except that it will be supplied with alpine water. This means that 225 million m^3/year of new water (300 – 75) will enter the groundwater system as a result of the CPWL Scheme. This is the same as the net use of the existing 90,000 ha of irrigation, meaning that on average, the groundwater system will be returned to its natural state. Stream flows should therefore be close to their natural state.

51 The groundwater modelling (Table 4 in Report R14/16) carried out by Mr Weir for the Council fully supports my conclusion. It shows that stream flow totals for Scenario 2 (the scenario with the CPWL scheme operating with 30,000 ha of new irrigation) are virtually identical to Scenario 0 (the no irrigation scenario).

52 Williams (2014) para 6.5.1 states that the “additional” water will likely improve flows in the lowland streams. My response to that is that it definitely will and it will be approximately the same magnitude as the effect of current irrigation on stream flows.

53 Williams also states that the additional CPW water (Scenario 2) is still less than that required to maintain flows in the lowland streams. I am not sure what Williams means by “maintain”, but the Council report R14/16 states in Section 3.2 that “these changes result in the long-term average stream flows being approximately equal to the prediction under Scenario 0 (No Abstraction).” I can find no information that supports Dr William’s statement in any of the Council technical reports.

54 Williams in the same paragraph also states that the reliability of the CPW scheme may not be sufficient to result in surrender of current groundwater consents in the scheme.

55 I know that CPWL is developing a high reliability scheme. I have not done the numbers, but even if the scheme is not 100% reliable, and groundwater was used to improve reliability, the amount of groundwater taken out on a net basis will be very small compared to what would be taken if groundwater was the sole source. Also, the biggest proportion of recharge to groundwater would occur in the shoulders of the season when reliability is less likely to have any impact. Another point to consider is that low alpine river flows occur after prolonged periods of easterly conditions, when irrigation demand also tends to be low. In high demand (northwest) conditions, alpine river flows are high. Those are the conditions that occurred in the 1988/89 drought.

56 According to CRC, studies and recent water use data suggest that on average around 50% of the allocated volume of water is used. They state that if all the water that is allocated was abstracted there would be a significantly greater adverse impact on the lowland streams than at present. (13.4 S42a).

57 In my net use analysis above, I have assumed that 90,000 ha of land is fully irrigated. Because allocation has been based on fully meeting demand in 9 years out of 10, average use will be significantly less than that figure. Using Irricalc analysis, again assuming that the area is fully irrigated, I have determined that average use will typically range from 50-75% of the allocated amount, depending on location. The range is primarily due to climatic variation and is fully expected.

58 Dr Williams, in his assessment of water use in the zone (Williams, 2010) concluded that there was a wide range of percentage uses of average allocation, from 40% in some areas to 72% in the main dairy farming areas. It seems to me from these figures that the dairy farming areas are close to fully irrigating.

59 There are many reasons why all of the land consented for irrigation will never be fully irrigated all of the time. Williams gives several reasons in his report – breakdowns, crop rotations, regrassing areas, personal choice. Consent holders who have not been using their full allocation have had ample opportunity to transfer or sell their allocation but few have done so, despite there being a "shortage" of groundwater allocation.

60 From a hydrological perspective, I cannot agree that if all the water that is allocated was abstracted there would be a significantly greater adverse impact on the lowland streams than at present. If the allocated amount was being taken and used every year, a high proportion of that water would return to the groundwater system, (albeit with some nutrients). There would be no significant change in the water balance. In addition, pumping for nothing is costly, which disincentivises users from unnecessarily irrigating.

61 From the perspective of actual use, the reality is that individuals may fully irrigate in some years, but not in others. All users collectively do not take their full allocation all of the time. The principle of diversity of use is well established in irrigation schemes and is why schemes often design parts of their infrastructure to a lower lower capacity than the collective sum of peak takes. The diversity principle applies to a large collection of groundwater supplied irrigators. History tells us that it just does not happen, even in the driest of years. It means that allocating on the basis of full irrigation use is a very conservative approach.

CRC'S RESPONSE TO THE OVER-ALLOCATION ISSUE

62 According to the Council, existing allocation is estimated to significantly exceed the proposed limits by 27% and 64% in SW and RS respectively. (13.8 in S42a). This state has obviously occurred because of where the allocation limits have been set and how estimates of existing allocation relates to those limits.

63 A number of initiatives have been proposed in Variation 1 to reduce current allocation to the allocation limits. The policies and rules within Variation 1 (Section 13.7 in S42a) are said to be an integral part of the solution package. The main approaches in Variation 1 are:

64 "*Surface water and groundwater managed and allocated as one "combined resource" across most of the catchment. This is to reflect the interactions between them and that the base flows in the lowland streams are derived from groundwater coming to the surface via springs and that losses from the hill-fed rivers contribute to recharge of the groundwater system."*

65 I accept that it is logical to combine surface water and groundwater allocation provided that the surface water resources are wholly feeding into or taking water from the groundwater system.

66 *"Revised Allocation Zones to account for natural differences in the movement and availability of water within the catchment (including creation of a Little Rakaia Zone) and to provide a structure that allows surface and groundwater to be allocated as a "one resource" and help avoid further over-allocation."*

67 It makes sense to align sub-zone boundaries with the movement of water in the catchment. There may be some further adjustment necessary such as around Banks Peninsula, but I support the intent of the policy. The reference to "*help avoid further over-allocation"* is unnecessary in my view.

68 "*A change in approach to calculating allocation limits so as to retain low flows of 80 to 90% of the natural 7DMALF in the lowland streams taking into account the addition of alpine water to the catchment and retirement of a portion of groundwater takes. In this way the limits would protect ecological and cultural values*."

