Gay Gibson

From: Sarah Drummond
Sent: Tuesday, 10 June 2014 1:44 p.m.
To: Mailroom Mailbox
Subject: TRIM: FW: CPW Selwyn Waihora
Attachments: Further Submission to Variaton 1 pLWRP by CPW Ltd.pdf

Categories: Purple Category
HP TRIM Record Number: C14C/91608

Can this please be trimmed please, Please note this is the combined submission of two emails I will send them separately to be trimmed

Thanks

Sarah

From: Ben Williams [mailto:Ben.Williams@chapmantripp.com]
Sent: Monday, 9 June 2014 4:30 p.m.
To: Sarah Drummond
Cc: 'Susan Goodfellow (sgoodfellow@cpwl.co.nz)'
Subject: CPW Selwyn Waihora

Sarah,

Please find **attached** the further submissions on behalf of CPW.

Please acknowledge receipt.

Kind regards,
Ben

BEN WILLIAMS
SENIOR ASSOCIATE

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Form 6

FURTHER SUBMISSIONS IN SUPPORT OF, OR IN OPPOSITION TO, SUBMISSION ON A PUBLICLY NOTIFIED PROPOSED POLICY STATEMENT OR REGIONAL PLAN

Clause 8 of Schedule 1, Resource Management Act 1991

To **Environment Canterbury**
Variation 1 to the Proposed Canterbury Land and Water Regional Plan
Freepost 1201
P O Box 345
Christchurch 8140

Name of further submitter: Central Plains Water Limited (*CPW*)

1 This is a further submission relating to:

- submissions on proposed variation 1 to the proposed Canterbury Land and Water Regional Plan (*Variation 1*)

2 Its further submissions are split between:

2.1 Supporting information (which provides a brief outline of matters cross-referenced from Annexure 2 and accordingly forms part of various CPW further submissions) (**Annexure 1**) ; and

2.2 Further submissions – the specific submissions of Variation 1 in relation to which CPW either supports, opposes (or both) (along with brief reasons for that support, opposition (or both)) (**Annexure 2**).

3 CPW provided an original submission in relation to Variation 1 and also has an interest greater than the interest of the general public.

4 CPW wishes to be heard in support of its further submissions.

5 If others make a similar submission, CPW will consider presenting a joint case with them at a hearing.

Signed for and on behalf of Central Plains Water Limited by its solicitors and authorised agents Chapman Tripp

_____

Jo Appleyard / Ben Williams
Partner / Senior Associate
9 June 2014

Address for service of submitter:

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c/- Ben Williams
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PO Box 2510
Christchurch 8041
Email address: ben.williams@chapmantripp.com

Annexure 1: Further modelling and alternative relief – a brief outline

Introduction

1 In its various original submissions CPW advised that it had commissioned a peer review of the modelling underlying the information set out in various tables (section 11.6) and that it was concerned to ensure that the allocations as set out in the proposed variation are correct and reasonable.

2 CPW has now provided various further submissions against submitters who either raised similar concerns to CPW or which sought certain tables to be retained. Those further submissions (included in **Annexure 2**) cross-reference this annexure (and accordingly this annexure, along with the information attached and referred to forms part of CPW's further submission).

Outline of modelling assessment undertaken

3 Following the completion of CPW's original submission, CPW (along with other interested persons) has engaged a peer review team (with international experience) to review the modelling work undertaken.

4 A copy of the initial report (titled *Selwyn Waihora catchment technical model review*) (the *Review*) is **attached** and accordingly forms part of CPW's further submission.

5 It is emphasised that this was the result of an initial review undertaken by the relevant experts and further work (including the development of a more integrated catchment model) is currently underway. This is likely to further inform CPW's original and further submissions (with both CPW's original and further submissions expressly contemplating more specific relief being sought once the outcomes of the review and modelling exercise become known).

6 For the purposes of this further submission it is however noted that a number of concerns have been raised with the Environment Canterbury (*ECan*) model and these are discussed in more detail in Review.

7 By way of brief summary, the Review for example advises:

7.1 the ECan modelling takes a simplified approach to water drainage, where a 'single bucket' daily soil-water balance model generates the amount of water used for irrigation and water draining through the soil profile into groundwater for dryland and irrigated land. This approach has significant sources of potential error including matters relating to: soil depth, plant available water depth, fixed crop/crop factors, climate stations, accounting for coastal high water tables, and irrigation issues such as irrigation type, efficiency adjustment application (flow rate or annual allocation) limits;

7.2 it appears that some of the modelling has the potential to grossly overestimate irrigation demand and drainage to groundwater. There are issues related to the conceptual understanding of groundwater and how nitrogen moves from the land usage in the catchment into streams and the lake. The approach in Variation 1 says that the groundwater aquifers are unconfined, but then states that all N stays in shallow groundwater while deep groundwater is sourced from major rivers:

(a) this 'separation' means that there is no allowance for broad-scale dilution or nitrogen attenuation effects; and

(b) a significant portion of the upper plains area does not have shallow groundwater, so nitrogen leaching would be into deep groundwater. FEMWATER's water balance shows a large component of outflow to the lake and directly to the ocean.

This means that a significant proportion of the N load is not passing through the lake (contrary to the general assumption in Variation 1).

7.3 the model adopted to assess nitrogen concentrations in groundwater uses the probability of exceeding of Ministry of Health Drinking Water Guidelines (Maximum Allowable Value, MAV) at bores within each zone and then compares this to the mean annual nitrate load in the zone. The Review advises that there are conceptual problems with this which mean the basis for these predictions is potentially flawed.

7.4 there is also inconsistency between the attenuation factors used to convert groundwater nitrogen concentrations to stream flow concentrations and the basic hydrological assumptions. The fact that an additional factor had to be introduced (to account for surface water supplied irrigation) means that there may be further errors with the approach;

7.5 it appears that the surface water catchment behaviour has been represented simplistically within the current ECan modelling framework and has a number of limitations. The focus of the water quantity modelling has been on the lower Canterbury Plains catchment area that is groundwater dominant and directly influences inflows and nutrient loads to the Lake. The overall modelling approach assumes that contributions from overland flow and direct surface runoff are minimal. This is neither substantiated, nor explained and seems unlikely to be the case;

7.6 the generalised relationships of surface (or quick) flows as inputs to the groundwater model provide less flexibility in accounting for changes occurring in the upper Selwyn and hill country, particularly for representation of the surface water transfers from the Rakaia and Waimakariri Rivers to the Central Plains Water Enhancement Scheme and corresponding land use changes directly related to increased water allocation in the command area. Such water usage would most likely modify the surface water flow component in terms of both flow and water quality;

7.7 the existing ECan model encompasses the main tributary inflows to Te Waihora and the corresponding groundwater extent – however, limited representation of the upper catchment restricts the ability to determine changes to reliability for downstream consented users (meaning that the ECan modelling approach is not fully suitable – or optimal - for the purposes of Variation 1); and

7.8 overall, the ECan model is likely to be overly conservative (under allocated) , particularly due to high nitrogen leaching values in the ECan approach (Lilburne Tables) used to calculate the catchment load and the variable groundwater flow pathways to the lake.

8 As noted above, it is also anticipated that further concerns will be raised (and further alternative relief proposed within the ambit of CPW's submissions and further submissions) as the modelling work and review progresses.

Further alternative relief

9 Following the review referred to above and various discussions around the development of a more integrated catchment model, it appears that the approach of Variation 1 (in short a relatively simplified direct regulatory framework that seeks to limit N discharge for all farmers (on the basis of the same underlying assumptions) across the zone) may not be fully appropriate.

10 On the basis of the work done to date it appears that this assumption may not be correct, meaning that the Variation 1 objectives, policy and rules package is not necessarily effective as it could be in terms of achieving the wider objectives of the plan

change (or to put that another way – some farmers will be subject to restrictions that are either unnecessary/unreasonable or which do not fully meet the 'test' of sustainable management under the Resource Management Act 1991).

11 In this regard it is for example noted (on a tentative basis given the nature of the work done to date) that:

11.1 the nitrogen leaching and connectivity to the lake may not be uniform across the plains (i.e. the upper catchment has groundwater zones which are not connected to the shallow groundwater system and instead connected to deep groundwater passing out to sea);

11.2 although it appears that the modelling undertaken is highly conservative, it is not yet readily apparent as to whether the water quality limits will be met, as the ECan model is unable to predict the water quality outcomes from the landuse scenarios under different irrigation and development proposals; and

11.3 the 'clawbacks' in, for example, Policy 11.4.14 for reductions in nitrogen loss appear arbitrary and not linked to modelled effects.

12 In light of the above (and given wider uncertainties with regard to the ECan modelling undertaken and overall delivery of the wider objectives of the plan change), CPW notes that consideration may need to be given to further alternative relief such as:

12.1 the spatial or temporal redistribution of the overall catchment load for nitrogen to better reflect actual effects (and mitigation effectiveness);

12.2 the provision of relief to the lower catchment by reducing minimum flow restrictions (on irrigation consents) – especially following development of the Central Plains Water Enhancement Scheme to reduce the pressure from increased nitrogen leaching risk; and

12.3 potentially even directly funding of positive mitigation interventions (e.g. a nitrogen levy to fund wetland works) instead of requiring ineffective mitigation practices.

13 It is however emphasised that these potential 'tools' may or not be considered appropriate once the further integrated modelling work is complete. Discussing them against CPW's further submissions has only been done for the purposes of ensuring no scope issues arise should be they be considered appropriate at some point in the future.

14 It is further noted that such alternative relief may also only be appropriate and (fully 'developed') once the Matrix of Good Management Practice Project is complete – against which CPW, and a number of other submitters, have suggested a further plan change occur (with uncertain restrictions being removed at this point in time from Variation 1).

Annexure 2: Specific further submission points[1]

Prov.	Original submitter	Particular parts	Reasons	Support / Oppose
Background / introduction				
11	Elesmere Irrigation Society Inc 52210	**V1pLWRP-464** (addition of a new sentence on the sixth paragraph on page 4-3).	CPW supports the possibility of any required improvements being implemented over time – potentially in timeframes that exceed the life of the plan.	Support
11	Nga Rūnanga and Te Rūnanga O Ngāi Tahu 52233	**V1pLWRP-367** (cross-boundary issues)	CPW is unclear on exactly what cross-boundary issues are relevant to the Selwyn-Waihora catchment. Care needs to be taken to ensure Variation 1 does not impact on the allocation and take of water from the Rakaia and Waimakariri Rivers.	Oppose
11	Nga Rūnanga and Te Rūnanga O Ngāi Tahu 52233	**V1pLWRP-360** (retain Variation 1 as notified except to give effect to the submitter's concerns)	CPW considers that a number of amendments are required to Variation 1 to better balance the interests of irrigation and the environment. It also considers that there are a number errors in the work underpinning the plan change which have implications for the plan.	Oppose
11	Bowden Environmental 52242	**V1pLWRP-600** (audit of consents)	CPW acknowledges that there is currently some uncertainty over the extent of actual allocation in the Selwyn Waihora catchment. However, particular care needs to be taken when approaching allocation – including actual use versus consented entitlements and concurrency arrangements. It anticipates that the concerns may be	Support in part

[1] Please note that the summary included in column 3 ("Particular parts") and the reasons provided in column 4 ("Reasons") are provided for ease of reference and for the purposes of informing CPW's position. In no context should either be read as strictly limiting or confining the specific further submission points.

Prov.	Original submitter	Particular parts	Reasons	Support/Oppose
			able to be addressed during the wider plan change/hearing process.	
11	Selwyn District Council 52245	**V1pLWRP-545** (not consistent with the RPS and pLWRP)	There are other aspects of the RPS and pLWRP that need to be better addressed in Variation 1 – including the recognition of the value of irrigation and an a wider planning regime that contemplates the development of the Central Plains Water Enhancement Scheme. There are other documents (such as the Canterbury Water Management Strategy) that are also relevant.	Support in part
11	Beef + Lamb New Zealand 52292	**V1pLWRP-568** **V1pLWRP-570** (objective recognising restoration and prosperous communities) *Note – both submission points seem to provide for the same thing*	CPW generally recognises the objective of restoring the mauri of Te Waihora while maintaining the prosperous land based economy and thriving communities. In this context "*maintain*" must be read broadly (and must be capable of accommodating future development such as the Central Plains Water Enhancement Scheme).	Support in part
11	Ravensdown Fertiliser Co-operative Limited 52249	**V1pLWRP-803** (withdrawal of Variation 1 until such time as the Matrix of Good Management Project numbers are available)	Although CPW does not consider the withdrawal of Variation 1 necessary at this time it considers the further restriction regime provided for by *inter alia* Policy 11.4.14 should be deferred until such time as the Matrix of Good Management Project can be completed (with the plan possibly providing, for example, a method or policy for the purposes of completing the Matrix of Good Management Project so that it can inform a later plan change)	Support in part
11	Ravensdown Fertiliser Co-operative Limited	**V1pLWRP-806** (Council clarify its	CPW supports the concern set out. Consistent with its earlier submission on **V1pLWRP-803**, Variation 1 should expressly outline	Support

Prov.	Original submitter	Particular parts	Reasons	Support/Oppose
	52249	intention to rely on Good Management Practice loss rate calculations)	the role of the Matrix of Good Management Project in informing a future plan change.	
11	Ravensdown Fertiliser Co-operative Limited 52249	**V1pLWRP-828** (delete the reference to Good Management Practice Nitrogen and Phosphorus Loss Rates)	Although CPW is not opposed to Variation 1 recognising the work currently under water in respect of the Matrix of Good Management Project, care needs to be taken to avoid both pre-empting the outcomes of that work and including an 'interim restriction regime' (prior to that work being completed) which cannot in itself be justified on the basis of section 32(2)(a).	Support in part
11	Ms Ronlyn Duncan 52307	**V1pLWRP-733** (further versions of OVERSEER)	CPW acknowledges the need for assessments (and Variation 1) to be able to accommodate subsequent versions in OVERSEER. Farmers however need certainty as to long-term nutrient allowances, so the implementation of further versions of OVERSEER should only be done in a manner that does not further penalise farmers.	Support in part
11	Horticulture New Zealand 52267	**V1pLWRP-1382** (withdraw Variation 1 or withdraw the parts of the Variation that do not relate to Community Irrigation Schemes).	CPW considers that all nutrient issues need to be managed at a catchment level. Although Community Irrigation Schemes have an important role in facilitating development of wider irrigation, existing farmers may also have a role in reducing or mitigating (in particular) existing higher nutrient loss activities.	Oppose
11	Dairy NZ 52271	**V1pLWRP-1352** (transfer of nitrogen loss rates)	CPW supports more flexible mechanisms in terms of managing nutrients.	Support

Prov.	Original submitter	Particular parts	Reasons	Support / Oppose
11	Dairy NZ 52271	**V1pLWRP-1377** (ensuring the Variation includes appropriate linkages between [freshwater] outcomes and non-regulatory methods)	CPW considers that non-regulatory methods have an important role to play in the management of nutrients. CPW also repeats the material set out in **Annexure 1** and notes there may also be a broader range of regulatory methods than just those set out in proposed Variation 1 in terms of managing nutrient effects.	Support
11	Horticulture New Zealand 52267	**V1pLWRP-1418** (rule and method framework to support the policy requested on transfer of nutrients)	The submission discusses this concern in the context of Policy 11.4.16 (of which Central Plains has no interest), but to the extent that a transfer regime is being suggested more generally, then CPW considers it an appropriate method for managing nutrients.	Support
11	Canterbury Grasslands Group 52314 Mr and Mrs Alistair and Sharon Rayne 52668 Mr and Mrs Harold and Relda Oakley 52669 Ellesmere Transport 52670	**V1pLWRP-1430** **V1pLWRP-1431** **V1pLWRP-1433** **V1pLWRP-1434** (establishment of baseline)	Although CPW supports the establishment of a baseline in a fair and reasonable manner, it is unclear on the exact concern raised (given the definition of baseline in the pLWRP, which applies in Selwyn-Waihora, is based on the period 1 July 2009 to 30 June 2013.	Support in part

Prov.	Original submitter	Particular parts	Reasons	Support/Oppose
11	Canterbury Grasslands Group 52314 Mr and Mrs Alistair and Sharon Rayne 52668 Mr and Mrs Harold and Relda Oakley 52669 Ellesmere Transport 52670	**V1pLWRP-1426** **V1pLWRP-1427** **V1pLWRP-1428** **V1pLWRP-1429** (Matrix of Good Management published by end of 2015)	Central Plains supports the Matrix of Good Management Practice Project but emphasises that it does not want to see it done in a rushed or potentially incorrect manner. Although Variation 1 might acknowledge the separate Matrix of Good Management Practice Project, it should not try to anticipate or pre-determine the outcomes of that project.	Support in part
11	Fonterra Co-operative Group Limited 52333	**V1pLWRP-1579**	CPW considers that non-regulatory methods have an important role to play in the management of nutrients. CPW also repeats the material set out in **Annexure 1** and notes there may also be a broader range of regulatory methods than just those set out in proposed Variation 1 in terms of managing nutrient effects.	Support
9	I & CM McIndoe Partnership 52286	**V1pLWRP-1583** **V1pLWRP-888** **V1pLWRP-894** **V1pLWRP-901** (*inter alia* delete all reference to West Melton Special Zone and all associated rules and	CPW seeks that the small area identified within the West Melton Special Zone that also falls within the Central Plains Water Enhancement Scheme area have no further restrictions than those that already apply to the Central Plains Water Enhancement Scheme. In the alternative, CPW seeks that the particular West Melton Special Zone provisions do not apply to any property that is receiving water from an irrigation scheme	Support

Prov.	Original submitter	Particular parts	Reasons	Support/Oppose
		allocations).		
11	Ellesmere Irrigation Society Inc 52210	**V1pLWRP-463** (amend sixth bullet point on p4-3 as follows: *"A ~~50 percent~~ reduction in the catchment phosphorus load."*)	Although CPW acknowledges the desire to reduce phosphorous losses, it is not clear whether the 50% reduction as set out is appropriate.	Support
11	Nga Rūnanga and Te Rūnanga O Ngāi Tahu 52233 North Canterbury Province of Federated Farmers NZ Inc 52318 The Canterbury Farming Company 52306	**V1pLWRP-365** **V1pLWRP-846** **V1pLWRP-1618** (include a new objective: To restore the mauri of Te Waihora while maintaining the prosperous land-based economy and thriving communities.)	CPW supports this objective to the extent to which it accommodates the development of the Central Plains Water Enhancement Scheme. To the extent that a different outcome is anticipated, the objective is opposed.	Part support/part oppose
11	Selwyn District Council 52245	**V1pLWRP-513** (freshwater as a resource)	CPW supports further recognition of the value freshwater especially to farming and primary production.	Support
11	Ravensdown Fertiliser Co-operative Limited	**V1pLWRP-813** **V1pLWRP-815**	CPW acknowledges the potential disconnect between the nitrogen baseline and the matrix of good management practices, but also	Support in part

Prov.	Original submitter	Particular parts	Reasons	Support/Oppose
	52249	(nitrogen baseline)	considers that in the absence of the matrix of good management practices at this time, the nitrogen baseline (and an allocation to the Central Plains Water Enhancement Scheme) may be the only useful 'benchmark' for permitting nutrient loss. CPW agrees the plan should set a framework that allows all farmers (including those within an irrigation scheme) to work towards implementing good management practices.	
11	KO Farm Ltd 52332	**V1pLWRP-988** (identification of all potential issues associated with the proposed nutrient management regime)	CPW agrees with the concern that not all issues (or costs) associated with Variation 1 are reflected in it – although it is also concerned to ensure that the plan goes beyond just identifying the costs and instead has objectives. Policies and rules that truly reflect the actual costs and benefits of what is set out. In the case of the submission point it is also noted that the "*lack of opportunities to undertake new land use options for landholdings*" will be addressed in part by the Central Plains Water Enhancement Scheme	Support in part
11	Horticulture New Zealand 52267	**V1pLWRP-1383** (recognition of importance to agricultural and food production)	CPW supports further recognition of the value the area for agriculture and food production.	Support
11	Horticulture New Zealand 52267	**V1pLWRP-1384** (objective to recognise and provide for the nationally significant benefits of food and fibre	CPW supports further recognition of the benefits of food and fibre production.	Support

Prov.	Original submitter	Particular parts	Reasons	Support/Oppose
		production)		
11	Dairy NZ 52271 Fonterra Co-operative Group Limited 52333	**V1pLWRP-1343** **V1pLWRP-1213** (value of catchment to primary production and recognition of innovation to better manage irrigation and nutrients)	CPW supports further recognition of the value catchment to primary production – and the likelihood that better technologies will be available in the future.	Support
11.1a	Beef +Lamb New Zealand 52292 The Canterbury Farming Company 52306 Whitefield Dairies Ltd & Nth Canterbury Federated Farmers 52313 Synlait Farms Ltd 52287 Horticulture New Zealand	**V1pLWRP-572** **V1pLWRP-566** **V1pLWRP-603** **V1pLWRP-1227** **V1pLWRP-1544** (definition of nitrogen baseline)	CPW does not have a view on the extent to which the submissions are within the scope of Variation 1 (noting that Variation 1 did not seek to amend the definition of nitrogen baseline) To the extent that the definitions are within scope, CPW seeks a definition that allows for the continued development of the consented Central Plains Water Enhancement Scheme. This includes ensuring that the CPW nutrient load is based on the likely average discharge in the catchment (and not the 'balance' of peak nutrient loads over the last period of X years).	Part support/part oppose

Prov.	Original submitter	Particular parts	Reasons	Support/Oppose
	52267			
11.1a	Ravensdown Fertiliser Co-operative Limited 52249	**V1pLWRP-818** (clarify definition of Good Management Practice Nitrogen and Phosphorus Loss Rate to state how will be determined)	CPW considers these are currently unclear – although it might be appropriate that any amendment is included in any subsequent plan change done to include the outcomes from the Matrix of Good Management Practice Project.	Support in part
11.1a	Ballance Agri-Nutrients Limited 52309	**V1pLWRP-781** (amendments to definition of 'Good Management Practice Nitrogen and Phosphorus Loss Rates')	As above	Support in part
11.1a	North Canterbury Province of Federated Farmers NZ Inc 52318	**V1pLWRP-862** (definition of nitrogen baseline)	If a definition is to be included, CPW seeks a definition that allows for the continued development of the consented Central Plains Water Enhancement Scheme. This includes ensuring that the CPW nutrient load is based on the likely average discharge in the catchment (and not the 'balance' of peak nutrient loads over the last period of X years). CPW is also unclear on the intended effect of *" a condition relating to the use of the water <u>or</u> a nitrogen discharge allowance"* and queries whether the correct reference should be "*and*" instead of "*or*".	Part support/part oppose
11.1a	North Canterbury Province of Federated	**V1pLWRP-875** (inclusion of a definition	CPW considers the definition provided might provide a clearer definition than that currently provided in the pLWRP (which refers to	Part support/part

Prov.	Original submitter	Particular parts	Reasons	Support/Oppose
	Farmers NZ Inc 52318	of farming enterprise)	"aggregation of land") – although it is not clear if the second definition is in fact required. As set out elsewhere in this further submission, CPW is generally supportive of transfers and farming enterprises, but notes that within the Central Plains Water Enhancement Scheme area, those properties supplied water by the Scheme will all be subject to CPW controls (and the environmental regime required by the CPW resource consents). Were a farming enterprise regime available to persons receiving water from the Scheme, care would need to be taken to ensure that it is not used as a mechanism to manage or transfer existing nutrients contrary to the Scheme requirements or from land irrigated by CPW water to land that is not irrigated by CPW (to the detriment of the allocation of N to the scheme).	oppose
11.1a	Environmental Advisor NZPork 52107	**V1pLWRP-1155** **V1pLWRP-1156** (amend definition of 'Good Management Practice Nitrogen and Phosphorus Loss Rates' and include a definition of Good Management Practice) (and also **V1pLWRP-1157** to the extent it refers to Good	Although CPW agrees with intent of providing a more comprehensive definition "*Good Management Practice Nitrogen and Phosphorus Loss Rates*" it also considers that it might be better if a definition of "*Good Management Practice*" is not included in Variation 1 (and instead included any a later plan change once the Matrix of Good Management Practice Project is complete).	Part support/part oppose

Prov.	Original submitter	Particular parts	Reasons	Support/Oppose
		Management Practice)		
11.1a	Mr Dougal Smith 52195	**V1pLWRP-1102** **V1pLWRP-1107** **V1pLWRP-1114** (definition of 'Good Management Practice Nitrogen and Phosphorus Loss Rates and including good management practice nitrogen loss in tables detailing losses per soil type and land use activity.)	CPW agrees, in part, with the sentiment that the plan cannot be supported if the nitrogen loss rates/reductions envisaged under policies 11.4.13 and 11.4.14 are in fact not known. CPW prefers an approach that implements the Matrix of Good Management Practices as and when they are developed.	Support in part
11.1a	Horticulture New Zealand 52267	**V1pLWRP-1387** **V1pLWRP-1388** **V1pLWRP-1393** (inclusion of "or farming enterprise")	Further reference to "or farming enterprise" is likely to assist in the application of the plan. As set out elsewhere in this further submission, CPW is generally supportive of transfers and farming enterprises, but notes that within the Central Plains Water Enhancement Scheme area, those properties supplied water by the Scheme will all be subject to CPW controls (and the environmental regime required by the CPW resource consents). Were a farming enterprise regime available to persons receiving water from the Scheme, care would need to be taken to ensure that it is not used as a mechanism to manage or transfer existing nutrients contrary to the Scheme requirements or from land irrigated by CPW	Support

Prov.	Original submitter	Particular parts	Reasons	Support/Oppose
			water to land that is not irrigated by CPW (to the detriment of the allocation of N to the scheme).	
11.1a	Irrigation New Zealand Inc 52278 The Canterbury Farming Company 52306	**V1pLWRP-1063** **V1pLWRP-1620** (definition of farming enterprise)	CPW considers the definition provided might provide a clearer definition than that currently provided in the pLWRP (which refers to "aggregation of land") – although it is not clear if the second definition is in fact required. As set out elsewhere in this further submission, CPW is generally supportive of transfers and farming enterprises, but notes that within the Central Plains Water Enhancement Scheme area, those properties supplied water by the Scheme will all be subject to CPW controls (and the environmental regime required by the CPW resource consents). Were a farming enterprise regime available to persons receiving water from the Scheme, care would need to be taken to ensure that it is not used as a mechanism to manage or transfer existing nutrients contrary to the Scheme requirements or from land irrigated by CPW water to land that is not irrigated by CPW (to the detriment of the allocation of N to the scheme).	Part support/part oppose
11.1a	Irrigation New Zealand Inc 52278	**V1pLWRP-1056** (include a definition of nitrogen baseline)	If a definition is to be included, CPW seeks a definition that allows for the continued development of the consented Central Plains Water Enhancement Scheme. This includes ensuring that the CPW nutrient load is based on the likely average discharge in the catchment (and not the 'balance' of peak nutrient loads over the last period of X years).	Part support/part oppose

Prov.	Original submitter	Particular parts	Reasons	Support / Oppose
11.1a	Synlait Farms Ltd 52287	**V1pLWRP-1031** (amend definition of 'Good Management Practice Nitrogen and Phosphorus Loss Rates')	CPW acknowledges the concern as set out but queries the extent to which this can be undertaken prior to the Matrix of Good Management Practices Project being completed.	Part support/part oppose
11.1a	Horticulture New Zealand 52267	**V1pLWRP-1533** (definition of irrigation scheme)	The Central Plains Water [Irrigation Scheme] is already defined for the purposes of the 11.1A. CPW is unclear on what the proposed definition is intended to achieve (given the rather different treatment of irrigation schemes under Variation 1). Reference might be better made to a nutrient management group that allows properties/farming enterprises to share their individual nutrient loads?	Part support/part oppose
11.1a	Dairy NZ 52271 The Canterbury Farming Company 52306 Fonterra Co-operative Group Limited 52333 Mr Hugh Macartney 52342 Mr and Mrs Alistair and Sharon Rayne	**V1pLWRP-1516** **V1pLWRP-1649** **V1pLWRP-1422** **V1pLWRP-1573** **V1pLWRP-1472** **V1pLWRP-1423** **V1pLWRP-1424** **V1pLWRP-1425** **V1pLWRP-1346** **V1pLWRP-1055** **V1pLWRP-613** (include/amend to include a definition of nitrogen baseline applying specifically to	If a definition is to be included, CPW seeks a definition that allows for the continued development of the consented Central Plains Water Enhancement Scheme. This includes ensuring that the CPW nutrient load is based on the likely average discharge in the catchment (and not the 'balance' of peak nutrient loads over the last period of X years).	Part support/part oppose

Prov.	Original submitter	Particular parts	Reasons	Support/Oppose
	52668 Mr and Mrs Harold and Relda Oakley 52669 Irrigation New Zealand Inc 52278 Mr Peter J. Chamberlain 52133	Selwyn-Waihora). *Note both V1pLWRP-1424* *V1pLWRP-1425 appear to relate to the same submitter/submission point.*		
11.1a	Fonterra Co-operative Group Limited 52333	**V1pLWRP-1574** (definition of Selwyn-Waihora Nitrogen Loss Calculation")	CPW supports the provision of the a definition of Selwyn-Waihora Nitrogen Loss Calculation as set out (assuming that the actual scheme load allocated to the Central Plains Water Enhancement Scheme is still based on average discharge in the catchment)	Part support/part oppose
Objectives and policies				
11.4	Te Taumutu Rūnanga 52215	**V1pLWRP-292** (over allocation and related policies generally)	Although CPW acknowledges the submitters concerns around over allocation, any such concern needs to be addressed in an integrated manner. In that context the development of the Central Plains Water Enhancement Scheme will result in significant additional alpine water entering the zone (which will address at least some of the concerns set out). CPW is also supportive of transfers as an effective mechanism of	Oppose

Prov.	Original submitter	Particular parts	Reasons	Support/Oppose
			addressing allocation issues (to the extent set out in its own original submission)	
11.4	Te Taumutu Rūnanga 52215	**V1pLWRP-370** (replace policies with aim of achieving a TLI of 4.8)	CPW does not consider the sought relief is realistic (and it is also inconsistent with the submitters other sought relief (V1pLWRP-365)). It is also contrary to the analyses undertaken to date, the concept of sustainable management and the various other planning documents applying to the Selwyn Waihora catchment.	Oppose
11.4	Nga Rūnanga and Te Rūnanga O Ngāi Tahu 52233	**V1pLWRP-401** (new policies)	Although CPW acknowledges the submitters concerns around over allocation, any such concern needs to be addressed in an integrated manner. In that context the development of the Central Plains Water Enhancement Scheme will result in significant additional alpine water entering the zone (which will address at least some of the concerns set out). CPW is also supportive of transfers as an effective mechanism of addressing allocation issues (to the extent set out in its own original submission). Damming needs to be approached in careful and considered way (with CPW considering discretionary activity status more appropriate). CPW is generally supportive of the storage as also suggested by the submitter.	Part oppose/part support
11.4	Selwyn District Council 52245	**V1pLWRP-525** (recognition of regionally significant infrastructure)	CPW supports the policy – and notes, in the absence of a definition in the pLWRP, it should be regionally significant infrastructure (assuming that "*(11) Established community-scale irrigation and stockwater infrastructure*" as set out in the Canterbury Regional Policy Statement will apply to it upon establishment – if not, clarification is sought)	Support
11.4	Selwyn District Council	**V1pLWRP-526** (discharges from	CPW repeats its submission in respect of V1pLWRP-525	Part support/part

Prov.	Original submitter	Particular parts	Reasons	Support/Oppose
	52245	Regionally significant infrastructure)	If the policy is accepted, (and although CPW is intent on managing its discharges in accordance with the approach set out) it is not clear whether the policy is also intended to apply to irrigation (if so, the sought policy should be amended to ensure that irrigation is managed on a separate basis outside of the policy)	oppose
11.4	Beef +Lamb New Zealand 52292	**V1pLWRP-571** **V1pLWRP-574** (amend policies to be more equitable and sustainable)	In the absence of relief being suggested, CPW is not clear on the implications of what is being sought. CPW supports the concerns to the extent they support the development of the Central Plains Water Enhancement Scheme. Anything contrary to that is opposed.	Part support/part oppose
11.4	Ravensdown Fertiliser Co-operative Limited 52249	**V1pLWRP-804** (policy outlining that Council will introduce into the pLWRP by Variation or Plan Change the Matrix of Good Management numbers)	CPW supports the concern set out. Consistent with its earlier submission on V1pLWRP-803, Variation 1 should expressly outline the role of the Matrix of Good Management Project in informing a future plan change.	Support
11.4	Ballance Agri-Nutrients Limited 52309	**V1pLWRP-762** (robust implementation plan)	CPW generally supports the sentiments around implementation although notes that as promulgated CPW will be the entity responsible for implementation on shareholder properties in the Central Plains Water Enhancement Scheme area.	Support in part
11.4	Ballance Agri-Nutrients Limited 52309	**V1pLWRP-783** (non-regulatory methods and introduction of the Matrix of Good	CPW supports the concern set out. Consistent with its earlier submission on V1pLWRP-803, Variation 1 should expressly outline the role of the Matrix of Good Management Project in informing a future	Support

Prov.	Original submitter	Particular parts	Reasons	Support/Oppose
		Management Practice Project outcomes)	plan change. CPW also considers that non-regulatory methods have an important role to play in the management of nutrients. There may also be a broader range of regulatory methods than just those set out in proposed Variation 1 in terms of managing nutrient effects.	
11.4	Fish and Game Council North Canterbury 52310	**V1pLWRP-661** (life supporting capacity and ecosystem function of water)	There are a number of considerations that need to go into setting water quality and quantity limits. The sought relief is not reflective of all relevant values.	Oppose
11.4	KO Farm Ltd 52332	**V1pLWRP-989** (balance between protecting the water quality of Lake Waihora/Ellesmere and enabling existing and consented farming operations to continue)	CPW supports the general concern set out. CPW is a consented irrigation scheme for the purposes of the balance sought.	Support
11.4	Mr Dougal Smith 52195	**V1pLWRP-1116** (distribution of nutrients and trade)	CPW supports the potential "trade" of nutrient entitlements (through, for example, a nutrient management group), but through a reflection of *inter alia* historic/existing land use, relative effects on the environment and consented authorisations, the allocation of nutrients may not be able to occur on an equal basis.	Part support/part oppose
11.4	Royal New Zealand Forest and Bird	**V1pLWRP-1251** (progressive reviewing	Although CPW acknowledges the concern set out and the approach taken in the Hurunui catchment, it also considers that parties need	Oppose

Prov.	Original submitter	Particular parts	Reasons	Support/Oppose
	Protection Society 52265	and monitoring of the Policies and Rules)	certainty now as to the planning framework applying to its operations. The review of policies and rules does not need to be included as a part of the plan (it can instead be dealt with, if required, as a part of any plan review process in the future)	
11.4	Royal New Zealand Forest and Bird Protection Society 52265	**V1pLWRP-1260** **V1pLWRP-1261** (significant indigenous vegetation and significant habitats of indigenous fauna are protected)	There are a number of considerations that need to go into setting water quality and quantity limits. The sought relief is not reflective of all relevant values. CPW does however acknowledge that there might be alternative approaches (either in addition to or in place of a restriction regime) that focus more directly on enhancement.	Part support/part oppose
11.4	Horticulture New Zealand 52267	**V1pLWRP-1391** (targets and limits set in this variation will be reviewed before 2017)	CPW is supportive of a further plan change once the Matrix of Good Management Practice Project is complete. Care also needs to be taken now to avoid both pre-empting the outcomes of that work and including an 'interim restriction regime' (prior to that work being completed) which cannot in itself be justified on the basis of section 32(2)(a).	Support
11.4	Fonterra Co-operative Group Limited 52333 [Dairy NZ] 52271 (*submitter name is shown as Horticulture New Zealand in*	**V1pLWRP-1305** **V1pLWRP-1524** (non-complying activity status)	CPW considers that non-complying activity status might be more appropriate – especially given there are uncertainties around the extent of actual effects at this time.	Support

