IN THE MATTER OF: **AND**	The Resource Management Act 1991
IN THE MATTER OF:	Applications by Central Plains Water Trust to: Canterbury Regional Council for resource consents to take and use water from the Waimakariri and Rakaia Rivers and for all associated consents required for the construction and operation of the Central Plains Water Enhancement Scheme. Selwyn District Council for resource consents to construct and operate the Central Plains Water Enhancement Scheme.
AND **IN THE MATTER OF:**	A Notice of Requirement by Central Plains Water Limited to: Selwyn District Council for the designation of land for works associated with the construction and operation of the Central Plains Water Enhancement Scheme.

BRIEF OF EVIDENCE OF RICHARD SPENCER ENGLISH

Qualifications and experience.

1. My full name is Richard Spencer English.

2. I am professional civil engineer. My tertiary qualification is BSc (Hons) Civ. Eng. I am a Member of the Institution of Professional Engineers New Zealand and The Institution of Civil Engineers (London)

3. I have had both a direct and indirect involvement with the local aquifers for over twenty years. Over the last two years I have conducted a personal investigation into the hydrology of the Avon River and its tributaries.

Introductory Comments

4. At the outset I would like to state that, in principal, I neither support nor oppose the Central Plains Water Enhancement Scheme. My concerns revolve around the level of understanding we have of the hydrology of the aquifers that will be impacted upon by the Scheme

5. I wish to acknowledge Aqualinc's willingness to take part in the discussions on the topics I have raised and to thank them for the time they have spent answering my queries. This has been a useful exercise but I imagine that the adversarial nature of the Hearing has introduced a degree of circumspection into their answers.

6. Whilst Aqualinc have, I believe, advanced our knowledge there remains a good deal of uncertainty as to both the inputs and the way the hydrological system operates. As I will demonstrate, further research is urgently needed to reduce these uncertainties to acceptable levels, if we are to make resource management decisions that will provide us with sustainable outcomes. I have lobbied for some time on the need for research to be undertaken (in which I hasten to add I have no pecuniary interest) but these requests have generally fallen on deaf ears with respect to those who might fund the work (i.e. local and central government.) I believe that this is a <u>significant failure</u> on behalf of those authorities. Consequently I seek to have this matter recorded in the Decision of the Hearing.

7. A considerable amount of the community's present angst over schemes such as CPW could have been avoided if the relevant research had been conducted in a timely manner and in a less adversarial setting. Much better management of the resource would have eventuated to the benefit of the environment, to those seeking to utilise these resources and to the community in general. Ironically, and with due deference to the legal fraternity, if the money that is being expended on lawyers fees over the next year (or more) at the various hearings on the CPW scheme had instead been spent on research the community, the environment and those wanting to use the resources would have been much better off - both figuratively and literally!

Summary of Evidence.

8. In order to be able to predict the impacts of schemes such as that proposed by CPWT (for example on Christchurch's water supply) it is important that a clear understanding exists of the hydrology of the local aquifers. Unfortunately present knowledge of the hydrology of the central Canterbury Plains aquifers is limited. (Witnessed, for example, by the sometimes divergent views expressed by Expert Witnesses in the Evidence to this Hearing)

9. This is particularly the situation with respect to the quantum and locations of the losses, in the form of recharge into the aquifers, from the Waimakariri and Rakaia Rivers. Inputs into the aquifers from these two rivers are uncertain (estimates vary widely between 1/3 to 2/3 - or more - of the total recharge for the area under consideration) In addition the inter-relationship between flow loss into the aquifers and the underlying levels of those aquifers is at best ill-defined. It is of considerable concern therefore that crucial aspects of the data under-pinning the Aqualinc model - on which much of the applicant's Evidence on the scheme's impacts depend – are, through no fault of theirs, little better than "guesstimates".

10 I am therefore unconvinced as to the Aqualinc's model's appropriateness as a decision making tool given its present state of development and the uncertainty surrounding its under-pinning assumptions.

11 In my opinion these uncertainties are of such magnitude that the scheme should not be permitted to proceed at this time.

12 I also believe that the Scheme should not proceed at this time because of the consequent impact of the, albeit uncertain, hydrological changes predicted by the Applicant in increasing:-

- the potential for contamination to Christchurch City's drinking water supply both from nitrates and more particularly from the old landfills located on the western and southern perimeters of the urban area.
- the potential for nitrate contamination of the existing water supplies for the rapidly developing urban areas in the eastern sector of Selwyn District
- the potential for reduced confined aquifer pressures under Christchurch and a consequential increase in the potential for surface contamination to penetrate into the aquifers.
- the potential for negative impacts on the Avon and its tributary streams
- groundwater levels and the consequent reduction in the availability of aggregate resources for Christchurch City and the eastern sector of Selwyn District.

13 In the following sections I will provide more detailed information to support these contentions and will provide my brief, broad brush assessment of the potential impact of the scheme on the local aquifers.

14 At the end of my evidence in general I have appended some additional notes extracted from my critique of the relevant parts of the Applicant's Evidence and of the S 42A reports. I request that the Appendix is read as it contains many pertinent comments and in some areas provides further explanation of my stance.

15 Whilst I recognise that the Commissioners have heard a plethora of information regarding the aquifers I would like to take a few moments to re-cap on the salient points of the system's hydrology.

The Canterbury Plains

16 The Canterbury Plains are underlain by a considerable depth of permeable gravels, interspersed with layers and lenses of less permeable silts and clays. Water that originates from alpine foot hill run-off, rainfall soakage (or “infiltration”) and losses from the major rivers passes through these gravels to emerge either as springs, that feed the area’s lowland streams, or from below the sea bed a few kilometres offshore. The flow direction is generally south eastwards down the Plains

17 Over recent years levels in the central Plains aquifers have been declining (although there has been a partial recovery more recently in some areas) These declines are the combined result of reduced rainfall infiltration and increased irrigation demand The quantum of the impact of each component is however subject to considerable debate.

Christchurch – West Melton Area

18 Locally water leaks out of the bed of the Waimakariri River into the surrounding permeable gravels. From there the water travels underground - much like a river – again in a generally south easterly direction until it either intersects the ground surface, emerging as springs and bank seeps, or travels further underground below the impermeable, confining layers that sit beneath the majority of Christchurch city.

19 There are weak spots in these 'confining layers' which, if the underground pressure is high enough, will allow the water to leak out to the surface, again emerging as springs.

20 These local aquifers are the sole source of supply for the high quality drinking water on which the residents of Christchurch rely and on which they also rightly place such great importance.

21 This aquifer sourced water also supplies the majority of the base flow for our iconic River Avon - the actual volumes of water entering the river being directly dependent on the levels in the aquifer. (i.e. The higher the aquifer level the greater the flow and vice-a-versa.)

Inter-relationship between Aquifers.

22 Whilst the aquifers under study are often described separately they are in fact not separate entities. They are inter-connected hydraulically such that pressure changes in one will impact to a greater or lesser extent on the other.

23 For example it is agreed that abstractions from the aquifer(s) reduce aquifer levels. It is also recognised that reductions in aquifer levels in the central Plains can, to an extent, reduce levels in the aquifers close to Christchurch as a result of their interconnectivity. Conversely if aquifer levels rise in the vicinity of the central Plains then aquifer levels close to the city may also rise (The actual relationship between the quantums of these rises and falls is again subject to debate.)

24 These level changes have the potential to impact on flow directions within the aquifers.

THE AQUALINC MODEL.

Background.

25 A number of attempts have been made over the years to model the hydrology of the Canterbury Plains. As more scientific information and greater computing power becomes available then so has the accuracy of the modeling increased. (Aqualinc's being one of the more complicated recent modeling exercises.)

26 There is not unanimity amongst hydrologists about some aspects of the modeling processes. For example, ECan staff were quite critical of parts of the Aqualinc model at a previous resource consent hearing, a similar tenor to which appears in their S42A Reports to this Hearing

27 Despite the apparent accuracy of the output from some models there is still the potential for significant problems with the basic assumptions that underpin them. The adage of "rubbish in; accurate rubbish out" should always be borne in mind !