69 I cannot comment on the setting of low flows, but the reference to "*taking into account*……." is important. It means that in theory at least, allocation limits can be adjusted providing 80-90% of the natural 7DMALF is achieved. With reference to the words "so as to retain", in practice, it is impossible to prevent flows from going below 80-90% of the natural 7DMALF because they will do so naturally, regardless of whether there is irrigation or not. The wording of the policies and rules need to reflect that.

70 *"Managing the risk of transfers of surplus water leading to increased abstraction by preventing Central Plains Water shareholders from transferring their groundwater consents and in other cases requiring 50% of transferred water to be surrendered in zones that are over-allocated."*

71 I have not seen any technical evidence that supports this statement. Based on Aqualinc's involvement in consent applications to transfer water, my understanding is that it is rare for water to be transferred from unirrigated properties that hold consents to dry land properties that don't have consents. Most transfers are for top-up allocations – typically arable properties that have converted to dairy, or existing dairy needing more water.

72 Sales of water come from property subdivision, especially into lifestyle blocks. These properties have previously been irrigated, but after subdivision no longer need consents. Sales also come from irrigated farms that have improved the efficiency of irrigation, such as converting from boom irrigators to pivots, and ending up with some unused allocation.

73 I am not saying that transfers to dry land properties do not occur. What I am saying is that the additional use of water resulting from transfers will be small and that the issue is much smaller than the Council reports are suggesting.

74 "*Support for the storage of alpine water to enable Central Plains Water to provide its members with a reliable surface water supply that in turn will enable the retirement of a proportion of groundwater abstraction within the catchment and to provide resilience against the potential effects of climate change."*

75 I agree with the support for storage of alpine water. As I stated earlier in my evidence, development of the CPWL Scheme will mean that all takes outside of the CPWL scheme could continue, with natural flows being achieved. In fact, more groundwater takes can be accommodated (e.g. the existing 30,000 Ha of irrigation in CPWL included) if some reduction from natural state can be countenanced.

76 "*Redefining water allocation for all takes so that records of past use (moderated for climate driven demand in 8.5 out of 10 years) are taken into account. Records of actual use should allow requirements to be more accurately determined on a case by case basis and contribute to reducing the "paper" allocation of water where users have demonstrably been allocated more water than they need."*

77 I agree that water should be allocated to properties on the basis of need, determined using an agreed methodology such as Irricalc. I do not agree with the 8.5 years out of 10 frequency (evidence given below).

78 *"Support for Managed Aquifer Recharge (augmentation of groundwater) and Targeted Stream Augmentation (augmentation of stream flows) to improve flows, water quality and the ecological health of the lowland streams."*

79 Managed aquifer recharge is one of the proposals to improve lowland stream flows. The intention is to inject 2 m^3/s of alpine water into the groundwater system at the top of the Canterbury Plains over the winter months.

80 If that occurred on a continuous basis for five months (150 days) days, it would inject 26 million m^3/year of water into the groundwater system. In the big picture, that volume of water is small compared to the magnitude of the components of the hydrological system.

81 The effect of managed aquifer recharge on lowland stream flows is difficult to establish, as the response at the bottom of the catchment will be damped, and some of the water will go directly out to sea. The flow budgets from the groundwater modelling (Scenario 0 in Table 4 in R14/16) show that not more than 30% of groundwater through-flow ends up in the lowland

streams when the system is close to its natural state. That equates to an average flow of about 250 l/s over all of the streams, about 25 l/s per stream. It is a small number.

82 If managed aquifer recharge is implemented, it will reduce the risk of low flows at times of very low groundwater levels, but it could also have the effect of exacerbating issues with high groundwater levels, which creates land access and drainage problems in the lower catchment

83 Targeted stream augmentation is more preferable, as it could occur in the places where it is most needed at times when it is required. It deals directly with the problem. Fortunately, because of the natural variability in the system, in most years it will not be required.

8.5 VERSUS 9 OUT OF 10 ALLOCATION

84 The Section 42A report states:

85 13.11 Many submitters strongly oppose the provisions in Variation 1 that require allocation to take account of records of past water use and that it is based on fully meeting climate driven demand in 8.5 years out of 10 instead of 9 years out of 10.

86 *13.12 It is considered unacceptable to simply increase the allocation limits to accommodate higher reliability as this will mean accepting lower stream flows. Therefore, if allocation is to meet demand in 9 out of 10 years something else has to give or change*.

87 13.13 Reducing allocation to meet environmental outcomes whilst also maintaining reliability of supply for abstractors is challenging and requires a finely balanced decision. The submitters may want to expand on their requests for alternative approaches to the solution in more detail during the hearing.

88 CRC has not provided any analysis that clearly quantifies the effect of reducing the allocation from a 9/10 basis to 8.5/10 basis, either on stream flows or on farm production. All that has happened is that reduction factors have been applied to 5 demand years (see R16/14 Table 3) within the Zone Committee scenario.

89 Using Irricalc, Aqualinc has calculated the difference between 8.5 and 9/10 year allocation. Details of the analysis are provided in Appendix A. A summary of the results for 26 sites in the Selwyn Te Waihora zone for a range of soils, climate and two irrigator types (centre-pivot and Roto-Rainer) are presented in Figure 5 below.