Prov.	Original submitter	Particular parts	Reasons	Support / Oppose
	summary of submissions – possibly an error and correct reference should be to Dairy NZ?)			
11.4	Horticulture New Zealand 52333 *(is shown wrongly as submitter #52267 in summary of submissions*)	**V1pLWRP-1399** (re-assessment of nitrogen baseline if not accurate)	CPW considers it important that the relevant baseline is appropriate and accurate. Any such re-assessment should be done in a manner that does not affect nutrient allocations to other entities/persons in the catchment.	Support in part
11.4	Horticulture New Zealand 52267	**V1pLWRP-1405** (transfer of nutrients)	CPW supports the potential transfer of nutrients (through, for example provision being made for the establishment of nutrient management groups)	Support
11.4.1	Selwyn District Council 52245	**V1pLWRP-515** (manage, and if practicable avoid adverse cumulative effects)	CPW supports the relied sought and, for the reasons set out in its original submission, considers it better achieves the purpose set out in Part II of the Act.	Support
11.4.1	The Fertiliser Association of New Zealand	**V1pLWRP-787** (avoid, remedy or mitigate cumulative	CPW supports the relied sought and, for the reasons set out in its original submission, considers it better achieves the purpose set out in Part II of the Act.	Support

Prov.	Original submitter	Particular parts	Reasons	Support/Oppose
	51972	effects)		
11.4.1	Synlait Farms Limited 52287 Dairy NZ 52271 Fonterra Co-operative Group Limited 52333	**V1pLWRP-974** **V1pLWRP-1344** **V1pLWRP-1215** (adverse effects)	There will in fact be a number of positive effects following the development of the Central Plains Water Enhancement Scheme. The policy should be focused on adverse effects	Support
11.4.1	Committee Malvern Hills Protection Society 51995	**V1pLWRP-1175** (include the Waikirikiri/Selwyn and tributaries, and Kowai River)	CPW considers this is already largely achieved by the policy (and express reference is not required or appropriate)	Oppose
Various	Mr Clive Thomas 52131	**V1pLWRP-42** **V1pLWRP-624** (amend policy so as not to allow an extra 30,000ha of new irrigation)	Sought relief is inconsistent with the development of the Central Plains Water Enhancement Scheme (and the wider framework of Variation 1).	Oppose
11.4.6	Ellesmere Irrigation Society Inc 52210	**V1pLWRP-472** **V1pLWRP-648** **V1pLWRP-1389** (delete reference to	CPW agrees there is currently some uncertainty over the extent to which various matters are being expressed as limits and others targets. Care needs to be taken to ensure that [an amended] Table	Neutral

Prov.	Original submitter	Particular parts	Reasons	Support/Oppose
	Fish and Game Council North Canterbury 52310 Horticulture New Zealand 52267	Table 11(i))	11(i) is appropriately reflected in the policy and rules framework.	
11.4.6	Royal New Zealand Forest and Bird Protection Society 52265	**V1pLWRP-1263** (review limits in 5 years)	CPW agrees in part with concern set out but considers it should instead be tied to the completion of the Matrix of Good Management Practice Project	Support in part
11.4.6	Dairy NZ 52271 Fonterra Co-operative Group Limited 52333	**V1pLWRP-1345** **V1pLWRP-1218** (review of load rate)	CPW supports a commitment in the plan to keep the nitrogen load limit under review (such that the appropriate limit is reconsidered once the Good Management Practice Nitrogen and Phosphorus Loss Rates have been confirmed).	Support
Various	Ellesmere Irrigation Society Inc 52210 Mr Tom Ferguson 52236 Mr Martin Bruce	**V1pLWRP-473** **V1pLWRP-798** **V1pLWRP-750** **V1pLWRP-629** **V1pLWRP-475** **V1pLWRP-476** (increase from 15kg)	CPW opposes any change to the nitrogen baseline to the extent it might result in a reduction of N allocation to the Central Plains Water Enhancement Scheme	Oppose in part

Prov.	Original submitter	Particular parts	Reasons	Support/Oppose
	52279 Mr Geoffrey John Bain 52154 Ellesmere Irrigation Society Inc 52210			
Various	Royal New Zealand Forest and Bird Protection Society 52265	**V1pLWRP-1271** **V1pLWRP-1273** **V1pLWRP-1274** **V1pLWRP-1275** **V1pLWRP-1286** (provide for a review of the achievement and efficacy of the proposed reduction targets and nitrogen baseline within five years)	CPW agrees in part with concern set out but considers it should instead be tied to the completion of the Matrix of Good Management Practice Project	Support in part
11.4.12	Canterbury Grasslands Group 52314 Mr and Mrs Alistair and Sharon Rayne 52668	**V1pLWRP-1446** **V1pLWRP-1447** **V1pLWRP-1448** **V1pLWRP-1449** (link on-going reduction in nitrogen leaching to current availability, viability and affordability	This is consistent with CPW's concerns around ensuring Variation 1 includes provisions supporting a review following the completion of the Matrix of Good Management Practice Project.	Support

Prov.	Original submitter	Particular parts	Reasons	Support/Oppose
	Mr and Mrs Harold and Relda Oakley 52669 Ellesmere Transport 52670	of tools)		
11.4.12	Fonterra Co-operative Group Limited 52333	**V1pLWRP-1575** (nitrogen baseline and monitoring of catchment load)	CPW repeats its further submission elsewhere in respect of any changes to the nitrogen baseline. CPW supports the balance of the submission on the basis that the catchment load limit should be kept under review (factoring in actual take up of the 15kg allowance).	Support
11.4.12	Dairy Holdings Ltd 53683	**V1pLWRP-1938** (nutrient management groups)	CPW supports the use of nutrient management groups and considers they should be extended to potentially include irrigation schemes.	Support in part
11.4.13	North Canterbury Province of Federated Farmers NZ Inc 52318 The Canterbury Farming Company 52306	**V1pLWRP-848** **V1pLWRP-1651** (new policy 11.4.3)	CPW supports the intended approach of having a plan change occur in 2 to 3 years' time but considers it should be more directly connected to the completion of the Matrix of Good Management Practice Project. As set out elsewhere in its further submission, CPW is concerned to ensure that any increase in the 15kg 'default value' does not cause any reduction in the nutrient allocation available to the Central Plains Water Enhancement Scheme	Part support/part oppose
11.4.13	Dairy NZ	**V1pLWRP-1350** (delete Policy 11.4.13.	As set out elsewhere in its further submission, CPW considers the development and implementation of the Matrix of Good Management	Support

Prov.	Original submitter	Particular parts	Reasons	Support/Oppose
	52271	Replace with a commitment (in a method or advisory note) to develop Good Management Practice Nitrogen Phosphorus Loss rates, for inclusion in the Plan)	Project an important part of Variation 1 (with the plan possibly providing, for example, a method or policy for the purposes of completing the Matrix of Good Management Project so that it can inform a later plan change)	
Various	Irrigation New Zealand Inc 52278	**V1pLWRP-1057** **V1pLWRP-1059** (not possible for farmers to achieve the good management practice nitrogen discharge levels as they have not yet been defined).	CPW agrees with the sentiment set out and considers it can be addressed by the plan providing, for example, a method or policy for the purposes of completing the Matrix of Good Management Project so that it can inform a later plan change. In the interim 11.4.13 should be deleted or redrafted to avoid reference to things that do not yet exist.	Support
11.4.13	Synlait Farms Ltd 52287	**V1pLWRP-1030** (completion of the Matrix of Good Management)	As above	Support
11.4.13	Fonterra Co-operative Group Limited 52333	**V1pLWRP-1238** (commitment to the Matrix of Good Management)	As above	Support

Prov.	Original submitter	Particular parts	Reasons	Support/Oppose
11.4.13	Dairy Holdings Ltd 53683	**V1pLWRP-1939** (commitment to the Matrix of Good Management)	As above	Support
11.4.13	Horticulture New Zealand 52267	**V1pLWRP-1545** (amendments to policy)	CPW supports the submission to the extent that it seeks to remove reference to good management practices that do not exist yet.	Support in part
11.4.14	Beef +Lamb New Zealand 52292	**V1pLWRP-573** (amend policy 11.4.14 (b)(iv) to 5% for irrigated sheep, beef, deer and 11.4.14 (b) (v) to 2% for dryland sheep, beef and deer)	Although CPW agrees with the sentiment set out, it considers it would be better dealt with the plan providing, for example, a method or policy for the purposes of completing the Matrix of Good Management Project so that it can inform a later plan change. In the interim no restriction regime should be provided for in Policy 11.4.14.	Part support/part oppose
11.4.14	Ravensdown Fertiliser Co-operative Limited 52249	**V1pLWRP-829** (percentage reduction in advance of Matrix of Good Management project)	CPW agrees with the sentiment set out and considers it can be addressed by the plan providing, for example, a method or policy for the purposes of completing the Matrix of Good Management Project so that it can inform a later plan change. In the interim no restriction regime should be provided for in Policy 11.4.14.	Support
11.4.14	Ravensdown Fertiliser Co-operative Limited 52249	**V1pLWRP-830** (amend 11.4.14 (b)(i) to 20%)	Although CPW agrees with the sentiment set out, it considers it would be better dealt with the plan providing, for example, a method or policy for the purposes of completing the Matrix of Good Management Project so that it can inform a later plan change. In the interim no restriction regime should be provided for in Policy 11.4.14.	Support in part

Prov.	Original submitter	Particular parts	Reasons	Support/Oppose
11.4.14	Fish and Game Council North Canterbury 52310 Committee Malvern Hills Protection Society 51995	**V1pLWRP-664** **V1pLWRP-1178** (retain Policy 11.4.14.)	The percentage reductions in Policy 11.4.14 are arbitrary and unreasonable. Until such time as the Matrix of Good Management Project is complete and the actual implications of reductions are properly understood, no restriction regime should be provided for in Policy 11.4.14.	Oppose
11.4.14	North Canterbury Province of Federated Farmers NZ Inc 52318 The Canterbury Farming Company 52306	**V1pLWRP-849** **V1pLWRP-1652** (revised policy 11.4.14)	Properties receiving water from the Central Plains Water Enhancement Scheme will already have farm environment plans (as required by the CPW resource consents). Care needs to be taken to avoid duplication. As set out elsewhere in its further submission, CPW is concerned to ensure that any increase in the 15kg 'default value' does not cause any reduction in the nutrient allocation available to the Central Plains Water Enhancement Scheme	Part support/part oppose
11.4.14	Environmental Advisor NZPork	**V1pLWRP-1163** (levels of loss reduction required will be agreed between Environment Canterbury and agricultural sectors pending completion of the Matrix of Good Management Project)	The percentage reductions in Policy 11.4.14 are arbitrary and unreasonable. Until such time as the Matrix of Good Management Project is complete and the actual implications of reductions are properly understood, no restriction regime should be provided for in Policy 11.4.14. As set out elsewhere in its further submission, CPW considers it would be better dealt with the plan providing, for example, a method or policy for the purposes of completing the Matrix of Good Management Project so that it can inform a later plan change.	Support in part

Prov.	Original submitter	Particular parts	Reasons	Support/Oppose
11.4.14	Dairy NZ 52271	**V1pLWRP-1351** (delete Policy 11.4.14 and replace with a commitment (in a method or advisory note)	As set out elsewhere in its further submission, CPW supports the use of, for example, a method or policy for the purposes of completing the Matrix of Good Management Project so that it can inform a later plan change.	Support
11.4.14	McKavanagh Holdings Ltd 52276	**V1pLWRP-1112** (restriction regime)	The percentage reductions in Policy 11.4.14 are arbitrary and unreasonable. Until such time as the Matrix of Good Management Project is complete and the actual implications of reductions are properly understood, no restriction regime should be provided for in Policy 11.4.14. CPW supports transfers and the use of nutrient management groups.	Support
11.4.14	Synlait Farms Ltd 52287	**V1pLWRP-1146** (alternative mechanisms)	As set out in **Annexure 1**, CPW supports consideration being given to alternative reduction/restriction mechanisms. In this context, the percentage reductions in Policy 11.4.14 are arbitrary and unreasonable. Unless an appropriate alternative approach is elected, until such time as the Matrix of Good Management Project is complete and the actual implications of reductions are properly understood, no restriction regime should be provided for in Policy 11.4.14.	Support in part
11.4.14	Lake Ellesmere Dairy Farmers Group	**V1pLWRP-1051** (delete Policy 11.4.14	CPW is supportive of a further plan change once the Matrix of Good Management Practice Project is complete. Care also needs to be taken	Support

Prov.	Original submitter	Particular parts	Reasons	Support/Oppose
	52329	and review when the Good Management Practice Nitrogen Loss numbers are determined)	now to avoid both pre-empting the outcomes of that work and including an 'interim restriction regime' (prior to that work being completed) which cannot in itself be justified on the basis of section 32(2)(a)).	
11.4.14	Fonterra Co-operative Group Limited 52333	**V1pLWRP-1239** (good management practice)	As above	Support
11.4.14	Horticulture New Zealand	**V1pLWRP-1403** (amend the policy to take into account revised assessments that are developed through the process)	As set out in **Annexure 1**, CPW supports consideration being given to revised assessments.	Support
11.4.14	Dairy Holdings Ltd 53683	**V1pLWRP-1940** (Replace with a method requiring the Council to commit to a nitrogen reduction strategy for inclusion in the subsequent notified plan variation)	CPW is supportive of a further plan change once the Matrix of Good Management Practice Project is complete. Care also needs to be taken now to avoid both pre-empting the outcomes of that work and including an 'interim restriction regime' (prior to that work being completed) which cannot in itself be justified on the basis of section 32(2)(a).	Support

Prov.	Original submitter	Particular parts	Reasons	Support/Oppose
11.4.15	Dairy NZ 52271 Fonterra Co-operative Group Limited 52333	**V1pLWRP-1353** **V1pLWRP-1242** (matters to be considered post 2022 under Policy 11.4.15)	CPW acknowledges the potential matters that might be taken into consideration under any further reduction regime post 2022 and generally supports those suggested by the submitter as they might apply to individual properties (especially those not receiving water from an irrigation scheme). In the case of irrigation schemes, it is essential that the plan provides certainty as soon as possible as to what long-term discharges might look like (appreciating that this will not be obtainable until completion of the Matrix of Good Management Practice Project).	Support in part
11.4.15	Horticulture New Zealand 52267	**V1pLWRP-1551** (*inter alia* removing reference to 2022 in Policy 11.4.15)	Although CPW acknowledges the submitters concern, it is not clear when the policy would be relevant prior to 2022 (given that the submitter has maintained reference to an "*extension of time to achieve the nitrogen baseline*" which should already be known and effectively be the status quo (?). The outcomes of the Matrix of Good Management Practice Project (and any associated plan change) should be the main matter informing farming activities prior to 2022. No regard should be given to further reductions post 2022 at this time.	Part support/part oppose
11.4.17	Fish and Game Council North Canterbury 52310	**V1pLWRP-667** (exception of not adopting limits and targets referenced in Section 11.7.3)	CPW is not clear as to what "exception" is intended by the submission. CPW seeks such relief as aligns with its original submission and its other further submissions on Policy 11.4.17.	Oppose
11.4.17	Dairy NZ 52271 Fonterra Co-operative	**V1pLWRP-1354** **V1pLWRP-1243** (delete Policy 11.4.17	CPW repeats the matters set out in its original submission	Support

Prov.	Original submitter	Particular parts	Reasons	Support/Oppose
	Group Limited 52333	(b)).		
11.4.17	Irrigation New Zealand Inc 52278	**V1pLWRP-1060** (delete clause (b) of Policy 11.4.17, as it is not possible for farmers to achieve the Good Management Practice Nitrogen Discharge Levels and subsequent reductions as they have not yet been defined)	CPW repeats the matters set out in its original submission (and elsewhere in this further submission in respect of complying with something that does not exist yet)	Support
11.4.17	Synlait Farms Ltd	**V1pLWRP-1161** (allow a lead in time to meet 'improved nitrogen loss rates' and concern re loss rates that have not been set through the Matrix of Good Management yet)	CPW supports the submitters concern but considers it would be better addressed after the completion of the Matrix of Good Management Practice Project. In the interim, not further restriction regime should apply (and Policy 11.4.17(b) should be deleted). The additional restrictions on irrigation scheme members (simply by virtue of the fact they are part of an irrigation scheme) are arbitrary and unreasonable.	Part support/part oppose
11.4.17	The Crossing Ltd 52398	**V1pLWRP-1492** (recognition of other irrigation schemes and same flexible management framework	The submitter refers to the Glenroy scheme in its submission. This was addressed in CPW's original submission and CPW simply repeats the matters set out there. Any recognition of the Glenroy Scheme should not reduce the nutrient allocation to CPW.	Part support/part oppose

Prov.	Original submitter	Particular parts	Reasons	Support/Oppose
		as Central Plains Water)		
11.4.18	Fonterra Co-operative Group Limited 52333 Dairy NZ 52271	**V1pLWRP-1244** **V1pLWRP-1519** (amend Policy 11.4.18 to include methods in the Variation that support development of a catchment strategy and implementation plan to, in particular, identify critical source areas for reducing phosphorus and sediment loss)	Although this policy, as drafted does not directly affect CPW, it acknowledges the submitters' concerns and considers they might be able to be addressed in any alternative mitigation approach as set out in **Annexure 1**. Any alternative mitigation approach should only be employed to the extent that it is offset in (or substitutes) a reduction in the required restrictions relating to nutrients under the balance of Variation 1.	Support
11.4.19	Fonterra Co-operative Group Limited 52333 Dairy NZ 52271	**V1pLWRP-1249** **V1pLWRP-1520** (amend Policy 11.4.19 to include methods in the Variation that support development of a catchment strategy and implementation plan to, in particular, identify critical source areas for reducing phosphorus and sediment loss)	Although this policy, as drafted does not directly affect CPW, it acknowledges the submitters' concerns and considers they might be able to be addressed in any alternative mitigation approach as set out in **Annexure 1**. Any alternative mitigation approach should only be employed to the extent that it is offset in (or substitutes) a reduction in the required restrictions relating to nutrients under the balance of Variation 1.	Support

Prov.	Original submitter	Particular parts	Reasons	Support/Oppose
11.4.20	Te Taumutu Rūnanga 52215 Nga Rūnanga and Te Rūnanga O Ngāi Tahu 52233	**V1pLWRP-290** **V1pLWRP-399** (amend Policy 11.4.20 to read: Enable managed aquifer recharge and targeted stream augmentation)	CPW acknowledges the submitters' concerns but also note that such concerns are likely to, at least in part, be addressed through the development of the Central Plains Water Enhancement Scheme.	Part support/part oppose
11.4.20	Fonterra Co-operative Group Limited 52333 Dairy NZ 52271	**V1pLWRP-1250** **V1pLWRP-1521** (amend Policy 11.4.20 to include methods in the Variation that support development of a catchment strategy and implementation plan to, in particular, identify critical source areas for reducing phosphorus and sediment loss)	Although this policy, as drafted does not directly affect CPW, it acknowledges the submitters' concerns and considers they might be able to be addressed in any alternative mitigation approach as set out in **Annexure 1**. Any alternative mitigation approach should only be employed to the extent that it is offset in (or substitutes) a reduction in the required restrictions relating to nutrients under the balance of Variation 1.	Support
11.4.21	Mr Joel Townshend 52175	**V1pLWRP-80** (if more water is going down the drains water should be able to be taken from surface water given that low flows at the end of the streams	CPW repeats the material set out in **Annexure 1** and notes that this is something that should be considered in any alternative mitigation approach and to that extent it is supported by CPW.	Support in part

Prov.	Original submitter	Particular parts	Reasons	Support/Oppose
		are met)		
11.4.21	Director General of Conservation 52225	**V1pLWRP-211** (reference to targets in Policy 11.4.21)	CPW does not consider the reference to meeting targets appropriate (and would effectively make the various "targets" further "limits" which may or may not be appropriate)	Oppose
11.4.21	HydroTrader 52235	**V1pLWRP-192** (amend Policy 11.4.22 to require that conditions are imposed to avoid increases in water usage that will have an adverse effect (cumulatively or otherwise) on flows in hill-fed lowland and spring-fed plains rivers).	CPW acknowledges the submitters concerns although considers that a transfer regime consistent with its own original submission (as expanded by this further submission) appropriate. There may be opportunities in any wider alternative mitigation package to provide access to further water in the lower catchment areas (either directly or by way of transfers).	Support in part.
11.4.22	Dunsandel Groundwater Users Group 52221	**V1pLWRP-327** (various amendments to Policy 11.4.22)	CPW supports the submission (and notes it is generally consistent with the development of the Central Plains Water Enhancement Scheme).	Support in part
11.4.22	Central Plains Water Ltd 52239	**V1pLWRP-374** (various amendments to Policy 11.4.22)	Although CPW supports its original submission, it also emphasises that care needs to be taken in respect of related entities (and the wider farming enterprise regime to which reference can also be made) to ensure that it is not used as a mechanism to transfer existing nutrients from land irrigated by CPW water to land that is not irrigated by CPW (to the detriment of the allocation of N to the scheme). Policy 11.4.22	Part support/part oppose

Prov.	Original submitter	Particular parts	Reasons	Support/Oppose
			should be clarified to ensure it only applies to water quantity. CPW also notes that within the Central Plains Water Enhancement Scheme area, those properties supplied water by the Scheme will all be subject to CPW controls (and the environmental regime required by the CPW resource consents) and accordingly a farm enterprise regime may not be appropriate (or would need to be carefully structured so the concerns set out elsewhere in this further submission do not arise).	
11.4.22	Franco Luporini 52174	V1pLWRP-699 (various amendments to Policy 11.4.22)	Although many of the matters set out are already addressed by the pLWRP and Variation 1 (including Policy 11.4.25), CPW supports recognition of the positive effects that the Central Plains Irrigation scheme will have on groundwater takes	Support in part
11.4.22	McKavanagh Holdings Ltd 52276 Irrigation New Zealand Inc 52278	**V1pLWRP-1113** **V1pLWRP-1061** (*inter alia* transfers within a farming enterprise)	CPW repeats the matters set out in its original submission (and its further submission for **V1pLWRP-374**).	Part support/part oppose
11.4.23	Ellesmere Irrigation Society Inc 52210 Erralyn Farm Ltd & Krysette Ltd	**V1pLWRP-483** **V1pLWRP-1401** **V1pLWRP-337** (move from "*demonstrated use*" to	CPW acknowledges the submitters concern. In the case of an irrigation scheme, the volume of water on renewal needs to that required to supply the Irrigation Scheme when fully developed.	Support in part

Prov.	Original submitter	Particular parts	Reasons	Support / Oppose
	52263 Dunsandel Groundwater Users Group 52221	"*reasonable use*")		
11.4.23	North Canterbury Province of Federated Farmers NZ Inc 52318 The Canterbury Farming Company 52306	**V1pLWRP-868** **V1pLWRP-1634** (various amendments to Policy 11.4.23)	As above	Support in part
11.4.23	Irrigation New Zealand Inc 52278	**V1pLWRP-1065** (reasonable use based on a nine in ten year reliability and 80% application efficiency)	As above	Support
11.4.23	Synlait Farms Ltd 52287	**V1pLWRP-1180** (amend Policy 11.4.23 so that allocation is based on technical efficiency and reliability. Allocations must also allow for future	As above	Support

Prov.	Original submitter	Particular parts	Reasons	Support/Oppose
		growth)		
11.4.23	Dairy Holdings Ltd 53683	**V1pLWRP-1942** (various amendments to Policy 11.4.23 – including reference to irrigation schemes being renewed at full development volume)	As above	Support
11.4.25	Irrigation New Zealand Inc 52278 Erralyn Farm Ltd & Krysette Ltd 52263	**V1pLWRP-1066** **V1pLWRP-1402** (wider reference to Schedule 10)	CPW supports more flexibility in terms of the method used to assess annual volume(s).	Support
11.4.26	North Canterbury Province of Federated Farmers NZ Inc 52318 Irrigation New Zealand Inc 52278 Synlait Farms Ltd	**V1pLWRP-869** **V1pLWRP-1070** **V1pLWRP-1193** **V1pLWRP-1437** **V1pLWRP-1407** **V1pLWRP-1635** **V1pLWRP-1643** **V1pLWRP-1497** (nine out of ten year reliability (and 80 %	CPW supports the use of nine out of ten year reliability for irrigation schemes.	Support

Prov.	Original submitter	Particular parts	Reasons	Support/Oppose
	52287 Erralyn Farm Ltd & Krysette Ltd 52263 Horticulture New Zealand 52267 The Canterbury Farming Company 52306 (*there appears to be two submission references in the summary of submission in respect of this submitter*) The Crossing Ltd 52398	efficiency for irrigation schemes)		
11.4.28	Dairy NZ 52271 Fonterra Co-operative Group Limited	**V1pLWRP-1357** **V1pLWRP-1262** (amendments to Policy 11.4.28 to reflect groundwater recharge	CPW acknowledges the comments made by the submitters and notes that development of the Central Plains Water Enhancement Scheme is an essential part of the wider outcomes envisaged by Variation 1.	Support

Prov.	Original submitter	Particular parts	Reasons	Support/Oppose
	52333	from the Central Plains Water Enhancement Scheme)		
11.4.31	Mr Joel Townshend 52175 Chiswick Farm Ltd 52218 Dunsandel Groundwater Users Group 52221 Mr Leo Donkers 52277 Irrigation New Zealand Inc 52278 Mr Rodney Booth 52335	**V1pLWRP-88** **V1pLWRP-182** **V1pLWRP-348** **V1pLWRP-1077** **V1pLWRP-1074** **V1pLWRP-1164** (deletion or amendment of policy relating to damming)	CPW repeats the matters set out in its original submission. Given the benefits that derive from storage, CPW considers Policy 11.4.31 should be deleted (or amended such that damming is a fully discretionary as opposed to prohibited activity).	Support
11.4.31	Director General of Conservation 52225	**V1pLWRP-223** **V1pLWRP-295** **V1pLWRP-414** **V1pLWRP-692**	CPW repeats the matters set out in its original submission. Given the benefits that derive from storage, CPW considers Policy 11.4.31 should be deleted (or amended such that damming is a fully discretionary as	Oppose

Prov.	Original submitter	Particular parts	Reasons	Support / Oppose
	Te Taumutu Rūnanga 52215 Nga Rūnanga and Te Rūnanga O Ngāi Tahu 52233 (*noting CPW opposes submitter's alternative wording discussed elsewhere in this further submission*) Fish and Game Council North Canterbury 52310 Mr Jules Snoyink 52327 Royal New Zealand Forest and Bird Protection Society 52265 Mr and Mrs Michael and Annette Hamblett 52311	**V1pLWRP-1004** **V1pLWRP-1301** **V1pLWRP-1540** (retention or amendment of policy relating to damming)	opposed to prohibited activity).	

Prov.	Original submitter	Particular parts	Reasons	Support/Oppose
11.4.32	Dunsandel Groundwater Users Group 52221	**V1pLWRP-349** (delete Policy 11.4.32(b) re avoiding or mitigating the mixing of water as it is unnecessary in light of (c))	CPW repeats the matters set out in its original submission and notes there is already authorised mixing of waters by virtue of the Central Plains Water Enhancement Scheme consents.	Support
11.4.32	Trustpower Limited 52280	**V1pLWRP-980** (amend Policy 11.4.32 to avoid need for cultural impact assessment and identification of significant trout and salmon spawning areas)	Although CPW respects Ngāi Tahu values, to the extent that a cultural impact assessment is required to address the mixing of waters then that is already an authorised activity by virtue of the Central Plains Water Enhancement Scheme consents. Little utility would be served in requiring a cultural impact assessment in respect of that. CPW also agrees that the relevant trout and salmon spawning areas should only be those that are significant (and that they are appropriately identified).	Support
11.4.32	North Canterbury Province of Federated Farmers NZ Inc 52318	**V1pLWRP-873** (amend Policy 11.4.32 to avoid need for cultural impact assessment)	As above	Support
11.4.32	Dairy NZ 52271 Irrigation New Zealand Inc 52278	**V1pLWRP-1362** **V1pLWRP-1075** **V1pLWRP-1264** (identification of significant trout and salmon spawning areas)	CPW agrees that the relevant trout and salmon spawning areas should only be those that are significant (and that they are appropriately identified).	Support in part

Prov.	Original submitter	Particular parts	Reasons	Support/Oppose
	Fonterra Co-operative Group Limited 52333			
Rules				
Various	Te Taumutu Rūnanga 52215 Nga Rūnanga and Te Rūnanga O Ngāi Tahu 52233	**V1pLWRP-297** **V1pLWRP-303** **V1pLWRP-427** **V1pLWRP-437** **V1pLWRP-305** (inclusion of Cultural Landscape/Values Management Area rule(s))	CPW repeats the various material set out in its original submission and opposes the relief sought to the extent that it impacts on the development of the Central Plains Water Enhancement Scheme. If, contrary to CPW's primary submission, a rule relating to activities within a Cultural Landscape/Values Management Area is to be imposed, CPW supports the use of controlled activity status and an exemption for areas irrigated by an irrigation scheme (as proposed).	Part support/part oppose
11.5	Nga Rūnanga and Te Rūnanga O Ngāi Tahu 52233	**V1pLWRP-431** (new rule making from 1 January 2020 the use of land for a farming activity in the Selwyn-Waihora catchment a restricted discretionary activity)	As proposed this suggested rule will not apply to CPW (it is not intended to apply to irrigation schemes). CPW provides this further submission on the basis of ensuring that remains the case and notes it is unclear as to how it is intended to integrate in with, for example, Rule 11.5.9. To the extent that reference is to be made to the Matrix of Good Management Practice then CPW considers it inappropriate for such reference to be made prior to the Matrix of Good Management Project being completed.	Oppose
11.5	KO Farm Ltd 52332	**V1pLWRP-990** (balance between protecting the water	CPW supports the general concern set out. CPW is a consented irrigation scheme for the purposes of the balance sought.	Support

Prov.	Original submitter	Particular parts	Reasons	Support/Oppose
		quality of Lake Waihora/Ellesmere and enabling existing and consented farming operations to continue)		
11.5	Royal New Zealand Forest and Bird Protection Society 52265	**V1pLWRP-1304** (5 year review)	CPW agrees in part with concern set out but considers it should instead be tied to the completion of the Matrix of Good Management Practice Project	Support in part
11.5	Dairy Holdings Ltd 53683	**V1pLWRP-1944** (nutrient management groups)	CPW supports the use of nutrient management groups and considers the establishment of such groups can provide significant benefits to members. It also agrees that it is important that any group between an irrigation scheme (and/or irrigation scheme members) and properties or farming entities that own land outside of the irrigation scheme area is structured in such a way that the effective allocation of nutrients to the irrigation scheme is not reduced.	Support
11.5	Dairy Holdings Ltd 53683	**V1pLWRP-1946** (take of water for dairy shed supply as a permitted activity)	CPW supports the take and use of small volumes (less than 100 m^3/day) groundwater as a permitted activity and considers this essential for dairy farmers who receive water (which will not be of 100% reliability) from the Central Plains Water Enhancement Scheme. The effects of such taking will be negligible due to the small volumes involved and the additional re-charge that will occur through the development of the Central Plains Water Enhancement Scheme.	Support
11.5	Dairy Holdings Ltd	V1pLWRP-1948	CPW supports the use of water users groups and considers they are a practical and effective way to address concerns around reliability for	Support

Prov.	Original submitter	Particular parts	Reasons	Support/Oppose
	53683	(water users groups)	the irrigation schemes and other users in the Selwyn Waihora catchment	
Various	Mr Clive Thomas 52131	**V1pLWRP-623** **V1pLWRP-625** (amend policy so as not to allow an extra 30,000ha of new irrigation)	Sought relief is inconsistent with the development of the Central Plains Water Enhancement Scheme (and the wider framework of Variation 1).	Oppose
Various	North Canterbury Province of Federated Farmers NZ Inc 52318 The Canterbury Farming Company 52306 Mr Geoffrey John Bain 52154 Mr Joel Townshend 52175 Ellesmere Irrigation Society Inc 52210	**V1pLWRP-630** **V1pLWRP-863** **V1pLWRP-1636** **V1pLWRP-1644** **V1pLWRP-97** **V1pLWRP-493** **V1pLWRP-799** **V1pLWRP-864** **V1pLWRP-1647** **V1pLWRP-98** **V1pLWRP-52** **V1pLWRP-495** **V1pLWRP-800** **V1pLWRP-854** **V1pLWRP-856** **V1pLWRP-857** **V1pLWRP-865** **V1pLWRP-1622** **V1pLWRP-1623**	CPW opposes any change to the nitrogen baseline to the extent it might result in a reduction of N allocation to the Central Plains Water Enhancement Scheme. This includes ensuring that the CPW nutrient load is based on the likely average discharge in the catchment (and not the 'balance' of peak nutrient loads over the last period of X years).	Oppose in part

Prov.	Original submitter	Particular parts	Reasons	Support/Oppose
	Mr Tom Ferguson 52236 Mr Graeme Power 52171	**V1pLWRP-1624** **V1pLWRP-1627** **V1pLWRP-100** **V1pLWRP-503** **V1pLWRP-859** **V1pLWRP-1646** **V1pLWRP-505** **V1pLWRP-506** (increase from 15kg)		
11.5.6	Nga Rūnanga and Te Rūnanga O Ngāi Tahu 52233	**V1pLWRP-423** (amendments to Rule 11.5.6)	The proposed amendments appear to duplicate, at least in part, the requirements of existing proposed rules 11.5.6 to 11.5.8. Although CPW is not necessarily opposed to duplication, it does seek rules that are coherent and easy to follow (and which do not impact on the development of the Central Plains Water Enhancement Scheme).	Part support/part oppose
11.5.6	Ravensdown Fertiliser Co-operative Limited 52249	**V1pLWRP-834** (extension of Rule 11.5.6 to apply to all properties where the discharge is under 15kg/ha)	Although CPW acknowledges the intent of the submission, it considers there may be some value, in terms of the wider catchment management of nutrients, in ensuring the further matters set out in, for example, Rules 11.5.7 and 11.5.8 are being complied with.	Part support/part oppose
11.5.6	Ballance Agri-Nutrients Limited 52309	**V1pLWRP-782** (extension of Rule 11.5.6 to apply to properties between 5 and 50 hectares where the discharge is under	Although CPW acknowledges the intent of the submission, CPW repeats the matters set out above and further notes inter-relationship between the various rules (if the amendment were accepted) is not that clear – with Rule 11.5.8(4) presumably serving no function by virtue of Rule 11.5.8(1).	Part support/part oppose

Prov.	Original submitter	Particular parts	Reasons	Support/Oppose
		15kg/ha)		
Various	Dairy NZ 52271 Fonterra Co-operative Group Limited 52333	**V1pLWRP-1363** **V1pLWRP-1272** **V1pLWRP-1364** **V1pLWRP-1277** **V1pLWRP-1365** **V1pLWRP-1278** **V1pLWRP-1366** **V1pLWRP-1280** **V1pLWRP-1367** **V1pLWRP-1281** **V1pLWRP-1368** **V1pLWRP-1282** (consequential amends following inclusion of definitions of Selwyn-Waihora nitrogen baseline and Selwyn Waihora nitrogen loss calculation).	If the definitions are to be included, CPW seeks that they are only used in a manner that allows for the continued development of the consented Central Plains Water Enhancement Scheme. This includes ensuring that the CPW nutrient load is based on the likely average discharge in the catchment (and not the 'balance' of peak nutrient loads over the last period of X years).	Part support/part oppose
11.5.7	Nga Rūnanga and Te Rūnanga O Ngāi Tahu 52233	**V1pLWRP-429** (amendments to Rule 11.5.7)	The submitter has made amendments that are consequential to its submission **V1pLWRP-423**. This appears to lead to some duplication. Although CPW is not necessarily opposed to duplication, it does seek rules that are coherent and easy to follow (and which do not impact on the development of the Central Plains Water Enhancement Scheme). CPW repeats its further submissions set out elsewhere in respect of	Part support/part oppose

