HAWKE'S BAY
REGIONAL COUNCIL

Ruataniwha Water Storage Scheme Review

Appendices

May 2017
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HAWKE'S BAY REGIONAL COUNCIL

RWSS Review Report APPENDICES

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SAINSBURY LOGAN & WILLIAMS
LAWYERS SINCE 1875

29 November 2016

The Group Manager – Strategic Development
Hawke's Bay Regional Council
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For: James Palmer & Tom Skerman

By email: james.palmer@hbrc.govt.nz; tom@hbrc.govt.nz

LAND SWAP – APPEAL BY HAWKE'S BAY REGIONAL INVESTMENT COMPANY LIMITED

1 Please find our advice **attached**.

2 There is one matter that I would like to clarify.

3 I was asked to be the 'solicitor on the record' for the proceedings between the Royal Forest & Bird Protection Society, the Minister of Conservation and the Hawke's Bay Regional Investment Company Limited (**HBRIC**). That is because barristers cannot accept instructions directly from a client for this type of proceeding. The client must have an instructing solicitor. Sainsbury Logan & Williams has filled that role.

4 Although the firm's name (and mine) appears on the documents filed with the court, no-one from the firm has been actively involved in the proceedings. All decisions and advice concerning the proceedings have been made or given by HBRIC and its barristers without reference to us.

5 If you have any questions, please contact the writer.

Yours faithfully

L J Blomfield

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LAND SWAP – APPEAL BY HAWKE'S BAY REGIONAL INVESTMENT COMPANY LIMITED

1 Thank you for your email of 22 November 2016.

2 You have asked for advice on the following issues:

2.1 Whether the Supreme Court is likely to grant Hawke's Bay Regional Investment Company Limited (**HBRIC**) and the Minister of Conservation leave to appeal the Court of Appeal's decision on the land swap;

2.2 Our view on the merits of the HBRIC's appeal; and

2.3 If the appeal by Minister and HBRIC is unsuccessful, whether HBRIC can use the provisions of the Public Works Act 1981 (**PWA**) to acquire the 22 hectares of Department of Conservation (**DoC**) land.

3 We address those issues in turn below.

Background

4 In June 2015 the Tukituki Catchment Proposal Board of Inquiry granted HBRIC resource consents to implement the Ruataniwha Water Storage Scheme (**the Scheme**). The Scheme involves the construction of a dam across the Makaroro River to capture and store approximately 90,000,000m^3 of water and will involve inundation of approximately 22 hectares of land on the periphery of the Ruahine Forest Park.

5 Separately from the Board of Inquiry process, HBRIC proposed to DoC that it exchange the 22 hectares of forest park land for a block of 170 hectares of land known as the Smedley Block.

6 The 22 hectares of forest park land is held for conservation park purposes under the Conservation Act 1987. Land held as conservation park land cannot be disposed of or

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exchanged under the Conservation Act. However, that prohibition does not apply to conservation land designated as a 'stewardship area'. Land designated as a stewardship area can be exchanged for any other land if the Minister is satisfied that the exchange will enhance the conservation values of land managed by the Department and promote the purposes of the Conservation Act.

7 In order for the proposed land swap to proceed, the Minister had to make two separate but related decisions:

7.1 The first was to revoke the conservation park purpose of the 22 hectares of land and to change that land's designation to a stewardship area (**the Revocation Decision**); and

7.2 The second was to exchange the 22 hectares of land for the Smedley Block (**the Exchange Decision**).

8 The Royal Forest & Bird Protection Society of New Zealand Incorporated (**the Society**) took proceedings in the High Court:

8.1 Challenging the lawfulness of the Revocation Decision. If that decision is found to be unlawful, then the exchange cannot proceed.

8.2 Claiming that the Director-General was required to consider whether to reserve a marginal strip when making the decision to exchange the land.

9 The Society lost in the High Court on the first issue, and appealed to the Court of Appeal. The Society's appeal to the Court of Appeal was successful. The majority of judges sitting on that Court held that the Director-General had taken into account the exchange proposal when making the Revocation Decision and should not have done so. The wrong legal test had been applied to the Revocation Decision. It was unlawful and should therefore be set aside.

10 The Society was partially successful on the second issue. The Judge held that the proposed exchange may create an obligation to reserve marginal strips from the exchange of the 22 hectares of forest park land but that no final decision could be made on that point because the exchange had not yet occurred.

11 HBRIC and the Minister of Conservation appealed this part of the High Court's decision dealing with marginal strips.

Reasoning for the Court of Appeal's decision

12 Section 18(1) of the Conservation Act allows the Director-General (under delegation from the Minister of Conservation) to declare any land held by the Department to be held for specific conservation purposes. Once that declaration has been made, the land must be held according to that declared purpose.

13 Section 18(7) of the Conservation Act gives the Minister the discretionary power to revoke or vary a special designation of land held for conservation purposes. It states:

> Subject to subsection (8), the Minister may, by notice in the *Gazette*, vary or revoke the purpose, or all or any of the purposes, for which any land or interest held under subsection (1) is held; and it shall thereafter be held accordingly.

14 Before invoking this power, the Minister must give public notice of his or her intention to do so. Members of the public may object in writing to that proposal, and must be given an opportunity to appear in support of that objection before the Director-General makes a recommendation to the Minister. The Minister must then consider the recommendation before deciding whether to proceed with the revocation proposal.

15 The majority of the Court of Appeal interpreted s18(7) in the following way:[1]

> However, we are satisfied that any inquiry conducted under s 18(7) is limited to whether revocation is appropriate by reference to the particular resource. It does not allow a relativity analysis of the type undertaken by the Director-General, conducted from the view point of what will yield the better net result or gain to the conservation estate, or a comparative inquiry into whether land offered in exchange has a higher intrinsic value. Once the land crossed the threshold of special protection ... its designation could only be revoked if its intrinsic values had been detrimentally affected such that it did not justify continued preservation and protection; for example, if the park purposes for which it is to be held were undermined by natural or external forces.

16 The majority went on to say:[2] [3]

> A proposal to exchange specially protected land will only be relevant to the s 18(7) inquiry if the Director-General is first satisfied that the specially protected area no longer merits its particular designation – in this case, a conservation park held for park purposes – and should be reclassified as a stewardship area. The Act does not allow the Director-General to exercise his or her revocation power by the touchstone of whether a decision will enhance the conservation values broadly construed of land managed by the Department. While that inquiry is appropriate to an exchange decision under s 16A(1), it is inapplicable where the revocation proposed is of a specially protected designation.
>
> ....
>
> The Director-General did not inquire into whether the 22 hectares should be preserved because of its intrinsic values or protected in its current state to safeguard the option of future generations where the scientific evidence established its ecological significance. Nor did he inquire whether preservation or protection of the area in its current state was not practicable. Nor did he inquire why the 22 hectares should lose conservation park status when its inherent characteristics remained unchanged and otherwise deserving of protection and preservation. This factor assumes particular relevance where destruction of the 22 hectares – land previously deserving of special protection – was the inevitable consequence of his decision. The decision would free much of the land to be submerged and *cease to be land*; there could not be a more fundamental corruption of its intrinsic value.

17 The Majority held that the process followed by the Department led to an unlawful decision (the Revocation Decision), and set that decision aside.

18 The President of the Court of Appeal (Ellen France) disagreed and issued a minority judgment. In her view, the decision made by the Director-General was lawful and the appeal should be dismissed. She considered that:

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[1] Paragraph [68] of the Court of Appeal's decision
[2] Paragraph [71]
[3] Paragraph [75]

18.1 The Director-General was required to make two separate decisions, the first of which was to revoke the status of the land as a conservation park so that the land became stewardship land, and the second was to exchange the stewardship land for other land; and

18.2 In making the first decision (to revoke the status of the land), the Director-General could consider conservation purposes broadly, and was not limited to a consideration of the conservation values of the 22 hectares of DoC land only.

18.3 The Director-General had taken into account the conservation values of the DoC land when making the Revocation Decision.

19 The Court of Appeal's finding on the Revocation Decision (that it was unlawful) meant that the Judges did not need to address the appeals relating to the marginal strips and they did not do so.

Applications for leave to appeal to the Supreme Court

20 HBRIC and the Minister of Conservation have separately applied for leave to appeal to the Supreme Court against the Court of Appeal's decision on the Revocation Decision. Both parties have requested that the Supreme Court rule on the correct interpretation and application of the Conservation Act's provisions concerning marginal strips.

21 There is no automatic right of appeal to the Supreme Court; that Court must first grant leave so that a party can appeal. The Supreme Court will not grant leave to appeal unless it is satisfied that it is necessary in the interests of justice for the Supreme Court to hear and determine the appeal. An appeal involving a matter of general or public importance will meet this "*interests of justice*" test.

22 The parties do not have a right to appear in front of the Court to be heard on that issue, but the Court can allow that. HBRIC and the Minister of Conservation have filed submissions in the Supreme Court setting out the reasons why they consider that leave should be granted. The Society filed its submissions opposing the granting of leave a fortnight ago. It is likely that the Supreme Court will make a decision 'on the papers'.

23 Having read the submissions for the parties, we think it likely that the Supreme Court will grant leave to appeal because the proposed appeal involves a matter of general or public importance. Both the High Court's and the Court of Appeal's decisions record that the appeal "*goes to the heart of the purpose of the Conservation Act*". This would be the first time that the Supreme Court had considered the correct legal test for revoking a special protection designation under the Act or the proper interpretation of the Act's purposes.

Merits of HBRIC's appeal

The Revocation Decision

24 We think there are merits in HBRIC's (and for that matter, the Minister of Conservation's) proposed appeals for the following reasons:

24.1 There is no explicit statutory test which has to be met in revoking the purpose of a conservation park for which land is held under s18(7). The Minister's power to revoke designations is a broadly framed discretion. Section 18(7) states:

> Subject to subsection (8), the Minister may, by notice in the Gazette, vary or revoke the purpose, or all or any of the purposes, for which any land or interest held under subsection (1) is held; and it shall thereafter be held accordingly.

24.2 The revocation power in s18(7) is not specifically constrained, other than by reference to the need for a public notification process.

24.3 A broadly framed discretion should be exercised to promote the policy and the objectives of the Conservation Act. The policy and objective is to be ascertained by reading the Act as a whole.

24.4 There is nothing in the text of the Conservation Act that requires the intrinsic value of a single resource (here the 22 hectares) to be preserved or protected if that diminishes conservation purposes interpreted broadly.

24.5 Nor is there anything in the Act which provides that a special protection designation for conservation land can only be revoked where the land no longer has any intrinsic values worthy of preservation and protection. That interpretation reads too much into s18(7).

25 For all of those reasons, we consider that the appeal is arguable, and that there is a reasonable prospect of success if leave is granted.

Marginal Strips

26 Section 24 of the Conservation Act requires that a 20 metre strip of land be reserved along the bed of any river or stream with an average width of 3 metres or more, where the Crown sells or disposes of land. The High Court judge accepted that the exchange was a proposed disposition of land which may create an obligation to reserve marginal strips along any rivers or streams over 3 metres wide on that land.

27 Both HBRIC and the Minister of Conservation have sought leave to appeal that finding for the following reasons:

27.1 That interpretation undermines the effectiveness of provisions allowing for the exchange of land. Here HBRIC asks: What is the point of reserving marginal strips on land which will be inundated if the exchange proceeds?

27.2 The Judge did not address two provisions of the Conservation Act (sections 16A and 26) when making his decision.

Other observations

28 We observe here that there are in fact two applications for leave to appeal to the Supreme Court – one by HBRIC and the other by the Minister of Conservation. That is relevant for two reasons:

28.1 It is unlikely that the Minister of Conservation would have sought leave to appeal if her legal advisors (Crown Law) did not share the writer's view that there was a reasonable prospect of that appeal being successful.

28.2 The Minister will proceed with her application and if leave is granted, that appeal will be heard regardless of whether HBRIC remains involved in the proceedings.

29 In addition to that, it is entirely expected that HBRIC would participate in an appeal given its investment in the Scheme to date and the fact that it has a commercial interest in the outcome, both of which are driving its request that the Supreme Court give any hearing priority. Of the two appellants HBRIC has a greater interest in the marginal strip issue than does the Minister. It may also wish to make submissions to the court about the effect its decision will have on the viability of the Scheme, which is not a matter of concern for the Minister.

Other means of acquiring DoC land

30 We understand that HBRIC has applied to become a requiring authority to enable it to use the Public Works Act 1981 (**the PWA**) to acquire land (including, potentially, DoC land). That application was made several months ago, before the Court of Appeal released its decision on the land swap.

31 HBRIC became a requiring authority in 2013 for the purpose of acquiring land for the distribution network only. We have not seen the latest application but understand it seeks requiring authority status for the dam, its environs and the reservoir footprint.

32 Under s186(1) of the Resource Management Act 1991 (**RMA**), a network utility operator that is a requiring authority may apply to the Minister of Lands to have land required for a project acquired or taken under the Public Works Act 1981 as if the project or work were a Government work within the meaning of that Act. If the Minister of Lands agrees, that land may be taken or acquired.

33 The 22 hectares of DoC land is land held by the Crown under the Conservation Act 1987, and can only be set apart for a project if the Crown agrees. The consent of the Minister of Conservation will also be required because the land is conservation area under the Conservation Act 1987.

34 The effect of s186 of the RMA and s52 of the PWA is that:

34.1 If HBRIC gets the necessary approval as a requiring authority it can use the provisions of the PWA to acquire the 22 hectares of DoC land.

34.2 That cannot occur without the consent of the Minister of Conservation and the agreement of the Minister of Lands.

34.3 HBRIC's ability to take the 22 hectares of DoC land under the PWA will not be directly affected by the outcome of the appeals by DoC and HBRIC. That said, we cannot anticipate whether the outcome of those appeals will affect whether or not Minister of Conservation consents to that land being set apart for the Scheme. That is not a legal matter, but rather a political one.

Conclusion

35 In summary, our advice on the issues set out in paragraph 2 (above) is as follows:

35.1 We consider it likely that the Supreme Court will grant leave to HBRIC and DoC to appeal to the Supreme Court.

35.2 We think that the appeals lodged by HBRIC and DoC on the land swap have merit. The majority of the Court of Appeal interpreted s18(7) of the Conservation Act in a particular way, and one which involved a very narrow reading of the matters that the Director-General could take into account when deciding whether or not to revoke the land's special status under that Act. There is nothing in case law or in the text of the Conservation Act which supports such a narrow interpretation.

35.3 Two other judges who have considered the same issue have come to a different conclusion (the President of the Court of Appeal, who wrote a dissenting judgment; and Justice Palmer, the High Court judge who heard the proceedings at first instance).

35.4 If HBRIC's current application for requiring authority status is granted, it can use provisions in the RMA and the PWA to acquire the DoC land and other land required for the dam and its environs.

35.5 Because the DoC land is a conservation area within the meaning of the Conservation Act, the consent of the Minister of Conservation is required before land can be set apart under the PWA.

35.6 Neither the Court of Appeal's decision nor any decision of the Supreme Court (if leave is granted) has a direct bearing on whether the 22 hectares of DoC land can be set apart under the PWA. It may, however, influence the Minister when making her decision whether or not to grant consent.

36 If you have any questions, please contact the writer.

Yours faithfully

Lara Blomfield
Partner

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SAINSBURY
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27 March 2017

Hawke's Bay Regional Council
Private Bag 6006
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Attention: James Palmer

REVIEW OF RWSS

1 You have asked us for advice on the steps available to Hawkes Bay Regional Council ("Council") including any associated legal risks, to withdraw or shelve the Ruataniwha Water Storage Scheme ("RWSS") in the event Council determines that either the Conditions Precedent are not met or as a result of any other policy matter determined by Council.

2 You have advised that Bell Gully and PWC will be advising on a parallel point which is to identify all anticipatable costs and liabilities for both Council and Hawke's Bay Regional Investment Company Limited ("HBRIC") arising from abandoning or shelving the RWSS in the event that Council determines that either the Conditions Precedent are not met or as a result of any other policy matter determined by Council. This includes advice on the residual value of RWSS related assets, including intellectual property, in the event Council abandons or shelves the scheme.

Summary

3 The proposal to invest in RWSS was conditional upon various conditions precedent being satisfied. The dates by which those conditions were to be met have constantly shifted. One of those conditions precedent has not been satisfied (being the securing of sufficient third party funding). Therefore, Council is entitled to resolve to withdraw from or shelve the RWSS.

4 In addition, the land swap that is required to occur with the Department of Conservation in order for RWSS to proceed has still not been resolved. As a practical matter this impedes the ability of HBRIC to complete the RWSS and therefore, unless or until a feasible solution to this issue is available, Council would be imprudent to proceed with the investment.

5 Any decision by Council to shelve or withdraw from the RWSS could be subject to challenge by any entity or member of the public. Particularly, as the withdrawal from the RWSS would be a significant change from Council's intended strategies within the region

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as set out in the LTP. On that basis it may be more appropriate for Council to temporarily shelve (rather than withdraw from) the RWSS until public consultation using the special consultative process can be undertaken on any decision to withdraw. This may be undertaken as part of the consultation on the next LTP in 2018 or the next annual plan or as a separate process solely relating to the RWSS.

6 Any decision to shelve or withdraw from the RWSS should be made taking into account Council's Significance and Engagement Policy. We consider that given the controversial nature of RWSS, the impact on residents in Central Hawkes Bay and the financial consequences that any decision to shelve or withdraw from RWSS will be Significant in terms of that policy.

7 Any decision to shelve or withdraw from the RWSS must comply with section 80 of the Local Government Act 2002 by identifying and explaining the inconsistency of the decision with Council's existing LTP and Annual Plan and indicating whether Council intends to amend the plans accordingly.

8 There are no contractual obligations that we have been made aware of that Council is bound by in relation to the RWSS. However, HBRIC may be bound by contractual obligations in relation to RWSS. The financial position and solvency of HBRIC should be considered as an important factor in Council's decision in relation to RWSS. We understand you are obtaining separate advice on this aspect.

Background

9 We have reviewed:

9.1 The Long Term Plan 2012-2022 and 2015-2025;

9.2 Various resolutions of Council from 2012 to 2016 as provided to us by Tom Skerman;

9.3 Summary of Statement of Proposal for investing in the RWSS from May 2014;

9.4 Statement of Proposal for investing in the RWSS from May 2014;

9.5 The 31 May 2016 version of the Concession Deed;

9.6 Parts of HBRIC's submissions to the Supreme Court on the land swap with the Department of Conservation;

9.7 Council's Significance and Engagement Policy;

9.8 Annual Plan 2016 -2017;

9.9 Relevant sections of the Local Government Act 2002.

Long Term Plan

10 The long term plan ("LTP") provides an outline of what Council is intending to do within the region over a ten year period. The LTP 2012 – 2022 provides at page 5, part 2.2 that the final decision to invest $80m for an equity stake in RWSS is subject to decisions as follows:

10.1 The project is recommended as being commercially feasible by HBRIC and clearly meets Council's environmental objectives;

10.2 Council has approved feasibility and undertakes further consultation with the community before proceeding;

10.3 The project is consented and bankable as demonstrated by the financial commitment from other investment partners compatible with HBRIC.

11 The LTP was reviewed in 2015 for the ten year period 2015 – 2025. There was no specific consultation on the RWSS during that process as it underwent a separate special consultation process in 2014. In the LTP 2015 - 2025 the sum of $71.5m is budgeted for the RWSS (including dam building and related infrastructure) but with statements on page 11 of Part 2 and page 16 of Part 6 that the project will not proceed unless farmers have contracted to take at least 40M m3 of water in the first years of the RWSS and unless investor commitment meets financial close requirements.

12 The LTP 2015 refers to financial close being due in February 2016 with funds of $71.5m being invested by September 2016. We note that in the Annual Plan for 2016 – 2017 at page 27 the investment figure has reverted to $80m and the date to January 2017. In both the LTP 2015 and the Annual Plan 2016 – 2017 specific details of the investment are set out providing that on financial close HBRIC will issue 71.5 million (Annual Plan 80 million) new shares to Council for $1 per share and simultaneously make a call of 20 cents per share to repay all outstanding advances. The remaining 80 cents per share will be called in instalments over the 2015 – 2016 financial year (Annual Plan 2016 – 2017 financial year) to complete the RWSS project. This level of detail in the LTP and Annual Plan suggests that Council is strongly committed to undertaking the project so a decision now to withdraw from that commitment is likely to be significant and will be inconsistent.

Special Consultation on RWSS

13 In 2014 Council undertook a special consultative process with the public on whether to proceed with investing in the RWSS. The statement of proposal produced by Council for consultation was worded on the basis that Council's preferred option was to proceed with investing in RWSS but that consultation was being undertaken with the intention of enabling Council to hear submissions and make appropriate decisions in 2014. The only alternative to Council's preferred option that was set out in the proposal was retaining the status quo (which was no investment in RWSS).

14 The statement of proposal included reference to the following conditions that would need to be met before Council would provide any funding to HBRIC for the RWSS:

14.1 The Environmental Protection Agency granting satisfactory resource consents conditions which are accepted by all investors;

14.2 Water user agreements to purchase a minimum of 40 million cubic metres of water;

14.3 Securing the funding required to build and operate the RWSS on acceptable terms for all investors;

14.4 Obtaining a bankable construction contract with a fixed cost, fixed time arrangement.

15 Submissions on the proposal closed on 3 June 2014 and Council met to consider submissions on 16 June 2014. We understand from the resolutions of Council in 2014 that the proposal to invest up to $80 million in RWSS received majority support from submitters.

16 Council is not bound to follow the outcome of a special consultative process but must consider the submissions with an open mind. In this case following the special consultation process, and in line with the majority support, Council determined to proceed with the project.

Resolutions

17 Following the consultation in 2014 Council resolved to invest up to $80 million in RWSS subject to:

17.1 Legal advice on documents (This was satisfied in 2016);

17.2 Review of the final business case (This was satisfied in 2016 subject to no further material adverse changes);

17.3 Advice from HBRIC that all conditions precedent by investing parties are satisfied or waived including:

(i) EPA granting resource consent on satisfactory conditions (This was agreed by resolution in 2016);

(ii) 40 million cubic metres of water per annum is contracted (This was satisfied in 2016 subject to no further material adverse changes);

(iii) Funding secured;

(iv) Construction contract is approved (This was satisfied by resolution in 2015);

17.4 HBRIC's lawyers summarising the water user agreements (This was satisfied in 2016);

17.5 HBRIC increasing the annual distribution to Council to provide a 6% return (This was satisfied in 2016).

18 According to the resolutions that we have reviewed the only matter outstanding relates to securing funding as per paragraph 17.3(iii) above.

19 A subsequent resolution indicates that the investors and financiers providing investment in the RWSS must provide final written confirmation of funding. It was agreed that if necessary Council would convene an extraordinary meeting under Standing Order 2.14 to confirm the condition precedent once written confirmation from the investors and financiers had been provided. We understand this has not yet occurred.

20 Given that the statements in the LTP and the Council resolutions to proceed with the RWSS were all conditional upon the various conditions precedent being met, Council is entitled to resolve to shelve or withdraw from the RWSS if those conditions are not met.

21 However, any such decision would be inconsistent with the strategies for the region's future as set out in the current Annual Plan and LTP and therefore if Council makes such a decision then Council must comply with section 80 of the Local Government Act 2002. That section requires Council to clearly identify:

21.1 The inconsistency;

21.2 The reasons for the inconsistency; and

21.3 Any intention of Council to amend the relevant plan(s) to accommodate the decision.

Concession Deed and Financier Direct Deed

22 The concession deed is intended to be between Council and the proposed Ruataniwha LP which has not yet been established. The document has not been finalised or signed.

23 The concession deed is expressed to be conditional upon financial close occurring under the project agreement (clause 5.1). If this condition is not satisfied by a date that has not yet been agreed then Council can terminate the concession deed under clause 5.3. In the event of termination, no payment is due or claim permitted but the obligations under clause 4.3 continue. According to clause 42.4 twenty (20) business days notice of the termination would need to be given. Once given, the termination of the concession deed automatically terminates the project agreement as well.

24 However, in 2015 Council directed HBRIC to proceed to financial close in July/August 2016 with drawdown subject to either:

24.1 Obtaining full access to land being exchanged between DOC and RWLP (which is not yet satisfied); or

24.2 Council funds being protected by financial arrangements and/or legal agreements approved by Council. We understand no arrangements have been made as yet.

25 Clause 42.6 provides that the financier direct deed prevails over the concession deed. We understand from Bell Gully that the financier direct deed has not been drafted at this time.

26 In this case, as neither the concession deed nor the financier direct deed have been finalised or signed, we consider Council is not bound by either document. We understand from Bell Gully that there are unlikely to have been any representations made which would enable any of the third party investors to believe that Council intended to be, or could be, bound by the documents prior to them being signed.

Challenge

27 Any decision by Council on this matter is at risk of:

27.1 a claim by any disgruntled party that Council has breached a duty of care owed to that party and/or is estopped from changing its position; or

27.2 an application for judicial review of the decision because it alters the rights of the applicant or deprives them of some legitimate expectation.

28 Case law indicates that the ability of councils to make decisions that are inconsistent with existing plans and policies (as permitted by section 80 of the Local Government Act 2002) means that any statements or assurances in those plans or policies are unlikely to create any duty of care or legitimate expectation that a complainant could rely upon to sue. The effect of section 80 is to specifically permit inconsistent decisions provided they are explained as required by that section.

29 Judicial review proceedings are most commonly based on either:

29.1 Illegality – where Council has failed to understand correctly the applicable law;

29.2 Irrationality – where the decision is so outrageous or perverse that no sensible person or body considering the relevant factors could come to the same decision;

29.3 Procedural Impropriety – where there has been a failure to observe basic rules of natural justice or procedural fairness.

30 While there is no way to prevent any disgruntled person from challenging a decision by Council, if all of the procedural steps are correctly undertaken by Council then the chances of any such challenge succeeding are greatly diminished. For this reason, we recommend that any decision made clearly considers the Significance and Engagement Policy and section 80 of the Local Government Act 2002 (along with the usual sections 77-79 of the Act). In addition to minimise any risk of challenge we also recommend undertaking a special consultative process as part of the decision making process.

Steps Available

31 On the basis of the documents we have sighted Council is not contractually committed to proceed with the RWSS. Rather Council's obligations in relation to the RWSS are found in the LTP, Annual Plan and in the various resolutions passed by Council from time to time.

32 The LTP sets out an intention of Council to proceed with the RWSS provided certain conditions are met. It appears at present that the funding condition has not been met. Therefore, Council is entitled to decide by resolution that the conditions have not been met and that Council is shelving RWSS.

33 There are no express acknowledgements that any policies or decisions set out in the LTP are irrevocable and we do not believe that Council is required to carry out all of the intentions set out in the LTP where Council determines that to do so would not be in the best interests of the region. However, an amendment to the LTP can only be undertaken in accordance with a special consultative process often as part of the annual plan. Given that a special consultative process was undertaken in 2014 specifically on the RWSS and received majority support for proceeding with the RWSS, for Council to now decide to withdraw from the RWSS would be a significant change to the LTP and in our view would require a special consultative process to be undertaken. Similarly, if Council decides to temporarily shelve the RWSS then such a decision should be included in the next annual plan as this would be a change to the position indicated in the LTP. In either case, Council will need to consider the application of its Significance and Engagement Policy and comply with section 80 of the Local Government Act 2002.

34 We are happy to discuss this further with you if required.

Yours faithfully

Andrew Wares/Lauren Hibberd
Partner Partner

Email: arw@slw.co.nz
ljh@slw.co.nz

From: Lara Blomfield [mailto:ljb@slw.co.nz]
Sent: Monday, 27 March 2017 4:19 PM
To: Tom Skerman <Tom@hbrc.govt.nz>
Cc: Lauren Hibberd <ljh@slw.co.nz>
Subject: Change 6 and RWSS - Potential Liability

Hello Tom,

I understand that you have asked for advice on whether the council could face legal proceedings from submitters on Change 6 if HBRC decides not to proceed with the RWSS.

I do not think that HBRC is at risk, or that any proceedings (if lodged) would be successful.

Change 6 and the RWSS were heard together and called the Tukituki Catchment Proposal. Change 6 provided the planning framework for the Tukituki River catchment and contemplated that a community irrigation scheme like the RWSS might be granted consent. Although it was drafted with the RWSS in mind, Change 6 did not rely on the RWSS or any other community irrigation scheme going ahead.

This was made clear in the opening legal submissions made to the Board of Inquiry on behalf of HBRC and HBRIC, which stated:

> Change 6 was accordingly drafted with the RWSS in mind, but as an example only of a community irrigation scheme which, if it would be demonstrated to meet the objectives and policies of Change 6, would properly receive consent.
>
> Importantly, however, Change 6 cannot rely on the RWSS, or indeed any other community irrigation scheme, proceeding. In relation to the RWSS, even if resource consents are granted, a number of other hurdles have to be crossed, including financial assessments, before the scheme can proceed.

That is also reflected in the Board's Final Report and Decisions issued in 2014 which stated (at para 102):

> .... PC6 will have to stand on its own feet and satisfy the tests under the RMA regardless of whether the RWSS (or any other irrigation scheme) proceeds.

I haven't been able to find the public notice that was given when Change 6 was notified by the council (it is no longer accessible on HBRC's website) but that may have said something similar. It would be helpful if it did, but would not be fatal if it did not.

If you have any questions, please let me know.

Regards
Lara Blomfield | **Partner**
Sainsbury Logan & Williams
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SAINSBURY LOGAN & WILLIAMS
LAWYERS SINCE 1875

Proposed Plan Change 6
Tukituki River Catchment

Proposed Plan Change 6 to the Hawke's Bay Regional Resource Management Plan: Tukituki River Catchment

(Clause 5 of Schedule 1, Resource Management Act 1991)

Change 6 proposes to:

- insert new sections in Chapters 5 (5.9) and 6 (6.9) of the Hawke's Bay Regional Resource Management Plan specifically relating to the Tukituki River Catchment (see map for location and extent of the Tukituki River Catchment), and
- make a number of consequent amendments to existing provisions in the Hawke's Bay Regional Resource Management Plan.

Change 6 is the first of a number of catchment specific plan changes for the Hawke's Bay region which seek to implement the National Policy Statement for Freshwater Management, as well as address specific water allocation and water quality issues in the catchment.

Change 6 contains one integrated suite of five objectives for the Tukituki River catchment. It proposes water quality limits and targets for a range of variables to achieve the objectives - to maintain or enhance aquatic habitats, maintain safe contact recreation and reduce the effects of algae and slime on recreational use and amenity. It proposes new policies and rules intended to implement a nutrient management framework.

Change 6 also proposes new water allocation limits for surface water and groundwater bodies and increases current minimum flows. It provides for the consideration of community irrigation schemes that improve and maximise the efficient allocation and efficient use of water.

Making a submission

Any person may make a written or electronic submission on Change 6. Written submissions may be sent to Hawke's Bay Regional Council, Private Bag 6006, Napier 4142, fax (06) 835-3601, or email submissions@hbrc.govt.nz. The submission must be in accordance with Form 5 of the Resource Management (Forms, Fees and Procedure) Regulations 2003 and must state whether or not you wish to be heard on your submission. Copies of this form are available from Hawke's Bay Regional Council, or can be downloaded from www.hbrc.govt.nz.

SUBMISSIONS CLOSE 5PM FRIDAY 31 MAY 2013

Change 6 can be downloaded from www.hbrc.govt.nz, or can be viewed at all public libraries in the region and at Hawke's Bay Regional Council, 159 Dalton Street, Napier. Printed copies are available upon request.

Request for Proposed Plan Change 6 to be called in by the Minister

Hawke's Bay Regional Council will be requesting the Minister for the Environment to call in Change 6 so that it can be considered alongside the Ruataniwha Water Storage Scheme applications as a Proposal of National Significance. If the Minister decides to call in Change 6, the direction (for the matter to be decided by the Environment Court or an independent Board of Inquiry) must be given by Monday 10 June 2013. The Environmental Protection Authority would manage the process from then on. The EPA would publicly notify the Minister's Direction and accept submissions and further submissions on Change 6, before handing over all submissions received to the Environment Court or Board of Inquiry for their consideration. Any submissions made to HBRC before 5pm 31 May 2013 in respect of this public notification will be treated as having been made to the EPA. The EPA will then make arrangements for a hearing to be held.

If Change 6 is not called in by the Minister

If the Minister decides not to call in Change 6, then the process is as follows. After submissions close on 5pm 31 May 2013, HBRC will prepare and notify a summary of the submissions lodged. There will be an opportunity to make a further submission in support of, or opposition to, the submissions already made. If a submitter asks to be heard in support of their submission, a hearing will be held. After the hearing, HBRC will give its decision on Change 6 (including its reasons for accepting or rejecting submissions). Submitters have the right to appeal these decisions to the Environment Court.

Liz Lambert
GENERAL MANAGER (OPERATIONS)

HAWKE'S BAY
REGIONAL COUNCIL

www.hbrc.govt.nz 06 835 9200

FOR FURTHER INFORMATION GO TO WWW.HBRC.GOVT.NZ

Council Review Question 3

Advice on all anticipatable costs and liabilities for both HBRC and HBRIC arising from abandoning or shelving the RWSS in the event HBRC determines that either the conditions precedent are not met, or as a result of any other policy matter determined by HBRC. Advice on residual value of RWSS-related assets, including intellectual property, in the event HBRC abandons or shelves the scheme.

The below table outlines a series of known cost exposures and areas of possible cost exposure associated with any decision to abandon or shelve the RWSS.

Attached also is a confidential letter of advice from Bell Gully with regards to litigation risk.

Further information on the total impact of abandoning or shelving the RWSS can be found in other Council Review work-streams (e.g legal risks and costs associated with implementing plan change 6 without the RWSS).

Cost or liability (known)	Total	Total (cumulative)
• Write-off of HBRIC intangible assets (e.g intellectual property, design work, consents) & land (to be netted off against any proceeds if HBRIC on-sells the assets) * Per balance sheet as at December 2016. Includes Phase 1 & 2 investment and includes $400k of land which may have a residual value ** note this figure may be higher by the time any write-off needs to be considered Note: The write-down would flow through both HBRIC and HBRC financial statements.	$19.5m* (less any proceeds from the re-sale of these assets, if any)	$19.5m
• Suppliers. All suppliers are paid up with no further liabilities (includes Design & Construction contractor) * Excludes residual small scale work orders associated with maintaining the value of the scheme until the review is completed.	$0*	$0*
Total known costs		**$19.5m**
Other possible costs		
• HBRIC Loan of $6m which has been incurred in lieu of shareholder equity for RWSS (i.e $19.5m of project costs/asset to date funded via $13.5m shareholder advance and $6m loan). • If the project did not proceed and the $19.5m asset was written off - HBRIC would still have a $6m loan liability associated with the RWSS. To eliminate this liability HBRIC would need to fund repayment from Port dividends (reducing dividends to HBRC by the equivalent amount).	$6m	

• Financial Advisors fees (if HBRIC terminates the agreements and then proceeds to complete the RWSS within 18 months) * note only limited advisory fees have been paid to date despite extensive services provided, with majority to be paid as a success fee dependent on achieving financial close	$1.3m	
• Cost to build alternative water storage solution to meet Plan change 6 requirements to avoid significant adverse effect on current farming systems * note this assumes circa 16m M3 of groundwater take needs to be suspended and an equivalent storage system to feed circa 6,000 ha is constructed. This should be verified by the Aqualinc workstream. ** Note the RWSS as proposed will service circa 30,000 ha.	Up to $60m	
• Claim by Farmers against HBRC re Plan Change 6. Covered in another Council Review work-stream. * Note claims cannot be made against HBRIC per terms of the water user agreements (whilst contracts remain live).	Unknown	
• Potential claim by investors for failure to act in good faith, seeking to recover costs &/or subsidies provided to HBRIC/HBRC to date * Confidential legal advice attached	Unknown c. $8.3m invested + additional internal costs and time invested to date	
• Whilst difficult to quantify, reputation in the contractor market could be affected leading to a higher pricing for future capital work projects as contractors price for political uncertainty (and ask for stricter terms such as guaranteed bid costs etc., which can exceed $5m for a single project)	Unknown	

Ruataniwha Water Storage Scheme (RWSS)

Financial Review for Hawkes Bay Regional Council (HBRC)

John Palairet

April 2017

Table of Contents

Introduction and Scope

I have been asked by Hawke's Bay Regional Council (HBRC) to conduct a review of elements of the business case for the Ruataniwha Water Storage Scheme (RWSS or the Project).

My scope of work is as follows:

1) *Review forecast revenue and expenditure, including levels of debt, finance and insurance costs, for Ruataniwha Water Limited Partnership (RWLP), the ownership and operating entity.*
2) *Review dividends, returns on equity for HBRC and private investors arising from the schemes cash flow model based on different levels of uptake of water:*
    a. *Base Case*
    b. *Downside Case*
    c. *Severe Downside Case*
    d. *Lewis Tucker Case*
3) *Consider the consequential impacts on spot market sales -in each case, over the first 35 years of the Project.*
4) *Advise on the return on and forms of debt provided by Crown Irrigation Investments Ltd (CIIL).*
5) *Assess the impact under each scenario of Hawke's Bay Regional Investment Co Ltd (HBRIC Ltd.) dividends to HBRC falling below 6% cash return on:*
    a. *HBRC's Long-Term Plan*
    b. *HBRIC Ltd.'s balance sheet*
    c. *The Port of Napier.*

I have had valuable assistance in the preparation of this report from Sarah Park. Sarah is a former senior consultant with PWC and a Director of several local companies including Hawkes Bay Airport Ltd.

Limitations

My review is limited to providing a financial perspective on the elements of the business case set out in the Introduction and Scope. The RWSS business case is comprehensive and has been developed over time with significant input from various expert and qualified parties. Two independent third party reviews have also been completed by Lewis Tucker & Co. (on behalf of the institutional investors) and Deloitte (on behalf of HBRC).

I have evaluated the relevant information provided for my assessment. I have relied on the accuracy and completeness of this information and have not sought to test or verify its accuracy except to the extent I have specifically been asked to do so in the scope of my work. Similarly, I have not sought to repeat work previously completed.

While I have examined the demand model and reviews undertaken, my examination is limited to consideration of the integrity of the process and validation by the various experts.

Source of Information and Context for Review

During my review, I have met with HBRIC Ltd. management, Waterview Capital Advisors (WCA or Waterview), who are formerly part of BNZ Advisory, HBRC management and staff, representatives of Lewis Tucker & Co. (Lewis Tucker) and the Community Reference Group. I have relied on a considerable body of work completed over several years.

My report considers four water demand scenarios:

- The Base, Downside and Severe Downside Cases are sourced from the Financial Model prepared by BNZ / Waterview and used in the latest business case presented to HBRC as at July 2016.
- The Lewis Tucker Case is from a review of the business case for the Institutional Investor and Funder which was undertaken in June 2016.

The level of gearing and the returns to equity investors are considered over three time periods:

- Years 1-15 cash return
- Years 1-35 cash return
- Over the Lifetime of the Project (Internal rate of Return)

Any conclusions drawn in this report are subject to:

1. Confirmation that the Farmers who have entered 35 year take or pay contracts (the Foundation Water Users -FWU) will renew their contracts which expire 30 June 2017.
2. A recalibration of the business case to reflect any material movements in operating and capital costs-in particular in the Design and Construction contract.
3. Reconfirmation of the bankability of the scheme.
4. Renewal of the Design and Construction Contract on acceptable terms.

Executive Summary

The specific objectives of this financial review of RWSS are outlined in the report, which in general terms are to examine in detail the components of the business case (capital expenditure, sources of funding, revenue, costs, debt and financial return) under various uptake (water sales) scenarios.

The RWSS business case was considered under the following conditions:

1. A forward sales level of 42.8Mm3 (42.8 million cubes) contracted to the Foundation Water Users (FWU's) who have entered a 35 year take or pay contract. These expire 30 June 2017 and will need to be renewed.

2. A construction contract fixed as to both time and cost of $282m to build the dam and network infrastructure, plus $10m provision for any network extension.

The contract has lapsed and will need to be renewed on mutually acceptable terms.

Key Findings

1. Robust development of the RWSS business case

The RWSS business case has had considerable expert input over the four years. It has been subject to independent reviews, an audit of the financial model, on-farm affordability, legal, environmental, economic advice and withstood the scrutiny of due diligence by Institutional investors. Expressions of interest in demand for water were also sought from farmers at the outset. This level of scrutiny and the positive response from farmers in general provides comfort on the robustness of the business case.

2. Construction Contract.

The contract is considerably de-risked, being fixed as to time and substantially in price. The major risk for the HBRIC Ltd. Directors to consider in addition to price on renewal of the construction contract is the balance sheet integrity of the Contractor's consortium. The recently announced takeover of Hawkins is likely to add balance sheet strength to the consortium.

3. The demand model – volume of water sold (or uptake).

Considerable work and modelling of on-farm affordability of water and consequent profitability was undertaken leading to the development of the demand model. This demand model was subject to extensive reviews by consultants on behalf of HBRIC Ltd. and other Institutional investors.

There was consistent general agreement with the assumptions around the on-farm impact on profitability and demand model outputs.

4. Capital and Debt Funding

The scheme will be financed by:

Equity Investment		
	HBRIC Ltd	$80m
	Institutional Investor	$80m
		$160m
Debt		
	Bank	$85m
	Crown Irrigation Investment	$95m
		$180m
Total funds at construction commencement		**$340m**

These funds are applied during the construction period to:

Dam generation and distribution	$287m
Construction period operating costs	$15m
Land acquisition costs	$8m
Finance development costs during Construction	$30m
Total spend	**$340m**

The project has an appropriate mix and level of debt and equity. Midway through construction a ~$35m capital raise is planned -the Tukituki Note. This Note is interest bearing, later converting to 16% equity share in RWLP. This Note is intended to part repay Crown Irrigation Investments (CIIL).

5. Priority of payments to Funders and Investors
    - Bank has first priority, then CIIL followed by interest payable on the Tukituki Note.
    - The Institutional Investor receives a greater share of distributions than HBRIC Ltd. for an estimated period of 15 years, then all equity investors will rank pro rata based on their shareholding.

Initially the shareholders will be HBRIC Ltd. 50% and the Institutional shareholder 50%. Subsequently, following conversion of the Tukituki Note the shareholding will be:

HBRIC Ltd	42%
Institutional Investor	42%
Tukituki Investors	16%

6. Revenue

Revenue as a function of water price times uptake of water is assessed over various demand scenarios:

- Base case - 100% uptake (100Mm3), year 11 of operation
- Downside case - 100% uptake, year 18 of operation
- Severe downside case - 82% uptake year 6 then stalled

The Institutional Investor's advisor Lewis Tucker assessed uptake to be slower in early years, but then accelerates as the benefits of increased irrigation are more understood to reach 100% uptake in year 7 of operation. This is earlier than the base case, but in aggregate provides a similar revenue outcome to the base case. The range of scenarios considered indicate a conservative forecasting approach.

7. Expenditure

Capital costs of the Dam and distribution network and other construction period costs are substantially fixed price. Operational and maintenance costs are well researched and appropriately inflation adjusted through the operating period.

8. Cash Flow

Cash flow from the scheme is sufficient to cover all debt obligations and expenses at the current contracted level of 42.8Mm3. At all demand scenarios, Base case, Downside case, Severe Downside case there is sufficient cash flow (after capital expenses) to pay all debt servicing and repayment obligations and provide dividends to investors as uptake increases in each scenario.

The table below illustrates how costs, payments to funders and returns to shareholders are covered as the level of water sales increase.

Costs covered	**Water sales level**	**When sales level achieved under base case assumptions**
All RWSS operational and capital costs + all bank interest costs	40-45Mm3	Financial Close
All operational and capital costs + all bank interest costs + all CIIL interest costs	46-49Mm3	Financial Close
All RWSS operational and capital costs + all interest costs + all debt repayment + all fixed payments due to other investors	57-62Mm3	During Construction
All costs covered and free cash can be used to pay dividends to shareholders	65-70Mm3	Day 1 of operations
Dividends equal for HBRIC and institutional investor who still receives investor fee until year 12	95Mm3	Year 8 of operations
Dividends to HBRIC match payments required to HBRC to meet 6% return requirement	100Mm3	Year 22 of operations

9. Return on Investment

Returns to HBRIC Ltd. as investor in the scheme based on an Internal Rate of Return (IRR) are:

	Base	Downside	Severe Downside
IRR after tax	7.1%	6.2%	5.8%

Increased Port of Napier throughput is assessed to increase the return (Base Case) to HBRIC Ltd. as 100% owner of the Port by 130 basis points, to 8.4% post tax.

The 7.1% base case return to HBRIC Ltd. compares with 9.6% IRR for other investors combined.

HBRC has stipulated a required cash return of 6% p.a. from the time funds are invested. This would enhance the return to the Council from HBRIC Ltd. to 9.2% (Base case) and adjusted for the Port increased throughput to 10.5%.

Overall the return to the Council as an investor is an acceptable infrastructure return at all levels aside from the significant regional economic financial benefit.

One additional consideration when assessing the potential financial return to HBRIC Ltd is that HBRC could consider a partial exit of its shareholding in RWLP in the future and therefore receive a lump sum return of capital it could recycle for other uses. An exit could take many different forms, but one option is that under the agreement with the institutional investor, the institutional investor has an option to purchase 20% of HBRIC Ltd.'s shares during the first 5 years of operations.

10. Impact of 6% cash return requirement by HBRC

As the cash return required by Council from HBRIC Ltd., does not equate to the forecast distribution from RWSS for around 20 years, HBRIC Ltd. will be required to fund the shortfall by increased Port of Napier dividends and borrowing.

The Base case debt required assuming special dividends paid by the Port of Napier during the construction period would be:

Year 10	$18m
Year 20	$20m
Year 30	$63m

Debt levels as a percentage of estimated HBRIC Ltd. value would range from 4.4% to 10.3%. This level of gearing is low.

11. Condition Precedent for water sales pre-financial close

After the initial completion of this report a condition precedent of achieving pre-financial close sales of 50Mm3 has been recommended by HBRIC Ltd. Directors. This would significantly increase operational cash flow by ~$1.5m p.a. from day 1 (compared with 42.8Mm3) and positively impact on returns and debt servicing.

Importantly, it would also help to mitigate any increase in construction price.
This is a prudent recommendation and should be accepted.

Hawke's Bay Regional Council Ownership Relationships

The chart below outlines the ownership relationships HB Regional Council (HBRC) has via HB Regional Investment Co Ltd (HBRIC Ltd.) with the Ruataniwha Water Storage Scheme (RWSS) and the Port of Napier.

HBRC owns 100% of HBRIC Ltd which in turn is the 100% owner of the Port of Napier and has a 50% interest in the Ruataniwha Water Storage Scheme through Ruataniwha Water Limited Partnership (RWLP).

Income from the RWSS is distributed through RWLP to HBRIC Ltd, as is dividend income from the Port of Napier Ltd. HBRIC then distributes income to HBRC.

As is described in more detail later, HBRIC contributes equity (ownership) capital ($80m) to the scheme along with an Institutional Investor ($80m) both of whom take an initial 50% interest in RWLP.

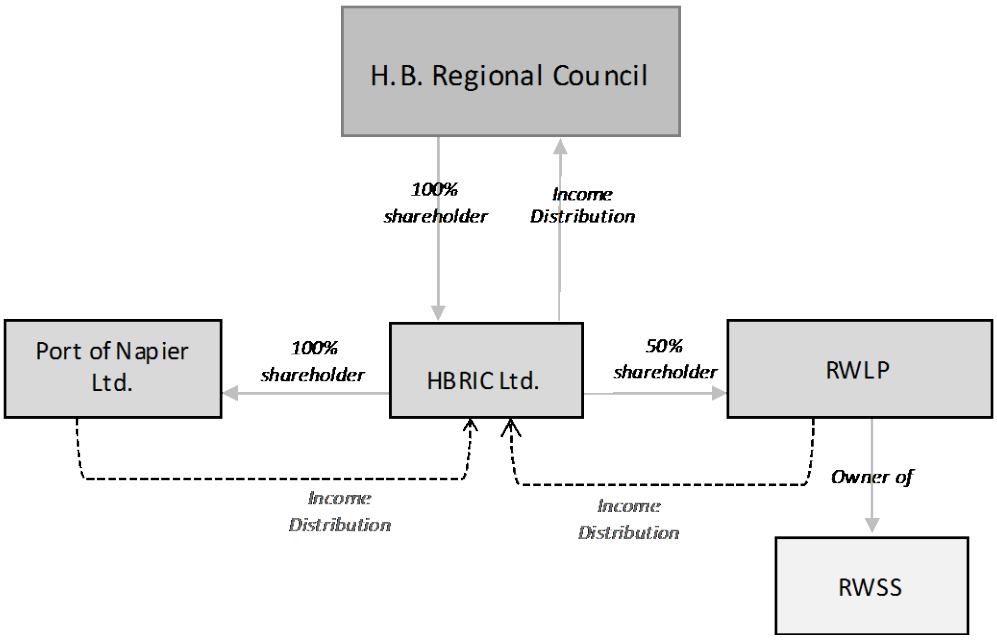
Debt funding is provided by senior debt -Bank ($85m) and Crown Irrigation Ltd CIIL ($95m).

Funding from CIIL is provided in 2 Tranches T1 $60m and T2 $35m. Tranche 2 is intended to be repaid by the raising of further debt by a convertible note -Tukituki Noteote some 18 months after commencement of construction.

The Tukituki Note as described later is intended in time to convert to a 16% equity interest in RWLP. At which point the Institutional Investor and HBRIC Ltd will each have a 42% equity interest.

Figure 1: Overview of Ownership and Flow of Funds

Ownership of RWLP – HBRC only



HBRIC Ltd – HB Regional Council Investment Company Ltd.

RWSS – Ruataniwha Water Storage Scheme

RWLP – Ruataniwha Water Limited Partnership

Construction Contract

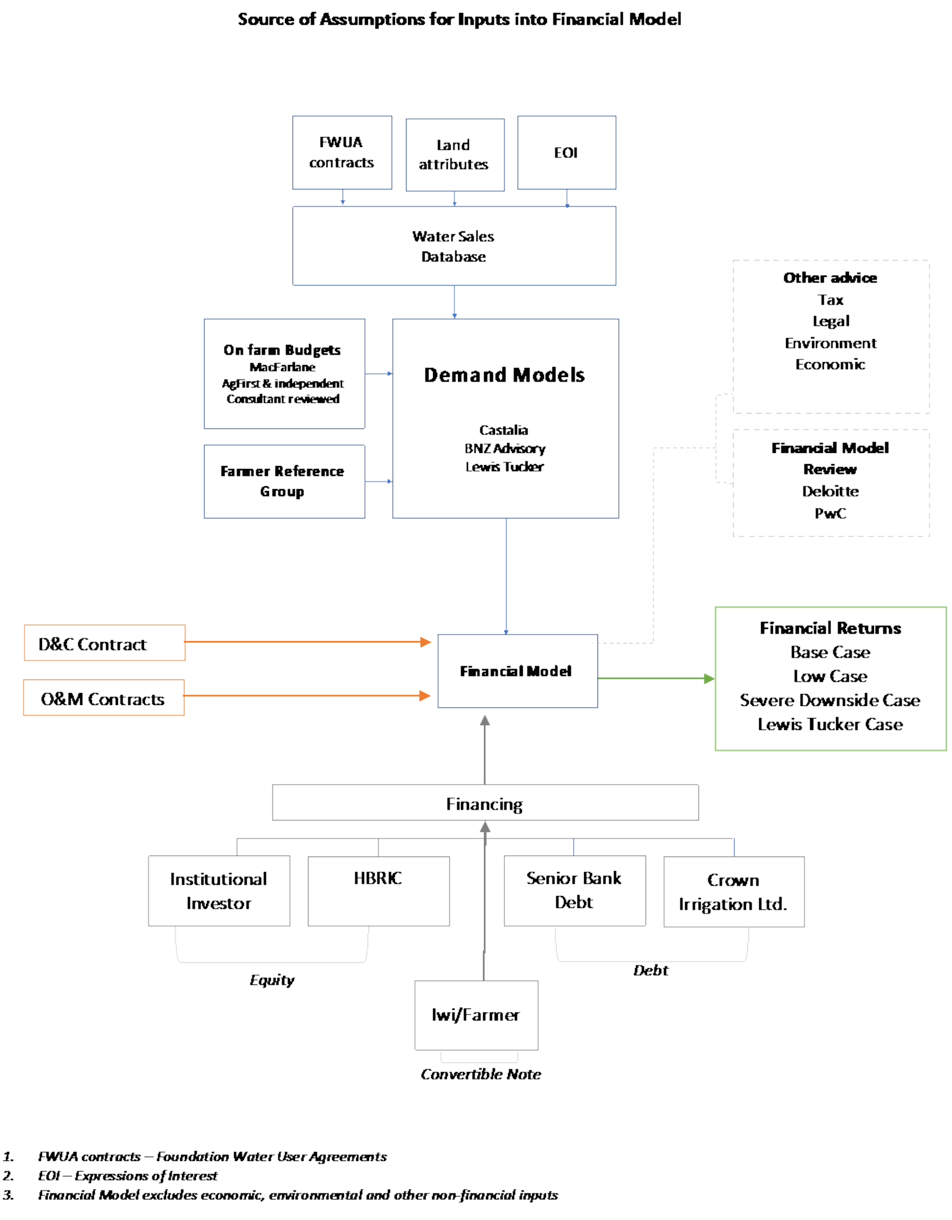
As described later, the Financial Model assumes the July 2016 negotiated construction cost of $282m is for Separable Portion 1 and 2, (SP 1 and SP 2) which is the Dam and associated infrastructure (SP 1) and the Primary and secondary distribution network (SP 2).

A further allowance is made for SP3 of $10m which is a further extension of the distribution network depending on demand, with an initial provision of $4.7m during the construction period.

Development of the RWSS business case

The RWSS has had considerable expert input over four years into the development of the business case and reviews of both the demand and financial models as shown in Fig. 2.

Figure 2: Development of the Business Case and Assumptions for Inputs into the Financial Model



The business and financial model is based on farmers contracting on a take or pay basis for 35 years aligning with the initial resource consent period, and or farmers buying water on the spot market.

The economic assumptions driving the demand model commenced with an on-farm profitability study undertaken in September 2012 by Macfarlane Rural Business Ltd (Macfarlane).

Macfarlane examined on-farm affordability of water and consequent profitability improvement and return on investment concluding that investment by the farmer (top 20%) in supporting on-farm infrastructure and the take or pay contract was economically justifiable.

Macfarlane budgets were presented to workshops involving farmers from within and outside the region, farm advisors, accountants, processors and other regional stakeholders; where parties tested, and debated the key assumptions used in Macfarlane reports, and ultimately concluded they were appropriate.

Further work on likely uptake following a survey of farmers was undertaken by Castalia Ltd (Castalia).

HBRIC Ltd. then sought expressions of interest (EOI) from farmers, which were then used by Castalia to produce a revised uptake forecast.

In 2015, Foundation Water User Agreements were released to water users which were maintained in a centralised database alongside potential water sales pipeline and comprehensive land mapping attributes.

A further dynamic demand model for HBRIC Ltd. was developed utilising these FWUA contracts and pipeline data by BNZ Advisory. Lewis Tucker completed a top down review for potential investors in the RWLP in 2016.

BNZ Advisory (BNZ) (now Waterview Capital Advisors) was retained by HBRIC Ltd. to assist in the development of the RWSS Business case model (including the Financial Model) which was presented to HBRC in March 2012.

Other key inputs to the Financial Model such as the design and construction costs, operating and maintenance costs and financing terms were derived utilising extensive tender processes combined with input and review from the respective expert advisers such as Snowy Mountain Engineering Corporation (SMEC), Bell Gully and Tonkin and Taylor.

Deloitte presented a comprehensive peer review of the business case to HBRC in May 2014, and presented subsequent updates up to July 2016.

A further audit (which included tax) of the financial model was undertaken by PWC in 2016.

Due Diligence completed by Institutional Investors and Debt Providers

Lewis Tucker completed a review of the business case on behalf of institutional investors and Crown Irrigation Investments Ltd (CIIL) as part of their Due Diligence. In this body of work, Lewis Tucker peer reviewed Macfarlane, and tested the water demand assumptions developed by BNZ Advisory.

In their report, Lewis Tucker supported Macfarlane's overarching conclusion that RWSS water is economically viable for a majority of farming systems.

"Comments by independent local experts who have also reviewed key assumptions and Farmax outputs suggest the assumptions are highly supportable and arguably conservative."

Lewis Tucker had some differences in approach to the BNZ methodology but did not materially disagree with the demand forecast at an aggregate level. As discussed later in my report, the slightly different approach produces some divergence in the earlier years in the respective demand curves and some difference in later years at the time of full take up.

Comment

Throughout the development, presentation and the gaining of funding and investment commitment for the business case, there has been consistent general agreement with the original Macfarlane findings determining on farm affordability for RWSS water and the demand model outputs developed by BNZ Advisory.

Further the introduction of third party shareholders and funders has brought an additional level of scrutiny. An institutional investor seeks good commercial returns in line with its risk appetite, and has a number of competing investments for its investment capital. Therefore, their commitment to invest in RWLP is an endorsement of the business case.

The business case has accordingly, through its phases of development and review, had a high level of scrutiny and consistent validation.

This should bring considerable comfort to HBRC as a major investor and scheme promotor via HBRIC Ltd., its 100% subsidiary.

Capital structure

RWLP will own and operate the RWSS. Based on the position as at July 2016, total funding required is $340 million, of which $310 million is the cost of construction and related activities and the balance is for financing and development costs. The source of funds and capital structure of RWLP at the end of the construction period is set out in Figure 3.

Figure 3: Capital Structure/Source of Funds

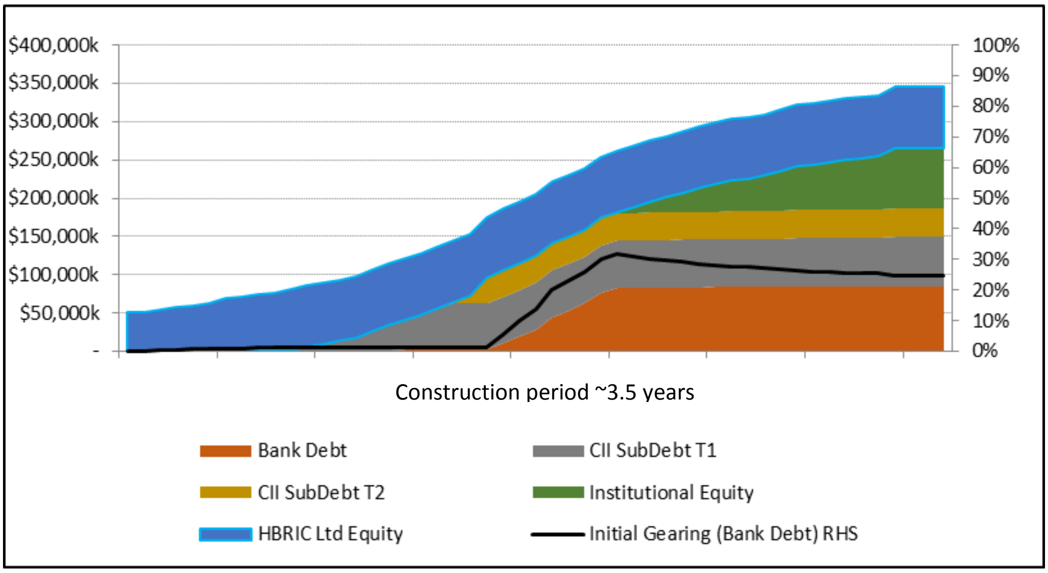
Sources of Funds	Total $'000	%
Debt Financing		
Main Bank Debt	80,000	23.6%
Bank Debt SP3	5,000	1.5%
Crown Irrigation Investment	95,000	28.0%
Total Debt Sources	**180,000**	**53.0%**
Equity Funding		
Institutional Equity	80,000	23.5%
HBRIC Ltd Equity	80,000	23.5%
Total Equity Funding	**160,000**	**47.1%**
Total Sources of Funds	**340,000**	**100.0%**

Source: The Financial Model

The construction of the RWSS and initial working capital required for its operations will be financed through a mix of senior bank debt, two tranches of sub-ordinated Crown debt (Crown Irrigation Investment or CIIL T1 and T2), an interest-bearing convertible note which converts to equity (Tukituki Note) and new equity provided by HBRIC Ltd. and an institutional investor.

Figure 4 demonstrates the funding waterfall required for the construction period. The flow of funds commences from financial close to the point of completion of construction with the investment first of HBRIC Ltd.'s equity (includes capitalised development costs to date) followed by CIIL (subordinated-debt), Senior Bank Debt and finally Institutional Investment.

Figure 4:Funding waterfall during construction period



HBRIC Ltd. Equity $80m

Institutional Equity $80m

CIL T2 Debt $35m

CIL T1 Debt $60m

Senior Bank Debt $85m

Total $340m

Source: The Financial Model

Financing of the RWSS

Summary of Terms

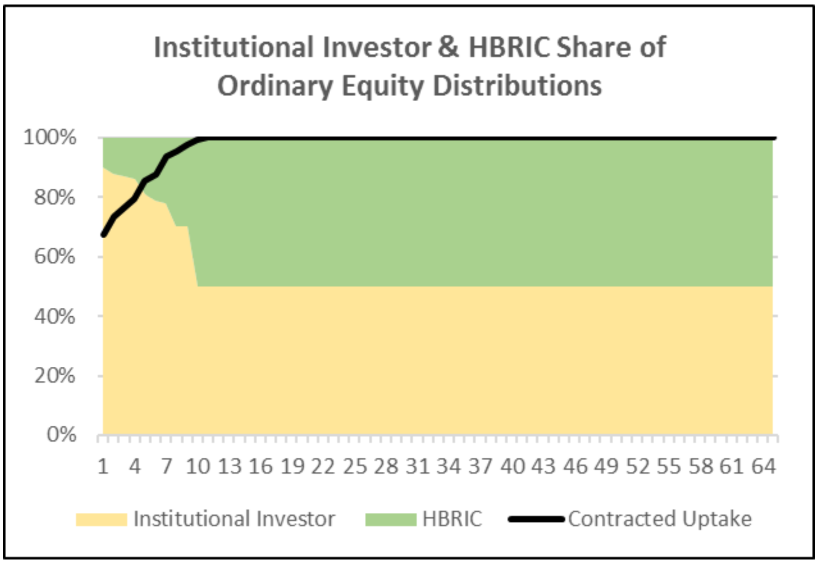
HBRC via HBRIC Ltd - will invest up to $80m

- Initial holding of 50% of partnership units, diluted to 42% following conversion of the Tukituki Note into equity in the partnership
- Right to appoint a board member
- Voting rights in proportion with partnership interest
- Distributions are by way of ordinary dividends, with the allocation as per the chart in Figure 5. HBRIC Ltd.'s returns are the inverse of the Institutional Investor during this period.
- At the later of 15 years post financial close or uptake reaching 75% the distributions are shared pro-rata.
-

Institutional Investor -will invest $80m (actual numbers may change)

- Initial holding of 50% of partnership units, diluted to 42% following conversion of the Tukituki Note into equity in the partnership
- Right to appoint a board member
- Voting rights in proportion with partnership interest
- Have an option to purchase 20% of HBRIC Ltd.'s shares during the first 5 years of operations
- Distributions are by way of a fixed investor fee and ordinary dividends
- Earns a greater than pro rata return prior to trigger date (the later of 15 years post Financial Close or uptake reaching 75%)
- Distributions are by the way of:
    - A Fixed Annual Investor Fee for 15 years post financial close
    - Ordinary dividends, with the allocation as per the chart below up to the later of 15 years or when uptake reaches 75%. At that point in time, distributions will switch to pro-rata.

Figure 5 Allocation of Ordinary Equity Distributions based on Uptake



Source: The Financial Model

Crown Irrigation Investments Ltd (CIIL) – will lend ~$95m (actual numbers may change)

- $95m subordinated debt split into two tranches
- Tranche 1 -$60m to be repaid from operating and financing cash flows
- Tranche 2 - $35 intended repayment from issue of Tukituki note (See below)
- If Tranche 2 not fully repaid from the proceeds of the Tukituki Note issuance, any outstanding balance will be added to Tranche 1
- Repayment of all outstanding principal required in year 15
- Interest at a concessional rate
- Facility establishment fee of 0.2% and undrawn fee of 0.2% p.a.

Bank-will lend up to $85m (actual numbers may change)

- Provision of $80m senior debt to fund construction plus additional debt to fund any new connections (assessed at $5m)
- Interest only for senior facility for initial 5-year term.
- Principal repayment commences in time for full repayment approx. 2 years prior to end of consent period and then the facility is redrawn in line with next consent period. To manage their risk, banks look to align the duration of their facilities with consent periods.
- First ranking security over RWSS assets
- Condition Precedent of 45m3 uptake pre-financial close

Tukituki Convertible Note (Tukituki Limited Partnership) – up to $35m

- Initial offer of Convertible Notes to be launched no later than 18 months post financial close for total subscriptions to repay CIIL Tranche 2 in full ($35m)
- Capital will be called from subscribers and allocated to CIIL repayment on construction completion
- It is envisaged a 5% coupon on the Tukituki Note will be payable from the date operations commence until the Trigger Date (the later of 15 years post financial close or uptake reaching 75%), at which point the Note converts to equity share in RWLP
- Returns prior to the trigger date will rank in cash flow priority above the Institutional Investor and HBRIC Ltd. but subordinated to senior and subordinated debt
- Units will attract RWLP voting rights from date capital is called (i.e. prior to conversion to equity)
- Initial offering will attract an ownership interest in RWSS extending beyond the end of the 70-year concession period
- Tukituki Note holders will have the right to nominate a board member if total subscriptions exceed $25m
- At year 71, they continue to own the same percentage as they did in year 69. E.g. the Tukituki Note accounts for 16% of common equity at year 69, and would account for 16% of common equity after the end of the concession period.

Priority payments to Investors and Funders

1. Senior bank debt has first priority, all interest and fees will be cash paid during operations and capitalised during construction.
2. CIIL's debt is subordinated to senior bank debt. It has second priority as to payment of interest and debt repayment. To the extent that Tranche 2, $35m is not repaid from the proceeds of the Tukituki Note issuance, the balance is repaid along with Tranche 1 over a 15-year period from operating and financing cash flows.
3. Tukituki Note ranks next in priority until conversion to equity, (the later of 15 years post financial close or uptake reaching 75%).
4. The Institutional Investor ranks next receiving an annual fixed fee 15 years from the commencement of operations and distribution of any excess cash available as per Fig. 5, then pro rata with other investors at 100% uptake (if achieved before 15 years) or the later of 15 years and 75% uptake (The trigger date).
5. HBRIC Ltd. shares the excess accordance with Fig. 5 -then pro rata with other investors at the trigger date.
6. Tukituki Note once converted to equity ranks pro-rata with other investors at the trigger date

Comment

The investors each have different priorities.

Tukituki funds are used to repay CIIL bridge funding, and are contributed at the end of construction. Tukituki has priority for its 5% coupon payment after the bank and CIIL, then ranks pro rata with other investors post Trigger Date on conversion to an equity investor.

HBRIC Ltd. funds are committed first to the Project as per Fig 4. Being equity, HBRIC Ltd. returns rank after banks, CIIL and Tukituki. Prior to the trigger date, it also ranks behind part of the return (the investor fee) received by Institutional Investors and HBRIC Ltd. After the trigger date, Tukituki, HBRIC Ltd. and Institutional Investor all rank equally and pro rata.

The Institutional Investor is the last funder /investor to advance capital into the Project, ~2.5-3 years after construction commencement. Prior to the trigger date part of its return (the investor fee) ranks ahead of HBRIC, but after Tukituki 's 5% coupon payment; the other part of its return ranks equally with HBRIC, as per Fig. 4.

As above, HBRIC Ltd. ranks last in distributions until conversion of Tukituki Note then pro rata with other investors.

Secondly, the investment has a different risk profile for each of the three investors.

Tukituki investors are protected as to income by the 5% coupon then participate pro rata when converted to equity and will continue to be owners of the scheme after 70 years. Additionally, the investment offers participating farmers a hedge against increasing water prices.

The Institutional Investor is in a preferred position from operations commencement until the trigger date (~8 years under the Base Case) earning a greater than pro-rata return prior to the trigger date and accordingly a higher overall return than HBRIC Ltd. receives directly from RWLP. However, the Institutional Investor's equity is cancelled after 70 years with the return of their equity in the scheme's assets to HBRC and Tukituki LP, who then benefit from the perpetual value of owning the Project.

Thirdly, more broadly there are additional benefits to HBRC which help deliver on their strategy as per its Long Term Plan.

While the Institutional Investor's position can be viewed as advantageous relative to HBRIC Ltd., it is indifferent to the benefits that the region receives in terms of environmental and economic impact, therefore it's more secure position can be seen as appropriate for a third-party investor.

HBRC has been established to deliver on the following strategies: (HBRC Long Term Plan -2015-2125)

-Economic growth through strategic investment

-Environmental benefits obtained in conjunction with economic growth

-Social improvements through job creation

-Limiting the Council's risk on future investment opportunities.

HBRIC Ltd. as the investment vehicle of HBRC and as an investor in RWLP seeks to deliver on those strategies, while also providing an appropriate return on investment. While HBRIC Ltd initially ranks behind the Institutional Investor in receiving investment returns, it ranks equally from the later of 15 years post financial close or uptake reaching 75% and also delivers significant enduring economic benefits to the region.

Revenue

Forecast revenue is a function of demand for irrigation and the price of water.

Demand for Water

The main determinant of the financial return from investing in the RWSS is the quantum and speed of water uptake. Key assumptions that drive the take up of water include affordability of water (contract and spot price), farm profitability, land use, appetite for farm conversion to maximise opportunities, on-farm conversion costs, level of irrigation optimisation and commodity prices.

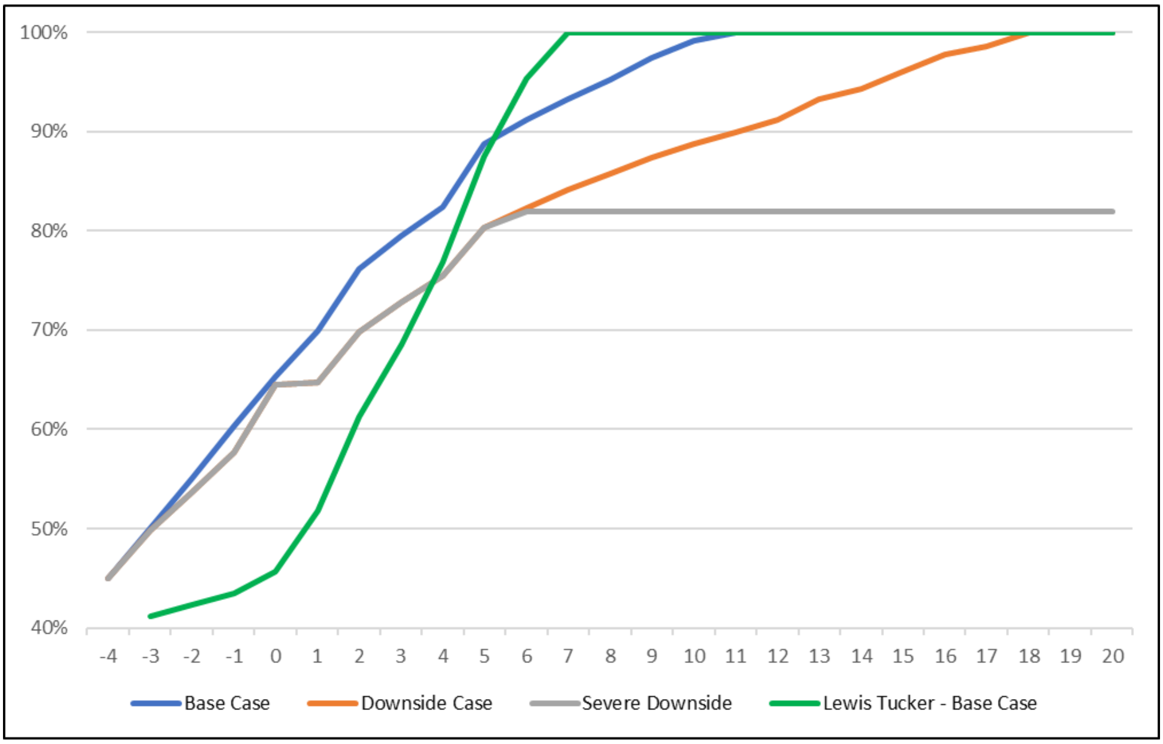
This report considers four water demand scenarios as described in Fig. 6 and calculated in Fig.7.

Figure 6 Description of Uptake Scenarios

Scenario	Description
Financial Model Base Case	Current contracted 42.8Mm3 increasing to 45Mm3 at start of Construction Period in line with Bank Condition Precedent then reaching full uptake 100Mm3 by Year 11 of Operations
Financial Model Downside Case	Current contracted 42.8Mm3 increasing to 45Mm3 at start of Construction Period in line with Bank Condition Precedent and then increasing to reach full uptake 100Mm3 by Year 18 of Operations
Financial Model Severe Downside Case	Current contracted 42.8Mm3 increases to 45Mm3 at start of Construction Period in line with Bank Condition Precedent and then caps at 82% in Year 6 of Operations
Lewis Tucker Case	Contracted uptake of 41mM3 at start of Construction Period. Slower contractual demand uptake during construction period but accelerates once operations start to reach full uptake by Operational Year 7.