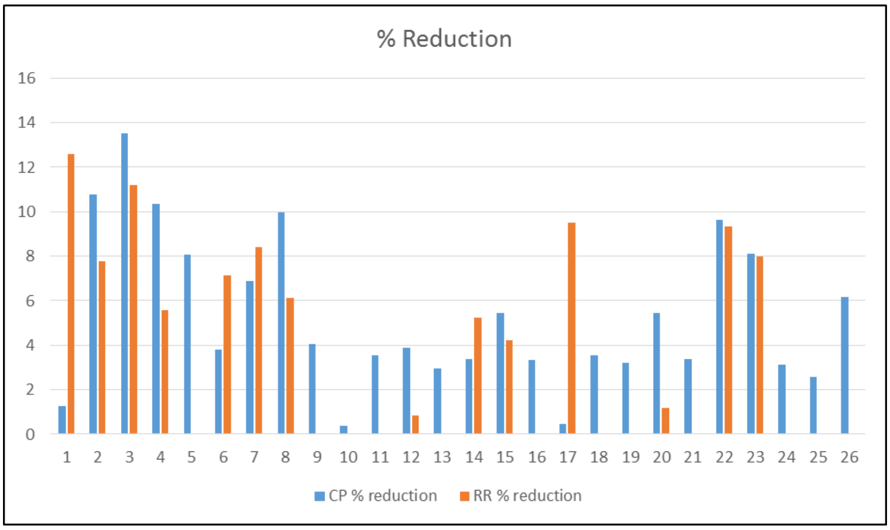


Figure 5: Percentage change in allocation under 8.5 and 9/10 options

90 The average reduction in allocation is 5.3% for centre-pivot irrigation and 3.9% for Roto-Rainer irrigation. Given that there is approximately the same area of centre-pivots and Roto-rainers in the zone, the impact on allocation will be in the order of 4.5%. Over the 26 sites, the reduction in allocation ranged from 0-13.5%.

91 A point I wish to reinforce is that while allocation is a fixed volume, actual use, which is what impacts on the environment, varies from year to year because of the effect of varying climate – rainfall and evapotranspiration. The average use of water, assuming fully irrigated pasture, is about 65% of the 9/10 year allocation and 68% of the 8.5/10 allocation. Average full irrigation use varies from season to season and typically ranges from 50% to 75% of the allocated amount, the differences depending on climate, soil properties and irrigation management.

92 Applying the 4.5% to the current allocation of 487 million m^3/year (the higher of the published figures), the reduction in allocation would be in the order of 22 million m^3/year. This is the same order of magnitude as the impact of managed aquifer recharge.

93 The impact of the reduction in allocation on lowland stream low flows will not be of the same magnitude. Firstly, the additional demand, which would be caused by a 1:10 demand year, would have to coincide with very low groundwater levels. Historically, that situation would have occurred in 1988/89, but even then groundwater levels were not near record lows. In the early 1970's, groundwater levels were very low, but irrigation demand was not particularly high. The instances when high demand coincides with low groundwater levels are infrequent. That being the case, this measure must be regarded as precautionary.

94 I do not accept the statement in S42a 13.12 that if allocation is on the basis of 9/10 years rather than 8.5/10 then something else has to give. It really depends on what else happens. If

CPWL goes ahead with 60,000 ha of irrigation, then the reduction in allocation is unnecessary to meet the 80% 7D MALF low flow target.

SUMMARY OF MY FINDINGS

95 Before suggesting alternative allocation limits, I recap on my findings.

96 With respect to the soil water balance modelling and groundwater scenario modelling, as reported in the Council report R16/14, I have referred to a number of issues with the modelling in detail in my CPWL evidence and added further comment in this evidence.

97 I accept that the outputs from Scenario 0 are probably the best we have at the current time as far as estimating natural stream flows are concerned.

98 My view is that the Scenario 1 modelling is over-predicting the impact of irrigation on lowland stream flows. The modelled flows at least for the last 8 years or so, should be consistent with measured flows and they are not.

99 The Scenario 2 modelling results predict that stream flows will broadly return to their natural flows. I agree with that prediction – it is consistent with my own big-picture independent modelling. Even though I question the Scenario 1 modelling, I think that the errors in the estimates of irrigation demand and drainage essentially cancel out in Scenario 2.

100 I accept that a target of allowing abstraction to not cause a reduction in stream flow 7DMALF to go below 80% of the natural 7DMALF has been chosen and that in principle groundwater allocation limits have been set to achieve that target. However, I have not seen any calculations that show how the allocation limits have been determined and linked specifically to that target and cannot reconcile it with the Scenario 2 modelling results.

101 I have assumed that current allocation is in the order of 487 million m^3/year. I have presumed that allocation is for the SW and RS zones only, and excludes Lower Rakaia. The proposed new allocation limits are 373 million m^3/year. I am not certain that the Council has correctly determined current allocation, but accept that if the proposed allocation limits are implemented, a significant degree of over-allocation exists. The numbers above suggest an over-allocation figure of 114 million m^3/year.

102 I do not have the exact allocation numbers for the 30,000 ha of groundwater in the CPWL command area, but I expect it would require an allocation of about 180 million m^3/year. If only Stage 1 of CPWL proceeds, the corresponding groundwater allocation is about 60 million m^3/year on 10,000 ha, which would partially offset the current over-allocation. On paper, that would reduce over-allocation to 54 million m^3/year.

103 The surrender of 10,000 ha worth of groundwater allocation and irrigating 20,000 ha of land with alpine water benefits the groundwater system by 75 million m^3/year. That is equivalent to an allocation of about 150 million m^3/year. That in itself virtually elminates most of the over-allocation (114 + 60 -150 = 24 million m^3/year).