Prov.	Original submitter	Particular parts	Reasons	Support/Oppose
			the Cultural Landscape/Values Management Area.	
Various	Ravensdown Fertiliser Co-operative Limited 52249 Bowden Environmental 52242 Ellesmere Irrigation Society Inc 52210	**V1pLWRP-810** **V1pLWRP-809** **V1pLWRP-808** **V1pLWRP-807** **V1pLWRP-839** **V1pLWRP-597** **V1pLWRP-900** (non-complying activity status)	CPW considers that non-complying activity status might be more appropriate – especially given there are uncertainties around the extent of actual effects at this time.	Support
Various	Irrigation New Zealand Inc 52278	**V1pLWRP-1089** **V1pLWRP-1091** (consequential amends following inclusion of definition of Selwyn Waihora nitrogen baseline)	If a definition is to be included, CPW seeks a definition that allows for the continued development of the consented Central Plains Water Enhancement Scheme. This includes ensuring that the CPW nutrient load is based on the likely average discharge in the catchment (and not the 'balance' of peak nutrient loads over the last period of X years).	Part support/part oppose
Various	Horticulture New Zealand 52267	**V1pLWRP-1410** **V1pLWRP-1411** **V1pLWRP-1412** (farming enterprise)	CPW considers the definition provided might provide a clearer definition than that currently provided in the pLWRP (which refers to "aggregation of land") – although it is not clear if the second definition is in fact required. Against the above, CPW notes that within the Central Plains Water Enhancement Scheme area, those properties supplied water by the	Part support/part oppose

Prov.	Original submitter	Particular parts	Reasons	Support/Oppose
			Scheme will all be subject to CPW controls (and the environmental regime required by the CPW resource consents) and accordingly a farm enterprise regime may not be appropriate in all circumstances. In the alternative, care would need to be taken in respect of the farming enterprise regime to ensure that it is not, for example, used as a mechanism to manage or transfer existing nutrients contrary to the Scheme requirements or from land irrigated by CPW water to land that is not irrigated by CPW (to the detriment of the allocation of N to the scheme).	
11.5.8	Nga Rūnanga and Te Rūnanga O Ngāi Tahu 52233	**V1pLWRP-430** (various amendments to Rule 11.5.8)	As proposed this suggested rule will not apply to CPW (it is not intended to apply to irrigation schemes). CPW provides this further submission on the basis of ensuring that remains the case and notes it is unclear as to how it is intended to integrate in with, for example, Rule 11.5.9. To the extent that reference is to be made to the Matrix of Good Management Practice then CPW considers it inappropriate for such reference to be made prior to the Matrix of Good Management Project being completed	Oppose
11.5.9	Nga Rūnanga and Te Rūnanga O Ngāi Tahu 52233	**V1pLWRP-432** (deletion of Rule 11.5.9)	The submitter has sought deletion of Rule 11.5.9 that is consequential to its submissions **V1pLWRP-423** and **V1pLWRP-429**. CPW is not clear on the intended effect of the amended rules but notes it seeks rules that are coherent and easy to follow (and which do not impact on the development of the Central Plains Water Enhancement Scheme).	Oppose
11.5.9	Ravensdown Fertiliser Co-operative Limited	**V1pLWRP-837** (deleting the requirement for Good Management	CPW is supportive of a further plan change once the Matrix of Good Management Practice Project is complete. Care needs to be taken now to avoid both pre-empting the outcomes of that work and including an	Support

Prov.	Original submitter	Particular parts	Reasons	Support/Oppose
	52249	Practice phosphorus loss rates to be applied in matter of discretion 2)	'interim restriction regime' (prior to that work being completed) which cannot in itself be justified on the basis of section 32(2)(a).	
11.5.9	North Canterbury Province of Federated Farmers NZ Inc 52318 The Canterbury Farming Company 52306	**V1pLWRP-861** **V1pLWRP-1648** (inclusion of methods to achieve nitrogen reductions from the property in accordance with Policy 11.4.13).	Although CPW acknowledges the intent of the submission, Policy 11.4.13 in turn refers to good management practices which are not known at this time.	Part support/part oppose
11.5.9	Dairy NZ 52271 Fonterra Co-operative Group Limited 52333	**V1pLWRP-1369** **V1pLWRP-1287** (amendment to Rule 11.5.9, including removing reference to the Good Management Practice Nitrogen and Phosphorus Loss Rates and insertion of replacement wording)	CPW supports the removal of reference to something that does not exist yet. In this respect, care needs to be taken now to avoid both pre-empting the outcomes of the Matrix of Good Management Practice Project and in including an 'interim restriction regime' (prior to that work being completed). It is unlikely such an approach could be justified on the basis of section 32(2)(a).	Support
11.5.9	Irrigation New Zealand Inc	**V1pLWRP-1076** (amendment to Rule 11.5.9, including	As above	Support

Prov.	Original submitter	Particular parts	Reasons	Support/Oppose
	52278	removing reference to the Good Management Practice Nitrogen and Phosphorus Loss Rates)		
11.5.10	Nga Rūnanga and Te Rūnanga O Ngāi Tahu 52233	**V1pLWRP-436** (amendments to Rule 11.5.10 to make it permitted but to include more conditions)	As proposed the suggested amendments to the rule will mean the rule does not apply to farming enterprises with interests in an irrigation scheme. CPW provides this further submission on the basis of that relief being accepted. In this regard, the rules need to ensure that all properties (that could from part of a farming enterprise) are able to join an irrigation scheme but care also needs to be taken for, as CPW has noted elsewhere in its further submission, within the Central Plains Water Enhancement Scheme area, those properties supplied water by the Scheme will all be subject to CPW controls (and the environmental regime required by the CPW resource consents) and accordingly a farm enterprise regime may not be appropriate in all circumstances. In the alternative, care would need to be taken in respect of the farming enterprise regime to ensure that it is not, for example, used as a mechanism to manage or transfer existing nutrients contrary to the Scheme requirements or from land irrigated by CPW water to land that is not irrigated by CPW (to the detriment of the allocation of N to the scheme).	Part support/part oppose
11.5.10	Dairy NZ 52271 Fonterra Co-operative Group Limited	**V1pLWRP-1370** **V1pLWRP-1293** **V1pLWRP-1209** (restricted discretionary activity status for Rule	CPW supports the use of restricted discretionary activity status for Rule 11.5.10.	Support

Prov.	Original submitter	Particular parts	Reasons	Support/Oppose
	52333 Synlait Farms Ltd 52287	11.5.10)		
11.5.10	Horticulture New Zealand 52267	**V1pLWRP-1413** (delete Rule 11.5.10 or provide a Restricted Discretionary Activity Rule for farming enterprises that takes into account the rotational nature of the operation and industry good management practices).	CPW acknowledges the submitter's concern and further notes that the rules need to ensure that properties that could form a farming enterprise are able to join an irrigation scheme. Care however needs to be taken in respect of farming enterprises as within the Central Plains Water Enhancement Scheme area, those properties supplied water by the Scheme will all be subject to CPW controls (and the environmental regime required by the CPW resource consents) and accordingly a farm enterprise regime may not be appropriate in all circumstances. In the alternative, care would need to be taken in respect of the farming enterprise regime to ensure that it is not, for example, used as a mechanism to manage or transfer existing nutrients contrary to the Scheme requirements or from land irrigated by CPW water to land that is not irrigated by CPW (to the detriment of the allocation of N to the scheme).	Support in part
Various	Dairy NZ 52271 Fonterra Co-operative Group Limited 52333	**V1pLWRP-1297** **V1pLWRP-1576** **V1pLWRP-1302** **V1pLWRP-1414** **V1pLWRP-1523** (Rule 11.5.12 be	CPW considers that non-complying activity status might be more appropriate – especially given there are uncertainties around the extent of actual effects at this time. CPW further notes that that the rules need to ensure that those properties able to form a farming enterprise are able to join an	Support in part

Prov.	Original submitter	Particular parts	Reasons	Support/Oppose
	Horticulture New Zealand 52267	combined with Rule 11.5.11 such that any farming activity that does not meet one or more of the conditions of restricted discretionary activity becomes a non-complying activity and not prohibited)	irrigation scheme although within the Central Plains Water Enhancement Scheme area, it is further noted that those properties supplied water by the Scheme will also be subject to CPW controls (and the environmental regime required by the CPW resource consents) and accordingly a farm enterprise regime may not be appropriate. In the alternative, care would need to be taken in respect of the farming enterprise regime to ensure that it is not, for example, used as a mechanism to manage or transfer existing nutrients contrary to the Scheme requirements or from land irrigated by CPW water to land that is not irrigated by CPW (to the detriment of the allocation of N to the scheme).	
11.5.14	Nga Rūnanga and Te Rūnanga O Ngāi Tahu	**V1pLWRP-439** (*inter alia* inclusion of farming enterprises in irrigation schemes)	CPW acknowledges the possibility of a farming enterprise being able join an irrigation scheme but notes that within the Central Plains Water Enhancement Scheme area, those properties supplied water by the Scheme will all be subject to CPW controls (and the environmental regime required by the CPW resource consents) and accordingly a farm enterprise regime may not be appropriate. In the alternative, care would need to be taken in respect of the farming enterprise regime to ensure that it is not, for example, used as a mechanism to manage or transfer existing nutrients contrary to the Scheme requirements or from land irrigated by CPW water to land that is not irrigated by CPW (to the detriment of the allocation of N to the scheme).	Support in part

Prov.	Original submitter	Particular parts	Reasons	Support/Oppose
11.5.14	Horticulture New Zealand (*query whether this should properly relate to Rule 11.5.15?)*	**V1pLWRP-1415** (amend Rule 11.5.15 (1) and (2) by deleting "listed in Table 11 (j)").	CPW is not clear on what is intended by the proposed amendment. To the extent that "irrigation scheme" becomes an open-ended definition, care would need to be taken that other schemes (should they exist) are bound to their existing (combined) nitrogen baseline – effectively as if they a farming enterprise (or in such a manner that does not cause detriment of the allocation of N to the Central Plains Water Enhancement Scheme).	Oppose
11.5.14	The Crossing Ltd 52398	**V1pLWRP-1505** (recognition of other irrigation schemes and same flexible management framework as Central Plains Water)	The submitter refers to the Glenroy scheme in its submission. This was addressed in CPW's original submission and CPW simply repeats the matters set out there. Any recognition of the Glenroy Scheme should not reduce the nutrient allocation to CPW.	Part support/part oppose
11.5.14	Dairy Holdings Ltd 53683	**V1pLWRP-1945** (the plan is amended to ensure that there is a requirement for each property receiving water from Central Plains to either comply with the Central Plains water supply agreement (and the management of nutrients by Central Plains) or, in the alternative, to comply with its own nitrogen	This accords with an agreement between CPW and the submitter. As suggested by the submitter, it should be done in a manner that does not reduce the effective allocation of N to the Central Plains Water Enhancement Scheme and a manner that does not raise issues with the concerns around farming enterprises discussed elsewhere in this further submission.	Support

Prov.	Original submitter	Particular parts	Reasons	Support/Oppose
		baseline)		
11.5.15	Irrigation New Zealand Inc 52278	**V1pLWRP-1078** (amend clause 2 of Rule 11.5.15 as Table 11(j), is not based on technically robust science, to reflect an alternative Table 11(j) that will be provided by the submitter at the hearing).	CPW repeats the material set out in **Annexure 1** and its original submission (and elsewhere in this further submission). CPW has significant concerns around the appropriateness of the modelling undertaken and to address the concerns, significant amendments are likely to be required to Table 11(j) (and a number of the other tables set out in section 11.7)).	Support
11.5	Mr Joel Townshend 52175	**V1pLWRP-763** (if more water is going down the drains water should be able to be taken from surface water given that low flows at the end of the streams are met)	CPW repeats the material set out in **Annexure 1** and notes that this is something that should be considered in any alternative mitigation approach and to that extent it is supported by CPW.	Support in part
11.5.32	Irrigation New Zealand Inc 52278 Erralyn Farm Ltd & Krysette Ltd	**V1pLWRP-340** **V1pLWRP-341** **V1pLWRP-1436** **V1pLWRP-1432** **V1pLWRP-1557** (wider reference to	CPW supports more flexibility in terms of the method used to assess annual volume(s).	Support

Prov.	Original submitter	Particular parts	Reasons	Support/Oppose
	52263 Dunsandel Groundwater Users Group 52221 Horticulture New Zealand 52267	Schedule 10)		
11.5.32	Fish and Game Council North Canterbury 52310	**V1pLWRP-707** (identification of trout and salmon spawning areas)	In accordance with its submission on **V1pLWRP-980**, the relevant trout and salmon spawning areas should only be those that are significant (and they should be appropriately identified).	Oppose
11.5.37	Dunsandel Groundwater Users Group 52221	**V1pLWRP-331** (delete condition 3(d) in Rule 11.5.37 – requiring that the transfer of groundwater is not from a person who holds shares in an irrigation scheme)	For the reasons set out in CPW's original submission, CPW supports (in limited instances) the transfer of water from a person who also holds shares in an irrigation scheme.	Support in part
11.5.37	Nga Rūnanga and Te Rūnanga O Ngāi Tahu 52233	**V1pLWRP-454** (transfer of water where person is a shareholder	CPW supports in part (in so far as it is consistent with CPW's original submission) the suggested amendments which would, in the case of a person who holds shares in an irrigation scheme, only prevent that person from transferring water to a person who either does not hold	Part support/part oppose

Prov.	Original submitter	Particular parts	Reasons	Support/Oppose
		in an irrigation scheme)	irrigation scheme shares or irrigation scheme shares in a different irrigation scheme. The balance of the submission is opposed.	
11.5.37	Mr Dougal Smith 52195 Erralyn Farm Ltd & Krysette Ltd 52263	**V1pLWRP-1101** **V1pLWRP-1396** (deletion of sub-condition 3(d) that prohibits irrigation scheme shareholders from transferring their groundwater permits)	CPW supports in part (in so far as it is consistent with CPW's original submission) the suggested deletion of sub-condition 3(d) .	Support in part
11.5.37	Irrigation New Zealand Inc 52278	**V1pLWRP-1083** (delete condition 3(c) and 4 from Rule 11.5.37 and amend condition 3(d) as follows: "… on the Planning Maps <u>unless it is within a farming enterprise</u>; and)	CPW acknowledges the possibility of a farming enterprise being able join an irrigation scheme but notes that within the Central Plains Water Enhancement Scheme area, those properties supplied water by the Scheme will all be subject to CPW controls (and the environmental regime required by the CPW resource consents) and accordingly a farm enterprise regime may not be appropriate in all circumstances. In the alternative, care would need to be taken in respect of the farming enterprise regime to ensure that it is not used as a mechanism to manage or transfer existing nutrients contrary to the Scheme requirements or from land irrigated by CPW water to land that is not irrigated by CPW (to the detriment of the allocation of N to the scheme).	Support in part
11.5.37	Erralyn Farm Ltd & Krysette Ltd	**V1pLWRP-1398** (amend condition 3(d) of Rule 11.5.37 to allow the	CPW supports (in so far as it is consistent with CPW's original submission) the suggested amendments which would, in the case of a person who holds shares in an irrigation scheme, allow the transfer of	Support in part

Prov.	Original submitter	Particular parts	Reasons	Support/Oppose
	52263	transfer of groundwater permits held by irrigation scheme shareholders within the Irrigation Scheme Area to other sites within the irrigation scheme)	water to other sites within the irrigation scheme [outline area].	
11.5.37	Dairy Holdings Ltd 53683	**V1pLWRP-1949** (transfer to another Property owned by the same person or a related entity)	As set out elsewhere in this further submission, CPW is generally supportive of transfers and farming enterprises, but notes that within the Central Plains Water Enhancement Scheme area, those properties supplied water by the Scheme will all be subject to CPW controls (and the environmental regime required by the CPW resource consents). Were a farming enterprise regime available to persons receiving water from the Scheme, care would need to be taken to ensure that it is not used as a mechanism to manage or transfer existing nutrients contrary to the Scheme requirements or from land irrigated by CPW water to land that is not irrigated by CPW (to the detriment of the allocation of N to the scheme).	Support in part
11.5.38	McKavanagh Holdings Ltd 52263	**V1pLWRP-1115** (amend Rule 11.5.38 as follows to enable the transfer of existing consents within a farming enterprise and deal with limitation to reliability of supply of	CPW supports (in so far as it is consistent with CPW's original submission) the suggested amendments which would, in the case of a person who holds shares in an irrigation scheme, allow the transfer of water to improve reliability at times when the surface water able to be accessed by the Irrigation Scheme is on restriction and within the person's existing farm enterprise. As set out elsewhere in this further submission, CPW is generally	Support in part

Prov.	Original submitter	Particular parts	Reasons	Support/Oppose
		water from Central Plains Water)	supportive of transfers and farming enterprises, but notes that within the Central Plains Water Enhancement Scheme area, those properties supplied water by the Scheme will all be subject to CPW controls (and the environmental regime required by the CPW resource consents). Were a farming enterprise regime available to persons receiving water from the Scheme, care would need to be taken to ensure that it is not used as a mechanism to manage or transfer existing nutrients contrary to the Scheme requirements or from land irrigated by CPW water to land that is not irrigated by CPW (to the detriment of the allocation of N to the scheme).	
11.5.38	Dairy Holdings Ltd 52263	**V1pLWRP-1950** (amend Rule 11.5.38 as follows to enable the transfer of existing consents to deal with limitation to reliability of supply of water from Central Plains Water)	CPW supports (in so far as it is consistent with CPW's original submission) the suggested amendments which would, in the case of a person who holds shares in an irrigation scheme, allow the transfer of water to improve reliability at times when the surface water able to be accessed by the Irrigation Scheme is on restriction.	Support in part
11.5.40	Ellesmere Irrigation Society Inc 52210	**V1pLWRP-906** (Retain Rule 11.5.40)	CPW supports the retention of Rule 11.5.40.	Support
11.5.41	Ellesmere Irrigation Society Inc 52210	**V1pLWRP-907** (Retain Rule 11.5.41)	CPW supports the retention of Rule 11.5.41.	Support

Prov.	Original submitter	Particular parts	Reasons	Support/Oppose
11.5.42	Director General of Conservation 52225	**V1pLWRP-246** (amendments to Rule 11.5.42)	CPW repeats the matters set out in its original submission. Given the benefits that derive from storage, CPW considers Rule 11.5.42 should be deleted (or amended such that damming is a fully discretionary as opposed to prohibited activity).	Oppose
11.5.42	Mr Joel Townshend 52175	**V1pLWRP-768** (delete Rule 11.5.42 as damming helps the water go through to ground water)	As above	Support
11.5.42	Mr Ross Manson 52241	**V1pLWRP-722** (submitter opposes restrictions on damming).	As above	Support
11.5.42	Fish and Game Council North Canterbury 52310	**V1pLWRP-708** (retain Rule 11.5.42.)	As above	Oppose
11.5.42	Mr Jules Snoyink 52327	**V1pLWRP-1003** (amendments to Rule 11.5.42)	As above	Oppose
11.5.42	Committee Malvern Hills Protection Society	**V1pLWRP-1204** (amendments to Rule	As above	Oppose

Prov.	Original submitter	Particular parts	Reasons	Support/Oppose
	51995	11.5.42)		
11.5.42	Royal New Zealand Forest and Bird Protection Society 52265	**V1pLWRP-1322** (amendments to Rule 11.5.42)	As above	Oppose
11.5.42	Irrigation New Zealand Inc 52278	**V1pLWRP-1088** (delete Rule 11.5.42)	As above	Support
Tables				
11.6	Irrigation New Zealand Inc 52278	**V1pLWRP-1092** (delete Tables in Section 11.6, as the science used to derive is not technically robust, and replace with alternative table to be provided at the hearing).	CPW repeats the material set out in **Annexure 1** and its original submission (and elsewhere in this further submission). CPW has significant concerns around the appropriateness of the modelling undertaken and to address the concerns, significant amendments are likely to be required (or the tables should be deleted).	Support
11(a)	Central Plains Water Ltd 52239	**V1pLWRP-435** (allocations be corrected to remove any errors and ensure that they are reasonable)	CPW repeats the material set out in **Annexure 1** and its original submission (and elsewhere in this further submission). CPW has significant concerns around the appropriateness of the modelling undertaken (which underpins the various tables and wider Variation 1) and to address the concerns, significant amendments are likely to be required to tables.	Support

Prov.	Original submitter	Particular parts	Reasons	Support/Oppose
11(a)	Selwyn District Council 52245	**V1pLWRP-536** (amendment to Table 11(a) *inter alia* clarifying that a number of the outcomes are aspirational)	CPW repeats the material set out in **Annexure 1** and its original submission (and elsewhere in this further submission). CPW supports the concerns set out to the extent they are consistent with the development of the Central Plains Water Enhancement Scheme.	Support in part
11(a)	Selwyn District Council 52245	V1pLWRP-538 (submitter seeks a review of the indicators in Table 11(a) so that they appropriately recognise the existing water quality values and existing activities occurring in the catchment).	CPW repeats the material set out in **Annexure 1** and its original submission (and elsewhere in this further submission). CPW has significant concerns around the appropriateness of the modelling undertaken (which underpins Table 11(a)) and to address the concerns, significant amendments are likely to be required to table.	Support in part
11(a)	Ellesmere Irrigation Society Inc 52210	**V1pLWRP-908** (inappropriate to have subjective references)	CPW agrees with the general concern of the submitter around the inappropriateness of having subjective references (unless it is made very clear that the relevant references are aspirational only)	Support in part
11(a)	Fish and Game Council North Canterbury 52310	**V1pLWRP-711** (no specific decision requested. Fish and Game seek clarification and may suggest alternative indicator levels to those proposed	Submission does not appear to disclose actual concern (or matter ordinarily capable of being a submission). CPW opposes any indicators that might be detrimental to the development of the Central Plains Water Enhancement Scheme. CPW otherwise repeats the material set out in **Annexure 1** and its original submission (and elsewhere in this further submission). CPW	Oppose

Prov.	Original submitter	Particular parts	Reasons	Support/Oppose
		in the table).	has significant concerns around the appropriateness of the modelling undertaken and to address the concerns, significant amendments are likely to be required.	
11(a)	Fonterra Co-operative Group Limited 52333 Dairy NZ 52271	**V1pLWRP-1356** **V1pLWRP-1578** (amend Table 11(a): Correct errors in the table relating to differing QMCI outcomes for some of the streams as indicated by the footnotes)	CPW repeats the material set out in **Annexure 1** and its original submission (and elsewhere in this further submission). CPW has significant concerns around the appropriateness of the modelling undertaken and to address the concerns, significant amendments are likely to be required.	Support
11(a)	Horticulture New Zealand 52267	**V1pLWRP-1558** (reconsideration of Table 11(a) informed by scientific review and the proposed national objectives framework)	CPW supports the general concern set out and also repeats the material set out in **Annexure 1** and its original submission (and elsewhere in this further submission). CPW has significant concerns around the appropriateness of the modelling undertaken and to address the concerns, significant amendments are likely to be required.	Support
11(b)	Selwyn District Council 52245	**V1pLWRP-539** (review of the indicators in Table 11(b) so that the appropriately recognise they existing water quality values and existing activities occurring in the	CPW repeats the material set out in **Annexure 1** and its original submission (and elsewhere in this further submission). CPW has significant concerns around the appropriateness of the modelling undertaken (which underpins Table 11(b)) and to address the concerns, significant amendments are likely to be required to table.	Support in part

Prov.	Original submitter	Particular parts	Reasons	Support/Oppose
		catchment)		
11(b)	Fonterra Co-operative Group Limited 52333 Dairy NZ 52271	**V1pLWRP-135** **V1pLWRP-1525** (inclusion of a new method in Variation 1 committing the Council to monitor and review the effectiveness of the outcomes in Table 11(b) and associated rules, as well as non-regulatory methods, and to make adjustments to the outcomes on the basis on improved information)	CPW supports the monitoring and review of the effectiveness of the outcomes in Table 11(b) and associated rules, as well as non-regulatory methods (as set out elsewhere in this further submission)	Support
11(b)	Horticulture New Zealand 52267	**V1pLWRP-1559** (reconsideration of Table 11(b) informed by scientific review and the proposed national objectives framework)	CPW supports the general concern set out and also repeats the material set out in **Annexure 1** and its original submission (and elsewhere in this further submission). CPW has significant concerns around the appropriateness of the modelling undertaken and to address the concerns, significant amendments are likely to be required.	Support
11.7	Mrs Jane Demeter 52312	**V1pLWRP-1015** (shorter timeframes for achieving the nutrient loads and water quality	CPW considers that shorter timeframes would be unreasonable	Oppose

Prov.	Original submitter	Particular parts	Reasons	Support/Oppose
		and quantity limits)		
11.7.1	Irrigation New Zealand Inc 52278	**V1pLWRP-1093** (delete Table 11(c) and (d), as the science used to derive is not technically robust)	CPW repeats the material set out in **Annexure 1** and its original submission (and elsewhere in this further submission). CPW has significant concerns around the appropriateness of the modelling undertaken and to address the concerns, significant amendments are likely to be required.	Support
11(c)	Central Plains Water Ltd 52239	**V1pLWRP-384** (allocations be corrected to remove any errors and ensure that they are reasonable)	CPW repeats the material set out in **Annexure 1** and its original submission (and elsewhere in this further submission). CPW has significant concerns around the appropriateness of the modelling undertaken (which underpins the various tables and wider Variation 1) and to address the concerns, significant amendments are likely to be required to tables.	Support
11(c)	Director General of Conservation 52225	**V1pLWRP-218** **V1pLWRP-219** (flow and part restriction regime in the Tables is implemented as soon as possible once Variation 1 is operative)	Implementation is dependent on the development of the Central Plains Water Enhancement Scheme - which will take time. CPW also repeats the material set out in **Annexure 1** and its original submission (and elsewhere in this further submission). CPW has significant concerns around the appropriateness of the modelling undertaken (which underpins the tables) and to address the concerns, significant amendments are likely to be required.	Oppose
11(c)	Nga Rūnanga and Te Rūnanga O Ngāi Tahu	**V1pLWRP-457** (amend table 11(c) to increase certain	Implementation is dependent on the development of the Central Plains Water Enhancement Scheme - which will take time.	Oppose

Prov.	Original submitter	Particular parts	Reasons	Support/Oppose
	52233	minimum flows)	CPW also repeats the material set out in **Annexure 1** and its original submission (and elsewhere in this further submission). CPW has significant concerns around the appropriateness of the modelling undertaken (which underpins the tables) and to address the concerns, significant amendments are likely to be required.	
Various	Ellesmere Irrigation Society Inc 52210	**V1pLWRP-910** **V1pLWRP-914** **V1pLWRP-913** **V1pLWRP-915** (various amendments to the minimum flows and allocation limits)	CPW supports the general intent of the submission. However, CPW also repeats the material set out in **Annexure 1** and its original submission (and elsewhere in this further submission). CPW has significant concerns around the appropriateness of the modelling undertaken (which underpins the tables) and to address the concerns, significant amendments are likely to be required.	Support in part
11(c)	Fish and Game Council North Canterbury 52310	**V1pLWRP-687** (no specific decision requested. Fish and Game seek clarification and may suggest alternatives to those proposed in the table).	CPW repeats the material set out in **Annexure 1** and its original submission (and elsewhere in this further submission). CPW has significant concerns around the appropriateness of the modelling undertaken and to address the concerns, significant amendments are likely to be required. In the absence of any sought relief, CPW opposes submission **V1pLWRP-687.**	Oppose
Various	Royal New Zealand Forest and Bird Protection Society	**V1pLWRP-1288** **V1pLWRP-1289** **V1pLWRP-1290** **V1pLWRP-1270**	CPW agrees in part with concern set out but considers it should instead be tied to the completion of the Matrix of Good Management Practice Project	Part support/part oppose

Prov.	Original submitter	Particular parts	Reasons	Support/Oppose
	52265	(limits set out in Tables are able to be reviewed within 5 years to ensure they continue to be appropriate)		
Various	Royal New Zealand Forest and Bird Protection Society 52265	**V1pLWRP-1324** **V1pLWRP-1325** **V1pLWRP-1326** **V1pLWRP-1327** **V1pLWRP-1328** **V1pLWRP-1329** **V1pLWRP-1330** **V1pLWRP-1331** **V1pLWRP-1332** (position on the data/tables reserved until Forest & Bird has had time to consider)	Submission does not appear to disclose actual concern (or matter ordinarily capable of being a submission). CPW opposes any suggested amendments which might be detrimental to the development of the Central Plains Water Enhancement Scheme. CPW otherwise repeats the material set out in **Annexure 1** and its original submission (and elsewhere in this further submission). CPW has significant concerns around the appropriateness of the modelling undertaken and to address the concerns, significant amendments are likely to be required.	Oppose
11(c)	Fonterra Co-operative Group Limited 52333 Dairy NZ 52271	**V1pLWRP-1358** **V1pLWRP-1380** (removing the minimum flows and regime restriction flow levels that apply from 2025. Introduction of those flows once actual flow	Implementation is dependent on the development of the Central Plains Water Enhancement Scheme - which will take time. CPW agrees with the approach suggested by the submitters. CPW also repeats the material set out in **Annexure 1** and its original submission (and elsewhere in this further submission). CPW has significant concerns around the appropriateness of the modelling undertaken (which underpins the tables) and to address the concerns,	Support

Prov.	Original submitter	Particular parts	Reasons	Support/Oppose
		increases)	significant amendments are likely to be required.	
11(c)	Horticulture New Zealand 52267	**V1pLWRP-1560** (reconsideration of Table 11(c) informed by scientific review and the proposed national objectives framework)	CPW supports the general concern set out and also repeats the material set out in **Annexure 1** and its original submission (and elsewhere in this further submission). CPW has significant concerns around the appropriateness of the modelling undertaken and to address the concerns, significant amendments are likely to be required.	Support
11(d)	Fish and Game Council North Canterbury 52310	**V1pLWRP-688** (no specific decision requested. Fish and Game notes further assessment required).	Submission does not appear to disclose actual concern (or matter ordinarily capable of being a submission). CPW opposes any changes that might be detrimental to the development of the Central Plains Water Enhancement Scheme. CPW otherwise repeats the material set out in **Annexure 1** and its original submission (and elsewhere in this further submission). CPW has significant concerns around the appropriateness of the modelling undertaken and to address the concerns, significant amendments are likely to be required.	Oppose
11(d)	Horticulture New Zealand 52267	**V1pLWRP-1561** (reconsideration of Table 11(d) informed by scientific review and the proposed national objectives framework)	CPW supports the general concern set out and also repeats the material set out in **Annexure 1** and its original submission (and elsewhere in this further submission). CPW has significant concerns around the appropriateness of the modelling undertaken and to address the concerns, significant amendments are likely to be required.	Support

Prov.	Original submitter	Particular parts	Reasons	Support / Oppose
11.7.2	Irrigation New Zealand Inc 52278	**V1pLWRP-1095** (delete Tables 11(e) to (h), as the science used to derive is not technically robust)	CPW repeats the material set out in **Annexure 1** and its original submission (and elsewhere in this further submission). CPW has significant concerns around the appropriateness of the modelling undertaken and to address the concerns, significant amendments are likely to be required.	Support
11(e)	Fish and Game Council North Canterbury 52310	**V1pLWRP-686** (no specific decision requested. Fish and Game notes further assessment required).	Submission does not appear to disclose actual concern (or matter ordinarily capable of being a submission). CPW opposes any changes that might be detrimental to the development of the Central Plains Water Enhancement Scheme. CPW otherwise repeats the material set out in **Annexure 1** and its original submission (and elsewhere in this further submission). CPW has significant concerns around the appropriateness of the modelling undertaken and to address the concerns, significant amendments are likely to be required.	Oppose
11(e)	Horticulture New Zealand 52267	**V1pLWRP-1562** (reconsideration of Table 11(e) informed by scientific review and the proposed national objectives framework)	CPW supports the general concern set out and also repeats the material set out in **Annexure 1** and its original submission (and elsewhere in this further submission). CPW has significant concerns around the appropriateness of the modelling undertaken and to address the concerns, significant amendments are likely to be required.	Support
11(f)	Horticulture New Zealand 52267	**V1pLWRP-1563** (reconsideration of Table 11(f) informed by scientific review and the proposed national	CPW supports the general concern set out and also repeats the material set out in **Annexure 1** and its original submission (and elsewhere in this further submission). CPW has significant concerns around the appropriateness of the modelling undertaken and to address the concerns, significant amendments are likely to be	Support

Prov.	Original submitter	Particular parts	Reasons	Support/Oppose
		objectives framework)	required.	
11(g)	Nga Rūnanga and Te Rūnanga O Ngāi Tahu 52233	**V1pLWRP-418** (amend table 1(g) to increase certain minimum flows)	Implementation is dependent on the development of the Central Plains Water Enhancement Scheme - which will take time. CPW also repeats the material set out in **Annexure 1** and its original submission (and elsewhere in this further submission). CPW has significant concerns around the appropriateness of the modelling undertaken (which underpins the tables) and to address the concerns, significant amendments are likely to be required.	Oppose
11(g)	Horticulture New Zealand 52267	**V1pLWRP-1564** (reconsideration of Table 11(g) informed by scientific review and the proposed national objectives framework)	CPW supports the general concern set out and also repeats the material set out in **Annexure 1** and its original submission (and elsewhere in this further submission). CPW has significant concerns around the appropriateness of the modelling undertaken and to address the concerns, significant amendments are likely to be required.	Support
11(h)	Horticulture New Zealand 52267	**V1pLWRP-1565** (reconsideration of Table 11(h) informed by scientific review and the proposed national objectives framework)	CPW supports the general concern set out and also repeats the material set out in **Annexure 1** and its original submission (and elsewhere in this further submission). CPW has significant concerns around the appropriateness of the modelling undertaken and to address the concerns, significant amendments are likely to be required.	Support
11.7.2	Irrigation New Zealand Inc 52278	**V1pLWRP-1095** (delete Tables 11(i) to (m), as the science used to derive is not	CPW repeats the material set out in **Annexure 1** and its original submission (and elsewhere in this further submission). CPW has significant concerns around the appropriateness of the modelling undertaken and to address the concerns, significant amendments are	Support

Prov.	Original submitter	Particular parts	Reasons	Support/Oppose
		technically robust)	likely to be required.	
11(i)	Central Plains Water Ltd 52239	**V1pLWRP-499** (allocations be corrected to remove any errors and ensure that they are reasonable)	CPW repeats the material set out in **Annexure 1** and its original submission (and elsewhere in this further submission). CPW has significant concerns around the appropriateness of the modelling undertaken (which underpins the various tables and wider Variation 1) and to address the concerns, significant amendments are likely to be required to tables.	Support
11(i)	Fish and Game Council North Canterbury 52310	**V1pLWRP-671** (amend to add phosphorus limits)	CPW opposes reference to phosphorous in Table 11(i). Such reference is unnecessary and inappropriate.	Oppose
11(i)	Horticulture New Zealand 52267	**V1pLWRP-1566** (reconsideration of Table 11(i) informed by scientific review and the proposed national objectives framework)	CPW supports the general concern set out and also repeats the material set out in **Annexure 1** and its original submission (and elsewhere in this further submission). CPW has significant concerns around the appropriateness of the modelling undertaken and to address the concerns, significant amendments are likely to be required.	Support
11(i)	Dairy Holdings Ltd 53683	**V1pLWRP-1952** (allocations be corrected to remove any errors and to ensure that they are reasonable)	CPW repeats the material set out in **Annexure 1** and its original submission (and elsewhere in this further submission). CPW has significant concerns around the appropriateness of the modelling undertaken and to address the concerns, significant amendments are likely to be required.	Support
11(j)	Central Plains Water Ltd	**V1pLWRP-498** **V1pLWRP-500**	CPW repeats the material set out in **Annexure 1** and its original submission (and elsewhere in this further submission). CPW has	Support