Note: the financial model assumes 100% uptake is 100Mm3 under all scenarios.

Figure 7 Demand for Contracted Water - Uptake %



Source: The Financial Model

Note: This report assumes an opening position of 45Mm3 of contracted water under Base, Downside and Severe Downside Scenarios This volume is the Condition Precedent for bank finance. Lewis Tucker's demand curve is based on their top down review of demand that was completed at an earlier date. On a % basis, we have adjusted their curve to reflect a total volume of 100Mm3 not 104Mm3 as per their report to allow a meaningful comparison with the other scenarios.

Lewis Tucker Case reaches 100% uptake faster than the Base & Downside cases due to their assumptions of increased demand from optimal water use by FWU, FWU irrigating more land, new contracts, FWU spot demand and additional spot demand from users with no contracts.

Comment

There may be scope for an increase in HBRC's Condition Precedent *(see recommendation in Section: 'Summary and Key Risks')* for uptake before Financial Close e.g. negotiating a second tier of contracts with new users, or selling the option for spot water to existing FWU's. The lack of certainty of the Project going ahead could be a barrier for further uptake as well as general farmer fatigue. There is also a risk that construction costs continue to escalate. Based on these clear risks I would caution against increasing the CP significantly and incurring any more significant delays.

Based on the demand dynamics reported by MacFarlane and considered by other experts, the Severe Downside Case where uptake caps at 82% would seem unlikely. However, considering different scenarios is always prudent and the four scenarios used create a demand envelope, which when interrogated demonstrates that the Project is viable under each scenario. Albeit with different levels of gearing and financial returns for equity investors.

Price of Water

Pricing assumptions in the Financial Model:

- Foundation water users (FWU's) **contracted rate** of 27.5c/m3 less discount of 6c/m3 for the first 4 years, plus 2% pa escalation
- Ground water takes 14.4c/m3 plus 2% pa escalation
- New water takes 27.5c /m3 escalated at 2.5%
- Spot water 27.5c/ m3 escalated at 2.5% pa

Base Case assumes the value of water increases by 2.5% per annum (benchmarked against the PPI Agricultural Indices for both agri inputs/outputs whose 20-year average is ~4% p.a. Whereas the Downside and Severe Downside Cases assume only 2% per annum (mid-point of the RBNZ's target range for CPI inflation of 1-3%). The higher growth rate of 2.5% assumed in the Base Case represents the scarcity value of water and assumes a degree of demand inelasticity. Conversely, the 2% growth rate reflects the lower demand scenarios and more availability of water. Lewis Tucker recommend the spot water price is set at a material premium to the contracted price. I agree with this proposition and discuss it further below under Section- *Spot Water.* For the purposes of assessing the impact of their estimated demand curve on the financial returns, I have used a conservative 20% premium. Based on discussions with HBRIC management, while still to be decided, the premium will likely be higher.

Comment

The commitment shown by FWU's in signing up to 42.8Mm3 of water to date prior to absolute certainty of the Project going ahead, combined with the depth of analysis undertaken by Macfarlane and others on the drivers of demand and the affordability of water gives confidence on the affordability of the current water pricing model.

It is noted from discussions with HBRIC Ltd. Management that water pricing strategies are still be developed for both alternative water contracts and spot water sale (see comments below re spot water). These strategies should be encouraged and be targeted at driving uptake especially in the earlier years.

Spot Water Demand and Pricing

Work completed to date, provides for two scenarios and sets of assumptions for Spot Water:

1. The Financial Model spot water price is 27.5c/ m3, the same rate as the underlying market price (pre FWU 6/cm discount) and escalated at 2.5% pa.
2. Lewis Tucker suggest the spot price should be at a material premium to contracted price rebating the difference if farmers convert to contracted water in a 2-3 year period.

Comment

In considering the sensitivity of the viability of the Project to Spot Water, I have considered the impact on spot water volume and revenues from both option 1 and option 2 above.

Spot water volume is forecast to decline as a % of total demand over time as the contracted volume increases (to less than 1%). Spot water revenue is not material in terms of the overall size of the opportunity as it accounts for only approx. 7-8% of revenues in the Base Case and similar in the Lewis Tucker Case. However, if packaged and priced correctly, it is a valuable tool to incentivise irrigators to sign up for contracts and therefore drive earlier uptake.

Over time investing financing counter parties have agreed that the best approach will be to sell spot water at a material premium to the contracted water price to ensure there is an incentive for irrigators to contract. However, the magnitude of the premium remains undecided.

The current water spot price modelling assumption must be viewed as conservative. Spot water pricing should be set (and will be) at a level that incentivises non-irrigators users to sign up to water contracts to guarantee supply.

Further it is clear from considering HBRIC Ltd. current plans to acquire more water sales that a range of water contract offers with increased flexibility including spot water pricing will be presented to market in the months preceding financial close.

The assumption is that HBRIC Ltd. sales staff will be incentivised to optimise uptake.

Insurance

The following insurance is taken out by the contractor and is included in the contractor's fixed price contract:

- Material Damage – full coverage for the construction period $300m cover (until works completed) and a 24 months defects liability period thereafter.
- Advanced Loss of Profits – Until construction completion (to cover loss of revenue for delay); coverage for year 1 revenue, plus additional coverage for increased costs and claims costs etc-
- Public and Products Liability Insurance – Construction period plus 24 month defects period following completion-$50 cover
- D&C Professional Indemnity Insurance – For the construction period plus a period of 6 years thereafter $50m cover
- Contractor's plant and equipment insurance – for the construction period plus 24 months defects liability period-all items over $50k must be insured.
- Contractor's motor vehicle insurance - for the construction period plus 24 months defects liability period.

The following is paid for by RWLP (or by/via the operator) during the construction period, for an estimated (by Marsh) $60k p.a. This is reflected in the Financial Model:

- Statutory fines and penalties liability insurance
- Directors & Officers Liability Insurance

The following is paid for by RWLP (or by/via the operator) during the operating period, for an estimated $730k p.a. (by Marsh). This is reflected in the Financial Model:

- Industrial Special Risks (Material Damage) insurance, $200m - $300m for dam and distribution network reinstatement.
- Consequential Loss (Business Interruption) Insurance $25m
- Public and Products Liability Insurance up to $250m, Pollution event $10m
- Statutory fines and penalties liability insurance-$3m
- Directors & Officers Liability Insurance-$4m
- Professional Indemnity Insurance-$4m
- Motor Vehicle Insurance

Final details to be confirmed closer to financial close.

Comment

The insurance cover as outlined is appropriate for an infrastructure business and a substantial D&C contract.

Expenditure

Capital Expenditure- Design and Construction Contract

Within the Design and Construct Contract, the scope of construction works is divided into 3 portions:

- Separable Portion 1: Dam and associated infrastructure (SP1)
- Separable Portion 2: Primary and secondary distribution network (SP2)
- Separable Portion 3: Additional distribution network based on demand (SP3)

As at July 2016, the combined construction cost of SP1 and SP2 was $282m. Due to the delays in the scheme achieving financial close, this estimate will need to be updated and is likely to be higher than current due to the inflationary construction environment in New Zealand. For the purposes of this report, I have used the July 2016 cost estimates as shown in Fig. 8.

Figure 8 Construction Cost breakdown

Application of Funds	Total $'000	%
Construction Costs		
Dam, Generation & Distribution	282,000	82.9%
SP3 During Construction	4,700	1.4%
Construction period operating costs	15,300	4.5%
Land Acquisition	8,000	2.4%
Total Construction Costs	**310,000**	**91.2%**
Financing Costs		
Development Costs	17,300	5.1%
Funded Bank Balance	1,450	0.4%
Cash Paid Bank Interest	9,900	2.9%
Bank Upfront Fees	1,350	0.4%
Total Financing Costs	**30,000**	**8.8%**
Total Application of Funds	**340,000**	**100.0%**

Source: The Financial Model

Note: Some of the $10m SP3 costs are anticipated to be spend during the operating period (in line with uptake ramp up) and accordingly are not included in the above table, which focuses only on the construction period (prior to operations commencement). These costs have been included in the capex budget in the operating period.

Substantially all (98%) of the above aspects will be fixed (or expended) prior to or on financial close (i.e. before construction commences).

- Dam & Distribution is under a fixed price contract with OHL-Hawkins JV (offer has expired, will need to be renegotiated. Construction period operating costs will be substantially (~85%) covered by a fixed price contract with the O&M providers

- Land acquisition will be completed /contracted prior to financial close
- Development costs will have been expended on or prior to financial close
- Bank debt interest will be substantially hedged (banks will require >=75% hedging, probably more like 95-100% hedging)
- Facility establishment fees will be agreed prior to and payable on financial close

The only material component for which there is scope for variation (once financial is achieved) is funding for the additional network for users who sign up during construction (SP3). A fixed formula for pricing these connections will be agreed OHL-Hawkins, or HBRIC Ltd. (via the HBRC Works Group) will have the option to undertake the construction themselves. The budgeted amount for these connections has been reviewed by technical advisors and is considered appropriate even for a wide range of uptake mapping scenarios.

To the extent costs are higher than expected, the relative cost of the additional network is so small (as it is largely infilling) that, even with a substantial increase in price, marginal economics are sufficiently compelling such that it can be 100% funded by bank debt. Furthermore, for connections that are relatively expensive, connections charges (which have not been factored into the model) can be utilised.

Comment

The D&C contract (if renewed on same terms and conditions) has so far as the conduct of the contract is concerned, been substantially de-risked with appropriate provisions in place to protect RWLP in the event of any performance issues.

The contract has a fixed price insulating HBRIC Ltd. against cost increases other than for expansion of the network which would not have a material impact.

The most significant risk is around balance sheet integrity of the consortium and both the HBRIC Ltd. Directors and the Bank will be giving that appropriate focus. The Directors will need to provide assurance that the consortium is financially fit for purpose.

The recent announcement of Hawkins change of ownership should give greater assurance on that issue.

Lifecycle capex estimates

The Financial Model correctly takes into account the need for lifecycle capex. Technical advice has been sought by RWSS from engineering firm SMEC (technical advisors to RWLP and experienced Hydro dam engineers) to determine the requirements. The total budget as shown in Fig. 9, is in aggregate $15.4m (in today's dollar) between Years 15 and 30. The budget also includes provision for recurring capex in subsequent periods.There are further estimates of $359k for hydro instrument upgrade and $2.16m for power station upgrade that are still in the model but turned off on the current assumption that the power station will not be built.

Figure 9 Lifecycle Capex Assumptions

Item	Year	NZ$'000
Controls & Instrument Upgrade - Distribution	year 15	3,303
Pumpstations Overhaul	year 20	7,985
Intake Hydro - Mechanical	year 30	342
Waterway Hydro - Mechanical	year 30	640
Dam Surveillance Instrumentation	year 30	171
Re-Consenting Costs initial application	year 29	1,000
Re-Consenting Costs continued application	year 30	2,000
Total over 30 Year Period		**15,442**

Source: The Financial Model

Note: estimated by SMEC, in current dollars and then inflated such that (for example) 15 years of inflation is applied to the first Distribution controls and instrument upgrade in year 15.

Comment

As commented above the expert advice, the level of detail and consideration given to key asset replacement is evidence of very good robust process followed to set the assumptions in the budget.

Operational and Maintenance costs (O&M Costs

O&M costs have been properly researched in considerable detail, during the construction and operating periods.

Ongoing operation costs for administration ($844k), Mitigation ($1m-$1.4m), Operational ($3.7m) have been inflation adjusted.

The ongoing cost of $7- $9m is at a level where any departure from budget will not have any material impact

Comment

Operation and Maintenance costs are shown in considerable detail over the construction period. There is clearly a very rigorous approach to cost estimation with input from independent experts where appropriate.

Costs throughout the construction period are substantially covered up to 85% through fixed price contracts.

Annual O&M costs are $7.7m in Year 1 and then are inflation adjusted throughout the operation period.

Overall there can be a high level of confidence in the cost estimation process.

Cost increases given the relatively low ongoing level should have little material impact on the project returns.

Growth assumptions –Revenue and Expenditure

Growth factors have been properly allowed for in the forecasts as follows:

- Market value of water: 2.5% p.a. (This covers spot volumes and new (post financial close) but excludes foundation contracts (contracts signed pre-financial close) which are based on CPI)
- OHL-Hawkins JV Fixed Price Construction Cost: 0% inflation added as inflation is already included in the JV's fixed price
- Everything else: 2.0% p.a. (this includes CPI based water contracts, and all other operating and capital costs)

The 2.0% p.a. assumption reflects the midpoint of the RBNZ's 1-3% CPI inflation target band, and slightly lower than historical CPI over the past ~20 years (which was closer to ~2.2% p.a. when last analysed).

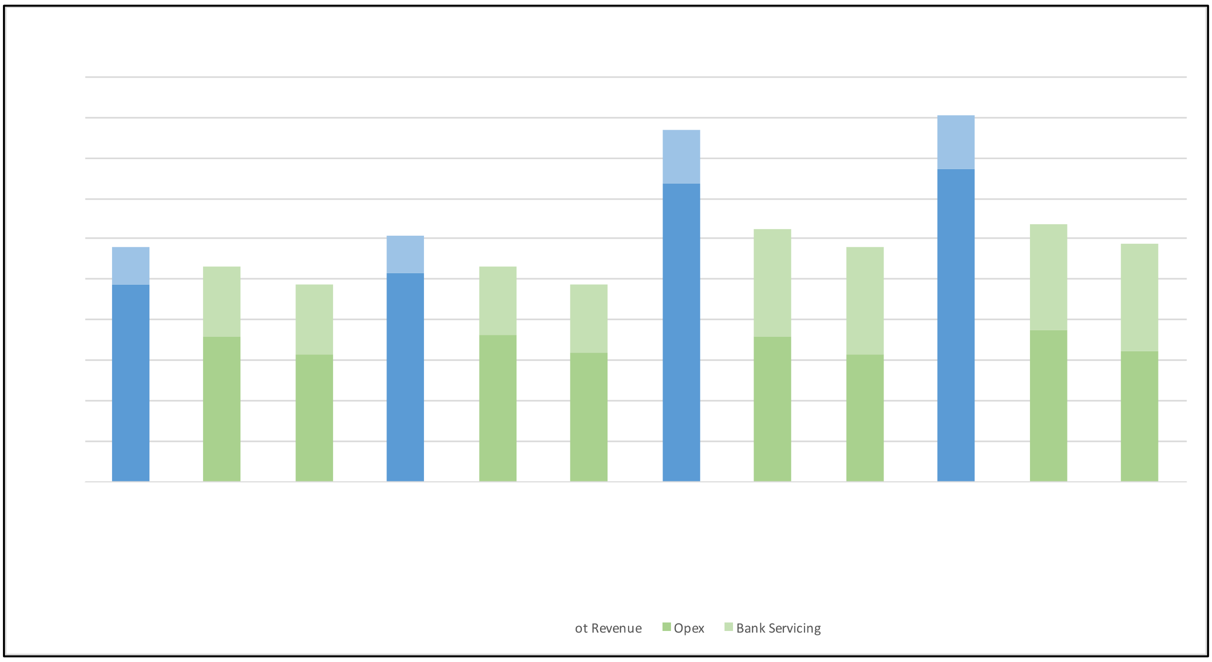
The 2.5% p.a. assumption reflects the fact that scarcity and value of water is anticipated to increase over time.

Cash Flow

Breakeven Assessment

If at the simplest level, it is assumed that "Breakeven" is defined as the scheme can generate sufficient revenue to cover its operational and first priority bank service costs as a minimum, as shown in Fig. 10, the scheme achieves this in Year 1 under both the current contracted uptake of 42.8Mm3 and the Bank Funding Condition Precedent amount of 45Mm3. In other words, even in the highly unlikely scenario there is no further uptake beyond what is currently contracted in the FWUA, the scheme would breakeven at this level in Year 1.

Figure 10 Breakeven Analysis (Revenue > Opex & Bank Servicing)



Source: The Financial Model

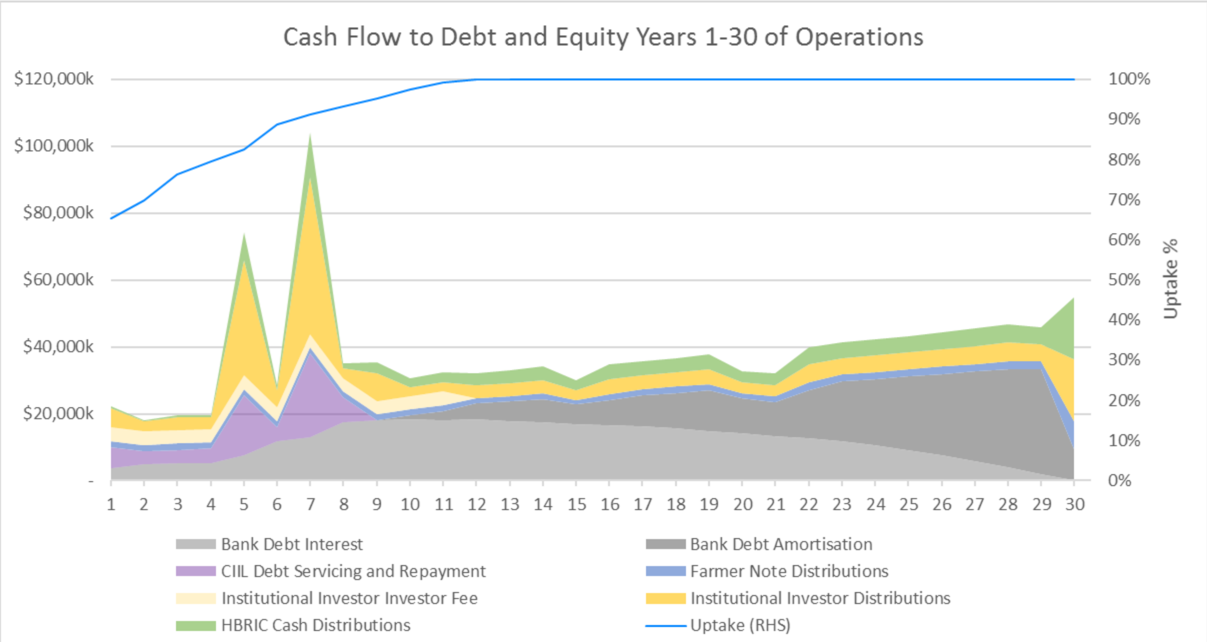
Note: in the Flat Uptake Scenario of 42.8Mm3 (Includes spot water), Year 6 revenue increases due to the discounts rolling off after 4 years and the impact of water price escalation.

Available Free Cash Flow to Service Debt and Distribute to Equity Investors

Figs. 11, 12, 13 denote the availability and use of free cash flow available from operations (less any capital expenditure) under the base, downside and severe downside case scenarios to pay dividends to the providers of equity after all debt servicing and repayment obligations have been met over the first 30 years of operation and as uptake increases.

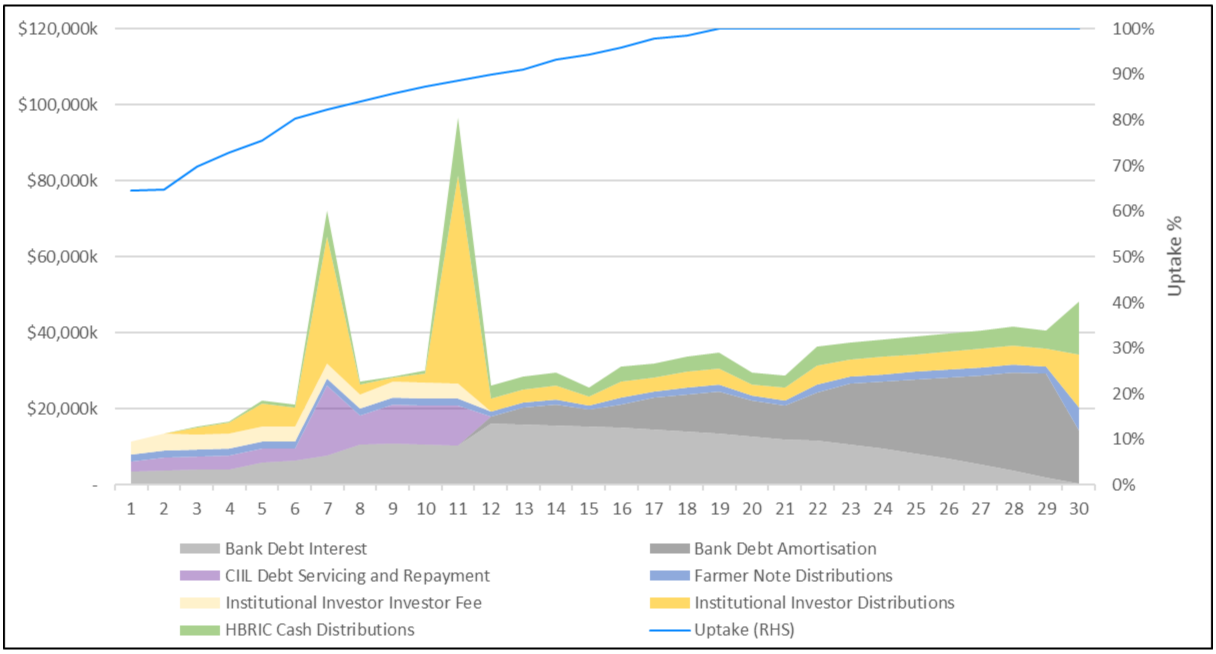
The spikes in Figs. 11, 12, 13 are due to additional debt being drawn down to repay CIIL as required and also pay lump sum distributions to investors as uptake and therefore contracted revenues increase, in turn allowing a step up in gearing as discussed later on in *Section- 'Gearing & Debt Servicing.'* These drawdowns are illustrative for modelling purposes, in reality a smoother Treasury Policy may be applied to mitigate any inefficiencies. The Lewis Tucker case is broadly comparable to Base Case so is not included.

Figure 11: Free Cash Flow to Debt and Equity Operational Years 1-30 - Base Case



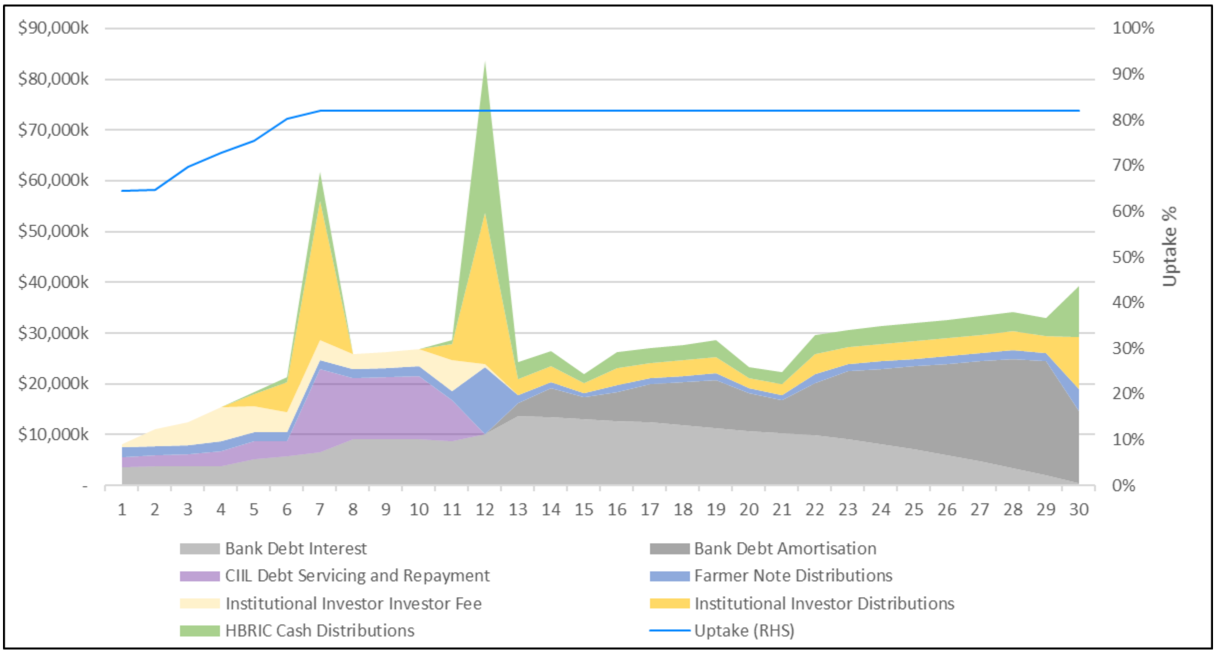
Source: The Financial Model

Figure 12: Free Cash Flow to Debt and Equity Operational Years 1-30 - Downside Case



Source: The Financial Model

Figure 13:Free Cash Flow to Debt and Equity Operational Years 1-30 - Severe Downside Case



Source: The Financial Model

Comment

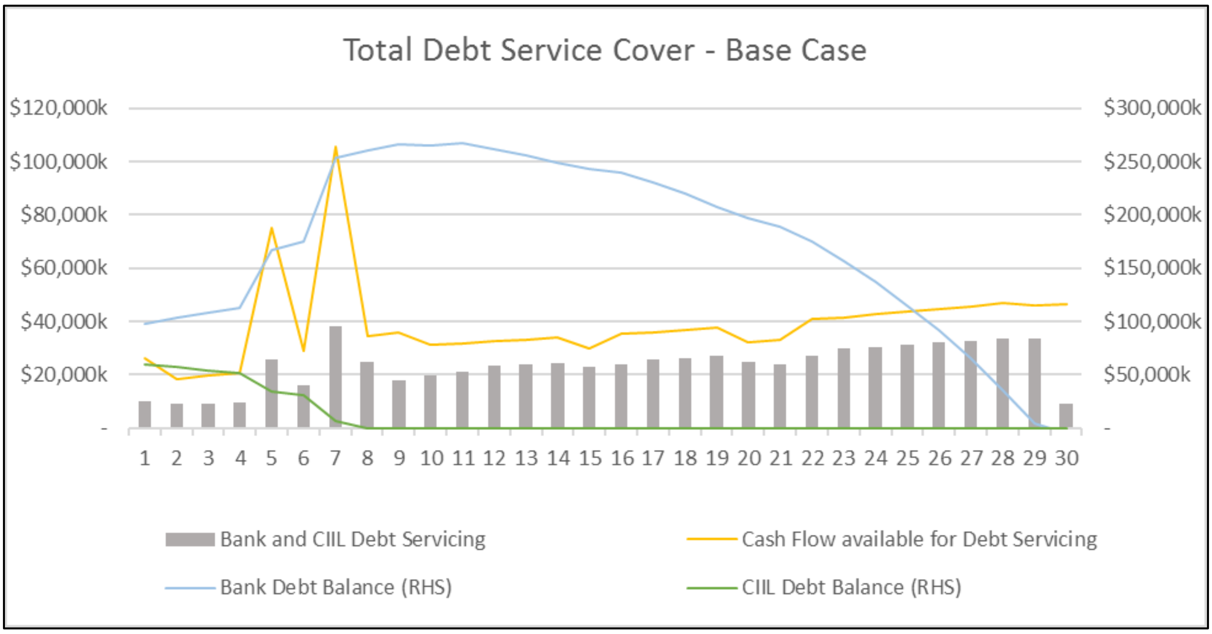
These charts illustrate the application of free cash flow to meet RWSS's debt servicing obligations (bank interest and Tukituki Note coupon payments), principal repayments (Bank and CIIL) and providing distributions to equity investors (HBRIC, the Institutional Investor and following conversion the Tukituki Note owners) as uptake increases in each scenario.

In the Base Case and all other demand scenarios there is sufficient free cash flow from operations to cover all debt obligations and to provide a return to the equity investors.

Debt Service Cover

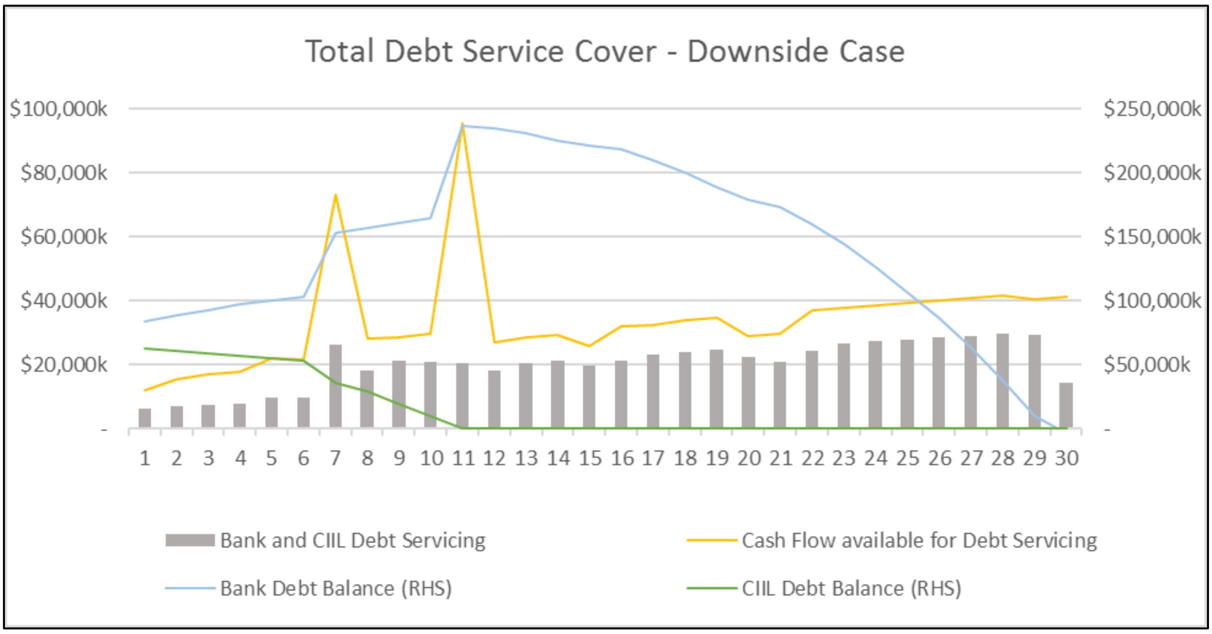
Under each scenario, the LHS axis shows there is sufficient cash flow available from Year 1 of operations onwards to cover the servicing and repayment of Bank Debt and remaining CIIL Debt (Tranche 1, plus any carry over of Tranche 2). Over time, the debt balances of both facilities can be reduced (as shown on the RHS axis of each chart in Figs. 14-16).

Figure 14 Total Debt Service Cover - Base Case



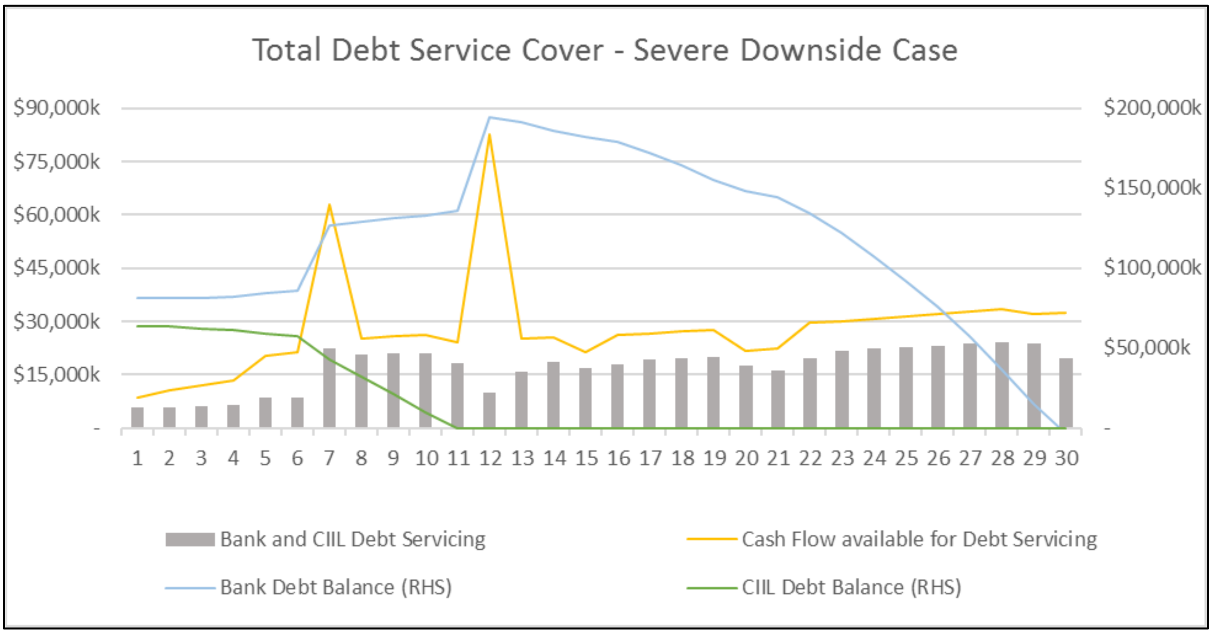
Source: The Financial Model

Figure 15 Total Debt Service Cover- Downside Case



Source: The Financial Model

Figure 16 Total Debt Service Cover- Severe Downside Case



Source: The Financial Model

Comment

In each scenario, RWLP meets its obligations to repay CIIL, by replacing it with bank debt.

Less debt is drawn down in the Downside and Severe Downside cases to maintain appropriate gearing (due to lower cash flow) of RWLP.

Subject to final confirmation, the only financial covenant being requested by the bank is the Debt Service Cover ratio of 1.1x. The Financial Model assumes RWLP can continue to increase borrowing beyond initial drawdown as long as it meets the debt servicing requirements. At this level of required cover, RWLP is fully covenant complaint under each scenario.

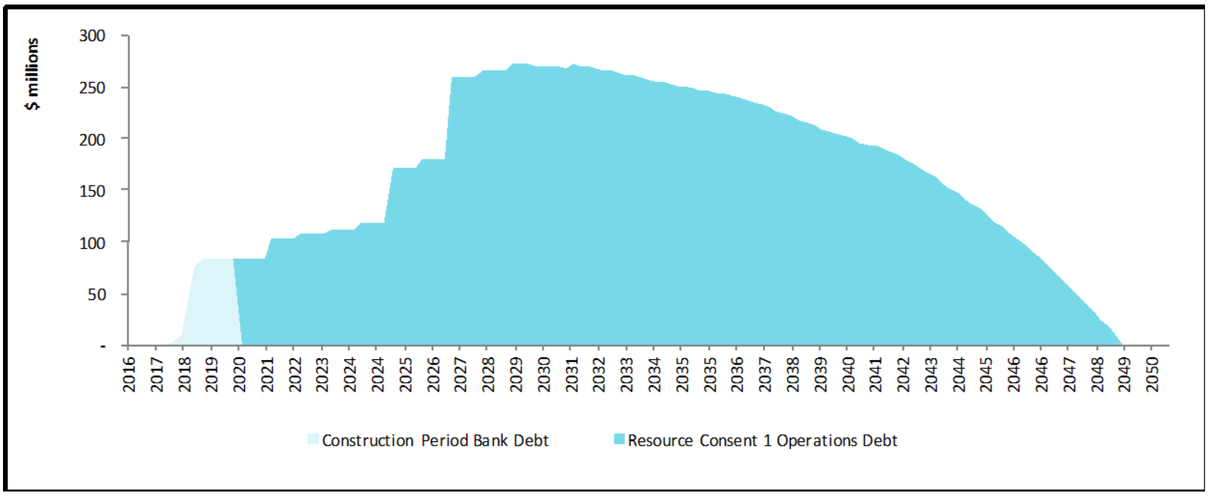
Gearing

Fig. 17 demonstrates RWLP will start to take on debt from Financial Close with a combination of senior bank debt and CIIL debt providing 53% of the required funds to be drawn down over the construction period.

In the operations phase, the proportion of the project funded by debt increases over time as uptake and therefore contracted revenues increase. The debt drawn down in Years 5 and 7, as shown in the step up of debt in Fig. 17, is used to repay CIIL and pay lump sum distributions to equity investors.

Debt is then anticipated to be fully repaid by end of first consent period and then redrawn. To maximise equity returns, over the 70 years, the Financial Model assumes debt increases where it can do prudently for financial efficiency at any point of time.

Figure 17 Debt Drawdown and Repayment during Construction and Operation



Source: The Financial Model

Note: Year dates used here are for illustrative purposes only. Construction start date is dependent on date of financial close. Construction period ~3.5 years. For modelling purposes Debt will be fully repaid by end of first consent period and then redrawn in line with new consent period.

The amount and timing of the draw down of debt, results in the gearing percentage increasing over time, e.g. from 24% pre-Close, to 35% gearing once operational and 50% gearing once uptake reaches 80%, and 70% once uptake reaches 90%. Gearing then then starts to decrease again as senior debt commences amortisation prior to the end of the first concession period

In the Base Case, Senior debt gearing peaks at 69% in Year 7,8,9 of Operations when Uptake reaches 93% and then starts to reduce. Fig. 18. shows the correlation between uptake and gearing in the early years.

Figure 18 Debt Gearing and Uptake % from Construction to Year 30 of Operations – Base Case

Balance Sheet Gearing Metrics																					
Year	$ 000's	-4	-3	-2	-1	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Gross Senior Debt / EV Gearing			1%	5%	29%	25%	35%	35%	35%	35%	48%	49%	69%	69%	69%	67%	66%	63%	61%	58%	55%
Gross Total Debt / EV Gearing			7%	58%	63%	44%	55%	53%	51%	50%	58%	58%	71%	69%	69%	67%	66%	63%	61%	58%	55%
Water Uptake %		45%	50%	55%	60%	65%	70%	76%	80%	82%	89%	91%	93%	95%	97%	99%	100%	100%	100%	100%	100%

Balance Sheet Gearing Metrics																
Year	$ 000's	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30
Gross Senior Debt / EV Gearing		52%	49%	46%	42%	39%	36%	33%	29%	25%	20%	16%	11%	6%	1%	0%
Gross Total Debt / EV Gearing		52%	49%	46%	42%	39%	36%	33%	29%	25%	20%	16%	11%	6%	1%	0%
Water Uptake %		100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%

Source: The Financial Model

Note: EV is Enterprise Value. The Enterprise Value has been estimated in the Financial Model using the Discounted Cash Flow valuation methodology and a WACC of 8.5%.

Comment

Bank debt is assumed to be paid down to nil in advance of the resource consent rollover at year 31 of Operations before being re-drawn once the consent renewal is secured. This is conservative relative to current banking practice for irrigation schemes, which generally allows for a level of debt to be outstanding through a consent renewal process.

While at 69%, the project is highly geared, it is only for a three-year period before its starts to reduce.

The drawdown of debt and the distributions to equity investors are a proxy for modelling purposes and are very lumpy in the Financial Model. I recommend an appropriate Treasury Policy should be developed by RWLP in consultation with the debt and equity providers to mitigate the inefficiencies.

Working Capital is provided for by a cash buffer assumption in the Financial Model. Cash is retained to meet at least the next 12 months' cash flow requirements whilst uptake is less than 60% and 6 months' cash flow requirements thereafter. This is a prudent assumption.

HBRIC Ltd. Returns from RWLP

Fig. 19 below shows the return received by HBRIC Ltd. as an investor in the owner of the dam RWLP. The returns to HBRIC Ltd. are considered over three time periods from start of construction onwards:

- Years 1-15 – from start of construction
- Years 1-35 – from start of construction and over the first consent period
- Over the lifetime of the Project

Based on the actual cash available for distributions the post -tax returns to HBRIC Ltd are as follows:

Figure 19 HBRIC returns from actual cash available

HBRIC Return on Investment from RWLP (post tax)

	Base	Downside	Severe Downside	Lewis Tucker
Years 1-15 (post-tax cash yield)	3.4%	2.6%	2.2%	3.5%
Years 1-35 (post tax cash yield)	10.8%	8.5%	7.3%	10.3%
Project Life IRR (Inc Terminal Value)	7.1%	6.2%	5.8%	6.5%

Source: The Financial Model

Notes: 1. Based on cash distribution from RWLP. Excludes 6% return requirement of HBRC. 2. For the Returns Analysis Year 1 is the first year of construction. 3. Assumes HBRC $80m is not fully drawn down on day 1 but progressively over construction period.

The post-tax cash return for the first 35 years to HBRIC Ltd. as an investor in RWLP ranges from 7.3% (Extreme Downside) to 10.8% % (Base Case.)

The Internal Rate of Return (IRR) for the life of the project in all demand scenarios is estimated to be within a range of 5.8% to 7.1%. This return is lower than the cash return because the cash return does not take into account time value of money, and is therefore not impacted by the ~nil return during construction and concessionary return during the uptake period.

The 7.1% base case return to HBRIC Ltd. compares with 9.6% IRR for other investors combined.

It is also worth noting that, given HBRIC is also the 100% owner of Port of Napier, it will also benefit to the extent RWSS results in increased Port throughput. Analysis undertaken by Butcher and Associates and WCA indicate an increase in post-tax IRR of ~130bps to 8.4%.

Fig. 20 considers the return to HBRC, taking account of its requirement expressed in the HBRC Long Term Plan (LTP) to receive at least a cash return of 6% year-on-year as discussed further in the next section.

Figure 20 HBRC Returns allowing for 6% dividend requirement to be met

HBRC Return on Investment from HBRIC Ltd. (Post tax)

	Base	Downside	Severe Downside	Lewis Tucker
Years 1-15 (cash yield)	7.0%	7.0%	6.1%	6.9%
Years 1-35 (cash yield)	14.0%	12.1%	11.4%	13.6%
Project Life IRR (Inc Terminal Value)	9.2%	8.7%	8.6%	9.0%

Source: The Financial Model

Note: Year 1 is the first year of construction. Assumes distribution of min. 6%, equivalent to $4.8m p.a. to HBRC

The cash return to the HBRC as the 100% investor in HBRIC Ltd. is enhanced by including from day 1 through the construction period the 6% required return of $4.8m and ranges from 11.4% (Severe Downside) to 14.0% (Base Case.)

The internal rate of return over all the demand scenarios is a range of 8.6% to 9.2%.

Base case IRR would increase in aggregate to 10.5% with the Port of Napier throughput impact referred to above.

The returns analysis shows that under all demand scenarios there is a return to HBRIC Ltd. which can be distributed to HBRC. Whilst returns in the first period measured (Years 1-15) are compromised by the nil return during the construction period, in the second measurement period (Years 1-35) both the Base Case and the Lewis Tucker Case show a good return compared to the benchmark data below (fig. 21). While in same period HBRIC Ltd receives a low to moderate return under the Downside and Extreme Downside case it is still within an acceptable range.

Overall, the return to HBRC as an investor is an acceptable infrastructure return at all levels.

Figure 21 Returns Benchmarking

Cash on 12-month term deposit	2-3.5%
Port of Napier (Return on Shareholder Funds)	7%
Electricity and Gas Industry IRR	6%

Sources: Cash rate from Depositrate.co.nz, Port of Napier from its "Statement of Corporate Intent 2016-2019" and is the forecast for FY16/17.

Further, importantly there is no additional capital required from HBRC as the cash flows support all operational and financing requirements under each scenario.

For additional consideration when assessing the potential financial return to HBRIC Ltd. is that HBRC could consider a partial exit of its shareholding in RWLP in the future and therefore receive a lump sum return of capital it could recycle for other uses. An exit could take many different forms, but one option is that under the agreement with the institutional investor, the institutional investor has an option to purchase 20% of HBRIC Ltd.'s shares during the first 5 years of operations.

The enhanced return received by HBRC as a consequence of HBRIC requiring a cash return of 6% from the outset, is reflected in the increased returns under all scenarios. It is assumed that HBRC receives all available income plus an additional amount so that in aggregate its 6% cash return requirement is met. As this 6% return is only enabled in the early years by HBRIC Ltd. taking on additional debt, it is open to HBRC to consider allowing HBRIC Ltd. to retain some excess income above the $4.8m p.a. distribution to reduce the level of debt on its balance sheet.The distribution received by HBRIC begins to equate and exceed the 6% cash return at Year 22 of Operations.

HBRC 6% cash return requirement

Impact of HBRC 6% cash return requirements on HBRIC Ltd. and consequences of returns not achieving 6%

A Condition Precedent (C.P.) of the scheme requires a cash return of 6% from RWSS equivalent to $4.8m per annum based on HBRC's investment of $80m from day 1.

As discussed below this requirement is reflected in HBRC's Long Term Plan provision for dividends from HBRIC Ltd.

The ability of RWSS to pay at a minimum a 6% return to HBRIC Ltd. is some years away. The distribution to HBRIC Ltd. begins to equate to $4.8m p.a. around Years 20-22 of Operations.

Accordingly, the funding of this requirement, which has to be seen as unorthodox, will require a combination of additional borrowing by HBRIC Ltd. and enhanced dividends from the Port of Napier (PON).

An April 2016 report from HBRIC Ltd. submitted to Council proposed special PON dividends covering the construction period (4 years) of $3.5-3.6m. per annum.

I have for the purposes of the exercise adopted this level of dividends leaving the balance of funding required from additional debt.

In the Base case, financial model distributions reach a level at Year 20-22 of Operations where funding the cash 6% distribution will no longer require borrowing to make up any shortfall.

The tables below illustrate the impact on debt levels and debt as a percentage of HBRIC Ltd. value* under the Base Case, Downside case and Severe Downside cases of funding the required dividend through special dividends from the Port and Debt.

It will be for the HBRIC Ltd Directors to determine the optimum capital structure and dividend and debt mix having regard to the need not to compromise the capital needs of the Port.

The debt required by HBRIC Ltd. to satisfy the 6% requirement ranges from:

Year 10: $18.1m to $44.5m

Year 20: $41.7m to $52.8m

Year 30: $63m to $80m

As illustrated below in Fig. 22 Debt levels as a percentage of value range from 4.4% to 13% which is above the current borrowing cap of 5% and would require Council approval.This level of gearing is relatively conservative.

**HBRIC Ltd. estimated value for the pruposes of this analysis is PON $238.5m plus RWSS $80m, adjusted for increase in value of 2% p.a. in line with CPI estimates.*

Figure 22 Impact on HBRIC Ltd. balance sheet of paying 6% cash dividend to HBRC

Impact on HBRIC of Paying Cash Dividend of 6% to HBRC
Assumes the dividend requirement is funded during the construction period through to Year 1 of operations by a combination of a Special Dividend from Port of Napier and bank debt.
From Year 1 of operations onwards, the requirement is funded by available cash distributions and bank debt.

	Base Case			Downside Case			Severe Downside case		
	10yrs	**20 yrs**	**30 yrs**	**10 yrs**	**20 yrs**	**30yrs**	**10yrs**	**20yrs**	**30yrs**
Cumulative Cash Dividend-6% ($m)	67.2	115.2	163.2	67.2	115.2	163.2	67.2	115.2	163.2
Cumulative RWLP distributions ($m)	36.3	62.1	89.8	14.6	51.7	75.7	10.8	56.1	73.3
Cumulative Port Special Dividend ($m)	14.3	14.3	14.3	14.3	14.3	14.3	14.3	14.3	14.3
Net Debt ($m)	18.1	41.7	62.8	40.5	52.8	77.6	44.5	48.8	80.7
Debt as a % of HBRIC value	4.4%	8.3%	10.3%	9.8%	10.5%	12.7%	10.8%	9.7%	13.2%
Cumulative Capitalised Interest	-1.5	-2.9	-3.7	-2.2	-3.5	-4.4	-2.4	-4.0	-5.1

Notes:
1 Assumes full $80m investment by HBRIC in RWLP drawn down in Year -3
2 Port of Napier opening value of $238.5m
3 HBRIC value comprises of HBRIC's shareholding in RWLP and Port of Napier adjusted annually for CPI at 2%
4 RWLP Distributions are post tax and take into account tax losses in earlier years.
5 Interest on debt is capitalised at an assumed interest rate of 4% to Year 0, 5% Year 1-3, 6% thereafter and adds to cost of bridging the gap between the required distribution and cash available
6 When balance sheet allows debt is repaid then re drawn at a later date if required
7 Years of Operation -ie plus 4 allowing for construction period

The amount of debt on HBRIC Ltd.'s balance sheet is not at an unacceptable level of gearing. However, it does illustrate the balance sheet impact of requiring a return over an extended period long before the scheme reaches that level year on year and commits HBRIC Ltd. to an extended level of debt than would otherwise be required in a more orthodox situation.

This will impose a constraint on HBRIC Ltd. on investment in other capital projects.

HBRIC Ltd.'s returns from the RWLP are relatively lumpy due the underlying assumptions of project debt levels. with RWLP drawing down debt in response to various uptake levels then repaid in accordance with the loan conditions and fully repaid around the end of the consent period.

The assumption is that this lumpiness can be smoothed by the application of a Treasury policy within RWLP, which will enable a smoother and more predictable distribution to HBRIC Ltd. and hence HBRC.

Further, in time RWLP should (if current banking dynamics persist) be able to get to a point that does not require full repayment of all remaining debt at the end of the first consent period. This has the potential to reduce the level of debt carried by HBRIC to finance the enhanced return required by HBRC.

This has the potential to reduce the peak level of debt carried by HBRIC Ltd. to finance the enhanced return required by HBRC.

A more effective Treasury policy should be considered and I am confident will be.

Impact on HBRC Long-Term Plan (LTP) of cash return falling below 6%

The LTP 2015-2025 has provided for a 6 % cash return on funds invested in the scheme.

Dividend income from HBRIC Ltd. for the next 3 years provided for in the Long Term Plan is:

2017/18	$10.5m
2018/19	12.5m
2019/20	12.5m

Dividends reflect returns from the Port of Napier and RWLP. The investment income provided for in the LTP forms a material part of the funding of LTP expenditure.

Revenue from rates is around the $18m level. A reduction of investment income arising from the RWLP return falling by $1-2m would for example have a negative rate impact of 5-10% per annum assuming the reduction was replaced by increases in rates.

Impact on Port of Napier

The Port of Napier Ltd operates as a separate legal entity and for the avoidance of doubt it is important to stress that a financial and legal failure of the RWSS will not impact on the financial integrity of the Port with its separate capital structure.

A need for enhanced dividends from the Port HBRC to underwrite the 6% cash return does have the potential to impact the Port but I am confident that the HBRIC Ltd. Directors will balance the needs of the Port and HBRC without adverse impact on the future capital requirements of the Port.

Summary and Key Risks

Design and Construct Contract(D&C)

The Design and Construct price risk has been covered by the fixed price contract except for any further extension to the distribution network (SP3) which would effectively be responding to demand and covered by additional revenue.

However, the project will need to be repriced at a level which does not adversely impact on the Financial Model outcomes in particular the contract water price. Rule of thumb, a $10m increase in construction price is covered by a 1c water price increase.

The major D&C risk is balance sheet integrity of the consortia partners, a risk that the Bank and other investor/funders will also wish to be satisfied. Recent ownership announcements in relation to Hawkins appear to provide some additional assurance.

Asset replacement costs (lifecycle capex) have been professionally assessed in years 15-30, therefore I am satisfied that asset replacement (depreciation) has been properly provided for.

Demand

Uptake remains the major risk issue influencing the success and viability of the project notwithstanding that the development of the demand curves has emerged from a very rigorous process.

Council needs to be satisfied that the uptake momentum is demonstrated i.e. FWUA contracts renewed and more uptake contracted in a time period which does not further contribute cost increases by delay but gives Council confidence around uptake targets.

This can be partly mitigated by the imposition of a demand condition precedent(CP). There is a tension here between further delay thereby creating the potential for increasing construction costs and giving the Council assurance of uptake momentum.

There remains a challenge for HBRIC Ltd. to obtain water contract commitments when final approval for the scheme to go ahead has not been made.

I recommend a Condition Precedent of achieving uptake of 48Mm3. This represents an increase on the FWUA's current commitment of 12.1% which is a material increase.

Operation and Maintenance Costs (O&M)

Operation and maintenance costs throughout the construction period and the first 15 years of operation are substantially fixed, and then modelled for the remainder of the consent period with appropriate allowances for inflation.

O&M costs are covered in all demand scenarios at present uptake levels.

The relative quantum of O&M costs is such that any increases more than inflation would have minimal impact and there is an allowance for cost increases in excess of inflation to be passed through to water users in the FWUA.

Debt

Debt servicing, senior bank debt and CIIL debt, are covered in all demand scenarios. RWLP also is also compliant with bank debt servicing cover covenants in all demand scenarios.

Investment

Failure to achieve the forecast return can have an impact on the HBRC Long Term Plan, although this would have to be a level where the 6% year on year cash return is not sustainable. Even at severe downside demand level a post-tax 7.2% return is achieved by HBRIC Ltd. although the debt then required to service the 6% cash dividend increases to maximum $80m in year 30.

A Treasury Policy which enables RWLP to roll over debt facilities through the end of the consent period into the next would enable increased distributions to HBRIC Ltd. and potentially reduced debt in HBRIC.

Debt as percentage of HBRIC Ltd. value would range in the demand uptake scenarios between 9-13% so on the face of it -not at an unacceptable level.

Failure not to procced with the scheme would also impact on the LTP, absent any alternative investment returning 6% cash or returns from the Port of Napier increasing to a level which enable HBRIC Ltd. to maintain the forecast dividend.

NOTE:

There is a potential tax liability arising from the payment of the 6% cash dividend to HBRC, however I note there is work being undertaken to address the capital structure of the Port of Napier and HBRIC Ltd. which could potentially mitigate an adverse tax impact.

Bankability

Continuity of Bank support is crucial, initially on renewal of the contract noting that there is a condition precedent of achieving uptake of 45M m3.

Extension of the banking facility to the end of the consent period (35 years) and beyond is necessary for RWLP. In addition, bank support for HBRIC with the anticipated additional debt loading to maintain distributions at $4.8m pa will need to be confirmed.

LEWIS TUCKER & CO.

UNLOCKING ENTERPRISE VALUE

HAWKE'S BAY REGIONAL COUNCIL

RUATANIWHA Water Storage

RUATANIWHA WATER STORAGE SCHEME (RWSS)

COMMERCIAL REVIEW BY THE HAWKES BAY REGIONAL COUNCIL (HBRC)

EXECUTIVE SUMMARY

Hawkes Bay Regional Council (HBRC) is undertaking a review of the Ruataniwha Water Storage Scheme (RWSS) Project for its recently elected Councillors. Lewis Tucker & Co (Lewis Tucker) has been retained to assist HBRC in reviewing on-farm affordability and assessing farmer uptake and aggregate water demand. This report also addresses two other relevant topics; spot water and RWSS's Foundation Water User Agreements (FWUA).

This analysis required Lewis Tucker to develop ten different 20-year discounted cash flow (DCF) models in order to test RWSS's water affordability framework undertaken by MacFarlane Rural Business Limited (MRBL) in 2016. Lewis Tucker's review included independent input by local (Hawkes Bay) farm consultants to validate MBRL's on-farm production assumptions. In Lewis Tucker's opinion, this DCF approach offered a more sophisticated framework on which to determine affordability, and better reflected the gradual transition dryland farmers make to farming under irrigation.

"In Lewis Tucker's opinion affordability is not the primary impediment to uptake, but rather farmer's ability to understand the necessary changes to capture the benefits irrigation

Lewis Tucker's analysis defined 'affordability' in terms of profitability, return on assets and the serviceability of increased indebtedness. The analysis concluded that RWSS water is affordable from the outset and that 'affordability' increases in the outer years due to the cumulative effect of on-farm productivity gains. In Lewis Tucker's opinion affordability is not the primary impediment to uptake, but rather farmers ability to grasp the change required to their farming systems to capitalise on the wide-ranging benefits that successful irrigation offers. History suggests that this change would greatly benefit the farmers and their families.

In addition, Lewis Tucker believes RWSS offers existing irrigators a compelling value proposition, but the benefits are less definitive, and likely demand is more difficult to forecast. Uptake by these farmers, who are typically high performing, sophisticated farmers will depend on existing irrigators' desire to improve the reliability of their water or increase their irrigation footprint.

HBRC's advisors (BNZ) developed a water 'Demand Model' forecasting the likely demand for RWSS water over the first 20 years of the project life. Despite Lewis Tucker's concerns about the robustness of the Demand Model's methodology and its computational integrity, the Demand Model's forecast water demand at an aggregated level did not materially disagree with Lewis Tucker's high level 'top down' analysis using the information collected from the FWUA signed by farmers.

Whilst farmers who signed a FWUA have contracted for less water than MRBL believes is optimal water use (being 3,962m3 per ha per year), these farmers, who have already taken the decision to irrigate collectively, own 61% of the irrigable area in the RWSS Command Area. If this 25,755ha area was irrigated to MRBL's optimal level, it would account for an estimated 98% of RWSS's water capacity. Whilst RWSS's contracted volume (per ha per year) is less than assumed optimal (needed to deliver 95% reliability) and less than the average in a normal year, there remains a large percentage of irrigable, but unirrigated area owned by farmers who have made the decision to irrigate.

Feedback from existing irrigators suggests uptake will not accelerate until such time as irrigators understand how much water is required to optimise their farming systems, and a realisation that RWSS capacity could quickly become fully contracted. In Lewis Tucker's opinion, this dynamic could be leveraged by RWSS to advance uptake through innovative pricing structures, tactical use of spot water and a targeted communications strategy.

It is important to acknowledge that the decision by farmers to enter into a 35 year take-or-pay contract is a significant obligation and not a decision any business or farmer should take lightly. As a minimum, a decision of this magnitude requires input from experts and requires farmer education.

In Lewis Tucker's opinion, the achievement by RWSS to secure 40% contracted water (to meet a Condition Precedent mandated by external investors) is a financially significant milestone that materially reduces the uptake risk for investors (including Hawkes Bay Regional Investment Company or HBRIC). This is a key finding from Lewis Tucker's analysis.

In response to questions about RWSS's pricing policies, Lewis Tucker suggested this was an area of RWSS's business plan which was under-developed. It required more thought around driving uptake and demand, tactical use of spot water and incentivising efficiency. This is an initiative that can be advanced during the construction period.

Whilst RWSS's water can be considered at the upper end of the price range for New Zealand, it is important to acknowledge that as a commercial irrigation scheme, farmers are not being asked to contribute to the pre-construction development of the scheme, nor invest in off-farm infrastructure, which in Lewis Tucker's opinion increases affordability. Of equal importance is the balance sheet flexibility this model offers HBRC once the project is fully operational, this includes the ability to sell RWSS shares or debt securities, as well as releasing capital through use of senior debt.

With respect to the commercial review of RWSS's FWUA, Lewis Tucker believes it is fit for purpose, but will need to evolve to efficiently accommodate the increase in complexity associated with transferability and to ensure the terms of supply do not constrain irrigators from maximising the value of their water. It is important that water can migrate to the highest value user in a cost-effective manner.

Whilst RWSS's financial viability is underwritten by the affordability (on-farm) of its water and assumed farmer uptake, the framework does not incorporate other measurable benefits to the rural communities that follow the successful development of irrigation schemes, many of which assist farmers in attracting farming talent to the region.

Lastly, it is Lewis Tucker's opinion that RWSS offers HBRC, as a regulatory body, a range of 'tools' and 'levers' that will enable it to guide the region towards an environmentally sustainable future within which farming businesses can reliably grow and prosper. This will ultimately be reflected in the market value of the land. The Ruataniwha Basin will enjoy the perception of being an attractive destination for capital targeting rural investment, capital which facilitates the migration of land to the highest value use that will unlock economic growth in the region.

BACKGROUND

Hawkes Bay Regional Council (HBRC) is undertaking a review of the Ruataniwha Water Storage Scheme (RWSS) Project for consideration by its recently elected Councillors. Lewis Tucker & Co (Lewis Tucker) has been retained to assist HBRC in reviewing some of the commercial aspects of the Project, in particular;

- On-farm affordability;
- Farmer take-up and likely aggregated water demand; and
- A commercial review of the draft FWUA.

These were the areas of the RWSS Project Lewis Tucker was asked to review as part of a comprehensive due diligence undertaken by institutional investors.

This report offers the readers a summary of the findings and conclusions drawn by Lewis Tucker that were articulated in a due diligence report provided to the institutional investors in June 2016. Further to this, it addresses some of the concerns HBRC Management believe Councillors currently hold, provides greater detail and analysis as suggested by the Community Reference Group and, where appropriate, articulates Lewis Tucker's evolving thinking on the topics under discussion.

SCOPE OF PREVIOUS WORK UNDERTAKEN BY LEWIS TUCKER

Lewis Tucker was engaged by institutional investors to:

- Peer review the analysis undertaken by MacFarlane Rural Business Limited (MRBL) which determined the on-farm affordability of RWSS water (delivered to the farm-gate at 3.5 bar pressure with 95% reliability at a cost of 27.5c per m^3);
- 'Stress test' water demand assumptions (as determined by BNZ Advisory) and analyse the subsequent water uptake profile and financial implications;
- Critique (from a commercial perspective) RWSS's proposed water offtake agreement with individual farmers that RWSS refers to as the Foundation Water Users Agreement (FWUA); and
- Recommend a proposed 'spot water pricing policy'.

To deliver this analysis Lewis Tucker developed ten different discounted cash flow (DCF) models (across 18 different land uses, which includes horticulture) to test RWSS's affordability over a 20-year period. These DCF models included independent input by local (Hawkes Bay) farm consultants, validating MRBL's production assumptions upon which its on-farm production outputs were derived.

As **Fig. 1.** below highlights, MRBL determined affordability of RWSS water by calculating the Return on Assets (RoA) in 6-8 years' time using validated 2016 on-farm production assumptions. This offered RWSS a static, or 'a point-in-time' perspective. It also assumed the farmer was a 'top 20% performer'.

The preparation of Lewis Tucker's DCF models is a more sophisticated framework on which to determine water affordability. They enabled Lewis Tucker to test affordability in both the immediate and outer years of RWSS's planning horizon as well as to incorporate year-on-year change that reflects the transition from dry to irrigated farming systems, in particular time-based variables such as the cumulative effect of on-farm productivity gains.

Productivity gains, for example, are an important economic driver behind the continued appreciation of land prices in New Zealand and represent an important

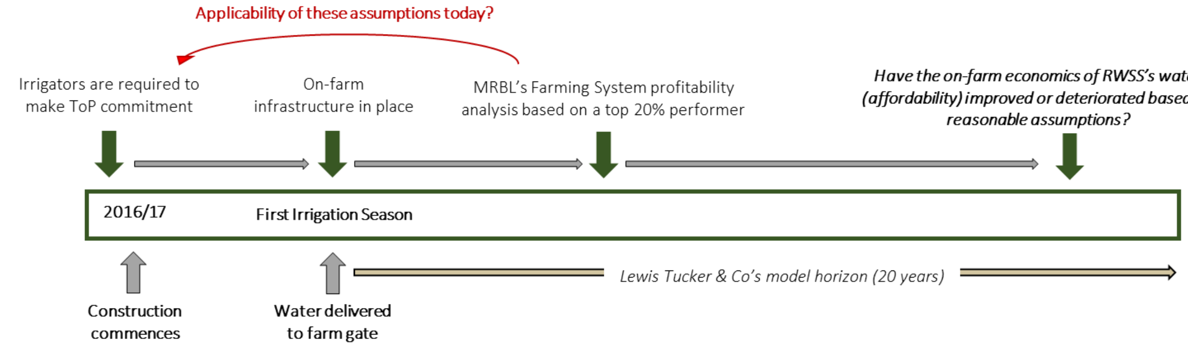


Fig. 1. *Lewis Tucker's Methodology*

economic justification for farm land ownership. It is an important factor farmers need to consider in their decision to irrigate.

Whilst the analysis was somewhat specific to on-farm affordability, the preparatory work required to fulfil the engagement for the institutional investors resulted in Lewis Tucker gaining a greater understanding of the commercial benefits of the RWSS Project to Hawkes Bay as a region, as they relate to farmers. Much of the understanding of these benefits is incorporated into this report.

> *"The benefits of irrigation are numerous and far reaching for both farmers and their immediate communities"*

OVER-ARCHING CONCLUSIONS OF ON-FARM AFFORDABILITY ANALYSIS

The benefits of irrigation are numerous and far reaching for both farmers and their immediate communities. Not only does the section below address the question, 'Is RWSS water affordable?' but it also outlines the broader benefits of irrigation to both dryland farmers as well as existing irrigators. For these reasons this section is broken into two parts:

DRYLAND FARMERS

- As **Fig. 2.** below highlights, RWSS is affordable from the outset. In Lewis Tucker's opinion, affordability is not the primary impediment to uptake.

Land Use	IRR (unlevered)	ROA[1]	ROA[2]	$Water Cost/EBIT	Real water price escalation (% EBIT)
S&B Extensive	8.5%	4.7%	2.7%	39%	1.4%
Arable	11.5%	6.7%	3.5%	42%	2.4%
Dairy heavy soils	8.2%	4.6%	4.0%	49%	1.5%
Dairy light soils	9.9%	6.1%	4.4%	43%	1.5%
Pipfruit	10.6%	24.8% (Yr. 5)	17.7% (Yr. 6)	4% (Yr. 5)	N/A
Demand weighted average[3]	10.1%	8.0%	5.31%	38.2%	1.6%

Fig. 2. *Lewis Tucker's Financial Returns by Farm Type*

[1] *MRBL uses EBIT ÷ Total Assets as a proxy for its Return on Assets calculation*
[2] *Lewis Tucker uses NPAT ÷ (Op. Assets + Cl. Assets/ 2) for its Return on Assets calculation (28% corporate tax rate)*
[3] *Weighted average based on MRBL May 2016 figures*

Lewis Tucker's analysis suggested RWSS water becomes more affordable in the outer years due to the impact of on-farm productivity gains. Sustained annual incremental productivity gains progressively drive higher output (per hectare) but also enable farmers to produce higher value crops more reliably. These two factors alone deliver higher sustainable gross margins per hectare that support appreciating land values

- The productivity gains assumed by Lewis Tucker in its DCF analysis are tabulated in **Fig. 3.** below. It is important to note that these assumptions are materially less than what has historically been recorded on-farm over the last 20 years

Land Use	Lewis Tucker Assumption	Benchmarks & Attributed Source
Sheep+Beef	1.0% real	2.5% (B+LNZ)
Dairy (H)	1.5% real	2.3% (Dairy NZ)
Dairy (L)	1.5% real	2.3% (Dairy NZ)
Arable	1.5% real	3-4% (FAR NZ)

Fig. 3. *Compounding annual productivity gain assumptions*

- Access to irrigation water in effect provides farmers with the ability to capture the productivity gains on offer in pastoral and arable agriculture, gains that, as history would suggest, can be material on a cumulative basis over the long-run

- **Fig. 4.** illustrates the principle benefit of irrigation. Put simply, irrigation provides farmers with the ability to reliably grow more crops or pasture throughout the growing season, in particular, during the summer months when sunshine hours are high and the soil temperatures optimal. In doing so, farmers reduce their reliance on the spring and autumn months as is currently the case in many Central Hawkes Bay farming enterprises

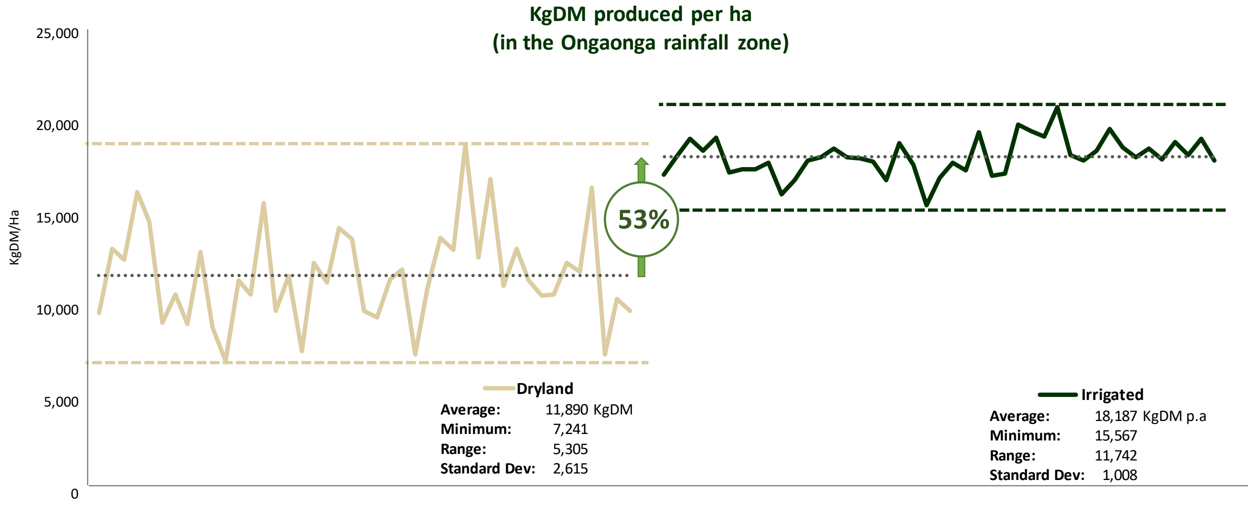


Fig. 4. *Grass production in OngaOnga rainfall zone (Dr Tony Daveron)*

- **Fig. 4.** above is based on data provided by Dr Anthony Daveron (for RWSS) forecasting grass production in the Ongaonga rainfall zone, based on the recorded climatic conditions over a 43-year period. The left-hand series represents dryland production, which produced, on average, 11,890 kg DM per hectare pa over the 43-year period (1973/74 to 2014/15 seasons). This can be compared with the series on the right-hand side which represents predicted production with exactly the same climate conditions, but under irrigation. This averaged 18,187 kg DM per hectare pa; a 53% increase over dryland production

- Importantly, production under irrigation is less variable. Using the series above, the standard deviation (which measures variability) of dryland production is over x2.5 greater than production under irrigation (see **Fig. 5.**). Whilst difficult to assign a precise economic value to this lower variability (and higher reliability), it delivers farmers a significant business benefit. Farmers under irrigation generate more reliable cash flows. Irrigation provides farmers greater confidence to positively invest into their farming businesses for the future and improves their credit worthiness. "Irrigators are a better credit risk than dryland farmers." (Wairarapa rural banker) notwithstanding it requires greater levels of debt

- The control that irrigation offers to farmers greatly improves asset utilisation. Pastoral farmers can better match pasture growth with animal feed requirements, resulting in higher pasture utilisation (or less wastage). The financial significance of this is the high correlation between farm profitably and pasture utilisation levels. For arable farmers, irrigation extends the growing season. It provides the opportunity to double crop and, for horticulturalists, enables more reliable crop yields. As a general 'rule of thumb', improved returns per hectare result in greater asset utilisation of both physical and biological assets. Greater utilisation improves farmers' return on assets and therefore return on capital

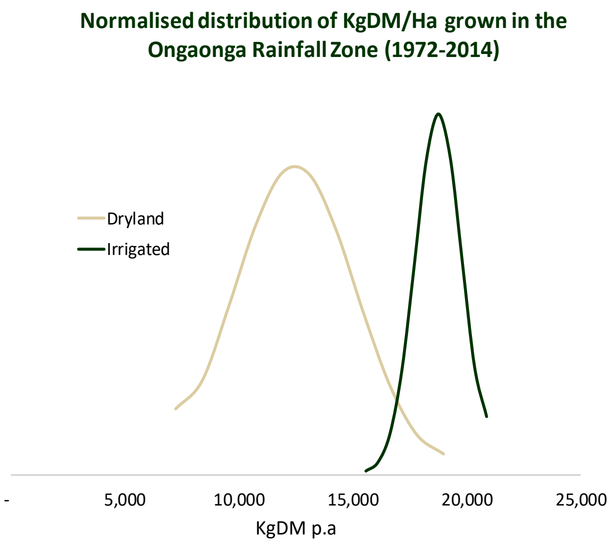


Fig. 5. *Normalised distribution of DM grown*

- Another measure of affordability is a farmer's ability to service the increased debt associated with investing in on-farm infrastructure. Lewis Tucker could not source data indicating the average level of farmer indebtedness within the Command Area directly from trading banks, but, Crowe Horwath, a major rural accounting firm in the region believed the average indebtedness of its clients in the area was ~20% of total assets. Lewis Tucker's DCF analysis suggests all farming systems (with the exception of dairying on heavy soils) comfortably exceeds the trading banks' minimum interest cover ratio of 1.75x EBIT to interest cost (measuring debt serviceability). As with the price of water, Lewis Tucker does not believe debt servicing capacity will be an impediment to affordability

"Irrigation can deliver greater asset utilisation, with reduced production variability"

- Irrigation offers farmers genuine choice. By removing soil moisture constraints farmers can convert to more intensive land uses, and enjoy more reliable cash flows. Other than permanent crops (such as pipfruit or grapes) and (arguably) dairy farming, irrigation offers farmers the ability to comfortably (and profitably) move between different farming systems to capture gross margins that reflect strong commodity prices

- This choice extends to a farmer's decision to irrigate or not. If farmers choose not to irrigate, they can choose to sell their property in the knowledge that water is available at the farm gate for use by the purchaser, which will be reflected in the value of the land. The significance of this point; the value of water does not just accrue to those who irrigate but rather to all farmers in the Command Area, on the assumption that water is available

- Evidence in Canterbury suggests that the land surrounding the Command Area also appreciates in value. These farmers, whilst not irrigators, are provided the many opportunities that are complementary to the irrigators' farming systems, such as diary support or irrigators being the buyers of their store lambs

- In many ways, the conscious decision not to irrigate is as significant as the decision to irrigate. In the case of trustees who are accountable to the beneficiaries of the trust they represent, the decision not to irrigate against the knowledge of forgoing the significant benefits of irrigation needs to be carefully considered from a prudent person's perspective. For that reason, many farm owners who choose not to irrigate often sell their properties before irrigation water is fully allocated

- The decision to irrigate cannot be underestimated. Once a farmer understands the benefits of irrigation and the impact of the decision on the current farming system, a significant investment will be required (in time and money) to ensure the water used (and being paid for) is optimised in a profitable manner. It will inevitably require the input of experts and will most likely result in a significant change in farming systems.