28 It is recognised that Aqualinc are attempting to model a very complex system and, understandably, they have therefore simplified aspects of the hydrology. The danger of course comes with over-simplification.

29 For example in the case of the rivers and streams in the model area Aqualinc have assumed a triangular cross-section such that as the flow increases not only does the depth of the river /stream increase but also so does its wetted perimeter. This might be a satisfactory representation of many rivers but it is debatable whether a triangular cross-section adequately represents braided rivers such as the Waimakariri.

30 As a further example of assumption uncertainty, Aqualinc's report L 07079/1 notes that "*Small changes in the stream bed conductivities of major rivers affected …. base groundwater levels".* However the report also states, with respect to river and stream parameters, that "......*there is no (or very limited) suitable data to compare measured and modeled river and stream parameters..."* and, with respect to parameters in addition to stream cross-sections, there is "........*substantial uncertainty in other river bed properties"* .

31 It should be remembered that once satisfactory model calibration has been achieved, there remain a large number of parameter combinations that could provide a similar calibration. Therefore, a calibrated model is simply one of a family of simulations that provide a reasonable range of parameters and responses under differing conditions. It does not necessarily prove that the individual parameters chosen are correct. Neither does satisfactory calibration therefore necessarily mean that a model is a suitable tool for predictive purposes.

Central Canterbury Plains Aquifer Recharge.

32 To re-cap, it is agreed by all parties that there are three basic recharge inputs into the system:

- Rainfall directly onto the Plains and its subsequent infiltration into the aquifers
- Rainfall run-off from the foot hills and its subsequent infiltration into the aquifers either directly or as losses from the foothill sourced rivers and streams (e.g. Selwyn River)
- Leakage losses from the major rivers into the aquifers (i.e. losses from the Waimakariri and Rakaia Rivers)

33 The quantum of the first recharge is reasonably well known as is the second although with less accuracy. However, in the case of the losses from the rivers into the aquifers the information is scant.

34 Aqualincs report (i.e. L 07079/1) notes that "......*recharge from the major rivers is significant in maintaining a relatively stable base groundwater level*." Indeed using data supplied by Aqualinc, for the area between the Rakaia and the Waimakariri Rivers, surface water recharge amounts to 57% of the total input into the system. The vast majority of this surface water recharge originates from the two, latter, major rivers in the area It is critical therefore that recharge from these rivers is modeled as accurately as is reasonably possible.

35 The Waimakariri River is the dominant influence on Christchurch area hydrology. If the assumptions embedded in the model with respect to the under-pinning relationships between flows in the river, recharge and the surrounding aquifers levels is incorrect then the outputs from the model as a whole will be in serious doubt. Accordingly I have concentrated my analysis of the model on these relationships.

36 It should be noted that the concerns expressed below are more than replicated in the case of the Rakaia where there is even less data available

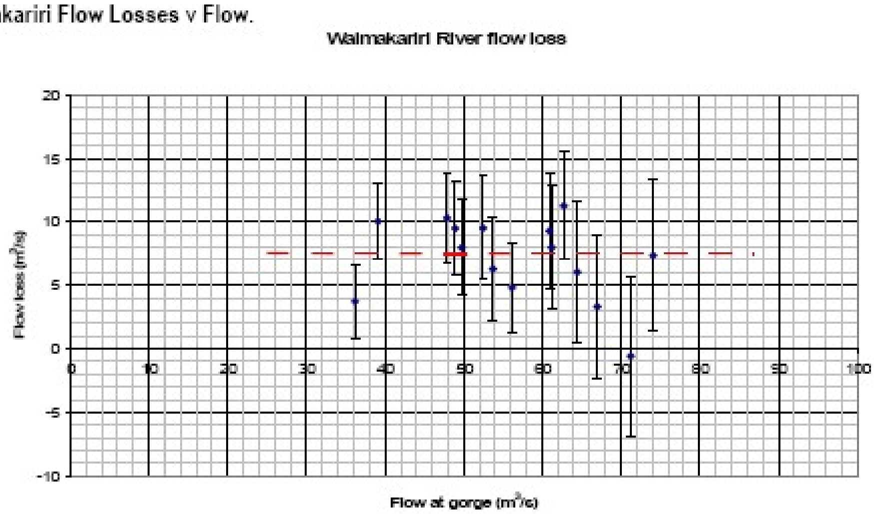
37 In the following paragraphs I have provided both a summary of the methodology I have used and background information which I believe is important in understanding the issues involved. Much of this information is either lacking from evidence so far presented by others and / or is not accounted for in the assumptions used by the Applicant.

Waimakariri River Recharge – 'Conventional' Theory

38 The 'conventional' theory has been to assume that the loss from the Waimakariri into the aquifer is constant (i.e. irrespective of the flow in the river.)

39 This hypothesis has arisen from a very limited number of flow loss readings taken by ECan and its predecessors over approximately the last thirty five years. This data is reproduced below. The bars associated with each reading are the estimated potential range of errors for that reading. (Note that there are other data sets available but ECan consider them to be unreliable)

Graph 1: Waimakariri Flow Losses v Flow.

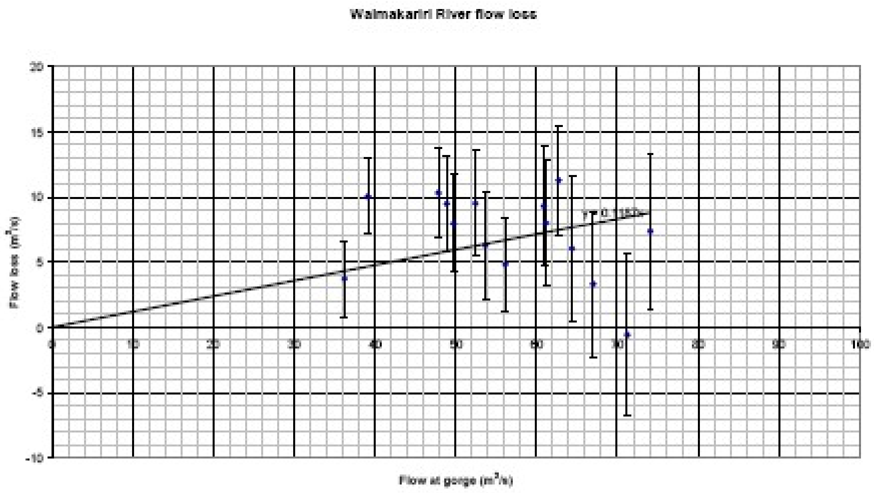


40 Clearly there are a scatter of results, however for the sake of simplicity the 'conventional' assumption has been to draw a horizontal straight line (shown red dashed) through the points - and hence the conclusion that flow losses are constant. This has given rise to the oft quoted loss from the Waimakariri being "7 to 8 cumecs" (Aqualinc have referred to this figure in their evidence as a partial validation of their model although it should be noted that they are not suggesting that the loss is constant.)

41 This is not an unreasonable conclusion to draw from the raw data although in my opinion it is a highly questionable one. Somewhat perversely for example, an inverse relationship could also be deduced such is the scatter of the results.

42 In contrast to the 'conventional' assumption, sensibly there will be no loss of flow at zero flow. If this point is added and a simple straight trend line is fitted then a quite different picture emerges.

Graph 2: Waimakariri Flow Losses v Flow (Zero Flow, Zero Loss Point added)



43 However the scatter of the results do not indicate a proven relationship particularly given the impact of these assumptions on the outcome of any modeling process.