104 In my view, if the CPWL scheme proceeds to 60,000 ha and with that 30,000 ha of groundwater takes are surrendered, further allocation is possible given that lowland stream flows will be close to their natural flows and that the allocation limit has been established based on allowing a reduction in natural flows.

105 I accept that measures such as managed aquifer recharge, reducing allocation to 8.5/10 years, full or partial surrender of consents during transfer will contribute to higher groundwater levels and stream flows, albeit each in a relatively small way. I do not accept that these measures are necessary to restore flows in the catchment to 80% of 7DMALF or even near natural state.

106 I believe that targeted stream augmentation is appropriate if it is found necessary to raise groundwater levels and stream flows in some locations in some years.

ALTERNATIVE LIMITS

107 I fully accept that allocation limits are required. I also accept that, given the nature of the hydrological system, setting limits is a cumulative issue, so a cumulative effect solution is appropriate. Specific effects on particular streams is appropriately dealt with by applying measures such as minimum flows on takes from or connected to surface water.

108 Regardless of how the currently proposed allocation limits have been determined, the intention behind the limits is to allow for irrigation abstraction to have a measured (but acceptable) effect on groundwater-fed stream low flows.

109 Within the currently assessed allocation, there are a number of consents (about 103 consents with approximately 60 million m^3/y of allocation) that have what is known as adaptive management conditions on them. Those conditions were specifically designed to prevent the abstraction allowed under those consents from having more than minor effects on stream low flows. The consents were granted on top of the allocation limits in place at the time of granting.

110 The allocation associated with those consents should not be included in the primary allocation block that is designed to meet lowland stream flow targets because the conditions require them to not take water (perhaps for a whole season) if groundwater levels are low. They are equivalent to “B” permits on a surface water supply, and should be included in a separate “B” allocation block that is on top of the primary allocation block. For simplicity, the size of the allocation block should be equal to the allocation under those consents, which is about 60

million m^3/year. That will address a significant part of the over-allocation currently in the primary allocation block. It is difficult for anyone other than the Council to figure out precisely how much water is allocated under these consents. My reading of the Reports suggests it has not been attempted.

111 Both the Council groundwater experts and I agree that if the CPWL scheme fully develops its 60,000 ha scheme, the groundwater system and the lowland stream flows will be in a state that is pretty close to the natural state. Current groundwater-supplied irrigation area would be reduced by about 30,000 ha.

112 That being the case, there is little point in introducing measures to reduce allocation from a water quantity perspective. I include the 8.5/10 year allocation proposal, the restrictions and surrender of allocation on transfers, and managed aquifer recharge in the unnecessary measures.

113 I think there may be a place for targeted stream augmentation if there is a desire to maintain stream flows above their natural state. I think that decision is best made after CPWL has developed its scheme and flows have been monitored for a few years.

114 The allocation limits for the primary block for the remaining groundwater consents not taking water from the CPWL scheme as a minimum could be made equal to the current allocation of those consents. If the system is returned to a "natural" state with the introduction of CPWL, that allocation can be accommodated. I make that statement assuming that the "natural" state is acceptable.

115 With CPWL operational, the "adaptive management" consents could also be included in the primary allocation block as they are already counted for as part of the actual allocation. The low water level conditions could be removed. The system would, cumulatively, still return to a Scenario 0 or natural state.

116 I used the words "as a minimum" above, because CRC has proposed the current allocation limit on the basis that a defined reduction in lowland stream 7DMALF is acceptable and allowed.

117 If CPWL returns the system back to a "natural" state as is modelled, there should be room to allocate additional groundwater that has been allowed for in the reduction of 7DMALF. That is especially the case if targeted stream augmentation is implemented. On this basis, the amount of groundwater used for 30,000 ha of irrigation within the CPW area (amounting to an allocation of about 180 million m^3/year) could be catered for.

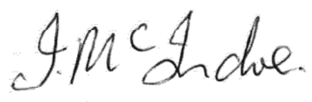
118 I suggest a stepped approach to allocation that takes into account the staging of the CPWL scheme development.

119 Stage 1 will remove most of the current over-allocation. The groundwater levels and lowland stream flows are currently very high. It will take two or three years of low recharge to cause seriously low levels. By then, CPWL Stage 1 will be operational and hydrological responses to the scheme development can be measured. From a water quality perspective there is no need to implement an allocation reduction programme in the short-term, as long-term it will probably not be needed. As Stage 1 is definitely proceeding, there is very little risk in irrigation causing the 80% 7d MALF thresholds from being exceeded. I consider that allocation limits can be set at current levels of allocation for now, with the proviso that the CPWL groundwater consents cannot be transferred.

120 Once Stages 2+ of the CPWL scheme are in place, further allocation could be considered. That could include transfer of the CPWL groundwater consents.

121 Long-term, I agree with CRC (13.55, S42a) that a dynamic (adaptive) water allocation regime based on groundwater levels may be an efficient way of allocating water in the long-term. I also recognise that now might not be the time to do that, so suggest that it re readdressed at a later date.

Dated 29 August 2014



Ian McIndoe

APPENDIX A

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Memorandum

To:	Ian McIndoe	21 July 2014
From:	John Knight	
Subject:	**Modelled irrigation demand changes – 90th percentile vs 85th percentile**	

Introduction

Schedule 10 of Variation 1 of the Proposed Canterbury Land and Water Regional Plan states that "*within the Selwyn-Waihora catchment method 1 shall determine seasonal irrigation demand based on eight and a half years out of ten*." This contrasts with the test for reasonable use under the Schedule 10 of the notified version of the pLWRP, which is based on demand conditions that occur in nine out of ten years. The purpose of this investigation is to estimate the reduction in allocation volumes that will occur by changing from a 90th percentile demand requirement to an 85th percentile demand requirement.