  Further, it will take 3-5 years before a new irrigator becomes proficient. Farmers are not only being asked to manage irrigation infrastructure but to transition to a more intense and complex farming system (needed to justify the increased investment and cost). Some farmers simply do not make this transition. Those who do not, or who choose not to, typically move on. "The Amuri (irrigation scheme) replicates the Waitaki (irrigation scheme) experience with 60% of farms changing ownership since the advent of irrigation" (Hunt, 1998).

- The counterfactual is that those remaining farmers who oversee profitable farming businesses are considered highly competent operators. Deriving profit from a higher cost, capital intensive (and irrigated) farming businesses requires a minimum level of competency above what is generally considered 'the average competent operator' in New Zealand

- The decision to irrigate requires farmers to sign a 35 year take-or-pay offtake contract, referred to as the FWUA. Optically this is a significant (and long-dated) liability for any business to consider and will naturally be cause for farmers to think carefully before making the commitment. Once water is embedded into a farmer's business it will quickly be viewed as an asset, and not a liability, especially as the value of the water appreciates through further intensification, reliability, diversification and productivity gains. RWSS needs to ensure the FWUA is a transferrable right, in part or whole, or can be leased so that farmers can manage the 'take-or-pay' obligation in the event circumstances change or a land use change occurs that requires less water

- Lewis Tucker believes the major impediment to uptake in RWSS water is farmers understanding the change that is required to capture the many benefits irrigation offers, or the ability to access the requisite expertise to make a rational (economic) decision. The major impediment is not affordability nor indebtedness. RWSS's experience seeking signatures on its FWUA suggests one of its challenges was the limited number of rural support professionals with the skillset needed to assist farmers through this complex decision making process. Access to expertise on-farm is an important driver that will influence the speed of uptake

EXISTING IRRIGATORS

- Lewis Tucker is of the view that RWSS also offers existing irrigators an attractive value proposition. **Fig. 6.** tracks indicative groundwater use over the last seven irrigation seasons and compares it to the allocation limits. Whilst the data in the 2008/9 and 2009/10 seasons is prior to water meters being mandatory, it illustrates a relevant point[1]. The reasons for under-utilisation of consented groundwater, in particular in Zone 3 (the larger of the two Ruataniwha Basin zones) is due to a combination of possibilities;

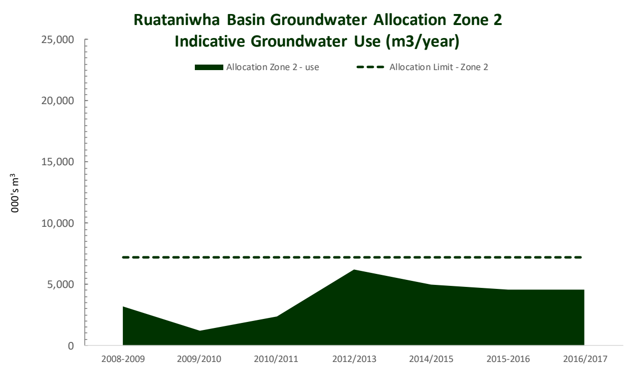
  1. Insufficient on-farm infrastructure (including storage dams) to extract the water when required;
  2. Access to, and use of advanced irrigation technology and equipment;
  3. The bores (on-farm) are too few in number, or not deep enough;
  4. The groundwater is simply not available; or
  5. Land-owners securing groundwater contracts without committing to use the water

  Having a consent is effectively a 'time bound licence' that enables consent holders to harness a natural resource neither they, nor the HBRC have a deep knowledge and understanding of. Securing reliable groundwater at sufficient volumes when it is needed requires constant management and ongoing investment by the consent holder. Compare this to RWSS water, which is pressurised, delivered to the farm gate, and 95% reliable

- All HBRC Consents have 'Lapse Dates'; a 5-year period within which the consent water must be used by the consent holder. If it is not used prior to the Lapse Date, the unused volume may lapse. This is designed to prevent consent holders 'sitting' on consented, but unused, groundwater

- Lewis Tucker understands that groundwater in the Ruataniwha Basin is now fully allocated. For existing irrigators who have used all their consented groundwater, or the cost of extracting their un-utilised consented groundwater is prohibitive, RWSS water is a means to increase their irrigation footprint. Lewis Tucker believes existing irrigators will be able to extract maximum benefit of RWSS water with their knowledge and experience of irrigation. As an illustration of this point, Lewis Tucker understands that existing irrigators have contracted to take ~8.6 million m^3 per year to replace consented water, and ~8.8 million m^3 per year of 'new water' to increase their irrigation footprints. The replacement water represents ~18% of Allocated Groundwater Limits in Zones 1, 2 and 3 of the Ruataniwha Basin.

- A FWUA offers irrigators a 35-year supply compared to an average consented period of ~10-20 years**.** Pressurised water at the farm-gate (at 3.5 bar pressure) comfortably drives a large centre pivot and removes the cost of establishing and



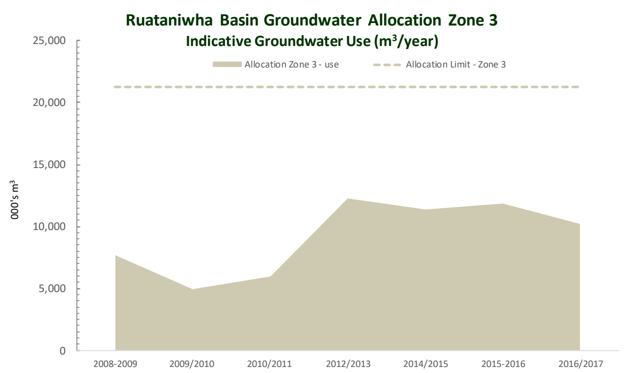


Fig. 6. *Indicative groundwater use on Ruataniwha Basin Zones 2 and 3 (year to date)*

[1] Whilst Lewis Tucker understands this data to be representative, there remains some potential inaccuracies in the data resulting from the quality of information provided, and in some cases not provided, by users.

maintaining deep-water bores, which is not insignificant

RWSS is offering existing irrigators the ability to transition to RWSS, the terms of which are encapsulated in the 'Deep Water User Agreement' (DWUA). This offers existing irrigators a five-year window to become a Foundation Water User (FWU), during which time they enjoy concessionary pricing. If after five years a DWU remains 'un-convinced' about RWSS water, they then have a right to revert back to the status quo, which also results in them no longer being able to irrigate under RWSS's 'Scheme Consent'. The extent to which existing irrigators transition to a DWUA is difficult to estimate. This decision will ultimately be influenced by their understanding of the real cost of groundwater, their desire to increase their irrigation footprint and how much value they place on reliability.

STRESS TESTING WATER DEMAND ASSUMPTIONS

BNZ Advisory, RWSS's commercial advisors, developed a DCF which had two parts to it. Part one was the 'Demand Model' which informed Part Two, the 'Financial Model'. The latter determined the financial metrics of the Project. It is also a tool designed to optimise the capital structure and ascertain commercial viability. Lewis Tucker's interest is limited to Part One, the 'Demand Model'.

The BNZ Demand Model uses the 'random number generator function' to determine the probability of a farmer assessing the economics of irrigation. If the economic calculation suggests irrigation is 'value accretive', then the farmer automatically transitions to irrigation. The model then weights land-use change under irrigation based on the profitability of each system relative to the other. After testing the model, Lewis Tucker developed concerns about robustness of the methodology and its computational integrity. The particular issue that concerned Lewis Tucker with the methodology was that the BNZ model determined 'value accretive' as a result of irrigation. It calculated the incremental EBIT on a marginal cost of capital basis on conversion from dryland farming to farming under irrigation. The marginal cost of capital was calculated by measuring the delta in total assets under each scenario. For the majority of these 'possible conversions' the incumbent farming system assets have no relevance to the new system or any likelihood of transferring or disposing at book value. In Lewis Tucker's opinion, this methodology overstated demand in the earlier years, and understated demand in later years which was (in part) compensated by the difference in spot water demand (see **Fig. 7.** below).

In addition, the BNZ model assumed each new irrigator (non-FWUs) immediately uses the optimal amount of water as determined by MRBL, which Lewis Tucker believes is unlikely. As RWSS Management has discovered, farmers have taken a more conservative approach, deliberately under-subscribing with the intention of using spot water to bridge any gaps. It is understandable farmers will wish to test their new irrigation systems and determine the optimal water requirements before making a 35-year contractual commitment.

Upon receiving this feedback the institutional investors elected not to develop a new demand model, a decision that Lewis Tucker supported. Notwithstanding these concerns, Lewis Tucker undertook a high level 'top down' analysis (see next sections) using the information collected from signed FWUA. This analysis did not materially disagree with the BNZ's forecast water demand at an aggregated level.

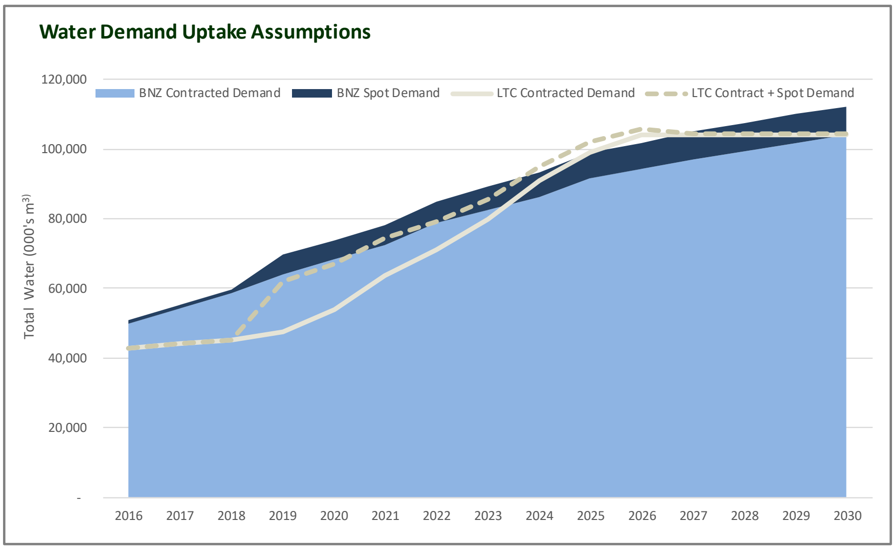


Fig. 7. *Contracted vs. Spot water demand dynamics*

ASSUMED WATER USAGE PER HA PER YEAR

The table in **Fig. 8.** outlines the assumed **optimal** water usage per hectare per year across the eight-different land uses as determined by MRBL. These water usage assumptions represent the water required to deliver farmers 95% reliability, or sufficient water to maximise production during 19 out of every 20 years. The difficulty in assigning a metric like this for each farming system in Hawkes Bay is the wide variation in soil types, temperature and climatic zones and therefore evapotranspiration rates within the Command Area.

Land Use	m³ per ha per year
Sheep + Beef Extensive	4,096
Finishing	4,096
Mixed	4,029
Arable	3,400
Dairy (Heavy Soils)	3,859
Dairy (Light Soils)	4,650
Pipfruit	4,106
Viticulture	2,188
Average Weighted (using MRBL mix of farming systems)	**3,962**

Fig. 8. *Assumed optimal water-use per hectare*

Whilst the assumed average weighted **optimal** water usage (weighted by percentage of land use) is 3,962m^3 per ha per year, MRBL holds the view that the **average** water usage is probably ~80-85% of the optimal water usage, or ~3,367m^3 per ha per year. This is marginally higher than the average contracted water usage of 2,968 m^3 per ha per year to which farmers have contracted under their FWUA. Optimal water-use tends to be higher than the average water-use because the marginal cost of the additional water is significantly lower than the opportunity cost of lower production from not having that water in a 1 in 20-year drought.

Many existing irrigators are applying a lot less water than what is assumed is the average, and have (rightly) challenged these assumptions. The reasons for these lower application rates range from lack of available groundwater, different climate conditions and soils and inadequate (and poorly designed) irrigation systems. MRBL suggested new irrigators often under-estimate their required water, and once they have experienced a drought, will seek to retain a buffer for dry years. Lewis Tucker is comfortable that the assumptions in **Fig. 8.** are well founded and incorporate the key behavioural and technical influences highlighted by MRBL. Differences between contract volumes and required volumes will be bridged by irrigators through the purchase of spot water.

Whilst technology and evolving management practices will progressively reduce usage per ha per year over time, it is expected that the water saved from these efficiency gains will be applied to irrigable land owned by the farmer but currently unirrigated. Further, technology is pushing irrigation onto previously un-irrigable topographies.

CONTRACTED UPTAKE AS OF JUNE 2016

One reason for not re-developing the BNZ Demand Model was that events had in effect superseded the need for a revision. The institutional investors both stated that RWSS had to contract 40% of its future demand as a condition to investing, which represented 41.6 million m^3 (104 million m^3 x 40%). At the time of preparing the due diligence report RWSS had met this requirement, which in Lewis Tucker's opinion was a significant milestone for the following reasons:

- Of those FWUA's signed, users had contracted to irrigate 14,408 ha with an average 2,986 m^3 per ha per year, which is ~75% of MRBL's weighted average optimal water usage of 3,962 m^3 per ha per year (see **Fig. 9.**). Lewis Tucker believes that once an irrigator has made the decision to irrigate, it is highly likely the individual will continue irrigating (using spot water beyond their contracted volume) to ensure production is maximised in order to recover the (significant) investment into irrigation

- If contracted irrigators irrigate to an optimal level (of 3,962m^3 per ha per year), then they only have sufficient contracted water to irrigate 10,794 ha, not

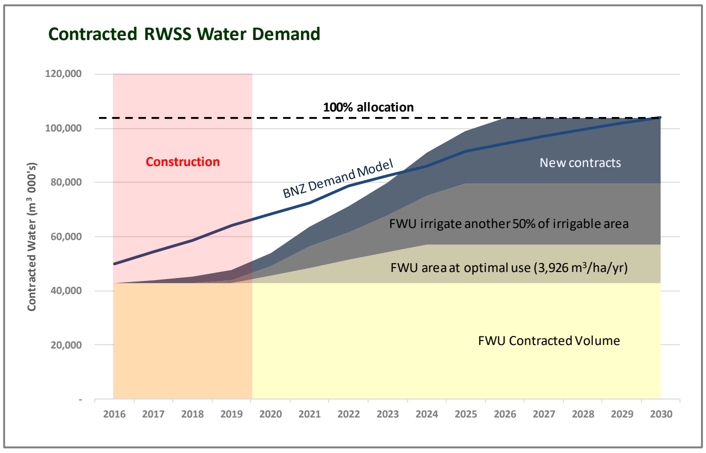


Fig. 9. Contracted RWSS water demand

the desired 14,408 ha (as contracted). If they apply the optimal water usage levels using spot water, then 57 million m^3 or 55% of RWSS's capacity will have been utilised

- RWSS's Command Area consists of 42,456 ha of irrigable land. More significantly, contracted irrigators (who have signed the FWUA) own 25,755 ha (or 61%) of that irrigable area. These are the FWU who have made the decision to sign a 35-year take-or-pay contract and commence irrigation, which history suggests (from Canterbury) is the single highest hurdle to initiating uptake. The decision for FWU to increase their irrigation footprint is less significant than electing to irrigate at all. It is highly likely this land will be irrigated by its owners, which at optimal water usage levels accounts for 98% of RWSS's capacity

- If these FWU only irrigate an additional 50% of the land they own and could irrigate, but have not yet contracted water for, it would account for 77% of RWSS's capacity at optimal water-use per hectare. These scenarios are outlined in **Fig. 9.** on the previous page

- Discussions with existing irrigators suggest demand for water 2-3 years after delivery commences will be driven by irrigators wishing to expand their irrigation footprint. Once irrigators become aware RWSS's capacity is tightening (i.e., being contracted), greater focus will be placed on ensuring irrigators have sufficient water on a per hectare basis to maximise production. This could accelerate uptake.

In summary, those farmers who have signed a FWUA could potentially contract almost all of RWSS's 104 million m^3 before RWSS needs to turn its attention to those farmers who own the remaining ~16,700 ha of irrigable land. In Lewis Tucker's opinion, the delivery by RWSS of the 40% contracted water (as a Condition Precedent) has materially reduced the uptake risk, especially given construction is yet to commence. This is a key finding from Lewis Tucker's analysis

The opportunity exists to use this demand dynamic to accelerate uptake during construction or immediately after construction when water is delivered to the farm gate. If RWSS water has the potential to be fully allocated, quickly, as this analysis suggests, then the possibility of RWSS water becoming scarce or fully allocated could be used as an effective marketing tool

SPOT WATER

As **Fig. 10.** demonstrates, spot water will fill the gap between what FWU have contracted to use and the water they require in either an average year or a dry year. BNZ's Financial Model assumes no price difference between spot and contracted water, and as a consequence, irrigators have no incentive to convert from spot water to contracted water. Spot water revenues will be dictated by the season and will be volatile.

Lewis Tucker believes FWU have undersubscribed for water, and will rely on spot water to maintain production yields in the early years as they tune their irrigation equipment and optimise their operating systems. As the region develops a better understanding of how to use irrigation, and experience a dry season, contracted water will move closer to the optimal water usage level. This will require less spot water sales. Through pricing, Lewis Tucker believes spot water should be used as a tool to increase contracted water.

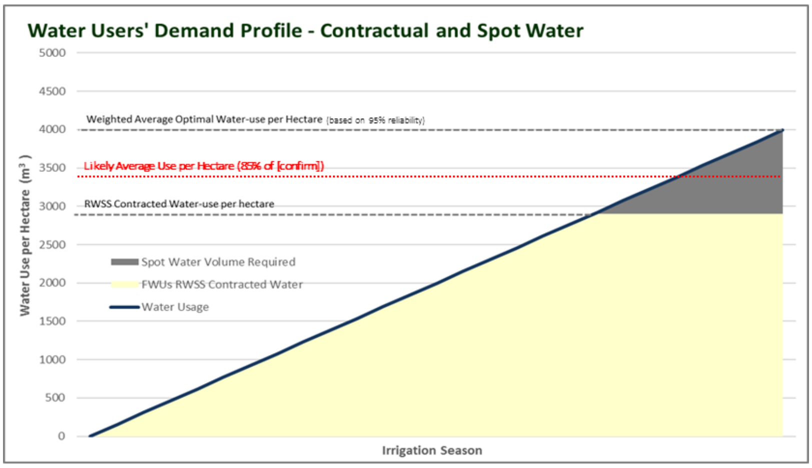


Fig. 10. Spot water pricing

PRICING RWSS'S WATER

Apart from determining the cost of water using a simplistic 'total cost' per m^3 basis, RWSS has not developed set pricing policies that drive irrigator behaviour or facilitates desired outcomes. Whilst Lewis Tucker offers some thoughts around possible pricing policies (outlined in **Fig. 11.**), it is important that some broader first principles are articulated:

- RWSS is being developed as a commercial entity. As such the price of RWSS water is at a level that delivers capital providers (both external investors and HBRC) a commercial return on their invested capital. This differs to cooperatives (the majority of the South Island schemes are cooperatives) in so much as they operate on a cost recovery basis (and only service debt). They also seek to retain control over the governance function. The financial differences are articulated in the table below:

  From a FWU or irrigator's perspective, the impact of the commercial model is as follows:

  1. It avoids the need to invest in pre-feasibility establishment costs or in off-farm infrastructure. In the case of cooperatives, this is compulsory. This reduces the overall capital burden on farmers by between $5,000- $10,000 per ha. The commercial model is increasing overall affordability;

  2. The quid-pro-quo is that farmers are being asked to enter into a 35-year take-or-pay contract. This is a significant legal commitment for any small business; and

  3. The proposed water price is arguably one of the highest in the country, because it incorporates a return to equity holders (including HBRIC).

- From HBRC's perspective, the impact of the commercial model is as follows:

  1. In Lewis Tucker's opinion, HBRC as the regulator and owner of Hawkes Bay Regional Investment Company (HBRIC) has access to more levers to manage the water catchment. RWSS's Scheme Consent, the Farm Environmental Management Plans (FEMP), a region of farmers skilled in irrigation management techniques and water dynamically moving to higher value uses together with innovative pricing structures, offer RWSS the ability to encourage irrigators to conserve water and minimise their environmental footprint;

  2. A commercially based water pricing policy offers HBRIC considerable balance sheet flexibility downstream, including the use of debt, securitisation and a future sell down to the Hawkes Bay public; and

  3. HBRIC (as the promoter) is effectively bringing outside capital into the region for the region's benefit.

"RWSS's pricing policy is under-developed and requires thought throughout the construction phase"

- Lewis Tucker's response to the institutional investors when asked about RWSS pricing policies was that it is under-developed and requires considerably more thought during the construction phase, in particular, the following points;

  1. Lewis Tucker recommended that spot water be priced at a material premium to contracted water (on a per m^3 basis). If a FWU purchased water on the 'Spot Market' over and above its contracted water volume during the first 2-3 years after first irrigating, then the premium should be rebated back to FWU for the volume of water (on a per m^3 basis) the FWU converted from spot to contract. This offers the FWU an incentive to quickly optimise water use with their chosen farming system and an incentive to secure long-term water supply. In addition,

Ownership Model	Pricing	Off-farm investment	On-farm Investment	Where does value accrue?
Co-operative	Cost recovery	Compulsory	Yes	With the land
Commercial	ROI on economic value of off-farm assets	Optional. Hedge against price increases	Yes	With the water supply contract

Fig. 11. Pricing strategy overview

revenue from contracted water is better for RWSS than spot water sales;

2. For those FWU who have unirrigated, but irrigable land, a price should be offered to encourage early uptake of water for use on that irrigable land. This approach is rewarding those farmers who took the upfront risk of signing a FWUA (i.e., it rewards loyalty);

3. A small discount should be applied to irrigators who use (approved) water conservation technology. The benefit to FWU is both the discount and reduced water usage; and

4. Whilst RWSS should encourage the trading of contracted water between FWU, RWSS may wish to consider a 'water buy back mechanism' in which it purchases small volumes of surplus contract water (at the current market price) resulting from water conservation practices (only). It will need to be capped (at say 10% of contracted volume for a given 5-year period), and will be relatively small (volumetrically). The significance being; water conserved can be sold to another irrigator by RWSS, and this mechanism rewards those who conserve water (on a permanent basis) by providing the opportunity to monetise the value of that water

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THOUGHTS ON THE FOUNDATION WATER USER AGREEMENT (FROM A FARMER'S PERSPECTIVE)

The institutional investors requested Lewis Tucker review the FWUA from a commercial perspective. Lewis Tucker was mindful that the draft it reviewed was the product of multiple (and sometimes exhaustive) reviews by RWSS's legal advisors. The points emerging from this review are as follows:

- The requirement to prepare FEMPs obligates the irrigator to Industry Good Practices (IGP) and places a material obligation onto irrigators to operate within the bounds of a well-defined environmental envelope. The irrigator's incentive to conform is strongly endorsed by RWSS's powers of enforceability (under section 10 of the FWUA). If an irrigator's non-conformance were acted upon by RWSS, it would completely undermine the profitability (and investment) for a given farming business. The stakes for non-conformance are high. Whilst RWSS's powers of enforceability are absolute, care will need to be taken during the transition phase from dryland farming to farming under irrigation, as mistakes will be inevitable

- Existing irrigators, referred to as DWU have a 5-year window in which to convert to a FWUA, but at a concessionary price (under section 9 of the FWUA). This is a pragmatic approach to dealing with what existing irrigators consider a 'property right' (i.e., their existing resource consent). Those DWU who have made an informed assessment of the 'true cost' (and value) of their existing consents to use (ground or surface) water are likely to form the view that RWSS water (at a concessionary price) represents fair value. It is important RWSS provides case studies to demonstrate the true cost of consented water to assist in the thought process

- The commercial model effectively decouples any appreciation in the value of having access to irrigation water from the ownership of land. Irrigators who have a Water User Agreement (WUA) with RWSS have a transferable asset (in part or whole) on their balance sheets that sits alongside other farming assets (such as land, plant, animals and cooperative shares). As farmers become more efficient users and require less water, they can either use the surplus water to irrigate more land or sell the surplus to another irrigator or RWSS (see point above).

"The commercial structure of RWSS will incentivise greater water efficiencies over time"

This differs from most co-operative schemes which place transfer restrictions in their WUA that legally lock the access to water to land ownership, such as is currently done with Resource Consents to remove ground and/or surface water (for logical reasons). This is a fundamental and financially significant difference of RWSS.

Lewis Tucker believes transferability of the WUA, (in part or whole) together with separating mandatory share ownership as a prerequisite to ensuring water migrates to the highest value user (at a commercial price that reflects its scarcity). It is effectively perpetuating the gradual shift of water to the most efficient and effective users, a dynamic that encourages efficiency and innovation throughout the Command Area. Lewis Tucker believes this will be an important facilitator of long term rural GDP and enhanced environmental performance

- If RWSS's FWUA is viewed as an instrument capable of storing economic value (because it provides access to reliable water), then the FWUA in its current form has few impediments to transferability between irrigators. Notwithstanding that, a framework needs to be put in place by RWSS to ensure transferability is time efficient and cost effective. This is relatively 'unchartered territory' in New Zealand's irrigation sector but there are many other industries from which RWSS can draw precedents

The key finding by Lewis Tucker is that the FWUA is fit for purpose, and will evolve. It must evolve if it is to deal with the inevitable increase in complexity of transferability and ensuring the terms of supply do not constrain irrigators from maximising the value of their water.

OTHER CONSIDERATIONS FOR HBRC

As the promoter of RWSS, HBRC may wish to consider other benefits RWSS is delivering to the broader farming community which enhance the overall 'value proposition' of RWSS's water. These are however difficult to assign economic value.

- RWSS's viability is underwritten by the affordability (on-farm) of its water and assumed uptake. This 'financial viability' does not incorporate other measurable benefits to the rural communities that follow the development of irrigation schemes. These include:

  1. The economic benefits to the broader region (Butcher Partners Report, dated March 2016) include the benefits of more product and service providers entering the region to support an enlarged, more diversified and vibrant rural economy. These services further enhance the region's attractiveness to skilled rural workers, other service providers, and rural investors; and

  2. The non-economic (or social) benefits of vibrant rural communities greatly assist in attracting rural talent. This manifests itself through a greater number of younger, more skilled rural workers revitalising rural schools, sport and social clubs.

- At a macro level RWSS offers HBRC, in its capacity as a regulatory body, a range of 'tools' and 'levers' that will enable it to guide the region towards an environmentally sustainable future within which farming businesses can grow and prosper. This will ultimately be reflected in the market value of the land. For example:

  1. Irrigation facilitates land intensification. It requires investment into irrigation infrastructure and greater on-farm skills. A region producing higher value agricultural commodities on a reliable basis that is being managed by skilled farm management professionals will attract investment by processors, rural service providers and talent. It will create sustainable economic vibrancy and momentum;

2. The behavioural shift that accompanies the development of irrigation schemes has historically resulted in a region of smarter, more commercially savvy farmers who are proactive and conscience managers of the environment. The trading banks make no secret of the fact that irrigators are more sophisticated and efficient farmers than non-irrigators;

3. The value to a farming enterprise of transitioning from a consented (ground and surface) water supply, which requires increasingly more onerous renewal terms and whose reliability is always 'under the spotlight', to a legally binding contract that delivers pressured water with 95% reliability is significant. The latter offers greater planning certainty for both farmers and processors of agricultural commodities;

4. The obligation to produce a FEMP which requires farmers to pursue Industry Good Practices, and supported by RWSS 'enforceability rights' is a powerful framework on which to migrate irrigator behaviour in the Command Area towards greater environmental sustainability;

5. RWSS is a means of rebalancing the seasonal value of water. Consented water is effectively allocating an otherwise public resource to the benefit of private users and some public users. RWSS provides a means of collecting and storing water during winter months when the value of that water to the public is low. Storage and distribution in the summer months (or irrigation season) is paid for by the irrigators, who benefit from it. The consented water not otherwise used by irrigators is made available for both public and private use when its value is highest (in the summer months). This arguably represents a more sustainable and equitable basis on which to use a public resource.

COUNCIL REVIEW

Advice on the barriers to faster uptake and/or reasons for landowners in the command area not contracting water, acknowledging the HBRC Condition Precedent threshold of 40Mm3 is deemed by HBRIC to have been met.

Comment: This information is expected to be necessarily generalised to protect commercial information provided in confidence.

The below information has been sourced from HBRIC's management team and water sales team, based on the scheme's design principles and farmer feedback to date.

There are no legal constraints to greater water uptake.

The information supplied provides an overview of possible barriers to faster uptake. It is not all inclusive and does not represent a detailed survey of all potential water users.

There are several key factors that could be impacting on the current level of uptake.

- **Condition Precedent:** The market has responded to the condition precedent to support the scheme being ready to proceed to financial close. The market has done what has been asked of it as noted in the review question. Further sales are anticipated post financial close (i.e. during construction and after delivery of first water).

- **Confidence in the scheme progressing:** The majority of farmers talked to have advised that uncertainty surrounding the scheme has limited their willingness to make further commitments to water purchases. Feedback suggests that there is a 'fatigue affect' associated with ongoing delays, negative media messaging and politically confused messaging from HBRC, which has discouraged early uptake. A number of farmers have indicated that they may seek to acquire more water once the scheme is confirmed as proceeding (with absolute certainty). It should be noted that HBRIC has always planned to make a final push to sell more foundation water immediately prior to and just after financial close.

- **Conservative investment planning and risk management (try before you buy more):** Many farmers wish to trial the scheme for a portion of their operation to ascertain their demand and return profiles. This is reflected in the uptake curve presented by HBRIC, which acknowledges that there will be a graduated migration to more water sales as farmers better establish their needs. Making the transformational change from farming systems built around a dry summer to all year round production will take time.

- **Water User Contract:** Only one offer has been taken to market at this stage, which requires a 35 year fixed price take or pay commitment. This offer comes with a discount, but also requires a large long term financial commitment. The Foundation contract was specifically designed to provide start-up cashflow security for investors. Once different water contract offers are presented with more flexibility in terms of start date, tenure and price, it is expected that this will appeal to the market, including those who have hedged their uptake by securing only a portion of the amount they may need. This was always planned to occur once financial close had been achieved.

- **Spot water availability:** As the scheme will offer spot water, the market is waiting to see the price point for this before committing to take or pay arrangements. The principle of spot water pricing is that it is set based on available supply and demand at the time of purchase.

- **Distribution system knowledge:** At this point farmers have not seen the full distribution plan which will identify where water will be available and the output capacity of each zone and pipe. It is HBRIC's view that once presented with a finite resource, farmers will make more water sales commitments to avoid the risk of 'missing out' on access or facing restricted supply.

- **Anticipated farm turnover:** Some farmers have hedged their position for the future, by acquiring a base take of water to maintain current farm practices, with a view to selling their farm at a later date, with the potential for farm development under new ownership. The 15 year uptake curve modelled by HBRIC anticipates some farm turnover and increased uptake over time.

Summary of HBRIC current plans to acquire more water sales

- Once the scheme is confirmed as proceeding, undertake a large scale push for more water sales prior to financial close (est. 3-6 months).
- Launch new water sales contract options to the market post financial close
- Further push for water sales as construction is completed
- Ongoing sales push post construction

RUATANIWHA WATER STORAGE SCHEME

2017 REVISED UPDATE OF REGIONAL ECONOMIC IMPACTS AND NET PRESENT VALUE

Butcher Partners Ltd – 2 May 2017

1. Introduction

This report was commissioned by Hawkes Bay Regional Council (HBRC).

This version reflects some additional changes made since the previous version presented to councillors in mid-April 2107, and a section addresses the issues raised by councillors who are sceptical of the conversion of additional land to vineyards and orchards, and believe that any existing orchards should be assumed to have the same productivity regardless of whether they use existing irrigation takes or use Ruataniwha water.
Other changes include:

- A reconciliation between the costs contained in the financial report and the economic assessment. The underlying figures are the same, but the two reports have slightly different purposes, and the two pieces of work were undertaken independently, so the presentations may differ.
  This has no impacts on any of the reported results.

- A consideration of the possibility that farm EBIT will be reduced by 5 % or by 15 %. This reflects different assumptions about water availability and reliability.
  This *reduces project NPV by $81 - $243m. There is no impact on household income and employment at full development, but regional GDP is reduced by $6 – 19 million / yr;*

- Removal of revenue from water used by HBRC for environmental flows, and from water used by CHBDC for potable water.
  This reduces project NPV by $23 million. No impact on reported regional economic impacts at full development;

- Exclusion of $2.6m of capital refurbishment costs which would be incurred only if the scheme includes hydro generation, and the base case assumes it does not.
  This increases project NPV by less than $1 million because of the long delay until the reduced cost is incurred;

- Spot water has been valued at 27.5c / unit for consistency with the financial model. *This makes minimal difference to NPVs or economic impacts*.

Changes since 2016

1. A minor change to the uptake rate. Using the Lewis Tucker figures for contracted water plus "Spot"[1] water as an indicator of likely irrigated area suggests that 64 % of the final irrigated area will be irrigated at the commissioning of the project (unchanged), with 100 % uptake being achieved by year 7 of operations (previously 95 % by year 10). Spot water use in the long term, once all available contracted water has been taken, has also been greatly reduced. The 2016 assumption was that in the long term, and on average, there would be 9Mm3 per year available from additional water that was reliable in most years but was not sufficiently reliable to be offered under long term contracts. The current assumption is that there will be only 0.6 Mm3 / year taken by farmers once all long term contracts are taken up.
2. Capital Cost has been increased by $19.4m. The dam and distribution network (including related roads and bridges and transactions costs during construction) is increased by $7.5m to $292 million, Opex during construction (including mitigation costs) have been increased by $3.9m, and power distribution costs (to supply scheme pumps etc) have been increased from $12m to $20m. The timing of construction costs has been changed slightly, with $10 m being spent on delayed extension of the distribution network during years 4 – 8 of the project. The net effect is to increase the NPV capital costs by $15m at 5% discount rate, and $14 million at 7%.

   N.B. Appendix 1 shows a reconciliation between these figures and the Financial Modelling figures, which include sunk costs (the economic model excludes them because they are sunk, but the financial model includes them as part of a "whole-of-life" financial analysis), interest costs (the economic model uses a discount rate which has a similar effect to using an interest rate), but excludes maintenance capex during years 15 – 30, and mitigation costs during the operating period (the financial model includes these as operating costs).

3. Major periodic capital replacement costs have been identified totalling $12.7 million over the first 30 years of the project's operational life and generally occurring in years 15 ($3.1m), 20 ($6.8m), 25 ($1.9m) and 30 ($0.9m). In additional there is a likely re-consenting cost of $2.7 million in operational year 30 (year 33 of the project life). The Net Present Value of this additional cost is estimated to be $5 million at a 5 % discount rate and $3m at a 7 % discount rate
4. There has been a minor reduction in the annual operating expenses (electricity), which increases the PV net benefits of the projects by $1.6 million.
5. The uptake of irrigation by orchardists and viticulturists (or activities with similar productivity and investment per Ha) has been the source of much debate. Sensitivity testing has been done to look at the effects of assuming that the conversion to these two land uses takes place more slowly, with only 25 % of the predicted area having been converted by year 10 and the other 75 % by year 20. This significantly reduces the PV benefits by delaying net revenues of these high-value-per Ha activities, but also reduces the PV capital costs of these high-investment-per-Ha activities.

There has been vigorous debate in recent years about an appropriate project life and discount rate to use in financial analysis of the project. These issues were covered in the last report, which argued for use of a 5 per cent discount rate and 70 year project life. Financial results for the project are presented for project lives of both 35 years and 70 years, and for discount rates of 5%, 6%, and 7%.

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1 Not subject to long term contracts.

Forecasts of irrigation water uptake were provided by HBRC, and are based on advice from Lewis Tucker. Capex and Opex costs were provided by Waterview Capital. Farm budgets for both dryland and irrigated farmers were taken from the report "Ruataniwha Water Storage Scheme - Review of Farm Profitability" dated 27 January 2016[2]. Land use, both existing and after the irrigation scheme reaches full capacity, came from the same source.

2 Prepared by MacFarlane Rural Business Ltd (Ashburton), Baker & Associates (Masterton) and AgFirst (Hastings).

2. Principle Changes to Assumptions & Effects on Net Present Value

In the original report it was argued that it was appropriate to assess Net Present Values over a 70 year project life and at a discount rate of 5 per cent (for further discussion on this see section 2.7.1 of that report). Accordingly, where changes to assumptions are accompanied by changes in Net Present Value, references in the text are to NPVs calculated on that basis. Tables show 35 and 70 year project lifetimes, and discount rates of 5%, 6% and 7%.

2.1 Construction Costs and Timing

The costs of dam and infrastructure were originally estimated to be $239.7m (including transaction costs and mitigation during construction). In addition there was $4.9 m for electricity reticulation, and $1.6m[3] of mitigations costs over 35 years giving a total of $246m. This was spread over a 4 year construction period and had a NPV (5 %) of $203m.

The March 2016 revised capital costs were estimated to be $333m[4], and this has since been further increased by $36 million to $369 million, principally through higher dam and distribution costs ($7.5 m), higher electricity distribution costs ($8m), higher Opex costs during construction ($3.9m) and an allowance for refurbishments of major items in years 15 – 30 ($15.4m). Construction is expected to take place over three years. **The NPV costs have risen by $21m** to $316m[5][6] (70 years & 5 %).

2.1a Scheme Operating Costs

The scheme cost of electricity has been decreased slightly from $2.734m / year to $2.554m / year at full development. **This decreases project NPV costs by $1.6m** (70 years and 5 %)**.**

2.2 Land Area, Land Use and Processing undertaken in region.

The assumptions about land use and processing in the region have not been altered in the base case. However, sensitivity testing (see section 3.5) has considered both (a) the impacts of considerably delaying the conversion to orchards and vineyards[7], which are expected to eventually cover 2,000 and 2,076 Ha respectively, and (b) the impacts of reducing the amount converted to these land uses to 1,130 Ha and 1,685 Ha respectively, this being the area originally proposed in the 2012 report

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3 There was some confusion as to whether the mitigation costs in years 2-5, 5-10 and subsequent years was an annual cost of a cost spread over the period. This led to total mitigation costs being stated as $1.56m, when it is now apparent that they should have been stated as $6.98m.

4 Costs over 70 years are higher than over 35 years because of the additional 35 years of mitigation costs, but discounting makes the difference negligible. There will also be some additional refurbishment costs in later years, but again, discounting means the additional costs are minor – perhaps NPV 1.5m. Residual benefits from residual values of plant in year 70 could be of the order of $4m.

5 This ignores scheme refurbishments beyond year 30 and also ignores residual values of the project.

6 Sunk costs of $17.3m are ignored in this analysis, as is the capitalized interest during construction because interest costs are implicitly taken into account in the discounting process. A CBA generally excludes sunk costs on the grounds that they cannot be recovered, and the CBA is an aid to deciding whether to continue with the project given the current environment. The March 2016 environment is that these costs cannot be recovered

7 Note that these may instead be other high value and intensive land uses which are not specifically identified.

2.3 Farm Capital Investment

There has been no change to the expected costs of development per Ha.

2.4 Water Uptake Rates

The original 2012 analysis reflected uptake rates of 56 % in the first year of operation, rising to 100% in year 8 of operations, and this was updated in 2016 to an uptake of 64 % in the first year, rising to 94 % in year 8 of operations, and 100 % in year 12 of operations. This 2017 review uses more recent data from Lewis Tucker[8], who has generated estimates for both contracted water take and "spot" water, although the "spot" water is generally being used by "Foundation Users"[9] to adequately irrigate the land they intend to irrigate, and then to irrigate additional land. Hence from a farm production point of view, the area of land being irrigated reflects a combination of both contracted and "spot" water. Under this assumption, demand in year 1 of operations is 64 % rising to 100 % in year 7[10]. Capital costs are bought forward a little, but so is increased farm production. **This modified uptake rate increase NPV project benefits (70 years and 5 %) by $36m.**

2.5 Contracted Water, Ordered Water and Price Paid

There has been no change to the price charged for water[11] or the total irrigated area at full development of 26,251 Ha.

Lewis Tucker has estimated a demand schedule for both contracted and spot supply. They argue that in the early years of the project, farmers will know there is a large amount of uncontracted water available and will be learning the limits of their irrigation systems, and hence are likely to rely on some uncontracted water from the "spot" market. Given this logic, we have assumed that prior to the full amount of water available for contract being taken up, the irrigated area will reflect the combined demand for both contracted and spot water as forecast by Lewis Tucker

2.6 Volume and Value of Sales of non-irrigation Water

2.6.1 Potable Water to Central Hawkes Bay District Council

These sales have now been removed. **This reduces the project NPV by $6 million (70 years & 5 %)**

2.6.2 Hawkes Bay Regional Council Purchase of Water for Environmental Flows

These sales have now been removed. **This reduces the project NPV by $17 million (70 years & 5 %)**

2.6.3 Spot Water Sold to Irrigators

It was earlier anticipated that, in a typical irrigation season, dam starting volumes plus inflows will exceed outflows by an average of 40Mm3, and that on average 9 Mm3 of that surplus water would be available to the spot market. Moreover, water that has been contracted for supply may not be

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8 Lewis Tucker, April 2017. Ruataniwha Water Storage Scheme, Commercial Review for Hawkes Bay Regional Council

9 i.e. Those who have a long term contract to take water.

10 The Lewis Tucker figures are expressed in calendar years rather than project years. For this report it has been assumed that 2020 will be the first year of operation.

11 $0.275 / m^3. The price charged does not affect the project economics. This is because a higher price for water increases water company profits and reduces farmer profits by an equal and offsetting amount.

used if farmers do not require it, since this will save them pumping costs[12]. This will leave substantial spare water in the system in an "average" year, and the 2016 analysis assumed a significant amount of this would be sold in the "spot" market for a NPV of $32m.

In contrast, Lewis Tucker expects that "Spot" water sales following full development will be only 0.6Mm^3 / year. The argument is that generally only farmers who are already connected to the scheme would be able to use this water, and most farm budgets assume eventual 100 % irrigation. Since irrigation development is only justified when water is reliably available, they will have contracted for water and will not want "spot" water, even if it is available. The small volume of "spot" sales are assumed to have a net benefit to the project (i.e. combined water company and users) equivalent to $0.28 / m3[13]. **This much more conservative approach to "spot" water use and sales reduces the project NPV by $30 million.**

2.7 Discount Rate and Project Lifetime

No Change. The arguments in favour of various discount rates are presented in the earlier report. Results are shown here for rates of 5 %, 6 % and 7 %.

2.8 Changes in Irrigated & Total Farm Area, and in Farm Profitability per Ha and Total

No Change.

12 Savings estimated at $1.1m / year over and above the farm profits used in this analysis. (100Mm^3 assumed – 73 Mm^3 required in average year) x $0.04 / m^3 electricity cost = $1.1m / yr

13 The standard delivered costs of water has been used

3. Updated Project NPVs and Economic Impacts

3.1 Project Net Present Values and Changes since 2016

If it is assumed that the project has only a 35 year life, then the project NPV varies from $105m to $385m depending on the discount rate (see bottom line of Table 1).

If it is assumed that the project has a 70 year project life, then the project NPV varies from $228m to $690m, depending on the discount rate (second to bottom line Table 2). The bottom line of that table assumes that sometime between year 35 and 100 the project is going to be closed with the cumulative probability rising to 100% by year 100. This assumption gives a probable project NPV of $205m to $624m.

Table 1 Net Present Value ($m) by Category, and Changes since 2016 Analysis – 35 yr project life

Project Life 35 years	Revised Estimates				2016	Difference at 5 %
Discount rate	no disc	7%	6%	5%	5%	
	a	B	c	d	e	f=d-e
Scheme Capital Costs (incl mitigat'n)	-369	-299	-307	-315	-294	-21
Farm Capital Costs	-556	-422	-438	-455	-444	-11
Electricity Generation	0	0	0	0	0	-0
Scheme Opex	-169	-52	-60	-70	-71	+1
Water Charges paid by farmers	+874	+264	+305	+355	+343	+12
Inc in farm profits (after irrig'n charges)	+2,380	+614	+727	+868	+833	+35
Other Water Charges*	+5	+1	+1	+2	+45	-43
Total	+2,164	+105	+228	**+385**	**+413**	-28

* Spot sales to irrigators

Table 2 Net Present Value by Category, and Changes since 2016 Analysis – 70 yr project life

Project Life 70 years	Revised Estimates				2016	Difference at 5 %
Discount rate	no disc	7%	6%	5%	5%	
	A	B	c	D	e	f=d-e
Scheme Capital Costs (incl mitigat'n)	-383	-300	-307	-316	-295	-21
Farm Capital Costs	-556	-422	-438	-455	-444	-11
Electricity Generation	0	0	0	0	0	-0
Scheme Opex	-351	-58	-69	-84	-79	-5
Water Charges paid by farmers	+1,834	+295	+353	+432	+421	+11
Inc in farm profits (after irrig'n charges)	+5,385	+712	+880	+1,111	+1,074	+37
Other Water Charges*	+10	+1	+2	+2	+55	-53
Total	+5,939	+228	+420	**+ 690**	**+ 732**	-42
Total with reducing probability of scheme survival after 35 years.		+205	+382	**+ 624**	**+ 665**	-41

* Spot sales to irrigators

The increase in capital costs from NPV $295m to NPV $316m has decreased project NPV by $21m[14] (see column f). The slightly faster rate of uptake proposed by Lewis Tucker, and hence earlier investment, has increased NPV of on-farm capital costs by $11m. However, this has been

[14] 5 % discount rate. Note that project costs are shown as negative NPVs. So a higher capital cost means a reduced project NPV.

accompanied by an NPV $11m increase in Scheme water revenue from farmers and an NPV $37m increase in farmer profits. Scheme Opex costs have risen by NPV $5m, while other water sales have declined by NPV $43m as a result of lower "Spot" water sales and the exclusion of sales to councils for environmental flows and potable water. Overall, the project NPV has decreased by $42m to $690m.

3.2 Project Benefit : Cost Ratios

A Net Present Value figure tells only part of the project financial story, and this figure needs to be put into the context of total project cost. The following table shows Benefit : Cost Ratios (BCRs) under various assumptions. This can be seen as a measure of robustness of the project to changes in the benefits or costs. A project with a positive Net Present Value will, by definition have a BCR >1, and a robust project will have a BCR significantly greater than 1.0.

Table 3 Project Benefit : Costs ratios for various Life-times and Discount Rates

	5 % Discount Rate			6 % Discount Rate			7 % Discount Rate		
NPVs ($m)	Benefit	Cost	Ratio	Benefit	Cost	Ratio	Benefit	Cost	Ratio
Project Life 35 years	1,224	840	1.46	1,033	805	1.28	879	774	1.14
Project Life 70 years	1,545	855	**1.81**	1,235	815	1.52	1,008	780	1.29

As is shown in Table 3, the BCR is above 1 in all cases, and is significantly above 1 at a 5 % discount rate and particularly for a 70 year project life. As is highlighted, for a 5 % discount rate and a 70 year life the BCR is 1.81.

3.2(a) Project Residual Values

No change has been made to residual values. As described in March 2016 report, these residual values have been excluded from the base case analysis on the grounds that it is quite likely to be offset by additional capital costs which are not identifiable and not included in the project analysis.

3.3 Interpretation of Financial Results

The financial Net Present Values and Benefit Cost Ratios shown here are an important input into decision making about the Ruataniwha Water Storage Project, but the results need to be put into the context of other social and environmental factors. There have been no changes made to these assessments apart from a small increase in economic impacts during construction and maintenance.

3.4 Economic Impacts

Economic Impacts are typically measured in terms of regional GDP[15], regional employment and regional earned household income. The initial impacts of the project occur during construction and continue over the entire period of farm conversion. The total of these is shown below and there is a very minor increase because of the increased capital cost during construction.

15 The returns to land, labor and capital. From an accounting perspective this is equivalent to EBITDA + wages and salaries

Table 4 Economic Impacts of On-farm and Off-Farm Construction

	Jobs (job-years)	Value Added ($m)	Household Income ($m)
Direct Impacts	n.a.	n.a.	n.a.
Total Impacts 2016 (rounded)	5,400	490	320
2017 update (rounded)	5,700	510	330
Difference	300	20	10

The estimates of on-going economic impacts, once construction finishes and farms reach full production, are unchanged (see Table 5 below). This reflect the lack of change to land uses and farm budgets. As noted in the earlier report, the impacts reflect the anticipated significant increase in processing activity with additional apples being packed and grapes, and vegetables being processed in the region, as well as half of the dairy and meat.

Table 5 Increases in Economic Activity Related to Expansion of Farm production, processing and Flow-on

	Increase	Output ($m / yr)	Jobs (FTEs)	Value Added ($m / yr)	Hhold Income ($m/yr)
	Pastoral and arable farming direct	100	125	29	7
	Vineyards	47	355	34	15
	Orchards	133	820	68	25
A	**Sub-Total – Farming**	**280**	**1,300**	**131**	**47**
B	Farm support effects	220	940	108	62
	Total Farming and Farm Support	**500**	**2,240**	**239**	**109**
	PROCESSING				
	Vegetables & juiced apples	161	530	57	32
	Meat (decline)	-14	-40	-5	-3
	Grapes	212	750	75	43
	Milk	71	100	13	7
C	**Sub-Total – Processing & Support**	**430**	**1,340**	**140**	**79**
D	**Grand Total – Combined Changes**	**930**	**3,580**	**380**	**188**

3.5 Sensitivity of Results to Areas of Land Use Changes, and Timing of this.

The earlier sensitivity analysis regarding changes in the final mix of land use has been repeated. Because farm budgets have not changed and the assumptions about processing in the region have not changed, then there is no change in the economic impact at final development (see bottom line of Table 6). A reduction in the area in orchards from 2,000 Ha to 1,130 Ha, and in viticulture from 2,075 Ha to 1,685 Ha, will still lead to a reduction in regional GDP of 85 million per year, and 910 fewer jobs.

The changes in scheme capital and operating costs and the small changes in uptake rates do have some impact on the effect of land use changes on project NPV. As is shown in the right hand column of Table 6, the effect of the reduced irrigated areas being in orchards and viticulture is to reduce the project NPV by $217 million (formerly $210 million) from $719 million to $500 million, and the Benefit : Cost ratio from 1.84 to 1.66, assuming a 70 year life and a 5 % discount rate. Even if the life time is shortened to 35 years and the discount rate is increased to 7 %, the project NPV is still positive at $45 million, and the benefit cost ratio is 1.07.

Table 6 Effects on Results of Reducing Viticulture and Orchards back to original Area

	Area of Land (Ha)		Difference	
	Original	Revised	**2017**	
LAND AFFECTED BY Irrigation	**43,250**	**43,250**	**0**	
Sheep & Beef (part irrig)	14,175	14,175	0	
Sheep & Beef – dry	4,671	4,671	0	
Finishing & Dairy Support	1,800	1,912	112	
Mixed	3,688	3,917	229	
Arable & Vegetable	5,667	6,018	351	
Dairy Heavy	1,150	1,221	71	
Dairy light	8,025	8,522	497	
Orchards	2,000	1,130	(870)	
Viticulture	2,075	1,685	(390)	
On-farm Capital Investment ($m)	$556m	$422m	(134)	
			2016	***2017***
Project NPV (70 yrs @ 5 % disc rate) $m	690	473	(210)	(217)
	1.81	1.62	(0.08)	(0.19)
Project NPV (35 yrs @ 7 % disc rate) $m	105	22	(69)	(83)
Benefit : Cost Ratio	1.14	1.05	(0.08	(0.09)
Economic impacts at full development				
Regional GDP ($m / yr)	$380m	$295	($85m)	
Regional Employment FTEs	3,580	2,670	(910)	

Additional sensitivity testing has considered the impacts of considerably delaying the conversion to orchards and vineyards[16]. While the assumption that the irrigated areas of these will eventually be

16 Note that these may instead be other high value and intensive land uses which are not specifically identified.

2,000 and 2,076 Ha respectively has been retained, the sensitivity testing assumes that only 25 % of that area is converted by year 10 of operations, with the remaining 75 % being converted over the following 10 years.

The effect of this is to reduce NPV costs of conversion by $118m[17], and to reduce NPV benefits of more productive land uses by $439 million[18]. **Hence the overall impact of this delay is to reduce the overall project NPV by $322 million** (70 years & 5 %)[19] to $368[20] million and the benefit costs ratio declines to 1.50 (70 years 5 %). In the extreme scenario of a project lifetime of only 35 years and a discount rate of 7 %, the project NPV actually becomes negative with a benefit : cost ratio of 0.87.

Table 7 Effects on Project Benefit : Costs ratios of Slower conversion to Orchards and Vineyards

	5 % Discount Rate			6 % Discount Rate			7 % Discount Rate		
NPVs ($m)	Benefit	Cost	Ratio	Benefit	Cost	Ratio	Benefit	Cost	Ratio
	Project Life 35 years								
Base Case Uptake	1,224	840	1.46	1,033	805	1.28	879	774	1.14
Slower Uptake	785	722	**1.09**	656	677	0.97	554	637	0.87
	Project Life 70 years								
Base Case Uptake	1,545	855	**1.81**	1,235	815	1.52	1,008	780	1.29
Slower Uptake	1,106	738	**1.50**	858	687	1.25	682	644	1.06

17 It has been assumed that in the interim there will be more irrigated land in mixed farming, which has a comparatively low capital investment to convert to irrigation. It is less likely that land will be converted to uses with high conversion costs, such as dairying, and then later be converted again to orchards or vineyards.

18 Assuming the new water uptake rates as discussed in a following section.

19 The reduction is the same for both the 35 year and 70 year project life because the expected land use from years 20 onwards is the same in both cases.

20 From ($1,545-$855=$690million) to ($1,106-738 = $368 million).

3.6 Effects on Port

In the original report it was estimated that the irrigation scheme would lead to an increase of 8,400 containers per year, with 1,530 of this being apples and 2,000 being wine. The revised productivity per Ha and total Ha for apples[21] suggests that there will be an additional 4.425m cartons, which at 1,175 cartons per 40 ft container is equivalent to an additional 7,500 TEUs (Twenty foot Equivalent units) per year, rather than the originally estimated 1,530 TEUs / yr. 1 tonne of grapes produces about 750 litres of wine, which is equivalent to 1,000 bottles or 83 cartons of wine. The expected production increase is 11.4 tonnes / Ha of grapes[22] x 2,075 Ha, or 23,700 tonnes of grapes which equates to 1,970,000 cartons of wine. At 700 cartons per 20' container this is equivalent to 2,800 containers or 2,800 TEUs / year, rather than the original estimate of 2,000 TEUs.

Imported Inputs were originally anticipated to increase by 1,000 TEUs per year, but the change in production has increased estimates of total farm inputs from $107m per year to $185m per year, or by 70 %. If we apply the same increase to inwards cargo then growth will be equivalent to 1,700 TEUs per year

Table8 ***Expected increases in Container Traffic (TEUs / yr).***

Product	Original Report	Updated Farm Production	Sensitivity testing-reduced orchards & vineyards
Meat	-84	-84	-84
Apples	1,530	7,500	4,200
Dairy	590	590	590
Vegetables	4,400	4,400	4,400
Wine	2,000	2,800	2,300
Inwards cargo	1,000	1,700	1,700
Total	9,436	16,906	13,106

Note: Scenarios with reduced EBIT have not been considered.

If port earnings (EBIT) at the margin are of the order of $150 per container[23], the increased traffic could increase EBIT by $2.5m / year, rather than the $1.4m / year originally estimated. If the increase in traffic is 13,106 containers, consistent with the reduced area in orchards and vineyards, then EBIT would increase by only $2.0m.

21 Productivity rising from 2,250 ctns / Ha to 3,000 ctns / Ha. Area increasing from 700 Ha to 2,000 Ha

22 25 Ha @ 12 tonnes / Ha and 5 Ha @ 8.5 tonnes / Ha = average 11.4 tonnes / Ha

23 According to the Port of Napier 2011 annual report, EBIT was $19m and traffic was 188,000 containers. Some of the earnings would come from bulk traffic, but a very rough approximation is that average EBIT is $80 / container. At the margin, one would expect significantly higher earnings per container, a point which was alluded to by the chairman who, in talking about the rapid increase in profit in the preceding year said that this "highlighted the impact of increased volumes through fixed infrastructure".

3.7 Effects of removing the difference in productivity in existing orchards, and assuming no new orchards or Vineyards

Councillors have asked what impact it would make if it was assumed that:

1. There was no difference in future productivity between existing orchards under the new irrigation scheme and under current deep water irrigation.

Answer: Project NPV declines by $90 million to $600 million, and Benefit : Cost ratio declines to 1.71. The increase in jobs drops from 3,580 to 3,450[24].

2. As above, AND that there is <u>no</u> additional viticulture or orcharding OR any other similarly intensive land uses, and existing orchards. At the moment it has been assumed that the land currently assumed to be converted to orchards and vineyards would instead be in mixed arable farming which is the least profitable of the financially viable land use changes. It may well be that the land would instead be used for more profitable horticulture and vegetable growing, in which case the declines would not be as great as shown below.

Answer: For a 70 year lifetime project the NPV is still positive, but the NPV drops to $188 million and the B : C ratio to 1.30. As the discount rate increases the NPV drops until it is zero at a 6.8 % discount rate. For a 35 year project the NPV is $58 million at a 5 % discount rate but drops to zero at a 5.8 % discount rate and is negative at any rate above this.

The expected number of <u>additional</u> jobs at full development is 3,580 in the base case and slower conversion, and drops to 3,450 jobs under the assumption that existing orchards have the same productivity under either irrigation regime (Ruataniwha or deep wells). However, if there is no additional conversion to orchards or vineyards, the number of additional jobs falls to only 1,130.

Table 9 Effects on Project NPVs and Benefit : Costs ratios of Change assumptions about Orchards and Viticulture

			Base Case	Existing orchards same productivity	Slower conversion to orchards and vineyards	No new orchards or vineyards
70 yr life	5% disc	NPV	690	601	368	188
		B: C ratio	1.81	1.71	1.50	1.30
	7 % disc	NPV	228	175	39	-12
		B: C ratio	1.29	1.23	1.06	0.98
35 yr life	5% disc	NPV	385	320	64	58
		B: C ratio	1.46	1.38	1.09	1.10
	7 % disc	NPV	105	63	-83	-65
		B: C ratio	1.14	1.08	0.87	0.88
	Economic impacts at full development					
Regional GDP ($m / yr)			$380m	366	380	141
Regional Employment FTEs			3,580	3,450	3,580	1,130

24 The productivity and numbers employed in existing orchards is assumed to rise to those values predicted for orchards under the irrigation scheme.

3.8 Effects of Reduced EBIT

The Review of Farm Profitability (2016) assumed that the reliability of water supply to scheme irrigators would be at least 95 % (i.e. full supply would be available 19 out of every 20 years). MacFarlane Rural Business have reviewed a range of RWSS dam supply scenarios, and where applicable, estimated EBIT reductions associated with the less than 95% reliability outcomes.

Annual average EBIT reductions range from 5-15% with the more severe reductions associated with the absence of the Tranche 2 (10GL) groundwater facility. As is shown in Table 10 below, the NPVs decline significantly, but the NPV remains positive for both project durations and over all tested discount rates with the exception of the extreme of a 15 % reduction AND a short 35 year project AND a high 7 % discount rate.

Table 10 Effects on Project Benefit : Costs ratios of Reduction in EBIT

Discount rate	5%			6%			7%		
	Base	- 5%	-15%	Base	- 5%	-15%	Base	- 5%	-15%
35 year project Life									
NPV ($m)	385	321	195	228	175	69	105	61	-29
Benefits : Cost Ratio	1.46	1.38	1.23	1.28	1.22	1.09	1.14	1.08	0.96
70 year project Life									
NPV ($m)	690	609	446	420	356	228	228	176	72
Benefits : Cost Ratio	1.81	1.71	1.52	1.52	1.44	1.28	1.29	1.23	1.09

The reduction in EBIT is assumed to arise from a change in output value rather than a change in inputs of labour and other goods and services. For this reason the regional economic impacts with respect to jobs and earned household income do not change. However, the change in EBIT (profit) has an equal effect on direct and total regional GDP. Hence a 15 % decline in EBIT reduces the base case regional GDP at full development by $19 million per year to $361 million per year. The comparatively small decline in total regional GDP (5 %) reflects the fact that the decline in on-farm GDP has no impact on GDP in all the non-farm sectors.

3.9 Combined Effect of Changed Assumptions about Orchards and Viticulture, and Reduced EBIT

5 % Reduction in EBIT

As is shown in table 11 below, with a 5 % reduction in EBIT over all irrigated land classes, then for a 70 year project which has no additional orchards and vineyard, the NPV at a 5 % discount rate drops to $132 million and the Benefit : Cost ratio declines to 1.21 (top right). At a 7 % discount rate, then the NPV is negative for both the slower conversion scenario and the zero additional conversion to orchards and vineyards.

A 35 year project with a 5 % discount rate has a positive NPV of $12 million even if there is no additional conversion to orchards and vineyards, but once the discount rate rises to 7 % then the project NPVs become negative for both the slower conversion and the zero additional conversion to orchards and vineyards.

15 % Reduction in EBIT

With a 15 % reduction in EBIT, the effects become more marked (see Table 12). The project NPVs are still positive with a 70 year lifetime and a 5 % discount rate, even for slower or zero conversion to orchards and vineyards. However, once the discount rate increases to 7 % then the slower conversion or zero additional conversion to orchards and vineyards leads to a negative NPV (see right hand side of line 3 of table 12). For a 35 year project the NPVs under all scenarios are negative at a 7 % discount rate, and only the base case land use has a positive NPV at a 5 % discount rate.

Table 11 Effects on Project NPVs and Benefit : Costs ratios of Change assumptions about Orchards and Viticulture – Assuming 5 % decline in EBIT

			Base Case adjusted for 5 % lower EBIT	Existing orchards same productivity	Slower conversion to orchards and vineyards	No new orchards or vineyards
70 yr life	5% disc	NPV	609	519	287	132
		B: C ratio	1.71	1.61	1.39	1.21
	7 % disc	NPV	176	122	-13	-50
		B: C ratio	1.23	1.16	0.98	0.91
35 yr life	5% disc	NPV	321	255	0	12
		B: C ratio	1.38	1.31	1.00	1.02
	7 % disc	NPV	61	17	-128	-98
		B: C ratio	1.08	1.02	0.80	0.82
	Economic impacts at full development					
Regional GDP ($m / yr)			374	360	374	137
Regional Employment FTEs			3,580	3,450	3,580	1,130

Table 12 Effects on Project NPVs and Benefit : Costs ratios of Change assumptions about Orchards and Viticulture – Assuming 15 % decline in EBIT

			Base Case adjusted for 15 % lower EBIT	Existing orchards same productivity	Slower conversion to orchards and vineyards	No new orchards or vineyards
70 yr life	5% disc	NPV	446	354	125	22
		B: C ratio	1.52	1.42	1.17	1.03
	7 % disc	NPV	72	17	-117	-125
		B: C ratio	1.09	1.02	0.82	0.78
35 yr life	5% disc	NPV	195	126	-127	-78
		B: C ratio	1.23	1.15	0.80	0.87
	7 % disc	NPV	-29	-75	-218	-165
		B: C ratio	0.96	0.90	0.66	0.70
	Economic impacts at full development					
Regional GDP ($m / yr)			361	347	361	130
Regional Employment FTEs			3,580	3,450	3,580	1,130

4. Conclusion

There has been a lot of debate about appropriate discount rates and project life times. For reasons I have previously outlined I believe that the project should be viewed as having at least a 70 year lifetime, and that a 5 % discount rate is appropriate.

Provided the anticipated land profitability is reached, then under all scenarios tested including base case, slower conversion to orchards and vineyards, and smaller final areas in orchards and vineyards, the project generates a net benefit from a financial perspective, ignoring non-market considerations, provided it continues for 70 years. This is the case even if a discount rate as high as 7 % is applied.

The project also generates a net benefit if it has a lifetime of 35 years, except where there is a long delay in the conversion of land to orchards, vineyards, or some other similarly profitably land use AND the discount rate exceeds 5.9 per cent. As argued in the earlier report, in my opinion a discount rate of 5 % is appropriate for assessing projects of this type.

Reduced profitability

If the anticipated profitability is not reached (i.e. if EBIT is less than has been predicted), then obviously the project financial benefits decline. If the project has a 70 year life, then at a 5 % discount rate all scenarios tested still have a positive NPV, even with a 15 % decline in EBIT. However, if the discount rate is increased to 7 %, then the scenarios which have slower or zero additional conversion to orchards and vineyards have a negative NPV.

If the project has only a 35 year life then at a 5 % discount rate all scenarios still have a positive NPV with a 5 % decline in EBIT, but with a 15 % decline in EBIT the scenarios which have slower or zero additional conversion to orchards and vineyards have a negative NPV. At a 7 % discount rate only the base case land use mix has a positive NPV with a 5 % decline in EBIT, and all scenarios have a negative NPV with a 15 % decline in EBIT

Employment Impacts

As has been previously noted, employment generation is heavily dependent on the final mix of land uses on the newly irrigated land. Under the expect land use mix there are an estimated 3,580 additional jobs created. If there are no additional orchards or vineyards, then only 1,130 jobs are created.

Appendix 1 Reconciliation of Financial Model and Economic Model

Table reconciling total cost as per Butcher Report and RWLP financial model

Fixed Price OHL-Hawkins contract for Dam and Distribution	$282.0m	
Portion of additional network ("SP3") build during construction	$4.7m	
Operating Costs during the construction period	$15.3m	*This includes a component of the mitigation and offset package to the extent it occurs before the scheme is operational*
Land Acquisition	$8.0m	
Development Costs	$17.3m	
Funded Bank Balance	$1.5m	
Bank debt Interest & upfront fees	$11.3m	
RWLP costs prior to / during Construction as per financial model	**$340.0m**	
Less: Bank Debt Funding Costs not included in the Butcher total	($11.3m)	*Butcher does not directly included cost of capital in his total cost analysis*
Less: Funded cash balance	($1.5m)	*This is not a cost for the scheme rather a prudent treasury measure, and is not included in Butcher's analysis*
Less: Development Costs	($17.3m)	*These costs are already incurred, and therefore are not included in economic analysis*
Plus: Additional Network ("SP3") incurred during operating period	$5.3m	*This is included in the financial model as capital expenditure during construction*
Plus: Centralines transmission / distribution expenditure	$20.0m	*This cost is incurred by Centralines, which charges RWLP an annual charge during the operating period that is included in RWLP model as an operating cost*
Plus: Maintenance Capex to be undertaken in years 15-30	$15.4m	*These costs are incurred in years 15-30 and therefore are included in the operating budget in the RWLP financial model, not in the upfront capital cost*
Plus: Mitigation costs to be undertaken during the operating period	$18.0m	*These costs are incurred in years 4-35 and therefore are included in the operating budget in the RWLP financial model, not in the upfront capital cost*
Costs as per Butcher Report (rounded)	**$369m**	
Difference	*-$0.3m*	*rounding*

RWSS Review – Item 10

Collation of views of downstream production demand from major regional meat, dairy and horticulture processors and exporters, as well as impacts on Port of Napier, from RWSS related production

Comment: *Given dynamic market conditions, it is recommended that the most recent views on the value of the scheme be canvassed with major supply chain participants. This work will have broader benefits of engaging these businesses in a discussion on the value of water.*

Process:

Interviews conducted with the parties listed at the end of this document. The comments recorded under the sector headings in this report strictly reflect the opinions and observations of the interviewees and not the author.

Matters of Disagreement between Parties:
In relation to the economic impacts of the scheme, one aspect of land use change has attracted particular focus: the suitability of the RWSS irrigation zones for horticultural production plus the rate at which additional horticultural investment in these zones will take place.

Costs and Benefits:
N/A

Risks:
Expansion of horticultural production is slower than that modelled by the scheme. As the Butcher Report considered both higher and lower horticultural production scenarios, weight should be given to the lower production scenario.

Opportunities:
Increased water availability will see a reduction in winter-focussed livestock systems (with consequential improved environmental outcomes) in favour of either outright land-use change or a change to more balanced production systems.
Increased security of existing processing capacity as well as accelerated likelihood of new processing capacity.

Summary:

1. The overwhelming majority of participants believe that, subject to prevailing market conditions, modelled land uses represent realistic profitable land use options over time in the RWSS Zones. Determining allocation of particular quantities of land area to particular land uses involve inherently high levels of uncertainty, and investment drivers external to the economics of the scheme.
2. Existing large-scale operators expressed strong reservations about the likelihood of which organisations, if any, are likely to lead significant horticultural development in the short to medium term.
3. Horticulturalland use change to greater horticulture and viticulture can be considered to be slikely in the medium to long term given the lower cost of land combined with the adaptive land management practices that have seen industries expand into non-traditional production areas (e.g. grape production in Central Otago, Kiwifruit production in Hawke’s Bay).

4. Land use change over time is dynamic. In the life of the RWSS project new land use options have emerged that represent scale opportunities (e.g. small seed production).
5. Competition for land use in the Heretaunga plains naturally tends to see land use change in favour of 'highest and best use', which is currently pipfruit. This is causing growers of other crops to look beyond the Heretaunga plains for land, with the focus areas being Northern and Central Hawke's Bay.
6. In terms of increased irrigation availability, industry leaders appear to place equal (if not greater) value on the reliability of production compared with increased productivity. Reliability is seen as an essential driver of increased efficiency, reduced waste and ensuring meeting the supply commitments demanded by higher value markets.

Apple Production and Processing.

Approximately 700ha of pipfruit is grown in the RWSS command zone, and McFarlane Rural Business modelling estimates that horticulture will eventually increase to 4,075 ha split between pipfruit (2,000 ha), grapes and other horticultural production.

Discussions with Plant & Food Research focused on the ability for horticulture to expand in the RWSS footprint. The panel noted that apples and pears were very adaptable and produced across a range of different climates around the globe. It was noted that the large corporate producers/processors are increasingly building exclusivity over certain fruit strains via plant variety rights (PVR's) in order to support their marketing and brand programs (e.g. Envy, Jazz, Smitten, Dazzle, Rocket, Diva, Kanzi, Ambrosia). This means the holders of the PVR's have more influence of the expansion (or restriction) of these closed varieties.

P&F's consensus was that the opportunities that flow from adaptive management practices combined with new technology should not be underestimated. Lower land values in CHB mean that new green-field horticultural plantings can be established with the tools and techniques best suited to the environment (e.g appropriate varieties, hail netting, frost protection). A number of examples of the successful establishment of new growing zones outside traditional areas were discussed, including kiwifruit in Hawke's Bay, grapes in Central Otago, and the prevalence of hail netting in Nelson/Motueka.

A pip-fruit consultant echoed these sentiments around adaptive management. He reiterated the importance of assessing a RWSS orchard established specifically in accordance with the needs presented by that environment instead of reflecting on the extent to which a Heretaunga plains model orchard would or would not perform under CHB conditions. The pressure on land availability was discussed, as evidenced by the recent sharp lift in horticultural land values. While expansion opportunities existed in northern Hawke's Bay, concerns were raised around challenges around logistics (transport costs and product damage) and the need to build processing and packing capacity. Overall, it was felt that the Horticultural sector was experiencing period of sustained profitability based on new varieties, new markets and better production systems – conditions which naturally see the footprint of any industry expand. The establishment of horticultural operations is becoming very capital intensive, which in turn makes climatic volatility and the consequences of reduced access to water a higher risk for a sustainable industry seeking to reliably deliver high quality products to overseas markets.

Of the 3 Pip fruit industry leaders interviewed, 2 currently grew apples on the Ruataniwha Plains.

For one, CHB orchards were at the bottom end of performance measures because of the cooler climate, poorer soils, frosts and higher service and harvest costs due to remoteness from main operations. This grower noted that while the area would favour later producing varieties such as Pink Lady, on balance the best risk-adjusted expansion option (excluding the Heretaunga Plains) lay to the North toward, including Wairoa. The company believed that there were still good opportunities for expansion on the Heretaunga Plains as the projected industry returns would see more land gravitate to pip-fruit production as highest and best use. The company was highly sceptical that 4,000ha of horticulture would be established in the footprint in the short to medium term. In terms of the value proposition of water, the company felt that on-farm storage options represented lower overall risk compared to the RWSS and noted that Tranche 2 water mitigated some of the risks associated with the Plan Change. Overall, the company believed that region needed to move away from promoting intensive pastoral production if it comes at a higher environmental cost and the company would prefer to see greater investment in the Napier Port and improved drainage in Northern Hawke's Bay.