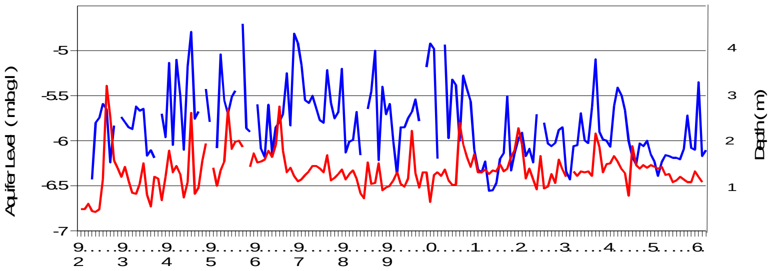
44 It should be noted that these readings were only able to be taken at relatively low flows (i.e. between 30 to 80 cumecs) whereas the average flow in the Waimakariri is around 120 cumecs and flood flows can be of an order of magnitude or more greater. One would also therefore have to question how well the readings represent the flow / loss relationship under more average, rather than low flow, conditions.

45 In view of these uncertainties, their importance to the modeling process and the whole hydrological outcome of the CPWT Scheme, I have attempted to test the underlying assumptions by other means.

Waimakariri River Depth and Adjacent Aquifer Levels.

46 Environment Canterbury's monitoring well at Mcleans Island (M35/0948) is immediately adjacent to the river, on its south bank. Monthly data from this well and the 'depths' and flows recorded in the Waimakariri River, at the old SH 1 Bridge, are plotted below.

Graph 3: Waimakariri Flow Depth(Blue) v Aquifer Level at Mcleans Island (Red)

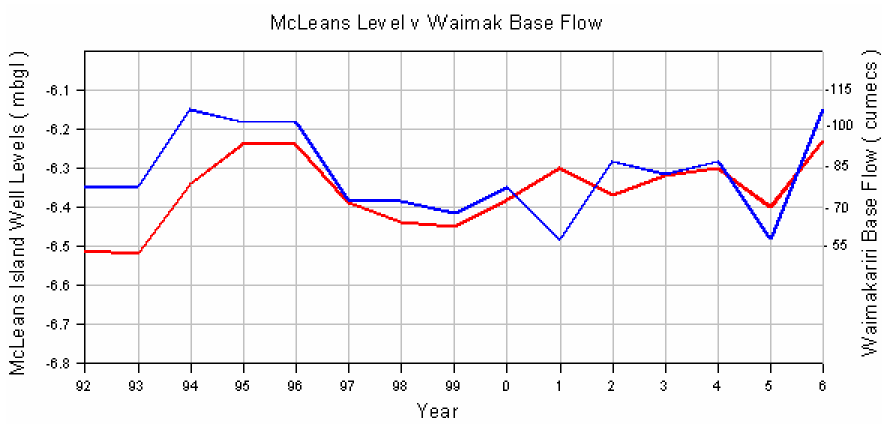


Only a weak relationship would appear to exist.

Waimakariri River Flows and Adjacent Aquifer Levels.

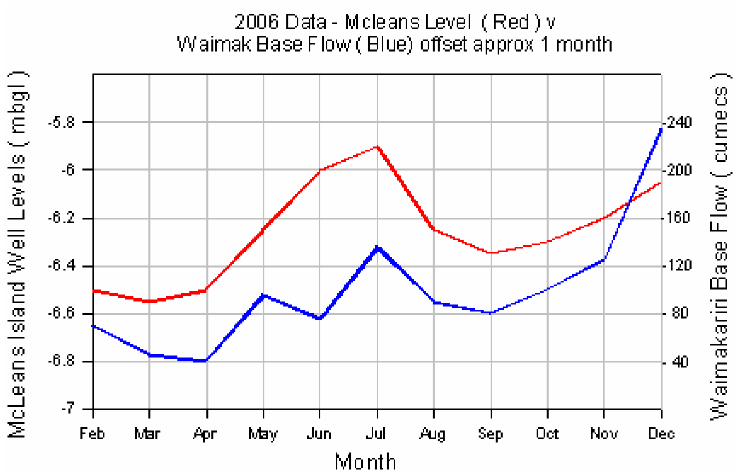
47 The annual average base flow in the Waimakariri - shown blue - (i.e. the annual average instantaneous flows excluding flood events) and the aquifer levels measured at Mcleans Island (shown red) over the period 1992 to 2006 were plotted and are shown below. There is a readily observable correlation between the two sets of data.

Graph 4: Waimakariri Base Flow (Blue) v Aquifer Level at Mcleans Island (Red)



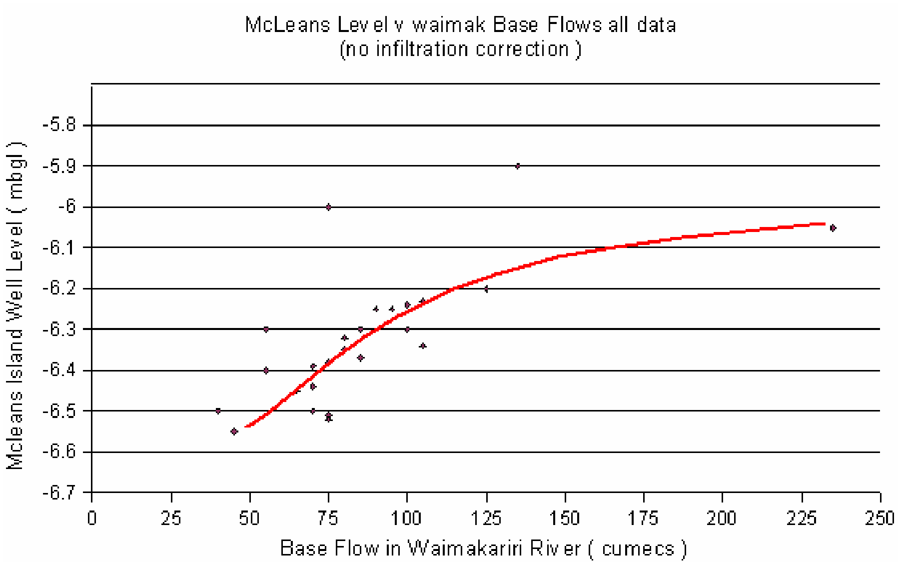
48 The monthly data for the 2006 has also been plotted. The relationship between base flows in the Waimakariri and aquifer levels at Mcleans Island is again observable.

Graph 5: Waimakariri Base Flow (Blue) v Aquifer Level at Mcleans Island (Red) - 2006



49 All flow and level data was then plotted together (some annual averages, some monthly readings)

Graph 6: Waimakariri Base Flow v Aquifer Level at Mcleans Island



Note: The postulated correlation shown - in red - is tentative only

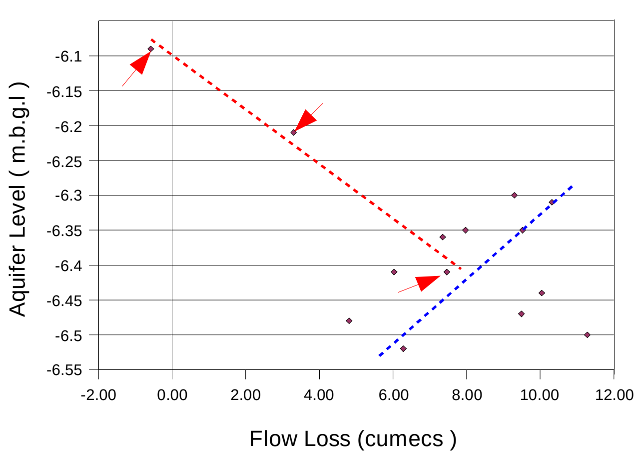
50 It is clear that there is a correlation between (at least base) flows in the Waimakariri and aquifer levels at Mcleans Island.

Losses from the Waimakariri River in relation to Aquifer Levels.

51 Rainfall infiltration also has the potential to produce (short term increases) in local aquifer levels. I therefore analysed the flow loss measurement data and compared it with rainfall infiltration data over the relevant time periods. (Note as I mentioned earlier only sixteen discrete measurements of flow losses have been undertaken by Environment Canterbury and its predecessors over a thirty five year time span.)

52 Three of the readings were found to have been taken when rainfall infiltration may have been influencing aquifer levels - arrowed in the diagram below (Note two flow loss readings could not be plotted as they pre-dated measurements at the Mcleans Island well.)