Prov.	Original submitter	Particular parts	Reasons	Support/Oppose
	52239	(allocations be corrected to remove any errors and ensure that they are reasonable)	significant concerns around the appropriateness of the modelling undertaken (which underpins the various tables and wider Variation 1) and to address the concerns, significant amendments are likely to be required to tables. These concerns extend to the adequacy of the CPW allocation. It also queries whether the allocation should be split between "existing" and "new" to give CPW certainty as the amount available for future development.	
11(j)	Director General of Conservation 52225	**V1pLWRP-249** (clarity in the heading that the limits in the table are nitrogen losses from farming activities supplied by the irrigation scheme - as no phosphorus limits are provided)	CPW acknowledges the concern raised by the submitter and considers that the word "Phosphorous" should be deleted. In the alternative, CPW opposes reference to phosphorous in Table 11(j). Such reference is unnecessary and inappropriate.	Part support/part oppose
11(j)	Ravensdown Fertiliser Co-operative Limited 52249	**V1pLWRP-842** (clarity regarding Matrix of Good Management numbers not being available yet)	CPW supports the concern set out. Consistent with its earlier submission on **V1pLWRP-803**, Variation 1 should expressly outline the role of the Matrix of Good Management Project in informing a future plan change.	Support
11(j)	Fish and Game Council North Canterbury	**V1pLWRP-672** (amend to add	CPW opposes reference to phosphorous in Table 11(j). Such reference is unnecessary and inappropriate.	Oppose

Prov.	Original submitter	Particular parts	Reasons	Support/Oppose
	52310	phosphorus limit)		
11(j)	Dairy NZ 52271 Fonterra Co-operative Group Limited 52333	**V1pLWRP-1378** **V1pLWRP-1390** (amend the Table heading to read: "Table 11(j): Irrigation Nitrogen Limits")	CPW acknowledges the concern raised by the submitter and agrees that no reference should be made to "Phosphorous".	Support
11(j)	McKavanagh Holdings Ltd 52276 Mr Rodney Booth 52335 Mr and Mrs Tim and Lucy Cookson 52399	**V1pLWRP-1125** **V1pLWRP-1162** **V1pLWRP-1167** (delete Table 11(j) and replace with a method requiring the Council to commit to the development of Good Practice Nitrogen and Phosphorus Loss Rates for inclusion in a subsequent notified plan variation)	CPW supports the general concerns set out. Consistent with its earlier submission on **V1pLWRP-803**, Variation 1 should expressly outline the role of the Matrix of Good Management Project in informing a future plan change.	Support in part
11(j)	Horticulture New Zealand 52267	**V1pLWRP-1567** (reconsideration of Table 11(j) informed by scientific review and the proposed national	CPW supports the general concern set out and also repeats the material set out in **Annexure 1** and its original submission (and elsewhere in this further submission). CPW has significant concerns around the appropriateness of the modelling undertaken and to address the concerns, significant amendments are likely to be	Support

Prov.	Original submitter	Particular parts	Reasons	Support/Oppose
		objectives framework)	required. These concerns extend to the adequacy of the CPW allocation. It also queries whether the allocation should be split between "existing" and "new" to give CPW certainty as the amount available for future development.	
11(j)	The Crossing Ltd 52398	**V1pLWRP-1494** (recognition of other irrigation schemes and same flexible management framework as Central Plains Water)	The submitter refers to the Glenroy scheme in its submission. This was addressed in CPW's original submission and CPW simply repeats the matters set out there. Any recognition of the Glenroy Scheme should not reduce the nutrient allocation to CPW.	Part support/part oppose
11(j)	Dairy Holdings Ltd 53683	**V1pLWRP-1953** (allocations be corrected to remove any errors and to ensure that they are reasonable)	CPW repeats the material set out in **Annexure 1** and its original submission (and elsewhere in this further submission). CPW has significant concerns around the appropriateness of the modelling undertaken and to address the concerns, significant amendments are likely to be required. These concerns extend to the adequacy of the allocation. It also queries whether the allocation should be split between "existing" and "new" to give CPW certainty as the amount available for future development.	Support
11(k)	Fish and Game Council North Canterbury	**V1pLWRP-712** (no specific decision requested. Fish and Game notes further	Submission does not appear to disclose actual concern (or matter ordinarily capable of being a submission). CPW opposes any changes that might be detrimental to the development of the Central Plains	Oppose

Prov.	Original submitter	Particular parts	Reasons	Support/Oppose
	52310	assessment required).	Water Enhancement Scheme. CPW otherwise repeats the material set out in **Annexure 1** and its original submission (and elsewhere in this further submission). CPW has significant concerns around the appropriateness of the modelling undertaken and to address the concerns, significant amendments are likely to be required.	
11(k)	Fish and Game Council North Canterbury 52310	**V1pLWRP-673** (amend to add phosphorus limit)	CPW opposes reference to phosphorous in Table 11(j). Such reference is unnecessary and inappropriate.	Oppose
11(k)	Dairy NZ 52271 Fonterra Co-operative Group Limited 52333	**V1pLWRP-1379** **V1pLWRP-1394** (amends to Table 11(k) a new method in Variation 1 committing the Council to monitor and review the effectiveness of the limits of Table 11(k))	CPW acknowledges the concern raised by the submitter and supports amendments and the need for monitoring and review.	Support
11(k)	Horticulture New Zealand 52267	**V1pLWRP-1568** (reconsideration of Table 11(k) informed by scientific review and the proposed national objectives framework)	CPW supports the general concern set out and also repeats the material set out in **Annexure 1** and its original submission (and elsewhere in this further submission). CPW has significant concerns around the appropriateness of the modelling undertaken and to address the concerns, significant amendments are likely to be required.	Support

Prov.	Original submitter	Particular parts	Reasons	Support/Oppose
11(l)	Dairy NZ 52271 Fonterra Co-operative Group Limited 52333	**V1pLWRP-1395** **V1pLWRP-1526** (monitor and review the effectiveness of the limits of Table 11(l))	CPW acknowledges the concern raised by the submitter and supports the need for monitoring and review.	Support
11(l)	Horticulture New Zealand 52267	**V1pLWRP-1569** (reconsideration of Table 11(l) informed by scientific review and the proposed national objectives framework)	CPW supports the general concern set out and also repeats the material set out in **Annexure 1** and its original submission (and elsewhere in this further submission). CPW has significant concerns around the appropriateness of the modelling undertaken and to address the concerns, significant amendments are likely to be required.	Support
11(m)	Dairy NZ 52271 Fonterra Co-operative Group Limited 52333	**V1pLWRP-1381** **V1pLWRP-1397** (monitor and review the effectiveness of the limits of Table 11(m))	CPW acknowledges the concern raised by the submitter and supports the need for monitoring and review.	Support
11(m)	Horticulture New Zealand 52267	**V1pLWRP-1570** (reconsideration of Table 11(m) informed by scientific review and the proposed national objectives framework)	CPW supports the general concern set out and also repeats the material set out in **Annexure 1** and its original submission (and elsewhere in this further submission). CPW has significant concerns around the appropriateness of the modelling undertaken and to address the concerns, significant amendments are likely to be required.	Support

Prov.	Original submitter	Particular parts	Reasons	Support/Oppose
Schedules				
11.11	Nga Rūnanga and Te Rūnanga O Ngāi Tahu 52233	**V1pLWRP-420** **V1pLWRP-461** (add new Schedule within the pLWRP within the pLWRP which sets out the information needed to be kept which would enable OVERSEER®)	Although CPW acknowledges the concern raised by the submitter, it queries whether this is better dealt with by relying on the OVERSEER best practice input standards which might change over time (making them unsuitable for inclusion in a plan).	Part support/part oppose
11.11	Nga Rūnanga and Te Rūnanga O Ngāi Tahu 52233	**V1pLWRP-462** (amend Schedule 7 Part B of LWRP by including various matters or insert a new Schedule within Selwyn-Te Waihora Section which incorporates all matters within the existing Schedule 7 and certain further matters)	Although CPW acknowledges the concern raised by the submitter, it does not consider the further amendments necessary or appropriate at this time for reasons stated elsewhere in this further submission (and in its original submission).	Oppose
Sch 7	Mr Joel Townshend 52175	**V1pLWRP-107** (increase from 15kg)	CPW opposes any change to the nitrogen baseline to the extent it might result in a reduction of N allocation to the Central Plains Water Enhancement Scheme. This includes ensuring that the CPW nutrient load is based on the likely average discharge in the catchment (and not the 'balance' of peak nutrient loads over the last period of X	Oppose in part

Prov.	Original submitter	Particular parts	Reasons	Support/Oppose
			years).	
Sch 7	Horticulture New Zealand 52267	**V1pLWRP-1419** (delete Schedule 7 bullet point 2 'Achieve the Good Management Practice Nitrogen and Phosphorus Loss Rates from 2017', and delete Schedule 7 bullet point 3: Further reduce nitrogen loss rates form 2022 where a property's nitrogen loss calculation is greater than 15 kg of nitrogen per hectare per annum)	CPW supports the general concerns set out. Consistent with its earlier submission on **V1pLWRP-803**, Variation 1 should expressly outline the role of the Matrix of Good Management Project in informing a future plan change.	Support
Sch 10	Dunsandel Groundwater Users Group 52221 Ellesmere Irrigation Society Inc 52210 Erralyn Farm Ltd & Krysette Ltd	**V1pLWRP-343** **V1pLWRP-923** **V1pLWRP-1443** (delete changes to Schedule 10)	CPW supports flexibility in terms of the method used to assess annual volume(s).	Support

Prov.	Original submitter	Particular parts	Reasons	Support/Oppose
	52263			
Sch 10	Horticulture New Zealand 52267	**V1pLWRP-1420** (amend Schedule 10 to better reflect farming operations)	CPW supports flexibility in terms of the method used to assess annual volume(s).	Support
Sch 10	Horticulture New Zealand 52267	**V1pLWRP-1431** (delete changes to schedule 10 or replace "eight and a half years" with nine years)	CPW supports flexibility in terms of the method used to assess annual volume(s).	Support
Sch 24	Nga Rūnanga and Te Rūnanga O Ngāi Tahu 52233	**V1pLWRP-460** Amend Schedule 24 [Farm Practices] to include further provisions regarding nutrient management and intensive winter grazing.	CPW considers the amendments are not appropriate at this time. Consistent with its earlier submission on **V1pLWRP-803**, Variation 1 should expressly outline the role of the Matrix of Good Management Project in informing a future plan change.	Oppose

Prov.	Original submitter	Particular parts	Reasons	Support/Oppose
Sch 24	Fonterra Co-operative Group Limited 52333 Dairy NZ 52271	**V1pLWRP-1234** **V1pLWRP-1518** (a new method or advisory note to the effect that Schedule 24 will not apply once the Good Management Practice Nitrogen and Phosphorus Loss Rates are introduced to the plan).	CPW supports the general concerns set out. Consistent with its earlier submission on **V1pLWRP-803**, Variation 1 should expressly outline the role of the Matrix of Good Management Project in informing a future plan change.	Support
Maps				
Various	Ellesmere Irrigation Society Inc 52210	**V1pLWRP-926** (clarify relationship between maps)	CPW supports the submitters concern and seeks clarification as to the relationship between maps in Variation 1 and pLWRP.	Support

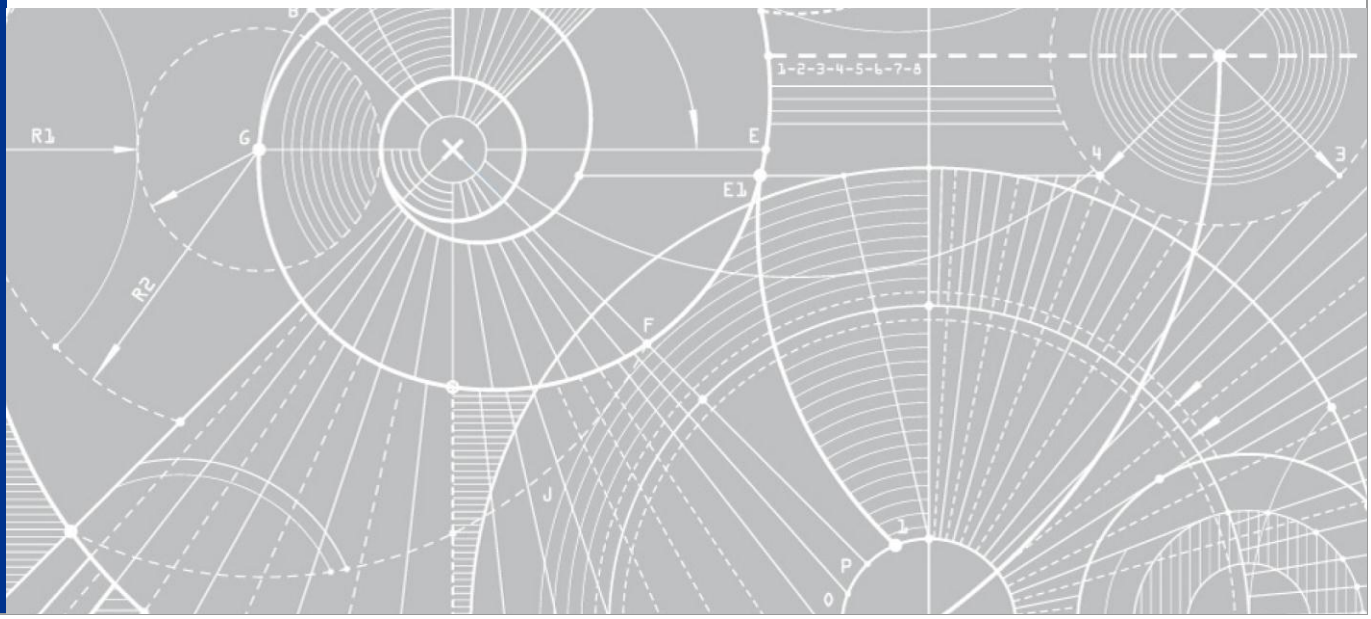
Selwyn Waihora catchment technical model review

Central Plains Water and Horticulture New Zealand

Appendix 1: Review of policy framework at risk following review of the modelling for Environment Canterbury Plan Change Variation 1

Final | 02

1st April 2014



JACOBS

Selwyn Waihora catchment technical model review

Project no:	AE04619
Document title:	Appendix 1: Review of surface and groundwater quantity and quality modelling for Environment Canterbury Plan Change Variation 1
Document no:	Draft
Revision:	4
Date:	1st April 2014
Client name:	Central Plains Water and Horticulture New Zealand
Client no:	Client Reference
Project manager:	Nic Conland
Author:	Nic Conland and Lydia Cetin
File name:	I:\AENVW\Projects\AE04619\Deliverables\Reports\Selwyn Waihora catchment modelling summary note.docx

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Document history and status

Revision	Date	Description	By	Review	Approved
Draft 1	12 March 2014	Summary for review comments	Lydia Cetin	Michelle Sands	Nic Conland
Draft 2	14 March 2014	Draft for circulation	Lydia Cetin	Michelle Sands	Nic Conland
Final 01	18 March 2014	Final including Variation 1 references	Brett Osborne	Michelle Sands	Nic Conland
Final 02	1st April 2014	Client review	Susan Goodfellow	Lydia Cetin	Nic Conland

Contents

1. Introduction

An international peer review was requested by Central Plains Water (CPW) following an announcement by Environment Canterbury (ECan) in late February 2014 that due to a calculation error the proposed nitrogen allocation for CPW had been reduced by almost 50%. ECan and CPWL (in collaboration with the primary sector partners DairyNZ and Horticulture New Zealand) have agreed to work collaboratively leading into the planning hearing for Variation 1 to the proposed Land and Water Regional Plan (pLWRP). As a result of this agreement, ECan confirmed they would provide any information and data to CPWL for the purposes of the peer review.

The peer review was undertaken to understand the assumptions and outcomes of the hydrologic and water quality modelling and analysis approaches employed by ECan to establish water quantity and quality limits and allocation rules as proposed by the Variation 1 to pLWRP. Where limitations or enhancements to the approach were found by the review panel an alternative modelling approach was proposed to address these limitations and/or knowledge gaps. Primary Sector Partners including DairyNZ and Horticulture New Zealand are collaborating with CPW in support of this process.

The review panel participants are listed in Table 1. The Documents available for review on the modelling and analysis completed to date on the ECan Variation 1 to the pLWRP is extensive. A targeted review of reports detailing the key modelling approaches was conducted by the review panel and is listed in Section 1.1. Figure 1 highlights those reports reviewed by the panel in the context of the supporting technical reports prepared for the Variation 1

Table 1. Review panel participants and associated topics reviewed

Reviewer	Topic	Organisation
Dr Ian McIndoe, Groundwater Scientist	Groundwater Quantity	Aqualinc
Dr Brian Barnett, Principle Groundwater Modeller	Groundwater Quantity	Jacobs
Dr Richard Cresswell, Senior Hydrogeologist	Groundwater Quality	Jacobs
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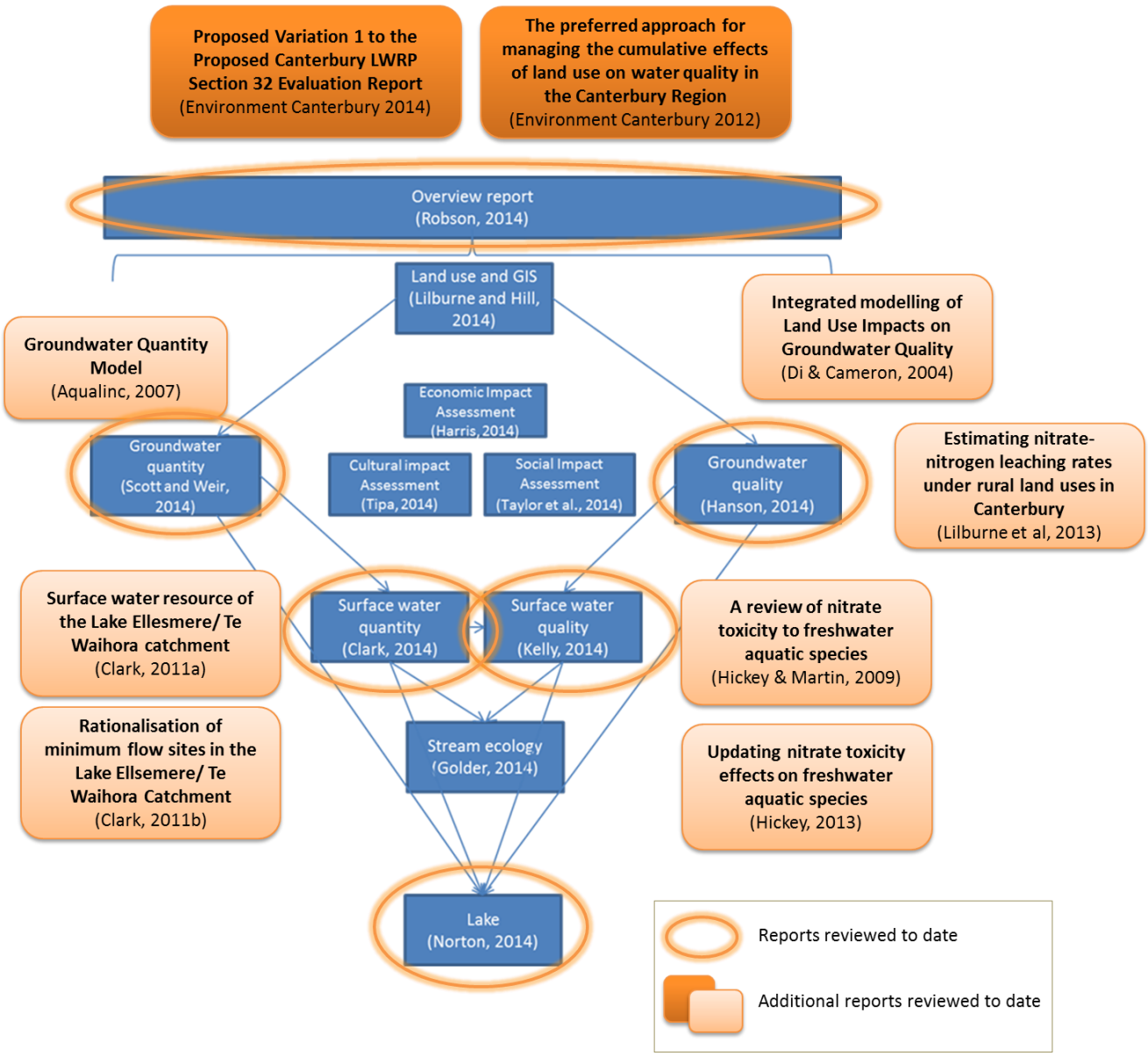

Figure 1: Overview report and supporting technical report schematic for Selwyn Waihora Water quantity and quality limit setting. Orange circles indicate the international peer reviewed reports to date and the orange boxes indicate additional reports undergone international peer review

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17) No authors stated - in preparation (2014), Development of a groundwater quality model for Selwyn-Waihora land-use scenario modelling.

2. Overview of key issues and proposed alternative modelling approach identified in ECan model review

The intent of any modelling is to approximate a natural system and represent through relationships of the observed and predicted data outcomes and results for supporting decision making on natural systems where an uncertain result needs to be tested. The degree of certainty in a model can be evaluated by calibration to observed data and the use of strong empirical relationships. The degree of simplification and errors in base assumptions can materially affect the confidence in the results from any model. The review undertaken points to some significant risks to the policy framework sought in Variation 1. The paragraphs below summarise these risks.

The ECan modelling takes a simplified approach to water drainage, where a 'single bucket' daily soil-water balance model generates the amount of water used for irrigation and water draining through the soil profile into groundwater for dryland and irrigated land.

This approach has significant sources of potential error including matters relating to: soil depth, plant available water depth, fixed crop/crop factors, climate stations, accounting for coastal high water tables, and irrigation issues such as irrigation type, efficiency adjustment application (flow rate or annual allocation) limits (except for ZC scenario).

Unrealistic modelling has the potential to grossly overestimate irrigation demand and drainage to groundwater. There are issues related to the conceptual understanding of groundwater and how nitrogen moves from the land usage in the catchment into streams and the lake. The approach in Variation 1 says that the groundwater aquifers are unconfined, but then states that all N stays in shallow groundwater while deep groundwater is sourced from major rivers.

This 'separation' means that there is no allowance for broad-scale dilution or nitrogen attenuation effects. Also, a significant portion of the upper plains area does not have shallow groundwater, so nitrogen leaching would be into deep groundwater. FEMWATER's water balance shows a large component of outflow to the lake and directly to the ocean. This means that a significant proportion of the N load is not passing through the lake.

The model adopted to assess nitrogen concentrations in groundwater uses the probability of exceeding of Ministry of Health Drinking Water Guidelines (Maximum Allowable Value, MAV) at bores within each zone and then compares this to the mean annual nitrate load in the zone. There are some real conceptual problems with this which mean the basis for these predictions is seriously flawed.

There is also inconsistency between the attenuation factors used to convert groundwater nitrogen concentrations to stream flow concentrations and the basic hydrological assumptions. The fact that an additional factor had to be introduced (to account for surface water supplied irrigation) means that there may be something conceptually wrong with the approach.

It is clear that the surface water catchment behaviour has been represented simplistically within the current ECan modelling framework and has a number of limitations. The focus of the water quantity modelling has been on the lower Canterbury Plains catchment area that is groundwater dominant and directly influences inflows and nutrient loads to the Lake. The overall modelling approach assumes that contributions from overland flow and direct surface runoff are minimal. This is neither substantiated, nor explained and seems unlikely to be the case.

The generalised relationships of surface (or quick) flows as inputs to the groundwater model provide less flexibility in accounting for changes occurring in the upper Selwyn and hill country, particularly for representation of the surface water transfers from the Rakaia and Waimakariri Rivers to the Central Plains Water scheme and corresponding land use changes directly related to increased water allocation in the command area. Such water usage would most likely modify the surface water flow component in terms of both flow and water quality.

The existing model encompasses the main tributary inflows to Te Waihora and the corresponding groundwater extent. Limited representation of the upper catchment restricts the ability to determine changes to reliability for downstream consented users.

With the advent of the Central Plains Water (CPW) Community Irrigation Scheme enabling a migration of groundwater abstractors to the use surface water in the upper Canterbury Plains, representation of surface water and unsaturated zone flow pathways across the whole catchment and their connectivity with groundwater flow pathways, will be essential for modelling a variety of current and future scenario to enable policy and planning rules to be captured and tested.

3. Proposed alternative approach to resolve issues with current modelling approach

An international review of the current modelling framework proposes a methodology that provides a comprehensive modelling framework that accounts for surface water quantity and quality attributes of the whole Selwyn Waihora catchment including the hills country, CPWL command area and the lower Canterbury Plains (including the Little Rakaia and Kaituna catchments) to the banks of the Te Waihora.

Daily rainfall-runoff modelling calibrated to spatially distributed historical climate will data improve the representation of the variability in nutrient generation (or leaching) from different farming enterprises and non-agricultural land uses within different parts of the catchment.

Nutrient transport and attenuation within reaches can be directly related to observed in-stream nutrient concentrations. Where the ECan modelling presented a number of different models to simulate these processes, our proposed approach integrates these components into a single model to represent spatial surface water hydrology and water quality and derive inputs for the more detailed groundwater modelling. The single model framework proposed is eWater's Source modelling platform ('Source').

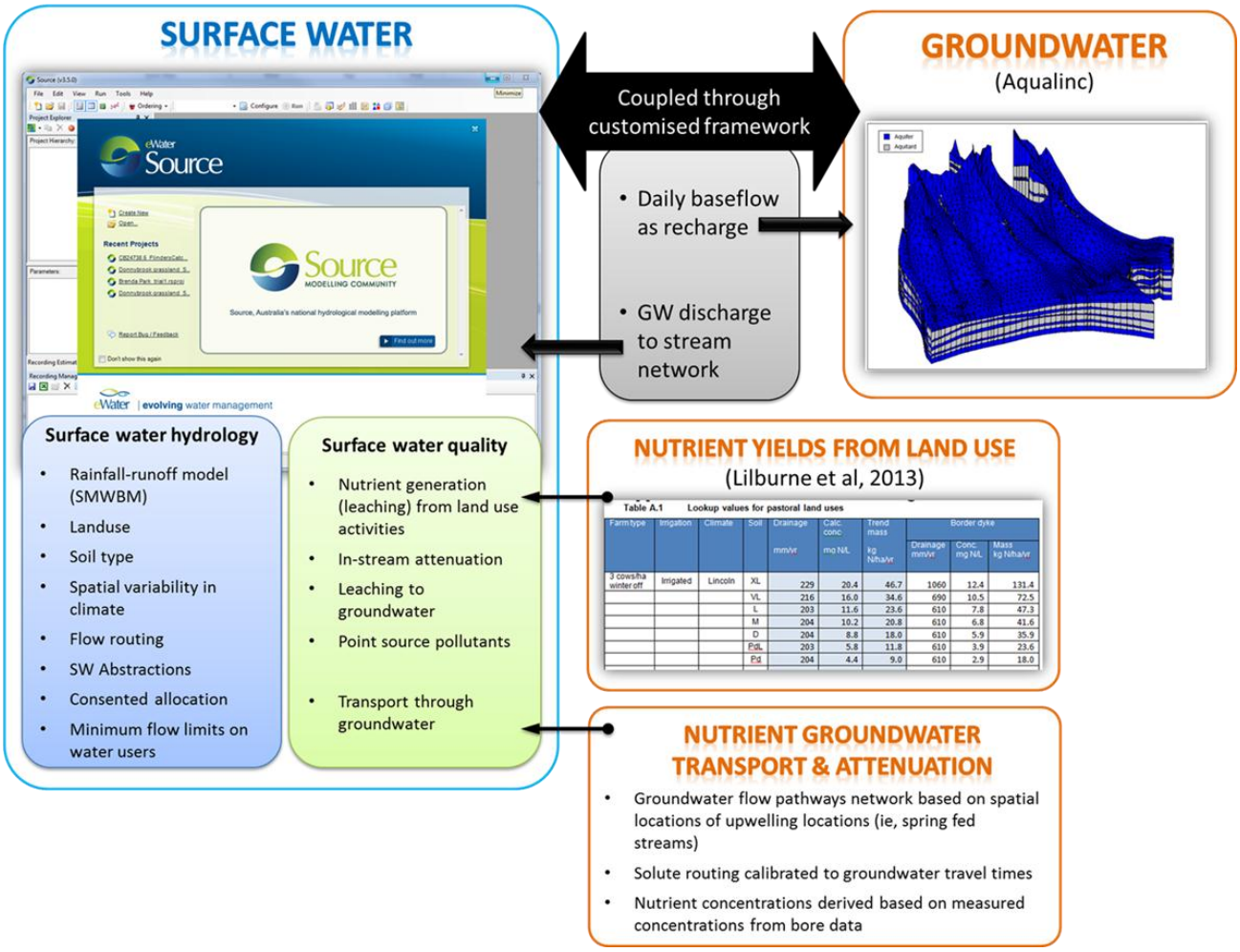
To complete the framework, the surface water model of the Selwyn Waihora catchment will be coupled to the existing groundwater model developed by Aqualinc to enable surface water-groundwater interactions to be represented and while retaining the detailed modelling completed to date of the groundwater system. A customised framework will be built that links, at each time step, the baseflow from Source as recharge inputs to the groundwater model and discharges groundwater back into the Source model at points in the stream network that drain to Te Waihora or discharge directly to the ocean.

This methodology, illustrated in Figure 2, includes the following processes:

- Catchment rainfall-runoff generation using Soil Moisture Water Balance Model (SMWBM) calibrated to spatially distributed, historical climate conditions for different landuses and soil types;
- Irrigation demand represented within SMWBM and related to abstraction types (ie, Surface water direct takes, stream depletors, potable) where allocation and minimum flow limits can be defined within a water user node model;
- Nutrients represented in the Source model will include Total Nitrogen (TN), Nitrate (NO_3), Nitrite (NO_2) and Nitrate and Nitrite Nitrogen (NNN). Nutrient generation from land will be based on leaching rates from Lilburne et al, (2013), and potentially other data sources if they are available, and derived for baseflow conditions and event (quick) flow conditions;
- Attenuation of nutrients through waterways using in-stream decay models **;**
- A groundwater flow pathways (GFP) network in Source that connects to the stream network based on spatial locations of upwelling locations (ie, spring fed streams) as configured in the FEMWATER model with groundwater quantity driving the transport and dilution of nutrients within the GFP network. Solute routing can then be implemented within these pathways calibrated to groundwater travel times. Groundwater nutrient concentrations derived based on measured concentrations from bore data and concentration in baseflow; and
- Linking of Source with FEMWATER as the adopted groundwater model.

A uniform daily time step model is proposed to capture changes in the flow regime and short term nutrient fluctuations as a result of seasonal variation (including storm events), the operation of the CPWL and Variation 1 change to the Land and Water Regional Plan.

Figure 2: Proposed model structure outlining a more detailed surface water hydrology and water quality modelling framework utilising information from Lilburne et al (2013) for nutrient generation and coupled to the groundwater model developed by Aqualinc.



4. Policy provisions at risk from current approach

The issues with the existing modelling puts at risk the proposed Variation 1 framework due to the significant potential error in the modelling approach used (*Policy 11.4.1 and tables in section 11.7*).

The uncertainty in the water balance questions the predictions for flow reliability in the lowland streams and the allocation of water as a single combined surface water-groundwater resource (*Policy 11.4.21; Table 11(e)*).

A change in the predicted 7D MALF (*Policy 11.4.21; Table 11(c); 11(k); 11.4.26; 11.4.28; and 11.4.29*) will mean that current users may experience a change in their irrigation reliability and the desired ecological flows (*Table 11(a) and Table 11(c)*) will not be met. This also means that the nitrogen limits for instream water quality may also be exceeded more regularly during summer low flows (*Policy 11.4.1; 11.4.6 to 11; Table 11(k)*).

The inability to predict the nitrogen concentrations across the catchment will create uncertainty for the proposed environmental indicators and the outcomes for Lake Te Waihora (*Policy 11.4.18; 11.4.19; Table 11(l)*).

These two factors above in combination where the observed load and the predicted are not clearly calibrated means the predicted nitrogen load limit for the lake isn't accurately determined for the protection of the lake or providing certainty to existing landusers in the catchment (*Policy 11.4.6 to 11; Table 11(i) and Table 11(j)*).

The lack of certainty in the catchment allocation has strong implications for the accompanying section 32 analysis to examine the costs and benefits and consideration of alternatives (*Policy 11.4.12; 11.4.18 to 20*).

In circumstances where the level of the nitrogen load to the lake was less than allocated in the proposed variation 1; or as predicted from the water balance inherent in the FEMWATER model split between a catchment load (with a proportion allocated to deep groundwater and the sea) and a lake load; the timing for the mitigation measures would be in question (*Policy 11.4.12; 11.4.14 to 17*). Essentially, a lot of detailed analysis of land use and zonation is distilled to a limited number of zones and parameters to simple arguments for analytical consideration. This approach leaves OVERSEER predictions for future development providing N loads which may never reach the lake (*Policy 11.4.6 to 11; Table (i) and Table (j)*).

If the mitigation measures are reduced or instigated over a longer timeframe then the cost for the existing landusers will be significantly lower (*Policy 11.4.12; 11.4.14 to 17; 11.4.20*). This will affect the community's ability to accept and afford the proposed environmental outcomes in the Variation 1 for Te Waihora (*Policy 11.4.1; section 32 analysis*).

An improved understanding and modelling of the relationship between the generation of nitrogen and transport through the groundwater and surface water network may also allow for the desired outcomes to be achieved more quickly along the proposed timeframes or in a spatially targeted approach (*Policy 11.4.1; 11.4.11.4.20; Table 11(b)*).

The lack of transparency in the N transport approach in different flow and allocation scenarios means that the proposed mitigations and interventions are difficult to assess for performance and efficiency. It appears that the cost and benefits are narrative assumptions rather than derived from empirical relationships (*Policy 11.4.1; 11.4.14 to 17; 11.4.20; Table 11(b)*).

The relationships between the nutrient loads from the catchment to the lake are not clearly linked to the production of Chlorophyll a; this implies that the degree and rate of benefit from the mitigations and interventions is uncertain. As above this implies that the true cost benefit assessment is missing (*Policy 11.4.1; 11.4.11.4.20; Table 11(a) and Table 11(b)*).

Little consideration of the future compliance and management needs are provided for in the current modelling framework both in terms of the long turnaround time to run for the scenarios and the inability to undertake a dynamic assessment of the proposed management 'levers' to reduce the effects on the lake (*Policy 11.4.6; 11.4.12 -17), .4.20; 11.4.22*). Such an approach will leave both the Canterbury Regional Council and landowner's exposed to increased costs and uncertainty for compliance and resource consent transaction costs.