Mr Apple, New Zealand's largest, fully integrated grower, packer and marketer of apples, sources 1/3 of its overall production from CHB. The overall orchard production performance in CHB is considered to be close to that of its Heretaunga Plains orchards, but the climate and conditons mean that any management lapses are likely to have a higher relative impact on yield. In particular, water security is non-negotiable as water deficits impact growing conditions much more quickly. Accordingly, without increased water availability and security in the future the chances of a significant increase in horticultural investment within the RWSS footprint is very small. Over time Mr Apple has adapted its management practices to make its Ruataniwha-based orchards a key part of its supply equation, and believes that some of the negative perceptions about growing apples in this area do not match the reality. While remaining committed to its CHB operation, Mr Apple's short term growth horizon is focussed on continuing to increase the productivity of its existing orchards combined with incremental expansion in the Heretaunga Plains. However, over a 15-30 year term Mr Apple believes that the RWSS scheme would be transformational for CHB and that horticulture will represent a significant proportion of that transformation.

Finally, T&G are not looking to expand to the RWSS footprint unless in response to a macro issue such as climate change. The pipfruit industry is growing strongly following investment in new varieties and global leadership in eating quality and food safety assurance. The market will support increased production, but an additional 1,300 ha in CHB (depending on the time-frame) represents a significant proportion (14%) of total NZ production. There is room for expansion on the Heretaunga Plains and into Northern Hawke's Bay, but the latter will require significant investment in post-harvest infrastructure.

Red Meat Sector

Despite acknowledging that the RWSS would in all likelihood lead to land use changes that are not in Progressive Meats best interests from a lamb supply perspective, the CEO expressed strong support for what he viewed as being 'the common sense of transferring water from winter to summer.' Craig felt history has repeatedly shown that, on balance, it is better to progress with initiatives like the RWSS and proactively manage and mitigate the risks rather than letting the risks overwhelm and do nothing. He noted it is impossible to predict land use changes accurately given they will be a function of economic and market returns that change over time but that it is likely that the price of water will see land use change beyond intensive pastoral/dairy farming. Craig felt that whichever land use dominates, it will represent economic progress and opportunity shared across the region. While the immediate benefits will accrue to CHB, Hastings District will be an equally significant beneficiary as the centre of processing, support and retail services, etc. Craig believes that looking forward, RWSS will be evolutionary, while. looking back, RWSS will be transformational.

Senior Managers at Silver Fern Farms noted that at the time of the interview (17/2) the dry condition had seen approximately 100,000 lambs leave the region (predominantly to the South Island). This represented an immediate economic loss to the region, not only from $1.3m processing related wages per week, but also the impact of those lost wages on local businesses. It was noted that approximately 200 employees commute from Napier & Hastings to the Company's plants in Takapau and Whakatu.

Current climatic conditions in the RWSS footprint favoured a winter-intensive farming policy utilising bull-beef. Here a high stocking rate was managed through the winter in order to capture the spring feed surplus with an animal that could achieve high live-weight gains while at the same time always being marketable (for slaughter or sale) in the event of abnormally dry summer conditions.

In terms of land use change it was felt that the introduction of irrigation (and greater certainty around summer and autumn conditions) would see these systems transition towards one that more consistently grows higher value animals (steers, heifers, lambs) throughout the year. This change would be positive for both the Whakatu and Takapau plants as they had specialist capacity for processing higher value cuts.

However, water security is not only important for the supply and procurement of livestock to local plants. For its Takapau plant, Silver Fern has a strategic interest in long-term water security for overall operations and growth. An ability to source RWSS water will be an important factor in future proofing its CHB operations, especially in light of the now concluded Chinese equity investment, which places greater emphasis on supplying quality assured, value-added, locally sourced and processed cuts of meat.

Cropping

HJ Heinz currently secures the bulk of its locally grown products from the Heretaunga Plains. The company views the challenges for Ruataniwha as being a shorter season due to the later spring. On the other hand, opportunities stemmed from access to cheaper land combined with a 35-year water take and the likelihood of a range of crops being suited to that zone, including sweet corn, beetroot, onions, squash and small seeds. Navy Beans, currently imported from Canada, were an opportunity for potentially up to 4,000ha of production. While it was likely that it would take time to transition to high value process crops, there is a consensus that the additional supply of suitable irrigated land would ultimately lead to significant land use change.

Process crops require significant annual investments to establish and grow ($10-13,000 per hectare) which means there is practically zero tolerance for production risk arising from a lack of water. Volatility of water supply does not attract investment. The TANK process and the proposed Water Conservation Order create a great deal of uncertainty except for the fact that change is inevitable. New Zealand has a good track record for producing food, and this has recently seen production shifted to Hawke's Bay from Australia. There is no question that our efficiency and reliability of production is a factor in these types of decisions.

Competition for land has increased significantly on the Heretaunga Plains and a failure to open up new areas of production combined, with a land management and water availability environment that is more restrictive, will serve to accentuate that pressure.

McCain Foods sources a significant percentage of its production within the RWSS footprint, including peas, beans, sweetcorn, carrots and potatoes. Ruataniwha is a close second to the Heretaunga plains and under the right management, the company believes the area will succeed as a significant supplier of higher value process crops. Although Heretaunga Plains yields are better on average, the company notes that good management plays an important role in production efficiency, with 5 of the 13 highest yielding pea crops coming from CHB.

The Hastings plant has been the beneficiary of significant investment following a consolidation of the company's Australasian enterprises, with the stable, predictable nature of the region's growing conditions and the processing expertise and labour skills in the Hastings district all playing an important role in this decision. McCain's are supporters of the RWSS.

Apatu Farms Ltd, a large-scale, Heretaunga-based, diversified cropping company, identified the current intense competition for land on the Heretaunga plains as being a catalyst for more cropping in CHB should the RWSS proceed. However, it was felt that this would take time as producers sought to understand the high variability of soil types and the corresponding management practises. While the availability of additional irrigated land was undoubtedly an opportunity, understanding factors such as transport costs are an important part of the investment decision. Small seed production was likely to scale up more quickly. The company saw Hawke's Bay as strategically well placed to benefit from the growth in viticulture, especially given the scarcity of land in Malborough. However, Ruataniwha is likely to experience only second-order growth behind the Heretaunga Plains, at least initially.

Ashburton-based Midland Seeds are significant producers and suppliers of high-value small seed crops and are a leading high-value arable production and marketing company in New Zealand. The company has taken a strong interest in RWSS as it represents an opportunity to diversify its production base, including high value carrot and radish seeds.

The company has strategic partners looking to invest and establish operations at scale in the area. This would also require additional investment in farm machinery and seed cleaning/drying infrastructure, as well as a need to access technical skills and support services. Once validated, it would be the company's expectation that the industry could, subject to land availability and suitability, scale quite quickly in the RWSS command area (estimated to be 5-10,000ha) based on market demand.

Dairy

Hawke's Bay has 83 dairy farms of which 41 are in the Tukituki catchment. 2/3rds are already irrigated with the remainder dependant on rainfall. Most of the dairy farms will be able to manage their businesses within PC6 LUC nutrient limits and even lower when accounting for run-off properties that form part of overall farming enterprises. Fonterra believes that the RWSS will result in an increase in production from this area both in property and cow numbers and on-farm productivity. It is also projected that the Scheme could accelerate the need for the establishment of additional milk processing and logistics capacity in the region over the medium term, and that the nature of the timing of the milk supply from CHB means that a higher value/specification plant could be required rather than a dryer facility. The recent $250m addition to the Pahiatua factory capacity gives an indication of the magnitude of investment that could be required at some stage.. Fonterra is confident that its supplier base has already internalised the community's concerns about on-farm environmental management and that the industry's ability to manage towards improved outcomes was vastly under-rated. Based on the experience of existing top performers it is evident that improved irrigation efficiency and modern crops under irrigation can and will result in significantly improved nutrient utilisation and capture.

On-Farm storage is viewed as an economically inferior alternative to RWSS with the estimated infrastructure cost being nearly 4 times greater per m3 before accounting for land loss and reticulation costs.

Viticulture

Although small in scale, there are 5-6 existing wine producing vineyards in CHB. For these operations, irrigation is essential to vine establishment, frost protection and crop production. Discussions with a significant winery pointed to the likelihood of vineyard expansion to be very nuanced and deliberate for a number of reasons.

Delegat's noted that outside of New Zealand's significant appellations e.g. Malborough and Gimblet Gravels, most other wine production is considered generic as far as the market is concerned which in turn demands, along with crop quality, an equal or greater emphasis on achieving high crop yields.

Dr R Balasubramaniam reported that new plantings require a close assessment of the varietal characteristics sought by the market, the climatic conditions of the proposed growing area and the production yield required to deliver an economic return. In many cases, the physical attributes will need to be assessed at a micro-climate scale to ensure a profitable yield of approximately 12T/ha is achievable.

It takes many years to develop the premium characteristics and qualities that lead to the recognition of a distinct appellation. As an example, a recent article in the Hawke's Bay Today reviewing the history of the establishment of the Gimblet Gravels, which was led by a individuals who challenged proposed Council-zoning changes in order to preserve soils that were considered unsuitable for viticulture.

Port of Napier Limited

Port executives noted that PONL currently operates at an 80:20 export/import ratio. With approximately 256,000 TEU's handled per annum, the projected 16,900 TEU increase in container traffic from RWSS production represents a 6.6% overall increase. Executives felt that additional pipfruit production would almost certainly be channelled through the Napier port, however it is likely that only wine bottled locally would be exported locally. Furthermore, it was noted that milk processed at Fonterra's Pahiatua factory is currently exported via Tauranga.

While the overall impacts of the scheme were at the margin over time, RWSS would represent another regional growth catalyst that is critical for the long term sustainability of the port and enables on-going investment in the type of infrastructure and facilities necessary to attract and retain shipping customers.

Bostock NZ - John Bostock
Midland Seeds - Chris Greene of (Sth Canterbury)
Plant & Food Research – Allan White, Paul Johnson, Stuart Tustin
Port of Napier – Garth Cowie & Andrew Locke
Apatu Farms – Paul Apatu
Ag First – Jonathan Brooks
McCain's – Mike Flynn
Progressive Meats – Craig Hickson
Delegats Wines – Dr R Balasubramaniam
Fonterra – Tony Haslett
H J Heinz – Mike Pretty, Bruce McKay
Silver Fern Farms - Daryn Jemmet, Shaun O'Neill, Allan Poy and Gary Williams.

T&G (BayWa) – Bruce Beaton
Mr Apple – Andrew van Workum, Tony Knight, Grant Rae.
CHBDC – Mayor and Paul Collits – *no comments incorporated into report.*
Te Tumu Paeroa – Blair Waipara – contacted via phone. No comments incorporated into report
PGG Wrightson – East Coast Regional Manager – contacted via phone – interview could not be arranged prior to report deadline.

Date: 7 April 2017

MEMORANDUM

FROM: Ned Norton (LWP)

TO: James Palmer (Group Manager Strategic Development, Hawkes Bay Regional Council)

SUBJECT: REVIEW OF THE RUATANIWHA WATER STORAGE SCHEME: ISSUE 12

Contents Page

Summary of key findings:

a) Environmental monitoring tells a complex story of how achievement of several Plan Change 6 (PC6) environmental objectives and limits currently varies in time and across the catchment. The two key measurable environmental objectives for periphyton and macroinvertebrate community index (MCI) health do not always comply and improvement is necessary.

b) Many factors influence achievement of periphyton and macroinvertebrate health objectives including; river flows, the nutrients nitrogen and phosphorus, sediment, organic contaminants, physical habitat quality, and riparian condition and shading.

c) In general, there is no headroom to increase dissolved reactive phosphorus (DRP) at a whole catchment scale; rather there is a need to reduce DRP in order to i) meet PC6 instream DRP limits and ii) as part of a multi-pronged approach to achieve periphyton and MCI objectives.

Land Water People Ltd
145c Colombo Street, Beckenham, Christchurch 8023, New Zealand
P.O. Box 70, Lyttelton 8082, New Zealand

d) There is considerable headroom for further nitrogen losses under the Land Use Capability (LUC) leaching rates set in Ruataniwha Water Storage Scheme (RWSS) consent conditions and in PC6 Policy Table 5.9.1D. It is estimated this headroom allows for an increase on current nitrogen losses in the order of 30-50% on a whole catchment basis (e.g. above Red Bridge). The amount of this headroom for nitrogen loss varies considerably between sub-catchments.

e) In contrast there is no headroom for further increase in dissolved inorganic nitrogen (DIN) concentrations in the upper catchment (i.e. above Shag Rock) when assessed against the 0.8 mg/L PC6 instream DIN limit. Reductions to current nitrogen loss would be needed in several catchments in the RWSS area to meet this limit.

f) I have discussed the apparent disconnect between the 30-50% LUC-based headroom for nitrogen and the nil (or negative) DIN limit-based headroom in the upper catchment, and the lack of clarity this creates for resource use. Planning and legal issues around the extent to which the RWSS is responsible to the 0.8 mg/L DIN limit are being addressed under review Issue 17.

g) The 0.8 mg/L DIN concentration is not a defensible threshold between healthy and unhealthy ecosystems. I have described it as a point on a risk spectrum, where increasing concentrations mean increasing risk of uncertain negative effects on periphyton blooms and macroinvertebrate community health (e.g. MCI). Other factors such as flow, phosphorus, sediment, physical habitat and riparian condition also influence whether periphyton and macroinvertebrate health objectives will be met.

Summary answers to three key questions:

QUESTION 1: What land uses and on-farm management practices would be required to meet LUC-based nutrient leaching allocation rates?

1. I think it would be relatively straight forward for the RWSS to operate with any of a wide range of possible land uses, using currently available good on-farm management practices, and meet its current consent conditions relating to LUC leaching rates, albeit with considerable management effort.

QUESTION 2: What land uses and on-farm management practices would be required to meet an instream DIN concentration of 0.8 mg/L?

2. In contrast I think it would be very difficult for the RWSS to operate within the significantly smaller nitrogen losses implied by the instream DIN limit of 0.8 mg/L. If the RWSS increased nitrogen losses under its LUC-based allocation and then had to subsequently reduce to meet the DIN limit of 0.8 mg/L by 2030, then it would need to: i) change land use to significantly lower nitrogen losses and/or ii) innovate to find new N-loss technologies and/or catchment-scale mitigations such as a network of wetlands and/or iii) revise the DIN limit upwards. There are unavoidable risks for RWSS in relying on any or all of these.

QUESTION 3: Could the water quality objectives of PC6 still be achieved in the event that the PC6 DIN limit of 0.8 mg/L is not met by 2030?

3. My answer is: Yes maybe, but it is undeniably and unavoidably uncertain; there are risks that periphyton and ecosystem health (MCI) objectives will not be achieved everywhere. Achieving them would rely on many things in addition to the effects of the RWSS total nitrogen loads and associated instream DIN concentrations. The multi-pronged strategy proposed by RWSS would need to be relied on, that includes:

a) reducing instream DRP from both diffuse sources and community wastewater treatment plant point discharges,

b) provision of flushing flows from RWSS storage to manage the frequency and duration of nuisance periphyton in some river sections (see review Issue 16),

c) riparian habitat enhancements that could improve habitat quality, shading and reduce fine sediment loss to streams,

d) an ability for the RWSS to adaptively manage local hotspots for nutrients by requiring extra phosphorus mitigations and lower than LUC-based nitrogen leaching rates in parts of the scheme area, in response to any monitoring that shows local breaches of periphyton and/or MCI outcomes, and

e) improved flows in some stream sections due to i) PC6 higher minimum flows, ii) migrating some current groundwater extractions onto RWSS stored water, and iii) the potential for providing some flow augmentation to some stream sections from RWSS storage.

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1. The scope of this review of Issue 12

1 The scope of this review is to assist with addressing “Issue 12” of the “Review of the Ruataniwha Water Storage Scheme [RWSS]” (the Review) as described in a paper to Council on 14 December 2016 which scoped Issue 12 as:

> “*Assessment of on-farm management practices, including stocking levels and associated land-use constraints, required to meet the nutrient leaching and groundwater water quality requirements of Plan Change 6* [PC6] *and the Regional Policy Statement. Estimate of current compliance within existing land uses and the extent of headroom for intensification and land use change will be provided. Estimate implications for the RWSS in meeting consent conditions relating to scheme water users and nutrient limits.*”

2 This scope has evolved as the work has proceeded. In particular the review of Issue 12 has expanded to include consideration of questions submitted in a letter from a joint submitter group comprising the Environmental Defence Society, Forest and Bird, and Fish and Game New Zealand dated 25 November 2016 (the EDS-F&B-F&G letter). The scope may also expand to take on any feedback and/or questions that may arise from a meeting with the Community Reference Group on 30 March 2017.

3 The assessment of Issue 12 requires a range of expertise that has been provided by several parties who have been engaged in consultation with Hawkes Bay Regional Council (HBRC) and is being led by HBRC staff. Other key contributors are Lachie Grant and Ian Millner (both external providers), Shane Lambert (HBRC Senior Planner), Nathan Heath (HBRC Acting Manager – Land Management) and several HBRC technical staff including Dr Andy Hicks and Mr Dougall Gordon. In brief, the assessment of on-farm management practices required to meet nutrient leaching rates and groundwater quality requirements of PC6 has been undertaken by Lachie Grant and Ian Millner, an assessment of current environmental state (based on monitoring data) compared to environmental objectives and limits in PC6 has been undertaken by Andy Hicks and Dougall Gordon.

4 I have assessed the current environmental state in relation to the concept of headroom for intensification and land use change, and assessed possible consequences of the RWSS on that headroom and for the water quality objectives defined in PC6 - specifically the periphyton and aquatic ecosystem health (macroinvertebrate) objectives.

2. Expertise

5 I do not have specialist expertise in assessing the on-farm management practices needed to achieve specific nitrogen and phosphorus loss rates from properties. However I am familiar with the methods used by others, such as Lachie Grant and Ian Millner, who do have this expertise. I am familiar with interpreting results of farm nutrient management assessments in order to assess effects on water quality and related environmental outcomes. I have specialist expertise in assembling and integrating information from multiple technical disciplines, including water quality and aquatic ecology, in order to assess consequences of land and water development scenarios on environmental outcomes. I also have expertise in relating such assessments to policy and planning requirements.

3. My approach to tackling Issue 12

6 I understand that I have been asked to provide a 'fresh eyes' review of matters around Issue 12 in order to assist the Council in understanding, overall "…*the costs and benefits of the scheme, as well as risks and opportunities with decisions to proceed, abandon or shelve the scheme*…". I understand that the purpose of the review is not to recommend to Council whether to proceed, abandon or shelve the RWSS but to objectively facilitate informed decision making by the Council.

7 I have read a large amount of information about the RWSS and PC6 in a short period of time. It has been challenging to read all this material and to sort the 'wood from the trees' in order to respond to Issue 12. While I have read everything I thought relevant, it is possible I could have missed something that has a bearing on my review conclusions. I am anticipating that this risk will be managed by the review process. This process will allow for feedback from the Community Reference Group and/or Council, and the opportunity to raise questions if something important has been missed.

8 I have found it necessary to explore a number of interrelated topics and give my view on them in order to establish sufficient background to answer the questions that arise from Issue 12. I cover these topics first under the following sub-headings, before returning to answer three specific questions arising under Issue 12 at the end:

- Current environmental state and the concept of headroom
- A disconnect between 2 types of headroom for nitrogen
- Confusion around the environmental significance of a 0.8 mg/L DIN concentration
- Dealing with issues of uncertainty, and thus risk
- Answering the questions that arise out of Issue 12

4. Current environmental state and the concept of headroom

9 Several HBRC technical staff[1] assisted this review by providing up to date summaries of current environmental state with respect to several relevant environmental measures that appear in PC6 in either the objectives (OBJ TT1) or policies (Limits and Targets Tables 5.9.1A-D and 5.9.2).

10 The relevant objectives appearing in OBJ TT1 are:

- "*The frequency and duration of excessive periphyton growths* [i.e. growths that exceed the Table 5.9.1 numeric periphyton limits as shown below] *that adversely affect recreational and cultural uses and amenity are reduced*".

- "*Groundwater levels, river flows, lake and wetland levels and water quality maintain or enhance the habitat and health of aquatic ecosystems, macroinvertebrates, native fish and trout*". [Numeric indicators of the habitat and health of macroinvertebrates are then provided in terms of Macroinvertebrate Community Index (MCI) scores in Table 5.9.1 as shown below].

11 The relevant measures appearing in policy Tables 5.9.1(A-D) and 5.9.2 are:

- Periphyton biomass limits of a maximum of 50 mg Chlorophyll a/m^2 for Zone 4 (Upper Tukituki and Waipawa Rivers) and 120 mg Chlorophyll a/m^2 everywhere else (i.e., Zones 1, 2, 3 and 5).

- Other periphyton limits for measures of visible percentage bed cover by filamentous algae, diatoms and/or cyanobacteria mats, the latter of which typically picks up the well-known potentially toxic *Phormidium* species mats.

- Dissolved Reactive Phosphorus (DRP) limits ranging from 0.004 to 0.015 mg/L depending on which of five management zones is considered.

- Dissolved Inorganic Nitrogen (DIN) limits of 0.150 mg/L for Zone 4 (Upper Tukituki and Waipawa Rivers) and 0.8 mg/L everywhere else (i.e., Zones 1, 2, 3 and 5).

[1] Dr Andy Hicks and Mr Dougall Gordon

- Nitrate-nitrogen limits for chronic toxicity protection of 2.4 or 3.8 mg/L (as a median and depending on zone) and acute toxicity protection of 1.5, 3.5 or 5.6 mg/L (as a 95th percentile and depending on zone).

- MCI minimum indicator scores (as an average calculated over 5 years) of 100 or 120 depending on zone and whether at a main-stem or tributary site.

- Tukituki Land Use Capability (LUC) Natural Capital Nitrogen Leaching Rates ranging from 3 kgN/ha/year for LUC Class VIII land, to 30.1 kgN/ha/year for LUC Class I land.

- Groundwater quality limits and indicators applicable 10m or more below ground level in productive aquifer systems: a maximum 95th percentile concentration of nitrate-nitrogen of 11.3 mg NO_3-N/L and a maximum annual average concentration of 5.65 mg NO_3-N/L.

12 Detail of the assessment of current environmental state with respect to the above indicators is provided in the memoranda attached by Dr Andy Hicks and Mr Dougall Gordon. Detail concerned with estimates of current compliance of existing land uses with the LUC-based nitrogen leaching rates are contained in the material provided by Mr Lachie Grant and Mr Ian Millner.

13 In this review I have found it necessary to examine and clearly define the notion of 'headroom' because this term is used in the definition of the scope of Issue 12 quoted above and is also used in the EDS-F&B-F&G letter. It seems to me that there is potential for confusion and parties talking past each-other if the concept of headroom and the different ways it can be assessed are not clarified here.

14 I will use the concept of 'headroom' here to mean the difference between a prescribed desired indicator state (whether it be a plan objective or a limit) and the current state for that indicator as estimated using monitoring data. If the current state for an indicator is within (i.e., achieves) the desired state then we say there is some headroom available in the catchment, nominally for use of land and water resources that might put pressure on that environmental state. In other words headroom can be thought of as available capacity for use. If the current state is at or beyond (i.e., not achieving) the desired state then we say there is no headroom, or indeed there may be negative headroom (sometimes called 'shortfall'), implying that some improvement is needed in the way that land and water resources are being managed in order to achieve the desired state. The size of the headroom (or negative headroom) is indicated by the size of the difference between the current state and the desired state, recognising the uncertainties involved in estimating this for any given indicator.

15 The following is a high level, whole catchment scale summary of the current situation with regard to current environmental state and headroom associated with each of the relevant indicators. The detail behind this summary is shown in the memoranda attached by Dr Andy Hicks and Mr Dougall Gordon. The situation is complex in that it varies in time and space (i.e., monitoring results vary from site to site across the catchment and across days, seasons and years); the following summary is intended to provide context for addressing the review questions at a broad scale (i.e., at the whole RWSS and catchment scale).

16 **Periphyton**: There are regular "excessive" periphyton growths (i.e., growths that exceed the numeric biomass limits) at many sampling sites. There is no headroom for further deterioration of this indicator because the objective established in OBJ TT1 is to reduce (i.e., improve) the current frequency and duration of these growths.

17 **MCI** (as the indicator of aquatic ecosystem health used in PC6): While 10% of sites currently meet the MCI indicator target scores, many sites currently regularly fail. There is no headroom for further deterioration of this indicator because the objective established in OBJ TT1 is to maintain or enhance ecosystem health.

18 ***Phormidium***: Approximately 90% of sites currently meet the relevant limits but *Phormidium* is sometimes an issue in some areas. In round terms, because *Phormidium* is a sub-part of meeting periphyton objectives, there is no headroom for further deterioration of this indicator.

19 **DIN**: Approximately 65% of sites currently meet the relevant DIN limit. The amount of potential headroom or negative headroom varies spatially. In general there is negative headroom in the upper catchment (i.e., above the Shag Rock monitoring site, with a few sub-catchment exceptions)[2], but due to attenuation that reduces DIN concentrations further downstream there is theoretically limited headroom downstream of Shag Rock. For example the EDS-F&B-F&G letter points to a valid estimate by the Board of Inquiry (BOI) of headroom of around 69 tonnes/yr of DIN at Red Bridge[3]. This is equivalent to approximately a 6.5% increase on current nitrogen losses from land in the catchment above that point.[4] In practice if the DIN limit of 0.8 mg/L is to be achieved everywhere then in round terms there is no headroom for further increase in nitrogen losses in the catchment above Shag Rock.

20 **Nitrate toxicity**: All sites meet the acute toxicity limits and almost all sites always meet the chronic toxicity limits. While there are a few exceptions that will require local reductions to fully achieve chronic toxicity limits (i.e., some areas of negative headroom)[5], in round terms there would theoretically be some headroom for further increases in instream nitrate concentrations in the catchment while staying within chronic and acute nitrate toxicity limits. However this headroom would only be available if nitrate did not need to be managed at a lower concentration in order to achieve periphyton objectives. The 0.8 mg/L limit for DIN (which is largely comprised of nitrate) effectively makes the nitrate toxicity limits and any theoretical headroom associated with them redundant.

21 **DRP**: Approximately 25% of sites currently meet the relevant instream DRP concentration limit. In general there is negative headroom for DRP at a catchment scale;

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[2] As illustrated in data and maps provided in an Agreed Joint Statement to the Board of Inquiry by Water Quality Experts (Olivier Ausseil, Adam Uytendaal, Kate McArthur) dated 10 February 2015.

[3] EDS-F&B-F&G letter paragraphs [7]-[8]

[4] I have deliberately expressed headroom in terms of allowable percentage increases on current N losses in order to avoid i) the confusion that is generated by use of absolute tonnages that change when new versions of OVERSEER come into play, and ii) confusion around the difference between tonnages of 'source' loads lost from land (which relate to LUC and OVERSEER-based nitrogen loss rates) and the related post-attenuation tonnages of 'receiving environment' loads which are relevant for testing likely compliance with instream DIN concentrations. For the purpose of broadly assessing the relative sizes of different amounts of headroom I consider that use of percentage increases/decreases compared to current are appropriate and are likely to be most helpful for Council in the context of informing broad decision-making from this review.

[5] For example as identified in the evidence of Bob Wilcock and Dr Kit Rutherford to the BOI hearings (September 2013)

i.e., there is a need for a reduction in instream DRP concentrations in order to i) meet the PC6 DRP limits everywhere, but also ii) as part of a necessarily multi-pronged approach to try and achieve the PC6 periphyton objectives, as will become clearer later in this review.

22 **LUC-based nitrogen leaching rates**: Details about the current extent of compliance with LUC-based leaching rates are provided in the attached memorandum by Lachie Grant who assessed farm plan data from 96 properties. He found that while 14 of the 96 properties leached higher than the LUC rates the other 82 properties leached lower, and the total amount of nitrogen currently leached across the 96 properties was 29% lower than the total amount permissible under the LUC rate allocation regime; i.e., there was 29% headroom[6]. This estimate is close to the estimate of 30% headroom that I calculated from the figures offered in the EDS-F&B-F&G letter[7]. A third line of evidence which supports an estimate of about 49% headroom under the LUC-based allocation rates can be found in modelling results produced by Kit Rutherford for the BOI hearings[8]. There are uncertainties with all these estimates but together they suggest that the amount of headroom is considerable and in the order of 30-50% on a whole catchment basis above Red Bridge.

23 Groundwater nitrate: All sites currently meet the11.3 mg NO_3-N/L groundwater quality limit (i.e., as a 95th percentile). About 36 % of sites have 95th percentile nitrate nitrogen concentrations between the ½ Maximum Acceptable Value (MAV) of 5.65 mg/L and the MAV of 11.3 mg/L which indicates emerging higher nitrate concentrations in shallower sections of the aquifer system; although all but one site met the 5.65 mg NO_3-N/L PC6 indicator as an annual average. In round terms this indicates that there would be some headroom for further increases in groundwater nitrate concentrations while staying within the relevant PC6 limits, although assessing the size of this headroom is confounded by uncertainty around lag times for nitrate from land use appearing in groundwater and variable attenuation rates (i.e., substantial attenuation in the Tukituki sub-catchment zone but little in the Waipawa sub-catchment zone)[9]. There are clearly risks with assuming that there is any headroom for increased groundwater nitrate concentrations. A pragmatic and conservative response is to strive to ensure that nitrate concentrations in drainage water leaving the root zone from farm operations are less than 11.3 mg NO_3-N/L so that after any dilution and attenuation the groundwater limit would always be met. Commentary has been provided by Lachie Grant (memorandum

[6] In his memorandum (attached) Lachie Grant described uncertainties around this estimate and illustrated the variability in headroom between sub-catchments; he estimated that the Papanui sub-catchment has headroom of 44%, the Tukipo 17%, the Waipawa 48% and the Maharakeke 29%.

[7] To explain: the EDS-F&B-F&G letter offered that LUC-based leaching requirements amount to an additional RWSS consented nitrogen load of 624 tonnes/yr which I have estimated to represent approximately 312 tonnes/yr after catchment attenuation at Red Bridge[7], which is approximately a 30% increase on current and is approximately 4.5 times the size of the DIN-based headroom estimated for that site earlier in this review.

[8] In Dr Kit Rutherford's evidence presented to the BOI he estimated that application of LUC-based limits would lead to increased DIN concentrations of between 19% and 120% at 10 sites and small decreases (3 to 9%) at three of the thirteen sites modelled compared to current. While it was not the purpose of that evidence to estimate catchment nitrogen loads and headroom under an LUC-based allocation regime, I asked him that question during this review and he was able to extract results from the earlier modelling exercise to produce an estimate of 49% headroom for the catchment as a whole above Red Bridge, with sub-catchment headroom estimates ranging from -5% to 150%.I note that this is not greatly different to the 30% increase in nitrogen losses predicted in Dr Rutherford's BOI evidence for the catchment as a whole (and between 30% and 70% in zones 2, 3 and 5) under the RWSS operating as originally proposed rather than under LUC-based leaching limits.

[9] Memorandum provided by Dougall Gordon (HBRC)

attached) which suggests that this is likely to be achievable on a whole farm average basis if farms use good management practices and are compliant with the PC6 LUC-based leaching rates.

5. A disconnect between 2 types of headroom for nitrogen

24 It is necessary, in order to address the requirements of Issue 12 and the questions raised in the EDS-F&B-F&G letter, to address both the notion of LUC-based allocation headroom ('LUC-based headroom') and of headroom associated with achieving the PC6 instream DIN concentration limits ('DIN-based headroom'). I think this is necessary in order to transparently explore the questions that arise from Issue 12.

25 While discussing these two types of nitrogen headroom, I make no inference about the extent to which the RWSS is enabled by its consent conditions to operate up to its maximum allocation (i.e., LUC-based headroom) versus requirements to contribute to achieving the instream PC6 DIN limits. It is clear from reading the available material[10] that different planning and legal views have been expressed by various parties on this matter. Legal and planning implications of this are being addressed elsewhere under Issue 17 of the wider Review. Here I will assess possible consequences for environmental outcomes in either case, which is essentially what has been requested by questions 3a(ii) and 3a(iii) in the EDS-F&B-F&G letter.

LUC-based headroom

26 As already identified in the previous section, the LUC-based nitrogen leaching headroom is substantial; in round terms it is in the order of a 30-50% increase on current estimated total nitrogen leaching losses from land on a whole catchment basis above Red Bridge.

DIN-based headroom

27 In contrast, the DIN-based headroom is negative in some upper parts of the catchment; i.e., reductions in nitrogen losses are required above the Shag Rock monitoring site in order to meet the instream DIN limit of 0.8 mg/L at that site. At best the data used by the BOI suggest there is headroom for around a 6.5% increase on current total nutrient leaching losses in the catchment upstream of Red Bridge in order to meet the instream DIN limit of 0.8 mg/L at that site, but not necessarily at sites upstream.

28 I will return to these two types of headroom for nitrogen and the apparent disconnect between them in PC6 shortly, after first discussing some confusion around the environmental significance of a DIN concentration of 0.8 mg/L.

6. Confusion around the significance of a 0.8 mg/L instream DIN concentration

29 Much has been said about the environmental significance of an instream DIN concentration of 0.8 mg/L, both during the BOI hearings and subsequently in relation to

[10] Multiple legal opinions, letters and meeting notes on the interpretation of RWSS consent conditions – see review of Issue 17.

both the Tukituki situation, and whether this DIN concentration is relevant for other parts of the country. Four observations are useful here:

a) The BOI sourced the DIN limit concentration of 0.8 mg/L from a model[11] provided in the evidence of Professor Russell Death to the BOI hearings, which was based on correlation relationships between desired MCI scores and DIN concentration data.

b) I have not been able to find any statements in the BOI evidence or in related material that demonstrate the strength or statistical significance of the correlation relationships used between MCI and DIN data in the Tukituki or other catchments.

c) In any case, even if a correlation relationship is statistically strong it is incorrect to infer cause and effect from that relationship. This is a basic and widely understood scientific principle.

d) Many factors influence the health of macroinvertebrate communities in addition to instream DIN concentration (e.g. other nutrients such as phosphorus, organic pollutants, physical habitat quality, stream flows, sediment and riparian shading). Many of these factors co-vary with DIN[12]. A correlation relationship between DIN and MCI may be influenced by these other factors. It is not possible to tell from the correlation which of the many co-varying factors is the dominant cause of the MCI observed.

30 These matters have been well discussed in a report by Young and Clapcott (2015)[13] who considered relevant New Zealand research in this area and offered that: "*The Macroinvertebrate Community Index (MCI) provides an excellent indicator of ecological health in wadeable rivers and is regularly used in regional and national environmental reporting on river condition*"; and "*Consideration of the effects of multiple stressors is important when considering mitigation approaches for maintaining overall stream health*"; and *"Clearly, the MCI does not indicate only nutrient levels either in Hawke's Bay, or anywhere else*"; and, in answer to the question of whether ecological health can be maintained or improved over the long term without a 0.8 mg/L DIN target being achieved and if so how?, "*Yes, the ecological heath of waterways is dependent on multiple factors including temperature, sunlight, nutrients, sediment, organic matter, flows and upstream-downstream connectivity, which in their turn are influenced by climate, catchment and riparian vegetation, land use, geography, stream morphology and the presence or absence of fish barriers. There is minimal scientific evidence to suggest that a [DIN] concentration of 0.8 mg/L represents a threshold between healthy and unhealthy ecosystems".*

31 Following from this, it is very important to clarify that the inference made in the EDS-F&B-F&G letter that *"…the PC6 objectives (which rely on achievement of the DIN limit/target) are unachievable"*[14] is incorrect because it is a statement that is built on

[11] In his evidence to the BOI Dr Russell Death refers to the Freshwater Animal Thresholds (FAT) model and discussions around this also appear in transcript quotes given in the BOI 2014 Final Report and Decision at [354-358].
[12] For example see discussion in section 2.2 of Young & Clapcott (2015) and in particular their Figure 2.
[13] Young, R., & Clapcott, J. (2015). Ruataniwha Water Storage Scheme: Monitoring and managing ecological health. Cawthron Institute Report No. 2759
[14] EDS-F&B-F&G letter paragraph 15

drawing a cause and effect conclusion from the correlative relationship between MCI and DIN. Similarly I am dubious about the statement that "*The Board of Inquiry set that concentration as the maximum level of nitrogen pollution that would preserve ecological health.*"[15] I have not been able to find a statement worded in exactly this way in the BOI paragraphs referenced in the EDS-F&B-F&G letter. I did find statements in the BOI Decision that link the preservation of ecological health to the indicator MCI, and that recognise the correlation relationship between MCI and DIN provided to them by Dr Death, and that "*as water quality science advances a different DIN limit may emerge as a more appropriate level*" and *"In the meantime the Board sees the DIN limit of 0.8 mg/L as a pragmatic level that appropriately protects ecological health while enabling more intensive land use."* [16]

32 It is very important to be clear about the difference between the EDS-F&B-F&G letter statements and the BOI statements because they amount to whether the ultimate test of meeting desired environmental objectives is achieving ecological health, as indicated by an agreed MCI score, or meeting a DIN of 0.8 mg/L regardless of MCI score. In my view the MCI score is definitely the more appropriate ultimate ecological test and a DIN limit in a plan is but one of several parallel policy and management approaches to try and achieve that end, albeit an important one. I note that the PC6 objectives (OBJ TT1) listed above include specific mention of both periphyton and macroinvertebrate health outcomes but no mention of nitrogen being an outcome in its own right; the DIN concentration limits appear in policy tables. This is important when I come later to answering the question posed in the EDS-F&B-F&G letter as to whether the water quality objectives of PC6 can be achieved, even if the DIN concentration limit of 0.8 mg/L is not.

33 The 0.8 mg/L DIN concentration is not a defensible threshold between healthy and unhealthy ecosystems. It is perhaps more helpfully described as a point on a risk spectrum spanning from very low risk, low DIN concentrations (e.g., in the order of 0.2 mg/L that might limit periphyton growth[17]) to higher concentrations that bring multiple risks. As DIN concentration increases above 0.2 mg/L this may stimulate increasing periphyton growth which increases the risk of indirect follow-on negative effects on habitat quality for invertebrates, and thus MCI scores. At some DIN concentration, periphyton becomes saturated and growth rate is not affected by further increases in DIN concentration. At this point the associated indirect risk to MCI stops increasing. However, the risk associated with chronic nitrate toxicity continues to increase with DIN increases. DIN concentrations that risk direct chronic nitrate toxicity effects on macroinvertebrates are in the order of 1.0 to 6.9 mg/L depending on the species[18].

34 The actual state of ecosystem health measured as an MCI score at any given site is a response to not only the risks arising from the DIN concentration at that site but also the

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[15] EDS-F&B-F&G letter paragraph 5c
[16] BOI 2014 Final Report and Decision at [357-358]
[17] Young and Clapcott (2015) state that limitation of aquatic plant growth is only likely if DIN concentrations are below 0.2 mg/L and attribute this to an earlier reference by Biggs (2000): New Zealand Periphyton Guideline: detecting, monitoring and managing enrichment of streams, Ministry for the Environment. 122p.
[18] For example as shown in the National Objectives Framework tables in the National Policy Statement for Freshwater Management and as reflected in the nitrate toxicity limits defined in PC6 policy Table 5.9.1, as summarised in paragraph 11 of this memorandum.

confounding interacting effects of the multiple other factors mentioned in paragraphs 29 and 30 above.

7. Dealing with issues of uncertainty, and thus risk

35 As already identified the RWSS proposal involves an increase in nitrogen losses from land in the catchment and an associated increase in instream DIN concentrations in the order of 30% for the catchment as a whole. This creates an undeniable but uncertain level of risk of not achieving periphyton and related macroinvertebrate health (e.g., MCI) outcomes. This risk is acknowledged in one way or another in evidence and other material by all of the various experts for both the RWSS applicant and the submitters that I have read[19]. All other things being equal one would not choose to create a situation where DIN increases; one would only consider doing that in order to achieve the other positive outcomes (e.g., economic and social outcomes) that could be gained by implementing the RWSS. So a strategy has been proposed by RWSS, that I would describe as a multi-pronged risk management strategy, that involves:

a) reducing instream DRP from both diffuse sources and community wastewater treatment plant point discharges,

b) provision of flushing flows from RWSS storage to manage the frequency and duration of nuisance periphyton in some river reaches,

c) riparian habitat enhancements that could improve habitat quality, shading and reduce fine sediment loss to streams,

d) an ability for the RWSS to adaptively manage local hotspots for nutrients by requiring extra phosphorus mitigations and lower than LUC-based nitrogen leaching rates in parts of the scheme area, in response to any monitoring that shows local breaches of periphyton and/or MCI outcomes, and

e) improved flows in some stream reaches due to the PC6 requirement to meet higher minimum flows, migrating some current groundwater extractions onto RWSS stored water, and the potential for providing some flow augmentation to some reaches from RWSS storage.

36 The crux question is whether the risk of allowing DIN to increase, but mitigating detrimental effects with the multi-pronged strategy described above, is justified in light of the wider benefits of the scheme. The answer to this question necessarily involves the need for decision makers to weigh risks and benefits, and then make value judgements. To some extent the constraint placed on how much DIN can increase by affects the risk-benefit balance; a tighter constraint (lower DIN limit) is less risky than a more resource-use-enabling (higher) DIN limit such as that originally proposed by the RWSS applicants in material put to the BOI hearings.

[19] For example the BOI evidence of Dr Bob Wilcock, Dr Kit Rutherford, Dr Adam Uytendaal, Dr Olivier Ausseil, Ms Kate McArthur, Ms Corina Jordan, Professor Russell Death and Dr Jonathan Abell.

37 The BOI Decision appears at first glance to have landed on an instream DIN limit of 0.8 mg/L as an appropriate level of risk by setting that number as a limit in Table 5.9.1. However the BOI has also simultaneously granted the RWSS consent with an LUC-based nitrogen load allocation that allows for a significantly greater increase in DIN, indeed one more in line with that originally proposed in the RWSS applicant's material that was assessed as likely to lead to approximately a 30% increase on current instream DIN concentrations (i.e., going well over 0.8 mg/L instream)[20]. Furthermore the same amount of LUC-based allocation granted to the RWSS in consent conditions has been set in the PC6 limits Table 5.9.1, meaning that all other non-RWSS land users in the catchment have also been given sufficient collective allocation to push instream DIN concentrations above the 0.8 mg/L limit.

38 From the material I've read I have not been able to reconcile this apparent disconnect between the LUC-based load allocated to RWSS and all other users in the catchment, and an apparent intention to manage environmental risk by setting the DIN limit at 0.8 mg/L. Setting the DIN limit at 0.8 mg/L is quite constraining for resource use and suggests a lower appetite for risk, while the LUC-based allocation rates are more enabling and amount to a greater appetite for environmental risk in order to achieve the other benefits offered by the scheme. It is therefore unclear where the value-based decision on an appropriate level of risk has landed. Much appears to hinge on the planning and legal question of the extent to which RWSS is responsible to both the LUC-based leaching rate allocation and the PC6 DIN limits. That question is being addressed elsewhere under Issue 17 of the wider Review.

8. Answering key questions that arise out of Issue 12

39 Having discussed and provided my views on current environmental state and the concept of headroom, the apparent disconnect between the two types of nitrogen headroom, confusion around the environmental significance of a DIN limit of 0.8 mg/L, and the resulting need to deal with issues of uncertainty and therefore risk, I can now identify and attempt to answer three key questions that arise out of Issue 12, as follows:

QUESTION 1: What land uses and on-farm management practices would be required to meet LUC-based nutrient leaching allocation rates?

40 Based on the attached assessment by Lachie Grant and other material I've read, I think it would be relatively straight forward for the RWSS to operate with any of a wide range of possible land uses, including a significant proportion of high nitrogen emitting land uses like dairying, using currently available good on-farm management practices to minimise nitrogen and phosphorus losses, and comfortably stay within the consented LUC-based nitrogen leaching rate allocation on a whole catchment basis[21]. I understand from the assessment provided by Lachie Grant and Ian Millner that the available on-farm measures to manage P losses make the RWSS intention to be P-neutral or better plausible. When this is combined with reductions in non-scheme diffuse and point

[20] Evidence of Dr Kit Rutherford to the BOI hearings (September 2013)
[21] I note that my answer here assumes that there will ultimately be a system for updating the LUC-based leaching rates to make them equivalent for testing with new versions of OVERSEER. Without such a system it is not possible to predict whether the RWSS could operate within the existing LUC leaching rates when tested using future unknown OVERSEER versions.

source wastewater discharges, the PC6 Table 5.9.1 DRP limits seem potentially achievable in future. It therefore seems achievable for RWSS to meet consent conditions relating to the LUC-based leaching rates, albeit with considerable management effort through time.

QUESTION 2: What land uses and on-farm management practices would be required to meet instream DIN concentration of 0.8 mg/L? (Note: this also partly addresses question 3a(ii) of the EDS-F&B-F&G letter)

41 In contrast to the first question, I think it would be very difficult for RWSS to operate within the significantly smaller nitrogen allocation implied by the instream DIN limit of 0.8 mg/L. Only low nitrogen emitting land uses would be possible, and in some sub-catchments where instream DIN already currently exceeds 0.8 mg/L, nitrogen loss reductions rather than intensification would be required. Indeed I understand that the BOI accepted HBRIC's arguments and concluded that requiring RWSS to immediately comply with the 0.8 mg/L DIN limit would frustrate (i.e., negate) the grant of the RWSS consent[22]. I understand that instead the BOI concluded that *"…if the RWSS is a material contributor to an exceedance of that DIN limit, the 'use' component of the consents is to be managed in a manner consistent with achieving the DIN limits and targets in Table 5.9.1B of PC6 by 31 December 2030."*[23]; although I note again that legal and planning considerations around this are being handled under Issue 17 of the wider review, and so question 3a(i) of the EDS-F&B-F&G letter is handled there.

42 Taken at face value it seems that if the RWSS was to develop initially with land uses that utilise all or most of their LUC-based allocation, and then strive to meet the PC6 instream DIN limit of 0.8 mg/L later by 2030, then at least one of the following would need to happen:

a) The RWSS would need to subsequently instigate a significant change in land use types in its area to land uses with lower nitrogen losses, in order to bring the scheme's total nitrogen losses to levels that would achieve the 0.8 mg/L DIN concentration instream; and/or

b) Significant innovation would be required to develop new on-farm nitrogen loss reduction technologies and/or catchment scale mitigations such as a network of treatment wetlands[24], to help reduce the nitrogen losses from the land use distribution that had developed under the greater headroom associated with the LUC-based allocation; and/or

c) The PC6 DIN limit of 0.8 mg/L would need to be revised upwards.

43 Clearly there are unavoidable uncertainties and therefore risks for the RWSS associated with relying on any or all of the bullets above.

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[22] BOI Decision [91]
[23] BOI Decision [91]
[24] For example Dr Andy Hicks (HBRC) has described to me a concept to construct trial treatment wetlands that could help reduce DIN concentrations in some sections of streams and also offer biodiversity and amenity benefits.

44 I note that it seems the disconnect between the LUC-based nitrogen leaching rates in PC6 Table 5.9.1D and the instream DIN limit of 0.8 mg/L in Table 5.9.1B is ultimately untenable for planning and management purposes in the long term; one or the other or both will need to change. Until then, HBRC is in the position of trying to manage to achieve an instream DIN concentration of 0.8 mg/L under circumstances where all land users, irrespective of whether they are in the RWSS or not, are allowed to emit nitrogen at the LUC-based rates, which if taken up in total could not achieve the instream DIN concentration of 0.8 mg/L. I understand from the assessment provided by Lachie Grant that even if the RWSS did not go ahead it is quite plausible that significant intensification could occur within the PC6 LUC-based rates that would frustrate achievement of the instream DIN 0.8 mg/L limit.

QUESTION 3: Could the water quality objectives of PC6 still be achieved in the event that the PC6 DIN limit of 0.8 is not met by 2030? (Note: this addresses question 3a(iii) of the EDS-F&B-F&G letter)

45 Building on the earlier discussion around the environmental significance of the 0.8 mg/L DIN limit and the conclusions provided by Young and Clapcott (2015)[25], I agree with their conclusions and in my view the answer to this question is: Yes maybe, but it is undeniably and unavoidably uncertain; there are risks that periphyton and ecosystem health (measured as MCI) outcomes will not be achieved everywhere. Achieving them would rely on many things in addition to the effects of the RWSS total nitrogen loads and associated instream DIN concentrations. The multi-pronged strategy proposed by RWSS already described in paragraph 35 above would need to be relied on.

46 If I was asked about the likelihood of achieving the PC6 water quality objectives under a scenario which assumes that an instream DIN concentration of 0.8 mg/L is achieved throughout the catchment, my answer would still be: Yes maybe, would still be uncertain, and would still rely on other parts of the described multi-pronged strategy being successful. All other things being equal I would be more confident of achieving the PC6 water quality, periphyton and ecosystem health (MCI) objectives if instream DIN was at 0.8 mg/L than at some higher level, mostly because this reduces risk of bigger problems if attempts to reduce DRP and/or other parts of the multi-pronged strategy fail.

47 If the tighter constraint on DIN meant that some other parts of the multi-pronged strategy were not able to be carried out, then my confidence that objectives will be achieved would reduce. In particular, I think that measures to reduce phosphorus losses and improve instream habitat quality by increasing summer flows, riparian enhancements and reduced fine sediment will be crucial. Flushing flows may also be important for achieving periphyton and ecosystem health (MCI) objectives in some sections of the main-stem, although I defer to the outcome of Issue 16 of the wider Review as to the likely success of these.

48 Striving to achieve the water quality objectives of PC6 by focussing solely on reducing nitrogen loads would be very risky. The science available today suggests that phosphorus is the predominantly limiting nutrient in much of the upper catchment much

[25] Young, R., & Clapcott, J. (2015). Ruataniwha Water Storage Scheme: Monitoring and managing ecological health. Cawthron Institute Report No. 2759

of the time, acknowledging that nutrient limitation is variable in time and space and is uncertain[26]. Therefore a narrow strategy focussing solely on reducing nitrogen loads would almost certainly not achieve the periphyton and ecosystem health (MCI) outcomes.

Sincerely

Ned Norton

[26] Evidence of Bob Wilcock, Kit Rutherford, Adam Uytendaal, Olivier Ausseil, Roger Young, Kate McArthur, Jonathan Abell

Date: 28 April 2017

MEMORANDUM

FROM**:** **Lachlan Grant (LandVision Ltd)**

Ian Millner (Rural Directions Advisory Services)

TO**:** **James Palmer (Group Manager Strategic Development, Hawkes Bay Regional Council)**

SUBJECT: REVIEW OF THE RUATANIWHA WATER STORAGE SCHEME: ISSUE 12

The scope of this review of Issue 12

The scope of this review is to assist with addressing "Issue 12' of the "Review of the Ruataniwha Water Storage Scheme [RWSS]" (the Review) as described in a paper to Council on 14 December 2016 which scoped Issue 12 as:

> "*Assessment of on-farm management practices, including stocking levels and associated land-use constraints, required to meet the nutrient leaching and groundwater water quality requirements of Plan Change 6 [PC6] and the Regional Policy Statement. Estimate of current compliance within existing land uses and the extent of headroom for intensification and land use change will be provided. Estimate implications for the RWSS in meeting consent conditions relating to scheme water users and nutrient limits."*

The assessment of Issue 12 as stated by Ned Norton requires a range of expertise and has been divided up in consultation with HBRC and is being led by HBRC staff. Other key contributors Ned Norton (external provider), Shane Lambert (HBRC Senior Planner), Nathan Heath (HBRC Acting Manager – Land Management) and several HBRC technical staff including Dr Andy Hicks and Mr Dougall Gordon. In brief, the assessment of on-farm management practices required to meet nutrient leaching rates and groundwater quality requirements of PC6 has been undertaken by Ian Millner and myself, the assessment of current environmental state (based on monitoring data) against environmental objectives and limits in PC6 has been undertaken by Andy Hicks and Dougall Gordon, and Ned Norton has assessed the current environmental state in relation to the concept of headroom for intensification and land use change, and assessed possible consequences of the RWSS on that headroom and for the water quality objectives defined in PC6 - specifically the periphyton and aquatic ecosystem health (macroinvertebrate) objectives.

In undertaking this review, Ian Millner and myself have focused on the following with regards to Issue 12:

- the assessment of on-farm practices with respect to nutrient losses of nitrogen and phosphorus instream levels,

- to provide an estimate of the current level of compliance with respect to meeting DRP (Dissolved Reactive Phosphorus) and DIN (Dissolved Inorganic Nitrogen) limits,
- estimate the current level of headroom with respect to current nitrogen and phosphorus instream concentrations, and
- estimate the implications for the RWSS to meet consent conditions.

In order to adequately assess the above, information was drawn from a variety of sources including that presented to the Board of Inquiry, Hawkes Bay Regional Council databases and from information generated from private work in the Tukituki catchment and farm plans as a requirement of Plan Change 6 by LandVision and Rural Directions.

Base data process

To make an assessment of Issue 12 above, base data relating to land, landuse and potential areas suited to irrigation used for the RWSS calculations need to be validated to determine the level of accuracy. This process found the following:

1. There are several different shape files for the RWSS scheme area containing the five proposed irrigation zones (A, B, C, D and M). Each one has a different total area ranging from about 60,000 ha through to 85,000 ha. Generally, the areas increased with newer versions as more accurate data pertaining to scheme structure and distribution became available and was incorporated.
2. The regional scale NZLRI (NZ Land Resource Inventory) was used to determine the LUC and soil distribution within the RWSS area. This was then used to determine the extent of soils or LUC classes suited to irrigation within the irrigation footprint, excluding roads and reserves etc. Those areas considered suitable for irrigation included areas of class 1 and 2 land, areas of class 3 and 4 land which don't have a wetness limitation or sloping land derived from yellow grey earths, and areas of flat class 6 and 7 land that are formed from alluvial gravels. Under these criteria there is about 42,300 ha of land within the five zones that is considered suitable for irrigation. The information presented to the BOI suggested that there was about 38,000 ha suitable to irrigation which was determined using slope. This variation is solely due to the sampling methodology used and considered insignificant.
3. Of more relevance is the most recent shape file from HBRC (17 March 17) containing boundaries for those properties that have committed to taking water and those that have not committed to taking water. For those properties that have committed to taking water it also includes areas of enterprises with land or farms outside the RWSS consent boundary. HBRIC has agreements to supply RWSS water to 188 properties, which have a total land area of 52,208ha (as of the 17 March 17). About 77% (39,994 ha) of this area with agreements occurs in the five zones and the remaining 23% is outside the scheme boundary. Despite, the land outside the scheme boundary not being able to receive irrigation water it still falls within its jurisdiction. This means that the environmental footprint of the scheme extends well beyond the scheme boundary and as a consequence provides greater environmental control to the council, via HBRIC consents, for being under one umbrella. Some of this is further discussed in Issue 13 around the implications of this wider footprint area on the PC6 implementation effort required. Of the area with agreements (52,208 ha) approximately half of this (26,253 ha) has land that is considered suitable for irrigation (which is notable given that full uptake of scheme water is anticipated to irrigate approximately 28,000ha). This means that the schemes control footprint is considerably wider than the area being irrigated alone and this brings with it a number of benefits through

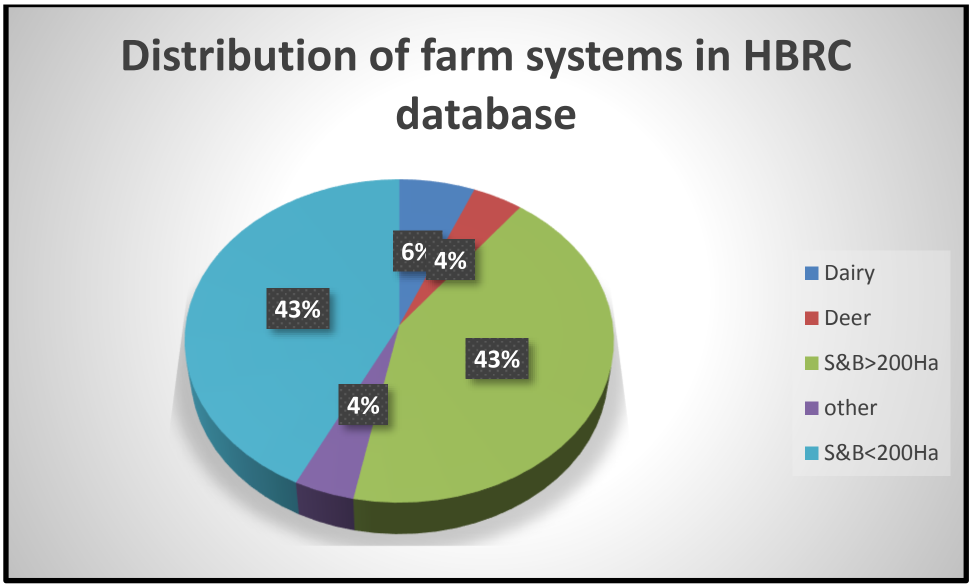
the greater range of controls the scheme possesses. It is noted that both the scheme land (through its consent) and non-scheme land are still required to operate under Plan Change 6. The difference is that the RWSS will control the properties within its scheme with tighter review protocols within contracted responsibilities whilst the HBRC will administer Plan Change 6 for non-scheme properties.

4. Of interest there appears to be some farming enterprises that are contracted to take water but don't appear to have [any?] suitable land for irrigation. This may possibly reflect the difference between regional scale LUC mapping and paddock scale mapping or farming enterprises buying water for the future.

Assessment of Farm Practices

HBRC provided a spreadsheet/database for all the farm environmental management plans (96 in total) that have been prepared in the Tukituki catchment in the last 18 months under the auspices of Plan Change 6, along with a small sample of completed plans. The information contained within these plans could provide answers to some of the questions above. In general the majority of these farm plans have been prepared on properties that are outside of the RWSS area as those who are contracted for water would prepare them as part of the scheme if this is to go ahead. The quality of the plans ranges from the very basic Beef and Lamb LEP level 1 prepared by the farmer through to comprehensive plans where the properties have been paddock scale mapped and detailed mitigation options provided. HBRC has undertaken some quality assurance monitoring of a selection of plans from the various providers. It was difficult to assess the quality of the completed plans as there were no Overseer XML files to examine and the handful of completed plans made available generally lacked detail to repeat the Overseer runs. It was however possible to examine those plans completed by LandVision and Rural Directions in more detail. In our experience and as the authors of this report we consider that using a small sub-suite of actual data obtained from the farm plans to be more reliable than assuming an average for a landuse sector. In summary, the information database on the plans from HBRC showed the following:

1. The 96 plans covered 30,114 ha (approximately12% of catchment) with an average property size of 317 ha (range of 5 ha to 1,537ha). About 17 of these plans were 20 ha or less whilst 32 properties were less than 75 ha. All of these could be considered lifestyle blocks. There were 36 properties over 300 ha. These breakdowns are typical for the relative proportion of property sizes in the Tukituki catchment.
2. It is difficult to properly assess landuse from the HBRC database as the land uses were classified as dairy, sheep & beef, deer or other. Often properties may contain several enterprises. Whilst recognising this, of the 96 properties, 6 were classed as dairy units, 4 were deer units, 82 were sheep and beef units and 4 were classified as 'other'. The dairy units were average to large properties and there was no indication of class of dairy unit. Three of the four deer units were moderate size properties. For the sheep and beef units half were properties over 200 ha. The properties under 200 ha perhaps should be classified as life style sheep and beef units as they would not be large enough to be considered an economic unit. The 'other' properties are all small (10-22 ha) and could involve a variety of land uses.



3. Each farm plan had an associated total nitrogen loss for the property generated from Overseer. The Overseer versions varied from version 5 through to the latest version (ver. 6.2.3). For Overseer runs using an older version there was no way of rerunning these on the latest version as there was no Overseer XML files. Despite this, the total permissible N loss from all the properties with plans completed was 631 T N (an average of 20.9 kg N/ha) and the total amount of nitrogen leached from all these properties was 447 T N (14.8 kg N/ha/yr). Therefore from this dataset only 71% of the permissible N loss limit was being utilised. Hence for these 96 properties there was 'headroom' of 29%. There is obviously a risk involved in using this figure for the following reasons:
   - Generally the more intensive properties have not completed a plan under Plan Change 6. The relevance of this is that more intensive land uses often have a higher N loss relative to allocation.
   - HBRC are to recalibrate the LUC allowable N loss figures with new versions of Overseer through a procedural guideline[1] required by PC6. This approach may not have been clear to all before, but as the regulator, HBRC are bound to administer PC6 as it is written. All the above farm plans have used the allowable N loss figures that came out of the BOI. The effect of this is that the headroom of those completed plans that used a newer version of Overseer will likely increase.
   - With time the Overseer modelling should become more accurate with better block setup and the use of farm scale resource information.
4. It could be assumed that within the Overseer models completed there will be opportunities to further reduce N loss through management but if a property is within the permitted activity status they have very little motivation to invest in more modelling work.
5. Analysing the N losses from all the sheep and beef properties over 200 ha showed that the N losses generally increased with new version changes. It is noted that these observations were from different properties where the Overseer run was not repeated under the different versions. Overseer runs were repeated for properties prepared by LandVision Ltd between versions 6.0 and 6.2.3 and the nitrogen losses increased by up to 32% within farms with no

[1] Footnote 43: Hawkes bay Regional Resource Management Plan, Plan Change 6 – Tukituki River Catchment.

changes to any inputs. The worst of these properties has a permissible N loss limit of 21 kg N/ha/yr. Under version 6.0 the N leached was 14 kg N/ha and the property was comfortably complying. Under version 6.2.3 with no changes to the Overseer setup it is now leaching 22 kg N/ha/yr and falls into the restricted discretionary category. To manage this HBRC are to recalibrate the LUC allowable N loss numbers for any new version of Overseer.

6. Looking at these properties in the farm plan database individually then of the 96 properties 14 properties (10 sheep and beef and 4 dairy properties) do not comply with their permissible N loss limits. Of these 14 properties four sheep and beef properties have nitrogen leaching 30% or more above their allocation limits. The other 10 properties are less than 30% over their allocated N loss and would be treated as restricted discretionary. Of these 10 properties, 4 are dairy units and the rest were sheep and beef properties. One of these sheep and beef properties with less than 30% over their N allocation also had irrigation. In terms of the Overseer version used to determine the property's N loss those properties that exceeded their N allocation mostly occurred when Overseer version 6.2.1 or higher was used. This highlights a consequence of using a model such as Overseer in a regulatory framework. Models of complex and variable biophysical systems like land and agriculture can never be completely accurate. Asking a farm system to comply with a nutrient loss number in an absolute sense is a tenuous outcome. Whereas expressing farm scale reductions as percentage reductions in effect uses a model in a relative sense. It is the relative change from one state to another, using consistent assumptions that is a defendable outcome. This point was made in evidence by David Wheeler[2] during the Board Of Inquiry
7. Of the 96 farm plans two of the sheep and beef properties had irrigation. There was no indication as to how much or what they were using it for but in terms of the permissible N loss limits one of the properties was just complying and the other just non-complying under Overseer version 6.2.3.
8. What was also interesting was that there was a range of N losses generated from Overseer from different properties with similar LUC N allocation limits. Possible reasons for this may include:

   (i) Management factors such as grazing regimes, stocking rate and stock classes, fertiliser use and timing, supplements, forage cropping, forestry etc.

   (ii) Land resources such as land with the same LUC class but the drainage characteristics may vary significantly affects N loss significantly.

   (iii) Climatic factors, particularly rainfall.

9. There is a difference between the relative proportions of LUC classes and soils between regional scale and actual farm scale soil and LUC mapping. This can have implications as to the permissible N loss limits for the property. On one property in the Tukituki that LandVision Ltd has remapped the permissible N loss limits under the regional scale map was 20.4 kg N/ha whilst under the farm scale mapping it was 22.3 kg N/ha. It has also worked in reverse were the regional scale mapping was more beneficial to the property by 1 kg N/ha.
10. Of concern are the accuracy of S Map in the Hawkes Bay and the use of this information in Overseer. This is solely a resolution issue from using information generated at 1:35,000-50,000 and blowing it up to the farm scale. Farm scale soil mapping that has been undertaken in the Tukituki has shown huge differences from S Map and this has significant

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2 Statement of Evidence, David Wheeler. Before the Board Of inquiry. Tukituki catchment Proposal

impact on the N loss generated by Overseer. Farmers can elect to have their properties mapped at a finer resolution but at their cost.

11. The farm plan database also allows you to investigate the N loss at a sub-catchment level and the results are shown in table 1.

Table 1; Farm scale N loss by sub catchment

	number properties	Area of plans (ha)	Total kg N leached (Kg N)	Total Allowable N (Kg N)	Percent of allowable limit used
Hawea;#Makara	1	1,537	18,444	27,666	67%
Kahahakuri	5	1,257	34,328	35,990	95%
Kahahakuri;#Upper Tukituki	1	564	16,369	15,240	107%
Lower Tukituki Corridor;#Mangatarata	1	136	1,088	3,196	34%
Lower Tukituki Corridor;#Upper Tukituki Corridor	1	61	854	1,281	67%
Maharakeke	9	2,384	35,214	49,608	71%
Maharakeke;#Mangatarata	1	270	5,265	6,156	86%
Maharakeke;#Porangahau	2	825	8,901	20,506	43%
Makara	3	1,513	13,913	24,418	57%
Makeretu	1	137	1,508	3,400	44%
Makeretu;#Porangahau	2	700	16,094	17,932	90%
Mangamahaki	2	1,637	15,875	29,264	54%
Mangaonuku	3	2,045	37,903	39,368	96%
Mangaonuku;#Papanui	1	1,060	10,596	22,251	48%
Mangatarata	1	365	3,285	8,322	39%
Papanui	31	4,394	52,051	92,990	56%
Papanui;#Waipawa	1	725	6,525	13,775	47%
Porangahau	5	2,069	46,016	51,129	90%
Tukipo	13	4,824	76,774	92,305	83%
Upper Tukituki	4	767	16,571	16,569	100%
Upper Tukituki Corridor	3	309	2,122	6,451	33%
Waipawa	5	2,535	27,460	52,900	52%
Total for all plans	**96**	**30,114**	**447,156**	**630,718**	**71%**

12. Care needs to be taken when using the data from a sub-catchment where only one or two plans exist. Despite this, the table above shows the Papanui contained 31 properties with plans covering 4,394 ha (about 25% of the sub-catchment) and has a headroom of 44%. These headroom calculations include all land uses and all versions of Overseer.

An estimate of compliance

<u>Dairying</u>

Research into the level of compliance with respect to land use within the catchment has drawn on data from many different sources. Industry data (provided to the authors in confidence) analysed show that within the Tukituki Catchment there are about 40 dairy farms and from a sample of 28 dairy farms about 70% will be either permitted activity status or manageably close to a restricted discretionary consent (where the loss exceeds the limit but by less than 30%). Within these 28 dairy farms, 10 currently have irrigation and significantly the level of compliance is also 70%.

Arable

A recent paper by Norris[3] et al (2017) looking at nutrient losses under irrigated cropping rotations showed that the nitrogen losses measured using drainage fluxmeters on sites in the Tukituki were significantly lower than the permissible N loss limits. It is acknowledged that this research is in its early days (after two years) and requires further repeatability, particularly around different cropping regimes and soil types. The initial results give confidence that cropping or arable systems are likely to be currently complying. The same trials also were modelled using Overseer. The modelled results, in some cases but not all, were significantly higher than that observed in practice. This is important because a significant area of the RWSS contracted area has arable as a portion of the farm system (approximately 63% of footprint). When modelling was first done for the RWSS feasibility study the science underpinning the N loss from arable systems was limited. This led to some very large N losses from modelled arable systems. Significant new work has since been done on arable systems to allow better alignment between modelled and actual. The Norris paper is an example of this. Well managed arable systems (of the type found in the Tukituki) with modern irrigation monitoring techniques are now generally modelled as comparatively low N loss systems.

Horticulture

The paper by Gentile[4] et al (2014) on land management practices and nutrient losses from farms on the Poverty Bay flats gives a level of confidence that some of the horticultural crops such as grapes, maize, squash, citrus, kiwifruit and broccoli/lettuce can leach nitrogen at or less than that of pasture. Some of these crops also received irrigation. The results were determined using SPASMO (soil plant atmosphere system model) which was developed by Plant and Food. Out of these crops the only one commonly modelled using Overseer is maize and the overall N loss is dependent on what happens to the crop at the end of the rotation and how the fallow period is dealt with. In Overseer there is very limit impact on N loss from maize provided the irrigation is adequately managed.

Sheep and Beef

In reviewing Overseer runs (version 6.2.3) from sheep and beef properties from LandVision Ltd and Rural Directions showed that for intensive beef operations and lamb finishing, these operations were generally slightly above or just at their permissible N loss limits. For less intensive sheep and beef properties they were up to 30% under their permissible N loss limits and the extent of the gap was more often dependent on rainfall or whether there was any fodder cropping associated with the property as both higher rainfalls and increased areas of fodder

[3] Norris M, P Johnstone, S Green, G van der Klei, C van den Dijssel, P Wright, G Clark, S Thomas, R Williams, D Mathers, and A Halliday (2017): *Root zone Reality – A network of fluxmeters measuring nutrient losses under cropping rotations. Summary of year 1 and 2 results.* A paper presented to the FLRC conference, Palmerston North, Feb 2017.

[4] Gentile R, S Green, K Mason, C van den Dijssel, P Johnstone, B Clothier (2014): *Land management practices and nutrient losses from farms on the Poverty Bay Flats*. Plant and Food Research report No. 10506.

cropping lead to increased nitrogen leaching. Evidence presented to the Board Of Inquiry on historical land use patterns[5] showed that between 1970 and 2000 the number of cattle stock units (RSU's) carried on the average sheep and beef farm increased by 62% with a change from 35% to 80% male. This data reflects the trend in bull beef farming as a flexible and profitable land use.

The weighted area effect of sheep and beef (and associated land use) within the catchment is worthy of specific comment. The issue is that this land use comprises approximately 74% of the total catchment (or approximately 90% of the productive land area). When this area is multiplied by a very conservative rootzone N loss the total amount of N contributed to the catchment is 62% of the full catchment loading, applying a less conservative rootzone loss (10kg N Ha) results in a contribution of 65%(approximately). As most of this land use will operate within its allocation the opportunity for HBRC to actively reduce N loss from this portion of the catchment is small. This will have corresponding limitations on the achievement of any DIN reductions as the weighted average effect is very difficult to overcome and the N loss from the sheep and beef sector is already relatively low and therefore is unlikely to achieve meaningful reductions. A simple way of looking at this issue is to understand the relativities between land uses. A 1Kg N Ha increase in N loss from the sheep and beef sector (74% of catchment) will equate to 187 tonnes of N. A 10kg reduction across the dairy sector (4% of catchment) will result in a 100 tonne reduction. Minor shifts in N loss from the majority of the area outweigh substantial movements in N loss from minor land uses. It should be noted that the majority (approximately 70%) of dairy systems are expected to be compliant with the N allocation framework.

Mitigation Options

The report by MacKay and Power[6] on the mitigation options for reducing N and P provides excellent commentary on nitrogen and phosphorus losses under different farm systems and the opportunities to reduce them through either the farm plan or farm system approach. The approach taken in this report was a logical stepwise reduction in contaminate loss in the absence of a defined target. The type of on farm practices that were adjusted include wintering practice, effluent management, N use and amount and type of supplementary feeding for dairy systems, for arable systems the mitigations were generally more complex and systems based and included adjusting crop type ratios, the ratios of high N use crops, management aspects of crop regimes and integration of different livestock policies. The N and P losses in this paper have been generated from an older version of Overseer and potentially these losses could be up to 30% higher under the most recent version. With respect to losses from arable and process vegetables the Overseer results are not that consistent with that found by Norris et al and this probably just reflects the modelling in Overseer being more focused under a Canterbury environment. Despite this the base assumptions relating to the effect of various mitigation strategies are still the same.

From our experience, there are a lot of on-farm practices that could be undertaken to improve N and P losses on-farm. Many of these would not cost a lot of money to implement and

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[5] RMA document suite M2 reports; Overseer Nutrient budget modelling

[6] MacKay A, I Power (2012): *Mitigation options for reducing N and P losses from intensive dairy and arable and process vegetables farm systems on the Ruataniwha Plains.* A report prepared for HBRC Ruataniwha Plans Water Storage Project.

furthermore would not necessarily impact on the N or P losses shown in Overseer. They would however impact on the DIN and DRP levels instream. Many of these techniques were described in the evidence of Prof RW McDowell[7] during the BOI. His evidence usefully describes the challenge of managing P. He describes a range of farm scale actions and applies a basic cost benefit. Some are relatively inexpensive to implement and have medium to good levels of effectiveness (e.g. low rate effluent application, optimised Olsen P levels and stream fencing) others are more expensive to implement with variable levels of effectiveness (e.g. sediment traps and constructed wetlands). Prof McDowell's evidence provides considerable confidence that sufficient scientifically validated techniques exist to address P loss to water in the Tukituki catchment. HBRC have identified a range of sub catchments that have elevated P concentrations with sufficient flow to be contributing significant amounts of P into the lower Tukituki. Implementation of P management via farm plans is targeted (at least initially) to these catchments. The farm plan process is a framework through which the techniques to mitigate P will applied to the context of any particular farm. This is the lowest cost method when compared to direct regulation, and done correctly will result in effective levels of mitigation.