Graph 7: Mcleans Island Aquifer Levels v Measured Flow Loss from Waimakariri



Note: Possible Flow Loss (without rainfall infiltration effects) v Aquifer Level Relationship – Blue
Possible Flow Loss (for rainfall infiltration effects) v Aquifer Level Relationship - Red

53 Coincidentally the arrowed data point measurements were taken when the river was flowing at effectively the same rate on each occasion. It can be seen therefore that when the aquifer levels were high because of rainfall infiltration the flow losses were much less than for the same flow without infiltration impacts.

54 It would appear, for example, that at average base flow, a "back pressure" created by a rise in aquifer level of about only 300mm is sufficient to reduce leakage from the river to zero.

55 To place this in context it should be noted that the range in variation in aquifer levels at Mcleans Island, on an annual average basis, is approximately only 250mm.

56 It would appear significantly, therefore, that the quantum of the flow loss is very sensitive to the level of the adjacent aquifer.

57 NIWA have undertaken modeling work on the river's hydraulics by developing flow / depth and flow / width relationships. The results may be found in Greg Burrell's Response to Section S42A Officer Reports. (I am unfortunately unable to reproduce the data here as the document is copy protected)

58 It is interesting to note that NIWA reported that the average depth of the river is less than 0.5m and that even *"(A)s river flow more than doubled across the range of modelled flows from 41 to 85 m^3/s, mean water depth changed little, increasing from 0.34 to 0.41 m"* (i.e. a doubling of the flow only increased river depth by 100mm)

59 This suggests that changes in hydraulic head in the river and changes in aquifer levels are of the same order and I would suggest both are much smaller than one would have initially anticipated.

60 The graph also shows that the apparently anomalously low flow loss readings in Graph 1 were in fact logical.

61 It can therefore be concluded that changes in the aquifer level close to the river can be created by:

- changes in the flow losses and
- rainfall infiltration (and / or other influences on aquifer levels such as abstraction)

62 Sometimes these influences will act independently or on occasions the two will occur simultaneously. For example where there is increasing flow rates and rainfall infiltration the latter will increase the aquifer levels which in turn will tend to reduce the impact of rising flow rates by 'throttling' the flow losses from the river.

63 Summarising the information from Graphs 6 and 7 it can be seen that there is a clear relationship between:

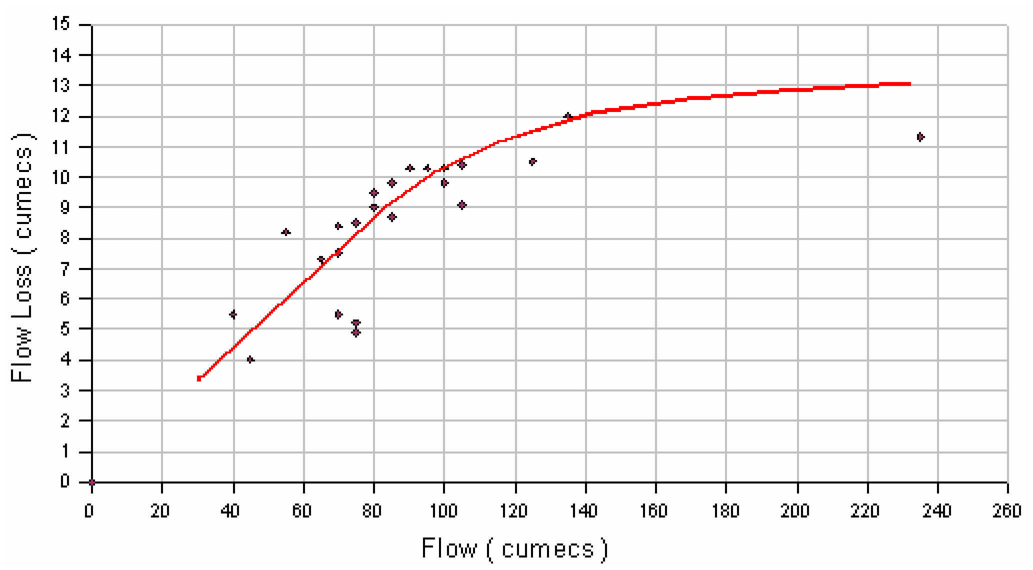
- River flow and levels in the adjacent aquifer, and
- Losses from the river and levels in the adjacent aquifer.

64 Therefore, as one would heuristically expect, there is a direct relationship between flows in and losses from the river. (i.e. the loss of flow is not constant)

65 The form of the relationship between flow, flow loss and aquifer levels is of crucial significance when determining the changes to aquifer recharge consequent on changed flow regimes in the river such as in the case of the CPW scheme. The problem comes in determining the form of the relationship to a level of detail that is satisfactory for modeling purposes.

66 I have attempted to determine the flow / flow loss relationship (without infiltration effects) by combining data from Graphs 1, 6 and 7; the outcome of which is shown below.

Graph 8: Derived Waimakariri River Flow Loss v Flow



67 The only experimental field data that I have been able to find relates to work conducted at Halkett by Lincoln University in the mid 1970's The relationship derived by the University is in line with the relationship indicated in Graph 8 for lower flows. (The Lincoln research was only undertaken at times of relatively low flows.)

68 Interestingly the form of this relationship is very similar to that shown in Graph 6 and to the relationships developed by NIWA for the flow / depth and flow / width relationships in the river (Refer Para 5.8 on page 13 and fig's 3 & 4 on page 47 of Greg Burrells Response) This provides some additional confidence as to the general correctness of the postulated form of the relationship.

Loss Mechanism and Aquifer Recharge from the Waimakariri River

69 In general there are two stages to river sourced aquifer recharge::

- Leakage out of the bed (and sides of the channels) into the gravels and down to the aquifer
- Movement of this water down gradient in the aquifer and away from the river.

70 In this case I believe that the asymptotic nature of the curve in Graph 8 shows that flood events have the ability to provide recharge at a rate greater than the aquifer can carry it away, particularly in the short term, and hence the reduced correlation between adjacent aquifer levels and average flows in comparison to aquifer levels and base flows.

71 So it would appear that the limiting factor with respect to recharge, at least in this case, is the ability of the aquifer to carry water away from the river rather than the water's ability to leak out of the river down to the aquifer.

72 As an aside, this could explain why Aqualinc have found that their model does not appear to be very sensitive to changes in bed conductance despite conventional theories that would intimate that the reverse should be the case.

73 I am very mindful that the data I have used to compile these relationships is limited. The outcomes are therefore only tentative. They would require further research to ensure that the relationships derived could be refined to a level that provides the required level of certainty to allow a project such as the CPW scheme to proceed.

74 The very important point however is that this is the self same limited data available to the modelers. Any issues with respect to the lack and reliability of data impacts just as much on the modeling assumptions as it does on my conclusions.

75 Hence my calls for the requisite research work to be urgently conducted especially since changes to this aspect of the local hydrology have the potential to have the greatest impacts. Some of these impacts could be unintended, negative and, from a practical point of view, irreversible.

76 I also note that some sources suggest that river ‘underflow’ may be significant but this topic is not commented upon in the Aqualinc reports. I have not been able to find sufficient data on which to base any analyses or conclusions. This is of concern as it is yet another area of potentially significant uncertainty with respect to aquifer recharge and hence the outcomes of the Applicants project.

The Model with respect to Flow Loss

77 Discussions with Aqualinc have suggested that their model, unlike some others, does in fact assume some relationship between flow in the Waimakariri River and loss into the aquifers, but what this relationship is they are not prepared to divulge.

78 Aqualinc, as you are no doubt aware, have used FEMWATER software. I have no experience of this package but I am able to understand the basic concepts it uses. The choice of a number of parameters, such as cross-sectional shape and bed conductivity may have significant impacts on the software's outputs.

79 As I noted earlier Aqualinc have stated that "......*there is no (or very limited) suitable data to compare measured and modeled river and stream parameters..."* and, with respect to parameters in addition to stream cross-sections, there is "........*substantial uncertainty in other river bed properties"* .