Methods

26 sites covering a range of different soils types (PAW 61.8 – 256) and climates were selected across the Selwyn-Waihora Catchment. Seasonal irrigation demand for these sites was modelled using IrriCalc for two different irrigation methods (Centre Pivot and Roto-Rainer). Soil PAW values were obtained from Landcare's S-Map GIS layer, and climate data were obtained from NIWA's Virtual Climate Network.

Table 1: Key modelling parameters

Parameter	Value
Irrigated Area	100 ha
Centre Pivot - Irrigation return period	4 days
Centre Pivot - Target soil moisture level	20 mm
RotoRainer - Irrigation return period	10 days
RotoRainer - Target soil moisture level	50 mm
Uniformity Coefficient	80%
Water loss	5.0%
Soil Profile Available Water (0-60cm)	Range: 68 - 256
Rainfall timeseries	NIWA VCN
Reference evapotranspiration timeseries	NIWA VCN

Model simulation period	1 Jan 1972 – 1 Jun 2012

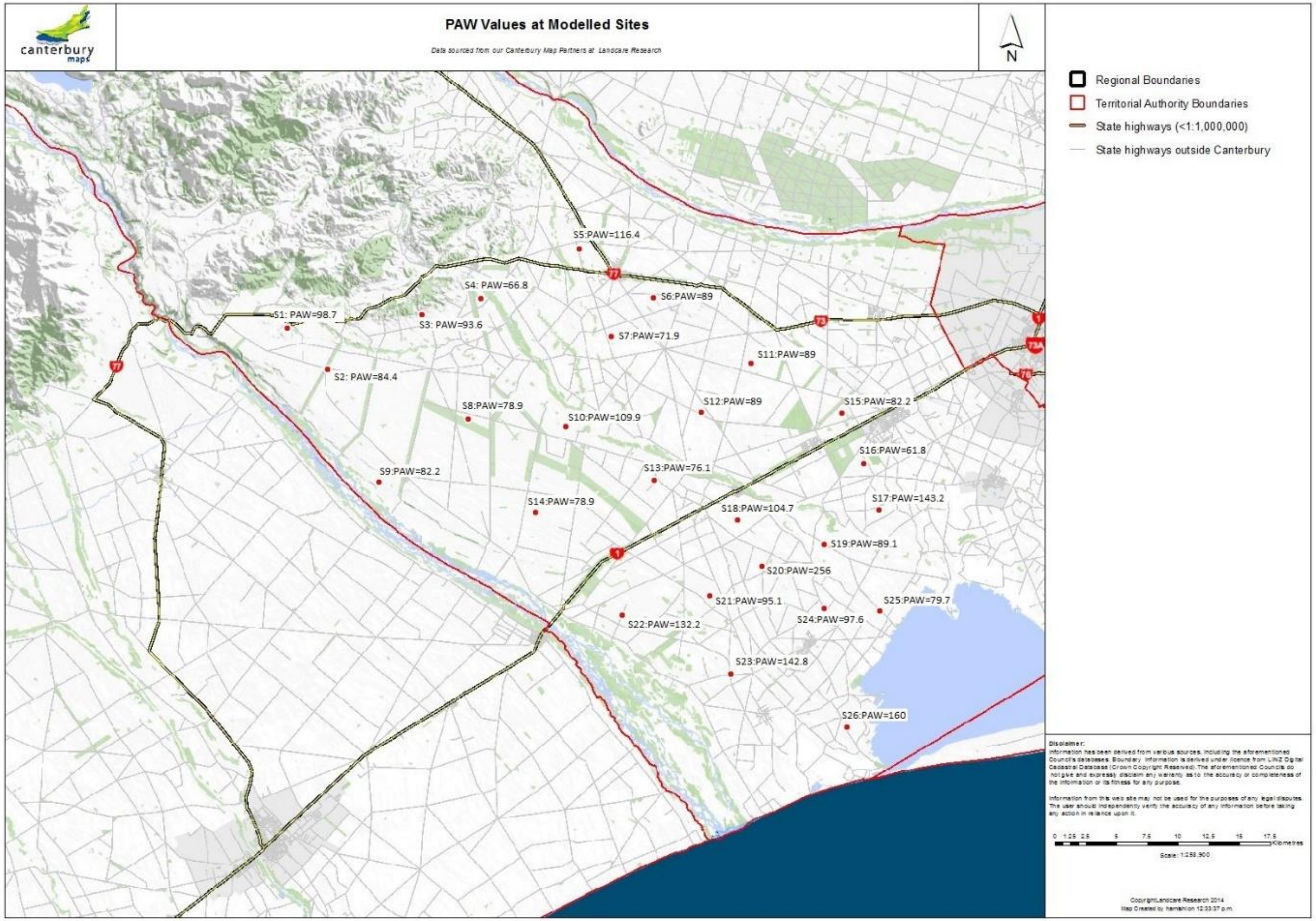

Figure 1: PAW Values at Modelled Sites

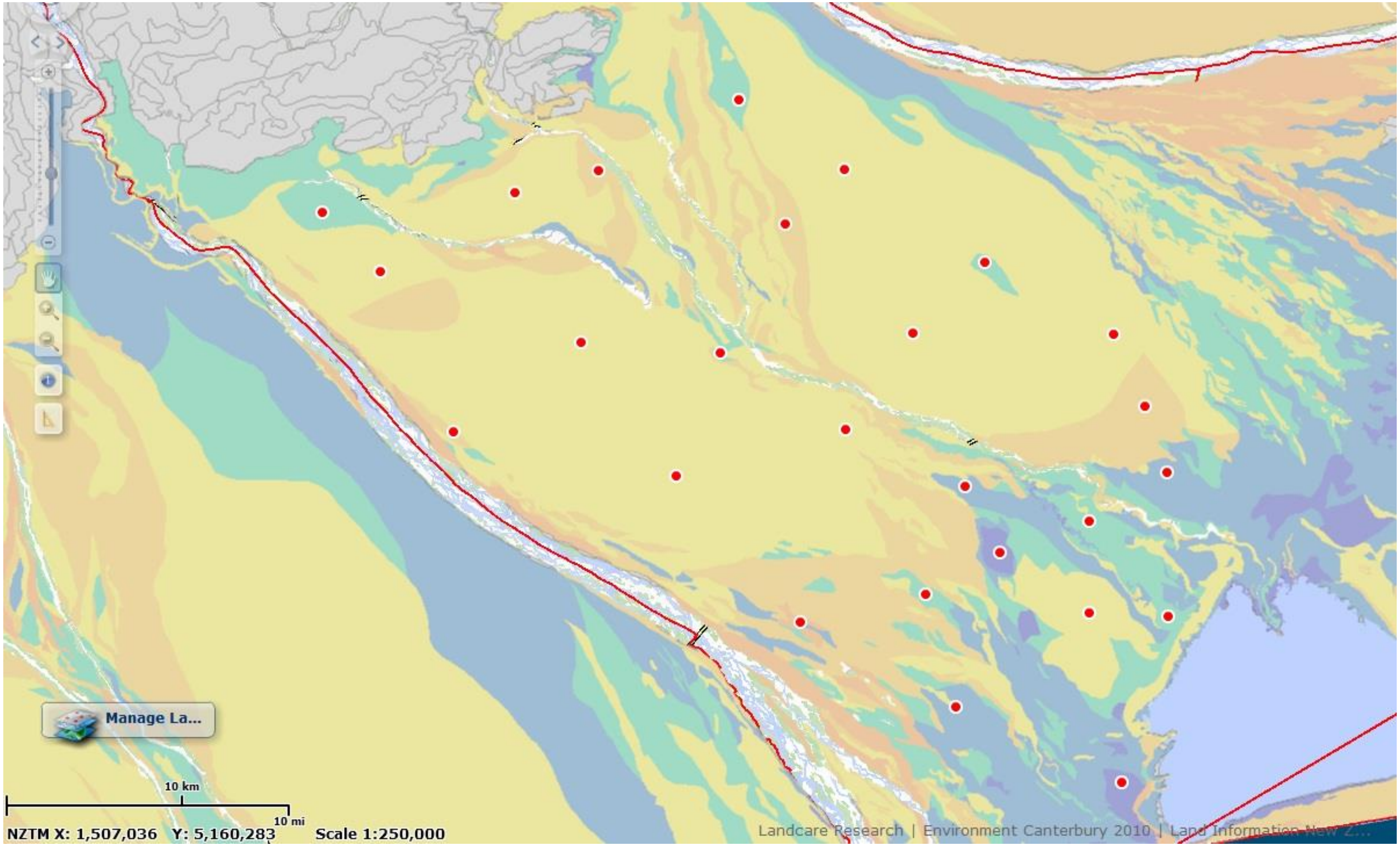

Figure 2: Soil Types at Modelled Sites

Demand modelling

IrriCalc was used to model irrigation demand for an eight and a half years out of ten scenario, and a nine out of ten years scenario. The results are given in Appendix 1. The average reduction in allocated volume was **5.27%** for centre-pivot irrigation and **3.92%** for Roto-rainer irrigation with a range of 1.25-13.5% and 0-12.59% respectively.