The authors have included basic data based on farm system type mitigations for clients within the Tukituki (2 partially irrigated and 2 dryland). This data (table 2) shows that significant amounts of contaminate mitigation on relatively intensive farm systems is possible in an actual sense as opposed to catchment scale modelling. It should be noted that in less intensive systems that form the majority of the catchment significantly more modest reductions are possible.

Table 2: Tukituki specific actual N loss reductions for three relatively intensive farm systems

Farm System	Mixed livestock	%N reduction	Irrigated Dairy	%N reduction	Arable /livestock (heavy soil)	%N reduction	Arable/live stock (light soil)	%N reduction
Start KgNHa	72		56		25		22	
Mitigation 1	Irrigation mgmt	32	Stock policy	3.5	Rotation change	32	Rotation change	9
Mitigation 2	Effluent + irri mgmt	40	Winter N use	12	Cultivation change	6	Adjust fert regime	5
Mitigation 3	Stock policy	25	Irrigation Mgmt	27				
End KGNHa	22		34		16		19	
Cumulative % diff		69%		39%		36%		13%
Cost implication	Med/high		med		low		low	

Table 2 illustrates the potential to mitigate N loss from a range of systems with variable levels in intensification. Within these systems there is no particular pattern or consistent parameter that drives higher levels of N loss except for management (good or best practice). Most of the reductions in the systems shown in Table 2 are associated with more accurate management capability, monitoring and investment. While the reductions are encouraging for the enterprises involved they should be interpreted as useful case studies for the type of investigation that can address hotspots within the catchment. The ability of system rationalisation of this kind to address the more diffuse (and larger spatial scale) DIN targets is hedged against catchment

7 Statement of evidence Richard William McDowell before the Board Of Inquiry, Tukituki Catchment Proposal.

scale characteristics where the predominant land use is generally low loss sheep and beef systems. The mitigation work referred to in table 2 only applies to mitigation work able to be modelled in Overseer to manage N. In practice, there will be more interventions managed through a farm plan, that will have direct influence on ecological health.

DRP Targets

Ultimately the achievement of in stream DRP targets will depend on the accurate identification of critical source areas (CSA's) and implementation of appropriate mitigations. This approach is capable of removing significant amounts of the manageable P from the system. However, the actual amount of P removed is extremely difficult to quantify. The approach in the Tukituki involves every farm completing, implementing and reviewing a farm plan. Assuming farm plans in the Tukituki are completed and implemented in a competent manner progress toward the instream DRP targets should be expected. Actual achievement of the targets will also depend on a range of other factors beyond the influence of farm plans. The completion of effective farm plans is in effect the metric by which progress toward the targets can be measured. The process of prioritisation, implementation and review of farm plans should be managed alongside a monitoring program instigated as or preferably before any actions are initiated on farm. This will allow objective identification of trends that can be used to guide further reviews and escalation of actions (if necessary)

It should be noted that farm plans are required to be completed across the entire catchment. This action should theoretically deliver the best possible cost benefit outcome for the management of in stream DRP levels across the catchment. This is because farm plans are the framework through which CSA's can be identified and relevant actions appropriate to the context can be developed. This allows greater accuracy and tighter control of cost. In our observation, perhaps the most significant threats to this happening are;

- farm plans being dominated by actions designed to reduce N levels and not maintaining an appropriate focus on P mitigation for the relevant sub catchment. This is simply a response to the need to achieve compliance with a N allocation as the first hurdle to remaining a permitted activity. The relevant sub catchments are generally the priority catchments where the level of P loss reductions will require at least a farm system review which is time consuming. Notwithstanding, PC 6 does have a N management framework that needs to be achieved.
- Farms plans being completed using regional scale information and therefore failing to capture the true potential in the P mitigation toolbox.

Where these issues are managed well, in our experience all farms are able to apply some mitigation measures to reduce P loss.

Significant evidence was presented to the BOI on the achievability of the RWSS being P (phosphorus) neutral. This evidence outlined various farm scale actions that could take place to mitigate P loss across the RWSS footprint using a variety of techniques ranging from simple farm plans to sophisticated modelling systems. This evidence is still relevant and therefore the consent condition requiring the RWSS to remain P neutral is still plausible. There is one significant change from the evidence presented to the BOI. That is that the RWSS total footprint is much larger. The increased footprint is not irrigated area. The RWSS consent will require it to manage farm plans and nutrient budgets over the wider area not just the irrigated area.

Therefore, the greater footprint provides greater opportunity to mitigate P loss. This opportunity could deliver a result better than neutral. The same opportunity exists to manage N across the wider footprint.

Some of the rules contained within Plan Change 6, such as stock exclusion rules and requirements to farm plan will capture these on-farm management practices. One thing HBRC needs to be aware of is that some rules in Plan Change 6 may, in the medium-long term, promote increased DRP or DIN levels. An example of this pertaining to DRP is where, in some situations, the stock exclusion rule where the riparian margin vegetation (especially long grass under certain conditions) can promote riparian slip (the build-up and collapse of the stream bank) into the waterways. This may lead to the situation where short term monitoring of DRP levels reduce due to stock exclusion but beyond that become variable as secondary effects begin to be measured.

N Allocation and Intensification

Relevant to DIN the same LUC N allocation system is operating in the Horizons region under the One Plan. There are occasionally properties under the One Plan that are operating within their N allocation limit but are actively increasing their N losses under the assumption that this will preserve longer term N losses at a higher level. Also, if farms are below their allocation limit they will not consider easy management options for reducing their N loss.

HBRC could expect the same as what has occurred in the Horizons region irrespective of whether the property is irrigating or not. This is a significant issue for PC6 as when deciding to introduce the LUC allocation framework the BOI worked under the assumption that there would be minimal further intensification within the catchment without the further availability of water for irrigation. This assumption was explained at paragraph 423 of the final decision below.

[423] The Board has difficulty with that assumption. Outside the areas to be irrigated the majority of the farmers in the catchment will already be maximising non-intensive production. In the absence of a secure water supply it would probably be difficult for stocking rates or intensification to be lifted to any significant extent. Thus, it is unlikely that there will be significantly higher leaching rates in areas that are not irrigated.

The difficulty with this assumption is that there are already significant amounts of intensification that do not rely on irrigation water and it is rational to expect that more land could be intensified to similar production systems as if they were irrigated systems. An example of this was presented as a case study during the BOI where an unirrigated dairy support farm was effectively leaching more N than if it had converted to a 650 cow irrigated dairy unit.

Of more significance is the approximately 17,000 ha of beef systems operating (on pasture) within the catchment. Most of these systems are dryland and are geared to use the resilient soils in the catchment between March and December when rainfall is relatively high. These systems will typically leach about 20-25 Kg N/ha whereas standard sheep and beef will typically leach 8- 14 Kg N/ha. Much focus has been on dairy systems in the catchment, which represents approximately 10,000 ha (and a significant amount of which is unirrigated).

There are significant areas within the catchment that could be intensified into these or similar intensity land uses without irrigation water. Land use intensification only needs to operate within an allocation framework and complete a farm plan and nutrient budget (with associated GMP expectations) to remain a permitted activity. The LUC framework is a new system for managing diffuse effects in the Tukituki and as such landowners will consider their individual responsibilities and options under this framework. An obvious response is to perceive allocation as a property right and farm to it. This could practically be done by a simple adjustment of stock ratios and increases in winter cropping to take advantage of seasonal soil moisture patterns. This is currently an accepted and increasingly prevalent practice in the region.

This contrasts with the consent conditions of the RWSS that operates an allowed maximum output (AMO) in KG N/ha that farmers will be contracted to achieve. This AMO will be set in a manner to accommodate localised monitoring results and therefore be responsive to localised in stream conditions. This process will be closely monitored by the consent holder in order to minimise commercial risk. In addition, the RWSS is obliged to develop five fully monitored focus farms (similar to that reported by Norris) that will be used to develop a range farm system mitigations that can further enhance the schemes participant's ability to manage the scheme to a that achieves the triple bottom line. These focus farms will aid significantly in the demonstration and communication of both challenges and solutions.

Operability of RWSS farm plan within a DIN framework

To become a contracted water user within the RWSS landowners will need to provide satisfactory nutrient budgets and farm plans. The RWSS Farm Environmental Management Plan (FEMP) will provide the farm specific detail that the land owner will need to manage within contracted conditions set by RWSS. The farm plan has four main objectives that must be addressed. These are;

- Nutrient management – this will involve identifying all sources and potential losses (including effluent and sediment).
- Effluent management (where applicable).
- Waterway management – involving plans to minimise stock damage to waterways and wetlands. A key aspect of this objective will be to enhance ecological health via riparian management.
- Irrigation management – covering the best practice design and installation of irrigation systems including management and monitoring systems.

The nutrient budget (Overseer) will form the basis of the agreed maximum output (AMO) within the individual landowner's water user agreement.

Before the RWSS accepts any FEMP as the conditions within a supply contract it will need to fully evaluate the impact of any additional farm within any particular sub catchment. The need for this is well reflected within the RWSS consent conditions with various conditions requiring continuous management and avoidance of hotspots within the catchment. The RWSS has several methods available to achieve this outcome the most important being the ability to coordinate land use activities before the scheme is commissioned. This action will need to carried out with close coordination with HBRC and will seek to place the most appropriate land use on the most appropriate land type. This pre-commission review may take place over entire farms or may be actioned at block level within farms. An example might be the inclusion of a viticulture operation on a gravel terrace as part of a larger mixed arable enterprise.

Nutrient budgets have limited assumptions that can be tested, whereas a farm plan allows far greater flexibility around assumptions (because it better reflects the actual system and has a spatial element) and therefore provides greater opportunity to describe and manage the risk of nutrient loss (particularly for P).

Within the farm planning framework risk equals source plus transport.

Should conditions within the RWSS consent be triggered that require RWSS to review FEMPs (depending on the test for material contribution) it is only the FEMP that needs to be reviewed and adjusted. Only reviewing the FEMP will allow the RWSS maximum flexibility and effect as to what actions it requires its customer base to complete. This will involve reviewing source areas and identifying transport pathways so that cost effective mitigations can then be developed that are appropriate to the property and activity in question. This is, in effect a critical source area (CSA) approach whereby capital is targeted to tailored solutions at an effective scale relative to an issue. The CSA approach is well tested and accepted by the leaders within this field (including HBRC) and in general delivers similar results as regulation but at a fraction of the cost.

The critical source area approach is possible because the RWSS conditions allow it. However, in addition to the RWSS conditions the scheme will have to operate within the nitrogen allocation framework as described by Plan change 6(PC6). The scheme will be able convert the N allocation of its customer base into a total load to redistribute via a contracted AMO within the limitations embedded within conditions. Based on the Macfarlane Rural Business (MRB) relative land use assumptions and nitrogen loss from representative case studies completed for the BOI process, the RWSS should be able to operate comfortably within the PC6 allocation framework.

Economic viability of farms achieving .8 (EDS F&G point 3a(ii))

*Shoul*d the scheme be *deemed to be a* material *contributor* (via a yet to be determined test) *to any DIN exceedance it will have to manage in a manner consistent with achieving 0.8 DIN at predetermined monitoring points by 2030. This will be determined based on a rolling five-year average. The earliest possible date the scheme could be deemed to be contributin*g to any exceedance will be 2026 (assuming 2020-21 *is the first irrigation season). Analysis has been carried out to understand what this may mean for the RWSS and its farmer base.*

*Currently DIN is exceeded in the Tukituki River at SH 2 by approximat*ely 158 tonnes (based on recent *monitoring).* High level analysis has been completed to understand the potential implications of the RWSS being deemed a material contributor. Significant assumptions are made in *that the entire RWSS will operate in the zones contributing to this exceedance (*irrigation *zones B, C, D) and t*hat the scheme is deemed to be a material contributor *as soon as it commences water delivery its contribution to the reduction would be about .5kgha per year – or 5kgha over 10 years. This obligation is based on the proportion of land class and therefore allocation that the RWSS could expect to operate across. It was assumed that RWSS would* *operate on the* highest class of *land available and therefore have the highest possible allocation and therefore obligation. These assumptions are conservative (worst case) as it is very unlikely the scheme will operate in its entirety within zones B, C, D or be deemed to be a material contributor in year one of operation*.

HBRIC had *previously asked MRB to analyse the economics of nitrogen loss mitigation for the arable and dairy systems used in feasibility. Figure 1 is a result of that analyse for dairy and clearly shows that a 5 kg N loss reduction has an effect on EBIT of approximately $15 kg N h*a yr. This data is based on the analysis discussed under mitigation options previously in this report whereby successive mitigations were applied to a farm system to achieve stepwise reductions in contaminate loss. The MRB report showed that reductions in N leaching of up to 15Kg Ha for the farm systems modelled did not impact significantly on farm income. Mitigation beyond that point had incremental reductions in farm income.

Analysis shown in figure 1 is completed using only Overseer. As explained earlier, while the test for material contribution may be unclear the response required is quite clear. This will involve progressively more stringent mitigations being implemented through the farm plan framework managed by RWSS. There will be significant opportunity to mitigate N and P loss via pathways not readily recognised or modelled in Overseer. This may result in instream DIN concentrations reducing without a corresponding reduction in Overseer based rootzone losses. It is this point that makes it difficult to predict the response of in stream DIN to farm scale mitigations. The relationship between in stream concentrations and rootzone loses at any particular point in time is very ambiguous. Therefore, any statement about the viability of farm systems seeking to be compliant with DIN has to be couched with the framework used to manage toward the target. If the framework is LUC and farm plans managing towards (i.e. a downward trajectory) then the above analysis is relevant. If the framework is an instream achievement DIN everywhere all the time then that target will be very onerous for most farm systems not just the scheme in some parts of the catchment. There are however some land based enterprises that do have lower N loss than pastoral based systems. In general grapes and apples will have lower N loss and offer greater flexibility.

It is expected that as the potential for mitigations to achieve contaminant reductions for any particular farm system is exhausted the emphasise will need to turn to land use change. This raises the vital questions of to what and how? As mentioned there are a number of land uses that in general, have lower N loss. These include some perennial tree crops and some housed livestock systems such as dairy goat or sheep.

There is uncertainty whether a wholesale change in land use to these systems, regardless of the commercial viability of that change, will result in the achievement of .8 DIN in some sub catchments. However, what is clear that in order for land use change of this type to occur significant further investment will need to be made. Very serious consideration needs to made as whether that investment would rationally be made before 2030 without a clear understanding of what the implications might be for any single business beyond that. This point is especially relevant in that there will most probably be another plan change before that time.

It is notable that resource consents are often granted for 35years presumably to allow rational and confident investment. It is also notable that the Waikato Healthy Rivers plan change is based upon achieving objectives over an 80-year time frame to allow for intergenerational land use change. An obvious example is the development of forestry systems that are acknowledged to have very low N loss but in general do not provide financial returns until 20 – 30 yrs after investment. An 80-year time frame allows for incremental land use change that allows investment expenditure and returns to be more equitably spread between generations and still allows for plan changes as an adaptive management strategy.

It is worth noting that in the authors experience that the best operators are performing this kind of analysis as part of any due diligence on new investment or reviews of existing investment. It should also be noted that highly profitable low footprint farming is a rapidly developing area with considerable investment in new management techniques and understanding being made. The five fully monitored focus farms the scheme is obligated to develop will be a significant further investment into this area.

Post the Board Of Inquiry's final decision significant further work has gone into development of farm systems with irrigation to comply with the LUC framework. This has resulted in significantly lower N loss figures per farm type than that used though the Inquiry process. Many of these farm type N losses are equivalent or less than current land uses. This is due to a review of some farm scale mitigations and as a factor of catchment scale modelling limitations whereby the nuances of managing land are not included in the model outcomes. E.g. not applying effluent at high rates to stony gravels.

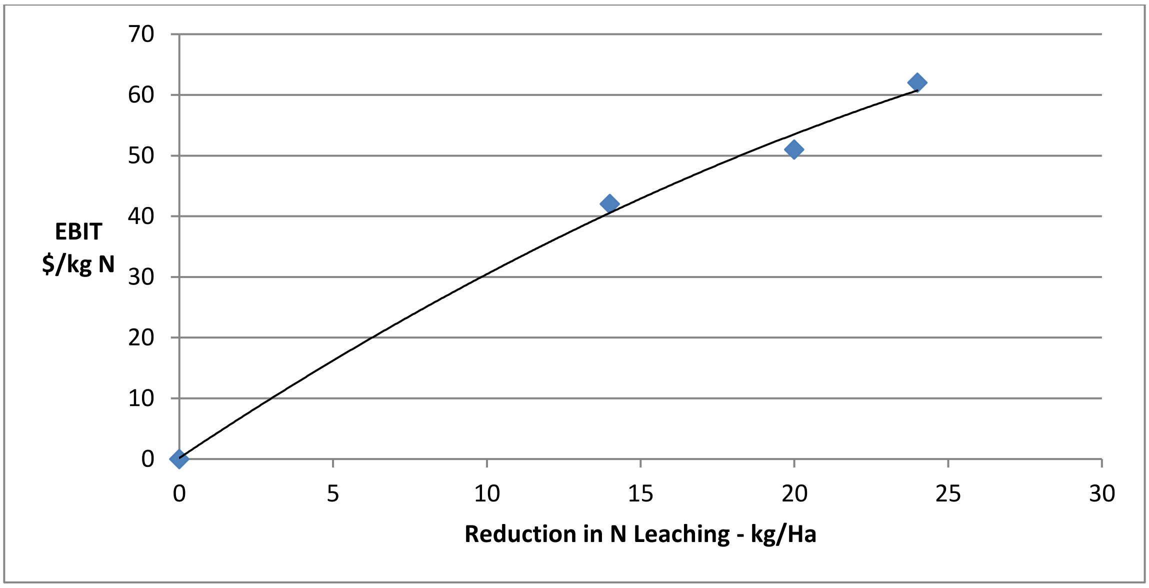

Figure 1: Cost of Nitrogen Loss expressed as $/kg of N[8]

Overseer

The effects of N loss under irrigation using Overseer can be variable. If the irrigation is properly managed then often you can have reduction in N loss. This is brought about by the plants increased requirements for nutrients while actively growing. If the irrigation is not actively managed then two things can happen – either there will be drainage leading to increased N loss or surface ponding and/or runoff leading to increased P loss. For a property to actively manage

[8] Modelling the effects of land use on nutrients entering the Tukituki River, Hawkes Bay. Report prepared by NIWA, June 2012. Reports prepared for the Hawkes Bay Regional Council. Appendix 3, Economics of nitrogen loss mitigation.

its irrigation then it needs detailed soils information, both spatially and quantitatively, that provide trigger points and knowledge of soil moisture holding levels. Furthermore it needs the ability to activity monitor soil moisture levels, knowledge of crop requirements, and the ability to differentially irrigate according to soil and plant requirements [This information, monitoring and precision management is typical of modern irrigation systems where capital and operating costs incentivise careful management]. It is expected that as the RWSS is in effect a greenfield development the standard of new irrigation systems will be at this level.

Several nutrient budgets of intensive dairy and arable farm systems in the Ruataniwha area that have been completed or reviewed by LandVision and Rural Directions were examined to assess the level of compliance with ground water drinking water standards. All the reviewed files modelled drainage water N concentrations less than the drinking water standards on a whole farm basis. Two issues did stand out from this exercise:

1. Irrigated blocks in general had lower concentrations of N in drainage water than dryland (within the same farm) e.g. a dryland block with a concentration of N in drainage water of 9.8 ppm and an irrigated block of 9 ppm within the same management unit.
2. Forage cropping blocks (particularly winter crops) had higher concentrations than the farm average e.g. winter grazed fodder beet with a N in drainage water of 45 ppm and barley (with winter oats) with 14.8 ppm

This leads to the conclusion that as farms move from dryland to irrigated you can reasonably expect to see less reliance on winter cropping as production systems move to more efficient summer production and therefore potentially lower concentrations of N in drainage water if they are currently actively winter cropping. This is manageable via the farm plan process. Whereas, any intensification that occurs without irrigation is likely to be significantly more reliant on winter forage crops. It should be noted that management capability has a significant influence on the outcomes from this effect.

Sub Catchment N loadings

The BOI land-use N loss values that were used to predict N loadings for the various sub-catchments have been adjusted for version 6.2.3 of Overseer as the original numbers were based on earlier Overseer versions. For individual catchments, this ranged from 65% through to 98% utilisation of allocation. Obviously, these calculations are very subjective and dependent on multiple variables that may or may not be right. With time the certainty around this headroom will improve due to the use of real data collected from properties using actual resource data. It was also noted that all the figures for the various catchments were higher than that obtained from the calculations from the farm plans that were determined from multiple versions of Overseer. This illustrates two important points:

- The disconnection between the LUC allocation levels and the catchment DIN levels.
- The conservative nature of high level catchment data lacks the resolution gained from analysis of actual data developed with spatial context.

Pre and Post Irrigation N loss

Some very high level analysis of pre and post irrigation and the potential effects on N loss was undertaken. This involved an analysis of all contracted farms and the intended land use for these farm post RWSS commissioning. The results were variable due to:

- the use of standardized N loss figures for the different land uses when in reality N loss will be variable,
- the lack of detailed spatial information as to where the intensification would occur, and
- the inability to adequately model multiple land uses on a property to reflect the degree of innovation and adaption that will occur.

The results did provide a level of confidence that the scheme would be able to manage within its potential LUC allocation consistent with the RWSS consent conditions. It is noted that this is to comply with the N allocation framework. The scheme participants will also have to comply with any localised DIN limitations should they be deemed to be material contributors. At present the test for material contribution sits with HBRC as the regulator. This should be covered in Item 17 of the RWSS review. This could manage the relative obligation between PC6 and RWSS. However, what is clear is that the response required by the scheme will be to review farm plans and seek progressively more stringent mitigations.

Sub catchment area weighted allocation and DIN targets.

To assist with understanding the connection between LUC based allocation and instream DIN yields a brief analysis was completed. The results are shown in Table 1 below.

Table 3 shows the weighted average allocation for a range of sub catchments in the Tukituki catchment (in purple). The orange cells indicate the respective DIN targets for that particular sub catchment. E.g. for the Mangaonuku sub catchment the DIN target is approximately equivalent to 5.9 kg N/ha that in turn equates to an allocation framework approximately .3 of the full allocation. It is acknowledged that the DIN levels represented here are developed from in stream concentrations and are very dependent on a number of variables but do provide useful relative difference.

There are several key observations to be made about this data which include:

- Using the Mangaonuku as an example, achieving the DIN target using the LUC framework would require reductions in allowable N per hectare of approximately .3 (30%) of the full allocation tabled in PC 6. The per hectare allocation allowed at 0.3 of full allocation would severely limit any intensive or semi intensive land use (including tree crops) and would require wide spread forestry establishment to allow even moderate areas of intensification.
- The sub catchments in table 1 have been organised into surface water allocation zones (Z1-4). Zone 4 is the foothills against the Ruahine range. This zone has been identified as needing to maintain N yield at current levels. Table 1 shows the N loss requirements for this zone as a DIN target but also shows that the potential N loss from this zone (at full allocation), to be 2-3 times the target level. Failure to maintain current losses in this zone will make attaining targets further downstream very difficult.

- It is evident from Table 1 that the range in allocation between sub catchments to achieve DIN targets is very significant. To try to manage the allocation framework to achieve DIN across the whole catchment would introduce severe management and equity obstacles for all parties.
- It is noted that the Board Of Inquiry were very clear that DIN was not intended to be managed at a sub catchment level. Indeed, this may not be feasibly possible due to the difficulty in attributing causation to any particular exceedance due to groundwater travel paths and lag times. [397] Before leaving this topic we should acknowledge that Fish and Game and EDS contended that nutrient management should be on a sub-catchment basis.192 While this may be ideal in a perfect world, the Board is conscious of the practical difficulties of achieving this in the Tukituki catchment and believes that these difficulties cannot be overstated. The Board has therefore concluded that such a requirement would be too onerous.[9]

[9] Final Report and Decisions of the board of inquiry into the Tukituki catchment proposal

Table 3:relationship between sub catchment area weighted allocation, DN and allocation rates

Allocation Class (Kg/ha)		full	0.90	0.80	0.7	0.6	0.5	0.4	0.3	0.2
	1	30.1	27.09	24.08	21.07	18.06	15.05	12	9	6
	2	27.1	24.39	21.68	18.97	16.26	13.55	11	8	5
	3	24.8	22.32	19.84	17.36	14.88	12.4	10	7	5
	4	20.7	18.63	16.56	14.49	12.42	10.35	8	6	4
	5	20	18	16	14	12	10	8	6	4
	6	17	15.3	13.6	11.9	10.2	8.5	7	5	3
	7	11.6	10.44	9.28	8.12	6.96	5.8	5	3	2
Weighted Average Allocation per Sub Catchment with DIN Targets (KG N/Ha)										
Sub-catchment	area (ha)	full	0.90	0.80	0.7	0.6	0.5	0.4	0.3	0.2
Makaroro Z4	12,143	**7.3**	**6.8**	**6.2**	**5.7**	**5.2**	**4.6**	**4.1**	**3.6**	**3.0**
Upper Tukituki Z4	18,775	**14.4**	**13.0**	**11.7**	**10.3**	**9.0**	**7.6**	**6.3**	**4.9**	**3.6**
Mangaonuku Z2	35,984	**19.5**	**17.6**	**15.6**	**13.7**	**11.7**	**9.8**	**7.8**	**5.9**	**3.9**
Waipawa Z2	22,343	**14.2**	**12.8**	**11.5**	**10.1**	**8.8**	**7.4**	**6.1**	**4.7**	**3.3**
Kahahakuri Z3	8,026	**24.3**	**21.9**	**19.4**	**17.0**	**14.6**	**12.2**	**9.7**	**7.3**	**4.9**
Maharakeke Z3	8,545	**21.1**	**19.0**	**16.9**	**14.8**	**12.6**	**10.5**	**8.4**	**6.3**	**4.2**
Porangahau Z3	7,256	**23.1**	**20.8**	**18.5**	**16.2**	**13.9**	**11.6**	**9.3**	**6.9**	**4.6**
Tukipo Z3	22,041	**21.4**	**19.2**	**17.1**	**15.0**	**12.8**	**10.7**	**8.5**	**6.4**	**4.3**
Upper Tukituki Corridor Z3	4,292	**19.4**	**17.5**	**15.6**	**13.6**	**11.7**	**9.7**	**7.8**	**5.8**	**3.9**
Makara Z1	12,764	**18.2**	**16.4**	**14.5**	**12.7**	**10.9**	**9.1**	**7.3**	**5.5**	**3.6**
Lower Tukituki Corridor Z1	18,920	**16.3**	**14.7**	**13.0**	**11.4**	**9.8**	**8.1**	**6.5**	**4.9**	**3.3**
Mangatarata Z1	19,106	**20.1**	**18.1**	**16.1**	**14.1**	**12.1**	**10.1**	**8.1**	**6.0**	**4.0**
Papanui Z1	16,413	**20.9**	**18.8**	**16.7**	**14.6**	**12.5**	**10.4**	**8.4**	**6.3**	**4.2**

Conclusions

1. Based on LUC unit, soil type and slope there is adequate land within the scheme area that is suitable for irrigation.
2. The current database of farm plans completed in the Tukituki catchment provides valuable actual information for analysis work rather than using standardized landuse predictions. These plans (96 plans covering approximately 30,000 ha) account for approximately 12% of the Tukituki catchment. As the number of plans increases then so will the level of accuracy of modelling for nutrient loss.
3. From the farm plans completed there is an estimated head room of 29% between the actual N loss and the LUC N allocation under Plan Change 6. The headroom for N loss at a sub-catchment level varied significantly. The Papanui for example has a head room of 44% (calculated from plans covering 25% of the sub-catchment), the Tukipo has a headroom of 17%, the Waipawa has 48% and the Maharakeke has 29%. These figures from the sub-catchment compliance indicate there is no linkage between the LUC allocation system and the recorded DIN levels.
4. The level of compliance from all properties was 85% permitted activity level status (N loss less than permissible N loss limits), 10% restricted discretionary (N losses between 0 and 30% above permissible N loss limits) and the remaining 5% non-complying (above 30% of permissible N loss limits).
5. There are no measurable on-farm targets for Phosphorus loss. P reductions will come about through targeting point source and non-point critical source areas identified in the farm plan and most farms will have opportunities to reduce P losses. Some of these opportunities will be more effective than others. Collectively, you would expect this to show up in the in-stream DRP levels across the catchment over time.
6. The effects of N loss under irrigation using Overseer can be variable. If the irrigation is properly managed then you can often have a reduction in N loss. An example of this is switching from winter cropping to summer cropping. If the irrigation is not properly managed then you get increased N loss through drainage or increased P loss through surface runoff. A properly managed irrigation system requires detailed spatial soils information with trigger points and knowledge of moisture holding capabilities. Furthermore, it requires detailed soil moisture monitoring, crop requirements, and the ability to differentially irrigate.
7. Experience from the Horizons region shows that properties that comply with the permissible N loss limits generally do not seek opportunities for further N loss savings when in some situations they could. The RWSS scheme will have control in terms of both P and N loss over both the irrigated and non-irrigated land within its footprint.
8. Under irrigation there is the potential for management systems to change from a winter intensification programme to summer intensification. This can have a positive effect on N and P losses.
9. In recent years intensification has been and can be expected to continue to (will) occur also on those non-irrigated properties if the LUC leaching rates remain the primary tool for controlling land use.
10. To assist with understanding the connection between LUC based allocation and instream DIN yields a brief analysis was completed. The results show that in some sub-catchments a significant reduction in the LUC N allocation limit is required. The Mangaonuku for example would require the LUC N allocation to be 30% of the full allocation to achieve the DIN levels. This would mean extensive landuse changes.

Lachlan Grant – LandVision Ltd

Ian Millner – Rural Directions

MEMO

To:	Ned Norton
From:	Andy Hicks
Date:	13/04/2017
Subject:	**RWSS REVIEW INPUT FROM HBRC WQE TEAM**
File Ref:	
Cc:	Shane Lambert; James Palmer; Nathan Heath

Purpose

I have been asked to provide evidence and commentary regarding water quality and ecology outcomes that are pertinent to the RWSS review. Specifically relating to the following tasks:

Estimate current compliance (existing land use) at each of:

- DIN instream
- DRP instream
- periphyton and MCI

Estimate current extent of headroom based on above for:

- DIN instream
- DRP instream
- periphyton and MCI

Method

Data collected from State of the Environment (SoE) monitoring sites by the water quality and ecology team was used to provide answers to the questions above.

The method and data used was suboptimal due to the time constraints on this review and available resourcing. Most importantly, undertaking an evaluation of DRP and periphyton requires each water quality data point to be matched with flow conditions at the time. This process is time consuming and could not be undertaken within the timeframes of this review. We are currently working on a system to expedite this process, but it is currently not ready for use. Additionally, new sites have been added to our programme where necessary to provide data from the downstream end of each sub-catchment. But, some new sites have only been sampled for a short while and do not satisfy the 5 year period as specified in PC6. This means the following caveats apply:

- **DRP**: An assessment against 5 year average DRP concentrations was undertaken on all data available from each site over the period Jan 2012 – Dec 2016. According to PC6, data relating to flows greater than 3 x median should have been excluded. Because high flows will typically carry higher concentrations, this means assessment against DRP compliance will paint a slightly more negative picture than if these high flow samples had been excluded.

- **Periphyton**: Compliance reporting against periphyton targets requires that only data collected from monthly SOE monitoring within a 30 day accrual period be used for estimates. Without screening the data according to this condition would result in an overestimate of non-compliance, because estimates of algal growth from long accrual periods would be included. As such, these data in particular should be viewed as an over-exaggeration of non-compliance with PC6 targets. However, the data does allude to the issues with periphyton growth in the river that stems from the naturally long accrual periods (i.e. several months without high flows) that occur in Hawkes Bay Rivers.

- **All**: Not all data had been through our standard quality coding process
- **New sites**: Many sites had less than the full five years required for DIN and DRP compliance reporting, as per table 1 below.

Table 1 Time periods over which data from each site was available. Highlighted sites indicate less than a full 2 years of data.

Site	Sampling period
Hawea Stream U/S Tukituki	27/9/16-14/12/16
Kahahakuri Stream U/S Tukituki Confl	17/1/12-13/12/16
Maharakeke Stream at State Highway 2 Br	23/2/15-13/12/16
Makara Stream at St Lawrence Road	17/1/12-13/12/16
Makara Stream U/S Tukituki	20/7/16-14/12/16
Makaretu Stream at Speedy Rd Bridge Gw8	12/4/12-13/12/16
Makaretu Stream at State Highway 50	17/1/12-13/12/16
Makaroro River at Burnt Bridge	19/7/16-13/12/16
Mangamahaki Stream at Tamumu	17/1/12-13/12/16
Mangaonuku Stream at Waipawa Tikokino Rd	17/1/12-13/12/16
Mangarara Stream U/S Tukituki	20/7/16-14/12/16
Mangatarata Stream at Mangatarata Road	17/1/12-13/12/16
Papanui Stream at Middle Road	17/1/12-13/12/16
Porangahau Stream at Oruawhara Road	17/1/12-13/12/16
Porangahau Strm US Maharakeke Strm	12/8/15-13/12/16
Tukipo River at State Highway 50	17/1/12-13/12/16
Tukipo River U/S Makaretu confluence	17/1/12-10/12/15
Tukituki River at Ashcott Bridge S.H. 50	17/1/12-13/12/16
Tukituki River at Black Bridge	17/1/12-14/12/16
Tukituki River at Red Bridge	17/1/12-13/12/16
Tukituki River at Tamumu Br.	21/11/12-13/12/16
Tukituki River at Tapairu Rd	19/1/12-13/12/16
Tukituki River at Waipuk Onga Road	17/1/12-13/12/16
Tukituki River at Waipukurau	21/11/12-13/12/16
Waipawa River at State Highway 50	17/1/12-13/12/16
Waipawa River at Waipawa SH2 (OLD)	21/11/12-13/12/16

With the above caveats in mind – the following describes the approach used to prepare the data for analyses. All data from 26 long term SOE monitoring sites were downloaded from our Puddle database covering the period Jan 2012 to December 2016. This database contains non-routine SOE samples, e.g. those that relate to high flow events or special priority catchment investigations. For compliance reporting, we should only be including the routine, monthly SOE sampling which cover the full course of the year, and so I attempted to limit the dataset to these routine samples. This was usually quite straightforward, but not always. So despite my best endeavours, there remains a risk that some non-routine data was included in the analyses. The final dataset was imported into the Time Trends and Equivalence Software and descriptive statistics were generated that enabled comparison to PC6 water quality objectives and limits.

The plan stipulates a fairly complex array of different statistics for compliance with difference variables (e.g. annual medians and 95th percentiles for nitrate nitrogen, compared with 5 year averages for DRP), and different sites have different targets for these variables, as per PC6 Table 5.9.1B. The different statistics used are summarised in Table 2 below.

Table 2: Statistics for assessing compliance with water quality objectives as outlined in PC6 Table 5.9.1B.

Parameter	Statistic	Time Period	Flow Limit
Periphyton (a) total biomass	Maximum	Annual	30 day accrual
Periphyton (b) long filament cover	Maximum	Annual	30 day accrual
Periphyton (c) thick diatom/cyanobacteria mat	Maximum	Annual	30 day accrual
Periphyton (d) cyanobacterial mat	Maximum	Annual	30 day accrual
DRP	Mean	5 years	< 3 x median
Nitrate nitrogen chronic	Median	Annual	All
Nitrate nitrogen acute	95th Percentile	Annual	All
DIN	Mean	5 years	All
Water Clarity black disc	Median	5 years	< median
MCI	Mean	5 years	All
Deposited sediment cover	Mean	5 years	All
Temperature	Maximum	Annual	All
Dissolved oxygen	Minimum	Annual	All
Total Ammoniacal Nitrogen (chronic, trigger only)	Median	Annual	All
Total Ammoniacal Nitrogen (acute, trigger only)	Maximum	Annual	All
E. coli bathing low flow	95th Percentile	1 Nov to 30 April, 20 sampling points	< median
E. coli bathing moderate flow	95th Percentile	1 Nov to 30 April, 20 sampling points	between > median and < 3 x median
E. coli non bathing times	95th Percentile	1 May to 31 Oct, 20 sampling points	< 3 x median

For each sub-catchment, the most downstream site has been used to act as the compliance monitoring site for that entire sub-catchment; i.e. there are 17 compliance monitoring sites. I have limited discussion to these 17 sites when discussing compliance with plan objectives and limits, rather than creating confusion by having multiple monitoring sites within a single sub-catchment. Appropriate values for each parameter for each sub-catchment were extracted from Table 5.9.1B.

In addition, data from the Tukituki at Red Bridge, which the council will probably use as the NPS-FM relevant monitoring site for the Tukituki ‘freshwater management unit, was included for comparison. This site is our second most downstream monitoring site in the Tukituki catchment, and has a long term monitoring dataset associated with it, and already has the established infrastructure to report against parameters like temperature, dissolved oxygen and pH, which makes it a logical choice for our FMU monitoring site.

Results – current compliance

In terms of overall compliance, Figure 1 shows how each parameter fared against objectives. Strikingly, no sub-catchment for which we had MCI data achieved the respective targets. Conversely, all sub-catchments achieved compliance with the nitrate toxicity targets. DIN and DRP levels of compliance were intermediate, with 24% of sub-catchments (n=4/17) achieving their DRP targets and 65% of sub-catchments (n = 11/17) achieving their DIN targets.

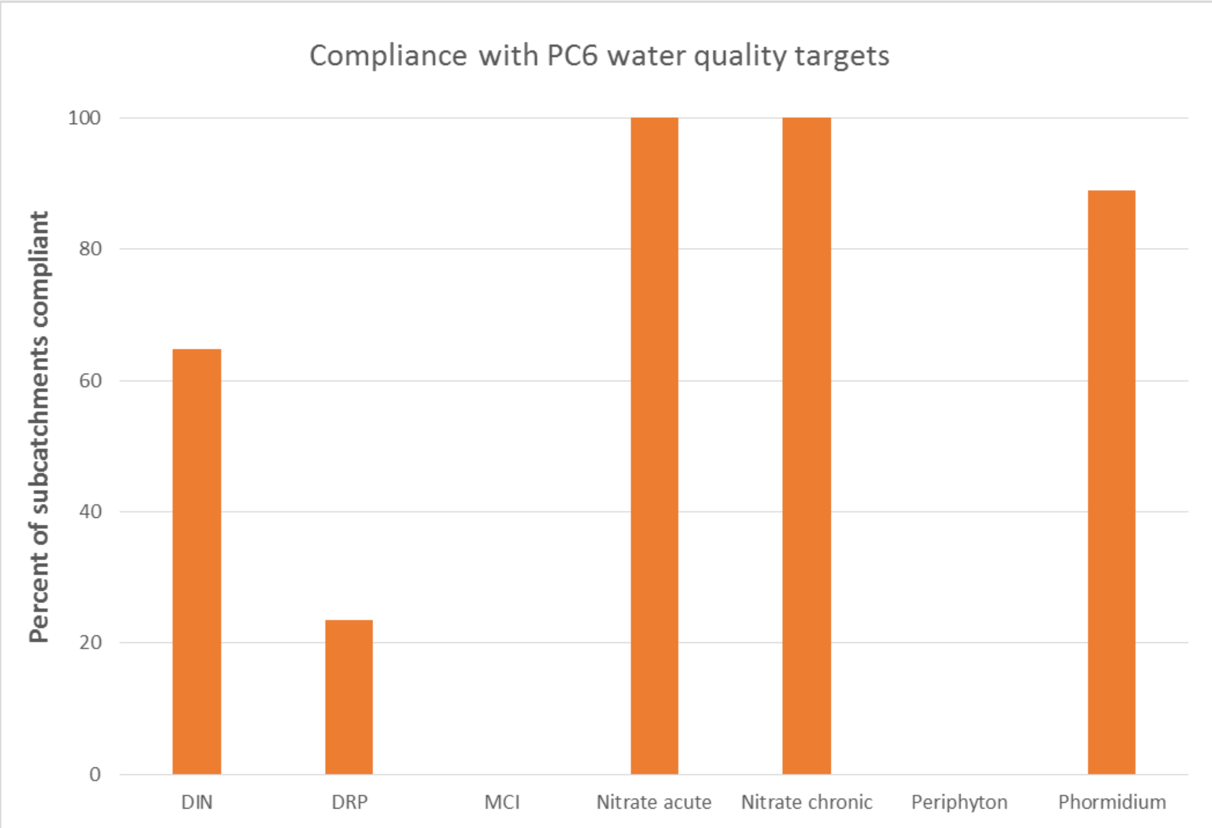

Figure 1: Compliance with PC6 water quality targets

As outlined in the caveats, the periphyton data was not screened for accrual period. Despite this, phormidium was compliant at 89% of the sub-catchments we had data for (n = 8/9). Periphyton biomass was non-compliant at all sites we had data for (0/4), but this represents an overly negative picture of this attribute with regards to PC6 targets.

To further explore periphyton compliance, time was spent screening the data from Red Bridge site based on flow conditions at the telemetered flow monitoring site there. For the period Jan 2012 – Dec 2016, there were 3 occasions when the recorded periphyton biomass was higher than the target of 120, and interestingly these occurred in May (n=2) and June (n=1). On all three occasions, the flows in the preceding 30 days had not breached the 3 x median flow threshold, and hence all three samples would have been excluded from the compliance assessment. So, the Tukituki at Red Bridge would have met the PC6 targets for that 3 year period.

For comparison, the Tukituki at Red Bridge would sit within the 'B' band when assessing against the National Objectives Framework (NOF)[1] for periphyton data collected between Jan 2012 and Dec 2016.

[1] See National Policy Statement for Freshwater Management 2014

In terms of measuring performance against periphyton targets, I think it may be difficult to reconcile the perception of excessive algal growth that the public has, with the targets that have been set in Plan Change 6 (i.e. no more than a maximum of 'X' within a 30 day accrual period). The time when the public are most upset with excessive periphyton growth (slime algae) will be during long accrual periods. But, our compliance monitoring will be excluding those data from our assessments. In other words, our plan compliance monitoring and reporting may suggest full compliance with periphyton targets, despite the river being covered with slime algae for much of the summer, and being deemed unacceptable by the community.

Results – estimate of headroom

It is worth noting that the actual objective in OBJ TT1 is to reduce the current frequency and duration of periphyton growths, rather than reduce them to a particular level. So with this in mind, there is no headroom for any increase in periphyton growth, despite the fact that current data suggest that the targets set in PC6 were met at most sites in the Tukituki catchment where these data are being collected.

Based on monitoring data and in comparison to PC6 targets and objectives, Figure 1 indicates there is no headroom for any deterioration of MCI, periphyton or phormidium. The data also indicate compliance with nitrate toxicity targets – but non-compliance with DIN targets in some instances. Because nitrate is a component of DIN, this indicates that DIN is the more limiting parameter for assessing headroom. DRP also shows non-compliance at some sites. So, for the remainder of this memo I will focus on indicative 'headroom' for DIN and DRP.

The following plots present data for each site in a manner which allows both current state and 'headroom' to be established. This was done by presenting the current state as a proportion of the target value – with anything more than 100% indicating negative headroom, and anything less than 100% indicating headroom. The results of inferred headroom for DRP and DIN are shown in Figures 2 and 3 and in Table 3.

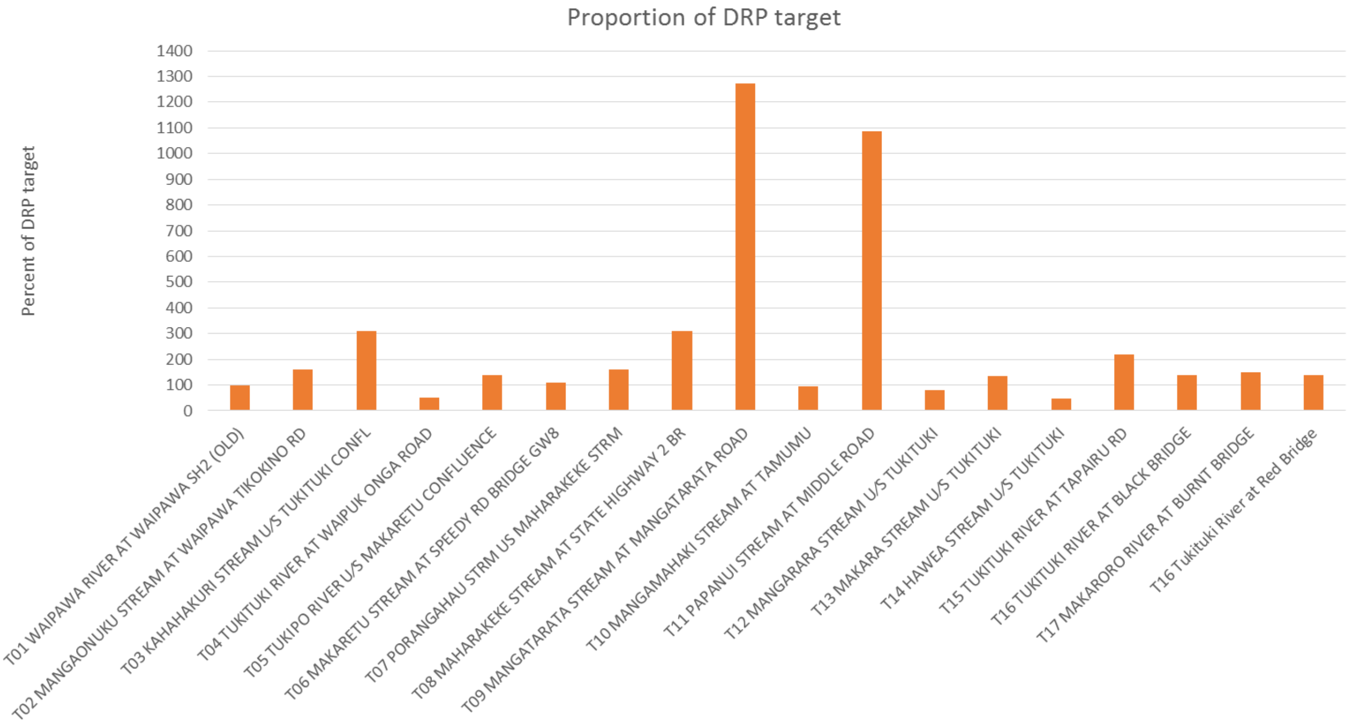

Figure 2: Compliance with DRP targets and inferred headroom

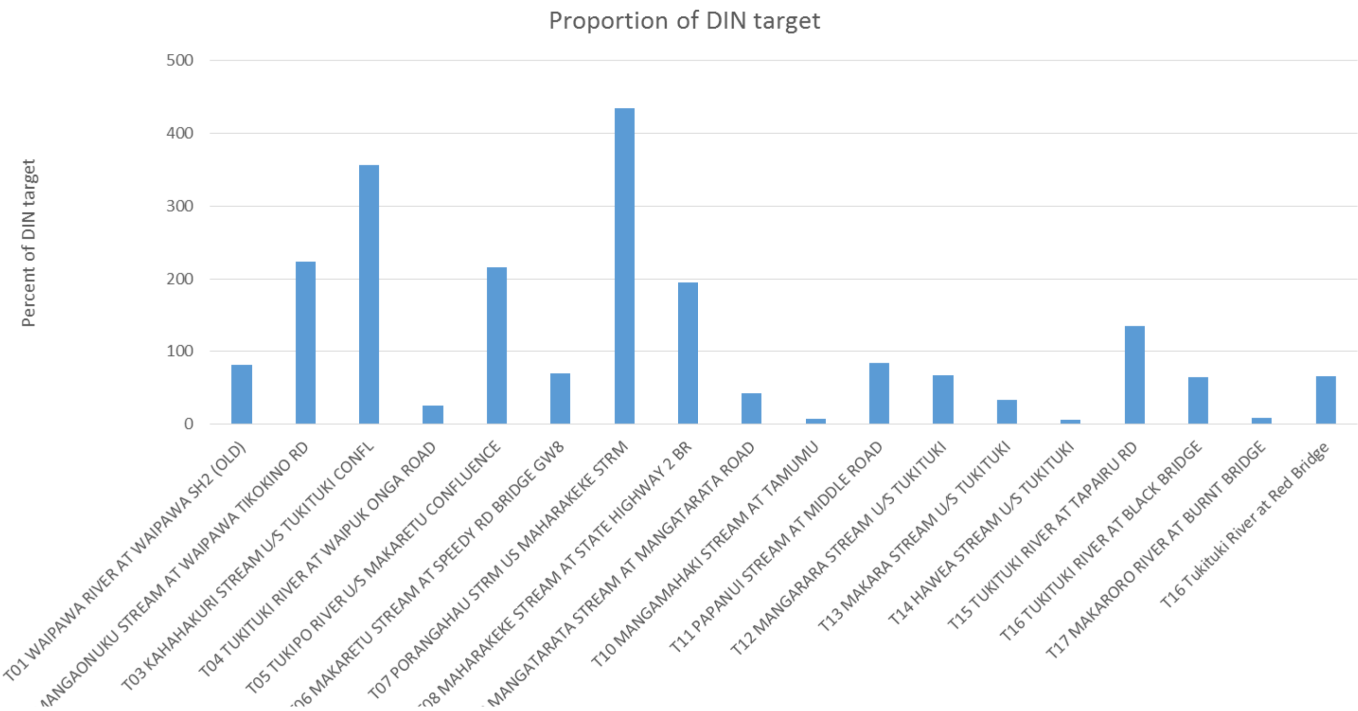

Figure 3: Compliance with DIN targets and inferred headroom

DRP: Some sub-catchment have considerable 'positive' headroom, such as the upper Tukituki (T4) or the Hawea Stream (T14). These are certainly the exception, however, and most sub-catchments are either close to or failing DRP targets, i.e. very little or negative headroom. Some sites, such as the Mangatarata and Papanui, are an order of magnitude higher than their respective DRP target.

Overall, and at the broader catchment scale, there is negative headroom for DRP. The Tukituki at Black Bridge is currently exceeding its DRP target, which means DRP at the entire catchment scale needs to be reduced for the DRP target to be met here.

DIN: There is more headroom for DIN at the broader catchment scale than there is for DRP. The Tukituki at Black Bridge is currently only at about 2/3rd of its target, which would imply some 'headroom' exists. Similarly, there are 6 sites that are less than 50% of their targets. Conversely, some sites are well over their allocation, and these sites are typically within or will be heavily influenced by the proposed RWSS footprint. In other words, the area of worst performance and those sub-catchments with negative headroom for DIN are mostly in the Ruataniwha Plains area (T02, T03, T05, T07, T08 and T15). See Table 3 and Figure 4 for % headroom and spatial distribution of DIN hotspots, respectively.

So, although in general much of the Tukituki is compliant with DIN targets, the area where compliance is worst is in the area of the proposed footprint for the RWSS. It is worth noting that instream growth of periphyton removes DIN from the water column and this attenuation reduces DIN levels as the Tukituki River flows downstream from the upwelling zones near State Highway 2.

Table 3 Headroom for DRP and DIN at sub-catchment compliance sites in the Tukituki River.

Plot name	DIN_%	DRP_%
T01 WAIPAWA RIVER AT WAIPAWA SH2 (OLD)	81	100
T02 MANGAONUKU STREAM AT WAIPAWA TIKOKINO RD	223	160
T03 KAHAHAKURI STREAM U/S TUKITUKI CONFL	357	310
T04 TUKITUKI RIVER AT WAIPUK ONGA ROAD	25	50
T05 TUKIPO RIVER U/S MAKARETU CONFLUENCE	216	140
T06 MAKARETU STREAM AT SPEEDY RD BRIDGE GW8	69	110
T07 PORANGAHAU STRM US MAHARAKEKE STRM	435	160
T08 MAHARAKEKE STREAM AT STATE HIGHWAY 2 BR	195	310
T09 MANGATARATA STREAM AT MANGATARATA ROAD	42	1273
T10 MANGAMAHAKI STREAM AT TAMUMU	7	93
T11 PAPANUI STREAM AT MIDDLE ROAD	84	1087
T12 MANGARARA STREAM U/S TUKITUKI	67	80
T13 MAKARA STREAM U/S TUKITUKI	33	133
T14 HAWEA STREAM U/S TUKITUKI	6	47
T15 TUKITUKI RIVER AT TAPAIRU RD	135	220
T16 TUKITUKI RIVER AT BLACK BRIDGE	65	140
T17 MAKARORO RIVER AT BURNT BRIDGE	8	150
T16 Tukituki River at Red Bridge	66	140

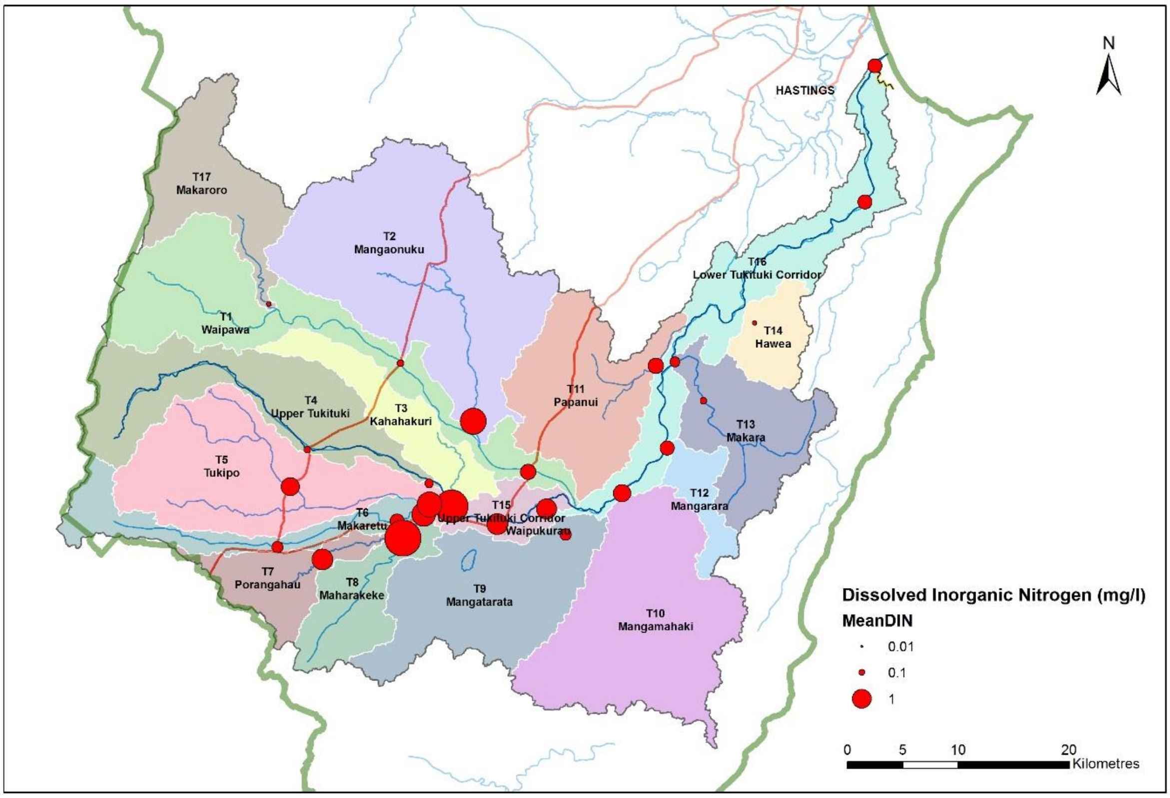

Figure 4: Mean Dissolved Inorganic Nitrogen recorded from all monitoring sites in the Tukituki catchment. NB: Time periods and samples size for different sites vary, so this figure is for illustrative purposes only.

MEMO

To:	Jeff Smith - Team Leader/Principal Scientist Hydrology/Hydrogeology
From:	Dougall Gordon - Principal Groundwater Scientist
Date:	21st February, 2017
Subject:	**GROUNDWATER NITRATE-N ASSESSMENT FOR RWSS**
File Ref:	
Cc:	

1) Introduction

An assessment of the current and state and trends in nitrate-nitrogen (nitrate-N) has been requested, to evaluate nutrient leaching and groundwater quality. The request is to inform a review of the Ruataniwha Water Storage Scheme (RWWS) for meeting consent conditions relating to nutrient limits set for the Tukituki catchment (which includes the Ruataniwha and Papanui aquifer systems). The Regional Plan Change 6 (PC6) for the Tukituki catchment has specific nutrient leaching requirements for surface and groundwater quality. For groundwater, PC6 refers to the limit of 11.3 mg/L and a trigger level of 5.65 mg/L for nitrate-N. The limit of 11.3 mg/L is the maximum acceptable value (MAV) specified in the New Zealand Drinking Water Standards (DWSNZ) (2008) published by the Ministry of Health.

2) Ruataniwha Aquifer System

The Ruataniwha plains is a geological basin that contains an alluvial gravel aquifer systems that flows west to east. The Ruataniwha aquifer system is recharged by rainfall, along with localised river and stream flow in the west and midpoints of the basin channel flow. The eastern hills force groundwater flow upward to the surface into the Tukituki and Waipawa Rivers, which then flow through an erosion rock gap in the hills. Three major rivers (Makaretu, Tukituki and Waipawa Rivers) flow across the Ruataniwha Plains.

Groundwater modelling along with water age and tracer studies conducted in 2012 and 2013 indicate that the groundwater is generally greater than 25 years old in the upper section of the aquifer system. There is also an increasing groundwater age or residence time with depth. Old groundwater in deeper parts of the aquifer typically have lower nitrate concentrations due to the long residence time in the aquifer. The older groundwater was recharged at the time of historical, predevelopment landuse. Natural nitrate-N attenuation processes due to denitrification also occur in groundwater systems. Denitrification processes permanently remove reactive nitrate from the groundwater system by converting it to gaseous forms of N (mainly benign N_2) (Close and Stenger, 2012).

Nitrate-N attenuation assessments of the Ruataniwha aquifer system have been conducted by Close and Stenger, (2012). Their assessment concluded that attenuation ranges from zero to 100 % but is dependent on the geology and spatial differences of hydrology in the catchment. Close and Stenger, (2012) also concluded there is substantial nitrate-N attenuation capacity in the deeper groundwater system in the Tukituki river groundwater sub-catchment, but there is little indication of attenuation capacity in the Waipawa river groundwater sub-catchment (Figure 1.4).

Water age tracer analysis has been reported by GNS Science (Morgenstern *et al*., 2012). The tracer analysis indicates that most groundwater has a mean residence time greater than 25 years, with a relationship between age and depth. The average age of shallow groundwater is approximately 39 years and the age of the deep groundwater is in the order of 130 years. Exceptions to this are eastern areas of the basin which are influenced by groundwater upwelling from depth that occurs prior to where the main rivers (Tukituki and Waipawa) exit the basin; and in the south and upper areas of the basin where groundwater is relatively older at shallow depths. Groundwater is very young (<2 years old) where there is strong interaction between groundwater and surface water close to these two major river networks on the Ruataniwha plains.

3) Groundwater Quality Data and Statistical Methods

There are currently 14 State of Environment (SoE) groundwater quality monitoring bore sites in the Ruataniwha aquifer system (Figure 1.1) which are sampled on a quarterly frequency. Five of the monitoring bore sites are located in deeper parts of the aquifer system, between 36 to 129 m in depth. The remaining nine sites are located at shallower depths from 8.7 m to 26.1 m (Table 1.1). Five of these nine sites were established in 2014 and 2015 as part of the PC6 implementation programme, for monitoring policy effectiveness.

The assessment of nitrate-N state in the Ruataniwha aquifer system is based on available data reported up to December 2015 for the 2014-2015 SoE reporting period.

For the current state analysis most existing monitoring bore sites were sampled on 7 or 8 quarterly occasions during the 2014 to 2015 data period, apart from the new sites which were sampled for 4 to 6 quarterly periods. Summary statistical analysis was conducted using the GNS Science automated calculator program (Daughney, 2010). Monitoring results that had an ion balance >5 % were excluded from the analysis as part of standard quality assurance procedures.

Table 1.1 Depth of State of Environment Groundwater Quality Monitoring Bores

Bore Number	Depth (metres BGL)	Aquifer Depth
4781	8.7	Shallow
2979	12.0	Shallow
16247	14.0	Shallow
16249	14.3	Shallow
1944	17.0	Shallow
16251	21.5	Shallow
1558	22.5	Shallow
1376	25.2	Shallow
16095	26.1	Shallow
6719	36.0	Deep
2749	49.0	Deep
1518	55.2	Deep
2219	94.5	Deep
4593	129.0	Deep

Trend information is documented in the groundwater quality state and trends report (Gordon, 2016). Most sites in the State of Environment Programme prior to the PC6 implementation programme have quarterly time series data from 1999 to 2013.

4) Current State of Nitrate-N: 2014-2015

Nitrate-N concentrations have been assessed based on the 95th percentile of the available data time series, which is the conservative approach specified in the DWSNZ (2008). Summary statistics for all sites are presented in Appendix 1 including average nitrate-N concentrations for the two year period.

64% of the sites in the Ruataniwha aquifer system area have nitrate-N concentrations less than ½ of the MAV (i.e.,<5.65 mg/L) and 36% of sites have nitrate-N concentrations between ½ MAV(5.65 mg/L) and the MAV of 11.3 mg/L (Table 1.2). No sites were found to have nitrate-N concentrations greater than the MAV. However, 44% of shallow monitoring bores sites have nitrate-N concentrations greater than ½ of the MAV (5.65 mg/L). Only one of the deep monitoring bores sites (bore No. 2749) has nitrate-N concentrations > ½ (5.65 mg/L) of the MAV.

Table 1.2 Nitrate-N concentrations in the Ruataniwha aquifer system relative to ½ of the MAV(5.65 mg/L) and MAV(11.3 mg/L) from the DWSNZ 2008.

Bore No.	Depth	Aquifer Depth	95th Percentile	<50 % MAV (5.65 mg/L) Nitrate-N	>50 % MAV (5.65 & <11.3 mg/L Nitrate-N	>Nitrate N MAV (11.3 mg/L)
4781	8.7	Shallow	5.970	**No**	**Yes**	**No**
2979	12.0	Shallow	1.225	**Yes**	**No**	**No**
16247	14.0	Shallow	6.340	**No**	**Yes**	**No**
16249	14.3	Shallow	6.485	**No**	**Yes**	**No**
1944	17.0	Shallow	0.106	**Yes**	**No**	**No**
16251	21.5	Shallow	0.008	**Yes**	**No**	**No**
1558	22.5	Shallow	4.370	**Yes**	**No**	**No**
1376	25.2	Shallow	<0.002	**Yes**	**No**	**No**
16095	26.1	Shallow	7.200	**No**	**Yes**	**No**
6719	36.0	Deep	0.004	**Yes**	**No**	**No**
2749	49.0	Deep	6.130	**No**	**Yes**	**No**
1518	55.2	Deep	1.062	**Yes**	**No**	**No**
2219	94.5	Deep	1.394	**Yes**	**No**	**No**
4593	129.0	Deep	0.003	**Yes**	**No**	**No**
% of Sites				**64%**	**36%**	**0**

5) Five Year State Assessment of Nitrate-N: 2019 to 2013

PC6 policy for Tukituki catchment refers to an environmental indicator of 5.65 mg/L (½ of the MAV) base on the annual average concentration of nitrate-nitrogen from monitoring data collected over a period of 5 consecutive years. A five year state assessment has been reported in the Groundwater Quality State of Environment Report (Gordon, 2016) for 8 monitoring bore sites between 1999 and 2014 (Table 1.3). The location of sites used in the five year reporting are shown in figure 1.3.

All sites in the five year assessment have average nitrate-N concentrations less than the PC6 environmental indicator of 5.65 mg/L. However one site, 2749 has a nitrate-N concentration of 5.19 mg/L which is approaching the environmental indicator (5.65 mg/L).

Table 1.3 Average nitrate-N concentrations for sites in the Ruataniwha aquifer system for the 5 year period (2009 to 2013) relative to PC6 environmental indicator of 5.65 mg/L nitrate-N.

Bore No.	Depth	Aquifer Depth	Average	Average <50 % MAV (5.65 mg/L) Nitrate-N
1376	25.2	Shallow	0.002	Yes
1558	22.5	Shallow	4.362	Yes
1944	17.0	Shallow	0.076	Yes
2979	12.0	Shallow	1.067	Yes
1485	66.4	Deep	0.574	Yes
1518	55.2	Deep	0.965	Yes
2749	49.0	Deep	5.194	Yes
6719	36.0	Deep	0.009	Yes
% of Sites				100%

6) Long Term Trends in Nitrate-N:1999 to 2014

Trend analysis has been reported in the Groundwater Quality State of Environment Report (Gordon, 2016) for 8 monitoring bore sites between 1999 and 2014 (Table 1.3). The location of sites used for trend analysis are shown in figure 1.3. The trend analysis used was the non-parametric Mann Kendall, where a rate of change greater than 1% per annum identifies a trend. A full description of the methods is reported by Gordon (2016).

Increasing trends of nitrate-N were observed at 75% of the monitoring bores screened in deeper parts of the aquifer system, whereas none of the shallow sites had any meaningful trends (Table 1.4).

Table 1.4 Sate of Environment monitoring bore sites with reported trends and water age data in the Ruataniwha aquifer system.

Bore No.	Depth m	Aquifer Depth	Median	95th Percentile	Meaningful trend	Water Age MRT (years)
2979	12.0	Shallow	0.74	2.00	No trend	N/A
1944	17.0	Shallow	0.03	0.11	No trend	57
1558	22.5	Shallow	4.60	5.27	No trend	34.5
1376	25.2	Shallow	0.00	0.04	No trend	>210
6719	36.0	Deep	0.01	0.03	No trend	149
2749	49.0	Deep	4.13	4.88	Increasing	N/A
1518	55.2	Deep	0.83	1.10	Increasing	80
1485	66.4	Deep	0.24	0.73	Increasing	N/A

N/A = No water age available, MRT Mean residence time after Morgenstern *et al.,* 2012.

Monitoring bore 1376 is a shallow bore (25.2m in depth) and located in the eastern plains where there is upwelling or upward flow of old groundwater. The nitrate-N concentrations in bore 1376 are typically low and there is no trend in nitrate-N concentrations. This is a consequence of long residence time in the aquifer, which means that groundwater recharge may have occurred prior to landuse development and intensification of the Ruataniwha Plains catchment.

Monitoring bores 1558 and 1944 are considered shallower bores and have a younger mean water age (35 to 57 years). However monitoring bore 1558 is shallower than 1944, and also has a younger groundwater age than 1944 and is also located in the Waipawa river groundwater sub catchment which is has a reported lower nitrate-N attenuation capacity. This may explain the higher nitrate-N concentrations found in bore 1588, which are most likely to be related to landuse intensification during the last 35 years.

Three of the “deep” monitoring bores (2749, 1518 and 1485) have increasing trends in nitrate-N, albeit sites 1518 and 1485 have low nitrate concentrations that are currently less than ½ of the MAV. All three sites are located in the midpoint of the basin close to SH50 (Figure 1.3). Monitoring bores 1518 and 1485 are located in the Waipawa river groundwater sub-catchment zone(Figure 1.4) whereas monitoring bore 2749 is located in the Tukituki groundwater sub-catchment zone, which is likely to have a greater nitrate-N attenuation potential. However monitoring bore 2749 has nitrate-N approaching ½ of the MAV (5.65 mg/L) and it is unclear why this bore has elevated nitrate-N. A possible hypothesis is that monitoring bore 2749 may be influenced by a local recharge source, or landuse activities in the recharge capture zone for this bore. Water tracer information is not available to confirm water age and recharge source for this site.

7) Summary and Conclusions

The latest results from the 2014-2015 SoE monitoring programme show that 64% of the sites in the Ruataniwha aquifer system area have nitrate-N concentrations less than ½ of the MAV (i.e. <5.65 mg/L) and 36% of sites have nitrate-N concentrations between ½ MAV and the MAV of 11.3 mg/L. No sites were found to have nitrate-N concentrations greater than the MAV. However 44 % of shallow monitoring bores sites in the SoE programme have nitrate-N concentrations greater than ½ of the MAV. Only one of the deep monitoring bore sites (bore No., 2749) has nitrate-N greater than ½ of the MAV. This assessment is based on the more conservative approach of using the 95th percentile of the available data in the time series rather than the average of the time series. However this would suggest there are indications of emerging higher nitrate-N concentrations in shallower sections of the aquifer system as observed from new sites included in the monitoring programme.

PC6 policy for Tukituki catchment refers to an environmental indicator of 5.65 mg/L (½ of the MAV) based on the annual average concentration of nitrate-nitrogen over a period of 5 consecutive years. A five year “state” assessment for 8 monitoring bore sites between 1999 and 2014 indicated that the average nitrate-N concentrations in the aquifer system are <5.65 mg/L except for one site 2749 which has a nitrate-N concentration approaching the environmental indicator (5.65 mg/L). However five year (2009-2014) state assessment does not include new shallow monitoring bores that have been recently included in the groundwater monitoring programme.

Long term increasing trends of nitrate-N were observed in 37% of sites. These trends were observed only in deep monitoring bore sites, which generally have nitrate-N concentrations less than ½ of the MAV. The increasing trends in the deeper sites are likely to be related to the longer residence time in the aquifer system at depth. Old groundwater will carry nitrate-N concentrations of historical landuse change.

Trend analysis of shallower monitoring bores suggests that nitrate-N concentrations in shallow groundwater are unlikely to change unless further land use change occurs. Nitrate-N concentrations in older, deep groundwater in the aquifer system were found to be much lower but have increasing trends. This would indicate that higher nitrate-N concentrations from shallower areas of the aquifer system are beginning to flow or recharge into deeper parts of the aquifer system.

The difference in the average water age between shallow and deeper groundwater is on average 90 years, which suggests that the higher nitrate-N concentrations currently observed in shallow groundwater might manifest in the deeper groundwater in the next 50 years, depending on the nitrate-N attenuation capacity. Assessments of nitrate-N attenuation have concluded there is substantial attenuation of nitrate-N within the deeper groundwater in the Tukituki sub-catchment zone, whereas there is very little evidence of nitrate-N attenuation in the Waipawa groundwater sub-catchment zone. This would suggest that increasing trends in nitrate-N in deeper groundwater are likely to be more prevalent in the Waipawa groundwater sub-catchment compared to the Tukituki groundwater sub-catchment.

8) Future Work

a. *Additional State of Environment Sites*
A further 20 sites have been established and data collection from these new sites in 2017 will improve the spatial understanding of the state and trends in shallow sections of the aquifer system.

b. *Shallow Groundwater Quality Survey*
A shallow synoptic survey of groundwater quality for the region is currently underway and is due to be reported in June 2017. This will provide an additional spatial understanding of nitrate concentrations in shallow groundwater.

c. *Papanui Catchment*
Groundwater quality investigations are currently being undertaken to explore the state of groundwater quality in the Papanui catchment and are due to be reported in May 2017. This work will improve understanding of nitrate-N concentrations in this catchment.

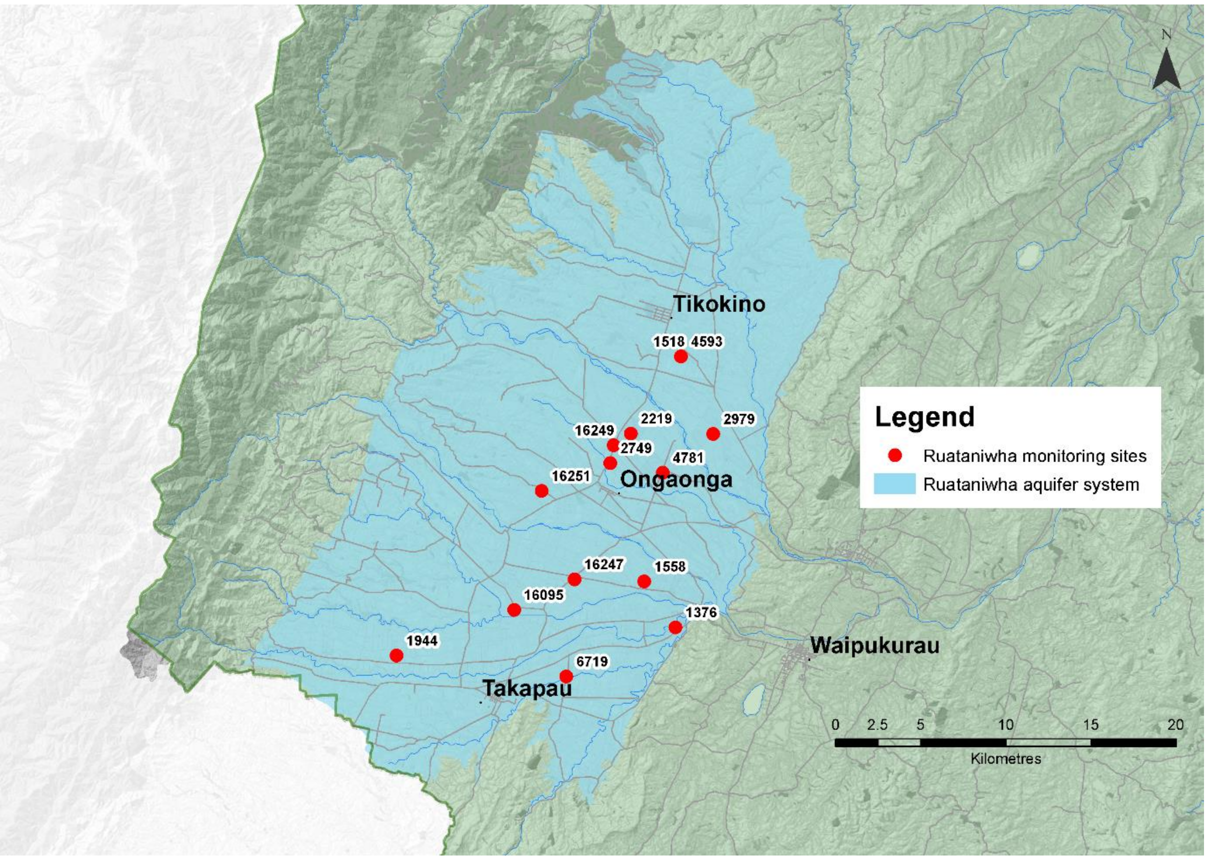

Figure 1.1 Current (2015) groundwater quality State of Environment monitoring bore sites in the Ruataniwha aquifer system.