For the primary sector partners alone the risk for their investors for changes to mortgage payments due to mitigation costs for N management and uncertainty around farm infrastructure investment for consent renewals where effects relating to stream concentrations and minimum flows from current landuse are not empirically matched to proposed and predicted future development and Nitrogen losses (*Policy 11.4.12 - 16*).

pLWRP Variation 1 Modelling Review Summary

Date	31 March 2014
Project No	AE04619
Subject	**Combined review table for Selwyn Waihora Modelling**

1. Introduction

An international peer review was requested by primary sector partners (Central Plains Water (CPW); DairyNZ and Horticulture New Zealand) following an announcement by Environment Canterbury (ECan) in late February 2014 that due to a calculation error the proposed nitrogen allocation for CPW had been reduced by almost 50%. ECan and the primary sector partners have agreed to work collaboratively leading into the planning hearing for Variation 1 to the proposed Land and Water Regional Plan (pLWRP). As a result of this agreement, ECan confirmed they would provide any information and data to CPWL for the purposes of the peer review.

The peer review was undertaken to understand the assumptions and outcomes of the hydrologic and water quality modelling and analysis approaches employed by ECan to establish water quantity and quality limits and allocation rules as proposed by the Variation 1 to pLWRP. Where limitations or enhancements to the approach were found by the review panel an alternative modelling approach was proposed to address these limitations and/or knowledge gaps. Primary Sector Partners including DairyNZ and Horticulture New Zealand are collaborating with CPW in support of this process.

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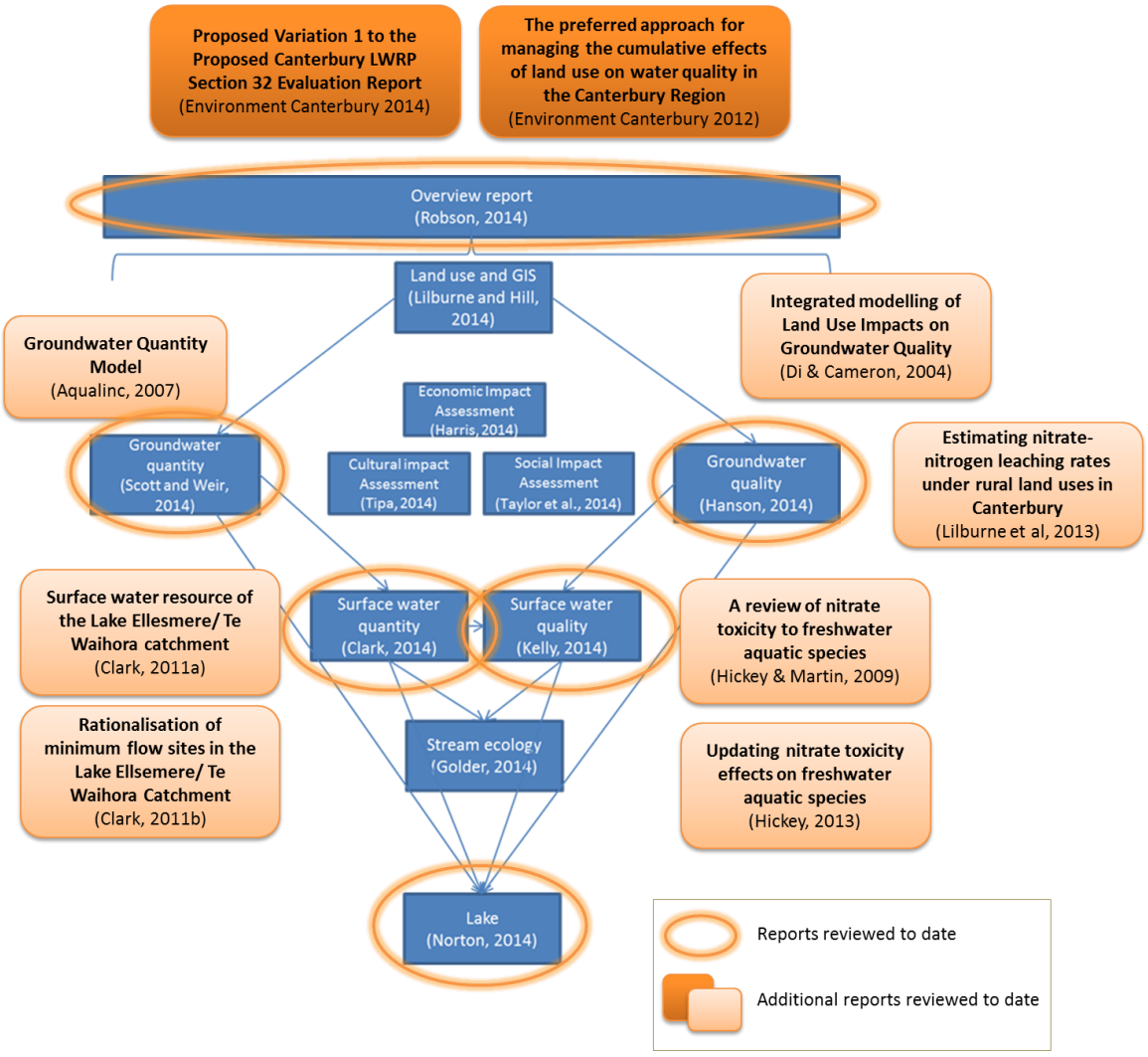
Dr Lydia Cetin, Hydrologist	Te Waihora water quality modelling	Jacobs

Figure 1. Diagram of the reports reviewed by the review panel



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17) No authors stated - in preparation (2014), Development of a groundwater quality model for Selwyn-Waihora land-use scenario modelling.

pLWMP Variation 1 Modelling Review

pLWRP Variation 1 Modelling Review Summary

2. Review Table

The review table below provides a summary of the findings from each of the reports reviewed and actions to resolve the findings.

- Table 2. Review Comments

Variation 1 Planning Provision	Technical aspect	Report name	Review conclusions	Recommended Actions	Degree of importance on model outcomes
Section 11.7 Environmental Flow and Allocation Regime and Water Quality Targets and Limits Policies: 11.4; including; 11.4.20, 11.4.21, 11.4.27 & 11.4.30 Rules: 11.5, including; 11.5.32 to 11.5.36	Groundwater Quantity model	Canterbury Groundwater Model 2 by Aqualinc Research Limited Report No. 07079/1 September 2007	The model described by Aqualinc, 2007 provides a comprehensive and well tested predictive tool (developed in FEMWATER) that can be used with confidence to predict groundwater responses to the changing stresses that may arise from increased availability of water for irrigation. The conceptualisation is sound and the model takes account of most of the important processes that control the storage and movement of groundwater in the aquifers and aquitards on the Canterbury Plains. The model has been developed in the FEMWATER finite element code. FEMWATER is available through the GMS Graphical User Interface. It is not widely used in Australia as a groundwater modelling code. Aqualinc has undertaken a number of modifications to the FEMWATER code as part of the model development phase. It can be concluded that no other group or individual would be able to run the model and reproduce the results as reported. Limitations: • The model does not take account of the enhanced recharge that occurs as a result of floods that cause overbanking of rivers and subsequent inundation of the surrounding land. In many regional groundwater models, this phenomenon is an important recharge mechanism and large volumes of water can infiltrate within a relatively short period.	Clarify/discuss current FEMWATER groundwater model with Aqualinc. Potentially revise ground water model calibration, depending upon outcome of discussions with Aqualinc.	High

Variation 1 Planning Provision	Technical aspect	Report name	Review conclusions	Recommended Actions	Degree of importance on model outcomes
			• No Flow model boundary conditions have been assumed on the north and southwest boundaries of the model. This configuration is not necessarily consistent with the hydrogeological conceptualisation which assumes the aquifers are continuous and extend beyond these boundaries. The use of head dependent boundary conditions at these locations would allow for exchange of water that may occur between the model and its surroundings in response to head changes that occur within the model domain. • Williamson, 2008 notes that the FEMWATER code is unable to quantify certain aspects of the model water budget. In particular the code does not provide an accurate account of the groundwater extraction nor the changes in groundwater storage. This shortcoming reduces the utility of the model and is illustrated in Figure 7-18 that illustrates that about 5% of the water budget cannot be accounted for. It is assumed that this imbalance is roughly equal to storage changes in the transient calibration model – although this cannot be confirmed. • The report is deficient in that it does not describe the approach to or parameterisation of the unsaturated zone model component, nor is there a clear description of how evapotranspiration is defined or accounted for. • Unfortunately its size, complexity and instability appears to have rendered it of little use for on-going simulation of groundwater flow and water quality (it does not simulate solute transport) responses. It appears that the long run times are related to the application of unsaturated zone modelling and the fact that the calculation time step needs to be exceptionally short (much less than one day) in order to manage numerical instabilities.		

Variation 1 Planning Provision	Technical aspect	Report name	Review conclusions	Recommended Actions	Degree of importance on model outcomes
Section 11.7 Environmental Flow and Allocation Regime and Water Quality Targets and Limits Policies: 11.4, including; 11.4.12, 11.4.17, 11.4.22, 11.4.24 to 11.4.26 and 11.4.29 Rules: 11.5.7, 11.5.14 and 11.5.15	Scott water balance model	Scott, D. and Weir, J., 2014. Technical report to support water quality and water quantity limit setting process in Selwyn Waihora catchment. Environment Canterbury Report No R14/16. February, 2014.	A simple standard single bucket daily soil-water balance model was used to generate amount of water used for irrigation and depths of water draining through the soil profile into groundwater for dryland and irrigated scenarios. Significant issues include: soil PAW, irrigation strategy, efficiency adjustment, fixed crop/ crop factors, climate stations, no account for coastal high water tables, no on-farm (flow rate or annual allocation) limits applied except for ZC scenario. Unrealistic modelling leading to gross overestimates of irrigation demand and drainage to groundwater.	Need to generate daily time series of realistic irrigation demand and drainage to groundwater	High as it is the start of the process that eventually leads to stream flow assessments and lake N loading
Section 11.7 Environmental Flow and Allocation Regime and Water Quality Targets and Limits Policies: 11.4, including; 11.4.12, 11.4.17, 11.4.22, 11.4.24 to	Pre - groundwater model data processing	Scott, D. and Weir, J., 2014. Technical report to support water quality and water quantity limit setting process in Selwyn	Outputs from the water balance model were processed into monthly values according to climate, irrigation option, soil PAW, areas and water source (CPW & other). Questionable whether Ashburton & Methven rainfall were appropriate stations to use. Irrigation areas for Scenario 1 overstated. No value (in fact a serious disadvantage) in using monthly rather than daily outputs.	Get consensus on more realistic climate stations and areas. Leave as daily values	High.

Variation 1 Planning Provision	Technical aspect	Report name	Review conclusions	Recommended Actions	Degree of importance on model outcomes
11.4.26 and 11.4.29 Rules: 11.5.7, 11.5.14 and 11.5.15		Waihora catchment. Environment Canterbury Report No R14/16. February, 2014.			
Section 11.7 Environmental Flow and Allocation Regime and Water Quality Targets and Limits Policies: 11.4, including; 11.4.12, 11.4.17, 11.4.22, 11.4.24 to 11.4.26 and 11.4.29 Rules: 11.5.7, 11.5.14 and 11.5.15	Aqualinc groundwater modelling	Scott, D. and Weir, J., 2014. Technical report to support water quality and water quantity limit setting process in Selwyn Waihora catchment. Environment Canterbury Report No R14/16. February, 2014.	A finite element model (FEMWATER) used to investigate the effects of irrigation abstraction on groundwater levels and rivers and stream flows. The Aqualinc model has been essentially used as a black box. Calibration of the model was previously done and did not form part of this analysis. Most inputs were monthly, while outputs were daily (showing the effects of lumped monthly stresses). Jan 1972 to Jun 1984 was used for a 'warming" period, which is excessive. Only Jul 1984 to Apr 2010 output was used in further analysis. Some important years removed from future analyses.	Need to generate output with daily inputs. Need to utilise as long a record as possible.	High.
	Stream flow modelling	Clark, D.A., 2014.	Clark, D.A., 2014. Technical report to support water quality and water quantity limit setting process in Selwyn Waihora catchment. Predicting	Check the regressions and relevance of	High

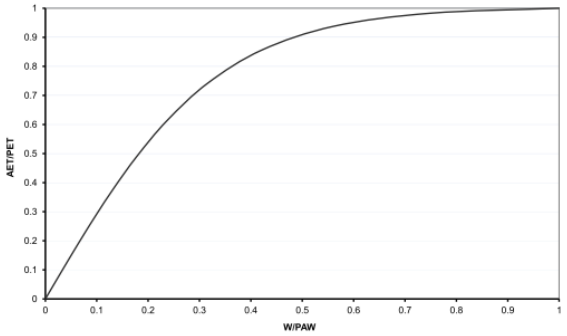
Variation 1 Planning Provision	Technical aspect	Report name	Review conclusions	Recommended Actions	Degree of importance on model outcomes
		Technical report to support water quality and water quantity limit setting process in Selwyn Waihora catchment. Predicting consequences of future scenarios: Surface water quantity	consequences of future scenarios: Surface water quantity	assumptions. Need to run all analyses on daily basis with revised groundwater inputs. Fix the problem with quick flow. Compare measured with Scenario 1 as a reality check.	
	Water quality modelling (related to hydrology)	Hanson, C., 2014. Technical report to support water quality and water quantity limit setting process in Selwyn Waihora catchment. Predicting	There are issues related to the conceptual understanding of groundwater and how N moves from the land surface into streams and the lake. They say that the groundwater aquifers are unconfined, but then say that all N stays in shallow groundwater while deep groundwater is sourced from major rivers. This ”separation” means that there is no allowance for broad-scale dilution. Also, a significant portion (about 1/3) of the SW plains area does not have shallow groundwater, so N leaching would be into deep groundwater anyway. Julian Weir’s flow budgets show a large component of outflow to the lake and directly to the ocean (30-45 cumecs, depending on the	We need to better understand the nutrient flow paths, which stem from groundwater hydrology. If a big part of CPW is not over shallow groundwater, the consequences need to be understood. If recharge on farms is substantially less than modelled, then N loading from CPW will be less	High

Variation 1 Planning Provision	Technical aspect	Report name	Review conclusions	Recommended Actions	Degree of importance on model outcomes
		consequences of future scenarios. Groundwater quality,	scenario). This means that a significant proportion of the N load is not passing through the lake. There seems to be an inconsistency between the attenuation factors used to convert groundwater N concentrations to stream flow concentrations and the basic hydrological assumptions. The fact that an additional factor had to be introduced (to account for surface water supplied irrigation) means that there may be something conceptually wrong with their approach.	than assumed. Our understanding of the hydrology needs to be incorporated into the analysis.	
Section 11.7 Environmental Flow and Allocation Regime and Water Quality Targets and Limits Policies: 11.4; including; 11.4.20, 11.4.21, 11.4.27 & 11.4.30 Rules: 11.5, including; 11.5.32 to 11.5.36	Groundwater Quantity model	Technical report to support water quality and water quantity limits setting process in the Selwyn Waihora Catchment. Predicting consequences of future scenarios: Groundwater quantity. By D Scott (Environment Canterbury) and J Weir	A smaller, simplified model (also developed in the FEMWATER code) has been used for assessing and comparing various predictive scenarios (Scott and Weir, 2014). The reporting of the revised model does not allow an objective assessment of the confidence with which it can replicate actual groundwater behaviour as the report is deficient in its description of the revised model and its calibration. As a result we do not have the same confidence that this version of the model is able to simulate the groundwater responses that arise from changed land use, irrigation water availability and groundwater extraction as assumed by the various scenarios that have been run. Results are presented as a table of water budget components (included change in storage terms) and differences in the 90th percentile groundwater levels for different scenarios (groundwater levels that are exceeded for 10% of the model duration). The water budget results are presented in very coarse terms and no attempt has been made to separate out the fluxes associated with individual model features. For example the *"stream"* fluxes have not been disaggregated to present the results for individual rivers and the *"specified head"* fluxes do not distinguish interactions with the lake and estuary from the ocean discharge flux. The results illustrate a 2 to 3% imbalance in the water	Clarify/discuss current FEMWATER groundwater model calibration with Aqualinc. Potentially revise ground water model calibration, depending upon outcome of discussions with Aqualinc.	High

Variation 1 Planning Provision	Technical aspect	Report name	Review conclusions	Recommended Actions	Degree of importance on model outcomes
		(Aqualinc). Environment Canterbury Report No R14/16. February, 2014.	budget indicating a rather large numerical error in the solutions. If it can be demonstrated that the revised model is well calibrated and can be run with reasonable model run times, then it should be applied in any future modelling scheme. Indeed the existing modelling results may be adequate for such a modelling exercise, without further simulation runs (although a significant amount of additional processing of model results may be required).		
Section 11.7 Environmental Flow and Allocation Regime and Water Quality Targets and Limits Policies: 11.4, including; 11.4.12, 11.4.17, 11.4.22, 11.4.24 to 11.4.26 and 11.4.29 Rules: 11.5.7, 11.5.14 and 11.5.15	Irrigation Efficiency Nominal efficiency of 80% Section 2.2, bullet point i.	Scott and Weir (2014) report entitled Technical Report to Support Water Quality and Quantity Limit Setting Process in Selwyn Waihora Catchment. Predicting Consequences of Future Scenarios: Groundwater Quantity.	It is important to have clarity on the type of efficiency being considered, and this in turn governs the efficiency value assigned – i.e. overall irrigation system efficiency versus irrigation application efficiency. As inferred, the latter is measured at the paddock scale, while system efficiency encompasses the losses in off-farm and on-farm delivery systems. 80% efficiency is more akin to a system efficiency value than an application efficiency value. Recent work by SKM and WaterForce has demonstrated application efficiencies under centre pivots at approximately 98%. Knowledge of all types of losses is required for determining the total water take volume required for irrigation. But efficiency is not required to be incorporated into soil moisture water balance modelling, which is aimed at purely determining the water required to satisfy deficits within predefined soil parameter criteria for effective irrigation. Once this is known, application efficiency can be added to determine the total volume of water required at the irrigator. Following this, we need to account for system efficiency to determine the total take volume required.	Clarify what efficiency referred to in this paragraph represents. Possibly update modelling to reflect correct usage of the term efficiency in the context of the modelling.	High
Section 11.7	Irrigation	Scott and Weir	This would appear to imply that the irrigation depth (or the water applied	Clarify exact depth of	High

Variation 1 Planning Provision	Technical aspect	Report name	Review conclusions	Recommended Actions	Degree of importance on model outcomes
Environmental Flow and Allocation Regime and Water Quality Targets and Limits Policies: 11.4, including; 11.4.12, 11.4.17, 11.4.22, 11.4.24 to 11.4.26 and 11.4.29 Rules: 11.5.7, 11.5.14 and 11.5.15	Efficiency An irrigation efficiency of 80% is represented by applying an irrigation depth that is in excess of the deficit, estimated as (PAW-W)/0.8 Section 2.2.1	(2014) report entitled Technical Report to Support Water Quality and Quantity Limit Setting Process in Selwyn Waihora Catchment. Predicting Consequences of Future Scenarios: Groundwater Quantity.	to the soil moisture model) is the water required to satisfy the soil moisture deficit multiplied by 1.25 times to account for inefficiency. Given that application efficiency is predominantly governed by losses between the irrigator and the ground surface, this should not be accounted for in a soil moisture water balance model. The model should only account for the water landing on the ground surface. The implication of applying an irrigation depth multiplied by 1.25 times is that sub-soil drainage and leaching would by over predicted.	water applied to the soil surface. Potentially revise leaching predictions to be consistent with correct depths of applied irrigation water.	
Section 11.7 Environmental Flow and Allocation Regime and Water Quality Targets and Limits Policies: 11.4, including; 11.4.12, 11.4.17,	Irrigation Application Depth (PAW-W)/0.8 Irrigation is triggered when soil moisture deficit reaches	Scott and Weir (2014) report entitled Technical Report to Support Water Quality and Quantity Limit Setting	The above row discussed the efficiency aspect of the irrigation depth formula. This comment relates to the application depth *per se*, which would appear to be equal to 50% PAW i.e. each time an irrigation event occurs, the soil moisture status is taken from 50% PAW to 100% PAW or fully satisfied. The problem with this is that it does not mimic actual irrigation practice under centre pivots, which is the predominant irrigator type in Canterbury, resulting in larger irrigation application than in practice. The following steps through the logic:	Comment on the process for determining irrigation application depth in the model and how interception and sub-soil drainage is handled in the model.	High

Variation 1 Planning Provision	Technical aspect	Report name	Review conclusions	Recommended Actions	Degree of importance on model outcomes
11.4.22, 11.4.24 to 11.4.26 and 11.4.29 Rules: 11.5.7, 11.5.14 and 11.5.15	50% of PAW Section 2.2.1	Process in Selwyn Waihora Catchment. Predicting Consequences of Future Scenarios: Groundwater Quantity.	• PAW of the three soil types is 60, 100 and 150 mm; • Application depths (D) of 30, 50 and 75 mm (or 38, 63 and 94 mm if efficiency was included) given D=50%PAW. • Typical centre pivots with radius of 300-650 m have return periods of typically 1.5-3 days (depending on pivot size). • Typical pivot system capacities in Canterbury are 5 mm/day, which means an application depth of 7.5 to 15 mm. In practice application depths are 7.5 to 15 mm (or thereabouts) whereas Scott and Weir (2014) would appear to implement 38 to 94 mm. The implication of this is likely to be a significant over prediction of sub-soil drainage and hence groundwater recharge.		
	<u>Evaporation</u> Section 2.2.1	Scott and Weir (2014) report entitled Technical Report to Support Water Quality and Quantity Limit Setting Process in Selwyn Waihora Catchment. Predicting Consequences of Future Scenarios:	The relationship between actual evapotranspiration (AET) and potential evapotranspiration (PET) is described by the following equation: $\frac{AET}{PET} = \frac{1 - \exp\left(-A * \frac{W}{PAW}\right)}{1 - 2 * \exp(-A) + \exp\left(-A * \frac{W}{PAW}\right)}$ The report indicates that this produces the following relationship.	Provide calibration charts of measured versus modelled soil moisture level. Also, please provide a description of how sub-soil drainage is handled in the model and interception losses.	High

Variation 1 Planning Provision	Technical aspect	Report name	Review conclusions	Recommended Actions	Degree of importance on model outcomes
		Groundwater Quantity.	 There is concern that actual evaporation is being over predicted as soil moisture deficits develop. The implication of this is faster development of soil moisture deficit than would occur in practice, which in turn means more water is required for irrigation to satisfy these deficits.		
Section 11.7 Environmental Flow and Allocation Regime and Water Quality Targets and Limits Policies: 11.4; including; 11.4.20, 11.4.21, 11.4.27 & 11.4.30 Rules:	Surface Water Quantity model	Clark, D (2014) Technical report to support water quality and water quantity limit setting process in Selwyn Waihora catchment, Predicting	The author acknowledges the model uncertainty resulting from integration of multiple models simulating different aspects of the catchment hydrology and water quality. *"Due to the large-scale nature of the modelling there is more certainly regarding the total water balance and changes between scenarios than for individual stream flows…Simulating individual streams on a daily time step for different scenarios provides a way of showing how the scenarios affect the flow regimes of these but the simulations should only be compared between scenarios and not to daily field observations. (Section 2, pg 6).* The overall modelling approach assumes that contributions from overland flow and direct surface runoff are minimal. This is neither substantiated, nor explained and seems unlikely to be the case. The generalised regression relationships of surface (or quick) flows as	Consider alternative of rainfall-runoff modelling of catchment inflows to derive inputs for recharge to the groundwater model and event flows and loads to Te Waihora	High

Variation 1 Planning Provision	Technical aspect	Report name	Review conclusions	Recommended Actions	Degree of importance on model outcomes
11.5, including; 11.5.32 to 11.5.36		consequences of future scenarios: Surface water quantity, Environment Canterbury Regional Council, Report No: R14/8, Jan 2014.	inputs to the groundwater model provides less flexibility in accounting for changes occurring in the upper Selwyn and hill country, particularly for representation of the interbasin transfers from the Rakaia and Waimakariri Rivers to the Selwyn River water supply scheme and corresponding land use changes directly related to increased water allocation in the command area. Such a scheme would most likely appreciably modify the surface water flow component, of both flow and water quality. The proposed model encompasses the main tributary inflows to Te Waihora and the corresponding groundwater extent. Limited representation of the upper catchment restricts the ability to determine changes to reliability for downstream consented users.		
Section 11.7 Environmental Flow and Allocation Regime and Water Quality Targets and Limits	Surface Water Quantity	Kelly, D., 2014 Technical report to support water quality and water quantity limit setting process in Selwyn Waihora catchment. Predicting consequences of future scenarios: Surface water	The report analyses the concentrations of the key water quality constituents in the lowland streams that empty into Te Waihora. The report also provides some semi-quantitative projections of future water quality outcomes for the same constituents for each of the scenarios. An analysis was performed of recorded monitoring data over a 5 year period (July 2006 to September 2011), with data available at most sites on a monthly basis (quarterly for two sites). For the current scenario, the comparisons to the recommended guidelines for Nitrate-Nitrogen concentrations from Hickey and Martin (2009) and Hickey (2013) are sound. For the current scenario, the analysis of compliance with Natural Resources Regional Plan (NRRP) objectives for macrophyte and filamentous algae cover is reasonably sound. There are limitations (appropriately recognised by the author) with estimating the percentage cover for macrophyte and filamentous algae using nutrients as the only explanatory factor, since it is acknowledged that cover may be influenced by either Disolved Inorganic Nitrogen (DIN) or Dissolved	None	Low

Variation 1 Planning Provision	Technical aspect	Report name	Review conclusions	Recommended Actions	Degree of importance on model outcomes
		quality. Environment Canterbury Report R14/13	Reactive Phosphorus (DRP) concentrations or other factors, such as stream shading, availability of fine sediments and turbidity.		
Section 11.7 Environmental Flow and Allocation Regime and Water Quality Targets and Limits	Surface Water Quantity	Kelly, D., 2014 Technical report to support water quality and water quantity limit setting process in Selwyn Waihora catchment. Predicting consequences of future scenarios: Surface water quality. Environment Canterbury Report R14/13	There are several limitations associated with the projections made for the future scenarios. The future scenarios appear to make relatively arbitrary assumptions about the likely DRP concentrations under each scenario, with no explicit attempt to model projected changes in DRP. The approach taken to projection of future DRP is inconsistent with the more sophisticated projections made for DIN under each of the future scenarios. The relative sensitivity of the chlorophyll a biomass to assumptions made about change in mean DRP concentrations for each scenario is unclear. The projections of future 95th percentile DIN concentration make an overly simplistic assumption for the scenarios that the ratio of the 95th percentile to mean concentration (let's refer to this as R95 in this document) of DIN from the monitored data for current (2006-2011 data set) will remain the same for the future modelled scenarios. As shown in Appendix 2, there is considerable variability in R95: between a factor of 1.14 in the Halswell River up to a factor of 3.61 in the Irwell River. R95 is likely to represent a combination of uncertainty in analysis of individual DIN samples, variability in the DIN concentration in the components of flow contributed at each site from surface and groundwater flow pathways at the time of each sample and variability in each stream in the relative proportions of the total flow contributed from surface and groundwater at the time of each sample. The streams with higher R95 values may be indicative of dominance of the last factor (i.e.	Test sensitivity of projected chlorophyll a concentrations under future scenarios to assumed future concentrations of DRP. Consider conducting additional analysis, similar to that conducted by Biggs (2000) to establish predictive relationships for chlorophyll a from streams that are more similar to those in the Selwyn Waihora. Provide justification for approach used to estimate 95th percentile DIN under the scenarios (or revise using more explicit modelling of the distribution of DIN concentrations at each	High

Variation 1 Planning Provision	Technical aspect	Report name	Review conclusions	Recommended Actions	Degree of importance on model outcomes
			relatively high contributions of surface water during some periods leading to strong dilution of DIN in some periods and other periods of low surface water contribution with low dilution of DIN) and the streams with lower DIN may be indicative of relatively low surface water contribution (i.e. consistent concentrations from ground water with relatively little surface water dilution). However, there is no analysis presented in the report to enable these influence factors to be deduced. Without this analysis, it cannot be supported that the R95 would remain the same under the projected scenarios. Different scenarios will have different effects on surface and ground water flow and nutrient concentrations (from surface and ground water contributions) at each site, which in turn will affect the R95 value for DIN at each site. This undermines the projections of DIN concentrations and hence projections of chlorophyll a biomass for all of the future scenarios. As acknowledged by the author, the relationships produced by Biggs (2000), which were adopted to predict chorophyll a, were derived from hill-fed gravel bed rivers that were very different from the spring fed systems. The nutrient concentrations recorded in Selwyn Waihora are much higher than those used to develop the regression relationships in Biggs (2000), which limits the predictive capability for chorlophyll a.	site given the projected changes in surface and ground water flows and concentrations).	
Section 11.7.3 Water Quality limits and targets	Estimation of probability of water extracted for drinking water supply exceeding maximum	Hanson, C. (2014) Technical report to support water quality and water quantity limit setting	The empirical model adopted uses the probability of exceedance of MAV at bores within each zone and then attempts to fit an exponential model with the mean annual Nitrate load in the zone as a predictor variable. There are some real conceptual problems with this. The form of equation used means that there will be a mean annual Nitrate load at which the probability of exceedance of MAV exceeds 1, which is impossible. The form of equation also means that there is a non-zero probability of exceedance of MAV, even if the mean annual	Completely revise the approach used to estimate the probability of exceedance of the MAV	High – if exceedance of MAV is a critical decision making criteria, otherwise

Variation 1 Planning Provision	Technical aspect	Report name	Review conclusions	Recommended Actions	Degree of importance on model outcomes
	acceptable values (MAV)	process in Selwyn Waihora catchment. Predicting consequences of future scenarios. Groundwater quality. Environment Canterbury Regional Council, Report No. R14/11	Nitrate load were to approach zero, which again is illogical. The direct estimation of the probability of exceeding MAV from just adopting the probability in the sample data, from relatively small (and potentially biased) sample sets is also questionable. With reference to the Modelling Strategy outlines in Section 2.3 (pg. 10), list item 3: Evaluate the risk to drinking-water supplies that tap the shallow groundwater, using empirical relationships developed from existing monitoring data.		Moderate.
Section 11.7 Environmental Flow and Allocation Regime and Water Quality Targets and Limits Policies: 11.4, including; 11.4.1, 11.4.6 to 11.4.11, 11.4.14 and 11.4.17	Groundwater Quality	Hanson, C. (2014) Technical report to support water quality and water quantity limit setting process in Selwyn Waihora catchment.	The recent attempt by Hanson to simplify and integrate surface nitrate production with groundwater models ultimately oversimplifies the treatment of nitrogen on the plains and ultimately comes up with results that cannot be verified and may not be accurate. This latest round of nitrate modelling seems to be a simplification on previous models and is based on empirical relationships, not analytical assessment, thereby of less use than the earlier models. The model is also based on a simplified version of the groundwater model, which does not appear to account for the (probably substantial) impacts from river recharge across the plains, in addition to the river recharge in the hills that supplies the deeper aquifer. • Recharge is a critical factor in the calculations and has been lumped	Further explain and justify approach adopted. Consider complete revision of method of modelling groundwater quality.	High

Variation 1 Planning Provision	Technical aspect	Report name	Review conclusions	Recommended Actions	Degree of importance on model outcomes
Rules: 11.5, including; 11.5.16, 11.5.17 and 11.5.18 to 11.5.29		Predicting consequences of future scenarios. Groundwater quality. Environment Canterbury Regional Council, Report No. R14/11 Di & Cameron (2004) Integrated modelling of Land Use Impacts on Groundwater Quality on a Regional Scale	for modelling. This is inappropriate and will generate biased results. Earlier models may have been too complex; later models are now too simple. • There should be sufficient information to provide a better spatial determination of nitrate movement, including an incorporation of nitrification and denitrification based on groundwater chemistry and inputs from the local river recharge. This is not considered. Areas outside the priority catchments have been included in the analyses. Results from these extraneous catchments are used to define empirical relationships across the entire region, though they do not appear to have a direct correlation with the results from the Selwyn-Waimakariri area. This provides misleading results. • It is unclear whether evaporation has been included in the model or if the effects of natural concentration of nitrate in the region have been considered. Natural nitrogen processes will be important limiting factors for nitrate generation. • There is an emphasis on results from the ends of the catchment (plains); from data collected near the lake and estuaries. This provides an incomplete and inaccurate picture of nitrogen dynamics. Surface water-groundwater interactions along the major rivers will be important and need to be incorporated. • The statistics used is naïve, superficial and sometimes misleading. Best-fit trend lines from disparate data give incorrect relationships. The early report (Di and Cameron, 2004) provides a comprehensive attempt to generate nitrate leaching equations and comparisons across multiple land use zones and under changing recharge and land use to predict nitrate levels at depth within the regional groundwater aquifers.		