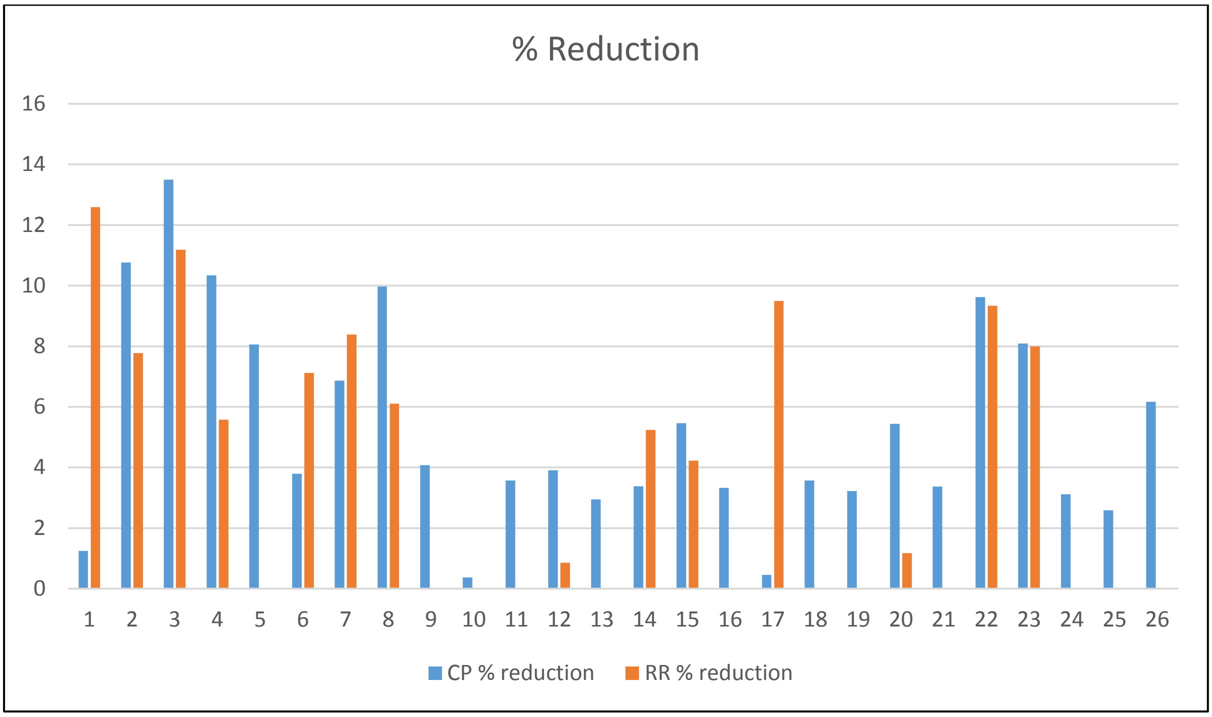

Figure 3: reduction in modelled irrigation demand at each site

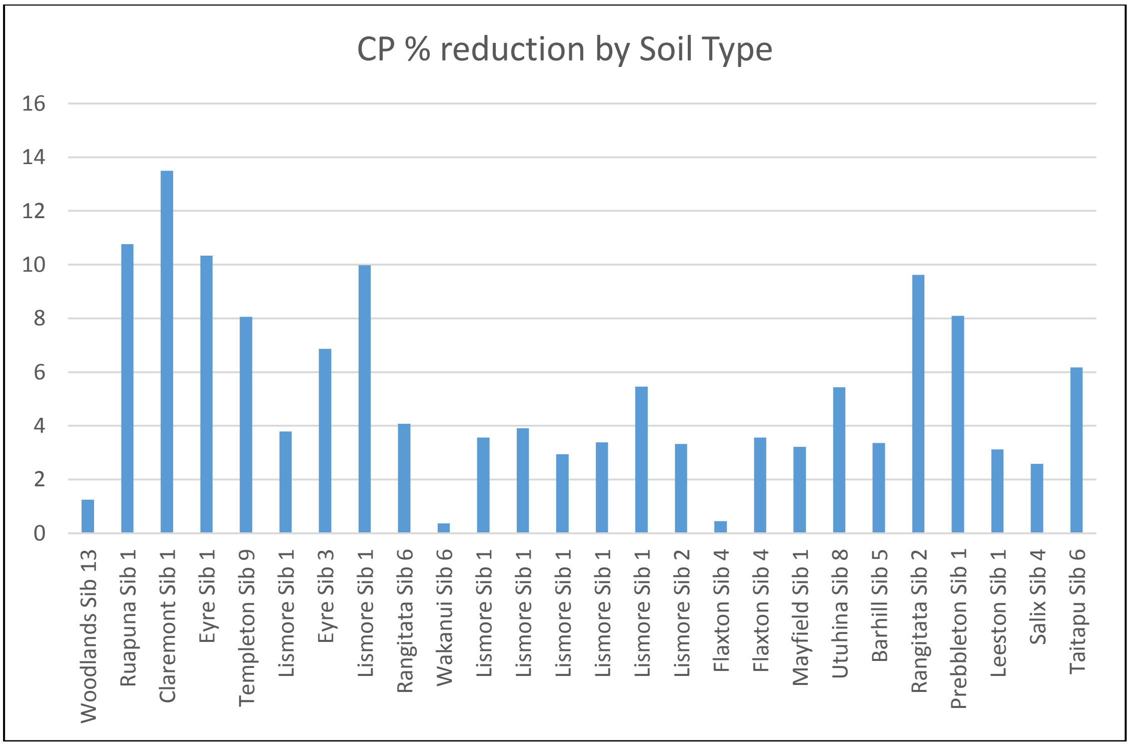

Figure 4: demand reduction for site soil type using centre pivot irrigation

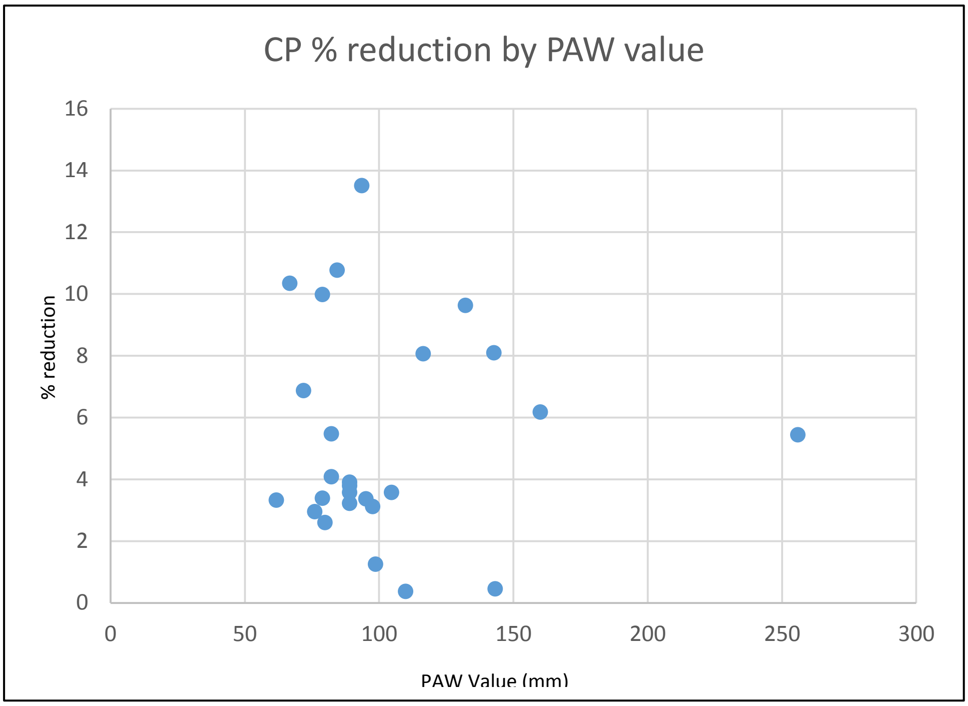

Figure 5: Demand reduction for site PAW value using centre pivot irrigation

Appendix A: Summary of Results

Site	X	Y	PAW (60 cm)	Soil Type	CP 90% - depth	CP 85% - depth	CP % reduction	CP 90% - vol	CP 85% - vol	% reduction	RR 90% - depth	RR 85% - depth	RR % reduction	RR 90% - vol	RR 85% - vol	% reduction	VCN
1	1501116	5180292	98.7	Woodlands Sib 13	320	316	**1.25**	320000	315790	1.32	421	368	**12.59**	421050	368420	12.50	19138
2	1504420	5176852	84.4	Ruapuna Sib 1	381	340	**10.76**	381055	338998	11.04	579	534	**7.77**	578950	534215	7.73	18723
3	1512030	5181284	93.6	Claremont Sib 1	400	346	**13.50**	400000	346314	13.42	474	421	**11.18**	473680	421050	11.11	18995
4	1516696	5182630	66.8	Eyre Sib 1	358	321	**10.34**	357890	321055	10.29	789	745	**5.58**	789470	744735	5.67	19173
5	1524826	5186748	116.4	Templeton Sib 9	484	445	**8.06**	484210	445268	8.04	579	579	**0.00**	578950	578950	0.00	18840
6	1530683	5182739	89	Lismore Sib 1	528	508	**3.79**	528425	508419	3.79	632	587	**7.12**	631580	586845	7.08	19185
7	1527372	5179630	71.9	Eyre Sib 3	568	529	**6.87**	568420	529478	6.85	632	579	**8.39**	631580	578950	8.33	18841
8	1515800	5170883	78.9	Lismore Sib 1	381	343	**9.97**	381055	343157	9.95	737	692	**6.11**	736840	692105	6.07	18843
9	1508524	5167724	82.2	Rangitata Sib 6	442	424	**4.07**	442110	424209	4.05	579	579	**0.00**	578950	578950	0.00	18824
10	1523718	5172076	109.9	Wakanui Sib 6	549	547	**0.36**	549475	547370	0.38	632	632	**0.00**	631580	631580	0.00	18842
11	1538819	5177315	89	Lismore Sib 1	505	487	**3.56**	505260	487368	3.54	579	579	**0.00**	578950	578950	0.00	18824