80 Aqualinc have chosen to represent the river's cross-section as an inverted triangle. I am not entirely convinced that this adequately represents the behaviour of a braided river such as the Waimakariri.

81 Using the NIWA derived cross-sectional and flow data, the included angle at the base of Aqualinc's conceptual triangle would need to be in the order of 179 degrees in order to even remotely mimic the actual flow / depth / width behaviour of the river. It would be interesting to hear from Aqualinc what angle they have in fact used. (Please note that this is not an esoteric question but one of importance in testing the validity of the model)

82 Looking at the model in more general terms Aqualinc (through GHD) have previously explained to me that the scheme will result in:

"*1. Less water in the Waimakariri, hence less head feeding the groundwater*
2. More seepage from irrigation and canal leakage, hence higher groundwater
3 .Less pumping from groundwater, hence higher groundwater
4. Higher groundwater levels further reduce gradients adjacent to the rivers, hence less loss from Waimakariri."

83 It appears therefore that Aqualinc's model does indeed contain a "feedback loop" in that if aquifer levels rise this reduces losses from the river. Reassuringly this is in general accordance with my thoughts, as outlined above, on how the local aquifer system.

84 My basic concern however is that whilst the model's iteration process takes aquifer level rises into account, the relationship between loss and aquifer level changes that the model uses, and which underpins this process, is potentially incorrect (i.e. it crucially underestimates the reductions in recharge per unit rise in aquifer level.)

85 For example Aqualinc quote the status quo loss from the Waimakariri River to be of the order of 9 - 10 cumecs. Post CPW Aqualinc note that there will be "*a reduction in the groundwater recharge rates of approximately 8% for the Waimakariri River"* or about 1 cumec or less.

86 All other factors remaining constant I would generally agree with the stated present average flow loss of about 9 cumecs. However I query the stated reduction in recharge once the CPW scheme is operating. (I will discuss this matter in later paragraphs)

87 It is interesting to note that Cliff Tipler has stated in his evidence that "*(T)he relationship between Waimakariri River flow and losses to groundwater is not defined as these losses are in the order of the uncertainty that exists in the measurement of river flow. Therefore the impact of the CPWL on recharge cannot be quantified precisely."*

88 The statement appears to be at odds with the evidence presented by Julian Weir of Aqualinc and others witnesses for the Applicant. In reality I believe that the actual situation falls between the two positions - i.e. we have some data but not sufficient to be conclusive to the level required given the potential impacts of the scheme..

89 I would like to re-iterate that I believe that it is <u>critical</u> that recharge from the rivers is modeled as accurately as is reasonably possible. I remain unconvinced at this stage that Aqualinc have achieved the latter.

AN ALTERNATIVE SCENARIO.

90 I would suggest that had Aqualinc taken greater cognisance of the impacts of increased aquifer levels the outputs from the model might have been quite different.

91 Accordingly I have attempted to determine, in very broad brush terms, the impact of the CPW Scheme on the Christchurch area hydrology using the relationships I have derived.

92 Referring to Graph 8, using an initial average base flow in the river of 80 cumecs the average loss / recharge from the river would be of the order of 9 cumecs.

93 Aqualinc have predicted that the average flow in the river will decrease by approximately 10 cumecs. once the CPW scheme is operational.. Again referring to Graph 8 it can be seen that at 70 cumecs the flow loss will be approximately 8 cumecs (i.e. approximately 1 cumec less than the pre CPW situation) The decrease in loss is similar to that postulated by Aqualinc (refer para 80 above)

94 However Aqualinc predict that on average the aquifer levels at the Mcleans Island well (M35/0948) will rise by approximately 0.25m due to the amounts of water being applied within the scheme area and the concurrent reductions in groundwater abstractions. (Remember that the existing range in variation in aquifer levels at Mcleans Island, on an annual average basis, is approximately only 0.25m)

95 Referring to Graph 7 it can be seen that if aquifer levels at Mcleans Island are raised by 0.25m, for reasons other than increases in flow in the river, average flow loss from the river will drop from approximately 9 cumecs to approximately 2 cumecs.

96 Combining the two impacts would suggest that the actual reduction in recharge is of the order of 8 cumecs not 1 cumec as stated by Aqualinc. (i.e. a reduction in Waimakariri River based recharge of about 88% not 8% as stated by Aqualinc)

97 (Note that Aqualinc make no reference to the fact that the drop in recharge would be significantly more than 8% at some times during the year, even using their assumptions.)

98 Of course if my postulated relationships were placed into the model then what I imagine would happen is that:-

- the predicted recharge from the river would be less than the model is presently showing, hence
- the aquifer level increase would not occur to such an extent, and
- the system would rebalance itself so that the recharge would be greater than the 1 cumec I have shown above but less than the 9 cumecs the model is apparently presently showing.

99 Remember that although these might sound like small differences as Aqualinc's reports states "......*recharge from the major rivers is significant in maintaining a relatively stable base groundwater level*." and that surface recharge, again according to Aqualinc, constitutes over 50% of the recharge in to the system. So changes in the river recharge of this magnitude are highly significant.

100 This potentially places many of Aqualinc's conclusions in doubt. For example this possibly means that the quantum of the reduction of natural inflows into the system might not be balanced by the additional recharge from the CPW scheme. This would clearly upset Aqualinc's conclusions on the complete hydrology of the system across the Plains (i.e. not just the Christchurch area.)

101 In turn this would upset Aqualinc’s predictions on matters such as flow and contamination pathways and pressures within the aquifers. I discuss these and other physical issues in the following paragraphs.

AQUIFER ISSUES WITH RESPECT TO CPW SCHEME.

Aquifer Flow Patterns.

102 There is much discussion in the Applicant’s Evidence about the "divide" (which is by no means well delineated) between predominantly Waimakariri sourced water and that from the central Plains.

103 I believe that the “divide” has moved south west, from its previous position say in the early 80's, because so much water is being extracted by existing irrigation bores in the central Plains area. The converse of this is that if the CPW scheme raises groundwater levels in the central Plains then the reverse will happen.

104 As I have noted, I believe that Aqualinc are seriously underestimating the quantum and impact of the reduction in recharge from the Waimakariri. This reduction in recharge in itself will have a marked impact on the location of the "divide" – It is likely to move northwards further into the city.

105 Should this occur it is readily conceivable that nitrates and other farming activity related contaminants could also move into parts of the aquifer supplying Christchurch.

106 Further, the scheme will directly impact on the quantum of the recharge from the Waimakariri River and hence impact on the Christchurch aquifer and flows in the Avon. I believe that it is quite conceivable that this loss of recharge could well be sufficient to overwhelm Aqualinc’s predicted aquifer level rises in the Christchurch area and could in fact lead to a lowering of levels.

107 This could have consequential impacts on water availability and, longer term, a potential to reduce the upward pressure from within the confined aquifers which presently helps to prevent the ingress of contaminants.

108 In addition my studies have shown that the Avon and its tributaries are already under pressure from locally declining aquifer levels. Flows in the Avon are very sensitive to aquifer level changes. Any possibility of a further lowering of aquifer levels is therefore viewed with considerable concern.

Aquifer Levels and Potential Contamination.

109 There are a number of old landfill sites and existing cleanfill sites, dotted around the western perimeter of Christchurch. These sites sit above the unconfined sections of the aquifer and their bases are potentially very close (vertically) to the groundwater.

110 Many of these sites were used before any operating safeguards were in place to reduce the risk of potential contamination of the adjacent aquifers.

111 Knowledge of the contents of these sites ranges from limited to nil. There is at least anecdotal evidence that industrial chemicals, along with other potentially leachable substances have been disposed of at some sites.

112 There have already been recorded instances of industrial chemical contamination in (at least) the shallow aquifers in the south western sector of Christchurch. Although there is no direct evidence, it is likely that the old landfill sites are the sources of this contamination.

113 Increases in groundwater levels, as predicted by Aqualinc, therefore increase the risk that contaminants from these sites will leach into the aquifer – and hence the drinking water supply.