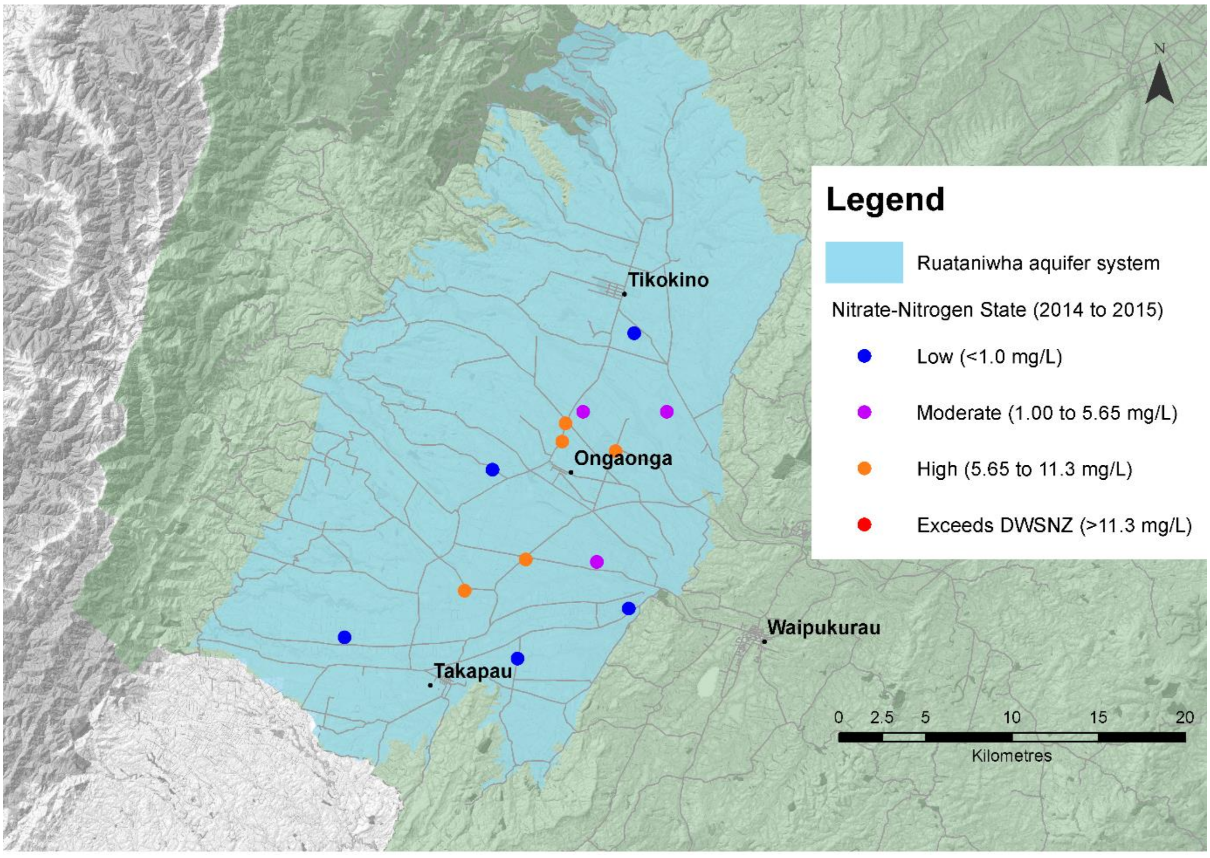

Figure 1.2 State of nitrate-nitrogen (NO_3-N) concentrations at groundwater quality sites in the Ruataniwha aquifer system 2014-2015 using the 95th percentile of the dataset.

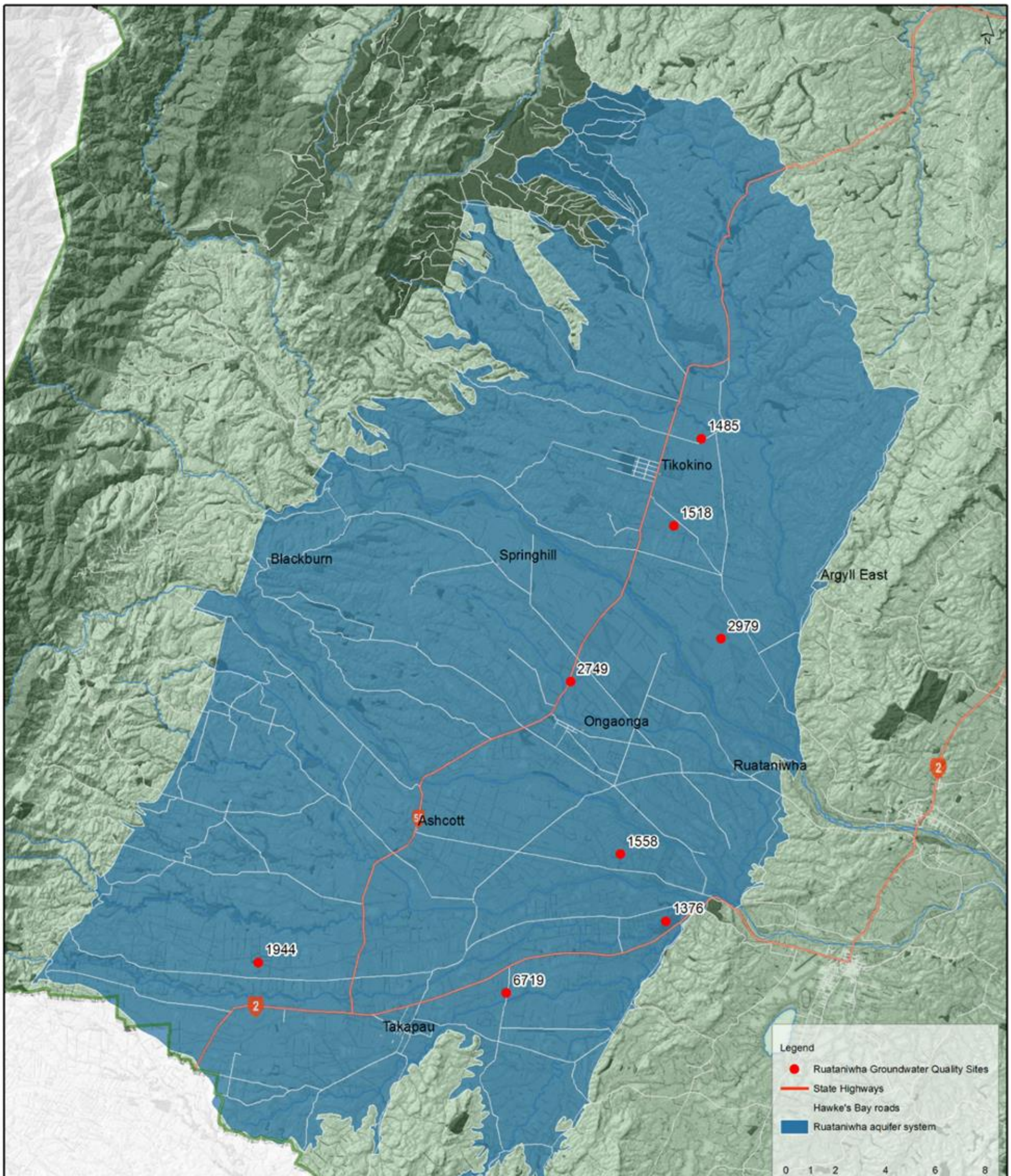

Figure 1.3. Location of groundwater quality monitoring sites in the Ruataniwha aquifer system used for five year state(2009 to 2014) and longer term trend (1999 to 2014) reporting.

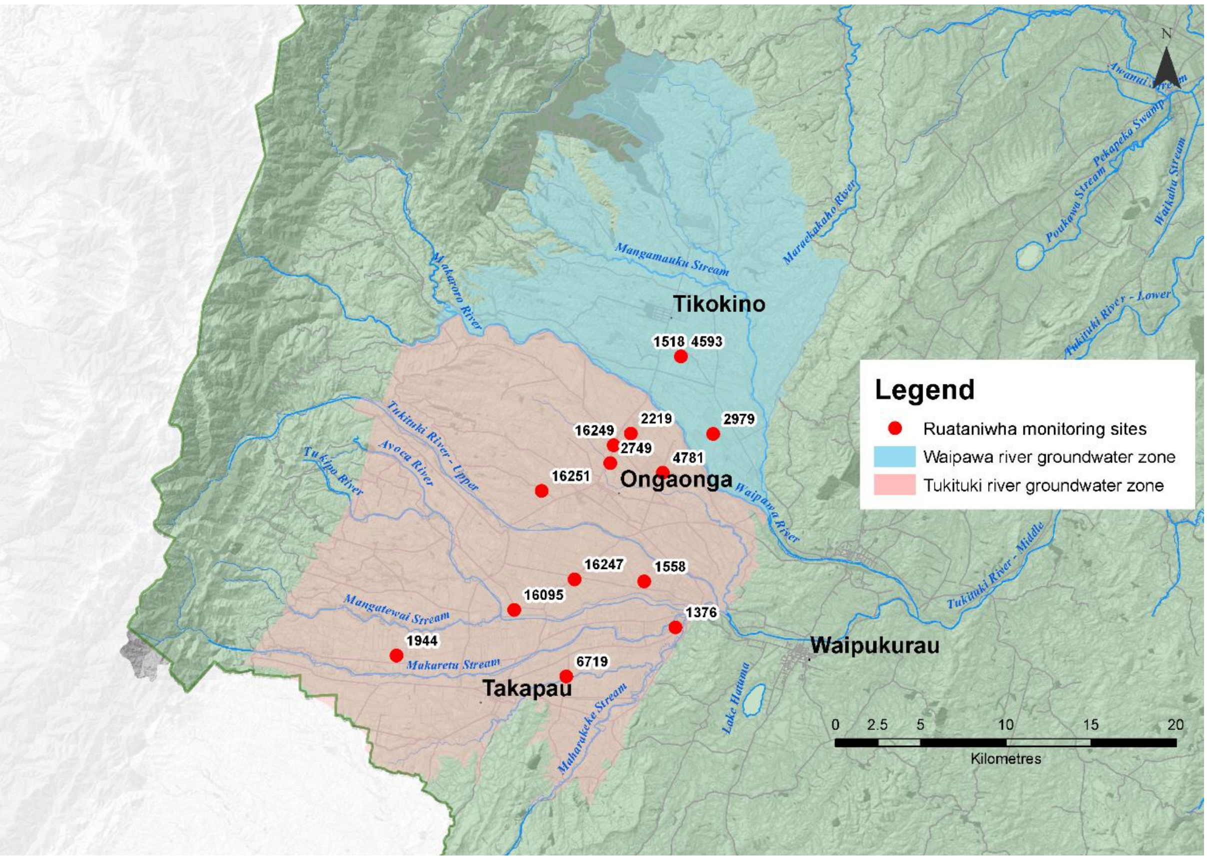

Figure 1.4. Location of groundwater quality monitoring sites and Waipawa and Tukituki groundwater sub-catchment zones.

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Appendix 1 Summary Statistics Nitrate-N for Monitoring bores in the Ruataniwha basin: 2014-2015.

Bore No.	Depth	Total Samples Current Site	# Results Used, Current Analyte/Site	Min	5^{th} Percentile	25^{th} Percentile	Median	75^{th} Percentile	95^{th} Percentile	Max	Average	Median Absolute Deviation (MAD)	Standard Deviation (SD)
1376	25.2	7	5	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	ND	ND
1518	55.2	8	5	0.880	0.894	0.950	1.010	1.030	1.062	1.070	0.988	0.060	0.074
1558	22.5	8	7	4.000	4.030	4.150	4.200	4.300	4.370	4.400	4.214	0.100	0.135
1944	17.0	8	8	0.006	0.013	0.028	0.039	0.095	0.106	0.109	0.055	0.022	0.040
2219	94.5	8	7	1.110	1.125	1.225	1.290	1.360	1.394	1.400	1.281	0.090	0.109
2749	49.0	8	8	4.000	4.210	4.750	5.600	5.925	6.130	6.200	5.338	0.500	0.780
2979	12.0	8	8	0.270	0.281	0.360	0.630	0.995	1.225	1.340	0.694	0.345	0.404
4593	129.0	7	5	<0.002	0.000	0.001	0.001	0.002	0.003	0.003	0.001	0.001	0.001
4781	8.7	4	4	4.800	4.860	5.100	5.500	5.850	5.970	6.000	5.450	0.400	0.551
6719	36.0	7	5	<0.002	0.001	0.001	0.002	0.004	0.004	0.004	0.002	0.001	0.002
16095	26.1	6	6	2.500	2.525	2.775	3.600	5.700	7.200	7.500	4.350	1.050	2.074
16247	14.0	5	5	3.600	3.800	4.600	5.200	5.700	6.340	6.500	5.120	0.600	1.099
16249	14.3	5	4	6.100	6.115	6.175	6.300	6.425	6.485	6.500	6.300	0.150	0.183
16251	21.5	4	3	<0.002	0.008	0.008	0.008	0.008	0.008	0.008	0.008	ND	ND

Date: 12 April 2017

FINAL MEMORANDUM

FROM: Nathan Heath, Acting Manager – Land Management, HBRC

TO: James Palmer, Group Manager - Strategic Development, HBRC

SUBJECT: REVIEW OF THE RUATANIWHA WATER STORAGE SCHEME: ISSUE 13

The scope of this review of Issue 13

The scope of this review is to assist Council with addressing "Issue 13" of the "Review of the Ruataniwha Water Storage Scheme", as outlined at the Council meeting on 14 December 2016.

Issue 13 requests the following –

"Assessment of high level implications for HBRC resources and approach to implementing PC6 should RWSS not proceed, including for the management of Tranche 2 water."

The scope for this work acknowledges the following statement detailed in the paper presented to Council –

"Extensive analysis and forecasting of detailed PC6 implementation resource requirements will be undertaken in 2017 in preparation for the next Long Term Plan. It is only proposed to undertake a high level assessment for the purposes of this review, building on an earlier assessment undertaken for the 2015-2025 LTP."

This assessment has been carried out in collaboration with HBRC staff who have been intimately involved in the development and implementation of the Tukituki Plan Change 6 implementation program over the last two years and includes contributions from Dr Andy Hicks, Charlotte Drury, Jeff Cooke, Jeff Smith, Shane Lambert, Paul Barrett and Rob Waldron.

The team has been briefed on the purpose of the review, to assist Council's understanding of "*the costs and benefits of the scheme, as well as risks and opportunities with decision to proceed, abandon or shelve the scheme".* We have worked towards this end without prejudice or pre-determination.

Key Issues

In response to this question the team has identified 5 key issues where the decision to proceed, abandon or shelve the RWSS would have implications on both the PC6 implementation effort and wider on-ground programs and projects in the Tukituki catchment. These include -

1. Approximately 186 landholders have committed interest in the scheme. The responsibility for their Farm Environmental Management Plans (FEMPs), nutrient budgets, auditing and compliance checking would be with the RWSS. If the scheme

does not proceed the responsibility for this task will fall to the individual farmers, and the wider PC6 implementation process, resourcing and team.

2. A significant package of environmental enhancement works and the raising of the minimum flow in the old Waipawa river bed has been proposed for the Papanui sub-catchment. This area is a key priority sub-catchment for the implementation process and the works proposed would provide significant benefits to supporting the achievement of HBRC and community objectives in the catchment.
3. The wider organizational program and environmental benefits of the proposed predator control and environmental enhancement packages committed to by the scheme.
4. A group of less tangible costs and benefits relating to research, data management, public perception and management.
5. The management of Tranche 2 groundwater.

Each of these issues will be further elaborated in the following sections.

1. The impact of ~186 potential RWSS users on existing implementation workloads and costs

Approximately 186 landholders have indicated a desire by signing contracts to use scheme water. This group of landholders represent some of the most complex farm systems in the Tukituki catchment to understand nutrient losses for, and there are significant challenges associated with calculating the nutrient budgets for arable and mixed cropping systems[1], this is further complicated by irrigation. The skill sets required by plan providers for undertaking these nutrient budgets and farm plans nationally is in short supply. It would be in the scheme's own best interest to ensure they possessed this capability in-house or via contracted providers to ensure nutrient losses within their footprint area were well understood. Outside of this scenario the PC6 implementation response would need to rely on the skill sets of existing farm plan providers, most of whom do not have much experience with cropping or irrigation systems.

Further complicating this is that the form of FEMP required by the scheme from its users[2] is different to the FEMPs required to meet PC6 requirements as outlined in Schedule 22 of Plan Change 6. The primary differences being in an increased need for detail around water use and irrigation infrastructure and use. This means that most of those landholders who are considering being scheme users have been waiting to see whether the scheme progresses before undertaking their farm planning and are further contributing to the looming bottle neck of 900 FEMP's required for completion in the next 14 months. Because all land owners in the Tukituki catchment require a FEMP by 1 June 2018 to maintain their permitted activity status, if the scheme proceeds at a later date landholders may be required to complete two costly (at a range of $3000-$15,000 per plan[3]) farm plans over a relatively short period of time.

The additional cost and staff time associated with dealing with an additional 186 landholders has been considered in detail in Appendix 1. There is the potential for a range of consents to be required by landholders who would have otherwise come under the scheme's global consent. The most likely scenario outside of the scheme progressing is the exceedance of the 0.8 DIN limit in-stream requiring landholders to obtain a consent as a restricted discretionary activity. Given current in-stream concentrations this could potentially trigger an additional 125 consents by 31 May 2020. The cost of consents varies depending on the conditions the

[1] http://www.massey.ac.nz/~flrc/workshops/16/Manuscripts/Paper_Mathers_2016.pdf & http://www.massey.ac.nz/~flrc/workshops/13/Manuscripts/Paper_Williams_2013.pdf

[2] (http://www.hbrc.govt.nz/assets/Document-Library/RWSS-Documents/Farm-Plan-Template.pdf

[3] Based on actual costs of plans received by HBRC for the 2016-17 financial year.

consent is being asked for and could range between $1,350-5,000 per consent. This cost is recoverable to HBRC on an actual and reasonable basis.

The on-going monitoring and auditing of consents is the responsibility of the compliance team. Generally the cost of checking consent compliance is recoverable. The monitoring and auditing of permitted activity status is also required by all landholders who do not have a consent. It is assumed that all landholders who have signed up to the scheme and are not consented (estimated at ~ 65) would need to be assessed on their activity status by 2022 if the scheme does not proceed. This cost is not recoverable and will need to come out of the general rate. Typically compliance visits are charged at around $500 per landholder adding an additional $15,000-20,000 to general rates annually from 2018[4][5] .

Finally the additional staff required to both issue and monitor these additional consents and to carry out permitted activity checks would be approximately 2 FTE's from 2018 and increasing further to 3.5 in 2020 at a total cost of $77,225 from 2018-2020 and $148,362 annually from 2020 to the general rate[6].

2. The implications of the schemes proposed environmental enhancement works within the Papanui sub-catchment

The Papanui sub-catchment, surrounding the Otane Township has been identified as Zone M of the RWSS supply network. The scheme proposed to utilise the Old Waipawa River Bed and Papanui Stream as the primary distribution mechanisms for Zone M. This sub-catchment was identified as a Priority Catchment for the implementation of PC6. Currently Dissolved Reactive Phosphorus (DRP) concentrations within that sub-catchment are 10 times over target levels and would require a 90% reduction of existing DRP losses. HBRC's Land Management and Science teams have been working in the Papanui catchment in collaboration with the community for the last 2.5 years. A strategy has been developed by the sub-catchment steering committee and in the vicinity of $300,000 has been invested in the catchment to better understand the nutrient loss pathways and mitigations required to reduce DRP in-stream. The greatest influence on achieving PC6 freshwater objectives in the Papanui catchment itself is controlling the proliferation of macrophyte growth through fencing and planting riparian margins in the catchments' waterways. There is a yet unquantified but associated link between the excessive macrophyte growth within the catchments waterways and the dissolution of DRP from sediments in-stream during periods of anoxic conditions that is also contributing to in-stream DRP concentrations.

The "Zone M Primary Distribution Concept" report[7] outlines the proposal to utilise the Old Waipawa River Bed and Papanui stream to provide for the distribution of irrigation water. As part of the conditions for the RWSS as outlined in Schedule 6[8] the scheme has committed to the following in the Papanui catchment –

- 24km of fencing over 5 years @ $360,000 total cost

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[4] Data obtained in consultation with Wayne Wright, Manager-Resource Use
[5] Costs have been adjusted from the figure in the appendices to provide an annual amount
[6] Refer to Appendix 1 of this memo
[7] Rautaniwha Water Storage Scheme – Zone M Primary Distribution Concept http://www.hbrc.govt.nz/assets/Document-Library/RWSS-Final-RMA-Reports/Key-Reference-Reports/RWSS-K2-Zone-M-Headrace-Concept-EMS-May-2013a-Part-A.pdf)
[8] Ruataniwha Water Storage Scheme – Conditions , schedule 6, http://www.epa.govt.nz/Publications/Volume%203%20of%203%20(pt%202%20Conditions%20Schedule%205%20and%206)%20RWSS%20Conditions.pdf

- Riparian planting of 85,000 plants over 10 years @ a total cost of $595,000
- Wetland creation fund over 5 years @ $150,000 total cost
- The requirement for a constant 50 L/s supplementary flow down the entire length of the Papanui Stream[9]. This is on top of any flow conveyed down the Papanui Stream to be subsequently abstracted by RWSS clients for irrigation purposes.

This represents a total cost of $1,105,000 of investment into environmental mitigations and enhancements in the Papanui catchment. This investment represents a positive opportunity cost in that other mitigations to further reduce DRP instream can be invested in by landowners who would benefit from these works directly on-farm. One big difference to this proposal is in the fencing and planting of riparian areas. The stock exclusion rule within PC6 does not specify either, so at a minimum - a 1 wire electric fence, 1 metre from the river bank that excluded cattle would generally meet the requirements of the stock exclusion rule and have minimal impact on reducing macrophyte growth in-stream.

For much of summer the old Waipawa River suffers from extreme low flows. By raising the minimum flows in the Papanui significant ecological benefits could be realised through the provision of flow and habitat year round, which would otherwise not exist without the scheme

3. The wider organizational program and environmental benefits of the proposed predator control and environmental enhancement packages committed to by the scheme

The RWSS has committed to a $10 Million package of mitigations and offsets as part of their conditions as outlined in schedule 6[10]. A number of these mitigations and offsets contribute to existing programs within the wider HBRC program of activities and includes –

1. Project A. The replanting of a natural riparian buffer of vegetation around a large portion of the reservoir and the provision of facilities for recreation in the area.
2. Project B. The control of weeds and enhancement of riparian habitats, wetlands and indigenous vegetation within the upper reaches of the Makaroro and Waipawa rivers
3. Project C. A threatened species program of works involving predator control, ecological enhancements for bats and the trap and transfer of native fishes to enable access to habitat above the dam.
4. Project D. The protection and enhancement of spring fed streams within the Ruataniwha plains and support to HBRC's priority sub-catchment mitigation program.
5. Project E. The Old Waipawa River Bed and Papanui Stream Restoration project – discussed under point 2.
6. Project F. This includes a range of actions in collaboration with local marae to better understand and mitigate any impacts of the scheme on the cultural values of iwi in the lower Tukituki and estuary.

Table 1 below outlines the total costs proposed for the projects outlined above

Mitigation / offset project	Annual budget provision	Total expenditure
Project A	$241,900	$2,549,000
Project B	$95,000	$1,740,000

[9] Condition 7, consent no. WP120375T

[10] Ruataniwha Water Storage Scheme – Conditions, Schedule 6. http://www.epa.govt.nz/Publications/Volume%203%20of%203%20(pt%202%20Conditions%20Schedule%205%20and%206)%20RWSS%20Conditions.pdf

Project C	$101,500	$3,097,500
Project D	$50,000	$500,000
Project E	$236,500	$1,330,000
Project F	$85,000	$885,000
TOTAL BUDGET	**$809,900**	**$10,101,500**

Not all works proposed are current priorities of work programs in Council and it could potentially be considered that some may also not be necessary either without the scheme progressing. It is important to note however that most of what is proposed is directly targeted at achieving the freshwater objectives within PC6[11], versus the nutrient management oriented approach to rules, regulations, programs and projects for the majority of implementation priorities in the Tukituki, which is the point of the plan in the first place.

4. Other organisational implementation impacts as a result of the scheme progressing or not

There are a range of other positives and negatives associated with the scheme progressing, that do have an impact on the implementation effort that are less tangible and these are outlined below –

a) A lack of clarity of the intent of PC6 and confusion between the drivers and conditions of PC6 and the RWSS

There is a real confusion within the farming community of the Tukituki catchment of the purposes and intent of PC6. A number believe that the plan exists to accommodate the scheme and or that the drivers for on-farm mitigation are simply to reduce nitrogen to enable headroom for the scheme to exist. There is a degree of animosity to the scheme with some who aren't able to utilise the water; that they are being asked to do significantly more themselves because of it, and; the belief that those who receive water will get special compensations for doing so.

Much has been said throughout the EPA hearings process and in the media about the focus on a single nutrient (phosphorus oriented) approach. Since the original notification of PC6, this argument around the relative significance of P versus N has caused more confusion than any other factor.

Fundamentally to achieve the freshwater objectives in PC6 will require a multi-pronged approach, dealing with multiple contaminants, entering the waterways through multiple pathways, that varies across the landscape. It is this message that is critical to get across to land holders.

There is also significant confusion with landholders struggling to understand what applies specifically to them through the confusion associated with the range of different spatial boundaries, rules and conditions within PC6 & the RWSS Consent conditions.

Without the scheme progressing, communicating the purposes of PC6, and the actions needed to be taken by individual landholders and the perception of probity for all could be more clearly enhanced. It would also be a significant priority for HBRC to communicate the implications on landholders of the decision of the RWSS review widely, clearly and concisely to ensure there is no confusion of the decision potentially affecting the on-going implementation of PC6.

[11] As outlined in section 5.9.1 of PC6

b) The ability to adaptively manage uncertainty and change.

The scheme possesses a wider range of mechanisms within its control to adaptively manage changes to a multitude of socio-economic or biophysical drivers that PC6 does not.

For example using the scenario of the Papanui catchment, following on from the intensive catchment characterisation that has occurred in that catchment over the last 2 years, had that information been known when the plan was being put together it is likely that there would have been:

- a different approach, and;
- targeting with a greater emphasis on the fencing and planting of the catchments waterways, and;
- more specific targeting of farm practices within the rules themselves.

To re-emphasise on-ground actions or collectively influencing a change in land management practices to meet emerging future challenges would very likely require a plan change. This would take considerable time to do. This should be compared to the relative agility that the RWSS has through its provisions, with the ability to change as, when and where required.

c) Data management

A huge amount of data is being generated by each individual in the Tukituki catchment as a result of PC6. From FEMP's, nutrient budgets, consents, compliance checks, audits and spatial information. This has presented a number of challenges to the organisation and significant effort is currently being put in to develop data management systems to cope with this additional data. A significant benefit of the RWSS is that it represents a single "point source" of information for ~ 186 landholders that would otherwise need to be managed under HBRC's data management system.

The detail of data being collected by the scheme is also significantly greater than that being collected by HBRC. There is a requirement for the RWSS to also undertake in-stream monitoring at a range of sites in excess to the HBRC monitoring network and to do ongoing modelling to assist with understanding the effects of the scheme on the catchments[12] which, will add to the understanding of the dynamic interactions between land use and water quality.

d) The promotion of water use efficiency

It is in the scheme's best interests to promote water use efficiency and irrigation good management practice, which are not currently a significant priority within existing HBRC work programs. HBRC should be able to leverage off the promotion of irrigation efficiency by the scheme with landholders outside of the scheme footprint. This will have benefits for achieving minimum flows elsewhere in Hawkes Bay.

e) Monitor farms

The RWSS has proposed to put a detailed monitoring program into place on 5 properties using a paired site methodology[13]. These monitoring sites will be measuring a range of

[12] Schedule 3, conditions 6 & 7

[13] RWSS consent conditions: Schedule Three, condition 27.

biophysical parameters including – soil, climate, land use, management practices and soil water drainage. This will enable a comparison to be made of the impact of the scheme on other biophysical factors. This information will have significant additional value to the wider region as well.

f) Research projects and commercial interest

The RWSS has and will attract a variety of private and public interest in research. For example the "Maximising the value of irrigation" project[14] A 6 year, $6 Million project looking at the use of precision agriculture technology, irrigation design and biophysical factors to maximise irrigation efficiency and use, was originally attracted to Hawkes Bay on the premise of significant new irrigation being likely to occur.

The scale of the RWSS also means that businesses associated with irrigated agriculture and those who support the production of other primary sector goods will now find it more viable to operate in the region, which will boost the range of options and advice for those landholders outside of the scheme footprint area as well.

5. The management of Ruataniwha Basin Tranche 2 groundwater

The Tranche 2 concept in the PC6 rule framework allows for abstraction of up to 15 million m^3/year from 'deep' groundwater (wells screened > 50 m in depth) provided that the effects of the take are mitigated though augmentation of the Waipawa or Tukituki River. The concept is that the consent holder will calculate their effect, and replace this by discharging water to the river affected[15].

There are currently six applications for Tranche 2 water, totalling a volume of 24.593 million m^3/year. The largest volume sought is by HBRIC (10 million m^3/yr). Several other applications can be expected in the near future. The volume sought exceeds the allocation limit – some applicants are likely to miss out on all or some of the volume they have sought.

The volumes sought are made up of a volume for irrigation and a volume for the required augmentation. The augmentation volume varies between 21% and 41% of the total volume sought. Some 4.5 million m^3/yr of the total sought (24.593 M m^3/yr) is proposed to be taken from the deeper aquifer and released for augmentation.

The applications are relatively complex. The complexities include calculation of the effect of the take on streams and rivers, and in particular the timing and location of effects and subsequent release of water to streams and rivers (when, where, how much and how long). The effects are such that they can occur after abstraction has finished, and there can even be residual effects from season to season. Establishing the rate and method of augmentation has also proved challenging for applicants, particularly if the potential effect on other surface water users is taken into account (i.e. augmentation is required before you reach minimum flow conditions, or else other users' security of supply could be affected). The local effects of abstracting groundwater also have to be considered, and the volumes of abstraction proposed are such that large interference effects on neighbouring wells can be expected. Abstraction of an additional 15 million m^3/yr of water from the basin will have an impact on overall groundwater levels. The Board of Inquiry was cognisant of this and decided that the additional allocation was sustainable[16].

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[14] http://www.landcareresearch.co.nz/publications/newsletters/soil/issue-25/maximising-the-value-of-irrigation

[15] See Pol TT8 and Rule TT4(c) in PC6

[16] see 2014 EPA's final decision para's 565 -569

The key issue we see if the RWSS does not proceed is that augmentation will have to occur from groundwater, rather than stored water. This will mean that the 15 M m^3/yr available will not be able to be used in full for irrigation, and it is anticipated that ~40 % of the volume taken for irrigation will need to be taken to augment effects of the take (i.e. 6 million m^3/yr). This will reduce the potential economic benefits of the Tranche 2, and will mean that the available allocation will not spread to as many potential users as it might otherwise. Other inefficiencies include the need for establishment of multiple augmentation systems (wells, pumps, telemetry and associated operation and maintenance (including pumping from depth)). There may also be an environmental cost in that the augmentation offered by the RWSS would occur further up the catchment (and potentially to a wider range of streams) than can likely be achieved by consent holders abstracting water for irrigation and augmentation on the plains.

In terms of staff resourcing, while the applications are complex and time consuming, the costs are charged directly to the applicants and recovered on an actual and reasonable basis.

Conclusions

In summary, the RWSS could have predominantly a beneficial effect to the implementation effort in the Tukituki catchment if it went ahead. The range of mechanisms the scheme has to leverage compliance, and their ability to adapt with change are positives with regards to implementation. The scheme will also deal en-masse with approximately 186 landholders or 17% of the landholders in the Tukituki, who generally have more complex farming systems and require significantly more technical skill and attention to understand and design appropriate environmental management actions. This is a significant saving on staff time and resourcing for HBRC.

Appendix 1. Additional Consent numbers and Compliance Costs if the RWSS does not proceed

The purpose of this memo is to assess the number of additional regional council resource consents that are likely to be triggered if the RWSS does not proceed, and identify likely associated compliance monitoring activities.

Table 1 sets out a number of circumstances that might trigger the requirement for a resource consent on properties that would be administered under the global RWSS consent if the scheme proceeds. Indicative costs have also been provided that could be used to estimate the impact of the RWSS not proceeding.

One of the key triggers for a resource consent is non-compliance with condition (j) of permitted activity rule TT1. This means that any farm over 4ha which is contributing to an exceedence of the nitrate-nitrogen or DIN water quality limit at the downstream monitoring site nearest the property/farming enterprise after 31 May 2020 requires consent as a restricted discretionary activity. This is Scenario 1 in Table 1. Six sub-catchments (listed in Footnote 3) currently exceed the DIN limit of 0.8 mg/L and it is unlikely that existing water quality will be reduced below that limit by 2018, or even by 2020, due to a combination of the scale of reduced leaching required (about 40% on average across all farms in the catchment[1]) and the groundwater lag effect, therefore it is assumed that the 125 properties that have signed up to the RWSS, who have some land within the six sub-catchments that currently exceed the DIN limit will require resource consent. These consents will be complex to process because of the reduction of nitrogen losses required.

The figures provided in Table 1 are based on the assumption that only one 'Scenario' needs to be considered. A need to assess more than one Scenario is likely to mean that the consents process will be more costly than indicated in the table.

It is anticipated that the consent processes for farms that (under existing use) are already exceeding the LUC leaching rate by over 30% will be complex and costly. There is a higher chance that these decisions will be appealed as farmers may be required to modify existing farming operations, and put in place potentially costly mitigation measures. Costs associated with appeals are not recoverable and therefore will fall to the general rate.

Annual monitoring charges will also be levied against any consents granted. Annual compliance costs (charged to consent holders) will vary from between $100 to $500[2] for each consent (depending on whether or not a site visit is required) and in addition there will be annual section 36 charges (administration and annual charges) of around $100-$200 for each consent. Site visits are likely to be undertaken every 2 to 3 years.

Where consents will be required because particular actions (FEMPs, stock exclusion) have not been implemented, there will be a cost to Council associated with following up on that non-compliance. The need to actively assess compliance with Rule TT1 is a huge task, that is likely to require changes to the way that the compliance section charges their time, as currently time spent assessing compliance with permitted activity rules falls to the general rate, and is an activity that has not historically not had much staff time spent on it. Clearly the need to review how this task is carried out and funded, exists whether or not the RWSS proceeds. For the purposes of this exercise, it seems appropriate to assume that the 65 properties that have signed up to the RWSS and are not likely to

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[1] Based on memo of Dr Kit Rutherford dated 28th April 2014 (revised version), original dated 22 April 2014.

[2] This estimate is based on a 3 hour site visit, and 1 hours associated administration time, and compliance's hourly rate in the 2017/18 annual plan of $110/hr.

require a resource consent, would need to have their compliance with Rule TT1 checked. This would require a site visit to be undertaken, therefore a cost of $500/farm seems appropriate (being the cost it takes to undertake a site visit to assess compliance with the conditions of a resource consent). Based on the current charging structure, this would result in an additional cost of $32,500 falling to the general rate, if the RWSS does not proceed.

In summary, it is estimated that an additional 125 resource consents will need to be processed by HBRC if the RWSS does not proceed. Obviously, the worst case scenario is that all 186 properties that have signed up for RWSS water will require a resource consent from HBRC, but that seems unlikely. A total cost of approximately $32,500 that will be incurred checking compliance with Rule TT1 on those farms that have signed up to the RWSS, but do not require resource consent, and will fall to the general rate.

Table 1. **Estimated costs of additional consents required (All figures quoted are GST exclusive**)

Scenario No.	Scenario Description	Relevant date/due date	Maximum no. of consents required	Activity status	Notes	Estimated cost of processing consent	Total cost to farmers[3]
1	Nitrate-N or DIN concentrations in sub-catchment exceeded	31 May 2020	125[4]	Restricted discretionary	These are likely to be complex consents processes which will have to assess the effectiveness of N mitigation proposed as well as FEMPs, PMPs and nutrient budgets, with the need for external technical support. There is considered to be a high chance that these consents may need to be notified, and depending on monitoring results, could have very stringent consent conditions especially where LUC leaching limits are also exceeded.	$5000	$625,000
2	No FEMP prepared	31 May 2018	120	Restricted discretionary	There are over 1000 properties/enterprises in the Tukituki Catchment for which farm plans need to be completed. Just over 100 have been completed to date. There are 6 farm plan providers currently approved by HBRC to prepare plans. Each provider can complete about 50[5] FEMP's each year. Based on these figures, it is estimated that 400 farm plans (40% of those required) will be completed across the catchment by next year's deadline. It could be assumed that a similar percentage of properties that had signed up to the RWSS get farm plans completed by next year's deadline, although it is	$1350	$162,000

[3] Calculated by multiplying the maximum number of consents by estimated cost of processing each consent

[4] Figure based on number of properties who have signed up for RWSS water (at the time of writing) that included land located within one of the 6 sub-catchments (Mangaonuku, Kahahakuri, Tukipo, Porangahau, Maharakeke & Upper Tukituki Corridor) that the latest sampling data (the most recent samples were taken in mid-Dec 2016) indicates currently exceed the DIN limits/targets of the Tuki Plan.

[5] Based on discussion with farm plan providers

					noted that this is likely to be an optimistic figure because many property/enterprise owners signed up to the RWSS may not have approached a farm plan provider yet, because they had assumed that their farm plan would be organised by HBRIC, therefore may have to wait before work can commence; and also because nutrient budgets and farm plans for irrigated properties[6] and/or complex farming systems which are common on the flatter areas served by the scheme, are more complicated and time consuming.		
3	FEMP prepared but not implemented	31 May 2020	120[7]	Restricted discretionary		$1350	$162,000
4	Nitrogen leached from land exceeds LUC by less than 30%	31 May 2020	50[8]	Restricted discretionary	Activities of this nature are likely to require a site visit as part of the technical assessment, and will therefore be more expensive to process (refer to Table 3 below)	$2100	$105,000
5	Nitrogen leached from land exceeds LUC by more than 30%	31 May 2020	50[9]	Non-complying	These consent processes are likely to be more complex and involve more time during the technical assessment and reporting stages and there will possibly be a need for external expert input. These consents could potentially be notified also	$5000	$250,000

6 Many of the properties who had signed up for water from the RWSS currently hold irrigation consents.

7 Number based on 120 FEMPs being completed by 2018, but not being implemented

8 Dr Kit Rutherford's memo dated 24 April 2014 estimates that approximately 25% of the 1200 properties in the Tukituki Catchment currently exceed the leaching rate for the LUC class on which they are located. His evidence dated September 2013 states that N losses once the RWSS is fully developed are predicted to increase by around 50% in sub-catchments with a high proportion of irrigable land. On that basis it has been assumed that half (100) of the 200 properties that have signed up for RWSS water will exceed the leaching rate for the LUC class on which they are located, and 1/2 of those 100 properties will not exceed the LUC by 30%, and 1/2 will (which is detailed in next row on the table).

9 Based on an assumption that up to 1/2 of the 100 properties that are currently exceeding the leaching rate for LUC exceed it by more than 30%

6	Stock exclusion not completed (flat land)	31 May 2020	40[10]	Restricted discretionary		$1350	$54,000
7	Stock exclusion not done in priority P catchments	31 May 2020	30[11]	Restricted discretionary		$2100	$63,000
8	Permanent and intermittent rivers not bridged or culverted	31 May 2020	30[12]	Restricted discretionary		$1350	$40,500

10 Flood prone catchments such as the Porangahau and Papanui may also not be fenced (or at least fences initially constructed are subsequently destroyed by floods and not replaced). There are about 40 properties in these two catchments that have signed up to the RWSS.

11 This figure is an estimate based on approximately 25% of the 120 properties located within the five priority P catchments who have signed up for RWSS water not complying with this requirement

12 An estimated number. Likely to be issue with intermittent rivers rather than permanent streams, although infrequently used crossings over permanent streams may not be bridged or culverted either.

Implications for Consents and Compliance staffing levels

Consents Staff
Over the last 6 years the HBRC consents team has processed an average of 572 consents per year normally with a team of six consent officers. If in 2018 HBRC was to receive an additional 125 consent applications as a result of the RWSS not proceeding, at least 1.5 more consents officers would be required (based on each officer processing approximately 100 consents per year).

Consents officers are remunerated at about $69,500. Increasing staff numbers in the consents team will result in capital costs associated with the equipment required to undertake the job, such as office space, IT equipment and personal protective equipment (i.e. wet weather gear).

Consents staff aim to recover 60% of their time (i.e. it can be charged to a consent applicant for consent processing work). The balance is funded by the general rate.

This information is summarised in Table 2. The figures presented in Table 2 are based on an assessment undertaken by HBRC's Corporate Accountant. That assessment calculated additional costs associated with increased staffing levels each year until 2030 however (where relevant) only the cost in the first year is provided. The costs used in this analysis included salaries, ACC payments, Kiwisaver contributions, staff training costs and staff welfare costs as well as overhead costs.

Compliance Staff
One Compliance Officer can monitor approximately 90 farms per annum (based on a site visit being undertaken every 2-3 years). Therefore it is estimated that an additional 1.5 compliance staff will be required to monitor the additional 125 consents likely to be required if the RWSS does not proceed. However, as noted above, compliance with all conditions of Rule TT1 will also need to be assessed on those farms that may not require a resource consent (estimated to be 75 farms), which effectively means that additional staff will need to be employed to monitor all 200 farms that had signed up to the RWSS, if it does not proceed. This would require approximately 2 additional full time compliance officers.

Presently compliance staff aim to recover 70% of their time (i.e. it can be charged to a consent holder for compliance work undertaken relating to their consent). The balance is funded by the general rate.

Table 2. Impact of additional staff required on general rate

Position	No. required	Time period	Total cost (per annum)	Cost to general rate[13] (per annum)
Consents Officer	1.5	2020 onwards	$192,842	$77,137
Compliance Officer	2	2018 onwards	$237,418	$71,225[14]

[13] Based on 40% of consent officers time not being recovered through direct charging to applicants
[14] Based on 30% of compliance officers time not being recovered through direct charging to applicants

Basis of Table 1 consenting costs

Table A. Average cost[15] of 'simple' non-notified restricted discretionary consents process
The cost of consents for Scenario's 2, 3, 6 and 8 in Table 1 have been calculated on this basis.

Activity	Time (hrs)	Cost ($ per hr)	Total cost
Receipt of application	0.5	$90	$45
Reading application & FEMP	2.0	$140	$280
Work request preparation	0.5	$140	$70
Technical assessment	3.0	$140	$420
Assessment & Reporting	3.0	$140	$420
Review	0.5	$140	$70
Decision administration	0.5	$90	$45
TOTAL		$1350	

Table B. Average cost of more complex non-notified restricted discretionary consents process when FEMP has to be assessed
The cost of consents for Scenario's 4 and 7 in Table 1 have been calculated on this basis.

Activity	Time (hrs)	Cost ($ per hr)	Total cost
Receipt of application	0.5	$90	$45
Reading application & FEMP	2.0	$140	$280
Work request preparation	0.5	$140	$70
Technical assessment	8.0	$89.73	$717.84
Assessment & Reporting	6.0	$140	$840
Review	0.5	$140	$70
Decision administration	0.5	$90	$45
TOTAL			$2067.84[16]

Average cost of notified consents
The average cost of a notified consent (based on actual consent processing costs charged to applicants over the last 10 years) is $4,768. For the purposes of this exercise, this cost has been rounded up to $5,000. Actual processing costs may be higher due to council staffs' hourly rates continuing to increase in each annual plan, however it is noted that the cost of a notified consent process varies considerably based on the complexity of consents being processed.

15 All figures quoted are GST exclusive
16 This figure has been rounded up to $2100

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AQUALINC RESEARCH LIMITED

MEMORANDUM

TO: James Palmer (Group Manager Strategic Development, HBRC.

FROM: John Bright

DATE: 8 April 2017

SUBJECT: Review of the Ruataniwha Water Storage Scheme: Issue 14

Review scope

Assessment of the impact of irrigation security and resultant farm-gate production in the Tukituki catchment arising from the increased minimum flows in PC6 if the supplementary flows required under RWSS consents are not available.

Comment: This work has been undertaken previously and it is recommended that it be reviewed and updated. The work will have ongoing value given that in 2018 increases in minimum flows will occur without the scheme regardless of the outcome of this review.

Qualifications

I have thirty years' experience in the development, testing and use of computer models and associated climate, plant and soil data for simulating plant water use, irrigation and soil water movement for the purpose of estimating irrigation requirements and drainage to groundwater. This experience has been gained through a combination of theoretical and applied research conducted throughout New Zealand.

Over the past 15+ years I have lead strategic water studies projects in Canterbury, Southland, Marlborough, Tasman, and Wairarapa. Common to all of these projects are: the estimation of potential water needs of irrigated agriculture, industry and municipalities, the estimation of region or catchment water supply capacity, and the matching of water needs with water supply from both groundwater and surface waterways to determine water supply reliability and potential water storage capacity requirements.

Approach

I reviewed relevant reports and evidence presented to BOI. This included the following documents:

- Waldron, R. (2013). "Tukituki Catchment: Modelling the impacts of groundwater and surface water abstraction". Hawkes Bay Regional Council.
- Waldron, R and Baalousha, H (2013). "Ruataniwha Water Storage Scheme, Tukituki Catchment. Assessment of potential effects on groundwater and surface water resources". Hawkes Bay Regional Council.
- Cetin, L and Sands, M (2013). "Tukituki Catchment Model". Sinclair Knight Merz
- Waldron, R. (2013). Statement of Evidence submitted to the Tukituki Board of Inquiry, September 2013.
- Barrett, P. (2013). Statement of Evidence submitted to the Tukituki Board of Inquiry, September 2013.
- Conland, N., Sands, M., Jordan, P. (2013). Statement of Evidence submitted to the Tukituki Board of Inquiry, October 2013.
- Bright, J. (2013). Statement of Evidence submitted to the Tukituki Board of Inquiry, October 2013.
- Harris, S. (2013). Statement of Evidence submitted to the Tukituki Board of Inquiry, September 2013.
- Ford, S. (2013). Statement of Evidence submitted to the Tukituki Board of Inquiry, October 2013.
- Ford, S., Harris, S. (2013) Joint Statement of Evidence submitted to the Tukituki Board of Inquiry, October 2013.
- Harris et al (2009). Economic Modelling: A tool to assist evaluation of the Canterbury Management Strategy and Trial Scenario 1 Assessment. Report prepared by Harris Consulting, Aqualinc Research Ltd, Agribusiness Group and Butcher Partners for Environment Canterbury, November 2009.
- Baalousha, H. (2009). Ruataniwha Basin Transient Groundwater and Surface Water Flow Model.
- Golder's (2013) "Ruataniwha Water Storage Scheme: Full Goldsim Model Report" (May, 2013) but its content was not relevant to this review.

I also reviewed two more recent reports that include information on the effects of water supply security on farm financial performance. These are:

- Fenemor, A., Green, S., Dryden, G., Samarasinghe, O., Newsome, P., Price, R., Betts, H., Lilburne, L. (2015). "Crop production, profit, and nutrient losses in relation to irrigation water allocation and reliability – Waimea Plains, Tasman District.
- Bright J, 2015. "Irrigation Allocation Rate effects on Farm Performance Indicators: Waimakariri Zone". Ministry for Primary Industries, C15035/1. Aqualinc Research Limited.

The content of each of these reports and statements of evidence was assessed and conclusions drawn regarding water supply security and farm gate production effects of PC6 on existing irrigated properties.

Water supply security, water supply reliability and farm-gate production

PC6's water allocation rules affect agricultural production by limiting the amount of water available for irrigation. At times the amount available is less than required to prevent crops and pasture from incurring yield-reducing soil moisture stress.

PC6 limits the flow rate made available for taking from rivers by setting a so-called "minimum flow" (better thought of as the cease-take-flow) and an allocation limit for the Tukituki River and its tributaries.

The effect of these management parameters (cease take flow and allocation limit) is to:

- Prevent water users from taking water if river flow at the relevant flow monitoring point is not greater than the cease take flow.
- Allow water users to take at their maximum consented rate if river flow is greater than or equal to the sum of the cease take flow and the allocation limit.
- Reduce water takes, relative to the maximum consented rate, if the flow is greater than the minimum flow but less than the sum of the cease take flow and the allocation limit.

The allowable rate of water take from a river therefore varies throughout the year as a consequence of time-varying river flow and the application of the PC6 water allocation rules.

This approach to water allocation management is the norm in New Zealand.

Three key questions are relevant to any assessment of the effects of water allocation rules:

1. To what extent can water actually be taken, relative to the maximum consented rate or volume?
2. To what extent can water actually be taken, relative to irrigation demand?
3. What is the production loss due to not fully meeting irrigation demand?

The answer to the first question is often referred to as water supply security. Waldron (2013), Cetin and Sands (2013) and Ford (2013) derive measures of security of supply

The answer to the second question is referred to as supply reliability. It is greater than the security of supply because irrigation demand is less than the maximum consented rate of take for much of the irrigation season. Harris (2013) and Bright (2013) derive measures of supply reliability

Production loss, the third question, is a function of the extent to which irrigation demand can be met. It is more strongly related to supply reliability than water supply security because the latter is affected by water supply restrictions that can occur when there is no, or very little, irrigation demand.

The magnitude of farm-gate production loss depends on the magnitude, duration, frequency and timing of water supply restrictions.

Production impact analyses typically apply one of the following approaches:

4. Define and apply a measure of what is an acceptable water supply restriction, such as 'no more than 10 consecutive days without water, no more than once per year'. The measure avoids directly quantifying production loss and defining an acceptable level of production loss for each type of farm enterprise. It is a surrogate for production loss.
5. Calculate the long-term average of annual water take relative to annual irrigation demand. This is often termed the average supply reliability. A rule of thumb that relates average annual production to average supply reliability is then applied to estimate the production

effects of the cease take flow and the water allocation limit. A simplification of this is to base it on water supply security, rather than supply reliability.

6. Simulate daily plant growth and crop yield with and without irrigation restrictions, for as many years as daily climate and river flow data allow. This is the most rigorous approach but was not readily available at the time of the PC6 Hearings. It is becoming more common, for example Fenemor et al (2015) and Bright (2015).

Harris (2013) and Ford (2013) applied method 5 to estimate production losses for the BOI.

Assessments of PC6 water allocation rules on water supply security in the Tukituki Catchment.

Water supply security in a water management zone is assessed by applying the PC6 water allocation rules for the zone to the natural flow record for the zone's flow monitoring site(s).

The effect of POL TT7 is to make surface water takes in the Waipawa Zone and the Middle-upper Tukituki Zone subject to two minimum flows. For the Waipawa Zone they are the Waipawa River at RDS and the Tukituki River at Red Bridge. For the Middle-upper Tukituki Zone they are the Tukituki River at Tapairu Rd and the Tukituki River at Red Bridge.

On any day, the more restrictive of the two sites applies. This is referred to as the Operative level of restriction in the tables below.

The natural flow record is simply the flow that would have occurred if there were no water takes from rivers and hydraulically connected groundwater up-gradient from the flow monitoring site.

The key flow monitoring sites in the Ruataniwha Basin are downstream of most surface water and groundwater takes. A naturalised flow record must therefore be calculated by adding to the recorded mean-daily river flow: the surface water takes; the direct stream depletion component of groundwater taken in close proximity to rivers; and the indirect stream depletion component of all groundwater takes.

Modelling has been relied upon to determine each of the 'add-back' quantities. In each case the method applied is consistent with standard practice. However Cetin and Sands (2013) and Bright (2013) have questioned the accuracy of key inputs to Waldron's (2013) estimates of direct and indirect effects on stream flow of groundwater takes (see Appendix 1).

Correcting these inputs to update the hydrology may have a significant effect on the calculated security of supply. However this requires changes to Baalousha's (2009) model, repeating the flow naturalisation process and then updating the security of supply analysis. This work is well beyond the scope of this review and update.

Notwithstanding the limitations in the naturalised river flow time-series, all parties to the BOI used them as the basis for their assessments of water supply security, water supply reliability or agricultural production impacts. However Cetin and Sands (2013) analyses differ from Waldron's (2013) in that they considered all groundwater takes assessed as being stream-depleting and not just those labelled as such in the HBRC consents database. They thus corrected for one of the inaccuracies described in Appendix 1.

I therefore rely on Cetin and Sands (2013) for the results presented below, taken from that source and Ford (2013b).

The following tables summarise the effects of PC6 on water supply security. In brief these are:

- From 2023 all surface water takes end up with the same security of supply, all being controlled by the flow in the Tukituki River at Red Bridge. The expected frequency of severe restriction events is 6 in 10 years.
- From 2018 to 2023, security of supply for surface water takes in the Waipawa zone reduce from 0.75 severe restriction events in 10 years to 3 in 10 years. Security of supply for surface water takes in the Upper-middle Tukituki zone improve from 5.25 severe restriction events in 10 years to 3.75 in 10 years. This is still significantly more frequent than the policy objective of no more than 1 event in 10 years on average.

The greatest degree of change is to water takes in Zone 1 – from having experienced no restrictions prior to PC6 to having severe restriction events 6 in 10 years from 2023 onwards.

Effect of PC6 on Water Supply Security for Zone 1: Lower Tukituki

Table 1

	Current	**From 2018 to 2023**	**From 2023 Onwards**
Severity			
Average # of restrictions per year	0	5	16
Maximum # of restrictions per year	0	73	122
Frequency			
Number of years when restriction events occur	0/40	7/40	19/40
Proportion of years when restrictions occur	0%	18%	48%
Duration			
Average number of consecutive days	0	14	20
Maximum number of consecutive days	0	34	56
Frequency of > 10 consecutive days of restriction	0	8 in 40 (2 in 10 yrs)	24 in 40 (6 in 10 yrs)

Effect of PC6 on Water Supply Security for Zone 2, Waipawa

Table 2a: 2018 - 2023

	Current			**PC6 from 2018 - 2023**		
	Restrictions based on Waipawa at RDS	Restrictions based on Tukitiki at Red Bridge	**Operative level of restriction for Zone 2**	Restrictions based on Waipawa at RDS	Restrictions based on Tukitiki at Red Bridge	**Operative level of restriction for Zone 2**
Severity						
Average # of restrictions per year	2	Not applicable	**2**	7	5	**7**
Maximum # of restrictions per year	46	Not applicable	**46**	98	73	**98**
Frequency						
Number of years when restriction events occur	3/40	Not applicable	**3/40**	11/40	7/40	**11/40**
Proportion of years when restrictions occur	8%	Not applicable	**8%**	28%	18%	**28%**
Duration						
Average number of consecutive days	9	Not applicable	**9**	14	14	**14**
Maximum number of consecutive days	13	Not applicable	**13**	36	34	**36**
Frequency of > 10 consecutive days of restriction	3 in 40		**3 in 40** **(0.75 in 10 yrs)**	12 in 40	8 in 40	**12 in 40** **(3 in 10 yrs)**

Table 2b: 2023 onwards

	Current			PC6 from 2018 to 2023		
	Restrictions based on Waipawa at RDS	Restrictions based on Tukitiki at Red Bridge	**Operative level of restriction for Zone 2**	Restrictions based on Waipawa at RDS	Restrictions based on Tukitiki at Red Bridge	**Operative level of restriction for Zone 2**
Severity						
Average # of restrictions per year	2	Not applicable	**2**	7	16	**16**
Maximum # of restrictions per year	46	Not applicable	**46**	98	122	**122**
Frequency						
Number of years when restriction events occur	3/40	Not applicable	**3/40**	11/40	19	**19**
Proportion of years when restrictions occur	8%	Not applicable	**8%**	28%	48%	**48%**
Duration						
Average number of consecutive days	9	Not applicable	**9**	14	20	**20**
Maximum number of consecutive days	13	Not applicable	**13**	36	56	**56**
Frequency of > 10 consecutive days of restriction	3 in 40		**3 in 40** **(0.75 in 10yrs)**	12 in 40	24 in 40	**24 in 40** **(6 in 10 yrs)**

Effect of PC6 on Water Supply Security for Zone 3, Middle-upper Tukituki

Table 3a: 2018 - 2023

	Current			**PC6 from 2018 to 2023**		
	Restriction based on Tukituki at Taiparu	Restrictions based on Tukitiki at Red Bridge	**Operative level of restriction for Zone 1**	Restriction based on Tukituki at Taiparu	Restrictions based on Tukitiki at Red Bridge	**Operative level of restriction for Zone 1**
Severity						
Average # of restrictions per year	14	Not applicable	**14**	12	5	**12**
Maximum # of restrictions per year	106	Not applicable	**106**	116	73	**116**
Frequency						
Number of years when restriction events occur	22/40	Not applicable	**22/40**	17/40	7/40	**17/40**
Proportion of years when restrictions occur	55%	Not applicable	**55%**	43%	18%	**43%**
Duration						
Average number of consecutive days	13	Not applicable	**13**	15	14	**15**
Maximum number of consecutive days	54	Not applicable	**54**	54	34	**54**
Frequency of > 10 consecutive days of restriction	21 in 40		**21 in 40** **(5.25 in 10 yrs)**	15 in 40	8 in 40	**15 in 40** **(3.75 in 10 yrs)**

Table 3b: 2023 onwards

	Current			**PC6 from 2023 onwards**		
	Restriction based on Tukituki at Taiparu	Restrictions based on Tukitiki at Red Bridge	**Operative level of restriction for Zone 1**	Restriction based on Tukituki at Taiparu	Restrictions based on Tukitiki at Red Bridge	**Operative level of restriction for Zone 1**
Severity						
Average # of restrictions per year	14	Not applicable	**14**	12	16	**16**
Maximum # of restrictions per year	106	Not applicable	**106**	116	122	**122**
Frequency						
Number of years when restriction events occur	22/40	Not applicable	**22/40**	17/20	19/40	**19/40**
Proportion of years when restrictions occur	55%	Not applicable	**55%**	43%	48%	**48%**
Duration						
Average number of consecutive days	13	Not applicable	**13**	15	20	**20**
Maximum number of consecutive days	54	Not applicable	**54**	54	56	**56**
Frequency of > 10 consecutive days of restriction	21 in 40		**21 in 40** **(5.25 in 10 yrs)**	15 in 40	24 in 40	**24 in 40** **(6 in 10 yrs)**

The security of supply statistics presented to the BOI preclude direct comparison with security of supply data for Canterbury river-supplied irrigation schemes.

However, assuming an irrigation season length of 227 days (mid-September to end of April), the average annual security of supply from 2023 onwards is 93% (16 days of restriction per season).

Average supply reliability for the Ashburton, Selwyn, Waimakariri and Amuri areas is reported as being in the range 94% to 96% (Harris et al, 2009). Several irrigation schemes in these areas are now actively pursuing storage development projects to boost reliability above what was once considered to be an acceptable level.

Assessments of PC6 water allocation rules on farm-gate production in the Tukituki Catchment.

Harris (2013) and Ford (2013) both apply rules of thumb to convert changes in water supply security measures to loss of agricultural production. Ford (2013) includes a survey-based measure of loss of quality, as well as loss in quantity, in his estimate of impact of farm financial performance. This is the primary basis of his claim that the relationship between farm-gate production and security of supply is non-linear, and that Harris (2013) underestimates the negative impact of raising the cease take flows.

In the joint witness statement that followed their initial evidence, Ford and Harris (2013) present updated estimates of agricultural and economic production loss based on an agreed methodology and input data.

In summary, they report the economic impact as:

	Per hectare, Weighted Average Cash Farm Surplus ($/ha per annum)			
	Average		1 in 10 year event	
Current	$3,900		$2,400	
PC6 above Red Bridge	$3,000	~23% reduction	$1,200	50% reduction
PC6 Red Bridge to Black Bridge	$3,600	~8% reduction	$1,500	~37% reduction

	Average annual total on-farm outcomes (as Earnings Before Interest and Tax)	
Current	$3.3 million / year	
PC6 above Red Bridge	$2.1 million / year	
PC6 Red Bridge to Black Bridge	$0.6 million / year	
Total under PC6 after 10 years	$2.7 million / year	~18% reduction from current

Effects on existing irrigated properties if they do not switch to an RWSS water supply AND the supplementary minimum flows required under the RWSS consents are not available.

Waldron and Baalousha (2013) computer modelled the operation of the RWSS assuming no existing holders of consents to irrigate switched to an RWSS supply, and RWSS did not provide supplementary minimum flows in accordance with consent conditions.

This showed that the percentage of time that existing irrigators would be on restriction would increase:

- From 5% to 7.2% (an increase of 8 days) based on the flow in the Tukituki River at Red Bridge.
- From 5.8% to 8.6% (an increase of 10 days) based on the flow in the Waipawa River at RDS.

Ford (2013) has not provided sufficient information to account for the nonlinear relationship between security of supply and economic impact.

Therefore a simple linear extrapolation has been applied to estimate the cost of the above changes, based on a reduction in cash farm surplus of $56.25 / restriction day (900/16).

The effect of not providing supplementary minimum flows and the PC6 minimum flows beyond 2023 is conservatively estimated to be to reduce cash farm surplus from $3,900/ha per year to $2,550/ha per year. This is a reduction of about 35%.

Applying the same approach to total on-farm outcome results in a reduction in Earnings Before Interest and Tax from $3.3 million/year to $2.4 million/year. This is a reduction of about 27%.

Summary

PC6 results in all irrigation water takes in the Waipawa and Middle-upper Tukituki surface water allocation zones being subject to minimum flows set at the Tukituki River at Red Bridge monitoring site, as well as Waipawa at RDS or Tukituki at Taiparu Rd monitoring sites.

On any day, the most restrictive site applies. From 2023 the most restrictive site, on average, is the Tukituki River at Red Bridge. Thus all takes have the same security of supply statistics from 2023 onwards.

From 2023 all surface water takes will experience restrictions of more than 10 days duration about six times more frequently than the Plan objective of 1 event in 10 years, on average.

From 2023 the security of supply is about 93%, as an average annual value. This is slightly lower than that of run-of-river irrigation schemes on the Canterbury Plains, which generally lie in the range 94 – 96%.

The economic impact of PC6 from 2023 onwards is to reduce the weighted average Cash Farm Surplus by about 23% and the total on-farm economic output, expressed as Earnings Before Interest and Tax, by about 18%.

If existing irrigation consent holders do not switch to RWSS and RWSS is unable to supply supplementary minimum flows in accordance with its consent conditions, Cash Farm Surplus is conservatively estimated to reduce by about 35% compared to pre-PC6 levels, and Earnings Before Interest and Tax by about 27%.

John Bright

Appendix 1

Cetin and Sands (2013) note that the list of bores considered to have a direct stream depletion component was taken from HBRC's consents database. In their view it is likely to be incomplete and thus underestimate direct stream depletion. Correction of this reduced their estimates of water supply security.

The indirect stream depletion component is an output from Baalousha's (2009) transient groundwater-surface water flow model. The groundwater recharge inputs to this model are of questionable accuracy, particularly the drainage flow from irrigated land (Bright, 2013). Originally drainage from irrigated land was assumed to be the same as from un-irrigated land (Baalousha, 2009). It is understood that the flow naturalisation method used data from this model.

Baalousha (2013) subsequently estimated that about 6% of the irrigation applied ended up as drainage to groundwater, based on NIWA soil water balance modelling. Bright (2013) provided evidence that the drainage to groundwater is about 14% of the irrigation applied. The difference appears to be the lack of recognition of the extra drainage that occurs due to summer-time rainfall on irrigated land compared to rainfall on un-irrigated land. Waldron (2013) demonstrated that increasing recharge by 6% of the irrigation applied significantly increased low flows (i.e. flows of the order of the cease take flow) in the Waipawa catchment, but made little difference in the flow of the Tukituki River at Red Bridge.

Preliminary assessment undertaken by Golders as part of the GoldSim modelling indicated that increased drainage from irrigated lands increased modelled groundwater discharge to rivers and that this effect may significantly increase modelled river flows in the low-flow range.

More reliable modelling of groundwater recharge from rainfall and irrigation may have a significant effect on the naturalised river flow time series used to estimate water supply security. The direction of change is expected to be to increase the estimated water supply security.

Assessment of the production systems, techniques and technologies for dry land farming, without irrigation, in the Tuki Tuki Catchment.

31st March 2017

An investigation for HBRC by
Kikorangi Farm
B.J. Ridler.

Soils, climate, forages, animals and management all interact to create a production system. Efficient integration of such variable and complex resources requires knowledge of the constraints and an understanding of how the opportunities presented can best be implemented to improve both profit and the environment.

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Overview

The conception that more production is the main criterion for profitable farming overlooks a fundamental principle, diminishing returns. This will occur at some point in any biological system. Knowledge of diminishing returns allows an ability to assess the value of the next input on the basis of the marginal cost vs. marginal return (Appendix 7).
The common use of averages and benchmarks makes it impossible for any marginal analysis to occur. The consequence is an excessive resource use and an unnecessary cost to the overall system.
Farmers tend towards relying on cash to assess their business. This takes no account of the often large underlying costs of depreciation nor the need to establish systems that are flexible within the boundaries imposed by a unique mix of soils and seasonal differences.
Intensification requires capital and increases fixed costs. Such costs can destroy a business if poor seasons occur (Anderson 2017).

This investigation briefly examines the core resources available in the Tuki Tuki catchment area; climate, soils, plants and forages, animals and management. This is required in order to establish the most likely combinations of current dryland forage options to best suit each soil area. The study then uses a specific analytical procedure that enables many resources to be compared on an equal basis and creates an integration of resources, including stock policies, in the most efficient/"balanced" systems manner. By understanding the basic core resources, this process can be undertaken with confidence. The final production systems will be capable of implementation provided the performance criteria that have been developed during the process are understood. The emphasis on a systems approach is crucial to undertaking profitable changes in farm management.

The specific procedure used combines a full systems approach which allows many options to be calculated in an iterative manner (by way of a final Linear Programming routine) until the best mix of resources (quantity, quality, timing based on marginal cost vs. marginal return) can be found.
This mix can then be adjusted for individual components (yield, use, cost, return) or differing amounts (constraints) to provide an economic and GHG/ nitrate sensitivity analysis. This process also provides information on the performance criteria required, best combinations of plants, stock type and production profiles and can be adjusted to suit management preferences.

It is hoped this necessarily short (time and budget) study will profile constraints but illustrate the very real opportunities for efficient dryland farming to reduce risk, yet enhance farming outputs, in the wider Region.

Materials and Resources

To provide objective analysis, good data are essential.
In many industries such as engineering, the accuracy of the data and consistency of the application environment are consistent.
Agriculture is however prone to wide variations in feed production. Plants (and to a lesser extent, animals) react in varying ways to temperature and moisture levels and although the soils may seem consistent, their plant available properties vary as climate and rainfall vary.
A brief literature overview of the main resources has been attempted. It cannot be exhaustive but lays the framework for identifying characteristics that become important when integrating combinations into balanced (and therefore more efficient) production systems.
The scientific data comes from reports and scientific papers.
These are considered alongside local farmer and consultant experience within the region.

Climate and Rainfall

Data and notes included in this section come mainly from HBRC reports with some local farmer's comments included.
To reduce document size reference to Report and page number has been used rather than the actual Figure.
The report from Kathleen Kozyniak 17th February 2014 "Climate overview for RWSS" is a major source of material.
(http://herbi.hbrc.govt.nz/site/airmngt/Climate/Ruataniwha Water Storage Scheme Irrigation Zones Climate Overview – 5th Assessment Update.docx).
This is supplemented from other sources.

Much of the area has rainfall of 800-1000mm with 1000-1200mm on its western fringes (page 4 Figure 1 of above report and reproduced Appendix 1 in this report).
Mean October to March rainfall (growing season) varies from 350-400 mm in the dryer Otane Zone M area, 400-450mm in the Tikokino to Onga Onga area and over 500 mm on the western fringes of the actual Ruataniwha basin area. (page 7 of report).
December to February rainfall varies from 200-300mm.

Future rainfall is not predicted to alter much except for dryer springs.
"Rainfall across the irrigation zones is projected to increase by no more than 1% by 2050 across all RCPs (Figure 2). By 2100, the level of increase from the base year remains less than 1% under RCP2.6 and RCP4.5 but reaches up to 1.5% and 2.5% for RCP6 and RCP8.5 respectively. " (Refer to Page 1 of report above).

This data is similar to that provided by Tonkin and Taylor in their pre-feasibility report (see Appendix 3 Prefeasibility Report)

But another report (Appendix 2) indicates long term trends will be for dryer conditions.
"The reductions in rainfall and river flow observed during the positive phase IPO demonstrate the potential for climate change to further decrease flows."

The rainfall itself seems, on average, to be well spread throughout the year with some increased winter falls (Appendix 4.)

The reality is that averages do not show what may be long periods of dry weather which may occur from the beginning of one month to the end of the subsequent month, nor yearly fluctuations.
Any study of dryland options must therefore allow for such variation and look for systems that best cope with such variations.

In terms of temperature extremes, the RWS area can have cold winters, late spring (October/November) and early Autumn (March) frosts.
(Zones A-D in the RWS rather than Zone M which includes the Otane area and is quite different due to being on the Eastern side of the Raukawa and

Turiri Ranges and contributes little to the Tuki Tuki catchment except through the often depleted Papanui Stream).
The Ruahine Mountains to the West have some snow falls in the winter which have an effect into spring. Locals often refer to “the fridge door left open” as cold air flows down into the basin through September and October. They comment on the likelihood of frosts into November and as early as February. One farmer who used to crop peas and other cash crops noted that peas suffered more from frost than dry conditions as they were harvested before most dry spells had any influence.
Another commented that cropping and pastures were more prone to temperature extremes than to dry spells. This farm was on the wetter soils of the Ruataniwha where cold air pools.

This is not a “dryland area” when compared to many areas of Canterbury but can suffer from frosts and colder temperatures well into late spring due to the confining features of the surrounding ranges.

Soils

A report on Nutrients to HBRC by Wheeler states;
"There is no high resolution or detailed soil map for the wider Tukituki catchment so development of a detailed modelling approach would not have been practical."

This also applies to this study and later analysis integrating climate, soils and different pasture and forage mixes must also assume some paddock uniformity for soils in any recommendations.

Although S maps of the region (Appendix 5) show some wider detail, they too are currently not precise enough to be used for farm level system changes until more thorough inspections are completed. This requires some expertise and a good spade.
The online "S-Maps" are being updated and the region will have more digitally capable farm level data.
Lachie Grant (LandVision) notes that some farms may have soils quite different to those currently depicted. More detailed study by Lachie and local farmers provides an insight into soils behaviour and provided guidelines for the soil/pasture/animal integration work included in this study.

About 42-45% of the region has Very Poorly or Poorly Drained soils (the MRB report RWS Water storage Project Review of On-Farm Profitability page 62 recognises this and uses 43% "heavier soils". See also S Map Appendix 5.)
This area is largely that land to the East of Highway 50 from the Tuki Tuki river to Onga Onga and Ruataniwha, and again to the East of Highway 50 near Tikokino to the edge of the Raukawa's (Mangaonuku Stream) in the lower rainfall zones (800-1000mm refer to Map Appendix 1).
A similar area is designated as Imperfectly Drained and this lies largely to the west of SH 50 and in the higher rainfall zones (1000mm).
The well drained area is that through the "central" (West/East) area of the Ruataniwha plains.
These soils have largely formed in this pattern due to the gravel and sediment loads being washed from the Ruahine Range from the main rivers (Waipawa and Tuki Tuki). Deposits vary on weight of the gravel and particles, water volumes, and the distance carried. Hence the more porous stony soils are alongside the rivers and heavier soils (less porous) where finer sediments have been deposited further from rivers. A series of photos in the Appendices attempts to illustrate this variation in soil characteristics.
The problem is in the detail with these broader categories containing at times quite significant differences in soil characteristics due to underlying structure.