Variation 1 Planning Provision	Technical aspect	Report name	Review conclusions	Recommended Actions	Degree of importance on model outcomes

			The methodology attempted to integrate the effects of surface-groundwater mixing and model defined land use changes with time. This was largely an analytical solution applied to spatially-defined zones across the plain with a very simplified groundwater model beneath that underlay the entire region as 2 layers. The zonation accounted for variability in the groundwater systems, whilst not varying the physical parameters of those systems.
			• The model calculates nitrate concentration at depth, but does not account for variability in aquifer thickness; hence reported concentration profiles extend seamlessly across the two aquifers and hence temporal changes in nitrate with depth plot as straight lines under differing scenarios. The limitations were outlined in a section on future research. Hence:
			  • Irrigation conditions are also an average and do not consider variability in application type or management, or the impacts of flooding on results.
			  • Surface-groundwater mixing is simplified and not spatially constrained. Indeed, the amount of mixing is poorly defined.
			Essentially, a lot of detailed analysis of land use and zonation is distilled to a limited number of zones and parameters regarding land use are also distilled to simple arguments for analytical consideration. Provision of these parameters is possible in the surficial model used to generate the average conditions (model = NLE), but oversimplification has been applied to facilitate incorporation into a groundwater construct that is also too simplified and does not consider:
			• The actual thickness and changing conditions with depth of the groundwater systems;		

Variation 1 Planning Provision	Technical aspect	Report name	Review conclusions	Recommended Actions	Degree of importance on model outcomes
			• Multiple recharge sources and variable groundwater conditions across the plains, and • The consequence of de-nitrification and other nitrogen cycle processes that would operate in the region.		
Section 11.7.3 Water Quality limits and targets	Groundwater Quality	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 Regional Council, Report No. R14/11	With reference to the Modelling Strategy outlines in Section 2.3 (pg. 10), list item 2: Set that concentration equal to the nitrate concentration in the shallow groundwater. No calibration data was shown in the report to demonstrate that the Lilburne method was accurately achieving the average groundwater concentration for the existing case. (with possible correction or explanation related to lag).	Provide more explicit calibration and reporting	Moderate

Variation 1 Planning Provision	Technical aspect	Report name	Review conclusions	Recommended Actions	Degree of importance on model outcomes
Section 11.7.3 Water Quality limits and targets Policies: 11.4, including; 11.4.1, 11.4.6 to 11.4.11, 11.4.14 and 11.4.17 Rules: 11.5, including; 11.5.16, 11.5.17 and 11.5.18 to 11.5.29	Groundwater Quality	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 Regional Council, Report No. R14/11	With reference to the Modelling Strategy outlines in Section 2.3 (pg. 10), list item 4: Multiply the nitrate concentration in the land surface recharge by attenuation factors derived from existing monitoring data to estimate long-term average DIN and TN concentrations in the nine monitored streams that flow into Te Waihora/Lake Ellesmere. There is repeated use of the term "attenuation". The attenuation factor relates to the existing average relationship, which could change under future irrigation and abstraction. To model the solutions packages attenuation factors were multiplied by an additional factor equal to the ratio of the land surface recharge rate to the total predicted flow in the streams. *For example, Scenario 2 includes increased irrigation inputs from surface water sources, which will cause increased land surface recharge. This would tend to increase the amount of land surface recharge in the spring-fed streams. As a result, the model would underestimate the nitrogen concentrations in the streams. At the same time, the scenario would have decreased groundwater abstraction, which could result in increased inputs of river recharge to the spring-fed streams. This would make the model overestimate nitrogen concentrations in the streams. It is not possible how to predict how these two competing effects would balance, so this must be regarded as a source of uncertainty in the model. (section 4.1.3 Hanson 2014)* The attenuation factor represents a range of things, including proportion of land surface recharge and river recharge, denitrification, attenuation. In general, this has been used where the term "dilution" would be correct. (Section 2.5.2 Hanson 2014).	Modify wording in report	High
Section 11.7.3	Groundwater	Hanson, C.	With reference to the Modelling Strategy outlines in Section 2.3 (pg.	Improve resolution with a	High

Variation 1 Planning Provision	Technical aspect	Report name	Review conclusions	Recommended Actions	Degree of importance on model outcomes
Water Quality Limits and Targets Policies: 11.4, including; 11.4.1, 11.4.6 to 11.4.11, 11.4.14 and 11.4.17 Rules: 11.5, including; 11.5.16, 11.5.17 and 11.5.18 to 11.5.29	Quality	(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 Regional Council, Report No. R14/11	10), list item 5: Estimate the nitrogen load to Te Waihora/Lake Ellesmere using the long-term average TN concentrations and predicted stream flows. *TN concentrations (Table 2-4) were calculated as flow-weighted averages, using the monthly or quarterly TN measurements recorded in Environment Canterbury's water quality database and daily flow data from unpublished Environment Canterbury records. Each daily flow rate was multiplied by the TN concentration from the most recent stream sample. The sum of the daily products calculated over the five-year period was then divided by the total flow volume for the same period to derive the flow-weighted average TN concentration" (Hanson 2014)*	daily model.	
Section 11.6 Freshwater Outcomes Policies:	Water Quality limits	Robson M (2014) Technical report to	The Freshwater outcomes are summarised in tables 11a and 11b of Variation 1. The variation 1 outcomes relate to a series of priority outcomes for the catchment developed by the Zone Committee, which are broader than the numeric outcomes in the variation. These are		Moderate

Variation 1 Planning Provision	Technical aspect	Report name	Review conclusions	Recommended Actions	Degree of importance on model outcomes
11.4, including; 11.4.1, 11.4.6 to 11.4.11, 11.4.14 and 11.4.17 Rules: 11.5, including; 11.5.16, 11.5.17 and 11.5.18 to 11.5.29		support water quality and quantity limit setting in Selwyn Waihora catchment Predicting consequences of future scenarios: Overview Report.	summarised in Table 1 of the Selwyn-Waihora limit setting: Overview report. (Robson 2014). The water quality water limits and targets are set out in tables 11i,11j 11k, 11l, and 11m. These limits reflect modelled outcomes for a future landuse and mitigation scenario - Option 7: Zone Committee Solution Package. (Described in Appendix 5 Section 32 report) The catchment load of nitrogen in tonnes from farming is modelled in the current situation as 4529 tonnes/year, under Variation 1 this could increase to 4830 tonnes/yr. The Option 7 modelled scenario, allowed for future intensification in CPW and some other areas, reductions in nitrogen load for existing users and mitigation measures. An assessment described in Selwyn Waihora limit setting: Overview report, estimates how likely the Zone Committees priority outcomes are to be achieved. This assessment takes into account more than water chemistry. For example, the outcome of “Healthy Lowland Streams” and “Te Waihora is a Healthy Ecosystem” is assessed as “probably” being achieved under Option 7 - Zone Committee Solution package. The proposed physical mitigation in this scenario are likely to result in improved habitat in these locations, however, the proposed nitrate toxicity limits in the spring fed plains streams of 6.9 and 9.8 NO3-N mg/l (table 11k Variation 1), relate to a 80% ecosystem protection for “highly disturbed systems “. At Te Waihora, the proposed TLI of 6.6 (table 11b Variation 1) in the mid lake is an improvement on the current average of 6.8, (Norton et al 2012) but this TLI score is still hypertrophic.		
Section 11.7.3 Water Quality Limits and Targets	Catchment nitrogen modelling	Lilburne, L., Webb, T., Ford, R.,	With reference to the Modelling Strategy outlines in Section 2.3 (pg. 10), list item 1: Determine the catchment-wide, long-term average nitrate nitrogen concentration in the land surface recharge for the land	Consideration on whether it would be useful to better spatially	High

Variation 1 Planning Provision	Technical aspect	Report name	Review conclusions	Recommended Actions	Degree of importance on model outcomes
Policies: 11.4, including; 11.4.6 to 11.4.17 Rules: 11.5, including; 11.5.6 to 11.5.13, 11.5.15 to 11.5.17, 11.5.22 and 11.5.25		Bidwell, V., (2013), Estimating nitrate-nitrogen leaching rates under rural land uses in Canterbury (updated). R10/127, Environment Canterbury.	use scenario. Lilburne, et al. (2013) took the results of Di & Cameron (2004), updated them and integrated the results into a GIS construct to provide long-term nitrate leaching rates for land uses under changing climate and land use conditions. This represents a substantial improvement over the early model and incorporated nitrogen cycle processes as part of the leaching estimations. This was achieved through the use of the SPASMO model and generated a series of look-up tables for nitrate leaching under different soil types, land use and rainfall regimes. This provides an ideal precursor to incorporation into a groundwater model, though this report focussed solely on accurately representing leaching across the plain. Caveats included: • The results should be seen as broad-scale, indicative values and not be used at paddock scale or for policy decisions; • Results do not consider changes/improvements to management practices; • Lack of good long-term measured leaching data; • Some soil/climate/land use conditions could not be modelled; • Different results from different models designed to carry out the same function, and • Lack of drainage values for some soil types. Nevertheless, the approach is a good approximation and appropriate for incorporation into a groundwater model.	represent some of the mitigation measures. It is unlikely that we would have any better information on the expected performance of measures.	
Section 11.7 Environmental Flow and Allocation Regime and Water Quality	Te Waihora/ Lake Ellesmere physical,	Technical Report to support water quality and	The report outlines multiple lines of evidence to assess the consequences of a range of future land-use intensification and mitigation scenarios on the physical, chemical and biological state of Te Waihora/Lake Ellesmere.		Medium

Variation 1 Planning Provision	Technical aspect	Report name	Review conclusions	Recommended Actions	Degree of importance on model outcomes
Targets and Limits	chemical and biological investigations	water quantity limit setting processes in Selwyn Waihora Catchment. Predicting consequences of future scenarios: Te Waihora/Lake Ellesmere. By Ned Norton (NIWA), Mathew Allan (University of Waikato), David Hamilton University of Waikato), Graeme Horrell (NIWA), Donna Sutherland (NIWA), Adrian Meredith	A modelling approach was adopted, supported by site-specific data and experimental studies, information from literature, national guideline documents, and expert consensus interpretation. The authors have used a coupled hydrodynamic-ecological model (DYRESM-CAEDYM) to undertake the scenario modelling of Te Waihora/Lake Ellesmere. DYRESM-CAEDYM is a well-established, international peer reviewed and widely applied modelling framework, and well suited to modelling the physical, chemical and biological state of Te Waihora/Lake Ellesmere with respect to assessing relative changes in nutrient loading and trophic changes in water quality. Limitations and uncertainties within the model are satisfactorily documented within the report and where possible appropriate measures suggested addressing these limitations in the future (i.e., undertaking additional research or monitoring/data collection campaigns to bridge knowledge gaps). An external peer review of the report has been conducted by Dr Marc Schallenberg (University of Otago). Dr Schallenberg review was comprehensive and the authors have satisfactorily addressed the review comments. It was noted that inflows to the Lake model was derived using linear interpolation between monthly samples for flow and concentrations. The authors acknowledge that “Interpolation between measurements has the potential to lead to some inaccuracies in estimated flow, nutrient concentrations and mass fluxes” and may underestimate large storm events that deliver large loads of nutrients and sediments to the Lake.		

Variation 1 Planning Provision	Technical aspect	Report name	Review conclusions	Recommended Actions	Degree of importance on model outcomes
		(Environment Canterbury); Incorporates comments from Marc Schallenberg (University of Otago). Report No. R14/14, Jan 2014.			

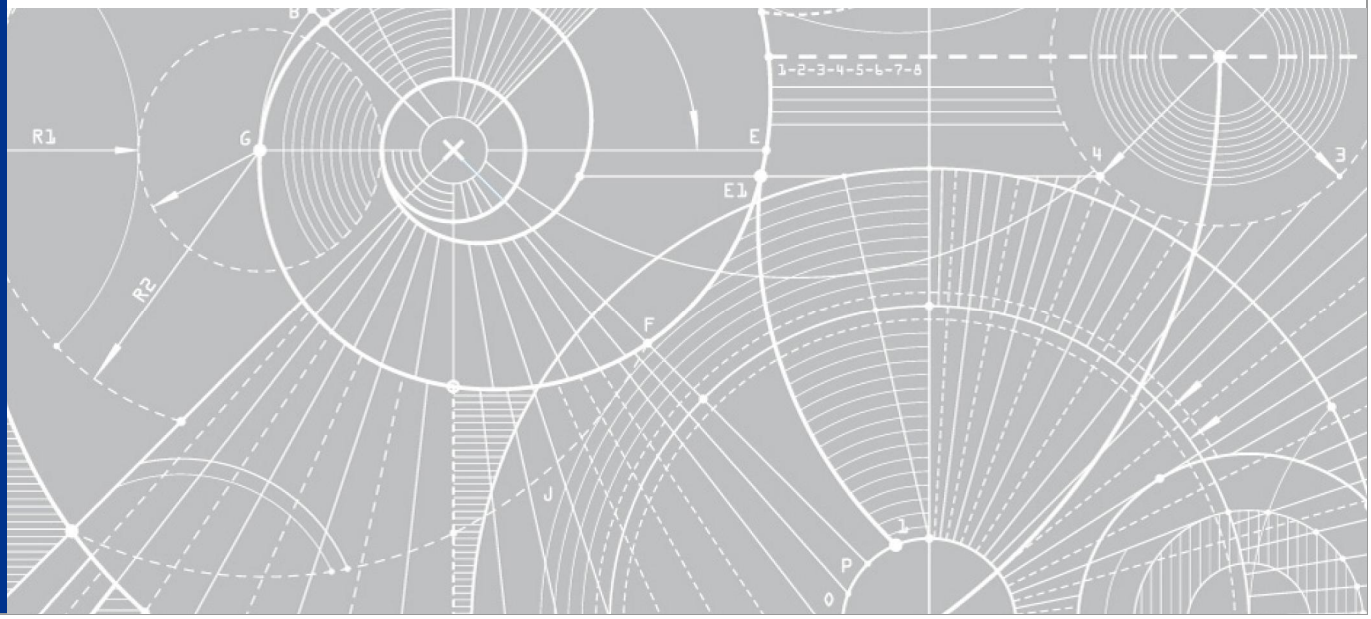
Selwyn Waihora catchment technical model review

CENTRAL PLAINS WATER

Review of surface and groundwater quantity and quality modelling for Ecan Plan Change Variation 1

Final | 02

21 Mar 2014



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Selwyn Waihora catchment technical model review

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Revision:	03
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Client name:	Central Plains water
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Project manager:	Nic Conland
Author:	Lydia Cetin
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Contents

1. Introduction

An international peer review was requested by Central Plains Water (CPW) to understand the assumptions and outcomes of the hydrologic and water quality modelling and analysis approaches employed by Environment Canterbury Regional Council (ECan) to establish water quantity and quality limits and allocation rules as proposed by the Variation 1 to the Land and Water Regional Plan (LWRP). Where limitations or enhancements to the approach were found by the review panel an alternative modelling approach was proposed to address these limitations and/or knowledge gaps.

The review panel participants are listed in Table 1 and CVs of the project team are given in Appendix A. The Documents available for review on the modelling and analysis completed to date on the ECan Variation 1 to the LWRP is extensive. A targeted review of reports detailing the key modelling approaches was conducted by the review panel and is listed in Section 1.1. Figure 1 highlights those reports reviewed by the panel in the context of the supporting technical reports prepared for the Variation 1.

Table 1. Review panel participants and associated topics reviewed

Reviewer	Topic
Brian Barnett, Principle Groundwater Modeller	Groundwater Quantity
Dr Richard Cresswell, Senior Hydrogeologist	Groundwater Quality
Jon Williamson, NZ Irrigation Development Manager	Groundwater recharge & Irrigation Demand Estimates
Dr Phillip Jordan, Principal Hydrologist	Surface Water Quantity and Quality
Michelle Sands, Senior Environmental Scientist	Water quality and nutrient limit setting
Dr Lydia Cetin, Hydrologist	Te Waihora water quality modelling

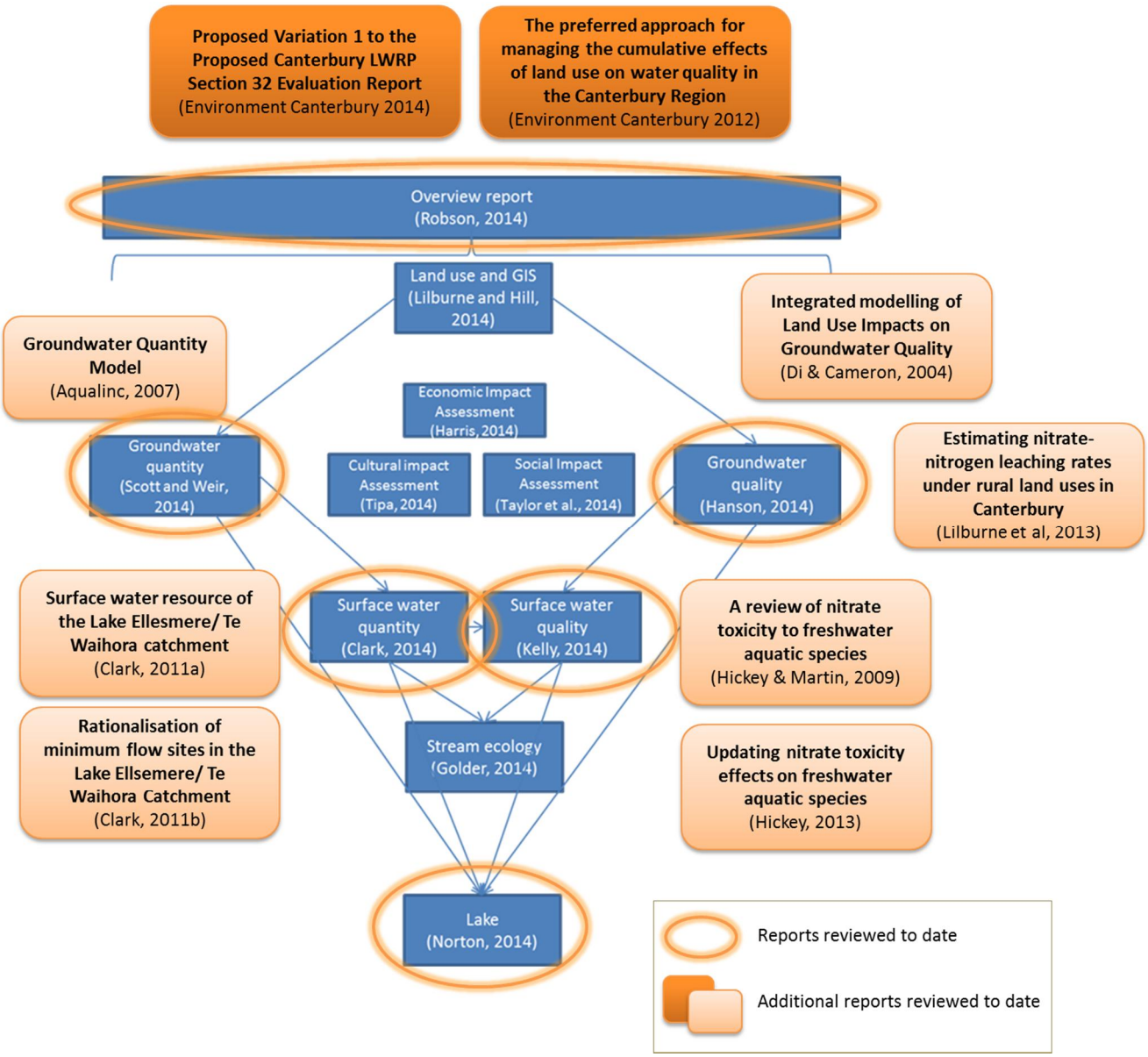


Figure 1: Overview report and supporting technical report schematic for Selwyn Waihora Water quantity and quality limit setting. Orange circles indicate the international peer reviewed reports to date and the orange boxes indicate additional reports undergone international peer review

1.1 List of papers reviewed

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

2) Clark, D. (2011a) The surface water resource of the Lake Ellesmere/Te Waihora catchment. Environment Canterbury technical Report R11/26 76p.

3) Clark, D. (2011b) Rationalisation of minimum flow sites in the Lake Ellesmere/ Te Waihora catchment.

4) 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

5) Environment Canterbury Internal Memorandum dated 1 June 2011, 11p.

6) Di & Cameron, (2004) Integrated modelling of Land Use Impacts on Groundwater Quality on a Regional Scale (Land_use_impacts_on_groundwater_quality.pdf)

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

8) Environment Canterbury, 2012. The preferred approach for managing the cumulative effects of land use on water quality in the Canterbury Region: a working paper. ECan report R12/23

9) 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

10) Hickey, C., Martin, M., 2009. A review of nitrate toxicity to freshwater aquatic species. Prepared for Environment Canterbury. R09/57.

11) Hickey, C. (2013). Updating nitrate toxicity effects on freshwater aquatic species. NIWA Client Report No: HAM2013-009. Prepared for Ministry of Building, Innovation and Employment.

12) Kelly, D., 2014. Technical report to support water quality and water quantity limit setting process in Selwyn Waihora catchment. Predicting consequences of future scenarios: Surface water quality Environment Canterbury.

13) Lilburne, L., Webb, T., Ford, R., Bidwell, V., 2013. Estimating nitrate-nitrogen leaching rates under rural land uses in Canterbury (updated). R10/127, Environment Canterbury.

14) Norton, N., Horrell, G., Allan, M., Hamilton, D., Sutherland, D., Meredith, A., 2014. Technical report to support water quality and water quantity limit setting process in Selwyn Waihora catchment. Predicting consequences of future scenarios: Te Waihora/Lake Ellesmere

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

16) 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. SWZC, S.W.Z.C., 2012. Selwyn

17) No authors stated - in preparation (2014), Development of a groundwater quality model for Selwyn-Waihora land-use scenario modelling.

2. Review Summary

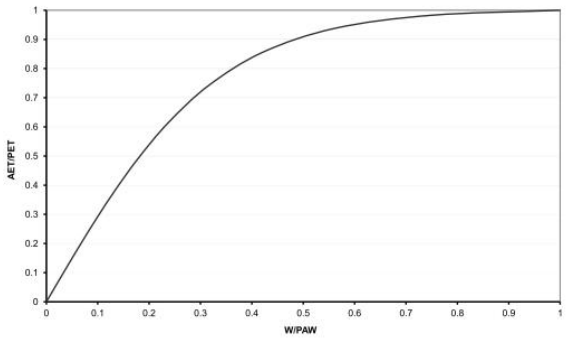
Variation 1 Planning Provision	Technical aspect	Report name	Review conclusions	Recommended Actions	Degree of importance on model outcomes	Alternatives (described in Section 3)
Section 11.7 Environmental Flow and Allocation Regime and Water Quality Targets and Limits Policies: 11.4; including; 11.4.20, 11.4.21, 11.4.27 & 11.4.30 Rules: 11.5, including; 11.5.32 to 11.5.36	Groundwater Quantity model	**Canterbury Groundwater Model 2** by Aqualinc Research Limited Report No. 07079/1 September 2007	The model described by Aqualinc, 2007 provides a comprehensive and well tested predictive tool (developed in FEMWATER) that can be used with confidence to predict groundwater responses to the changing stresses that may arise from increased availability of water for irrigation. The conceptualisation is sound and the model takes account of most of the important processes that control the storage and movement of groundwater in the aquifers and aquitards on the Canterbury Plains. The model has been developed in the FEMWATER finite element code. FEMWATER is available through the GMS Graphical User Interface. It is not widely used in Australia as a groundwater modelling code. Aqualinc has undertaken a number of modifications to the FEMWATER code as part of the model development phase. It can be concluded that no other group or individual would be able to run the model and reproduce the results as reported. Limitations: • The model does not take account of the enhanced recharge that occurs as a result of floods that cause overbanking of rivers and subsequent inundation of the surrounding land. In many regional groundwater models, this phenomenon is an important recharge mechanism and large volumes of water can infiltrate within a relatively short period. • No Flow model boundary conditions have been assumed on the north and southwest boundaries of the model. This configuration is not necessarily consistent with the hydrogeological conceptualisation which assumes the aquifers are continuous and extend beyond these boundaries. The use of head dependent boundary conditions at these locations would allow for exchange of water that may occur between the model and its surroundings in response to head changes that occur	Clarify/discuss current FEMWATER groundwater model with Aqualinc. Potentially revise ground water model calibration, depending upon outcome of discussions with Aqualinc.	High	Adopt Aqualinc's FEMWATER groundwater quantity model that addresses the CPW review comments and couple to the proposed Source surface water model via a customised framework to simulate surface water-groundwater interactions more holistically

Variation 1 Planning Provision	Technical aspect	Report name	Review conclusions	Recommended Actions	Degree of importance on model outcomes	Alternatives (described in Section 3)
			within the model domain. • Williamson, 2008 notes that the FEMWATER code is unable to quantify certain aspects of the model water budget. In particular the code does not provide an accurate account of the groundwater extraction nor the changes in groundwater storage. This shortcoming reduces the utility of the model and is illustrated in Figure 7-18 that illustrates that about 5% of the water budget cannot be accounted for. It is assumed that this imbalance is roughly equal to storage changes in the transient calibration model – although this cannot be confirmed. • The report is deficient in that it does not describe the approach to or parameterisation of the unsaturated zone model component, nor is there a clear description of how evapotranspiration is defined or accounted for. • Unfortunately its size, complexity and instability appears to have rendered it of little use for on-going simulation of groundwater flow and water quality (it does not simulate solute transport) responses. It appears that the long run times are related to the application of unsaturated zone modelling and the fact that the calculation time step needs to be exceptionally short (much less than one day) in order to manage numerical instabilities.			
Section 11.7 Environmental Flow and Allocation Regime and Water Quality Targets and Limits Policies:	Groundwater Quantity model	**Technical report to support water quality and water quantity limits setting process in the Selwyn Waihora Catchment. Predicting consequences of future scenarios: Groundwater quantity.** By D Scott (Environment Canterbury) and J Weir	A smaller, simplified model (also developed in the FEMWATER code) has been used for assessing and comparing various predictive scenarios (Scott and Weir, 2014). The reporting of the revised model does not allow an objective assessment of the confidence with which it can replicate actual groundwater behaviour as the report is deficient in its description of the revised model and its calibration. As a result we do not have the same confidence that this version of the model is able to simulate the groundwater responses that arise from changed land use, irrigation water availability and groundwater extraction as assumed by the various scenarios that have been run. Results are presented as a table of water budget components (included	Clarify/discuss current FEMWATER groundwater model calibration with Aqualinc. Potentially revise ground water model calibration, depending upon outcome of discussions with Aqualinc.	High	

Variation 1 Planning Provision	Technical aspect	Report name	Review conclusions	Recommended Actions	Degree of importance on model outcomes	Alternatives (described in Section 3)
11.4; including; 11.4.20, 11.4.21, 11.4.27 & 11.4.30 Rules: 11.5, including; 11.5.32 to 11.5.36		(Aqualinc). Environment Canterbury Report No R14/16. February, 2014.	change in storage terms) and differences in the 90th percentile groundwater levels for different scenarios (groundwater levels that are exceeded for 10% of the model duration). The water budget results are presented in very coarse terms and no attempt has been made to separate out the fluxes associated with individual model features. For example the *"stream"* fluxes have not been disaggregated to present the results for individual rivers and the *"specified head"* fluxes do not distinguish interactions with the lake and estuary from the ocean discharge flux. The results illustrate a 2 to 3% imbalance in the water budget indicating a rather large numerical error in the solutions. If it can be demonstrated that the revised model is well calibrated and can be run with reasonable model run times, then it should be applied in any future modelling scheme. Indeed the existing modelling results may be adequate for such a modelling exercise, without further simulation runs (although a significant amount of additional processing of model results may be required).			
Section 11.7 Environmental Flow and Allocation Regime and Water Quality Targets and Limits Policies: 11.4, including; 11.4.12, 11.4.17, 11.4.22, 11.4.24 to 11.4.26 and	<u>Irrigation Efficiency</u> Nominal efficiency of 80% Section 2.2, bullet point i.	Scott and Weir (2014) report entitled **Technical Report to Support Water Quality and Quantity Limit Setting Process in Selwyn Waihora Catchment. Predicting Consequences of Future Scenarios: Groundwater Quantity**.	It is important to have clarity on the type of efficiency being considered, and this in turn governs the efficiency value assigned – i.e. overall irrigation system efficiency versus irrigation application efficiency. As inferred, the latter is measured at the paddock scale, while system efficiency encompasses the losses in off-farm and on-farm delivery systems. 80% efficiency is more akin to a system efficiency value than an application efficiency value. Recent work by SKM and WaterForce has demonstrated application efficiencies under centre pivots at approximately 98%. Knowledge of all types of losses is required for determining the total water take volume required for irrigation. But efficiency is not required to be incorporated into soil moisture water balance modelling, which is aimed at purely determining the water required to satisfy deficits within predefined soil parameter criteria for effective irrigation. Once this is known, application efficiency can be added to determine the total volume of water required at the irrigator. Following this, we need to account	Clarify what efficiency referred to in this paragraph represents. Possibly update modelling to reflect correct usage of the term efficiency in the context of the modelling.	High	Rainfall-runoff modelling using the Soil Moisture Water Balance Model (developed by SKM) that accounts for irrigation effects on surface water drainage.

Variation 1 Planning Provision	Technical aspect	Report name	Review conclusions	Recommended Actions	Degree of importance on model outcomes	Alternatives (described in Section 3)
11.4.29 Rules: 11.5.7, 11.5.14 and 11.5.15			for system efficiency to determine the total take volume required.			
Section 11.7 Environmental Flow and Allocation Regime and Water Quality Targets and Limits Policies: 11.4, including; 11.4.12, 11.4.17, 11.4.22, 11.4.24 to 11.4.26 and 11.4.29 Rules: 11.5.7, 11.5.14 and 11.5.15	Irrigation Efficiency An irrigation efficiency of 80% is represented by applying an irrigation depth that is in excess of the deficit, estimated as (PAW-W)/0.8 Section 2.2.1	Scott and Weir (2014) report entitled **Technical Report to Support Water Quality and Quantity Limit Setting Process in Selwyn Waihora Catchment. Predicting Consequences of Future Scenarios: Groundwater Quantity**.	This would appear to imply that the irrigation depth (or the water applied to the soil moisture model) is the water required to satisfy the soil moisture deficit multiplied by 1.25 times to account for inefficiency. Given that application efficiency is predominantly governed by losses between the irrigator and the ground surface, this should not be accounted for in a soil moisture water balance model. The model should only account for the water landing on the ground surface. The implication of applying an irrigation depth multiplied by 1.25 times is that sub-soil drainage and leaching would by over predicted.	Clarify exact depth of water applied to the soil surface. Potentially revise leaching predictions to be consistent with correct depths of applied irrigation water.	High	
Section 11.7 Environmental Flow and Allocation	Irrigation Application Depth (PAW-W)/0.8	Scott and Weir (2014) report entitled **Technical Report to Support Water Quality and**	The above row discussed the efficiency aspect of the irrigation depth formula. This comment relates to the application depth *per se*, which would appear to be equal to 50% PAW i.e. each time an irrigation event occurs, the soil moisture status is taken from 50% PAW to 100% PAW or fully satisfied.	Comment on the process for determining irrigation application depth in the model and how	High	Rainfall-runoff modelling using the Soil Moisture Water Balance Model (developed by SKM) that

Variation 1 Planning Provision	Technical aspect	Report name	Review conclusions	Recommended Actions	Degree of importance on model outcomes	Alternatives (described in Section 3)
Regime and Water Quality Targets and Limits Policies: 11.4, including; 11.4.12, 11.4.17, 11.4.22, 11.4.24 to 11.4.26 and 11.4.29 Rules: 11.5.7, 11.5.14 and 11.5.15	Irrigation is triggered when soil moisture deficit reaches 50% of PAW Section 2.2.1	**Quantity Limit Setting Process in Selwyn Waihora Catchment. Predicting Consequences of Future Scenarios: Groundwater Quantity**.	The problem with this is that it does not mimic actual irrigation practice under centre pivots, which is the predominant irrigator type in Canterbury, resulting in larger irrigation application than in practice. The following steps through the logic: • PAW of the three soil types is 60, 100 and 150 mm; • Application depths (D) of 30, 50 and 75 mm (or 38, 63 and 94 mm if efficiency was included) given D=50%PAW. • Typical centre pivots with radius of 300-650 m have return periods of typically 1.5-3 days (depending on pivot size). • Typical pivot system capacities in Canterbury are 5 mm/day, which means an application depth of 7.5 to 15 mm. In practice application depths are 7.5 to 15 mm (or thereabouts) whereas Scott and Weir (2014) would appear to implement 38 to 94 mm. The implication of this is likely to be a significant over prediction of sub-soil drainage and hence groundwater recharge.	interception and sub-soil drainage is handled in the model.		accounts for irrigation effects on surface water drainage
	<u>Evaporation</u> Section 2.2.1	Scott and Weir (2014) report entitled **Technical Report to Support Water Quality and Quantity Limit Setting Process in Selwyn Waihora Catchment. Predicting Consequences of Future Scenarios: Groundwater Quantity**.	The relationship between actual evapotranspiration (AET) and potential evapotranspiration (PET) is described by the following equation: $$\frac{AET}{PET} = \frac{1 - \exp\left(-A * \frac{W}{PAW}\right)}{1 - 2 * \exp(-A) + \exp\left(-A * \frac{W}{PAW}\right)}$$ The report indicates that this produces the following relationship.	Provide calibration charts of measured versus modelled soil moisture level. Also, please provide a description of how sub-soil drainage is handled in the model and interception losses.	High	Rainfall-runoff modelling using the Soil Moisture Water Balance Model (developed by SKM) that accounts for irrigation effects on surface water drainage

Variation 1 Planning Provision	Technical aspect	Report name	Review conclusions	Recommended Actions	Degree of importance on model outcomes	Alternatives (described in Section 3)
			 There is concern that actual evaporation is being over predicted as soil moisture deficits develop. The implication of this is faster development of soil moisture deficit than would occur in practice, which in turn means more water is required for irrigation to satisfy these deficits.			
Section 11.7 Environmental Flow and Allocation Regime and Water Quality Targets and Limits Policies: 11.4; including; 11.4.20, 11.4.21, 11.4.27 & 11.4.30	Surface Water Quantity model	Clark, D (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 Regional Council, Report No: R14/8, Jan 2014.	The author acknowledges the model uncertainty resulting from integration of multiple models simulating different aspects of the catchment hydrology and water quality. *"Due to the large-scale nature of the modelling there is more certainly regarding the total water balance and changes between scenarios than for individual stream flows…Simulating individual streams on a daily time step for different scenarios provides a way of showing how the scenarios affect the flow regimes of these but the simulations should only be compared between scenarios and not to daily field observations. (Section 2, pg 6).* The overall modelling approach assumes that contributions from overland flow and direct surface runoff are minimal. This is neither substantiated, nor explained and seems unlikely to be the case. The generalised regression relationships of surface (or quick) flows as inputs to the groundwater model provides less flexibility in accounting for changes occurring in the upper Selwyn and hill country, particularly for representation of the interbasin transfers from the Rakaia and Waimakariri Rivers to the	Consider alternative of rainfall-runoff modelling of catchment inflows to derive inputs for recharge to the groundwater model and event flows and loads to Te Waihora	High	An alternative approach to addressing some model uncertainty in deriving inputs to the groundwater and lake models is to use a single model to represent surface water quantity and quality that can be associated with spatial land use and climate data.