114 In the worst case scenario, where the aquifer actually rises into the base of the disposal areas, contamination is almost certain. The severity of this contamination and its implications for Christchurch's drinking water supply are less certain without further study. The ramifications however are potentially of much greater health significance than the widely debated issue of nitrate contamination.

115 I have been unable to find anywhere that CPW have addressed this possible issue. However I am aware that some members of the local quarrying industry have raised not dissimilar issues in their submissions.

116 With respect to nitrate contamination, I have made comment in more detail in the Appendix under evidence from Cliff Tipler and the Section 42A report from Carl Hanson, however I would like to take the opportunity here to correct comments passed by the Applicant with respect to possible mitigation strategies in the event of nitrate contamination entering the Christchurch water supply aquifers.

117 The Applicant argues that mixing of any nitrate contaminants will occur in the upper aquifer and that the deeper aquifers under Christchurch will therefore be unaffected by CPW (The latter appears to be at odds with the particle tracks generated by the Aqualinc model.) Therefore in a worst case scenario, it is suggested, should the upper aquifers become contaminated the majority of water used for water supply, which is drawn from the lower aquifers, would have a dilution effect such that nitrate levels in the reticulation as a whole would be maintained below the MAV.

118 I would like to suggest that this is not correct for at least three reasons.

119 Christchurch City Council have provided information which delineates the proportions of water supplied to the city from each aquifer viz:-

Shallow				Deep	
Aquifer 1	26%	Aquifer 3	8%	Aquifer 4	39%
Aquifer 2	16%			Aquifer 5	11%
Total	42%			Total	50%

120 Firstly it is therefore not correct to suggest that the major portion of Christchurch's water supply is drawn from the deep aquifers

121 Secondly there is little mixing of waters between the areas supplied by individual pump stations and accordingly unless there is sufficient water available from deeper aquifers at the effected pump stations the dilution effect may not be great enough to reduce nitrate levels below the MAV in the area subject to the contamination

122 And thirdly the pressure zones within the city, which are a legacy of the varying pre-Council amalgamation supply philosophies, mitigate against pumping water in bulk from one pressure zone to another.

123 In the event of nitrate pollution of the upper aquifers a strategy of dilution, whilst not impossible, would therefore be extremely expensive. (Dilution strategies for industrial chemical contaminants are unlikely to work under any practical circumstances)

124 Whilst the Hearing has tended to focus on the impacts on Christchurch's water supply we should not forget the resident's of the likes of Rolleston, which will expand significantly over coming years, Prebbleton, and Lincoln. The Applicant has acknowledged that these areas are directly in the path of aquifer flows that originate under the CPW scheme area and are therefore at risk if nitrate levels should rise above the MAV - although the Applicant is arguing that this is unlikely.

125 However my discussion with Selwyn District Council suggests that, like Christchurch, the water supply bores are at various depths. - i.e. not all source wells are "deep" – and the dilution strategy may not therefore be appropriate.

Aquifer Levels and Impacts on Aggregate Resources.

126 The local method of gravel extraction generally consists of layer mining to a point above or, in some past cases, to the level of the ground water depending on the physical and planning constraints at the time the quarry was established. Because of the relatively high water table on the Canterbury Plains close the coast, and in particular close to Christchurch City, the excavations tend to be shallow and more latterly, extensive in area.

127 Ready availability of aggregates has historically resulted in a large number of small quarries being scattered across the region.- and hence the numbers of old landfills on the outskirts of Christchurch that I referred to earlier. More recent practice has been to set large areas aside which are zoned for "Quarry" purposes

128 Over the last five years there have been large increases in demand for aggregates. As a consequence existing quarries are rapidly being depleted and appropriately zoned resources are becoming scarcer.

129 Modern environmental practice prohibits excavation deeper than 1m above groundwater. In the case of the areas within Christchurch and the eastern sectors of Selwyn District excavations depths now accordingly range between approximately 12 and 2m. Any increases in groundwater levels are therefore of concern.

130 The CPW scheme has the potential to significantly impact on both the location and extractable volumes of materials from new and existing sites. This may be particularly problematic in the areas east of S.H.1 in Selwyn District where groundwater levels are already relatively high. It is of equal concern in the north eastern areas of the District where the materials are of a generally higher quality than elsewhere in the Selwyn area

131 Whilst I have not completed a study of the overall potential impact of the scheme I have undertaken a quick assessment of the loss of resource in the area presently zoned Ru(Q) in Pound Road to provide an example / context for the Hearing panel deliberations.

132 Aqualinc are predicting an approximate 0.75m increase in groundwater levels in this area. This increase would reduce the available quantity by approximately 10% or 1.5 million tonnes, with a market value approaching $10 million.

133 It can be seen that even apparently small aquifer level increases can produce potentially large monetary losses. Of course given the uncertainty of Aqualinc's predictions, the actual aquifer level increase and hence the loss could be greater or, to be fair, less than I have calculated. This is just another example of the impact of uncertainty inherent in the present hydrological predictions.

134 Overall in the short term these impacts could lead to increased community costs of the order of several tens of millions of dollars and considerably more in the longer term

135 However in addition there are social and environmental consequences entwined in the loss of resource in that quarrying activities would have to re-locate sooner than may have otherwise been necessary.

136 I understand that both Christchurch City Council and the quarry owners will be making submissions on these matters.

CONCLUDING COMMENTS.

137 As you will have gathered, the theme of my evidence is “Uncertainty”. We may never reach, nor need we, a perfect understanding of the local aquifers and their inter-relationships with the various inputs and outputs. Like all engineering decisions it’s a matter of weighing the risks, and their levels of certainty, against the potential gains.

138 Unfortunately I do not believe that we are anywhere near close enough to a level of knowledge that would allow us proceed at this stage with a project the size of that proposed by the Applicant – a project which has the potential for significant negative, unintended, and potentially irreversible environmental and health consequences.

139 My overall conclusion is that the model being used in an effort to determine the project outcomes is not yet representing local hydrology sufficiently accurately to warrant the Scheme proceeding.

140 I therefore request that the resource consent applications be declined.

Richard English
22 April 2008

APPENDIX.

ANALYSIS OF SELECTED EVIDENCE TO CENTRAL PLAINS WATER RESOURCE CONSENT HEARING.

A. CENTRAL PLAINS WATER.

Julian Weir - modeller / hydrologist, Aqualinc

General Comments

A number of the queries I previously held have been answered by the additional information provided in the Appendices to the evidence Julian Weir presented at the Hearing.

It is interesting to note however that there have been some significant changes in the Mass Balance charts (which show the total water flows through the aquifer system) from those originally presented in Aqualinc's earlier Report in June 2006.

For example the Mass Balance pie chart for the Status Quo scenario (i.e. pre CPW) in the earlier report stated that there was a total input into the Waimakariri / Rakaia area of 56.2 cumecs of which 22.3 cumecs (or 40% of the total) was from surface water.(i.e. basically rivers and streams) Under Appendix P of Julian's evidence these figures have now become 77.3 cumecs, 44.4 cumecs and 57% respectively. (i.e. An increase of a quarter in total volumes and a doubling of the earlier estimates for surface water recharge)

Given that the differences between the two versions of the model on which Aqualinc's reports are based are supposedly small, it is surprising that there are such large differences in these figures. The magnitude of these late changes certainly don't help to engender confidence in the model.

Aquifer Flow Directions.

Aquifer flow directions are obviously one of the key elements in determining the potential pathways contaminants might take. (This is why it is so important that the hydrology is modelled correctly)

The new information in the Appendices to Julian Weir's evidence helps in visualising the flowpaths as presently determined by Aqualinc's model. As a general comment it would have been useful to see the data included in Appendices I, J, & K expanded to include all the scenarios not just the "average" I recognise there would be a lot of diagrams involved but given the importance of the issue I believe this suggestion is warranted.