A district tour with another farmer who had owned land in various areas of the district provided insight into more farm level problems. This was echoed by a soil and fertiliser specialist who also resides in the area.
Soil type may be classed as "Hastings" but drainage can vary from impeded to moderate depending on the subsoil. Some is hard pan whereas within 50 meters this may change to a gravelly sub soil.

Already this knowledge is being more widely disseminated within the region. The apple orchards are quite precisely located on compatible soils but suffer from frosts (as evidenced by the number of “windmills” per area and sometimes augmented with other frost protection), some problems such as “BBD” (Braeburn Browning Deficiency) and smaller apple size.

Farmer attitude is changing and willingness to adapt new knowledge to improve farm systems is more widespread.
To upskill farmers in the region before Plan Change 6 is adopted in 2018, an example of upskilling are the initiatives being taken by some specialist district consultants and larger organisations such as Beef + Lamb New Zealand. Their environment extension manager Erica van Reenen and Lachie Grant from LandVision have run workshops on B+LNZ's Farm Environment Management Plan toolkit.
These and other initiatives are ensuring that individual farm soils are more accurately detailed. Different soils may prove very good or very poor for various stock types (pugging, surface runoff), pastures and crops (perched water tables over harder rock) or Argyle soils which require about 12-18mm plant available water every 3 days when shorter rooting, high moisture plants are sown.
But although some soils benefit from additional water, others such as Hastings and Mangatewai can remain wet well into summer and early in autumn.
So any farm system must recognise this mix and select species that best suit the environment, provided they are also able to be used profitably.

Comments from two Australian soils and water people (B Gardiner Melbourne Water and L Martin farm systems consultant specialising in soils and water - pers comm) emphasised the need for adequate drainage before any investment in improved species or farm systems is made. Drainage is critically important if using additional water or where the soil type holds water naturally during rain. (Think McLean Park Napier and cancelled ODI February 2017 when only 5mm of gentle rain over 12 hours made an ideal soil unplayable due to inadequate drainage.) Overwatering can reduce plant growth especially as autumn approaches.
With 40-45% of the soils in the Region classified as Very poorly or Imperfectly drained, plant root depth can be impaired due to the “perched” water tables that can occur when a hard pan impedes water movement downwards.
Both Australians stressed the requirement for initial drainage, a point also made also by Lachie Grant.
However some attempts at drainage can be ineffective as there are areas of soils near Ruataniwha where if the hard pan is ripped, water actually comes up from below the pan. Local farmers are aware of this problem which will limit intensification of any type.
The soil map (Appendix 6) shows areas of Hastings soil which characterises these poor drainage qualities, but only in specific areas with an underlying largely impermeable pan.

Soil types can show similar surface characteristics but have differing depths of soil before hard pans, gravels of varying size and even residual pumice alter the overall moisture holding capacity and fertility. (Photos).
Soil fertility varies between soil types but can be modified by correct fertiliser applications.
Addressing soil fertility correctly is another area that has received only limited attention. Balanced inputs that correct the marginal minerals rather than just the NPK approach was a conversation that occurred frequently. Without this, some farmers note that many other ways to improve overall productivity are unlikely to return the benefits often touted by the “vested interests” or salesmen that push particular new products. Different crops and pastures have differing mineral requirements to balance growth and ensure longevity.

Any further detail on soil fertility and drainage is beyond the scope of this current discussion, however discussions with various soil and fertiliser consultants emphasise the fact that even within paddocks, differences in soil structures and fertility occur. Within a farm the differences may vary from heavier soils with impervious layers to light soils, capable of high surface soil losses from wind erosion during cropping operations (Photo) or just stock movement in risk areas.
Knowledge of these is critical if efficient and productive farm system changes are to be made.

Forages

The climate and soil maps begin to provide some knowledge on the basic resources and provide an initial guide for which forages may, or will not be, suitable in different areas.

What has been established is that:

- The area is not a "dryland" area compared to many areas of Canterbury where rainfall is in the 400-550 mm rain per year.
- Zone M (Otane 500-750 mm rainfall per year) is quite different to Zones A-D (750-1100 mm rainfall per year).
- Soils vary within farms and may have areas of very poor draining soils and others that are much freer draining.
- This may seem to create management difficulties but also offers opportunities to plan more flexible production systems.
- These soil differences require differing approaches to stock and management policies but when integrated correctly are capable of developing very flexible and profitable production systems.

The key is to select the grass and forage crop species and cultivars that best suit the soils and climate and match them to a production system.

Although the following list is by no means exhaustive nor contains the level of detail required to immediately start changing current pastures and practice, they do provide enough detail to enable some preliminary analysis on what pasture species best suit a particular soil and climatic environment and what production system can best be adapted to suit.

A range of different pasture and forage options have been available for many decades. Some have been tried and abandoned but the emphasis has always been on ryegrass despite it being at a disadvantage in much of this area due to the soils and climate. It is prone to shallow root systems under irrigation and the hard grazing it often endures. This leaves the plant prone to any dry spell as it cannot access lower water reserves in the soil.

The reason for abandonment of alternative grass and forage types may also be that management has not understood the different grazing management required compared to the more familiar ryegrass.

For any comparative analysis to be undertaken a defined comparative base must be established. In this case the base used is a Ryegrass pasture.

Ryegrass is considered the basic pasture grass throughout New Zealand yet is not well suited to the many environments and changing production requirements that marginal land and better stock performance potential demands. It was originally a grass that inhabited wetter or damp areas of country. It requires control through grazing to prevent loss of quality in the late spring with animals that should be well fed to exploit their production potential. Unless left with good Leaf Area Index (LIA), the ability to grow fast is limited and roots are also depleted of energy and do not spread nor establish a deeper rooting network.

All this again culminates in poor dry period growth (inability to access moisture through a large band of soil) and induces “summer droughts” as pastures brown off.
It does otherwise exhibit very good persistence due to resistance to treading damage and many insect pests. But the “toxins” that provide such resistance can unfortunately also cause problems in the animals (such as ryegrass staggers) and curb intakes.
Continued hard grazing can weaken even ryegrass swards. Such management seems at odds with efficient productivity gains but frequently occurs due to the almost inherent habit of New Zealand farmers to overstock.

Balancing animal production to specific pasture production while still providing some slack for the natural fluctuations that will occur in any pasture based system is a far simpler and more profitable system.

So how do farmers accommodate this need for good quality plant growth to best match the particular requirements of productive farming systems?
Currently we farm more for high stocking rates based on ryegrass characteristics than adapting systems to best suit combinations or specific types of animal production.
With New Zealand’s largely commodity based product chain, there are self-imposed commodity price limits to what can be profitably achieved.

Starting with the basic “characteristics” of climate and soils however provides some basics for any changes to pasture species or forages.

The plants that still prosper even in the driest conditions have a few things in common:

1) Long root systems
2) High seed production
3) Normally not edible.

This describes weed species. (See photo series Appendices).

However there are highly edible pasture plants that have at least one, sometimes two, of these attributes. Some pasture and forage combinations are now gaining favour in various dryland areas but often without much regard to the additional costs and returns incurred, nor the best way to integrate them with livestock into more profitable production systems.

Much of this dryland work has been sourced from Professor Moot’s work (Lincoln), past work by Dr. Paul Muir (Poukawa), discussions with the Australians who have been researching different dryland options for over 50 years and local industry people and farmers who have been trialing various options over many years.
There is a valuable amount of literature that concentrates on dryland forages and their production and a good source of knowledge and experience already in the community.

Ryegrass:
most common pasture species. Grows up to 20,000+ kg dry matter per ha. (kgDM/ha) on irrigated high fertility soils (Lincoln University Dairy Farm or LUDF – Pellow 2013) where additions of nitrogen plus increased general fertiliser and good management boost production. This ryegrass has higher crude protein% (CP% of up to 30%) which can cause some animal problems but also high energy levels of up to 12.5 mega joules of metabolisable energy /kgDM (MJME/kgDM). Energy is required to maintain animals and if extra is offered and eaten this allows excess energy for additional meat, fat and milk production.
In the RWS region, ryegrass grows between 8,000 and 15,000kgDM/ha on farms. (Day length and sunshine hours limit the energy available for photosynthesis compared to Canterbury.) Dairy and some beef operations grow the higher levels with added water and fertiliser.
Dry-stock (sheep and beef farms which may also breed replacements and finish them) apply less fertilser than dairy as they are lower input systems and normally on the poorer soil areas. Because of this, ryegrass may produce as low as 8,000kgDM.
It must be noted however that where lower fertility and other factors apply some existing pastures may produce as little as 4-5,000kgDM/ha. This is inevitably due to poorer species dominating ryegrass (especially Browntop, Sweet Vernal and Ratstail, with Poa species on wetter poorer drained areas). These poorer species may be annuals or perennials with stoloniferous root systems and sprawling growth patterns.
Such pastures have great potential for improvement with differing species combinations and can obviously more than double production at little cost. Replacing these poorly growing, low digestibility and energy species through some form of forage crop will provide large increases in both quantity and quality.
However a number of farmers commented on newer ryegrass cultivars as having less longevity and disappearing from pastures after only a few years. This has led to a number of them no longer replacing pastures at all rather than looking to alternatives.

Ryegrass may suffer from pests such as Argentine Stem Weevil, Black Beetle (photo), grass grub, Porina and Black Field crickets. Some ryegrasses are bred to inhibit some of these pests.
There is evidence that more intense grazing will lower the growth and longevity of ryegrass. Anecdotal figures from LUDF show that when post grazing levels increased from 1500 kgDM/ha pre-2010 to 1700-1800 kgDM/ha post 2012, total pasture grown increased even though less nitrogen was applied.
(See LUDF farm walk reports over this time http://www.siddc.org.nz/lu-dairy-farm/latest-farm-walk-notes/).

So the important characteristics for any pasture species are quantity, quality, production seasonality, palatability, pest/disease resistance, fertility requirements and longevity.
All these can be negatively influenced by management.

Clovers
There are many varieties for many purposes.
They are generally a higher quality feed but more seasonal than ryegrass.
Clover flowers and seeds normally in early summer but can do so throughout the warmer months.
They set seed which can survive for many years in the soil. They "fix" nitrogen from the air and thus work well in systems with grass species.
They have good root systems and most varieties survive dry periods well.
They may be earlier to grow following dry spells where stock have not preferentially grazed them down hard.
Almost always a "companion" species with grasses and the "ryegrass white clover" mix has been synonymous with NZ agriculture.

All clovers work best within a compatible mix of other species:
"Interaction of several plant species and pasture types is the key to creating a productive, persistent and profitable dryland farming system". (beef+lamb FACT SHEET April 2014 based on Professor Derek Moot's work, Lincoln University).
White clover is better in damper conditions but if managed appropriately (laxer grazing) within compatible pasture species mixes (that also require lax grazing) will compete and contribute well even in dryer conditions. This is because the root system can develop wider and deeper under such grazing and withstand dry periods well. This applies to other clovers and companion species too.
Many papers note the importance of clover in any sward as the main contributor to production, particularly lamb growth. The advent of high nitrogen applications, clover pests and intensive grazing have all (misguidedly) diminished clover's role in many farm systems. (Hyslop, 2000).

Red Clover
Grown with taller species of grasses (to compete for light as it is a larger leafed taller grower) or in some cases as a dominant species for specialist lamb fattening. This is especially the case in dryer areas of Australia where early lambs can grow at over 350 -400 grams/day. Obviously a high quality high palatability clover which is normally preferentially grazed out in any normal pasture.
Can be grown in wet or dry environments and is often used with Prairie Grass and even Lucerne mixes.

"**Sub" clover**
An annual but can produce high amounts of high quality feed over spring and into dry summer months. It germinates and begins growth at lower temperatures in spring than other clovers which provides an advantage in pasture mixes for lamb production both up to and after weaning. The reason is that along with other clovers it has energy levels of 12 MJME/kgDM which means more energy from each bite.
Trials ("Max Clover" project at Lincoln University) have shown yields of 10-14,000kgDM with rainfall varying from 460-767 mm/year.
It has a high re-seeding rate, so although an annual, will re-appear in pastures for decades.

Normally sown as a minor component but this is changing with the new varieties showing prolonged growth periods compared to older Australian varieties.
Sub clover fixes nitrogen as do the other clovers and lucerne. This aids any pasture species mix and provides greater DM production and quality (beef+lamb R&D fact sheet brief 126).
Light grazing pressure not only enhances feed intakes and animal weight gain but also ensures persistence. Ryegrass therefore is not the best grass for the mix as light grazing leads to ryegrass seed head formation and lowers quality, quantity growing and palatability during late spring.
Can withstand damper soils but best in lighter dryer conditions.
One farmer has altered his pasture mix and management to favour Sub clover and finishes both lambs (pre-Christmas) and beef (with any rainfall event) over summer.

Caucasian clover
This has now become a clover of choice for dryland within mixtures of lucerne, Prairie Grass, Cocksfoot and other taller grass species, including even ryegrass.
In grass mixtures (older varieties of Cocksfoot, Tall Fescue, Phalaris, Yatsyn Ryegrass) this clover spread by rhizomes or stolons to increase plant numbers. (Black 2000).
Yields varied with pasture species but were over 10,000kgDM /ha where annual rainfall varied from 408-752 mm/year and evapotranspiration rates varied from 680-1034mm.
Laxer grazing and longer rooting ability allowed survival of these pasture mixes in these dry conditions over this time period (6 year trial data).
The longer foliage retains moisture and deeper root system accesses moisture from lower levels of the soil during dry conditions.
Caucasian clover out-yields White clover in these dryer conditions.

Lucerne.
Some eye-opening results have been produced from swards of lucerne as varieties and management have improved since the 1980's.
Farmer experiences from that time are not good. Aphids, animal health problems, plant health (various fungal wilts, leaf diseases) poor establishment and survivability and the expense of establishing what turned out to be a variable feed quantity and quality crop, all combined to remove it from any farmers' "to do" list.
Much has changed due to understanding the importance of grazing management for both stock and the lucerne.
(Refer to D.J. Moot 2016, D Avery 2008 and beef+lamb Research and Development July 2009).
Lucerne survives drought, stabilises easier slopes, minimises soil loss, provides high quality conserved feed and is a high quality feed.
BUT ***it requires a lax grazing regime and well drained soils for good yields and longevity.*** (Refer to S Map Appendix 5. Most of the blue shaded area may not be suitable for lucerne due to impeded soil drainage).

Lucerne is winter dormant and suffers from treading damage if hard grazed. Doug Avery (Avery 2008) has described what management he uses and emphasises a “strategic redesign of the farm system.”
This lax grazing can lead to a perception of “poor management” where ryegrass grazing control rules. Utilisation may be lower than 50% after grazing but this does not mean 50% wastage.
Quality is high as the leaf has over 12 MJME/kgDM. Lambs therefore grow very well and may all be trucked off before mid-December.
Stock adapt to a lucerne regime but some pre-conditioning (for the digestive system) is required on pure swards and unless mature, bloat can be a problem with fast growing bull beef on rotation. (High crude protein levels.)
Fertiliser is also a key determinant of not only plant but animal health.
When looking at systems design, the growth pattern suits a breeding ewe feed profile with lucerne producing peak quantity and quality at highest demand times from birth to slaughter and on through to tupping.
However autumn to late spring dormancy requires lucerne to be in a mixture or limited to manageable areas on preferred soils. (See Modelling section where as part of the modelling process, lucerne, high lambing% ewes and breeding cows were allowed to combine. The system suited this mix well with cows keeping poorer pastures under control, providing progeny for slaughter while the ewe flock was reduced but sold all lambs to the works before a dry summer. Lucerne area chosen as best fit by the model was 66 ha of the 400 ha.)
Lucerne requires higher potassium and pH but does fix nitrogen so can work well within some mixes (Prairie Grass/Red Clover/Lucerne.)
Lucerne alone in very dry conditions (<400mm rain on stony soils) can still produce 6,000kgDM. Prairie Grass/Lucerne has produced up to 20,000 kg DM with low summer and total rainfall (<800mm/year) in a pattern that suits many animal production system requirements.
The key to its very good dry land growth is the very deep root system but is therefore not suited to damp or wet soils.

Farmer opinion of lucerne varies widely. One farmer has had a stand for over 14 years. It is used for hay and some grazing but the farmer was adamant that it needed to be well fertilised with potassium and sprayed in early establishment with a special selective herbicide for weeds. This farmer removed about half the growth as hay.
Another farmer remembers the problems of earlier cultivars and the animal deaths that occurred from grazing. Many of these may now be overcome with the new cultivars and more informed grazing management. Doug Avery recounts his experiences in the paper cited.
Stock deaths can occur if rapidly growing lucerne is freely grazed. This reinforces the point that good information and visual reinforcement from impartial demonstration trials (Poukawa) are important.
It is NOT a “golden bullet” for the region. Many of the soils and drainage characteristics make conversion to lucerne unwise.
Lucerne cannot be oversown with more lucerne as it will not germinate. Some farmers direct drilled chicory into depleted swards but then could not control weeds, particularly thistles due to no selective weed spray available.

It is therefore very important to ensure good soil preparation and sowing to ensure an even plant density (Moot 2015).

Phalaris and Paspalum offer some advantages in dry summer growth and slope stabilisation. There is a specialist use for these species to impede soil and phosphate runoff if sown as a strip below slopes. Also good for riparian strips as can tolerate some shade.
Both have fallen from favour as a grazing forage more due to the popularity of new species rather than major deficiencies. Both suffer from poorer quality if allowed to go to seed-head but do persist in most pastures throughout dry summers. Both tolerate damp or dryer conditions. Paspalum is often the first plant to show growth when rain falls after very dry spells, often alongside young clovers (white and Sub) from buried seed. (Photo)

Tall Fescue. Has been planted by the Irrigation Day farmer near Tikokino. Requires careful management as can become less palatable in dry summers or when allowed to gain height in summer. May need topping to retain quality in spring.
Although it has reasonable dry period resistance, the need for shorter length grazing for quality reasons limits the ability of the plant to push roots deeper for water.
Irrigation may also reduce the drought tolerance of Tall Fescue (and other pasture species) by encouraging "lazy" root growth to only shallow depths. When dry windy weather occurs, the plants contribute little extra growth even under irrigation as insufficient water can be accessed (Davidson Field Day).
Research work has been conducted in Zone M (Poukawa On Farm Research) and the results are summarised here: (http://www.agricom.co.nz/products/tall-fescue)

Prairie Grass. The NZ breeding of **Matua** in the late 1970's produced an excellent all season grass that thrives under lax grazing (Clark 1984). This did not suit NZ farmers with their ryegrass management style (Ridler 1988) but with the advent of lucerne is rapidly coming back into focus as a very good grass whether in dry or damp ground and in dry summers with cool/cold winters.
It provides an ideal companion plant to Lucerne, Red Clover and Caucasian clover, as these fix the nitrogen that the Prairie Grass requires. It naturally (high and frequent seed set) fills in any poor growth gaps of lucerne or as the lucerne dominance wanes over time. Quality is similar to ryegrass (11-11.8 MJME/kgDM) (Rugambwa 1991) but high quantity (up to 20,000+ kgDM/ha) with good dry weather, winter and early spring growth.
Prolific seeder but seed-head is eaten readily by stock at all times of the year. Sheep struggle a little with the height of the plant and the plant struggles with the level sheep graze to. Best in beef or dairy but can be used in lucerne with sheep to provide excellent all year production that fits a breeding and early lamb finishing system mixed with beef finishing (to eat the very good Prairie Grass summer and autumn growth) and also breeding cows with all progeny finished (see modelling section).
The problem comes from Overseer N leaching figures. Despite lucerne storing nitrogen which the Prairie Grass can then recycle in the winter as it grows

well, the fixing of nitrogen by lucerne and resulting higher total feed production from the combination may result in higher Overseer N leaching figures.
Time and more research should overcome this model trait.
Chicory, plantains. High quality but incorrect grazing management can weaken the plant and it will disappear (Photo). Again good root depth when established and resists dry periods but the plant crown can be crushed if trodden in winter when it is normally dormant. A specialised early lamb finishing summer/autumn feed that may be better substituted for a broader growth and longer life option.(Glassey 2012).
Prone to weed invasion as weed spraying will damage the plant.

Other forages; Rapes, chou, root crops. Have their place where pasture renewal and better pastures make poorer yields acceptable. Deeper rooting than ryegrass and can establish then continue growing through dry conditions.

Turnips are probably the best as fill feed gaps in dry January and February/March to relieve grazing pressure on pastures. (Photo and modelling section).
They provide quality feed quickly (sow late October/November and up to 12,000kg DM for February/March) to bridge a summer feed gap. Used mainly for dairy cows. Turnips have a wider application than just this use however. They are “cheap” to sow and are finished in time to get new pasture established before winter with minimal working of the soil.
This is a very valuable consideration as the new pasture is available in the critical early spring period for ewes with lambs.
Very good for dryer areas of dairy production. Lower overall stock numbers plus summer turnip better matches overall pasture growth, even with a summer dry. Some dairy farmers now utilise effluent sprayed paddocks to ensure good establishment and growth.

Winter crops are now under threat as they are very likely to increase soil runoff and have higher Overseer N leaching. They also tend to have poor utilisation and ruin soil structure if grazed in situ in winter.
Although **fodder beet** is the new best thing and does have high yields (18-22,000 kgDM) it is almost a year-long crop/pasture cycle and due to a combination of specialised planting requirements, the need for pre- and post-conditioning feeding, difficulties in harvest/feed or feeding in situ along with animal health issues at times (low phosphate), needs to be carefully considered before planting in any farm system.
There are other options that may prove more manageable and far cheaper.

Animals:

There are currently a number of different stock types in the area. The stock policies vary from intensive dairy, to more extensive sheep. Few breeding cows are present, yet they can offer a more valuable role in some production *systems* than most realise (See modelling analysis). Most work on the economics of breeding cows have relied on Gross Margins which do not reflect the full contribution these animals have to dry and lower fertility soils. Some dry stock land is used for grazing dairy cows (winter mainly) and heifers from weaning in October/November through to rising 2 year olds (R2yr) prior to first calving in late July/August.
Dry stock farmers who have or do offer this service have varying opinions of how worthwhile dairy grazing is. Many have realised that wintering cows may impair their main breeding ewe system. This is due to inadequate post dairy pasture regrowth in spring when feed is required for lambed ewes.
There is also a requirement to shut areas up in late summer to ensure feed for the grazing cows in May. This can interfere with lamb finishing or ewe tupping.

Production systems

Any stock policy requires specific planning to ensure required feed is provided in the right quantity, quality and at the right time to ensure the liveweight gain (LWG) or milksolids required
The dairy herds often use irrigation to provide growth through any dry periods. Few sheep or beef farms are as intensive although some techno systems for bulls and some feedlots are also present.

Finishing cattle and grazing heifers requires a different feed profile to dairy production or breeding ewes producing lambs.
Breeding ewes produce meat for sale as store (weaning onwards) or to the works. This stock policy (when properly integrated with breeding cows perhaps) best follows the normal feed production profile if lambing/calving date, growth rates and sale dates can be well planned around feed supply. The desire to "finish" all lambs does however prevail when a better option would be to sell earlier. (See later analysis work).

These differing demand profiles do not always coincide with the production profile of the feeds. It costs money to either alter or extend feed availability on farms in this area due to the cool/cold winters and some dry periods in the summer.
This feed profile must somehow be "smoothed" out to cater for the differing requirements.
Any large alteration to the natural soil, climate and plant interaction is difficult to achieve, often complex, can be risky and therefore expensive.

So the challenge is to match all resources in the best manner to minimise cost, maximise natural advantage and make good profit without too much risk or environmental damage.

Management

This is the area that is most difficult to profile or predict.
Farmers have their own personal objectives, motivation, skill level, attitudes, beliefs and risk profiles. This makes any change to their existing "models" of farm management particularly difficult to not only ascertain, but to predict.
Some farmers appear to make decisions more on the desire to "make the big change" than analysis. This trait entails considerable monetary risk and often hinges purely on conversations with a neighbour or salesperson.
Others have a "suck it and see" attitude which often means that little is learnt as they have no comparable base.
The increasingly large costs involved with any change puts systems at greater financial risk.

All inputs have diminishing returns. Although classically seen as a nice curvilinear relationship (see Appendix 6a), this is rarely the case in agriculture where additional inputs are costly and can quite abruptly alter the marginal value of the next additional input from a profit to a loss.
The use of average costs or Gross Margins disguise this "tipping point".
The use of averages and the static models that rely on them (I/O models see McCall Ref.) can rapidly erode any profits already made up to the point where more precise allocation of resources should have ceased (Appendix 6b illustrates in more detail what the 6a Graph shows visually).
This Table of data requires a little more thinking as it forces the mind to move past averages to marginal thinking.
This is designated as "System 2" thinking as discussed at length in Daniel Kahneman's book "THINKING, FAST and SLOW but is a step many no longer take.

Marginal analysis will become the preferred method of working through options as the financial squeeze, Overseer N leaching, GHG limits and the variety of inputs increases.
This marginal value methodology allows a large number of similar or quite different options (which may use the same or very similar resources) to be filtered and find the "best fit" for any farm system.
All farms differ (as the soils section of this study shows for example) and require sometimes subtle but more often quite pronounced, adjustments to pastures, animals, stock policies and finance.
Any "big change" option adds complexity and risk yet may not alter the bottom line much. They may however give a feeling of "doing something innovative".

Methodology

The main motivator for any change for many farmers seems to be other farmers making a change that works. The fact they can **see** results is the main driver even though the farm system that they are “transferring” those results from may be quite different in crucial elements to their own farm e.g. stock quality, slope, aspect, current pasture status and fertiliser status.

If the desire to change was backed by some individualised quantitative analysis for discussion it would be more likely to encourage a more widespread adoption of new ideas.

Many of the major leaps in farm ***production*** have been from better water reticulation, irrigation of dry land, fertiliser knowledge and application methods, better pasture and forage species, use of nitrogen and the continual improvement in genetics – both animal and plants.
Improvements now need to be based on ***productivity*** with better recognition of opportunities and constraints and how best to select and manage change that actually suits the system.
Measures of productivity require marginal analysis whereas measures of production are simplistic add and subtract calculations. This is why production averages, KPI’s and benchmarks are used. They are simple but provide inadequate insight into the real productivity of change.
Changes may seem small but have very large marginal impacts on profit and the environment. The emphasis must now be on marginal costs not average costs. (Fraser 2014).
If an option that allowed more individual understanding of what the constraints were likely to be on each farm, what the likely cost was to overcome that constraint and for what reward - plus include a set of performance standards required to be met for each option, it would increase confidence, reduce risk and therefore reduce the stress being felt by the rural community.
If such a systems answer could also reduce likely environmental issues, the positive outcomes would become Region-wide instead of just farm sized.

This study uses a resource allocation model (the “GSL” model Ref. Anderson, McCall) based on marginal analysis to study how each additional input to a base system will impact the balance of feed vs. demand, the best profit outcome, the change in GHG and nitrate leaching and the likely constraints or opportunities that may occur.

The modelling of systems can combine the knowledge of soils and climate to adjust likely pasture and forage quantity, quality, growth pattern and utilisation, the costs to maintain, plant, harvest and resow pasture and the production possible from the stock and production system developed.
The results allow an objective means to choose which resource combinations to use, what stock numbers should be run and the profit to be made. Then the model can be adapted (constrained) to provide a cost/benefit for each resource if required to finalise a system that suits the farm and finally the farmer.

The model resource selection is based on data for the type, performance and costs vs. income for a range of animals and stock policies.
This forms an “array” of possible resources all with associated performance and economic data. On this basis the model can then choose the “best” mix. If this does not suit farmer objectives, additional constraints can be added to force the model to use resources differently or not at all.
The result is based on marginal costs vs. marginal returns. Such results are in a $surplus form that can immediately be compared to any of the previous outcomes because the base resources remain the same between runs even though the selections differ.
As an added bonus, the model also produces an equivalent nitrate leaching and GHG figure. As Overseer has the soil models, the farm model can correlate closely when Overseer has been run. Output constraints (rather than the input constraints as imposed for farmer preference) can also be applied and the model can be used to reduce potential N leach and GHG production as a least cost abatement analysis.

Technology

This GSL model is the “new” technology that was used to change the Lincoln University Dairy Farm from a “Top 10%” dairy to top 1% and reduce N leach at the same time. (Pellow 2013)
A series of papers produced using this model are referenced.
(Fraser; Anderson; Ridler)
The model has also been used with a number of Regional Councils (2012-2017) and MPI (2007-2010) to provide a link between farmers, profit, nitrate/ GHG regulations and farm systems.
Some of these reports are also referenced.
This type of model allows “constraints” to be recognised in advance. As an example, it took time for Avery to recognise that a winter feed deficit occurred as lucerne area and stock numbers increased. This was “plugged” with winter fed Omaka Barley. The systems model optimised with 70 ha of lucerne and sold all surplus animals before April to allow feed reserves to accumulate for winter and early spring rotation use. No winter crop required.
This option also reduces N leach and GHG emissions.

Otherwise very little “new” technology is required to expand a dry land culture. The NZ invented “Baker boot” is the preferred method for under-sowing in Australian dry conditions but that has been around for over 30 years.
Normal cultivation techniques have become more efficient and reliable.
The internet provides almost any advice/how to/basic knowledge on most pastures, feeds and forages (provided it is from a reputable source such as DairyNZ, beef+lamb, Universities, some seed companies and feed suppliers such as RD 1). Caution needs to be applied however as some information sources and “Apps” use simplistic data that should not be used for making full systems change as they are not capable of doing so and may also be more “advertorial” than scientific. (Eastwood 2017).
Again, ready access to a reputable source of information and visual production system practice will be the key for change.

Technologies for change and the knowledge to do so needs to be applied in a more systems conscious manner.
A resource allocation farm systems model that can be used to simplify yet educate users on how resources can best fit into individual farm systems may provide that final key to successful change.

Profit

If asked, some farmers may not put profit as their main driver. Many take an attitude that if they do something that seems right, it will be alright.
The more indebted the farm, the more likely risk will sway (some) farmers.
Many of the options now being suggested to improve “productivity” (which is more likely to just mean more production) involve spending anything from $10,000 on a new paddock of pasture to a few $million to irrigate.
Often the ongoing costs of intensification are overlooked (Anderson 2017).

So how best to look at what change, how best to make change, how much that change will cost, the ongoing associated costs, management changes required, additional income and the risks of actually achieving the targets being set or being correct on the commodity prices fluctuations over the time of the investment?

- Gross Margins are inadequate.
- The use of averaged costs and returns does not reflect the diminishing returns that biological systems undergo with increasing use of inputs (resources).
- Marginal costs and not averaged costs are the new “must understand.”
- Accountants budgets and advice are stranded in a static accounts based state
- Farm systems dynamics are continually interacting with other factors beyond farmer control
- Change (even if only a little at times) is constant and systems must be “non-fragile”.

Farm systems models are an attempt to handle all these factors in a structured manner. But to emulate a farm system, inputs must be allowed to alter with the resources (quantity, quality, costs and returns) to provide efficient resource allocation by way of marginal analysis.

The following analysis does just that. It uses a systems model that can review the best mix of resources in an iterative (repeating) framework and select those that integrate to provide best overall profit.

Modelling

Based on a full farm systems resource allocation optimisation model. This model is better suited for economic analysis and systems integration than those that use averages in an input/output (I/O) model format.
(Ref. McCall and Anderson).

Dairy Farm.
Rainfall varies from 780-900mm (Dryer bands of Zones A and B, not Zone M)
200 ha. (170 ha flat, 30 ha effluent area)
Available for irrigation 170 ha (not applied to effluent area).
15,500 kgDM/ha. Irrigated land (+6,000kg additional DM at higher MJME/kgDM compared to dry land. C. Lewis (Appendix 7) grew less additional feed than this from irrigated pasture as does Davidson (pers. com.).
11,000kgDM/ha from effluent block
9,500 kgDM/ha and lower MJME/kgDM from base dry land pasture.
Assumed soil type which will respond to irrigation in dry periods.
Adjusted DairyNZ costs for efficiency.
425 kgMS /cow @ $6.00/kgMS and 25% replacement rate grazed off Nov-May 31
All mature cows grazed off. R2yr heifers brought back and grazed on June July.
Price of water 27 cents per cubic metre.
Purchased water 370 mm /ha over 160 ha. ($1,000/ha/year)
3.2 cows per hectare on 200 ha (possible irrigated 170 ha.)

Model was allowed to adjust cows on optional pastures/forages 200 ha.
Model was allowed to select between varying areas of mixed or pure pasture species

Drystock Farm.
400 ha. (100 ha gentle rolling, 300 ha rolling/steeper).
9,000 kgDM/ha base gentle rolling
7,500 kgDM/ha rolling/steeper poorer soil land.

Base system of breeding ewes and some bull beef finishing.
Model adjusted systems depending on model adjusted forage and pasture combinations.

Results:
For up to 170 ha irrigated, 425kgMS/cow 640 cows fixed.
Costs of irrigation (C. Lewis Baker and Assoc. Appendix 8.Table from HBRC irrigation field day Kevin Davidson).
$200 electricity;
$200 R&M;
$180 depn;
$945 interest (7%)
Total $1525 / hectare.
ADD water at 27 cents per cum 370 mm contracted
$1000/hectare

$2525 / hectare to irrigate 170 ha. **Total cost /year of $429,250.**

15,500kgDM/ha (irrigated) vs. dryland pasture non irrigated (no crops no water) 9,500kgDM/ha.
Cows producing 425 kgMS/cow.

The model would not irrigate more than 136 hectares of the 170ha possible. The best run with irrigation was 98 ha of irrigation with **640 cows fixed**.

When model was left to find best mix (no crops no water) and could **vary** herd number made
$655,000 $surplus
Reduced herd to 463 cows
Producing 197,700 kgMS No irrigation used.

NOTE: Tables are presented but only contain limited data and results compared to what is reported within the model reports. This is for simplicity and study size.
If required, more detailed data can be supplied but that is beyond the current scope of the project. The Tables are to indicate the major changes in terms of major inputs and amounts and the ability to analyse many differing combinations to produce applicable farm systems scenarios.
This then allows discussion of what the modelling has revealed.

Table 1.

Irrigated area	**$surplus**	PKE fed	Hay fed	kgN/ha	Date PKE fed	Date Hay fed
98 ha	**$606,600**	467 Tonne	50 tonne	175kg	Jul-Sept Mar-May	Jun-Jul R2yr hfrs
136 ha	**$564,000**	293 tonne	38 tonne	130kg	Jul-Aug April	May lateJune
0 ha	**$655,000**	116 Tonne	27 tonne	175kg	Apr-May	Jun-Jul R2yr hfrs

When the model was able to utilise various crops:

Turnips 9 tonne/ha crop cost $900 from pasture to crop to pasture.
Prairie Grass + Lucerne (PG+L) mix is semi-permanent but allow $1560/year for all costs plus cost for fertiliser.
This is more likely to revert to all Prairie Grass over time as this reseeds well. There is however some farm evidence that the lucerne retains vigour when in this mix as the lucerne/lucerne resistance effect is diminished.
The yield is 16,000 kgDM per ha (farm areas have grown to 22,000kg with dry but not drought summer) with both winter (in this case reduced due to frost reducing some winter growth of PG) and summer production (more from L).
The model is firstly constrained in crop area used. No more than 14 ha of turnip and 15 ha of PG.
Model allowed to choose herd number and any bought in feeds (BiF such as PKE, grass silage, hay, maize silage at price /kgDM and MJME with all additional feeding costs and utilisation also within the option).

The model improved $surplus and chose to plant the maximum allowed of each Turnip and PG+L. (See Table 2).

Another run was therefore allowed to increase each crop to 40 ha. and adjust herd number.
In this case the model chose the maximum 40 ha of PG+L but only 13 ha of turnips.

A further run adjusted the /cow production upwards to better reflect the potential for the better quality feeds to increase cow intake and production.
The average per cow of the herd was improved to 450 kgMS/cow.
The model adjusted herd number and altered the balance of the BiF. As there was more winter feed available, it could reduce hay bought and fed to R2yr heifers late winter and fed more PG dominant winter feed.
There are provisos to ensure these yields from these crops.
Turnips must be sown around late October and receive adequate moisture through until their root structure can access lower soil water.
The PG+L “crop” must be grazed laxly and because of this the utilisation of this crop was reduced in the model to reflect this.
Minimum grazing levels of around 2000 kgDM/ha were imposed but maximum level can extend out to 4200 kgDM/ha without quality falling greatly in summer.

Further runs using other options can now quite quickly be completed and costs and yields can be ranged to look at limits. However it was decided that as the examples and explanations have provided an insight into how the resource allocation works and adjusts the system as it solves, it would be a better use of limited time to move on to dryland options.

Table 2. Dry land dairy crop options and results.

Ha crops Max allow	Herd No	MS total	$surplus	BiF use	N use 175kgN total allowed	Crop areas used
Turnip 14ha	470 425/cow	201,000	**$665,000**	89T PKE 26T Hay	175kgN	14ha
Turnip14 PG+L 15	490 425/cow	210,000	**$675,000**	105TPKE 19T Hay	175kgN	14Turnip 15PG+L
Turnip30 PG+L40	524 425/cow	224,000	**$691,000**	128TPKE 7T Hay	175kgN	13Turnip 40PG+L
Turnip30 PG+L 40	506 450/cow	229,000	**$741,000**	126TPKE 5T Hay	175kgN	13Turnip 40PG+L

Summary of these Tables:

1) Irrigation costs using Baker and Associates data (Appendix 8.) but MRB yields. Model limits irrigation to no more than 80% of the farm.
2) The need for "shoulder periods feeds" after the irrigation effect ceases and before the cows go to winter grazing, and the period before any irrigation effect cuts in after cows return from winter grazing and throughout spring means feed quality from bought in feeds (BiF) is deficient. Unless high quality (MJME feeds) and therefore more expensive feeds are bought in, early spring milk production may suffer.
3) Such BiF adds cost to the system as more cows are required in the irrigation period to harvest the feed.
4) Feeding BiF at these levels results in low pasture covers at times when high growth (spring) or dry conditions (summer dry) require better LIA. Although this effect was not modelled, this reduces overall yearly growth and soil moisture (Perley and Milner. C.Perley pers com).
5) Dry land systems using some summer crops (Turnip) or mixed sward areas (Prairie Grass and Lucerne) provide more profit from fewer inputs.
6) Higher quality mixed swards offer the potential for increasing per cow production and higher profits.
7) The requirement for lax grazing from such swards encourages root depth growth, sustained dry period growth and high animal intakes.
8) Increased sward height and cover reduces potential evapotranspiration rates and further conserves soil moisture.
9) Increased sward height also reduces potential across-surface soil movement and phosphate movement into waterways.

Sheep and Beef systems.

These are far more complicated than dairy as there are multiple options for flock size, lambing %, lamb sale dates and weights; mix of stock.
If bulls are bought they may be weaner Friesian bulls at 90 kg LW, bulls or beef weaners March April and sold at various times if store or finished.

The basic farm was set up on 400 ha with a poorer pasture growth and pattern than dairy.
Poorer pastures reflect not only less feed produced but also less quality (energy) in the feed.
As ewes have limited intake capacity, the lower MJME limits total intake of energy and this is reflected in loss of weight on the ewes and/or poorer lamb LWG.
This in turn means less efficient use of feed as more is used for maintenance due to the slower LWG and time to sale.
With the current mix and quality of feed and animals, the bulk of the lambs are sold store as the pasture quantity for this stock number and the pasture quality is not sufficient to enable lambs to grow rapidly.

Overall, the pasture system is not providing the performance demanded from the production system to produce enough profit to justify the investment in land and management time.

The advice may be to grow a summer crop to finish lambs on, to switch to more bull beef as that seems more profitable (even though some of those are sold store too) or to push for higher lambing percentages. Adjustments to many aspects of the farm system would need to be made for any of the options above to be viable. Understanding the integration of stock number, type, changes in pasture availabilities, cash flow and management would be required.

By allowing the model to choose options (or forcing the model to include options that have previously been excluded), a more complete picture can be formed of what the constraints and opportunities may be. At the same time, varying costs and yields of crops or differing pasture mixes can define where the cost/benefit boundaries may lie for each input.

To ensure this "system" works, the model has already indicated that energy levels at critical times are lacking (twin bearing 2th ewes and twin lambs LWG) plus sufficient feed to finish all November bulls bought.
Reduced pasture growth and therefore feeding levels during the dry summer period force sale of store lambs and also some store 16 month bulls.
The feed production is not fit for the purpose being demanded.

The Base system is therefore suffering from these problems.
Modelling such complex interactions in a systems context takes longer as far more iterations are required to find the best mix based on economics. Linear programming routines minimise this time and select the best mix from a wide variety of possibilities.

The Base result forms the base for comparison between subsequent changes to pasture and forage combinations from which the model can combine stock type and number that best fits each situation.
Note that these systems are not “user” specified but can be influenced (constrained) to suit specific management preferences for stock and forages.
As the schedule prices and per head stock costs remain constant between runs, no inflated buy/sell margins for particular stock types can occur between runs.

By using this farm system modelling approach using the farm’s actual data, the areas of poor performance can be identified, and clues as to the best way to remedy them become obvious.
Now it merely requires more options to be included in the “resource array” so that the model can choose the most appropriate combinations based on performance, timing, cost, usefulness and therefore profit.
These analyses have been limited due to time constraints for this whole study.
However many future options can be explored if ideas and data are presented.

Base sheep and beef Farm.

400 ha.
300 ha rolling (some steeper sidling) 7,500 kgDM/ha MJME vary up to best of 11.6 MJME.
100 easier rolling 9,000kgDM/ha with MJME of up to 11.8MJME.

Ewe flock 3000 60 kgLW breeding ewes 1000 replacements 110% lambing (540 twins, 2730 singles).
Bull beef buy in policy about 75 Friesian bull weaners 90 kg through to finish or when feed dictates.
All pasture, no cropping, 20kgN/ha over 100 ha.of nitrogen to boost “best” pastures over lambing.

The model shows that this stocking level requires at least “average” growth rates to succeed.
All twin and ewe lambs must be sold store at weaning ($57-62) in early January.
The single wethers are taken through to 38 kgLW and to works early April ($83-90).
The R2yr bulls must be sold store early February due to feed constraints.
The main problem areas are winter to late spring and in managing feed through summer/autumn to ensure spring lambing is not impacted.

So the model has clearly defined the problem times.
Lucerne grows well in summer so fills that gap, but is largely winter dormant so may exacerbate that gap. Some of the rolling flats are prone to a higher water table which restricts use compared to the more porous areas of rolling country.

A summer crop of rape/chou may be advised to finish lambs. How does that fit the current stock policy and production system?

So the model can be provided with a number of possible crop and pasture/forage alternatives. Each of these includes growth patterns, yield, quality variations, utilisation, costs of establishment and/or yearly costs that are more than the costs of the existing system.
They also have crude protein levels and digestibility data that allows total nitrogen excreted and GHG totals to be calculated at the same time.
(The final selection of resources is based on a Linear Programming (LP) technique that can analyse all these option against the objective function of the marginal cost vs marginal $ return of many alternative options. But it can also have an output constraint imposed to limit the GHG emissions or N excreted to prescribed maximum limits when N or GHG abatement is required at least cost.)

Only a small sample of possible options have been included as an example. All that is needed is the data that applies to each option.

The analysis process is not simple but what makes it possible is the power of current laptops and the use of the "new but old" technology of LP which has not been used for full systems farm analyses using marginal analysis, before.

Some results are displayed in the accompanying Table as the Base system is altered and differing options are selected by the model.
Note that "better" resource use adds to $surplus. As there is no N abatement (N excreted) required at this stage, the relative changes to likely N leach and GHG emissions are merely noted, not constrained.

All the changes that the model makes to produce the solution for each option are not documented. However an extensive and detailed record of all these is contained on the output files in a database system where any Run can be accessed and reused at any time.

Table 3.

	Ewe Flock	Lamb%	Bulls	Crop	Forage Pasja	New Pasture Species	Nexcreted kgN GHG KgCO2	$surplus
Base Farm **Run 1**	3000	110	72	0	0	0	75,500 kgN 637 tonne CO2	$175,100
Add Pasja 35ha **Run 2**	2700	125	150	0	35ha	0	78,800 KgN 648 tonne CO2	$191,500
Pasja Plantin /Chic Mix **Run 3**	2700	125	138	15ha	0	0	77,200 kgN 652 tonne CO2	$196,000
Less Ewes Aug **Run 4**	2440	125	150	0	0	0	75,200 kgN 625 tonne CO2	$229,,500
Swede Chou Winter **Run 5**	2400	125	150	8ha	0	0	76,700 KgN 635 tonne CO2	$230,600
Lucerne 70ha **Run 6**	2400 Twin 3600 Single 600	175%	150	0	Lucerne 70ha.	0	103,000 kg N 786 tonne CO2	$262,000
Lucerne 60 ha 140Beef Cows + Ewes **Run 7**	2400 Twin 3600 Single 600	175%	0 (144 Cows)	0	Lucerne 66ha.	0	102,000 kgN 793 tonne CO2	$289,000

Notes:
Base Farm is **Run 1**

Run 2 forced Pasja into the system. Lambing% increased to 125% but allowed flock number to decrease (minimum 2700) and the bull buy to increase.
The model would not initially use Pasja (it just wanted to drop ewe numbers further and buy more bulls). When forced to use Pasja, the model dropped ewe numbers to finish more lambs on the Pasja but increased bulls and also took them on longer.
So a "simple" decision to use Pasja required several other management changes to provide a better outcome.
The Pasja's extra MJME provided the marginal lift in energy to allow lamb finishing rather than sell store. The decrease in ewe number (despite the increase in lambing%) allowed the more lucrative bull buy/sell system to expand.
These changes also lead to higher N and GHG levels.

Run 3 allowed a mix of plantain and chicory to be direct drilled after herbicide (Glassey 2012) but forced the model to use at least 15 ha of this mix. However the model was now allowed the option of using Pasja only if it would improve the $surplus and improve the feed constraint period (spring).
It did not choose pasja at all and only used the minimum of 15 ha of plantain and chicory that it was forced to use.
This was due to this option not overcoming the constraint of low spring growth and quality.

These two runs indicate that more stock and production do not produce more profit if the costs of that production exceed the return (MC>MR).
The reason the MC>MR is still occurring is that the winter/spring constraint period has not been addressed.
In order to get a basic stock policy that better matched the feed profile, the model was allowed to choose a ewe flock and sale date/weight of lambs and bought in bulls that would smooth the requirements better.

Run 4 allowed flock reduction to a minimum 2440 ewes, lambing date dropped to 24th August all lambs finished April and May, bulls mainly gone by March at 540 kgLW. Energy limits were being exceeded at times in spring.

These runs show the relative better profits from buying and selling well fed and fast LWG bulls at current prices compared to ewes and lambs.
They also show that there is no advantage from crops at these levels of cost, yields and timing and pasture that cannot produce quality feed when most required.

Run 5 Swedes/Chou mix for winter feed overcomes the spring deficit and allows bulls to be taken through to 300 kgCW.
Lambs are taken through to works April/May with 24th August lambing.
The profit improves (mainly due to bulls and lamb finishing) from a smaller ewe flock fed better.
No other forages were selected by the model. It could have selected an area of up to 35ha for the winter crop but chose only 8ha. This fills a winter gap without creating a subsequent larger gap when winter crop cannot produce enough new pasture until December.

But this relies on bull beef prices remaining strong (the price used was $4/kg for bull which is lower than current March 2017 prices; and $4.70/kg CW nett for lamb) and good LWG for efficient conversion of pasture to beef.
The bull schedule price was reduced in stages to see when bulls were not selected.
It was of interest that the model sold bulls earlier (in February) as the schedule reduced.
When all bulls had left the system, the best that all ewes and lambs could achieve was $166,000 and no crops could be afforded.
However as the bull schedule decreased below $3.00, there was very little marginal difference in $surplus between all sheep (3010 ewes at 125% lambing, selling all lambs April/May and not growing any crops or forages) and ewes plus bulls (3670 ewes and 80 bulls sold early February store.)

Although it would seem logical to just improve flock efficiency by increasing lambing% to over 160%, it is clear that pasture quality just cannot prioritise feeding for twinning ewes and twin lambs.(Litherland 2000).

If the Doug Avery lucerne system is used with the model choosing the area to sow (so some on flatter areas and some on easy hill) we can get some idea of opportunities and constraints again.
Lucerne has winter and early spring dormancy and this farm already has problems there but the very good lucerne quality (12+MJME/kgDM) means that more twin lambs can be produced and finished.

Run 6. The model chose 70 ha of lucerne and a flock of 2400 175% lambing ewes with the maximum allowable bulls of 150.
All lambs grew faster and were sold to the works at heavier weights of 18-20 kgCW.in early April.
The bulls were kept on a similar LWG profile and sold at beginning of March.

This system (if it can be managed) does allow higher *productivity* ewes to better reflect genetic ability --
BUT the **production of GHG and N excreted increases markedly due to extra feed grown (lucerne yield at 16,200 kgDM/ha /year) and Crude Proteins as high as 22-25%.**
Both these can be modified by fertiliser “tweaks” as can the danger of animal health issues going on to a full lucerne diet.
Despite the high Lucerne MJME levels, energy was still deficient for this lambing % and twin + some triplet growth rates.

The final **Run 7** allowed breeding cows into the mix.
This system had a better ability to control poorer species and pasture quality figures were improved. This allowed a simpler, better balanced and more quality focussed system.
The model chose 66 ha of lucerne to complement the system balance. The breeding cows consumed “surplus” early summer pasture and gained weight. A reduced cow intake after weaning saved pasture and balanced the system better allowing cost reductions (no additional feed required).

Summary of sheep and beef systems;

1) The model has **confirmed that 50% increase in $surplus** can be achieved from utilising existing technologies and knowledge.
2) These however need to be modified for each individual farm system but can be carefully applied throughout the region and have a major impact on money retained in the region. Unlike irrigation, minimal capital expenditure or risk is involved.
3) The main emphasis should be on providing applied farm systems knowledge in a manner that farmers can both observe and be enabled to understand.
4) This would involve an increase in the extent and education of case study examples in the region.
5) There is a concern over inadequate energy levels for improved animal production due to the poorer pastures used in the basic farm.
6) No runs were reported using improved basic pastures but there is this opportunity. Such runs show an even greater reward for alternative pasture and forage options.
7) However the consequences of the extra production are higher GHG emissions and N leach potential.
8) Depending on how Overseer will come to view Lucerne (which grows little in winter but a lot in early summer onwards and therefore at a least risk time for leaching to occur), this may be a problem for farmers being judged by a “grand-parenting” N abatement Regional policy.
9) There are costs and risk associated with crops. They require cash to plant and returns may be some time away.
10) In these examples, very little altered in terms of stock numbers so there were few added costs (all extra animal health and husbandry costs are accounted during the models iterations) but productivity and therefore efficiency of the farm as a system improved.
11) The risks of buy/sell remained with higher bull numbers being run. Although a drop in beef schedule still finds bulls preferred, the margin is reduced and hence the risk is increased.
12) Breeding cows and breeding ewes decrease the margin of buy/sell risk (or opportunity).
13) Further options are possible to model. Accurate data and options are all that are required. If time permits more runs will be completed for inclusion in this study.

Study Summary

The Ruataniwha region has been formed by river aggradation deposits over time.
This has resulted in wide variations in the materials that make up the soils. Surface soil characteristics may appear similar but further examination at varying depths can reveal free or impeded drainage. These properties will determine the success of plant and animal combinations.
There are a complex of soil zones and sub-zones, many of which are within individual farm boundaries.

These differing soil areas must then be overlaid with rainfall and temperature which can also vary within quite defined areas in terms of frost, wind frequency and severity.

Pasture production and longevity will vary widely depending on how species combine with the unique combinations of soils and climate.
Pastures will also react differently to varying animal management systems which may enhance or damage both plant and animal productivity.

Animals require sufficient intake and concentration of energy within that intake to be fully productive. But such production must be matched with the normal pasture produced to provide the simplest and least risky production system.

The productivity and therefore profitability of any farm system depends on integrating all of the above factors in a management policy (stock, pasture, cash flows, profit) that best fits both the physical and managerial attributes available.

All these factors are difficult to match given the variations in the natural environment and the multitude of possibilities for matching the resultant pasture with different stock types, production potentials, product price variations, input cost changes, attitude to risk and management preference.

Currently these complexities are largely ignored and more generalised recommendations given depending on who or what is currently promoting services. These can be described as “component” services with little or no appreciation of how the change(s) being advocated will fit into the farm production system in a balanced manner.

This in turn has led to a resistance to change (compared to “tried and true” practical experience) amongst a number of farmers approached during the study.

Although the rewards for change are being illustrated by some farmers and adapted into research projects (e.g.The Sustainable Farming Fund's project, the East Coast Future Farming Systems at Poukawa led by Dr. Paul Muir) much of the advice does not include any in-depth discussions on what other adjustments may be required for the system to re-balance inputs vs. output and just what the marginal costs were compared to the returns achieved.

This study summarised soil types, attempted a discussion on making appropriate pasture species decisions and then combined some of these factors into a variety of farm systems.

These systems were modelled to allow change to “ripple” through all the factors involved. The model solutions clearly showed that system change is not a simple component driven exercise measured by Gross Margin.

Even small change needs to be accompanied by alterations to many aspects of the system, yet this is rarely if ever discussed in the context of what crop, what pasture species, what stock sale/date/weight changes must be made.

Change is most often predicated on component based advice which fails to identify how to integrate that component into a unique (soils, pastures, stock, policy, management) farm system.

General component advice is not good enough and farmers are now realising this.

Dry land is a special case that requires a far more systems conversant approach to produce the very real advantages that have been shown to be possible.

Conclusions

There are large gains to be made from adapting farm systems to better align with the soils and climatic conditions of the region.

Many different pastures and forage options are available but need to be chosen in a more informed manner to ensure compatibility within a system and the specific farm environment.

The aim is to save water in the soil rather than in dams. This can be achieved with correct management of pastures and animals. Such management will improve plant and root growth (more organic matter build-up in the soil which also retains moisture and minerals - FAO Reference), reduce evapotranspiration and soil loss from wind, and increase productivity of the animals and crops.

An integrated systems approach will provide a better appreciation of constraints. This in turn will reduce costs, improve “workability” and therefore profitability.
Balancing systems to ensure each part is contributing efficiently will limit environmental impacts, enhance product quality and improve quantity.

Such changes are applicable across both the flat and hill country of the Region and will require minimal risk or capital expenditure.
Successful change will however require more informed and practically based messaging.

To minimise mistakes, better targeted resources such as applied research information and pre-system modelling should become a standard operational procedure.

This will revitalise the local economy with increasing product for local industries (meat, wool, hides, services, contractors) and wider vocational employment opportunities (farm staff, contractors, technical and general support services) and a revival of more applied educational opportunities.

The low cost structure but increased profitability of dryland systems will ensure that the extra revenue earnt will be retained in the area (reductions in both farm debt and interest payments to overseas banks).

The improvements to land and water from less intensive farming will once again provide wider recreational opportunities for local communities and attract visitors to the area.

The area is not really dryland with respect to either soils or rainfall but the options presented are applicable to all farms in the region.

Research work, Poukawa and farmers in New Zealand and Australia have trialled management techniques for various forages and pasture species. But integration of new options into a farm system is farm specific and the best ways of doing so have not yet been adequately addressed.

Any options must be integrated into a system that allows resources to be used efficiently. Better understanding how this systems integration can be implemented and increase the likelihood of success is now possible through using resource allocation systems modelling technology to minimise costly trial and error.
It is this next step into systems thinking and implementation that will provide the key to stabilising the farm environment and improving profit.

A number of farmers were approached during this short study. They discussed pastures, grazing, stock, soil, climate (and climate change) water and irrigation, but also expressed their opinions, objectives and views on farm systems and agriculture in the region.
They all contributed very good comments (which have been largely accounted for in this study) but this one summed up an attitude that was echoed by many:

"I found myself falling out of favour with farming - then realised it was not the *farming,* but the *way* I was farming, that was the problem."

If the profitable and environmentally beneficial systems of dryland farming were encouraged and supported more widely in the region there would be less emphasis on irrigation and most Plan 6 changes would be profitably met.

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Dr. David McCall Farm Management DairyNZ October 2012.
“3. The GSL model was chosen over Farmax (which was used for the calculations of Brown et al presented in 2011 and of which the author of this evidence was the developer). This was because GSL is more efficient at finding optimal resource use allocations due to it being an optimising, rather than a simulation model. With simulation models (such as Farmax) the definition of optimal resource use requires the user to iterate their way towards an optimal solution. This iteration is time consuming and not always fool-proof as optima may be missed.”

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Beef+lamb FACT SHEET from various months and years.
e.g.
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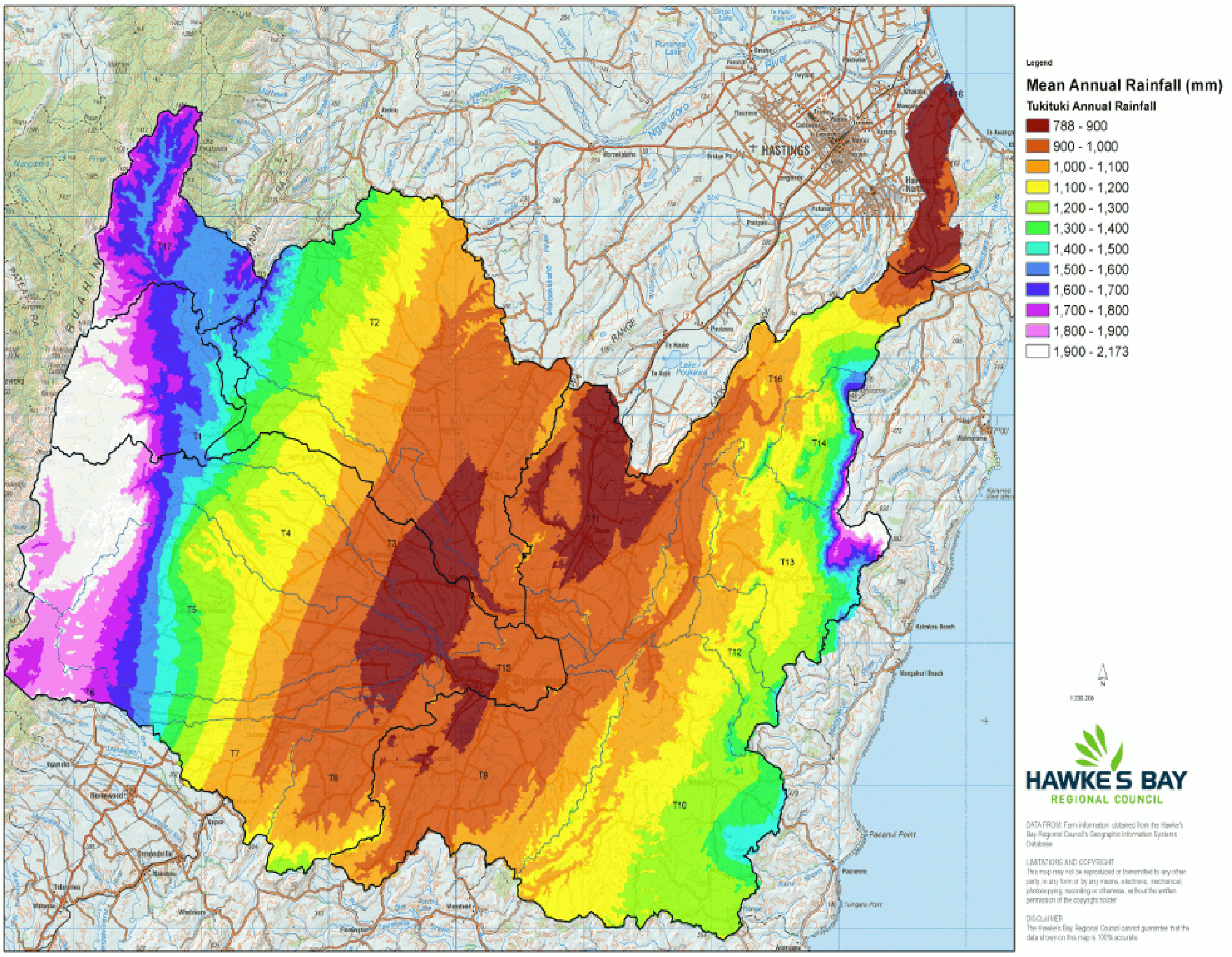
http://www.beeflambnz.com/news-events/News/2015/february/demo-farm-explores-optimal-establishment-method/ (Dryland Hill new species establishment methods.)
http://www.beeflambnz.com/news-events/News/2015/april/achieving-mating-weight-critical/ (Beef cows ability to eat surplus feed to ensure higher quality pasture and reduction in winter feed demand.)

Appendices.



Appendix 1
Rainfall Map RWSS. HBRC.

Appendix 2 Long term climate trends in RWS area:
September 2012
ISSN 1179 8513
EMT 12/18
HBRC Plan No. 4405
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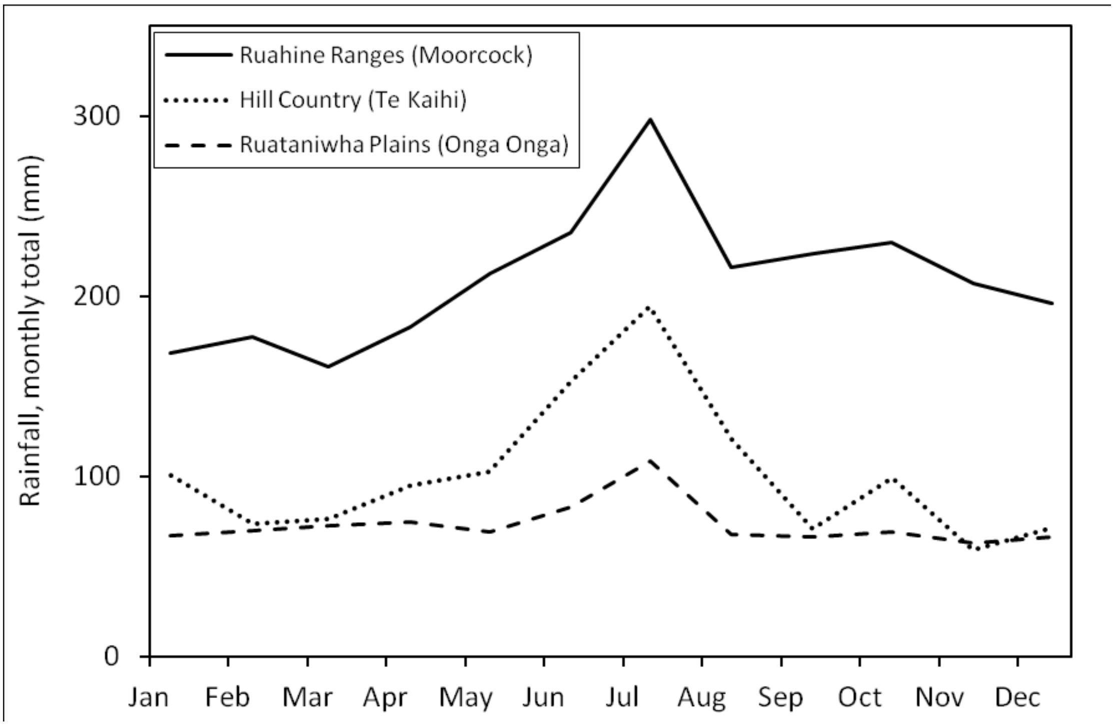
The IPO (Inter-decadal Pacific Oscillation) provides a measure of longer-term climate trends, with a positive phase lasting from 1978-1998, and a negative phase from 1947-1977. The El Niño pattern is more likely to develop (and be more severe) during positive phases of the IPO. La Niña climate patterns can last several years, and are associated with increased rainfall in the Hawke's Bay region (including ex-tropical cyclones) because of increased easterly winds during summer months (see Section 3.2 in MfE, 2008). In contrast, El Niño events reduce rainfall, and increase the risk of drought, because the moisture from increased westerly winds is intercepted by the Ruahine Ranges before reaching the Ruataniwha Plains.

Appendix 3. From the Tonkin and Taylor pre-feasibility study:

The results of this assessment indicate the following:

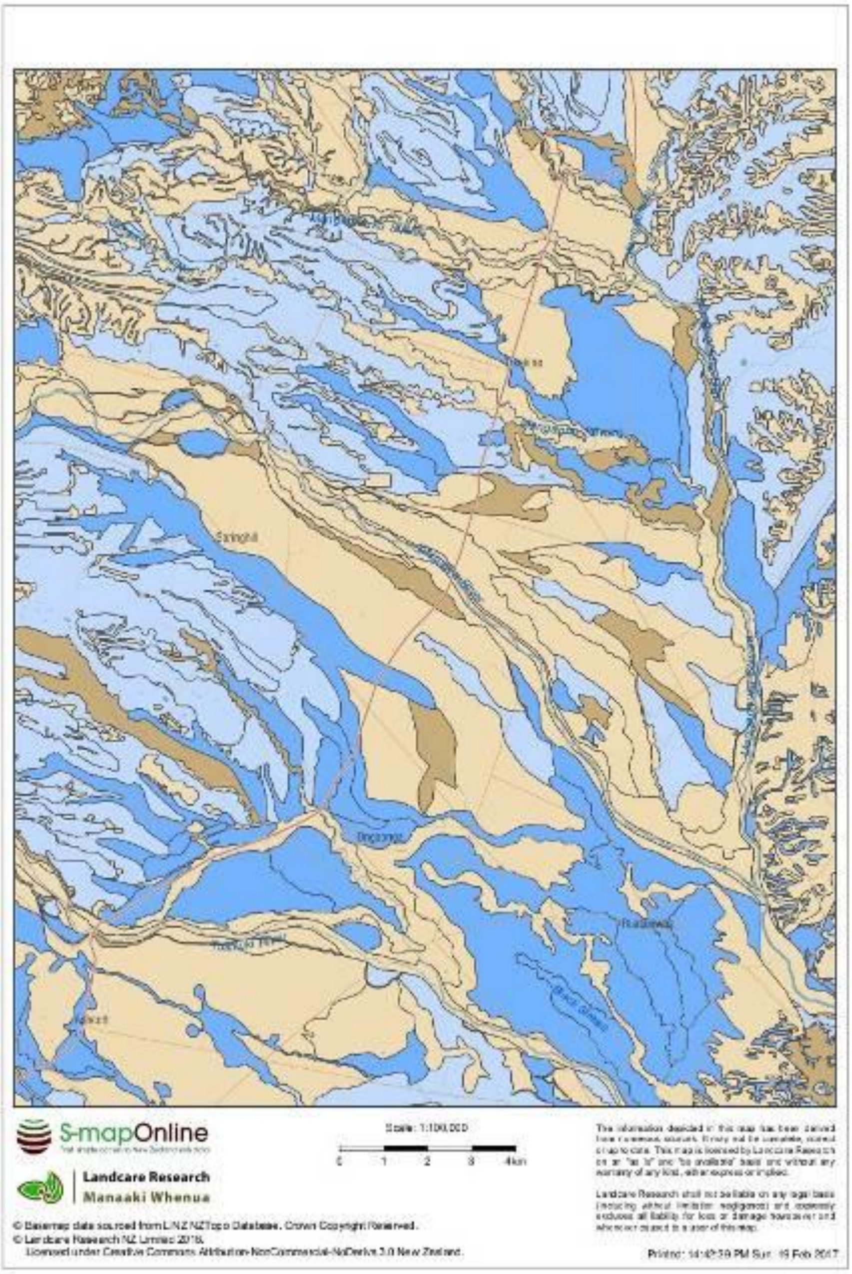
- in a "normal" non-drought year, all of the Plains appear to enjoy a moisture surplus throughout the growing season, i.e. no irrigation required;
- in a 10 year drought, the seasonal deficit ranges between zero and about 240 mm, averaging around 190 mm (or 1900 m^3 per hectare);
- in a 20 year drought, the seasonal deficit ranges between zero and about 450 mm, averaging around 330 mm (or 3300 m^3 per hectare);
- from the above, there is a very steep increase in the irrigation water requirement with increasing drought security desired, for example an area requiring 225 mm in a 10 year drought would require about 400 mm in a 20 year drought;
- within each zone there is a large difference between the minimum and maximum water requirement per irrigated hectare, with particularly steep drop off in seasonal moisture deficit, and thus irrigation need, towards the western foothills of the Plains, which is commensurate with the rainfall distribution (see Figure 3.1);
- there is also a significant difference in the average water requirement across the zones, for example zone D in a 20 year drought requires about 240 mm (area weighted average) while zone A requires about 400 mm (area weighted average); and
- the western extents of zones C and D will not require irrigation in most years and then only a modest amount even in significant drought events, and this suggests that it will be both uneconomic and unwarranted to irrigate these areas.

Appendix 4: **Figure 6: Seasonal rainfall pattern in the Tukituki catchment.** Means of the monthly total rainfall are plotted for three monitoring sites that were selected to represent the Ruahine Ranges (Moorcock 1988-2010, 770 m elevation), Hill Country (Te Kaihi 1981-2010, 183 m) and Ruataniwha Plains (Onga Onga 1981-2010, 170 m).



"The seasonal distribution of rainfall is relatively even for the Ruataniwha Plains, when considered in terms of monthly totals"

Appendix 5 S Map of region.



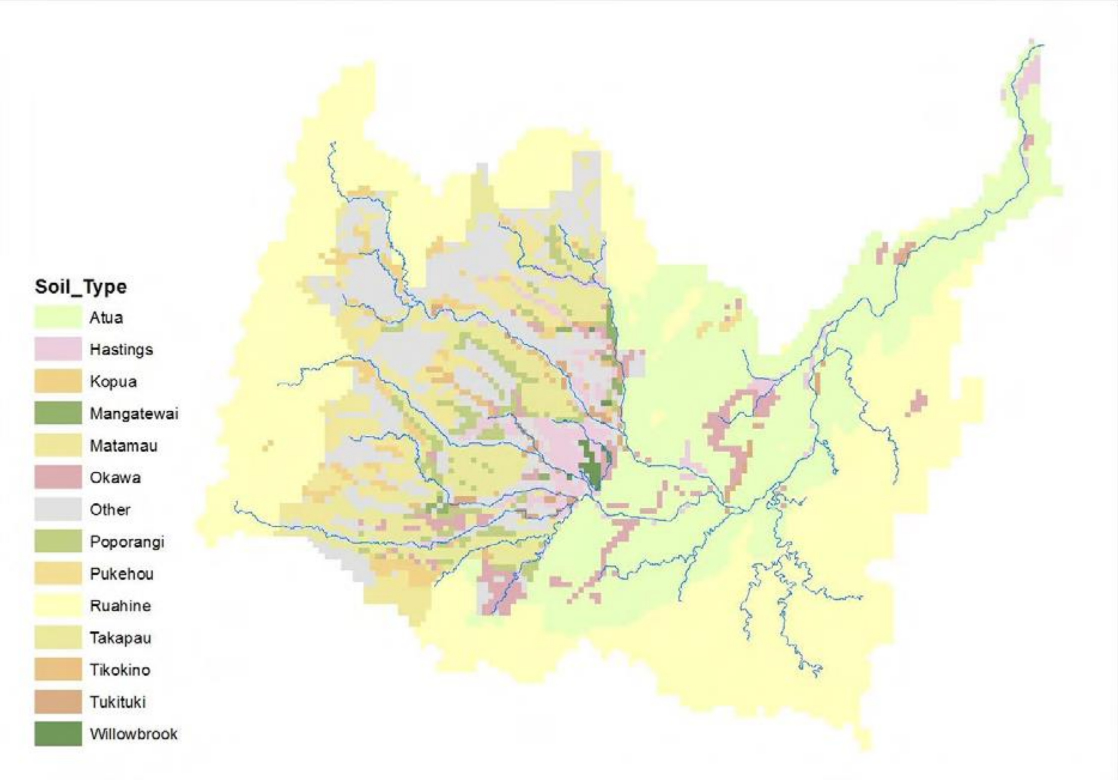
Appendix 5. Soil drainage (S Map reference). Blue areas range from Very poorly drained soils (darker blue) to Imperfectly drained soils (lighter blue).

Brown areas range from Moderately well drained soils (darker brown) to Very well drained soils (lighter brown.)

The central road marked on the map is SH 50 with Tikokino in the brown (well drained) soils marked mid upper right and Onga Onga in the deep blue (Poorly drained) soils mid lower left.

Plant species should be selected to suit soil type and rainfall. (See Rainfall Map Appendix 1. in conjunction with this map). Refer back to brief descriptions of plant species requirements and constraints.

Appendix 6 Soil names of region.