Variation 1 Planning Provision	Technical aspect	Report name	Review conclusions	Recommended Actions	Degree of importance on model outcomes	Alternatives (described in Section 3)
Rules: 11.5, including; 11.5.32 to 11.5.36			Selwyn River water supply scheme and corresponding land use changes directly related to increased water allocation in the command area. Such a scheme would most likely appreciably modify the surface water flow component, of both flow and water quality. The proposed model encompasses the main tributary inflows to Te Waihora and the corresponding groundwater extent. Limited representation of the upper catchment restricts the ability to determine changes to reliability for downstream consented users.			
Section 11.7 Environmental Flow and Allocation Regime and Water Quality Targets and Limits	Surface Water Quantity	Kelly, D., 2014 **Technical report to support water quality and water quantity limit setting process in Selwyn Waihora catchment. Predicting consequences of future scenarios: Surface water quality.** Environment Canterbury Report R14/13	The report analyses the concentrations of the key water quality constituents in the lowland streams that empty into Te Waihora. The report also provides some semi-quantitative projections of future water quality outcomes for the same constituents for each of the scenarios. An analysis was performed of recorded monitoring data over a 5 year period (July 2006 to September 2011), with data available at most sites on a monthly basis (quarterly for two sites). For the current scenario, the comparisons to the recommended guidelines for Nitrate-Nitrogen concentrations from Hickey and Martin (2009) and Hickey (2013) are sound. For the current scenario, the analysis of compliance with Natural Resources Regional Plan (NRRP) objectives for macrophyte and filamentous algae cover is reasonably sound. There are limitations (appropriately recognised by the author) with estimating the percentage cover for macrophyte and filamentous algae using nutrients as the only explanatory factor, since it is acknowledged that cover may be influenced by either Disolved Inorganic Nitrogen (DIN) or Dissolved Reactive Phosphorus (DRP) concentrations or other factors, such as stream shading, availability of fine sediments and turbidity.	None	Low	None
Section 11.7 Environmental Flow and Allocation	Surface Water Quantity	Kelly, D., 2014 **Technical report to support water quality and water quantity limit**	There are several limitations associated with the projections made for the future scenarios. The future scenarios appear to make relatively arbitrary assumptions about the likely DRP concentrations under each scenario, with no explicit attempt to	Test sensitivity of projected chlorophyll a concentrations under future scenarios to assumed	High	daily simulation of flow and constituent concentrations from surface water and ground

Variation 1 Planning Provision	Technical aspect	Report name	Review conclusions	Recommended Actions	Degree of importance on model outcomes	Alternatives (described in Section 3)
Regime and Water Quality Targets and Limits		**setting process in Selwyn Waihora catchment. Predicting consequences of future scenarios: Surface water quality.** Environment Canterbury Report R14/13	model projected changes in DRP. The approach taken to projection of future DRP is inconsistent with the more sophisticated projections made for DIN under each of the future scenarios. The relative sensitivity of the chlorophyll a biomass to assumptions made about change in mean DRP concentrations for each scenario is unclear. The projections of future 95th percentile DIN concentration make an overly simplistic assumption for the scenarios that the ratio of the 95th percentile to mean concentration (let's refer to this as R95 in this document) of DIN from the monitored data for current (2006-2011 data set) will remain the same for the future modelled scenarios. As shown in Appendix 2, there is considerable variability in R95: between a factor of 1.14 in the Halswell River up to a factor of 3.61 in the Irwell River. R95 is likely to represent a combination of uncertainty in analysis of individual DIN samples, variability in the DIN concentration in the components of flow contributed at each site from surface and groundwater flow pathways at the time of each sample and variability in each stream in the relative proportions of the total flow contributed from surface and groundwater at the time of each sample. The streams with higher R95 values may be indicative of dominance of the last factor (i.e. relatively high contributions of surface water during some periods leading to strong dilution of DIN in some periods and other periods of low surface water contribution with low dilution of DIN) and the streams with lower DIN may be indicative of relatively low surface water contribution (i.e. consistent concentrations from ground water with relatively little surface water dilution). However, there is no analysis presented in the report to enable these influence factors to be deduced. Without this analysis, it cannot be supported that the R95 would remain the same under the projected scenarios. Different scenarios will have different effects on surface and ground water flow and nutrient concentrations (from surface and ground water contributions) at each site, which in turn will affect the R95 value for DIN at each site. This undermines the projections of DIN concentrations and hence projections of chlorophyll a biomass for all of the future scenarios.	future concentrations of DRP. Consider conducting additional analysis, similar to that conducted by Biggs (2000) to establish predictive relationships for chlorophyll a from streams that are more similar to those in the Selwyn Waihora. Provide justification for approach used to estimate 95th percentile DIN under the scenarios (or revise using more explicit modelling of the distribution of DIN concentrations at each site given the projected changes in surface and ground water flows and concentrations).		water flow systems

Variation 1 Planning Provision	Technical aspect	Report name	Review conclusions	Recommended Actions	Degree of importance on model outcomes	Alternatives (described in Section 3)
			As acknowledged by the author, the relationships produced by Biggs (2000), which were adopted to predict chorophyll a, were derived from hill-fed gravel bed rivers that were very different from the spring fed systems. The nutrient concentrations recorded in Selwyn Waihora are much higher than those used to develop the regression relationships in Biggs (2000), which limits the predictive capability for chorlophyll a.			
Section 11.7.3 Water Quality limits and targets	Estimation of probability of water extracted for drinking water supply exceeding maximum acceptable values (MAV)	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 Regional Council, Report No. R14/11	The empirical model adopted uses the probability of exceedance of MAV at bores within each zone and then attempts to fit an exponential model with the mean annual Nitrate load in the zone as a predictor variable. There are some real conceptual problems with this. The form of equation used means that there will be a mean annual Nitrate load at which the probability of exceedance of MAV exceeds 1, which is impossible. The form of equation also means that there is a non-zero probability of exceedance of MAV, even if the mean annual Nitrate load were to approach zero, which again is illogical. The direct estimation of the probability of exceeding MAV from just adopting the probability in the sample data, from relatively small (and potentially biased) sample sets is also questionable. With reference to the Modelling Strategy outlines in Section 2.3 (pg. 10), list item 3: Evaluate the risk to drinking-water supplies that tap the shallow groundwater, using empirical relationships developed from existing monitoring data.	Completely revise the approach used to estimate the probability of exceedance of the MAV	High – if exceedance of MAV is a critical decision making criteria, otherwise Moderate.	Completely revise the empirical equation used to estimate the decision making criteria. A preferable alternative approach would have been to fit a theoretical probability distribution to the data in each zone. A regionalised fitting procedure then could have been adopted with the mean annual Nitrate load as an explanatory variable. This should produce a much more robust and defensible outcome than the method that was adopted , which would be regarded as highly questionable.
Section 11.7 Environmental Flow and	Groundwater Quality	Hanson, C. (2014) **Technical report to support water quality**	The recent attempt by Hanson to simplify and integrate surface nitrate production with groundwater models ultimately oversimplifies the treatment of nitrogen on the plains and ultimately comes up with results that cannot be	Further explain and justify approach adopted. Consider complete revision	High	**Nutrient concentration in recharge** The Source model will

Variation 1 Planning Provision	Technical aspect	Report name	Review conclusions	Recommended Actions	Degree of importance on model outcomes	Alternatives (described in Section 3)
Allocation Regime and Water Quality Targets and Limits Policies: 11.4, including; 11.4.1, 11.4.6 to 11.4.11, 11.4.14 and 11.4.17 Rules: 11.5, including; 11.5.16, 11.5.17 and 11.5.18 to 11.5.29		**and water quantity limit setting process in Selwyn Waihora catchment. Predicting consequences of future scenarios. Groundwater quality**. Environment Canterbury Regional Council, Report No. R14/11 Di & Cameron (2004) **Integrated modelling of Land Use Impacts on Groundwater Quality on a Regional Scale**	verified and may not be accurate. This latest round of nitrate modelling seems to be a simplification on previous models and is based on empirical relationships, not analytical assessment, thereby of less use than the earlier models. The model is also based on a simplified version of the groundwater model, which does not appear to account for the (probably substantial) impacts from river recharge across the plains, in addition to the river recharge in the hills that supplies the deeper aquifer. • Recharge is a critical factor in the calculations and has been lumped for modelling. This is inappropriate and will generate biased results. Earlier models may have been too complex; later models are now too simple. • There should be sufficient information to provide a better spatial determination of nitrate movement, including an incorporation of nitrification and denitrification based on groundwater chemistry and inputs from the local river recharge. This is not considered. Areas outside the priority catchments have been included in the analyses. Results from these extraneous catchments are used to define empirical relationships across the entire region, though they do not appear to have a direct correlation with the results from the Selwyn-Waimakariri area. This provides misleading results. • It is unclear whether evaporation has been included in the model or if the effects of natural concentration of nitrate in the region have been considered. Natural nitrogen processes will be important limiting factors for nitrate generation. • There is an emphasis on results from the ends of the catchment (plains); from data collected near the lake and estuaries. This provides an incomplete and inaccurate picture of nitrogen dynamics. Surface water-groundwater interactions along the major rivers will be important and need to be incorporated. • The statistics used is naïve, superficial and sometimes misleading. Best-	of method of modelling groundwater quality.		include a concentration for each constituent associated with baseflow recharge as input to the groundwater modelling components. The nutrient concentrations in the baseflow represent the concentration that is generated off of the catchment based on land use and soil type that drains below the root zone. **Nutrient transport and attenuation in groundwater** Develop a groundwater flow pathways (GFP) network in Source based on spatial locations of upwelling locations (ie, spring fed streams) as configured in the FEMWATER model with groundwater quantity driving the transport and dilution of nutrients within the GFP network. Solute

Variation 1 Planning Provision	Technical aspect	Report name	Review conclusions	Recommended Actions	Degree of importance on model outcomes	Alternatives (described in Section 3)

			fit trend lines from disparate data give incorrect relationships.
			
			The early report (Di and Cameron, 2004) provides a comprehensive attempt to generate nitrate leaching equations and comparisons across multiple land use zones and under changing recharge and land use to predict nitrate levels at depth within the regional groundwater aquifers. The methodology attempted to integrate the effects of surface-groundwater mixing and model defined land use changes with time. This was largely an analytical solution applied to spatially-defined zones across the plain with a very simplified groundwater model beneath that underlay the entire region as 2 layers. The zonation accounted for variability in the groundwater systems, whilst not varying the physical parameters of those systems.
			• The model calculates nitrate concentration at depth, but does not account for variability in aquifer thickness; hence reported concentration profiles extend seamlessly across the two aquifers and hence temporal changes in nitrate with depth plot as straight lines under differing scenarios. The limitations were outlined in a section on future research. Hence:
			  • Irrigation conditions are also an average and do not consider variability in application type or management, or the impacts of flooding on results.
			  • Surface-groundwater mixing is simplified and not spatially constrained. Indeed, the amount of mixing is poorly defined.
			
			Essentially, a lot of detailed analysis of land use and zonation is distilled to a limited number of zones and parameters regarding land use are also distilled to simple arguments for analytical consideration. Provision of these parameters is possible in the surficial model used to generate the average conditions (model = NLE), but oversimplification has been applied to facilitate incorporation into a groundwater construct that is also too simplified and does not consider:
						routing can then be implemented within these pathways calibrated to groundwater travel times.
						Groundwater nutrient concentrations derived based on measured concentrations from bore data and concentration in baseflow.

Variation 1 Planning Provision	Technical aspect	Report name	Review conclusions	Recommended Actions	Degree of importance on model outcomes	Alternatives (described in Section 3)
			• The actual thickness and changing conditions with depth of the groundwater systems; • Multiple recharge sources and variable groundwater conditions across the plains, and • The consequence of de-nitrification and other nitrogen cycle processes that would operate in the region.			
Section 11.7.3 Water Quality limits and targets	Groundwater Quality	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 Regional Council, Report No. R14/11	With reference to the Modelling Strategy outlines in Section 2.3 (pg. 10), list item 2: Set that concentration equal to the nitrate concentration in the shallow groundwater. No calibration data was shown in the report to demonstrate that the Lilburne method was accurately achieving the average groundwater concentration for the existing case. (with possible correction or explanation related to lag).	Provide more explicit calibration and reporting	Moderate	
Section 11.7.3 Water Quality limits and targets Policies: 11.4, including; 11.4.1, 11.4.6 to 11.4.11, 11.4.14 and 11.4.17	Groundwater Quality	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**.	With reference to the Modelling Strategy outlines in Section 2.3 (pg. 10), list item 4: Multiply the nitrate concentration in the land surface recharge by attenuation factors derived from existing monitoring data to estimate long-term average DIN and TN concentrations in the nine monitored streams that flow into Te Waihora/Lake Ellesmere. There is repeated use of the term "attenuation". The attenuation factor relates to the existing average relationship, which could change under future irrigation and abstraction. To model the solutions packages attenuation factors were multiplied by an additional factor equal to the ratio of the land surface recharge rate to the total predicted flow in the streams.	Modify wording in report	High	**Nutrient attenuation** Changes in in-stream nutrient concentrations due to factors such as denitrification, uptake by algae or particulate flocculation will be represented as a decay function with a reach in the Source surface water

Variation 1 Planning Provision	Technical aspect	Report name	Review conclusions	Recommended Actions	Degree of importance on model outcomes	Alternatives (described in Section 3)
Rules: 11.5, including; 11.5.16, 11.5.17 and 11.5.18 to 11.5.29		Environment Canterbury Regional Council, Report No. R14/11	*For example, Scenario 2 includes increased irrigation inputs from surface water sources, which will cause increased land surface recharge. This would tend to increase the amount of land surface recharge in the spring-fed streams. As a result, the model would underestimate the nitrogen concentrations in the streams. At the same time, the scenario would have decreased groundwater abstraction, which could result in increased inputs of river recharge to the spring-fed streams. This would make the model overestimate nitrogen concentrations in the streams. It is not possible how to predict how these two competing effects would balance, so this must be regarded as a source of uncertainty in the model. (section 4.1.3 Hanson 2014)* The attenuation factor represents a range of things, including proportion of land surface recharge and river recharge, denitrification, attenuation. In general, this has been used where the term "dilution" would be correct. (Section 2.5.2 Hanson 2014).			model and calibrated to observed concentrations at various water quality monitoring sites within the catchment. A decay function will better approximate variability in nutrient losses based on observed temporal changes in nutrient concentrations within a reach.
Section 11.7.3 Water Quality Limits and Targets Policies: 11.4, including; 11.4.1, 11.4.6 to 11.4.11, 11.4.14 and 11.4.17 Rules: 11.5, including; 11.5.16, 11.5.17	Groundwater Quality	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 Regional Council, Report No. R14/11	With reference to the Modelling Strategy outlines in Section 2.3 (pg. 10), list item 5: Estimate the nitrogen load to Te Waihora/Lake Ellesmere using the long-term average TN concentrations and predicted stream flows. *TN concentrations (Table 2-4) were calculated as flow-weighted averages, using the monthly or quarterly TN measurements recorded in Environment Canterbury's water quality database and daily flow data from unpublished Environment Canterbury records. Each daily flow rate was multiplied by the TN concentration from the most recent stream sample. The sum of the daily products calculated over the five-year period was then divided by the total flow volume for the same period to derive the flow-weighted average TN concentration" (Hanson 2014)*	Improve resolution with a daily model.	High	Improved simulation of nutrient concentrations and loads by using a daily surface water catchment-scale model. **Nutrient generation from the land** Derived based on EMCDWC (Event mean Concentration Dry Weather Concentration) models, which improves the simulation of event driven (e.g. storms) and dry weather (baseflow)

Variation 1 Planning Provision	Technical aspect	Report name	Review conclusions	Recommended Actions	Degree of importance on model outcomes	Alternatives (described in Section 3)
and 11.5.18 to 11.5.29						concentrations generated as a result of a variable/ managed flow regime.
Section 11.6 Freshwater Outcomes Policies: 11.4, including; 11.4.1, 11.4.6 to 11.4.11, 11.4.14 and 11.4.17 Rules: 11.5, including; 11.5.16, 11.5.17 and 11.5.18 to 11.5.29	Water Quality limits	Robson M (2014) **Technical report to support water quality and quantity limit setting in Selwyn Waihora catchment Predicting consequences of future scenarios: Overview Report**.	The Freshwater outcomes are summarised in tables 11a and 11b of Variation 1. The variation 1 outcomes relate to a series of priority outcomes for the catchment developed by the Zone Committee, which are broader than the numeric outcomes in the variation. These are summarised in Table 1 of the Selwyn-Waihora limit setting: Overview report. (Robson 2014). The water quality water limits and targets are set out in tables 11i,11j 11k, 11l, and 11m. These limits reflect modelled outcomes for a future landuse and mitigation scenario - Option 7: Zone Committee Solution Package. (Described in Appendix 5 Section 32 report) The catchment load of nitrogen in tonnes from farming is modelled in the current situation as 4529 tonnes/year, under Variation 1 this could increase to 4830 tonnes/yr. The Option 7 modelled scenario, allowed for future intensification in CPW and some other areas, reductions in nitrogen load for existing users and mitigation measures. An assessment described in Selwyn Waihora limit setting: Overview report, estimates how likely the Zone Committees priority outcomes are to be achieved. This assessment takes into account more than water chemistry. For example, the outcome of “Healthy Lowland Streams” and “Te Waihora is a Healthy Ecosystem” is assessed as “probably” being achieved under Option 7 - Zone Committee Solution package. The proposed physical mitigation in this scenario are likely to result in improved habitat in these locations, however, the proposed nitrate toxicity limits in the spring fed plains streams of 6.9 and 9.8 NO3-N mg/l (table 11k Variation 1), relate to a 80% ecosystem protection for “highly disturbed systems “. At Te Waihora, the proposed TLI of 6.6 (table 11b Variation 1) in the mid lake is an improvement on the current average of 6.8, (Norton et al 2012) but this TLI score is still hypertrophic.		Moderate	

Variation 1 Planning Provision	Technical aspect	Report name	Review conclusions	Recommended Actions	Degree of importance on model outcomes	Alternatives (described in Section 3)
Section 11.7.3 Water Quality Limits and Targets Policies: 11.4, including; 11.4.6 to 11.4.17 Rules: 11.5, including; 11.5.6 to 11.5.13, 11.5.15 to 11.5.17, 11.5.22 and 11.5.25	Catchment nitrogen modelling	Lilburne, L., Webb, T., Ford, R., Bidwell, V., (2013), **Estimating nitrate-nitrogen leaching rates under rural land uses in Canterbury (updated). R10/127, Environment Canterbury**.	With reference to the Modelling Strategy outlines in Section 2.3 (pg. 10), list item 1: Determine the catchment-wide, long-term average nitrate nitrogen concentration in the land surface recharge for the land use scenario. Lilburne, et al. (2013) took the results of Di & Cameron (2004), updated them and integrated the results into a GIS construct to provide long-term nitrate leaching rates for land uses under changing climate and land use conditions. This represents a substantial improvement over the early model and incorporated nitrogen cycle processes as part of the leaching estimations. This was achieved through the use of the SPASMO model and generated a series of look-up tables for nitrate leaching under different soil types, land use and rainfall regimes. This provides an ideal precursor to incorporation into a groundwater model, though this report focussed solely on accurately representing leaching across the plain. Caveats included: • The results should be seen as broad-scale, indicative values and not be used at paddock scale or for policy decisions; • Results do not consider changes/improvements to management practices; • Lack of good long-term measured leaching data; • Some soil/climate/land use conditions could not be modelled; • Different results from different models designed to carry out the same function, and • Lack of drainage values for some soil types. Nevertheless, the approach is a good approximation and appropriate for incorporation into a groundwater model.	Consideration on whether it would be useful to better spatially represent some of the mitigation measures. It is unlikely that we would have any better information on the expected performance of measures.	High	Adoption of the nitrate leaching rates developed by Lilburne et al (2013), and additional data where it is available, to derive parameter sets for nutrient generation models in Source
Section 11.7 Environmental Flow and Allocation Regime and	Te Waihora/ Lake Ellesmere physical, chemical and	**Technical Report to support water quality and water quantity limit setting processes in Selwyn Waihora**	The report outlines multiple lines of evidence to assess the consequences of a range of future land-use intensification and mitigation scenarios on the physical, chemical and biological state of Te Waihora/Lake Ellesmere. A modelling approach was adopted, supported by site-specific data and experimental studies, information from literature, national guideline		Medium	Inflows to the Te Waihora model could be improved to some degree by deriving inflows based on daily rainfall-runoff

Variation 1 Planning Provision	Technical aspect	Report name	Review conclusions	Recommended Actions	Degree of importance on model outcomes	Alternatives (described in Section 3)
Water Quality Targets and Limits	biological investigations	**Catchment. Predicting consequences of future scenarios: Te Waihora/Lake Ellesmere.** By Ned Norton (NIWA), Mathew Allan (University of Waikato), David Hamilton University of Waikato), Graeme Horrell (NIWA), Donna Sutherland (NIWA), Adrian Meredith (Environment Canterbury); Incorporates comments from Marc Schallenberg (University of Otago). Report No. R14/14, Jan 2014.	documents, and expert consensus interpretation. The authors have used a coupled hydrodynamic-ecological model (DYRESM-CAEDYM) to undertake the scenario modelling of Te Waihora/Lake Ellesmere. DYRESM-CAEDYM is a well-established, international peer reviewed and widely applied modelling framework, and well suited to modelling the physical, chemical and biological state of Te Waihora/Lake Ellesmere with respect to assessing relative changes in nutrient loading and trophic changes in water quality. Limitations and uncertainties within the model are satisfactorily documented within the report and where possible appropriate measures suggested addressing these limitations in the future (i.e., undertaking additional research or monitoring/data collection campaigns to bridge knowledge gaps). An external peer review of the report has been conducted by Dr Marc Schallenberg (University of Otago). Dr Schallenberg review was comprehensive and the authors have satisfactorily addressed the review comments. It was noted that inflows to the Lake model was derived using linear interpolation between monthly samples for flow and concentrations. The authors acknowledge that “Interpolation between measurements has the potential to lead to some inaccuracies in estimated flow, nutrient concentrations and mass fluxes” and may underestimate large storm events that deliver large loads of nutrients and sediments to the Lake.			modelling using spatially distributed rainfall and evaporation data. This would capture the loading to the lake during large flow events. The proposed catchment modelling described in Section 3 may change the volume of inflows to the lake in which case the Te Waihora model may need to be rerun to determine the impact of a change in inflows and nutrient loads to the lake.

3. Overview of proposed alternative modelling approach to address issues identified in ECan model review

It is clear that the surface water catchment behaviour has been represented simplistically within the current ECan modelling framework and has a number of limitations. Focus of the water quantity modelling has been on the lower Canterbury Plains catchment area that is groundwater dominant and directly influences inflows and nutrient loads to Te Waihora. With the advent of the Central Plains Water (CPW) Community Irrigation Scheme enabling a migration of groundwater abstractors to consents for surface water supply in the upper Canterbury Plains, representation of surface water and unsaturated zone flow pathways across the whole catchment and their connectivity with groundwater flow pathways, will be essential for modelling a variety of current and future scenario to enable policy and planning rules to be captured and tested.

This report proposes a methodology that provides CPW with a comprehensive modelling framework that accounts for surface water quantity and quality attributes of the whole Selwyn Waihora catchment including the hills country, Community Irrigation Scheme command area and the lower Canterbury Plains (including the Little Rakaia and Kaituna catchments) to the banks of the Te Waihora. Daily rainfall-runoff modelling calibrated to spatially distributed historical climate will improve the representation of the variability in nutrient generation (or leaching) from different farming enterprises and non-agricultural land uses within different parts of the catchment. Nutrient transport and attenuation within reaches can be directly related to observed in-stream nutrient concentrations. Where the ECan modelling presented a number of different models to simulate these processes, our approach integrates these components into a single model to represent spatial surface water hydrology and water quality and derive inputs for the more detailed groundwater modelling.

To complete the framework, the surface water model of the Selwyn Waihora catchment will be coupled to the groundwater model developed by Aqualinc to enable surface water-groundwater interactions to be represented and retain the detailed modelling completed to date of the groundwater system. A customised framework will be built that links, at each time step, the baseflow from Source as recharge inputs to the groundwater model and discharges groundwater back into the Source model at points in the stream network that drain to Te Waihora or discharge directly to the ocean.

Our methodology, illustrated in Figure 2, includes the following processes:

- Catchment rainfall-runoff generation using Soil Moisture Water Balance Model (SMWBM) calibrated to spatially distributed, historical climate conditions for different landuses and soil types,
- Irrigation demand represented within SMWBM and related to abstraction types (ie, Surface water direct takes, stream depletors, potable) where allocation and minimum flow limits can be defined within a water user node model
- Nutrients represented in the Source model will include Total Nitrogen (TN), Nitrate (NO_3), Nitrite (NO_2) and Nitrate and Nitrite Nitrogen (NNN). Nutrient generation from land will be based on leaching rates from Lilburne et al, (2013), and potentially other data sources if they are available, and derived for baseflow conditions and event (quick) flow conditions
- Attenuation of nutrients through waterways using in-stream decay models
- A groundwater flow pathways (GFP) network in Source that connects to the stream network based on spatial locations of upwelling locations (ie, spring fed streams) as configured in the FEMWATER model with groundwater quantity driving the transport and dilution of nutrients within the GFP network. Solute routing can then be implemented within these pathways calibrated to groundwater travel times. Groundwater nutrient concentrations derived based on measured concentrations from bore data and concentration in baseflow.
- Linking of Source with FEWMATER as the adopted groundwater model

A daily time step model is proposed to capture changes in the flow regime and short term nutrient fluctuations as a result of storm events, the Community Irrigation Scheme and Variation 1 change to the Land and Water Regional Plan (LWRP).

To simulate the surface water flow and unsaturated zone components of the model, we are proposing that the model be constructed in eWater's Source[1] modelling platform. The eWater Source platform has been developed by eWater in Australia, which was a partnership of 45 of Australia's leading State Government water management agencies, water authorities, Universities, research institutes and consulting firms (including SKM). The eWater Source platform has strong core functionality in hydrology, pollutant generation and water management, such as regulated river systems. Source has been written in such a manner that it can easily be customised to a particular problem, such as this one, via the use of plugins. SKM have considerable previous experience in writing code for eWater Source plugins and applying those plugins to models for several catchments.

The proposed modelling approach will address the critical limitations highlighted by the review panel in Section 2 and provide CPW with a rigorous, fit-for-purpose modelling framework from which policy changes resulting from Variation 1 can be tested and alternative options put forward to ECan. In addition, the modelling framework will have longevity beyond the life of the current project and can be used to facilitate future catchment planning activities within the Selwyn Waihora catchment.

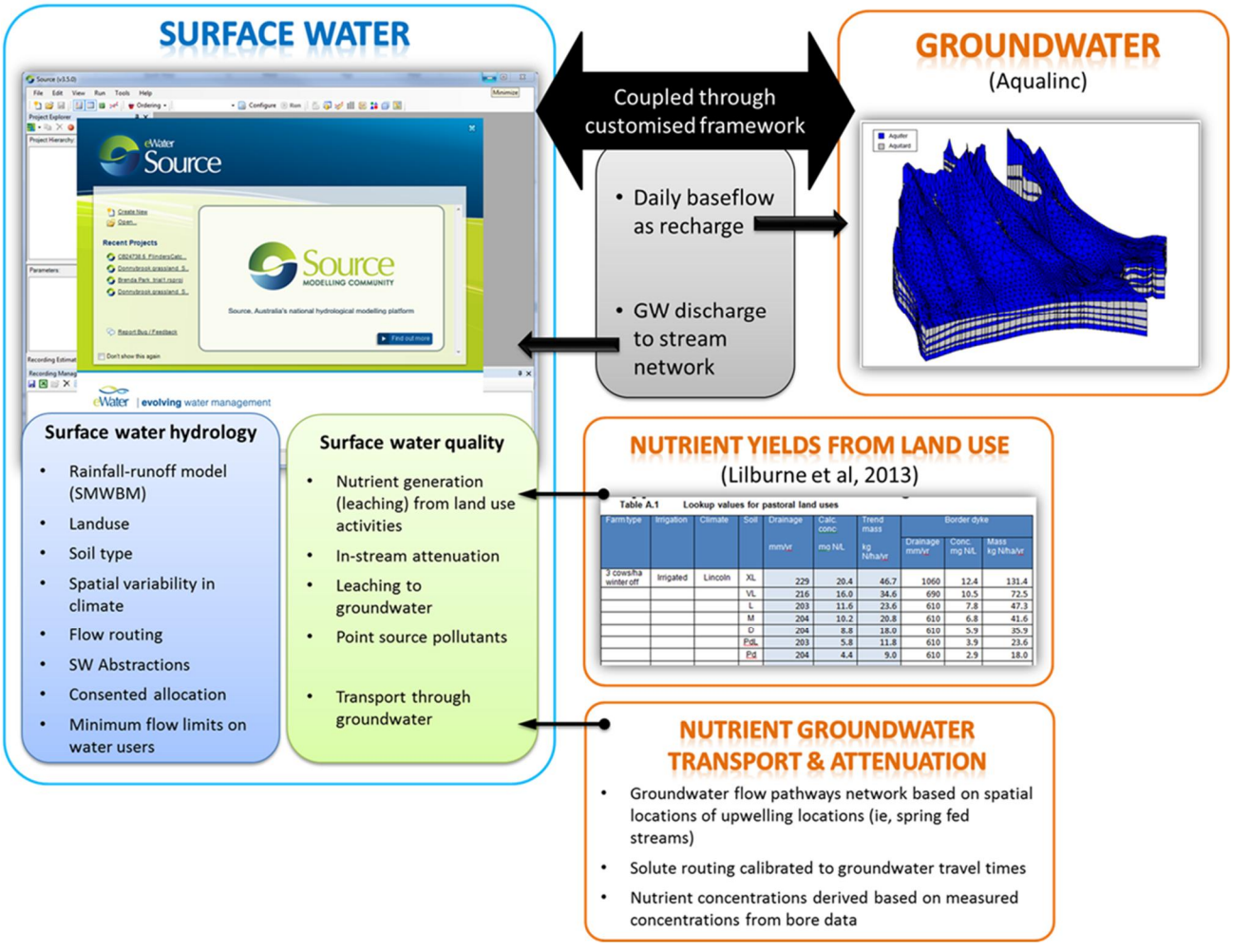


Figure 2: Proposed model structure outlining a more detailed surface water hydrology and water quality modelling framework utilising information from Lilburne et al (2013) for nutrient generation and coupled to the groundwater model developed by Aqualinc

[1] Welsh WD, Vaze J, Dutta D, Rassam D, Rahman JM, Jolly ID, Wallbrink P, Podger GM, Bethune M, Hardy M, Teng J, Lerat J. (2012). An integrated modelling framework for regulated river systems. *Environmental Modelling and Software*, 39, 81-102.

Appendix A. Review Panel CVs

Brian Barnett

GROUNDWATER MODELLER

CURRENT POSITION

Groundwater Modelling Practice Leader

QUALIFICATIONS

BE (Civil)

EXPERTISE

- Groundwater Modelling
- Hydrogeology
- Geothermal Reservoir Engineering
- Geothermal Reservoir Modelling

Summary of competencies

Brian Barnett is SKM's Practice Leader in groundwater modelling. He has more than thirty years of experience in the groundwater and geothermal consulting industries and has specialised in numerical groundwater modelling since joining Kingston Morrison (merged with SKM in 1999) in 1998.

Projects of National Significance

Australian Groundwater Modelling Guidelines

Client: National Water Commission.

Role: Project manager, co-editor and principal contributor to the Australian Groundwater Modelling Guidelines

Key achievements

- This document has been widely adopted throughout Australia as the benchmark for best industry practice for groundwater modelling in Australia. The Guidelines were published by the National Water Commission in June 2012.

Murray Darling Basin Sustainable Yields Project

Client: CSIRO

Role: Groundwater modelling team for major project covering groundwater resources in Queensland, New South Wales, Victoria and South Australia.

Key achievements

- SKM was contracted by CSIRO in 2007 to undertake the groundwater resource assessment for the entire Murray Darling Basin. The project involved the numerical modelling of all major fresh water aquifers in the basin. Twelve finite difference numerical models were run for the study. Results were used to quantify the available groundwater resources of the basin and to assess the impacts of future climate change and impacts of groundwater development on river flows.

PROJECT | Hobart Railyards Contaminated Site Assessment and Contaminant Transport Model

Client: Solute Transport

Role: Groundwater modeller

Key achievements

- A detailed groundwater flow and contaminant transport model of the Hobart railyards was developed to investigate the migration of dissolved petroleum hydrocarbons from the site towards the Derwent River. Specific models were developed for benzene, naphthalene and benzo(a)pyrene and incorporated advection, dispersion, decay and adsorption processes. Models were calibrated against observed groundwater levels and against the historic growth and migration of hydrocarbons at the site.

Gibbs Burge Contaminant Transport Model.

Client: Australian National Railway

Role: Site Assessment

Brian Barnett

GROUNDWATER MODELLER

Key achievements

- A large MODFLOW 2000 and RT3D reactive transport model were developed and calibrated to assess the likely off-site migration of chlorinated solvents from a former dry cleaning factory site in Richmond, Victoria. The models incorporated advection, dispersion, decay and chemical reactions from PCE through to vinyl chloride. Calibration of the reactive transport model involved matching model-predicted growth of PCE, TCE, DCE and VC plumes against the observed contaminant plumes emanating from the site.
- This work was undertaken as part of the SKM site assessment team. This site was subject to an environmental audit by an independent auditor.

Alva Beach Prawn Farm - Solute Transport Models

Client: Pacific Reef Fisheries

Role: Groundwater modeller

Key achievements

- Groundwater flow and solute transport models were developed for a prawn farm site in Alva Beach North Queensland. Models were used to assess the accumulation, mixing and migration of contaminants in groundwater originating from the prawn farm. The modelling was undertaken in the Finite Element, FEFLOW modelling code and incorporated density dependent groundwater movement in a coastal environment.

Darling Downs Contaminant Transport

Client: Brisbane City Council

Role: Groundwater modeller

Key achievements

- A three dimensional groundwater flow and solute transport model in the Upper Condamine Groundwater Management Unit was developed. The model was used to assess the accumulation of dissolved salts and nutrients under land irrigated by treated effluent. The model was developed in MODFLOW96 with MT3D used to assess the movement of dissolved contaminants.

Nepean Peninsula Septic Tank Contamination

Client: Southeast Water

Role: Groundwater modeller

Key achievements

- Groundwater flow and solute transport models were developed for sites on the Nepean Peninsula to assess the fate of septic tanks effluent once it enters the shallow groundwater system. Models helped to determine likely travel times between entry to the aquifer and extraction from nearby bores. Models were developed in MODFLOW2000 and MT3D and incorporated advection, dispersion, pathogen adsorption and die-off.

Fire Training Facility, Newcastle Airport

Client: Spotless

Role: Groundwater modeller

Key achievements

- A contaminant transport model in MT3D was developed to assess potential

Brian Barnett

GROUNDWATER MODELLER

movement of contaminants originating from a proposed fire training facility at Newcastle airport. The site is particularly sensitive as it is located on the shallow Tomago Sands Aquifer which is used extensively for municipal water supply purposes.

Various Projects – advice to Victorian EPA Auditors.

- Advised EPA site auditor on various contaminated groundwater sites in which groundwater modelling has been undertaken. These have included:
- the PCE/TCE contamination of groundwater at the Arvin Meritor site in Preston, Victoria,
- TCE contamination of groundwater from former landfill/industrial site at Welland, South Australia,
- TCE, TCFM and DCM contamination of groundwater at the Bunnings, Maidstone site in Victoria.

Various Projects – MAR Projects.

- Various managed aquifer recharge (MAR) groundwater modelling projects in which recycled water (typically treated stormwater) is injected into shallow aquifers and recovered at times when water is in demand. Solute transport groundwater modelling is used to assess the changes in groundwater quality as the MAR scheme is implemented and used. The modelling also provides estimates of the quality of water that is extracted from the aquifer and whether or not there are likely to be future water quality changes in the aquifer and in any groundwater discharge sites near the MAR scheme.

Dr Richard Cresswell

SENIOR HYDROLOGIST

CURRENT POSITION

Senior Hydrologist

QUALIFICATIONS

Bachelor of Science (Honours), Geology, University of Sheffield (1984)

Master of Science, University of Toronto (1987)

Doctor of Philosophy, University of Toronto (1993)

PROFESSIONAL MEMBERSHIPS AND AFFILIATIONS

Hydrogeologists

Member, Australian Water Association

Member, International Association of Hydrological Scientists

Member, American Geophysical Union

Member, International Association of Geochemists

EXPERTISE

- Water resource management (availability, yield, reliability and management)
- Groundwater – surface water interaction
- Novel techniques in water resource assessment
- Groundwater in the Coal and Coal Seam Gas industries
- Salinity dynamics
- Project management

Summary of competencies

Richard is SKM's Practice Leader for Coal Seam Gas-related Groundwater projects and is a Member of the federal Minister's Expert Panel for Large Coal Seam Gas Projects. He also leads significant groundwater impact assessments for the coal industry in NSW. Richard is the lead hydrogeologist in SKM's Sydney office.

Richard has over 25 years research experience across a range of disciplines, including geology, archaeology, meteoritics, geomorphology and biomedicine and has spent the last 15 years dedicated to water resources, specialising in geochemical and isotope applications in groundwater assessment. Richard has authored over 40 science journal articles and 18 scientific book chapters and has been the author / presenter of numerous papers and presentations on salinity, water resources planning, groundwater research and water in the coal and coal seam gas industries, both nationally and internationally.

Recent project experience

Water Resource Assessments

Hydrochemical interpretation on Broken Hill Project data

Client: Geoscience Australia

Role: Project Leader

Key achievements:

- Assessment of hydrofacies and interactions between surface, ground and pore waters in the Menindee Lakes region

Great Artesian Basin Water Resource Assessment

Client: CSIRO/Department of Environment, Water, Heritage and the Arts/National Water Commission

Role: Project Leader

Key achievements:

- Hydro-dynamic re-assessment of the water resources of the GAB, now and predicted to 2070

NWC Coastal GDE and Groundwater Project

Client: NSW Office of Water

Role: Project Manager

Key achievements:

- Preparation of compilation summary report of the various reports submitted as part of the NWC Coastal GDE and Groundwater Project

Northern Australia Sustainable Yields Project

Client: National Water Commission

Role: Project Leader (CSIRO)

Key achievements:

- Assessment of the surface and groundwater resources across 64 river

Dr Richard Cresswell

SENIOR HYDROLOGIST

basins and 18 groundwater provinces of northern Australia.

Murray-Darling Basin Sustainable Yields Project

Client: National Water Commission

Role: Project Scientist (CSIRO)

Key achievements:

- Management of Queensland Murray Darling Basin groundwater assessments

Geochemical Assessment of Seawater intrusion in the Pioneer Valley, Queensland

Client: Queensland Department of Natural Resources and Water

Role: Project Leader (CSIRO)

Key achievements:

- Revised geochemical indicators and triggers to delimit the extent and impact of seawater intrusion and define the marine salinization region for the Pioneer coastal plain.

Hydrogeochemistry of Hodgson Creek

Client: CRC landscape Environments and Mineral Exploration

Role: Project Leader (CSIRO)

Key achievements:

- Integrated surface water-groundwater interaction study in the northern Murray-darling Basin, Queensland.