It would appear that there already is potential for contamination into Aquifers 3,4 & 5 that feed under Christchurch however I believe that not much weight can be placed on these predictions given my doubts over the veracity of Aqualinc's conclusions re losses from the Waimakariri. Looking at the flow charts provided and my doubts I certainly wouldn't be happy to claim that contamination of the aquifers supplying Christchurch's drinking water is "unlikely" without further study.

<u>Conclusion</u>

My overall conclusion is that the model is still 'a work in progress' and is not yet representing local hydrology sufficiently accurately to warrant the Scheme proceeding until further modeling work is undertaken.

Cliff Tipler - Senior Principal, URS

(Please note that Cliff Tipler has presented several sets of Evidence. My comments refer to that specifically relating to water quality issues)

The first section of this evidence relates to the potential impacts of nitrate contamination on the central plains aquifers. Cliff Tipler's conclusion is that *"(T)he potential risk to groundwater from increased nitrate concentrations is very low ....While there will be more nitrate entering the groundwater system, there will also be more clean water entering the groundwater system, and these effects offset each other such that the result is effectively no change."*

As far as I can determine this evidence expands, on that previously reported elsewhere by CPW and commented on by Carl Hanson of ECan in his S 42A report (For my comments on the latter refer below)

I note that the inputs into the system from surface water assumed by Cliff (Tables 1 & 2) appear to be significantly at odds with the latest figures (i.e. January 08) from the Aqualinc model both in total (i.e Tipler - less than 50% of the model) and specifically recharge from the Waimakariri (Tipler - one third of model) .This is a cause for concern in a general sense although it may not impact on Cliff's conclusion re nitrate contamination as he assumes that the contributions from the Rakaia and Waimakariri Rivers " *feed the deep groundwater aquifers*" which are, he proposes, not impacted by nitrate contamination (This of course may or may not be the case)

The second section of Cliff's evidence (i.e. paras 105 onwards) deals directly with CPW's assessment of the quality (and peripherally quantity) impacts of the scheme on Christchurch's water supply.

It is interesting to note (para 8) that Cliff says that the Aqualinc "...*model has not been developed to include the tools needed to assess the direction of contaminant transport or the mechanism's by which contaminants are dispersed and diluted throughout the complex aquifer systems"* Given this statement it is also interesting therefore to note the reliance placed on model generated particle tracking in other CPW reports to demonstrate the purported low level of risk of contamination to Christchurch's water supply

Cliff notes that the input from the Waimakariri is the most dominant influence on recharge for the Christchurch aquifers (I have no argument with this) and he demonstrates that aquifer flow directions are presently such that little or no water enters the Christchurch aquifers from those areas that will be included in the CPW scheme. This is potentially correct for the present situation. Significantly it may not be true however once the CPW scheme is implemented.

It is surprising therefore, given the stated uncertainty over the quantum and mechanism of the recharge from the Waimakariri, that Cliff can state that the " *groundwater flow direction from the river to the city is not changed*" post CPW and to hence conclude that the "*potential for nitrate to contaminate the city's drinking water supplies such that it is unsuitable for public supply is essentially zero."*

As I have noted several times before I believe that there is significant uncertainty as to the reliability of the outputs from the Aqualinc model (on which Cliff is apparently basing his conclusions and over which ECan staff appear to share my concerns) I certainly wouldn't be prepared to be make such a bold statement.

Cliff argues that mixing of any nitrate contaminants will occur in the upper aquifer and that the deeper aquifers under Christchurch will therefore be unaffected by CPW (The latter appears to be at odds with the particle tracks generated by the Aqualinc model.) Therefore in a worst case scenario, it is suggested, should the upper aquifers become contaminated the majority of water used for water supply, which is drawn from the lower aquifers, would have a dilution effect such that nitrate levels in the reticulation as a whole would be maintained below the MAV.

Unfortunately this is not correct as there is little mixing of waters between pump stations and accordingly unless there is sufficient water available from deeper aquifers at the effected pump stations the dilution effect may not be great enough to reduce nitrate levels below the MAV.

Cliff also states that the " *potential for raised natural groundwater levels in Christchurch is real......"* It is surprising therefore that no consideration has been given to the potential impacts of these increased levels on contamination from cleanfills and landfills on the western fringes of the city. As I have noted before this is an area that requires urgent investigation. (It may or may not prove to be significant but we won't know until an investigation is undertaken.) In the event that contamination does emanate from these sources it is highly unlikely that Cliff's nitrate dilution strategy could be applied to this situation for the contamination that might arise from these sources. (e.g. hydrocarbons, organics, etc.)

In summary, whilst I can understand how Cliff has come to his conclusions - which are based generally on the outputs of the Aqualinc model - I cannot support his contentions given the uncertainties inherent in the model at its present stage of development.

B. ENVIRONMENT CANTERBURY.

David Scott

David Scott is a groundwater hydrologist and modeller. His evidence relates mainly to the flow modelling undertaken by Aqualinc. (David has had previous experience of the fore-runner of the present model through earlier Hearings for groundwater abstraction on the Canterbury Plains. He therefore has a good background from which to comment, particularly on local issues.)

His conclusions with respect to the Peer Review conducted on the model are in line with my thoughts. David says that "... *missing from the peer review is any consideration of the application of the model to the prediction of effects of the CPW scheme*" and ".... *the standard section addressing model predictions has been omitted from the review and the recommendations propose further improvements as a pre-requisite to practical use*." (i.e. The peer reviewer has looked solely at the 'mechanics' of the model - and has concluded that they are satisfactory although long run times severely restrict its usefulness - but has not reviewed its practical outputs.)

David Scott is critical of both the basic vertical layering concept of the model (and he quotes several other authorities to support this contention) and some of the important aquifer properties chosen by Aqualinc. (I can not comment on this as I do not have specific knowledge in this area.)

David suggests that the long run times, which are presently of the order of six weeks, place significant constraints on exploring "*data and system characteristics.......... through sensitivity analysis and optimization to attain a reasonable level of model calibration."* I have previously commented along similar lines.

David's report goes on to explore areas of model calibration where he has particular concerns including increased groundwater levels - he believes that the model will underestimate rises -and stream flows where he has issues with the model parameters chosen.

With respect to system Mass Balances David comments that the imbalance (between inputs and outputs) is outside accepted modelling guidelines to such an extent that it *"leaves uncertainty about the numerical accuracy of the model calculations"* David also notes that the outflows predicted to Lake Ellesmere are "*implausible"* and that there are some significant areas of uncertainty with the latest surface water recharge figures (I will comment further on the latter at the end of this section)

It should be noted that David shares my concerns over the significant changes in the Mass Balance charts between the two most recent versions of the model - i.e. September 2007 and January 2008. This does not help in increasing confidence in the model.

David expresses concerns over several other aspects of groundwater mounding, lowland stream flows and *"effects on surface water/groundwater interaction".* With respect to the latter he states that the *".... predictions seem plausible but, given the significance of any potential for effects on recharge to the Christchurch groundwater system, it would have been desirable to have provided more detailed analysis and to have considered alternative scenarios"* (Please note that I believe that what David may be signaling here is that whilst the predictions may be "plausible" there is considerable uncertainty over the figures such that they should be tested further - a suggestion which I have been pushing for some considerable time)

With respect to particle flow paths David and I are in agreement that the deeper aquifers 4 and 5 (and I believe 3) under Christchurch appear to be at some degree of threat of contamination from water from the central plains once the CPW scheme is in place. We are also both in agreement however (although for partially different reasons) as David says "*the particle tracks provided in Weir (2008) should be regarded as speculative."* (i.e. in reality the outcomes for Christchurch's water supply could be the same as, better or worse than shown by the model .)

If you'll forgive me I'd like to return here to the specific issue of the interaction between surface water (i.e. rivers and streams) and groundwater I would like to re-highlight the fact that this is one of the critical elements of the system yet it is one on which we have possibly the least (and potentially the least reliable) information. It is also a topic that people seem to have a propensity to gloss over.