12	1534784	5173422	89	Lismore Sib 1	512	492	**3.91**	512120	492036	3.92	584	579	**0.86**	584213	548950	6.04	20863
13	1530914	5167955	76.1	Lismore Sib 1	611	593	**2.95**	610531	592629	2.93	737	737	**0.00**	737840	737840	0.00	20793
14	1521191	5165310	78.9	Lismore Sib 1	592	572	**3.38**	591740	572111	3.32	745	706	**5.23**	745362	706214	5.25	18844
15	1546260	5173184	82.2	Lismore Sib 1	604	571	**5.46**	603574	571652	5.29	711	681	**4.22**	711003	681244	4.19	18867
16	1547977	5169235	61.8	Lismore Sib 2	632	611	**3.32**	632485	611055	3.39	745	745	**0.00**	745366	745366	0.00	15596
17	1549306	5165544	143.2	Flaxton Sib 4	444	442	**0.45**	444215	422110	4.98	474	429	**9.49**	473680	428945	9.44	15598
18	1537797	5164724	104.7	Flaxton Sib 4	505	487	**3.56**	505267	487368	3.54	579	579	**0.00**	578950	578950	0.00	15596
19	1544798	5162571	89.1	Mayfield Sib 1	653	632	**3.22**	652630	631580	3.23	737	737	**0.00**	737840	737840	0.00	20056
20	1539662	5160951	256	Utuhina Sib 8	423	400	**5.44**	423156	400000	5.47	426	421	**1.17**	426313	421050	1.23	15596

21	1535508	5158592	95.1	Barhill Sib 5	654	632	**3.36**	654630	631580	3.52	737	737	**0.00**	737840	737840	0.00	20054
22	1528335	5156979	132.2	Rangitata Sib 2	613	554	**9.62**	612635	553685	9.62	643	583	**9.33**	642834	582845	9.33	20743
23	1537331	5152348	142.8	Prebbleton Sib 1	618	568	**8.09**	618535	568420	8.10	638	587	**7.99**	636834	586845	7.85	20742
24	1544878	5157518	97.6	Leeston Sib 1	674	653	**3.12**	673680	652630	3.12	737	737	**0.00**	737840	737840	0.00	20055
25	1549346	5157237	79.9	Salix Sib 4	695	677	**2.59**	694740	676839	2.58	842	842	**0.00**	842110	842110	0.00	20056
26	1546690	5147870	160	Taitapu Sib 6	632	593	**6.17**	631580	592629	6.17	632	632	**0.00**	631580	631580	0.00	20054