Angas-Bremer Plains Integrated Water Model

Client: Department of Agriculture Fisheries and Forestry, Australia

Role: Project Leader (CSIRO)

Key achievements:

- Integrated surface water-groundwater-socio-economic model for a premium wine-growing region of South Australia.

Salinity

PROJECT | Salinity Dynamics, Co-operative Research Centre for Landscapes, Environments and Mineral Exploration Program 4

Client: CRC LEME

Role: Project Leader (CSIRO)

Key achievements:

- Quantification of salinisation processes across Australia

South Australia Salinity Mapping and Management Program

Client: Department of Agriculture Fisheries and Forestry, Australia

Role: Project Leader (Bureau of Rural Sciences)

Key achievements:

Dr Richard Cresswell

SENIOR HYDROLOGIST

- Integration of airborne geophysics with hydrogeological and hydrogeochemical studies of water resources across diverse terrains in South Australia

Groundwater Recharge, Mixing and Salinity across the Angas-Bremer Plains, South Australia

Client: Department of Agriculture Fisheries and Forestry, Australia

Role: Project Leader (Bureau of Rural Sciences)

Key achievements:

- Groundwater recharge, mixing and salinity determined through the use of geochemistry, isotopes and geophysics.

Groundwater Flow Systems and Salinity in the Valleys around Jamestown, South Australia

- **Client:** Department of Agriculture Fisheries and Forestry, Australia
- **Role:** Project Leader (Bureau of Rural Sciences)
- Key achievements:
- Groundwater flow patterns, interactions and relation to salinity determined through the use of geochemistry, isotopes and geophysics.

Catchment Characteristics Case Study: Kyeamba Creek, NSW

Client: Murray-Darling Basin Authority

Role: Project Leader (Bureau of Rural Sciences)

Key achievements:

- Groundwater and salinity assessment of a high salt exporting catchment in the Murray-Darling Basin

Coal Seam Gas

Emu Park Brine Injection Trials Geochemical Modelling

Client: Santos GLNG

Role: Practice Leader and geochemical modeller

Key achievements:

- Review of preliminary geochemical modelling of deep injection of CSG-related permeate and modelling of conditioned water injection

NSW Western CMA Phase 1 Bioregional Assessment

Client: NSW Western Catchment Management Authority

Role: Practice Leader

Key achievements:

- Assessment of potential CSG impacts on water assets emphasised cumulative impacts from possible activities outside the CMA; gas pipelines cross the region

Central West CMA Phase 1 Bioregional Assessment

Client: Central West Catchment Management Authority

Role: Practice Leader

Key achievements:

Dr Richard Cresswell

SENIOR HYDROLOGIST

- Assessment of potential CSG impacts on water assets emphasised cumulative impacts from possible activities outside the CMA and future localised impacts in the south-east: coal mines will have greater impact than CSG extraction

Sulfate reducing bacteria associated with groundwater wells

Client: Santos Energy NSW

Role: Practice Leader

Key achievements:

- SRBs are ubiquitous and just require the right (generally anoxic) conditions to proliferate; SRBs and CSG are generally not compatible

Critical literature review of subsidence and coal seam gas activities

Client: Office of Water Science (DSEWPaC)

Role: Practice Leader

Key achievements:

- CSG activities are likely to have negligible subsidence impacts; bridging of competent overlying layers will mitigate against impacts

Impacts of CSG-associated extraction of groundwater water on stacked aquifers

Client: NSW Office of Water

Role: Project Leader

Key achievements:

- Likely impacts of CSG-produced saline water on ‘stacked aquifers’ in NSW; information gaps and options for water use and remediation

Expert Panel on Major Coal Seam Gas Projects

Client: Department of Sustainability, Environment, Water, Population and Communities (DSEWPaC)

Role: Member

Key achievements:

- Providing advice to the Federal Minister on major CSG approvals in Queensland

Characterisation of Coal Seam Gas Associated Water in NSW

Client: NSW Office of Environment and Heritage

Role: Project Scientist

Key achievements:

- Background paper on potential risks from CSG-generated waters

Coal

Review of proposed barrier monitoring bores, Mangoola Mine, NSW

Client: Glencore Coal/Mangoola Coal Operations

Role: Project Leader

Dr Richard Cresswell

SENIOR HYDROLOGIST

Key achievements:

- Review and critique of a bore monitoring requirements for a potential cut-off barrier and staged slot ahead of mining.

Mt Owen Continuing Operations Groundwater Impact Assessment

Client: Umwelt Australia/Xstrata Coal NSW

Role: Project Leader

Key achievements:

- Integration of regional groundwater modelling program for development approval and delivery of environment impact statement to regulatory agencies

Rapid Groundwater Ingress Assessment for Wilpinjong Coal Mine

Client: Peabody Energy Australia

Role: Project Leader

Key achievements:

- Revised assessment of groundwater ingress to the mine and impacts on Wilpinjong Creek; reduced reliance on external water supplies for on-going operations

Mt Owen Groundwater Investigation Program

Client: Xstrata Coal NSW

Role: Project Leader

Key achievements:

- New monitoring network established for baseline and groundwater impact assessment; telemetered, automated data collection

Groundwater Impact Assessment for the RP2 Expansion – Ravensworth East Coal Mine

Client: Umwelt Australia/Xstrata Coal NSW

Role: Project Leader

Key achievements:

- Integrated water management plan and impact statement for on-going development of the Ravensworth East Coal Mine

Groundwater Impact Assessment for Liddell Coal Operations' Environmental Impact Statement and Mt Owen Optimisation Project

Client: Liddell Coal/Xstrata Coal NSW

Role: Project Leader

Key achievements:

- Legacy and potential future impact assessment of a complex coal mining operation in the Upper Hunter region

Transport

PROJECT | Maldon to Dumbarton Rail Link – Planning Approvals Groundwater Assessment

Dr Richard Cresswell

SENIOR HYDROLOGIST

Client: Transport for NSW

Role: Groundwater Lead

Key achievements:

- Groundwater impact assessment for a 35km rail link traversing State Reserves with critical ecosystems and including a 4km tunnel.

Groundwater Impact Assessment for a Major Metropolitan City Tunnel

Client: *confidential*

Role: Hydrogeology Lead

Key achievements:

- Inflow, drawdown and groundwater impact assessment for a constrained tunnel development

Pacific Highway Upgrade – Woolgoolga to Ballina Upgrade

Client: NSW Roads and Maritime Services (RMS)

Role: Practice Leader

Key achievements:

- Groundwater impact assessment for the Woolgoolga to Ballina upgrade Environmental Assessment

Pacific Highway Upgrade – Nambucca Heads to Urunga

Client: NSW Roads and Maritime Services (RMS)

Role: Groundwater specialist

Key achievements:

- Groundwater Strategy for the NH2U upgrade - Detailed Design and Construction

Pacific Highway Upgrade – Warrell Creek to Nambucca Heads

Client: NSW Roads and Maritime Services (RMS)

Role: Groundwater specialist

Key achievements:

- Groundwater impact assessment of alternative routes: Detailed Design stage

Great Western Highway upgrade – Kelso upgrade

Client: NSW Roads and Maritime Services (RMS)

Role: Groundwater specialist

Key achievements:

- Professional services: Groundwater for the NH2U upgrade ` Detailed Design and Construction

Jon Williamson

PRINCIPAL HYDROGEOLOGIST

QUALIFICATIONS

BE (Earth Science) – University of Waikato, NZ.

Master of Science and Technology (Hons 1), University of Waikato, NZ.

Certified RMA Commissioner (Decision Maker) - 2007 to present.

NZ Irrigation Development Manager

PROFESSIONAL MEMBERSHIPS AND AFFILIATIONS

International Association of Hydrogeologists (Australian Chapter)

New Zealand Hydrological Society (Member: Exec Committee 2007 to present)

EXPERTISE

- Hydrogeological (groundwater) and catchment hydrology (surface water) processes.
- Bore design and preparation of drilling tender documentation
- Groundwater flow modelling.
- Water related RMA consent applications.
- Preparation and presentation of expert witness evidence.
- Rainfall-runoff modelling.
- Water management plans
- Water supply planning.
- Dam storage analysis.
- Environmental impact and sustainability assessment

Summary of competencies

Jon has over 18 years' professional experience in natural resource management in both New Zealand and Australia, with specialist skills in all facets of water resource science and engineering. His key areas of expertise include hydrogeological and catchment hydrology processes and modelling, catchment balance and water management studies, hydrogeological engineering and water chemistry analysis. He has extensive experience as a project director, a technical leader, certified RMA commissioner, resource consenting practitioner and as an expert witness.

Recent project experience

PROJECT | Pauanui-Tairua Water Supply Strategy

Client: Thames Coromandel District Council, 2006-2013

Role: Project Director and Technical Reviewer for design of long term water supply strategy for Tairua and Pauanui, which addressed the peak seasonal demand, and the projected increase in population. Work conducted included a review of previously developed water supply options, assessment of water supply requirements, analysis of regulatory provisions, development and implementation of a hydrogeological investigation programme to assess health of existing production bores and to identify new groundwater production zones, assessment of bore yield, aquifer sustainability, and effect on environment, and preparation of consent applications to both Regional and District Councils, and the preparation of AEE and water management plan.

PROJECT | Further North Alliance

Client: New Zealand Transport Agency, 2013

Role: Jon was Lead Hydrogeologist for a study providing assessment of environmental impact reports. The project comprises an 18.5 km long 4-lane dual carriageway, with an estimated 8Mm^3 of earthwork cuts, each of which required hydrogeological investigation.

PROJECT | Environmental and Compliance Monitoring

Client: Wairakei Pastoral Ltd, 2013-2014

Role: Project Director and Technical Reviewer for environmental and compliance monitoring. Wairakei Pastoral Ltd has numerous water take consents that have specific compliance monitoring requirements. This project covers the work required to complete this compliance, as well as work involved in the wider estate environmental monitoring.

PROJECT | Broadlands Irrigation

Client: Landcorp Farming Ltd, 2013-2014

Role: Project Director and Technical Reviewer for hydrogeological advice on the construction of an irrigation system at Broadlands farm in the Waikato. Work includes a design review, exploratory drilling, intake well design, preparation of tendering documents, contractor management, and construction monitoring.

PROJECT | Whangamata Water Management Plan

Client: Thames Coromandel District Council, 2010

Role: Project Director and Technical Reviewer for the development of a water management plan for the Whangamata water supply, supplied form six

Jon Williamson

PRINCIPAL HYDROGEOLOGIST

groundwater bores. Work included data review, demand projections, demand management options, supply configuration, operational details, network design review, cost benefit analysis, water quality assessment, network design review, and drought management plan.

PROJECT | Wairakei Estate Water Management Strategy

Client: Wairakei Pastoral Ltd, 2009

Role: Project Manager for water management strategy to supply water to the farm zones of the Wairakei block for basic farm operations. Work included assessing the demand needs of the Wairakei Estate farms, monitoring bore performance, developing local water supply sources using a combination of existing and new bores, and developing a centralised ring-main reticulation system.

PROJECT | Woodhaven Gardens Water Take Assessment for AEE

Client: Woodhaven Gardens, 2011-2012

Role: Project Director and Technical Reviewer for Woodhaven Gardens Water Take Assessment. Provided information and supporting reports for an application to Horizons Regional Council for a groundwater and surface water take for a medium scale horticultural production.

PROJECT | Hahei Water Management Plan

Client: Thames Coromandel District Council, 2011

Role: Project Director and Technical Reviewer for preparation of a water management plan, including drought and demand management strategies, in accordance with resource consent conditions. Work conducted included review of the production bore including effects on neighbouring users, assessment of current and future water demand, review of existing water supply network, treatment system, and operational details, review of water level and quality to ensure compliance with consent conditions, and development of a demand management plan and drought management plan to minimise water losses and reduce demand on system.

PROJECT | Pahiatua Water Supply Bore Technical Review

Client: Tararua District Council, 2010

Role: Project Director and Technical Reviewer of hydrogeological information available for the newly constructed water supply bore at Pahiatua. Work conducted included a review of technical hydrogeological information, advice regarding the adequacy of the current bore to meet stated demand and water quality criteria, review of the site geomorphological and hydrogeological information, and options for location of additional bores.

PROJECT | Hydrogeological Study and Drainage Management Plan, Otway Basin Drainage Scheme

Client: Environment Waikato, 2006-2010

Role: Project Director and Technical Lead for a hydrogeological impact study to determine whether drainage works will impact on the wetland ecosystem. Piezometers were installed to determine the groundwater hydraulic gradient between the Kopouatai peat bog and the Otway Basin catchment, which is subject to a resource consent application for drainage works associated with floodplain protection. Study led to SKM being commissioned to determine an appropriate and holistic long term approach to planning and design of the drainage scheme.

PROJECT | Review of Lower Waikato Flood Protection Scheme

Client: Environment Waikato, 2008

Role: Project Director for Review of Lower Waikato Flood Protection

Jon Williamson

PRINCIPAL HYDROGEOLOGIST

Scheme. Environment Waikato required an asset condition inspection and study that makes recommendations for future proofing of 38 pump stations within the Lower Waikato Flood Protection Scheme. Work included hydrological review of historical land use, geotechnical review of settlement, mechanical review of floodgate mechanisms, review of electrical components, and review of pumps and structure.

PROJECT | Impact of Changing Land Use on Floods in the Waikato Catchment

Client: Environment Waikato, 2008

Role: Project Director for study to determine the impact of changing areas in the Waikato catchment, from forest to pasture, on floods in the river.

PROJECT | Wanganui Deep Bore Groundwater Supply

Client: Wanganui District Council, 2011

Role: Technical director for development of a finite element groundwater model for the assessment of municipal groundwater supply bores from a 100 to 700 m deep dipping shell rock aquifer.

PROJECT | Coca-Cola Christchurch Operations Source Vulnerability Assessment

Client: Coca-Cola Amatil (NZ) Ltd, 2012

Role: Project and Technical Director for a study that involved review of the hydrogeology and groundwater supply risks at the Woolston soft drink bottling plant, the Hornsby juice and powdered drink factory, and artesian water bore at Ouruhia. The work was initiated as part of Coca-Cola's Global Watershed Management and Source Water Protection Program.

PROJECT | Valetta-Ashburton Groundwater Management Zone Hearing

Client: Environment Canterbury, 2008

Role: Jon undertook a review on behalf of Environment Canterbury and prepared a Section 42 Officers Report (expert evidence) of the Canterbury groundwater model used by 78 applicants for the assessment of the effects from their proposed groundwater takes (combined 3.6 m^3/s) for pastoral irrigation.

PROJECT | Waitaki Catchment Groundwater Investigation

Client: Ministry for the Environment, 2005

Role: Project Director for a comprehensive review of groundwater resources within the Waitaki catchment. Data was obtained from Environment Canterbury, their predecessor catchment board and Electricity Corporation of NZ archives. A component of the study identified the impact of seepage from canals on local groundwater resources of the Mackenzie basin.

PROJECT | Groundwater-surface water interaction policy review for basalt aquifers in Northland

Client: Northland Regional Council, 2013

Role: Project Director and Technical Reviewer for this study, which was undertaken in three parts: a) high level review of policy development and technical assessments undertaken both in New Zealand and internationally relating to surface water and groundwater interconnection, particularly in regards to applicability to basalt aquifer catchments; b) development of a conceptual groundwater model to independently evaluate key processes responsible for the interconnection between surface water and groundwater in basalt aquifers and enable the evaluation of the relative influence of

Jon Williamson

PRINCIPAL HYDROGEOLOGIST

management strategies/policies; and c) as case study of the Otakia surface water catchment, which is hydraulically linked to the Maunu-Maungatapere-Whatitiri aquifer, to inform decisions on surface water groundwater management.

PROJECT | Whangamarino Wetland Water Quality Influx Modelling Options

Client: Department of Conservation, 2012

Role: Project Director and technical director for the development of advice on modelling methodologies that could be used to estimate sediment and nutrient loads entering the wetland and to assess the effectiveness of potential mitigation options to improve water quality within the wetland.

PROJECT | Chamberlain Park Golf Course Groundwater and Baseflow Impact Modelling Study

Client: Auckland City Council, 2002

Role: Project Manager/Modeller

Two phased study aimed at assessing the efficiency of the irrigation management system and determining impacts on Meola Creek and Western Springs from increased groundwater abstraction at the golf course for irrigation. A dynamic soil moisture water balance model (SMWBM) was utilised for irrigation analysis. A MODFLOW groundwater flows model was developed including transient calibration to assess the groundwater and baseflows impacts from increased abstractions. The study also involved assessment of historical irrigation efficiencies using SMWBM and recorded irrigation usage data.

PROJECT | Ruawai Town Supply Bores Hydrogeology and Bore Security Assessment

Client: Environmental Operation Ltd on behalf of Kaipara District Council, 2009

Role: Sinclair Knight Merz was commissioned to provide a specialist hydrogeological assessment of the Ruawai town water supply bores. The study was initiated during the options analysis process for improving the water quality of the water supply, which also included preparation of a resource consent renewal application. The primary objectives of the study were to: i) assess the security of the groundwater supply from surface influences in line with the NZDWS 2000 and ii) assess the impacts of pumping on other bores users. The study involved a downhole casing condition assessment using submersible camera, review of regional hydrogeology and water quality, groundwater modelling assessment of impacts and travel paths using MODFLOW and MODPATH, and formulation of recommendations for verifying the security of supply from surface contamination.

PROJECT | Northern Southland Groundwater Modelling Study

Client: Environment Southland, 2005

Role: Extending on the work completed for the Riversdale Aquifer, Sinclair Knight Merz were commissioned to develop a transient MODFLOW model of the Riversdale, Longridge Waipounamu and Wendonside gravel aquifers. The model is currently being completed and will be implemented to defend water policy decisions that Environment Southland need to make with respect to pending groundwater abstraction consents and the impact on the Mataura River. Jon managed the project and modelling effort.

Jon Williamson

PRINCIPAL HYDROGEOLOGIST

PROJECT | Riversdale Aquifer Sustainable Yield Assessment

Client: Environment Southland, 2005

Role: Development and steady state calibration of a MODFLOW model for preliminary assessment of the aquifer dynamics and sustainable yield of the Riversdale gravel aquifer. Aquifer recharge is predominantly governed by water level in the Mataura River. Aquifer hydraulic conductivities are in the order of 100-500 m/day and a recent influx of large consent applications, some as much as 15,000 m3/day, has raised concerns regarding the sustainability of the supply and effect on spring-fed stream and river flows.

Dr Phillip Jordan

SENIOR HYDROLOGIST

QUALIFICATIONS

BE (Hons. Class I), University of Queensland (1993). Awarded the University Medal for 1993

PhD, Monash University (2001). Thesis: “Effect on Flood Modelling of Rainfall Variability and Radar Rainfall Measurement Error”

PROFESSIONAL MEMBERSHIPS AND AFFILIATIONS

Chartered Professional Engineer

Member of Engineers Australia

Registered Professional Engineer in Queensland (RPEQ)

EXPERTISE

- Development and calibration of integrated catchment models.
- Incorporating impacts of climate change in hydrological modelling.
- Leadership of software development and professional engineering teams
- Statistical analysis of time series of rainfall and stream flow.
- Development of specialist computer code for hydrological modelling.
- Analysis of radar rainfall data and application to modelling of streamflow.
- One and two-dimensional hydraulic modelling of irrigation channel, river and floodplain systems.

Summary of competencies

Dr Phillip Jordan has 20 years of experience in hydrology and water resources engineering. He has well-developed skills in statistical hydrology and modelling.

Recent project experience

PROJECT | Tukituki River Catchment Flow and Water Quality Assessment

Clients: Horticulture New Zealand and Hawkes Bay Regional Council

Roles: Senior Hydrologist, Practice Reviewer

Key achievements:

- Developed an eWater Source Catchments model of the Tukituki River Catchment
- Applied scenarios to analyse the impact of forecast increases in irrigated agriculture on in-stream Nitrogen and Phosphorus concentrations (including nutrient species)
- Applied scenarios to analyse the impact of proposed changes in minimum flow rules in the catchment on water availability for irrigators

PROJECT | Melbourne Stormwater Quantification Tool

Client: Melbourne Water

Roles: Senior Hydrologist, Practice Reviewer

Key achievements:

- Developed an eWater Source Catchments model of the entire Melbourne Water area
- Developed a customised plugin that estimated, on a catchment by catchment and total upstream area basis, the available harvestable volume of additional storm water that is derived from urban parts of the Melbourne Water area

PROJECT | eWater Source integrated water quantity and quality modelling platform

Client: eWater CRC

Role: Product Project Leader

Key achievements:

- Led development of calibration tool within Source
- Developed plugin versions of rainfall runoff models
- Development of plugin for simulating flow through catchments with multiple on farm dams

PROJECT | Hawkesbury-Nepean Integrated Water Quantity and Quality Model

Client: Sydney Water

Role: Senior Catchment Modeller

Dr Phillip Jordan

SENIOR HYDROLOGIST

Key achievements:

- Led the development of an eWater Source model for the entire Hawkesbury-Nepean basin
- Produced flow and water quality outputs for 25 different constituents for 100 different future scenarios, representing projections for sewage treatment plant discharge and landuse change
- Calibrated the rainfall runoff model parameters of the model to observed flows
- Developed customised tools for integration of point rainfall into the Source model
- Developed customised plugins for the eWater Source model

PROJECT | Murray Darling Basin Sustainable Yields Project

Client: CSIRO Land and Water

Role: Hydrologist – Farm Dam Impacts

Key achievements:

- Modelling projected effects of future farm dam impacts on runoff from every subcatchment in the Murray Darling Basin, as part of the 2007 Sustainable Yield study.
- Synthesis of diverse spatial data sources to estimate and project farm dam capacities

PROJECT | Assessment of Water Quantity and Quality Impacts of Proposed Coal Seam Gas Permeate Discharge into Glebe and Chinchilla Weirs

Client: SunWater

Role: Senior Hydrologist

Key achievements:

- Led development of an eWater Source model of the Dawson and Fitzroy River systems, including Glebe Weir to model water quality in the system
- Led development of an eWater Source model of the Balonne River system, including Chinchilla Weir to model water quality in the system
- Development and testing of impacts from various scenarios for discharge of permeate and re-use of the permeate for irrigation downstream of each of the two weirs

PROJECT | Sustainable Diversion Limits for South West Western Australian Catchments

Client: Western Australia Department of Water

Role: Project manager

Key achievements:

- Estimation of sustainable diversion limits for water from unregulated catchments in South West Western Australia. This project involved analysis of hydrological data from 160 catchments, use of an expert panel process to set the sustainable diversion limits in the gauged catchments and regionalisation of the results for application to 1900 ungauged catchments completely covering the southwest corner of WA

Dr Phillip Jordan

SENIOR HYDROLOGIST

PROJECT | Nerang River Catchment Freshwater Health Study

Client: Gold Coast City Council

Role: Senior Hydrologist, Practice Reviewer

Key achievements:

- Developed an eWater Source model for flow and water quality of the Nerang River catchment to Hinze Dam
- Estimation of the impact of various mitigation measures to improve water quality entering Hinze Dam, using the eWater Source model

Michelle Sands

SENIOR ENVIRONMENTAL CONSULTANT

Summary of competencies

Michelle is an Environmental Scientist based in SKM's Wellington office and has 15 years' experience. Currently she is involved in both planning and technical aspects of a variety of stormwater, water quality and urban catchment projects. Michelle has experience in the use of a range of hydrological and hydraulic modelling packages. She also has experience in the development of water quality monitoring programmes, collection and analysis of water quality data, design of stormwater treatment devices, and stream restoration.
She has experience working on an number of assessment of effects. She has presented evidence at hearings, including providing expert witness testimony at Board of Inquiry and Environment court mediation.

CURRENT POSITION

Senior Environmental Consultant

QUALIFICATIONS

BSc Hons (Physical Geography), Victoria University, New Zealand

PROFESSIONAL MEMBERSHIPS AND AFFILIATIONS

CEnvP - Certified Environmental Practitioner

EXPERTISE

- Water quality
- Modelling
- Catchment and stream management
- AEE and consents
- Expert witness and mediation
- Low impact drainage
- Project management

Recent project experience

Tukituki Plan Change

Client: Horticulture New Zealand

Role: Water quality advice

Key achievements:

- Provided water quality advise to Horticulture New Zealand and a primary sector group. This involved input into the development of a SOURCE catchment model to assess the effects of the proposed dam, and water quality and flow limits on surface water users, participation in Board of Inquiry conferencing and development of expert witness testimony.

Whangamarino wetland modelling

Client: Department of Conservation

Role: Conceptual modelling

Key achievements:

- Technical input into the catchment, hydrological and hydraulic modelling, which identified sediment and nutrient loads and the wetland water levels under different flood scheme operating conditions. The output of the modelling was the extent of sediment and nutrient distribution within the wetland under different events. The project has also included providing technical advice to Department of Conservation on the review of Waikato Regional Council's consent for the Lake Waikare discharge.

Mt Victoria Tunnel Duplication– Road of National Significance

Client: NZTA

Role: Water quality technical lead

Key achievements:

Developed the water quality scheme assessment report the water quality expert assessing the effects of the project on water quality in in the marine receiving environments, during the construction and operational phases of the project. This has included working with NIWA to develop a methodology for sediment yield modelling.

Michelle Sands

SENIOR ENVIRONMENTAL CONSULTANT

Puhoi –Warkworth - Road of National Significance.

Client: NZTA

Role: Water quality technical lead

Key achievements:

- Undertook the water quality assessment for the Puhoi–Warkworth Project. This involved working with a multi-disciplinary team of scientists, engineers, planners, lawyers and client representatives. The assessment has included monitoring to describe existing water quality, involvement in the development of the modelling methodology estimate background and future sediment loads and the fate of this sediment in the freshwater and marine receiving environments, and contaminant load modelling to calculate operational effects.

Te Roto - Retrofit Wetland

Client: Kapiti Coast District Council

Role: Technical lead

Key achievements:

- Te Roto wetland project was identified as a project to improve stream water quality in an industrial catchment. Reviewed the design to ensure hydraulic performance of the flood storage area was maintained while water quality performance was optimised and that a high level of amenity was achieved. Developed the assessment of effects, including developing a construction methodology to mitigate against effects during construction.

Transmission Gully - Road of National Significance.

Client: NZTA

Role: Water quality technical lead

Key achievements:

- Water quality expert witness for the Board of Inquiry consent application. This involved conferencing and evidence presentation. Developed a methodology to assess the impact of the construction and operation of the Transmission Gully road on the surrounding water quality for the assessment of environmental effects of this project, this included catchment and harbour modelling. The effectiveness of a range of mitigation measures was considered, including erosion and sediment control and stormwater management devices.

Kapiti Coast Stormwater Discharge Consents.

Client: Kapiti Coast District Council

Role: Technical lead

Key achievements:

Developed a water quality monitoring programme for 18 catchments within the Kapiti Coast District, and obtained resource consents for all of the Council's stormwater discharges to both freshwater and coastal receiving environments. The basis of the consent is on a programme of continuous improvement towards acceptable standards for ecosystems and contact recreation. I have been involved in the ongoing monitoring programme for the consent since 2006.

Dr Lydia Cetin

HYDROLOGIST

CURRENT POSITION

Hydrologist

QUALIFICATIONS

PhD in Science (Freshwater Ecology and Ecosystem Modelling), 2005-2007

Bachelor of Environmental Science, Major in Ecology (Freshwater Ecology, Honours), 1997-2001

PROFESSIONAL MEMBERSHIPS AND AFFILIATIONS

University of Adelaide Alumni

EXPERTISE

- Catchment Hydrology and Modelling
- Water quality modelling
- Water resource management
- Ecohydrology and Freshwater Ecology
- Skills with a variety of model-building applications – Source, eWater tools (e.g. RAP, RRL), IQQM, R, STELLA

Summary of competencies

Dr Lydia Cetin is a hydrology and water quality modeller with eight years of experience in the fields of catchment hydrology, river management, and lake/wetland water quality processes. She has skills in designing, building, and applying catchment-scale planning models and reservoir/wetland water quality models, and undertaking surface water quality assessments.

Lydia's previous project experiences include catchment modelling for informing natural resource management planning and policy development, qualitative and quantitative analysis of hydrological and water quality data, relating water quality information to ecohydrological processes and management, and rapid uptake of new modelling approaches. Lydia spent four years involved in the eWater CRC Product Development team for the Source Integrated Modelling System, and has detailed knowledge of building Source models for investigating the hydrological and water quality management aspects of catchment and river systems

Recent project experience

Water resources and nutrient limit setting for the Tukituki Catchment, New Zealand

Client: Horticulture New Zealand

Role: Hydrological Modeller

Key achievements:

- Development of a catchment-scale water quality model of the Tukituki catchment to assess policy changes on water security, water quality mitigation and optimisation of water allocation
- Customisation of Source through plugin development for surface water-groundwater interaction coupled to Soil Moisture Water Balance rainfall-runoff model and nutrient leaching to groundwater

Water science services secondment position (DEWNR)

Client: Science, Monitoring & Knowledge Division, South Australian Department of Environment, Water and Natural Resources

Role: Senior Hydrologist

Key achievements:

- Wetland flow regime modelling for assessing management and watering objectives for the Riverine Recovery Project
- Risk assessment on flooding from environmental water delivery on water quality in regional areas along the Lower River Murray
- River Murray flood mitigation planning – analysis of flood damage-cost relationships
- Water balance modelling for River Murray and Lower Lakes barrages operations
- Support role for Science, Monitoring & Knowledge Division on eWater Source modelling

Dr Lydia Cetin

HYDROLOGIST

Integrated Options Analysis for a Resilient and Efficient Bulk Water Supply for Upper Brisbane, Lockyer and Mid-Brisbane catchments

Client: Seqwater, Qld

Role: Water Quality Modeller

Key achievements:

- Water quality data analysis and catchment pollutant load reduction modelling to evaluate integrated management options for improving resilience and efficiency in bulk water supply in the Brisbane River catchments, Qld

Water Quality modelling of the Hawkesbury-Nepean River System, NSW

Client: Sydney Water

Role: Hydrological Modeller

Key achievements:

- Hydrological and water quality modelling using eWater Source of the Hawkesbury-Nepean Catchment to determine the effects of urbanisation, water quality improvement strategies and implementation of WSUD on water security and quality for Sydney Water

Glebe Weir: Assessment of coal seam gas permeate discharge, Qld

Client: SunWater, Qld

Role: Water Quality Modeller

Key achievements:

- Water quantity and quality analysis and modelling using IQQM and eWater Source to determine the effects on coal seam gas permeate discharge on in-stream water quality of the Dawson and Fitzroy Rivers, Qld

Nic Conland

SENIOR ENVIRONMENTAL CONSULTANT

CURRENT POSITION

Senior Environmental Consultant

QUALIFICATIONS

Bachelor of Science (Chemistry, Information Systems), Waikato University, Hamilton

Diploma of Design (3D), Waikato Polytechnic, Hamilton

Post Grad Certificate of Proficiency (Environmental Planning and law), Victoria University, Wellington

PROFESSIONAL MEMBERSHIPS AND AFFILIATIONS

Associate member NZPI

WasteMINZ

EXPERTISE

- Regional Policy development
- Strategic planning for Land use effects
- Environmental management systems
- Environmental monitoring programmes
- Water Quality Assessments
- Waste treatment systems
- Trade Waste network risk assessments
- Resource Management Planning and Compliance
- Environment and District Court processes
- Direction and leadership of teams across multiple work disciplines
- Management of technical experts to produce reports for District and Environment Court

Summary of competencies

Nic has 18 years' experience in the environmental assessment field having experience in both the preparation and review of water quality effects assessments and in managing, reviewing and reporting on water quality monitoring programmes. A significant part of his career has been spent within a regional council where he has been a compliance programme manager and a water quality specialist responsible for reviewing applications for resource consent to discharge to water, reporting and presenting expert advice to council, preparing meaningful and workable consent conditions and setting requirements for mitigation, control and monitoring with contractors undertaking bulk earthworks in the Wellington region.

Nic has extensive experience in land use project assessments and determining catchment effects on groundwater and river systems for large primary industry operations; golf courses; Landfills and urban infrastructure and stormwater where a long-term whole of catchment environmental assessment was required to provide solutions for staged works over many years. These projects, with a particular focus on performance management and discharge monitoring, includes experience in the policy, planning and legal instruments of environmental law.

He has presented at national conferences on best practice for adaptive management for discharge controls and relationship management between local authorities and construction projects. At Wellington Regional Council, Nic contributed to the development and drafting of the Fresh water, Indigenous ecosystems and Coastal environment chapters of the Proposed Regional Policy Statement [May 2010] and was involved in the development of the second generation Natural Resources Management Plan.

In the second phase of his career, Nic has worked in consultancy both continuing with the policy and environmental effects assessments and directly undertaking project management for a wide range of clients including MfE, the EPA and several regional councils. Nic's recent experiences leading expert teams has included the Tukituki Plan Change 6, MfE SOI measures project, Environmental Manager for the Wellington Tunnels Alliance and AEE project manager for the NZTA Kawarau bridge replacement and the Nelson Pine stormwater consents.

Nic has provided strategic policy advice for Wairakei Pastoral Limited, Ravensdown, Horticulture New Zealand and Landcorp Farming Limited on their water quality impacts for catchment management within the new limits framework under the National Policy Statement for Freshwater Management and regional plan developments in the Northland, Auckland, Waikato, Taranaki, Manawatu, Bay of Plenty, Wellington, Hawkes Bay, Canterbury, Otago and Southland.

Recent project experience

Submission, modelling and evidence for Tukituki Plan Change 6

Client: Primary Sector Partnership, led by Horticulture New Zealand

Role: Project lead, Expert Evidence and Policy advice

PROJECT | Franklin Lowland Streams Expert Evidence and Policy advice, 2013

Nic Conland

SENIOR ENVIRONMENTAL CONSULTANT

Client: Horticulture New Zealand

Role: Expert Evidence and Policy advice

Establishing a Compliance Monitoring Regime for the Exclusive Economic Zone and Continental Shelf, 2012

Client: Environmental Protection Authority

Role: Project lead and policy developer

Review of second generation plan development across New Zealand's regional and unitary authorities, 2012

Client: Landcorp Farming Limited

Role: Project lead and reviewer

NPS Freshwater Management SOI measures, 2011

Client: Ministry for the Environment

Role: Project Manager and Policy Reviewer

Second Generation Plan workshop, 2013

Client: Regional Council [name withheld]

Role: Project lead and workshop presenter

Franklin Lowland Streams Expert Evidence and Policy advice, 2013

Client: Horticulture New Zealand

Role: Expert Evidence and Policy advice

Duplication Study for Mount Victoria Tunnel and Terrace Tunnel refurbishment, 2010-2014

Client: NZTA

Role: Water Quality lead and Technical Reviewer

Canterbury Land and Water Plan submission, 2012-13

Client: Landcorp Farming Limited

Role: Project lead and Technical Reviewer

Resource Management Act Compliance and Enforcement

Client: Greater Wellington Regional Council

Role: Environmental Regulation Team Leader

- Direct management of three regulatory programme areas with 6 direct report staff and functional responsibility for 12 within the Environmental Regulation department.
- Direction and leadership of the regional council's responsibilities for compliance activities associated with the RMA..
- Coordination of the Fonterra Accord, dairy compliance for the Wellington Region.

Career History

2010 - present	SKM: Senior Environmental Consultant
2006 - 2010 team leader	Wellington Regional Council, Environmental Regulation
2004 - 2006	Wellington Regional Council, Environmental Protection

Nic Conland

SENIOR ENVIRONMENTAL CONSULTANT

Officer

2002-2004	Hutt City Council, Trade Waste Officer
2000-2002	Unilever Australasia, Process Analyst
1996-2000	Anchor Products Limited, Process Analyst
1994-1996	Analyst Environmental Chemistry, Australasian Laboratory Services