Under para 36 David Scott says " *The description of simulated surface water/groundwater interaction for the Rakaia and Waimakariri Rivers (Appendix N, Weir 2008) suggests that they loose approximately 25 m3/s and 10 m3/s to groundwater respectively. If 50% of the simulated Rakaia River loss and 100% of the simulated Waimakariri River loss are regarded as likely inputs to the Rakaia-Waimakariri sub-area then the reported input of 44.4 m3/s leaves a balance of 21.9 m3/s supposedly contributed from other surface water sources. The model report provides no comment on where this additional water might be derived from."*

I certainly agree with the last sentence. In a round about way this is a question I have previously posed to Aqualinc but to which I have not received a direct answer. However hidden behind this are the (assumed?) input figures from the Waimakariri, of which not a great deal is known, and of the Rakaia of which even less is known.

Given that we are talking about the largest single input into the system (i.e. over 50% according to Aqualinc figures) it is of considerable concern that this aspect of the model appears to be underpinned by (to overstate the fact for emphasis) little better than guesses. Furthermore I have been arguing that the model underestimates the impacts of the predicted rise in aquifer levels on a number of relationships within the system.(David Scott is suggesting that even the rises themselves may have been underestimated.)

Again as I have noted before this all feeds back into flow path directions and hence the possibility or otherwise of contamination reaching Christchurch's water supply It is surprising therefore that comment has not been passed by David Scott on this topic.

In summary however David Scott has concluded that " *The magnitude of simulated effects should be viewed with some caution and should not be accepted as being worst-case assessments. Water balance errors and concern regarding the plausibility of some water budget terms leaves doubt regarding the reliability of the model predictions."*

Dr Howard Williams

Dr Williams is a groundwater scientist with a background in geology and civil engineering. His evidence takes issue with the modelled layering of aquifers and aquitards and provides a greater degree of detail to support David Scott's evidence on this topic and on aquifer properties. (As noted above I cannot comment on this other than to say that Dr William's evidence appears to be supported by other experts in the field)

With respect to rises in groundwater levels Dr Williams states that ".... *there is little disagreement that mounding will occur as a result of irrigation with imported water. However, the details of its spatial and temporal development and magnitude are still unclear ..."* He also says that " *I cannot accept that the revised results are a realistic prediction of mounding and related surface water discharge effects."* and " *I am uncertain whether the mounding scenario for a dry or wet year is a realistic assessment of the worst case scenario."* (This has implications for existing sewage disposal systems and, although not mentioned, potential contamination from old land and cleanfills)

Dr Williams adds to the concerns over the model when he says that "*I consider the modelled inflow to Lake Ellesmere from groundwater of 11 to 12 m3/s to be a gross overestimate..... (V)erified modelling of the lake water budget by Graeme Horrell* (of ECan) *indicate a value at least an order of magnitude lower than modelled. Inconsistencies of this magnitude in the water budget are worrisome when considering the reliability of the groundwater model."*

Maurice Duncan

Like Maurice I had "*found it difficult to determine the exact extraction regime proposed by CPW especially with regard to the consents to take water from the Waimakariri River. "* I am therefore grateful to him for teasing out the abstraction regimes that CPW are proposing.

The drops in the mean flow for the Waimakariri post CPW calculated by Maurice Duncan are in line with those provided to me by Aqualinc. Whilst he has concluded that the flow impacts appear to be in line with the applicants assessments I find it interesting that in the case of the Waimakariri in particular there will be "..*a significant increase in the flat-lining"* .(i.e. of the river flows).This may have regular, but shorter term impacts on the aquifers that feed Christchurch although it is not mentioned elsewhere in the ECan officers reports - which tend to be addressing the longer term impacts of the scheme. It would be a topic worthy of further discussion.

Maurice is critical of the applicants assessment of the geomorphic effects of CPW on the Waimakariri and Rakaia Rivers. He says that "*Key information is lacking "* Further he notes "*The effect of CPW on bedload transport is likely to be small but no numerical information has been presented to justify that view. The applicant's view that the effect will be small because rivers are undersupplied with sediment is unsupported."* These items may impact on the permeability of the beds of the rivers which may (or may not depending on their quantum) in turn impact on the losses from the rivers as recharge into the adjacent aquifers. (although un-commented upon by ECan reports)

Carl Hanson

I have been told in the past during general discussions with experts in the field that unless you have a clear understanding of the hydrology of an area then you are mostly wasting your time trying to decide what will happen to nitrates from the likes of dairying for example.

It is pertinent therefore that Carl Hanson's report notes ".... *that there is considerable uncertainty in many of the inputs to the model....* " a statement with which I fully concur. The thrust of my past work, lobbying, etc, in prior acknowledgement of these uncertainties, has accordingly been directed towards promoting the need for a better understanding of the local aquifer systems. Whilst the Aqualinc model has helped in this regard, as I have noted before, it is I believe still "a work in progress". Carl Hanson's comments support this view.(i.e. The predictions made by URS are potentially subject to a good deal of variance.)

Although toxicology is outside my field I do know from my previous experience in the potable water field that the NZ MAV for nitrates has been derived from overseas regulations which I'm not too convinced were based themselves on much research. Certainly the "blue baby syndrome" is often mentioned but in reality when I last looked I could not find much evidence of it being other than a potentially minor issue numbers wise.

So although I do not wish to minimise the matter I do believe that it should be put back into perspective. If nitrate levels rose above the MAV (but not grossly) then a simple answer is, in the very few cases of potential harm - i.e. bottle fed babies under 6 months according to Carl - that bottled water be used. Please note that I am not recommending that we should ignore the issue but suggesting that rather than using it as a "Go, No Go" item for the scheme with respect to the Central Plains area it should just be one more part of the decision matrix.

When considering impacts in the Christchurch area the problems and ramifications associated with a lack of knowledge of the aquifer system I mentioned above are of course magnified many fold if for no other reason than the size of the population potentially at risk.

From my own point of view it is interesting to note Carl's and ECan's comments / description of the aquifer system in the southern sector of the city. This is generally in line with my past experience and some more recent work I have been undertaking..(paras 143 and 144)

With reference to flow paths and to Julian Weir's Evidence Appendices I, J, & K, I have already commented directly to Aqualinc that I believe it would be useful for the diagrams to be "*expanded to include all the scenarios not just the "average"* I have also commented to Aqualinc that "...*there already appears to be potential for water from the Central Plains to pass into Aquifers 3,4 & 5 that feed under Christchurch "* Carl Hanson appears to be expressing similar conclusions to my last sentence.

Under para 142 it is noted that "*for the most part, the groundwater that flows beneath Christchurch is derived from the Waimakariri River and from soil drainage from land between the city and the river."* This is agreed by all parties. There is not however absolute agreement as to the ratio between the two sources - nor the quantum of the recharge - but it is generally accepted that the flow from the Waimak constitutes of the order of 80% of the total input. Hence any change in the input from the river could have a marked impact on local flow paths.

I am presently arguing that Aqualinc are underestimating the combined impact of their predicted rises in groundwater levels and changed flow regime in the river (both of which are determinants of the volumes of Waimakariri sourced recharge) and that potentially flow paths post CPW could be such that a greater sector of the city's water supply could receive water from the Central Plains area than at present or as predicted by Aqualinc. Without some certainty on this topic I couldn't therefore support Carl's claim that "*the CPW scheme probably does not pose a threat to most of Christchurch's water supply*" although we both certainly agree that we *"would like to see more work done on these flow paths before I* (we) *accept the model result "*

Carl only mentions potential health impacts of aquifer level rises in passing but as I have stated previously there are a number of old landfill and cleanfill sites on the western and south western outskirts of the city's urban area. Any rises in aquifer levels are therefore of potential concern.

As I have noted above I have been unable to find anywhere that CPW have addressed this possible issue. Accordingly it needs to be studied.

Overall Conclusion

My overall conclusion is that these reports reinforce my previous view that the model is not yet representing local hydrology sufficiently accurately to warrant the Scheme proceeding. Further modelling work needs to be undertaken.

The potential contamination issues relating to old landfills and cleanfills remains to be addressed. (Neither the CPW or ECan officer reports broaches this subject)