Major soil types. Extract form HBRC nutrient modelling report: (Wheeler)

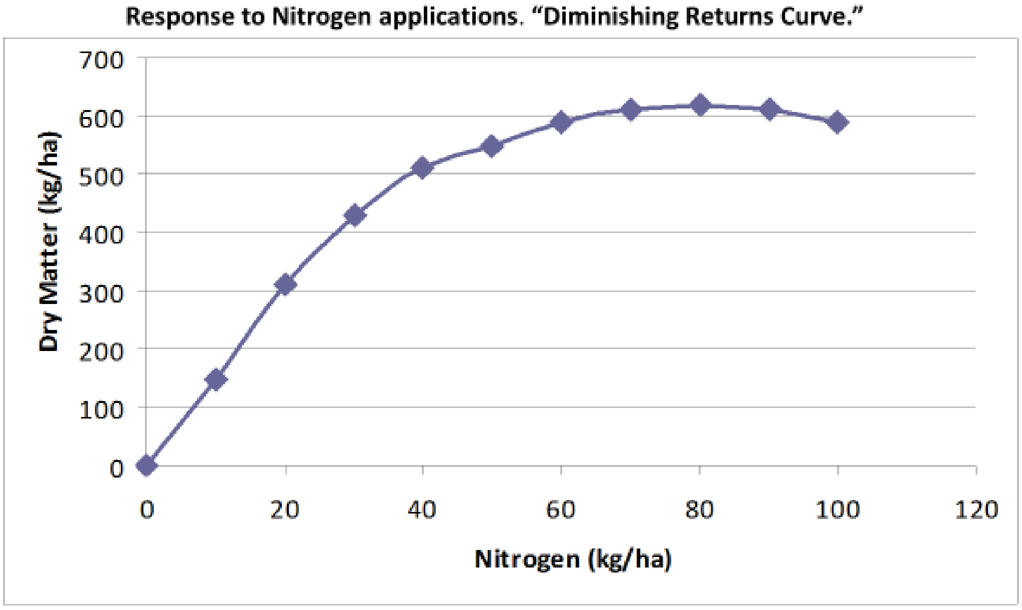
5.2.2 Tukituki catchment

For the wider Tukituki catchment modelling, one representative soil was used for each climate zone. Thus, the Atua was used for the drier zones (900 mm) and the Ruahine for the wetter zones (1200 mm)(see Figure 10). These soils are in the database accessed by O*verseer* - the soil water properties were the default settings for a pallic and brown soil order respectively. There is no high resolution or detailed soil map for the wider Tukituki catchment so development of a detailed modelling approach would not have been practical. Classifying geology at the level of 'Rock Group' provides an overview of land systems at a catchment scale. Important sub-classifications must also be recognised within each Rock Group. The gravel group on the Ruataniwha Plains can be sub-divided into the older and thicker Salisbury Gravels and the Young Gravels (Baalousha, 2010). The soils of some older river terraces have formed a cemented clay pan (Part 1.3 in HBRC 2003), which can limit infiltration of water to more permeable alluvium beneath. The Young Gravels have high permeability and form a thinner layer over the Salisbury Gravels. McGuinness (1984) proposed that the groundwater-surface water interaction is associated with the shallow, unconfined aquifer housed in these Young Gravels.

More recent research indicates that interchange also occurs between the shallow aquifer and the more confined deep-aquifer (Undereiner, et al. 2009; Section 3.1 in Baalousha, 2012).

A limestone ridge (Ruakawa & Turiri Ranges) forms the eastern boundary of the Ruataniwha Plains.

Appendix 7. Diminishing Returns Curve.



Data for Diminishing Returns Graph (based on Ball 1980)

Units N applied	Total DM grown	Average Product AP/10kgN	Total Cost $TC	Total Revenue $TR	**$AR**=Av Revenue TR/TC	AddedDM /Added Unit N kg	Return/ Unit N **$MR**	Cost/ Addtn **$MC**
0	0	0	0	0	0	0	0	0
10	150	150	16	40	2.5	15	4	1.60
20	310	155	32	82.7	2.6	16	4.27	1.60
30	430	143.3	48	114.7	2.39	12	3.2	1.60
40	510	127.5	64	136	2.13	8	***2.13***	***1.60***
45							***1.63***	***1.60***
50	550	110	80	146.7	1.83	4	***1.07***	***1.60***
60	590	98.3	96	157.3	**1.64**	4	1.07	**1.60**
70	610	87.1	112	162.7	1.45	2	0.53	1.60
80	620	77.5	128	165.3	1.29	1	0.27	1.60
90	610	67.8	**144**	**162.7**	1.13	-1	-0.27	1.60
100	590	59.0	**160**	**157.3**	.98	-2	-0.53	1.60

Productionists apply N to about 92 kg N/ha as **Total Revenue-Total Cost** (TR-TC) is still positive.
Averaged figures allow application of N until about 63kg N/ha as Average Revenue is about same as added unit cost **AR=MC**.
But the correct calculation is that application should cease at about 45 kg N/ha where **additional revenue vs. additional cost is still positive** or up to the point where Marginal Cost = Marginal Return (**MC=MR**) $1.60 = or < $1.60.

Appendix 8. Irrigation costs. Davidson Field Day. Baker and Associates.

			Kevin Davidson Field Day Dairy Costs as presented by Baker and Associat					
						Additional Options		
Forms of Irrigation		B.Dyke	Gun	K.Line	Centre Pivot			
Capital costs per ha		$13,000	$12,800	$11,800	$13,500	$13,500	$13,500	$13,500
Depn (years for above ground)		35	25	15	25	25	25	25
KW / Ha		0.00	1.00	0.60	0.50	0.50	0.50	0.50
Labour /hrs /Ha /yr		1.00	4.00	5.00	0.10	0.10	0.10	0.10
Electricity / charges		$0	$400	$240	$200	$200	$200	$200
Labour		$18	$72	$90	$2	$2	$2	$2
Tractor/bike		$50	$200	$250	$5	$5	$5	$5
R&M		$125	$150	$150	$200	$200	$200	$200
Depreciation		$114	$152	$187	$180	$180	$180	$180
Interest		$910	$896	$826	$945	$945	$945	$945
Irrigation Cost per ha per year (b4 Water)		$1,217	$1,870	$1,743	$1,532	$1,532	$1,532	$1,532
Water Price per cubic metre	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00
Irrigation depth (mm)	0	0	0	0	0	0	0	0
Plus Cost of water per ha		$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00
Cost per ha per year inc Water		$1,217.00	$1,870.00	$1,743.00	$1,532.00	$1,532.00	$1,532.00	$1,532.00

Photos and comments from farm locations throughout the region.

Figure 1 Dense Paspalum. Can be used for Riparian Strips or soil retention strips on hill base. Good summer growth and palatable pre seed head emergence. Creates a barrier for any hill surface soil (and phosphate) movement.

Figure 2 Porina damage in lighter soils. The caterpillar lives subsurface but comes up to feed on pasture foliage at night.

Figure 3. Black Grass grub beetle (February). The grub ravages pastures by eating plant roots in summer. These grass grub beetles are prevalent in some years in lighter soils. The brown grass grub emerges in November ("November beetle") http://www.terrain.net.nz/friends-of-te-

henui-group/local-insects/grass-grub-chafer.html) but inflicts similar damage to the roots of pastures.

Figure 4 Summer turnips provide excellent feed for stock to supplement pastures and prevent overgrazing in dry summers.

Figure 5. Clovers can survive dry periods due to very good root systems. Buried seed provides new plants when rain occurs especially with Sub(teranean) Clover. Proven high quality feed for lamb finishing.

Figure 6. Buttercup is a sign of poor drainage.

Figure 7. Lucerne at about the recommended height for light grazing. There are some animal health issues if immature lucerne is fed to lambs and beef. More intensive grazing weakens the sward and opens it up for weed invasion. Expensive selective sprays must then be used.

Figure 8. Prairie Grass provides excellent feed in both summer and cooler winter. Also early spring grower. It must be grazed laxly to ensure high growth rates and longevity. This lax grazing also means high intakes for productive stock. Proving to be a valuable feed source in combination with Lucerne in some soils and dryer climate combinations. Aimed at specific stock types and management systems.

Figure 9. Weeds have very good root systems capable of extracting water and growing when many pasture plants cannot due to dry conditions.

Figure 10. Some summer growing forages suffer from overgrazing or treading damage and require renewal or re-grassing.

Figure 11. Very light soils can be blown away if strong late spring winds occur. In this case, direct drilling into previously cropped ground illustrates this type of soil loss in calm conditions.

Figure 12. Soil depth before hitting a hard pan. Note poor pasture species (Browntop) and very shallow root depth due to imperfectly drained soil.

Figure 13. Note small stones in soil. The stonier layer provides better drainage and allows more root growth as above. More ryegrass dominant pasture with some clover.

Figure 14. Shallow soil overlying gravel. Dry conditions but some sub clover and Yarrow are growing. Note the roots from the sub clover which are able to extract moisture from a wider soil profile. Good for lamb finishing.

Ryegrass has poor performance in these soils and will not survive if hard grazed.

Mid-summer convection rainfall and irrigation will largely evaporate on the surface of these stony soils if pastures are hard grazed. The hot sun heats the stones many degrees more than air temperature and kills grass plus soil micro-organisms. Any plant system with higher sward/plant height conserves water and supplies increased organic matter to the soil (FAO Reference) which therefore minimises the need for additional applied water. Ryegrass is not ideal for this laxer type of grazing management but will respond to irrigation.

Figure 15. A small stand of trees (Poplar variety) within a paddock. They offer stock shade in summer but also encourage better pasture growth under the trees compared to the open paddock (Foreground.) This is largely due to the summer sun not excessively heating the surface level stones, evaporating water and soil moisture and "baking" the plant and soil life. The Poplar also reduce the effect of the hot, dry winds prevalent in the area. Leaf loss in autumn returns organic matter and allows light for plant winter production.

Pivot irrigation is the "one big thing" that can manage the amount of water supplied but trees cannot be a part of that. In contrast, Dryland agriculture consists of a number of smaller and far less expensive adjustments that require more thought (but far less capital and ongoing costs) yet return a more balanced and systems friendly result that can prove more profitable with less risk.

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11 April 2017

James Palmer
Hawke's Bay Regional Council
159 Dalton Street
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Dear James

Review of RWSS flushing flows – including additional analysis of periphyton monitoring data

1. Introduction

1.1 Background

The Ruataniwha Water Storage Scheme (RWSS) is a proposed water storage and irrigation scheme in Hawke's Bay. The proposed scheme includes a dam on the Makaroro River, a tributary of the Waipawa River which is itself a tributary of the Tukituki River. The proposed dam will store winter high flows for release and use in summer when demand on the water resource is greatest.

The Scheme design incorporates the capacity for four flushing flows of up to 30 m^3/s for 9 hours (or 25 m^3/s for 11 hours when the dam is at lower levels and it is not possible to discharge 30 m^3/s) to be released from the dam per year to aid the management of periphyton growth in reaches downstream of the dam.

The RWSS is controversial, and Hawke's Bay Regional Council (HBRC) have decided to undertake an additional review of the scheme. They have identified and agreed to review 24 specific issues, of which flushing flows is one.

1.2 Scope of the review

This independent peer review is to fulfil the requirement of HBRC to provide additional review of the proposed flushing flows. In particular this review focusses on:

- the efficacy of the proposed flushing flows, and
- the impact of losses to groundwater on flush effectiveness.

The following documents have been considered as part of the review:

- Ruataniwha water storage scheme: Aquatic ecology assessment of effects (Young et al. 2013).
- Ruataniwha Water Storage Scheme - Environmental Flow Optimisation (Ausseil et al. 2013).
- Statements of evidence presented by Roger Young and Olivier Ausseil that deal with flushing flows (Ausseil 2013, Young 2013).
- Goldsim Losing Reach Modelling Report (Pechey 2015).

These documents cover a broader subject than just flushing, but the review focuses solely on those aspects of the reports relating to the design of flushing flows and assessment of their effectiveness.

As well as the main documents listed above, several of their appendices are particularly relevant to this review of flushing flows and were examined in detail. These include:

- Appendices in the Ruataniwha Water Storage Scheme - Environmental Flow Optimisation report (Ausseil et al. 2013).
  - Appendix A: MIKE11 Modelling - memo prepared by Ir. Craig Goodier, Senior Design Engineer, Hawke's Bay Regional Council.
  - Appendix B: Memo relative to flow losses along the Waipawa River, prepared by Thomas Wilding, Senior Scientist –Hydrology (HBRC).
- Appendices in the Ruataniwha water storage scheme: Aquatic ecology assessment of effects report (Young et al. 2013).
  - Appendix 26: Calculations associated with flushing flow analyses within RHYHABSIM.
  - Appendix 28: The size of flushing flows required.
- Appendices in the Goldsim Losing Reach Modelling Report (Pechey 2015).
  - Appendix T: RWSS losing reach analysis – summary report – memo from David Leong to Graeme Hansen.

In addition to reviewing the documents and relevant appendices I have also discussed specific aspects of the analysis contained in the reports with other NIWA staff including: Dr Cathy Kilroy, a freshwater ecologist with expertise in periphyton; Geoff Holland, an environmental monitoring technician involved in the National River Water Quality Network (NRWQN) monitoring at the Tukituki and Makaroro sites; Dr Kit Rutherford, a catchment processes scientist who led development of the TRIM model of periphyton accrual in the Tuktuki River; and Dr Joanna Hoyle, a river geomorphologist who has recently completed new research into threshold flows for periphyton removal.

Following completion of my initial review HBRC requested that I extend the review by conducting additional analysis of available periphyton monitoring data from the Tukituki to provide further insight into the likely effectiveness of proposed flushing flows. I have completed this analysis and extended the original review letter (dated 29 March 2017) to include this analysis.

1.3 Review structure

The purpose of this review is to assess the science/engineering analysis relating to flushing flows presented within the reports. In order to focus on this cross-cutting theme this review is presented as a discussion of the evidence presented by the reports as a whole, with references to specific relevant sections of the documents where necessary. It does not review the reports individually, or address aspects such as report clarity, except where this impacts my understanding of the analysis presented. In the case of most of the reviewed reports they have already been subjected to peer review individually and it is not the purpose of this review to duplicate that process.

The two review focus areas are discussed under separate headings: Section 2: Efficacy of proposed flushing flows and Section 3: Impact of losses to groundwater on proposed flushing flow effectiveness. My additional analysis of observed periphyton data is presented within Section 2 as it relates to understanding the efficacy of proposed flushing flows.

2. Efficacy of proposed flushing flows

The flow required for effective removal of periphyton is assessed in four different ways in the reviewed reports. Appendix 28 of the aquatic ecology assessment of effects report (Young et al. 2013) applies three approaches based on hydraulics and hydrology to identify flow thresholds for effective flushing, while a fourth approach based on analysis of historic monitoring data is presented in the environmental flow optimisation report (Ausseil et al. 2013). I have summarised these four approaches and my opinions regarding their strengths and weaknesses in Table 1.

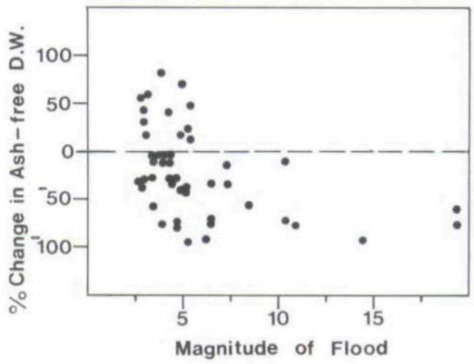

Figure 1: Change in observed periphyton biomass vs flood magnitude (as a multiple of preceding baseflow). Reproduced from Figure 7, Biggs & Close 1989.

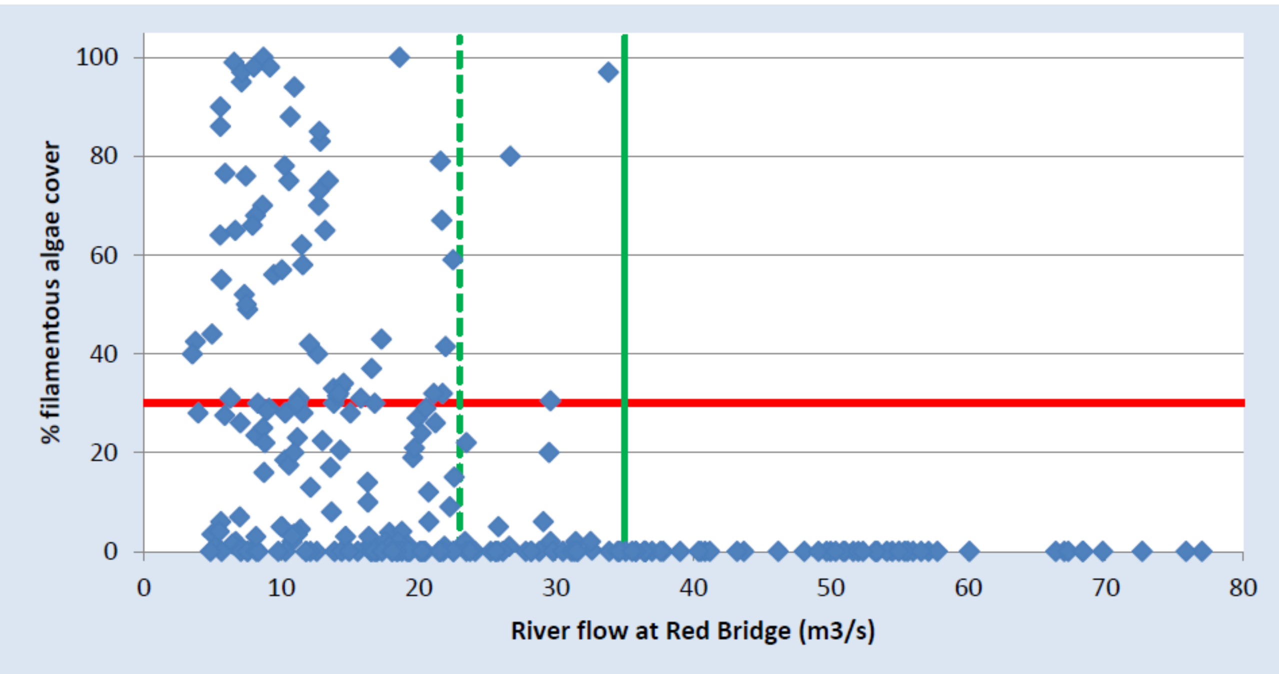

Figure 2: Filamentous algae coverage vs river flow on day of observation at Tukituki at Red Bridge. 1989-2012 data from NIWA's national river water quality network. Figure reproduced from Figure 10 of the environmental flow optimisation report (Ausseil et al. 2013). Red line shows 30% algae cover target in the proposed Tukituki Plan Change 6. Solid green line shows flow above which this algae cover target has never been exceeded. Dashed green line shows flows above which this target is rarely exceeded.

Table 1: Approaches applied to calculate threshold flows required for effective periphyton flushing

Approach:	1. Three times the median flow
Background:	Statistical analysis of observed periphyton biomass at 83 sites in New Zealand rivers identified that the average frequency of occurrence of flows three times the median flow (FRE3) explained a statistically significant amount of between-site variance in periphyton biomass (Clausen & Biggs 1997).
Strengths/ weaknesses:	While FRE3 shows merit statistically in between-river comparisons, it was not designed for site-specific analysis and can produce potentially large errors in threshold flow. Also, it is not clear what median flow should be used when applying this approach to a modified flow regime (i.e. original or modified).
Approach:	2. Six to eight times preceding baseflow
Background:	Analysis of data from fortnightly sampling of periphyton biomass in nine Canterbury rivers identified that floods peaking at greater than six times the preceding baseflow always resulted in a reduction in periphyton biomass. Figure 1 below shows the observed relationship between flow magnitude and change in periphyton biomass which this approach was developed from (Biggs & Close 1989).
Strengths/ weaknesses:	This approach is relevant for site specific analysis and was developed for rivers including the Canterbury foothills rivers Ashley, Opihi and Selwyn, which are reasonably similar to the Tukituki system. While flows six times the preceding baseflow all induce a reduction in observed biomass, this is not necessarily the same as effective flushing.
Approach:	3. RHYHABSIM analysis based on threshold dimensionless shear stresses for flushing
Background:	Analysis of observed bedload transport data in a gravel bed river (Oak Creek, Oregon, USA) identified threshold dimensionless shear stresses for sand removal from the bed surface, "surface flushing" (Milhous 1998). The calculation of dimensionless shear stress is a function of substrate size and shear stress. The application of this approach in RHYHABSIM is described in Appendix 26 of the aquatic ecology assessment of effects report (Young et al. 2013).
Strengths/ weaknesses:	Unlike the other approaches this approach is physically based, i.e. it considers the mechanism of periphyton removal – which is assumed implicitly to be abrasion by mobile sand - and is based on river hydraulics. As the calculation includes the effect of substrate size this approach has the capability to test how flush effectiveness is likely to change as a result of bed armouring. Due to variations in shear stress across the channel this method does not identify a single threshold for effective flushing, but instead quantifies the proportion of the baseflow channel which would be effectively flushed under different flows. Disadvantages are that this approach was not designed to quantify thresholds for periphyton removal, but rather for maintenance of fish spawning habitat. The assumption in this application is that 'surface flushing' is sufficient to also remove periphyton.
Approach:	4. Plot of observed filamentous algae cover vs river flow in the Tukituki at Red Bridge
Background:	The long term national river water quality network (NRWQN) dataset collected by NIWA since 1989 includes a monitoring site on the Tukituki at Red Bridge. By plotting % filamentous algae cover verses river flow (see Figure 2) it is possible to identify the flow above which there are few/no measurements of algae cover that exceed the 30% cover target in the proposed Tukituki Plan Change 6.
Strengths/ weaknesses:	This analysis is particularly valuable since it is specific to the Tukituki and based on a long record of observed periphyton data. The data at the Red Bridge monitoring site is collected at a consistent location on the river irrespective of flow (Geoff Holland, pers. comm.) so should be free of bias which affects this type of analysis elsewhere. One weakness acknowledged by the environmental flow optimisation report is that "*Periphyton removal by flow events is of course determined not only by the flow on the day the observation is made, but also by the flow history in the 2 to 3 weeks period preceding the observation*" (Ausseil et al. 2013).

By applying multiple approaches the reports have done a good job of trying to understand the uncertainty inherent in trying to predict threshold flows for effective flushing. I have attempted to collate/summarise the required flushing flows identified using the different approaches in Table 2.

Table 2: Summary of flushing flow requirements identified in reviewed reports. Flushing flow thresholds requirements identified using each of the four approaches described in Table 1 are presented as well as the recommended flow identified in the aquatic ecology assessment of effects report (Young et al. 2013). 'NA' indicates where it was not possible to apply a particular approach due to lack of data and dashes indicate where I could not find the relevant value in any of the reviewed reports.

Location	Assumed baseflow (m^3/s)	Flushing flow required (m^3/s)				
		Approach 1.	Approach 2.	Approach 3. †	Approach 4.	Recommended flow‡
Makaroro	1.2	10	7.2-9.6	12 (72%)	NA	10*
Waipawa upstream of irrigation	3.9	28	23-31	20 (82%)	NA	20
Waipawa downstream of irrigation	3.2	15	19-26	30 (90%)	NA	20
Waipawa at RDS	-	18	-	NA	NA	20
Tukituki at Red Bridge	6.3	65	38-50	150 (80%)	23-34	50

† Percentages in brackets indicate the proportion of baseflow channel with dimensionless shear stress exceeding the threshold for 'surface flushing' at the specified flow. The flows and corresponding percentages in the table are taken from the text of Appendix 28 of the aquatic ecology assessment of effects report and generally correspond to the point at which the relationship between flow and flush effectiveness flattens out (i.e. increasing flow beyond this point results in little improvement in flush effectiveness). The full flow vs percent effectiveness curves which are presented in the appendix.

‡ How the 'recommended flow' is selected based on the alternative approaches is not explicitly defined in the aquatic ecology assessment of effects report.

* It is identified in the aquatic ecology assessment of effects report that this flow would not achieve effective flushing when the Makaroro flow has been released at or close to the irrigation demand/design generation flow (approximately 11 m^3/s) for an extended period of time.

Approach 4 is likely to provide the most reliable estimate of required flushing flows as it is based on observed periphyton response, unfortunately this approach is only possible where there is periphyton data. To further validate the analysis presented in the reports I have conducted additional analysis of available periphyton monitoring data using Approach 4. My analysis differs from previous analysis in two main ways:

1. I have considered the effect of high flow events in the days leading up to the periphyton measurement, rather than just the flow on the day of the measurement. This addresses the weakness identified in the environmental flow optimisation report and referred to in Table 1 (Ausseil et al. 2013).

2. I have made use of new data, collected since the original analysis was completed. This includes data from HBRC periphyton monitoring sites (available since January 2013), as well as the long term NRWQN Tukituki at Red Bridge site monitored by NIWA.

Key plots from my analysis of the NRWQN periphyton data is shown in Figure 3, and Figure 4 shows analysis of the HBRC periphyton data. The NRWQN periphyton data is a visual estimate of periphyton cover in two classes, filamentous and mats. The HBRC periphyton monitoring data includes more sites and a greater range of periphyton parameters than the NRWQN data, although it is available for a much shorter period of record. Due to limited time available to undertake this analysis I have focussed on three parameters (total cover, *Phormidium* cover and chlorophyll a) and two sites (Tukituki at Red Bridge and Waipawa at SH2) when analysing the HBRC data. Both total cover and *Phormidium* cover are based on visual estimates whereas chlorophyll a is based on analysis of samples scraped from rocks on the river bed (for a description of HBRC periphyton data collection see Ausseil et al. 2016). When analysing total periphyton cover I have excluded 'film' as this is thin periphyton which has less nuisance impacts than other periphyton classes.

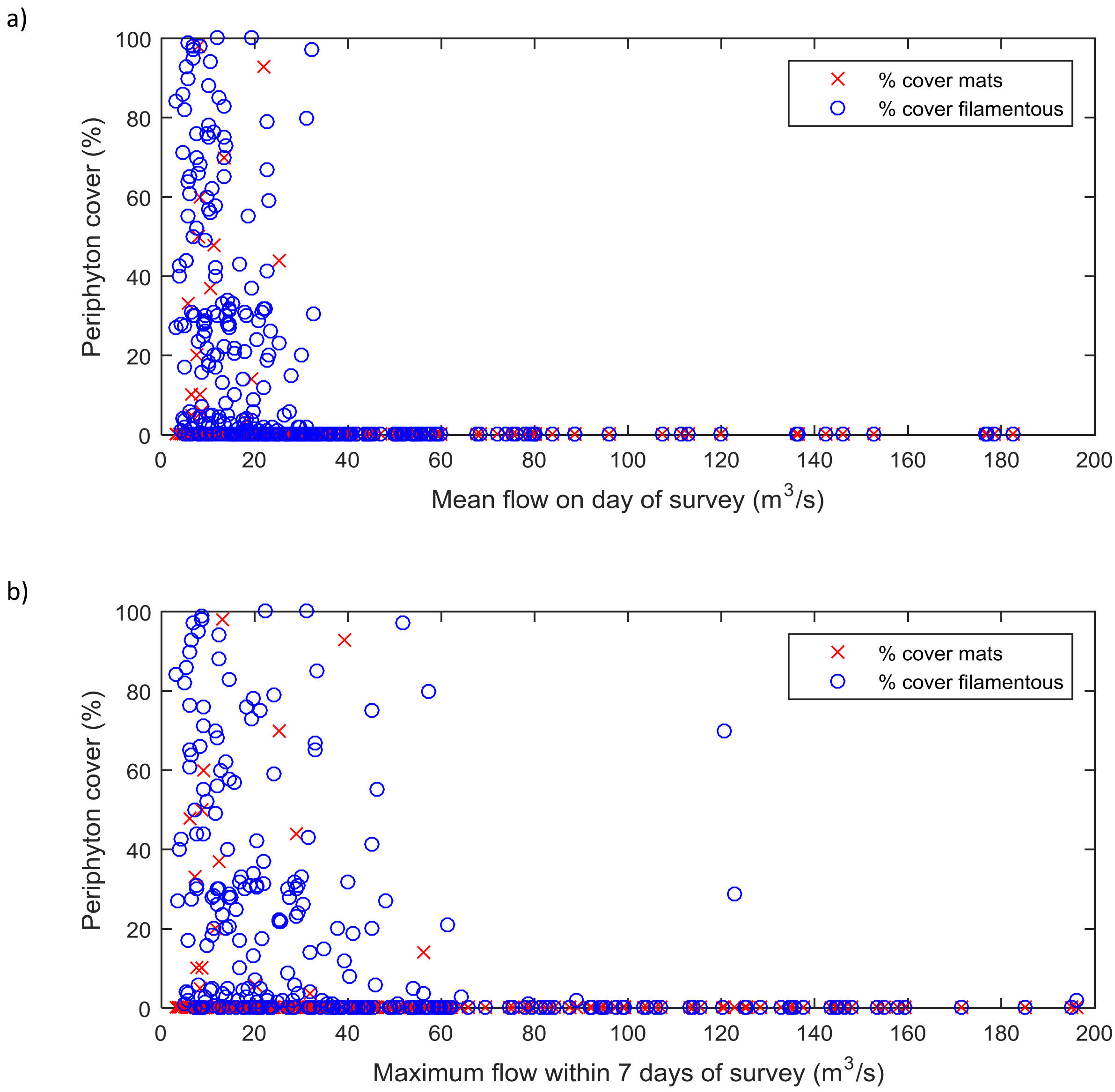

Figure 3 Analysis of NRWQN periphyton cover vs (a) current and (b) maximum preceding flow for Tukituki at Red Bridge

a)

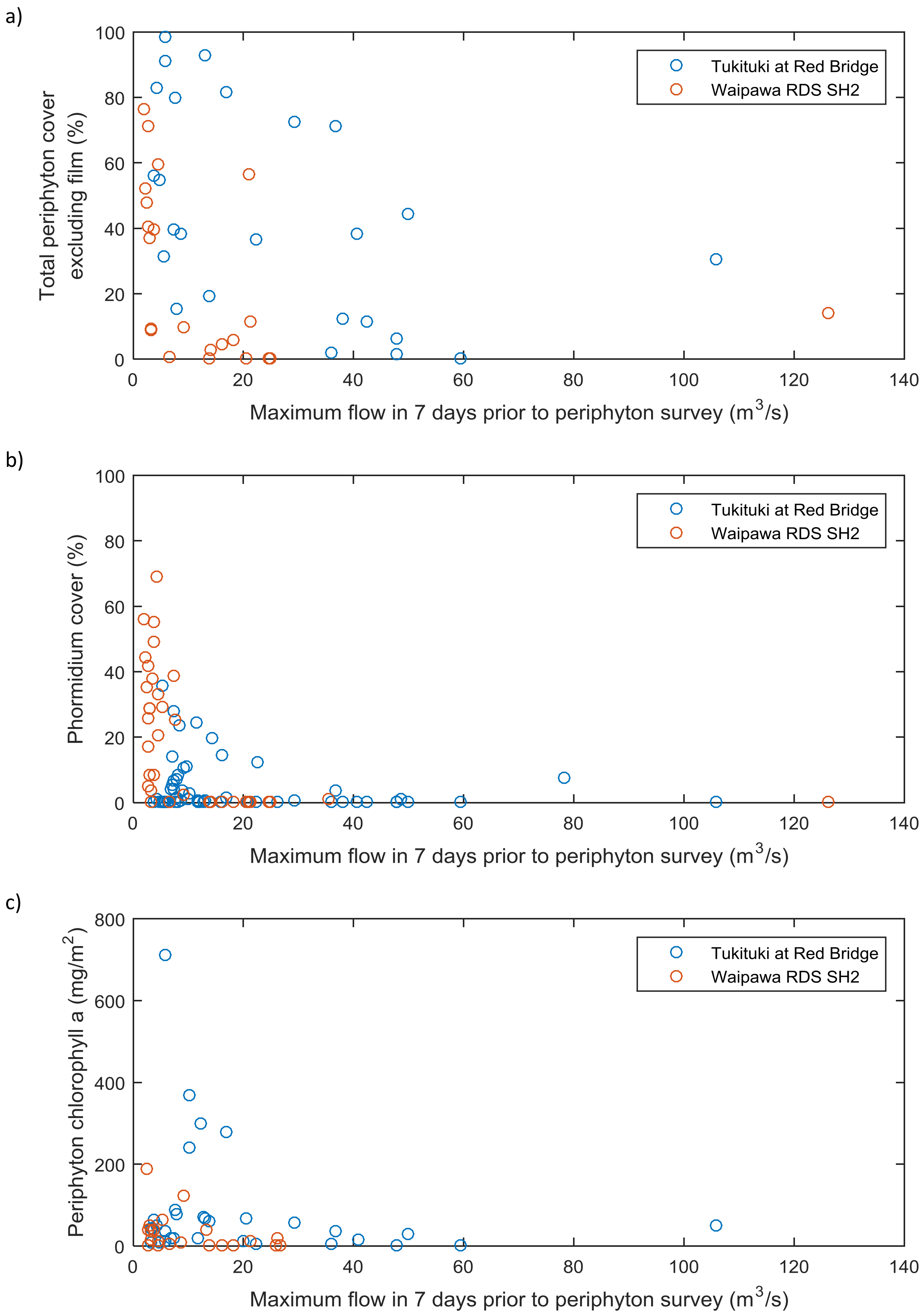

Figure 4 Analysis of HBRC Periphyton data vs preceding flow for Tukituki at Red Bridge and Waipawa at RDS SH2 monitoring sites

The analysis of NRWQN data shown in Figure 3a, which compares periphyton cover to flows observed on the day of monitoring, is very consistent with Figure 2 and suggests that flushing flows greater than 37 m^3/s are always effective on the Tukituki. However, expanding the analysis to include peak flow in the 7 days prior to the periphyton sampling, as shown in Figure 3b, clearly shows that even flows up to 120 m^3/s are not always effective at removing filamentous algae. In my opinion Figure 3b is the more reliable analysis as it is based on the reasonable assumption that regrowth to high levels of periphyton coverage within 7 days of an effective flushing flow is unlikely.

In my analysis of the HBRC data I only present results based on the maximum flow in the 7 days prior to the flush. Figure 4a, b and c show total periphyton cover, *Phormidium* cover and periphyton chlorophyll a respectively. Figure 4a indicates increasing flush effectiveness with flow but that at both sites flows in excess of 100 m^3/s may not always result in full flushing. There is only a single data point for flows greater than 60 m^3/s on the Tukituki and 25 m^3/s on the Waipawa so analysis of high flows is very uncertain. Figure 4b and c suggest that significant lower flows are required to effectively flush *Phormidium* and reduce chlorophyll a to low levels than to reduce total periphyton to low levels. This is reassuring in that it suggests although total cover may remain significant at more moderate flushing flows of 20-30 m^3/s in the Tukituki and 10-15 m^3/s in the Waipawa, cover of Phormidium, and the mass of periphyton on the bed, will be significantly reduced.

In general my analysis of observed periphyton data shows that, depending on the parameter being considered (total periphyton cover, *Phormidium* cover, or chlorophyll a), effective flushing flows lie within the range of values given in the reports (see Table 2), but significant uncertainty remains.

There are a few small inconsistencies/weakness in the application of the different approaches to the calculation of required flushing flows which could be improved:

- **No consideration of the effect of bed armouring:** Elsewhere in the reports (e.g. section 3.4.3.1, Young et al. 2013) it is identified that bed coarsening is one likely impact downstream of the dam, and estimates are presented of the possible magnitude of this effect. A lack of sand and/or fine gravel in the river bed, particularly in the Makaroro, is likely to make it harder to flush periphyton from the river bed. This would occur through two effects. First, armouring will increase the 'hiding factor' for sand entrainment, increasing the threshold stress. Second, the flush effectiveness will depend on the physical availability of fine sediment (if there's none there to entrain, then there would be no abrasion). The sensitivity of flush effectiveness to grain size could be investigated within a threshold shear stress type analysis (such as approach 3). However, I consider the importance of this omission relatively minor as the proposed flushing flows (25-30 m^3/s) significantly exceed the identified requirements in the Makaroro, which is likely to be most impacted by armouring.

- **Low assumed pre-flush baseflow:** The assumed pre-flush baseflow under which periphyton accrual occurs is important in the application of both Approach 2 and Approach 3. In the application of these approaches the lowest baseflow is used, but this is not always consistent with the time of year when maximum growth rates are expected. For example in the Waipawa upstream of the intake a baseflow of 3.9 m^3/s is assumed in the analysis, which is the mean monthly low flow for March, April and May, but during the summer months of December, January and February, the mean monthly low flow is approximately 4.5 m^3/s, and the median flow is approximately 10 m^3/s. Applying these higher baseflows in the analysis would result in the identification of higher flushing flow requirements.

- **Details of RHYHABSIM shear stress calculation:** River hydraulics and shear stress can be calculated in a number of ways within RHYHABSIM and there is insufficient detail in Appendix 26 of the aquatic ecology assessment of effects report to determine full details of the calculation. For example there is no information on how slope was determined in the calculation of shear stress at each cross-section. There is not necessarily a weakness in the calculation it has prevented full review of this analysis.

The main health risks associated with nuisance periphyton are linked to the deposition of detached mats along river margins during flow recession. I note that both the environmental flow optimisation report and evidence presented by Olivier Ausseil (Ausseil 2013, Ausseil et al. 2013) refer to outputs from a HBRC workshop which identified that even moderate sized flood events could substantially reduce the public health risk by removing these. I agree that this is a possible mechanism whereby flushes which are not large enough to be fully effective at removing well attached periphyton could still have a significant benefit. However it should also be recognised that flushes themselves have the potential to deposit algae on the recession if they are not continued for long enough. This has been observed during some trial flushes I have been involved in on the Opuha/Opihi river system (e.g. Figure 5).

Figure 5: Periphyton deposits on the channel margins after the February 2013 trial flush in the Opuha River

Overall, the reports do a good job of assessing the required flows for effective flushing using a range of different techniques. It should, however, be noted that predicting the effectiveness of flushing flows with high certainty is very challenging, and significant uncertainty is present in all of the approaches applied. This uncertainty is recognised by Roger Young in his statement of evidence to the board of inquiry:

> "*I recognise that there is some uncertainty about how much of the riverbed will be able to be flushed by these flushing flows, but note that their effectiveness will be assessed using a monitoring programme that has been incorporated into the consent conditions for the RWSS*" (Young 2013).

Monitoring for the purposes of optimising the use of flushing flows is also recommended by Olivier Ausseil:

"*I agree that monitoring data of actual flushing flows would be very useful and would assist the optimisation of their use, and have recommended that detailed monitoring of periphyton abundance be undertaken before and after flushing flows*" (Ausseil 2013).

I am concerned, however, that the proposed flushing flows are already the maximum that it is possible to release with the proposed dam design, so there is no capacity for bigger flushing flows if monitoring identifies that this would be beneficial. This has parallels with the Opuha Dam in South Canterbury where dam design limits the capability to adaptively manage nuisance periphyton with flushing flows (Lessard et al. 2012).

One final thought regarding flushing flow effectiveness is that if didymo were to become established and proliferate in the Tukituki system this would significantly change the periphyton dynamics, and likely make effective flushing more challenging. I note that in an assessment of didymo presence in relation to water chemistry it was identified that the Makaroro at Burnt Bridge is one of the top five NRWQN sites in the North Island most vulnerable to didymo (Kilroy & Unwin 2013). Again, the scheme has no capacity for larger flushing flows should didymo require them.

3. Impact of losses to groundwater on proposed flushing flow effectiveness

As flushing flows travel downstream they are attenuated by the flushing wave spreading in time and space, and by infiltration into the river bed/banks. The attenuation due to wave spreading has been modelled and is reported on in Appendix A of the environmental flow optimisation report (Ausseil et al. 2013). While there is relatively little detail of the model presented I am familiar with the capabilities of the modelling software used (Mike-11) and am confident that this modelling approach can accurately account for attenuation due to flood wave spreading.

Conceptually, losses due to infiltration can be classified as steady-state losses or transient losses. Steady-state losses are losses that would occur under steady/constant river flows. During a flushing flow there are likely to be additional short term losses into gravels adjacent to the river channel. This is termed "bank storage" in Appendix T of the Goldsim losing reach modelling report (Pechey 2015) and is illustrated conceptually in Figure 3 of that appendix (reproduced in this review as Figure 6).

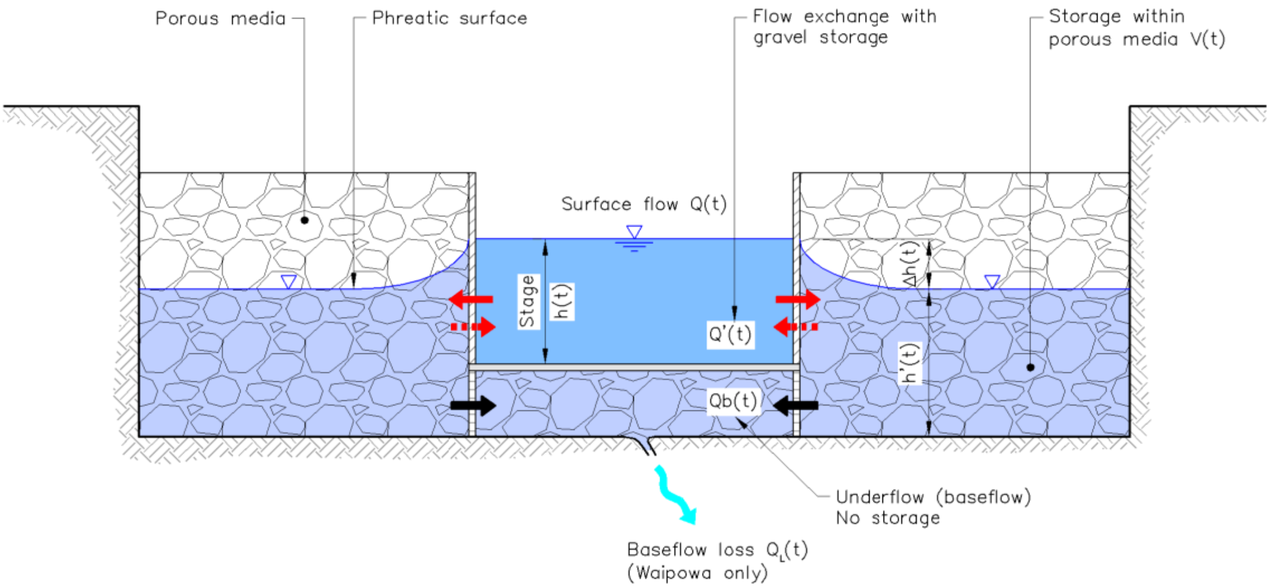

Figure 6: Conceptual model of losing reach including river flow – gravel storage interaction. Reproduced from Figure 3 of Appendix T of the Goldsim losing reach modelling report (Pechey 2015).

Steady-state losses are discussed in Appendix B of the environmental flow optimisation report (Ausseil et al. 2013). This appendix contains an analysis based on the relationship between upstream flow and reach losses/gains developed from concurrent gaugings at different locations collected during steady-state flows. This appendix identifies that steady-state losses and gains in the Waipawa vary approximately linearly with flow. It also identifies that during flushing flows additional steady-state losses are likely to be realised, but additional gains are unlikely to occur as groundwater levels will not have had time to respond. An example of this effect is presented in the appendix for a flushing flow of 15 m^3/s preceded by a baseflow of 5 m^3/s, but there is no calculation presented for the proposed flushing flow magnitude (30m^3/s). Using the relationships presented, I have calculated that steady-state net losses of 2.4 m^3/s are likely for a flush of the magnitude presented in the main report Figure 12 (losing reach losses of 6.0 m^3/s at flush peak of 35 m^3/s, followed by gains of 3.6 m^3/s calculated based on the preceding 5 m^3/s steady baseflow). As noted in the appendix this calculation involves extrapolating the relationships well outside the range of flows for which they were developed which introduces some additional uncertainty.

Neither Appendix B nor the main body of the environmental flow optimisation report (Ausseil et al. 2013) recognises the potential for additional transient losses due to bank storage. It should also be noted that despite the detailed analysis of changes in steady-state losses during flushing in Appendix B, the main body of the report incorrectly states that additional steady-state losses from flushes to groundwater would be up to 1 m^3/s greater than during preceding baseflow, whereas my calculations based on the equations in Appendix B show losses of 2.4 m^3/s.

Appendix T of the Goldsim losing reach modelling report (Pechey 2015) is the only place in any of the reviewed reports where transient losses from flushing flows due to bank storage are explicitly considered. That appendix describes the losses conceptually and explains how they were included in the model. Continuous monitoring of flows at a number of temporary flow sites for 50 days to investigate gains and losses. Critically, as this monitoring was continuous and included various rain events, it provides information on transient losses. This is a significant advantage over spot gaugings during periods of steady flow. Small flow events monitored on 8 and 12 March 2015 provide examples of moderate events after an extended dry period. The report identifies that these can be used to give guidance to flushing flow design. These events are shown in Figure 7 (reproduced from Appendix T, Pechey 2015).

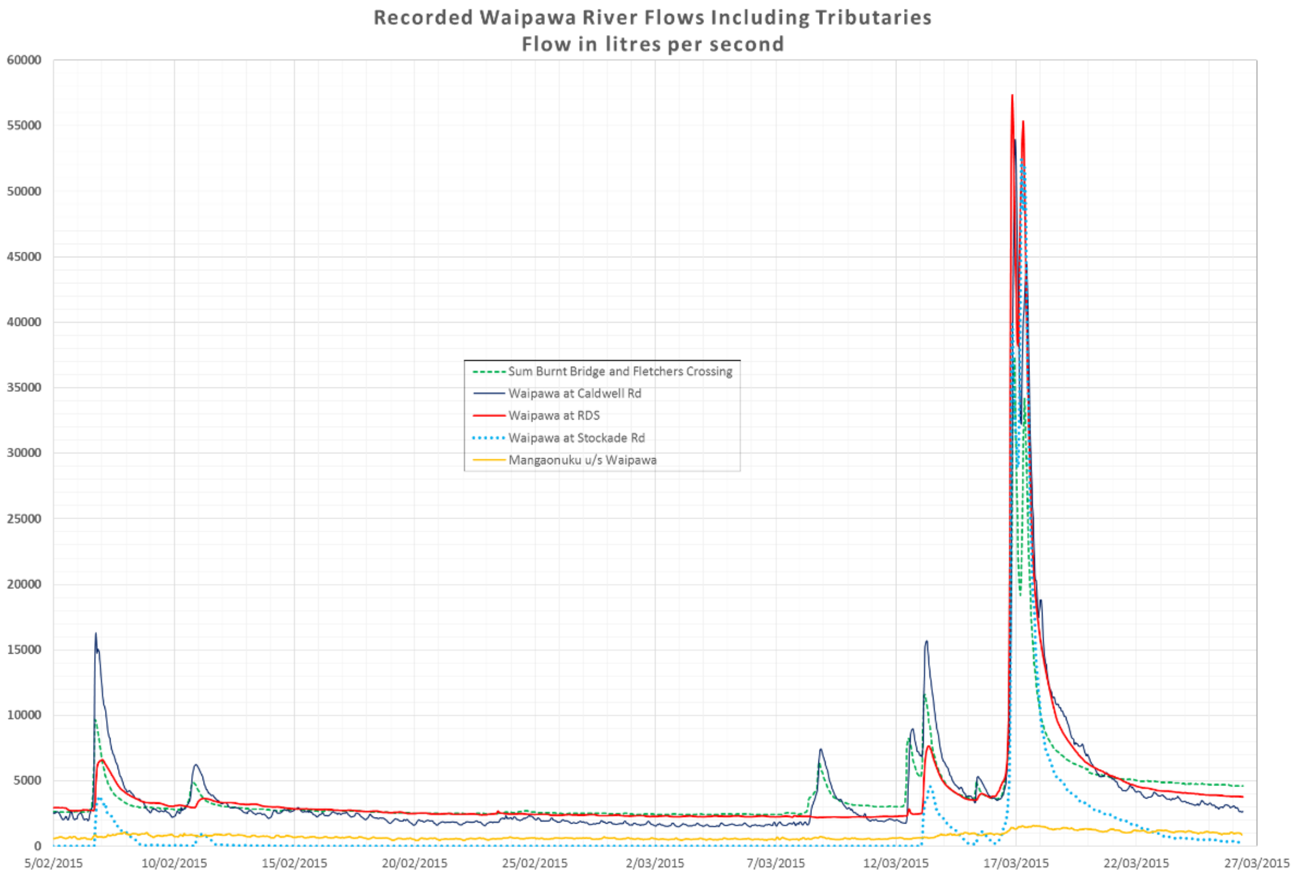

Figure 7: Recorded flows in the Waipawa River including its tributaries 5 February to 26 March 2015. Reproduced from Figure 4 of Appendix T in the Goldsim Losing Reach Modelling Report (Pechey 2015). Note that individual hydrographs have been shifted in time such that flow peaks line up. The order of sites from upstream to downstream is: (1) sum of Burnt Bridge and Fletchers crossing, (2) Caldwell Rd, (3) Stockade Rd, and (4) RDS.

There is no further analysis of the impact of transient losses on flushing flow attenuation presented in Appendix T or the main body of the Goldsim losing reach model report (Pechey 2015). However, flow losses between the monitored sites for the events on 8 and 12 March 2015 can be can be quantified from the flow hydrographs (reproduced in Figure 7). During the 8 March event the entire flow pulse (5.5 m^3/s above preceding baseflow) was lost between Caldwell Road and Stockade Rd, and during the 12 March event peak flow was attenuated from 14 m^3/s above preceding baseflow to 5 m^3/s above preceding baseflow for the same reach. Without knowing the details of these events (spatial and temporal rainfall patterns etc.) it is difficult to assess their similarity to the proposed flushing flows. For example there may have been additional inflows into the losing reaches during these natural events which would not happen in an artificial flush. Despite this uncertainty it is clear that the observed total losses in the Waipawa recorded during these events (up to 9 m^3/s) are much greater than the predicted steady state losses (~1 m^3/s for these events based on Appendix B of the environmental flow optimisation report, Ausseil et al. 2013). This discrepancy indicates that transient losses during flushing could be important.

4. Conclusions

My review of reports, appendices and evidence around the RWSS shows that a generally thorough analysis has been undertaken, using a range of different approaches, to identify the flushing flows required to effectively remove nuisance periphyton at different locations down the Makaroro-Waipawa-Tukituki system. These show that unless transient losses to ‘bank storage’ significantly attenuate peak flows, the proposed flushing flows of 30 m^3/s for 9 hours should exceed the predicted thresholds for effective flushing in the Makaroro and Waipawa. In the Tukituki the reports recognise that this flow alone will not be completely effective but by piggy backing flushes onto natural freshes their effectiveness can be maximised.

I have two main concerns regarding the proposed flushing regime:

- The effect of transient losses to ‘bank storage’ has not been assessed. Based on the continuous monitoring of flow gains and losses between sites on the Waipawa presented in Appendix T of the Goldsim losing reach modelling report (Pechey 2015), it appears possible that transient losses during short duration flow events could significantly reduce flush peak flow, to the extent that flush effectiveness would be impacted.
- The proposed flushing flow is the maximum that can be released by the proposed dam design. This means it would not be possible to increase higher peak flows, even if monitoring of flush effectiveness (proposed as a consent condition) identified that this would be beneficial, or if an unexpected change within the catchment (such as didymo becoming established) required a change in flush magnitude. This limitation on adaptive management is similar to what has occurred with flushing flows downstream of the Opuha Dam (Lessard et al. 2012), and it would be unfortunate if the Opuha lessons went unlearnt.

5. Recommendations

I recommend that the model of losing reach behaviour which has been developed and calibrated for the Waipawa/Tukituki system, and then implemented in the Goldsim model (Appendix T, Pechey 2015), should be used to investigate the effect of losing reaches on the proposed flushing releases. The model appears to show good skill in replicating losses associated with transient flows (e.g. Figure 7, Appendix T, Pechey 2015), and simulation of flushing flows under a range of background river flows would provide valuable insight into expected flush attenuation including transient losses.

I feel that it would be valuable to give some consideration to whether it is possible to modify dam design to allow greater flexibility to release larger flushes if required, or at least whether it would be possible to modify the dam to do this at a later date should it be required.

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Yours sincerely,

Richard Measures
Hydrodynamics Scientist

Letter internally peer reviewed by:

Dr Murray Hicks
Principle Scientist – River and Coastal Geomorphology

NIWA Project code: HBR17502

19. High level assessment of the available storage capacity if the scheme is altered to keep the reservoir below the DOC land and not impact on currently approved consents, and associated impacts on capital requirements, distribution, revenue and expenditure.

There are essentially three factors to consider with respect to the dam location chosen for the Ruataniwha Water Storage Scheme. These are:

- technical feasibility, with site geotechnical conditions and proximity to faults particularly limiting,
- the cost of the dam, generally related to the volume of the dam material itself, and
- the amount of water stored in the reservoir.

The responses to this question will address these factors. Over the course of selecting the ideal dam location during the feasibility study, these factors and a number of others were considered to ensure that the location selected was optimal.

In addition, specific studies addressed other dam locations which would avoid inundating areas of the DOC land. An investigation was recently undertaken to determine the maximum volume able to be stored within the current consented dam site location, without requiring the sections of DOC land within the Makaroro River or Dutch Creek sites to be affected.

Location of the DOC land in relation to the dam

The most downstream position of the DOC land is approximately 4 km upstream of the current dam site (see figure 4). This is compared to the total reservoir length of 6.6 km. The lowest section of DOC land is 32 m lower in elevation (438 m) than the proposed maximum reservoir storage level, which infers that only a 51 m height dam can be constructed, if the current dam location is used. This is compared with the 83 m dam structure proposed.

Dam material volume and costs.

The total capital cost of the RWSS is currently estimated at $345 M. The capital cost for the dam itself is $130 M, or approximately 40% of the total cost. If the dam was reduced in height to 51 m to avoid the DOC land, its cost is estimated to amount to $111 M, a $19 M or 15% reduction. However, this cost saving is associated with an 80% reduction in the reservoir volume, with the 51 m option providing only 18 million cubic metres (Mm^3) of storage.

The total project costs for the various project components are:

- $130 M dam,
- $162 M headrace and to farm distribution, and
- $53 M developments costs, land and other capitalised costs.

Reservoir storage

A review of the reservoir storage-volume curve for the current dam site indicates that a maximum volume of 18 Mm³ is able to be stored for a 51 m high dam that does not impact the DOC land (see Figure 1 below). This is compared to 91 Mm³ for the chosen and consented 83 m high design.

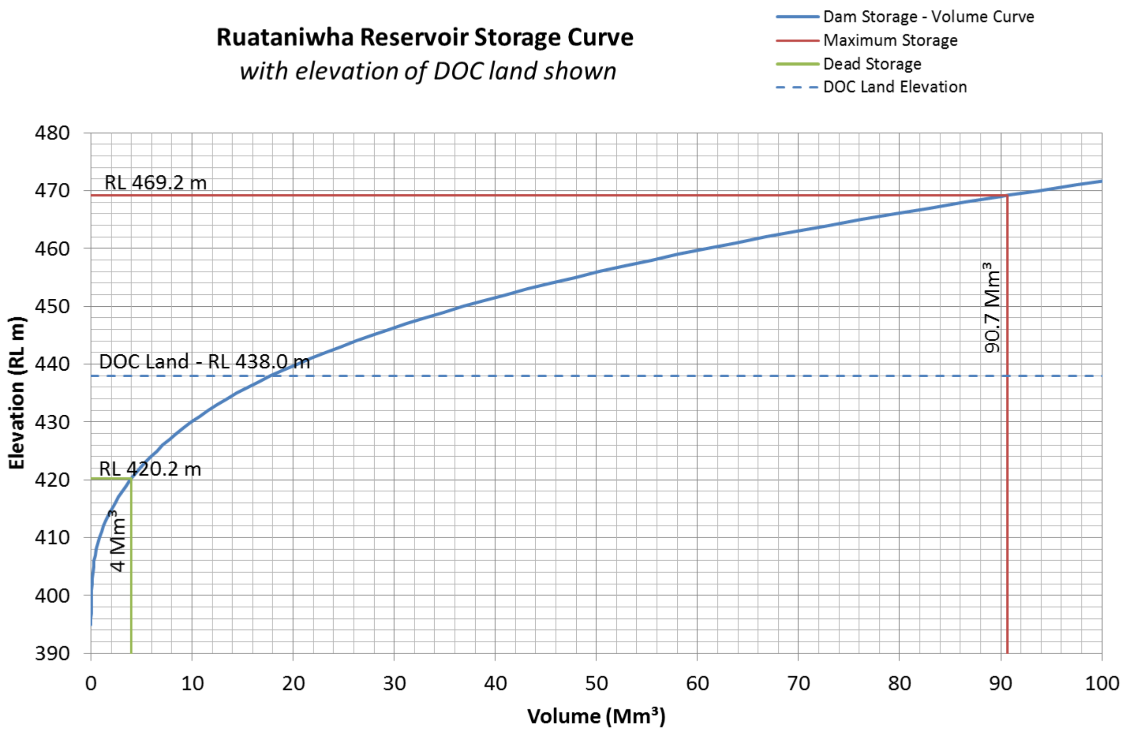

Figure 1- RWSS reservoir storage curve

Other dam site options

A further assessment was made to determine if a viable site (which could provide the equivalent 91 Mm³ storage, and apart from technical feasibility) downstream of the consented location could be identified.

This exercise identified a site 3 km downstream of the current dam site (refer map in figure 4) which made it possible to avoid the DOC land. However, due to the conditions at that location the dam could only be constructed to a maximum height of 72 m and provide 60 Mm³ of available storage.

The relocated position of the dam site falls outside the current consented envelope for the current site and therefore would require additional consents, landowner approvals and land-taking requirements. The dam structure is also substantially longer at 650m, when compared with the currently proposed dam length of 400m and this increased construction volume significantly impacts the project's capital cost.

To construct a 72 m high dam at this location is estimated to cost $165 M. However, this does not take into account the extra costs which would be required for the redesign, consenting, approvals, etc.

Geotechnical suitability

As part of the advanced pre-feasibility studies (T+T, 2010), several sites on a 3 km reach of the river within the greywacke block east of the Ohara Depression were investigated, involving two separate geological walkover inspections. Figure 2 shows several of the potential storage options that were assessed; the initial site investigated, labelled A7e, was found to be unsuitable because of large scale landsliding debris on the true left abutment. Site A7h, the most upstream site assessed, was adopted as the preferred option on the Makaroro River after the second visit to this reach of the river. This is the currently consented dam site.

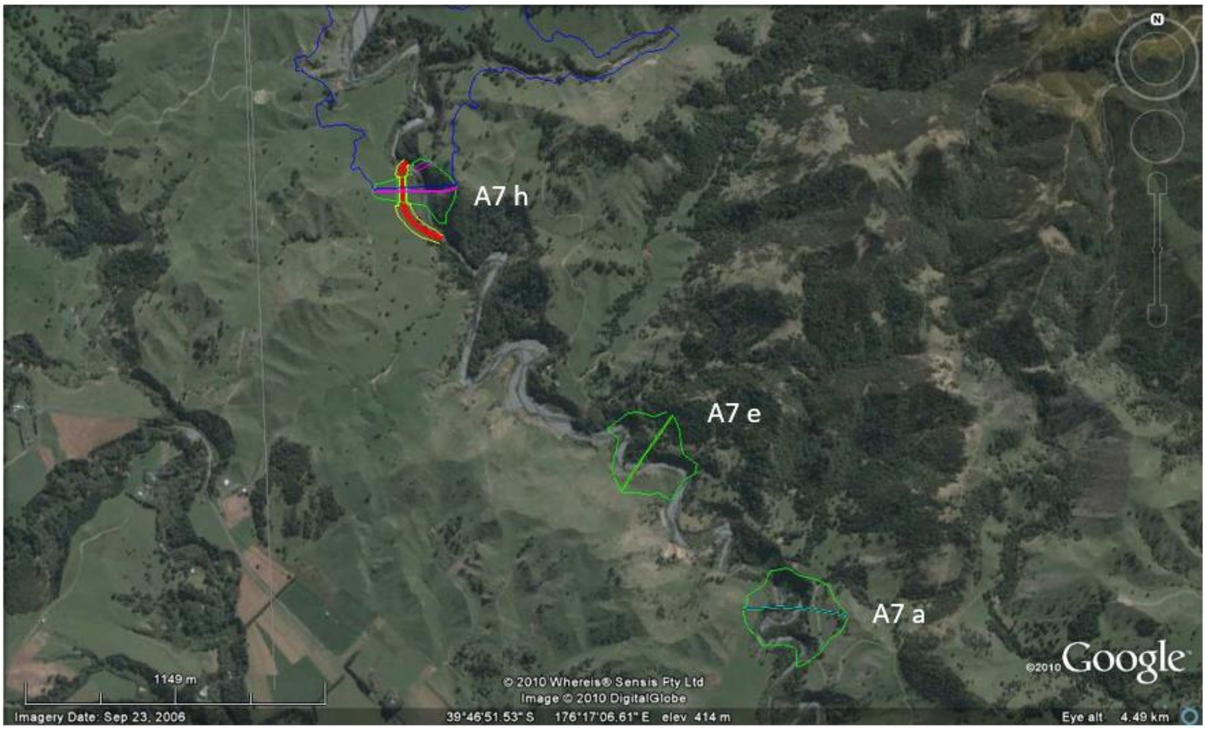

Figure 2 – Three of the five dam sites investigated on the Makaroro River (A7) in the advanced prefeasibility (T+T, 2010)

Summary of dam options

Table 1 outlines the options, reservoir volumes and potential issues for the considered dam locations.

Table 1 – Summary of dam site options

Option	Dam height	Volume stored (million cubic metres)	Construction cost $ M	Construction cost Mm³ stored	Consent implications
A	83 m	91	130	$1.43	Ok

B	51 m (upstream solution)	19	111	$5.84	Ok
C	72 m (downstream solution)	60	165	$2.75	New consents required

Another way to visualise the above information is presented in figure 3,

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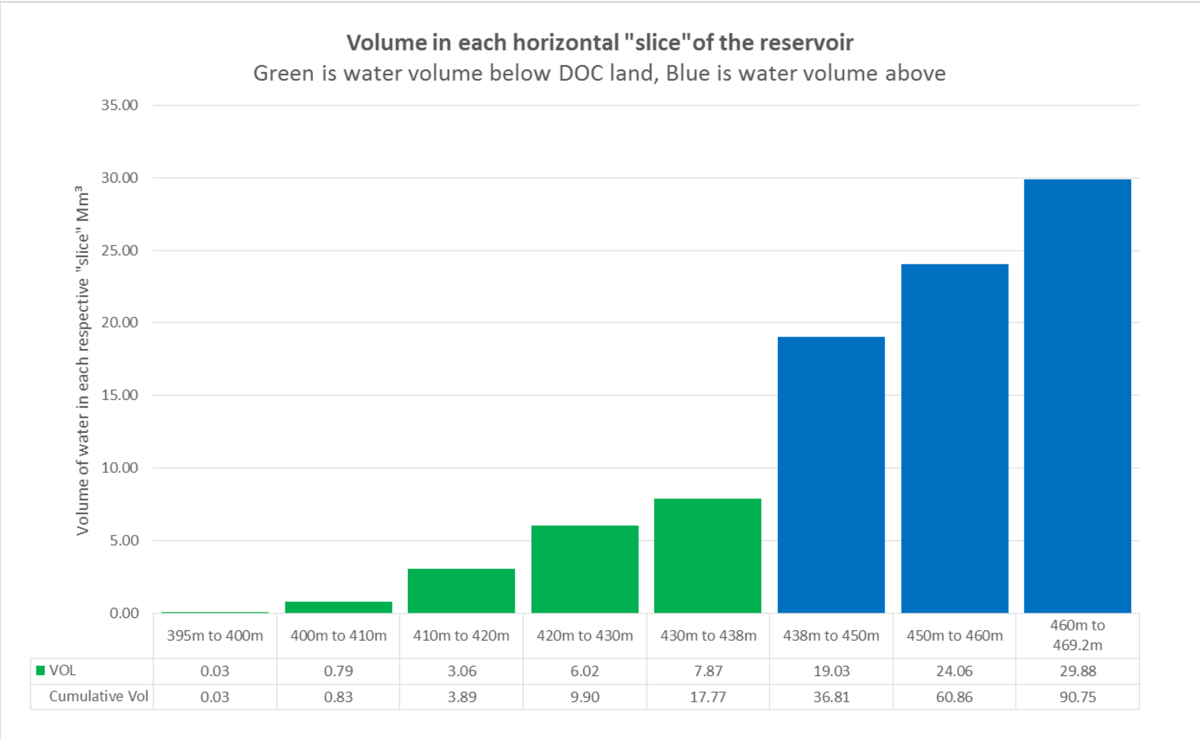


Figure 3- RWSS volume of water stored in each reservoir slice.

This shows that in the deep parts of the reservoir, the volume of water stored is relatively minor. In addition, a portion of the reservoir called the “dead zone” of 4Mm3 is intended to be filled in by the long term disposition of sediment.

Therefore, the majority of the water stored is in the upper parts of the reservoir. These are the areas that are above the elevation of the DOC land and shown in the chart with the blue bars. Essentially there is 17.8 Mm^3 stored at elevation 438.0 m or lower (max. DOC land elevation), and 73.0 Mm^3 stored at the elevation of the DOC land and above.

The image below shows the current consented dam and reservoir extent for 90 million m^3 of storage, in green. The reservoir extent for a 51 m high dam is shown in blue. Here it can be seen that the reservoir is significantly reduced in terms of area.

The alternative, downstream dam location is also shown, with the associated reservoir extent. The footprint of the dam itself can be seen and is considerably larger in both area and volume, due to the wider river channel and topographical conditions. This option can store 60 Mm³, compared to the original consented 90.7 Mm³ design with 83 m high dam.

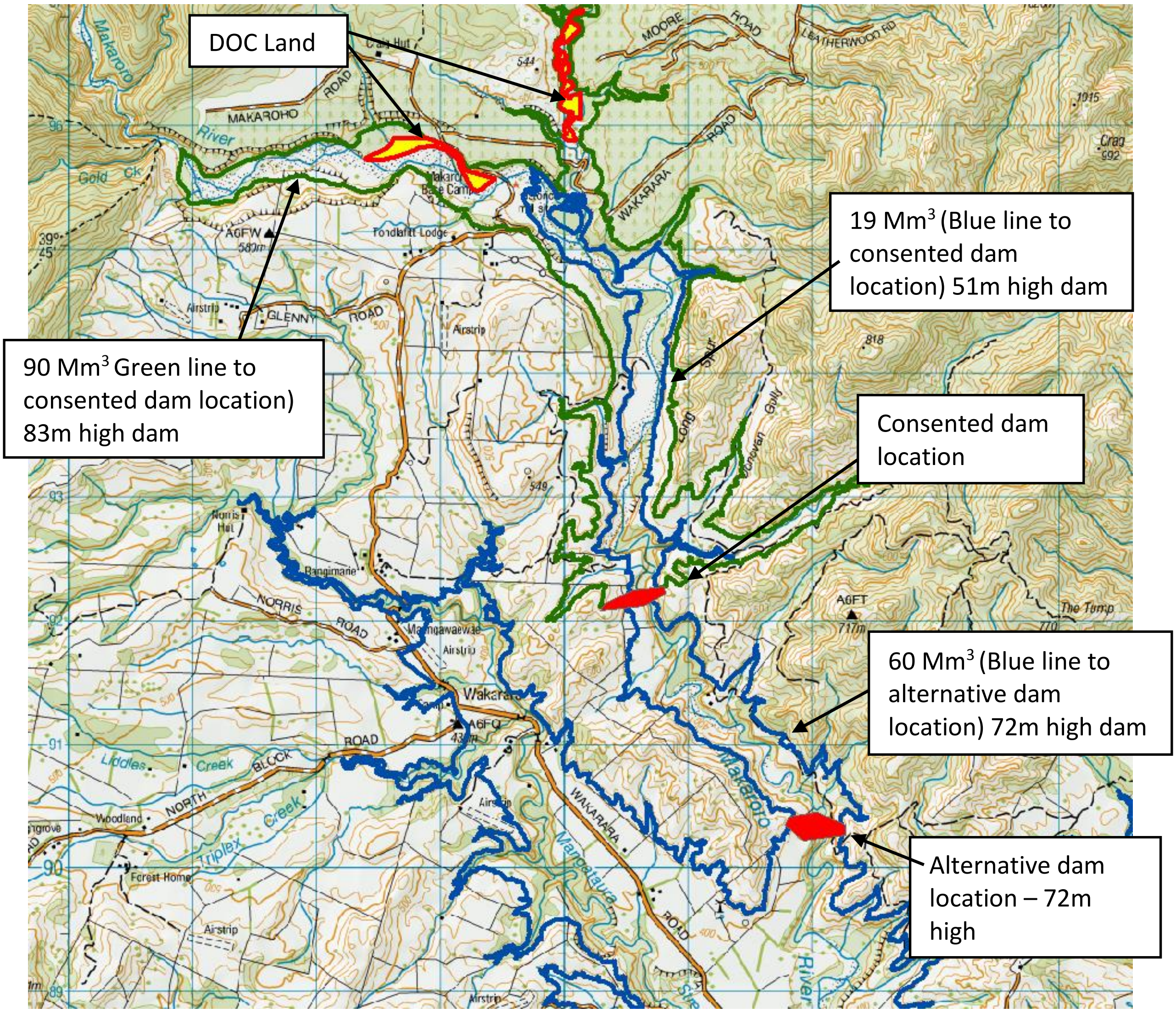


Figure 4- Topographical map showing reservoir extents at different water levels

Conclusion

This analysis confirms and reinforces the work completed during the prefeasibility and feasibility phases of the project where a number of potential dam sites were identified and investigated, rationalising storage volumes, geotechnical issues and dam sizes, and the further work completed during the tender phase where more refined work on more specific dam site locations, optimised storage volumes and dam structure arrangements were undertaken.

Reducing the height of the dam, or relocating the dam to a different location, if a technically feasible site can be found, will have a negative effect of project economics. This is because there is a large reduction in the volume of water stored in the reservoir (which is sold to pay back the scheme) for a minor cost saving realized.

20. High level assessment of alternative dam sites off river main stems and assessment of specific on-farm storage options, including impacts on distribution costs and revenue, and impacts on primary production output.

Alternative dam site options

This issue has been approached using the current Makaroro dam site and Ruataniwha plains distribution system as the benchmark (base case) for alternative dam type comparisons. The analysis has assumed Large scale storage constructed at the base of the Ruahine Ranges as being the base case. Moderate scale storage has assumed smaller community type dams constructed within the adjacent foothills, immediately above the Ruataniwha Plains, as originally considered by Tonkin & Taylor in early pre-feasibility work for RWSS. On-Farm storage assumes individual storage dams on specific properties within the Ruataniwha Plains irrigation footprint.

Large scale storage (Makaroro) – The RWSS scheme proposes an 83m high Central Core Rockfill Dam, storing 90Mm^3 of water, situated on the Makaroro River at the base of the Ruahine Ranges. The dam and reservoir area require 400 ha's for infrastructure.

The distribution design for the current dam option includes a combination of 30km's of open headrace canals and large diameter pipelines (Primary distribution system) servicing 180km's of smaller diameter pipelines and associated pumpstations (Secondary distribution system). The primary and secondary systems distribute up to 90 Mm^3 of water to individual farm properties at a working pressure of 3.5 bar (50psi), minimising the need for further on-farm boosting or pressurisation. (see figure 2).

Moderate scale storage – This option has utilised work carried out by Tonkin & Taylor during the Advanced Prefeasibility phase of the scheme that considered a number of smaller (19m to 46m high) dams constructed in the adjacent foothills immediately above the Ruataniwha plains. Six dams (Sites A4, B1, B2, C2, D3 & D5) have been selected to replicate the 90Mm^3 scheme storage requirement, storing between 8 to 25Mm^3 each, 15Mm^3 average. These sites have geotechnical and foundation features similar to the large scale dam option so the capital costs reflect this situation. A number of the sites chosen require pumping or infilling from adjacent water courses and catchments to fill the dam reservoirs, recognising the limitations or inability for individual catchments to fill the respective reservoirs. This also recognises the significantly lesser average rainfall in this area, when compared to the Ruahine Ranges.

Smaller examples of foothill storage are Springhill Dairies dam on Wakarara Rd, storing 0.5Mm^3, which is filled by a combination of tributary water and supplementing river takes. The multiple dams and reservoir areas require 1,000 ha's of land for infrastructure for the equivalent 90 Mm^3 of storage. (See figure 3).

On-farm (Plains) storage – On-farm plains storage in New Zealand currently consists of small scale (<10Mm^3) lined buffer or secondary storage dams, providing security and increased reliability to primary run of river supplies at times of low river flows, as opposed to primary storage volumes.

Information relative to on-farm storage has been sourced from earlier work carried out by Tonkin & Taylor for RWSS and the Wairarapa Water Use Project and work carried out by OPUS consultants for the Wairarapa Water Use Project. This work reviewed the size, scale, construction and cost of four existing South Island plains storage projects. These are the Waimakariri Irrigation scheme, Rangitata South Irrigation Scheme, Carew Irrigation and Storage Ponds and Ashburton Lyndhurst Irrigation Scheme.

Taking account of this information, the scenario for RWSS would necessitate the construction of small scale lined storage ponds on a property by property basis, or multiple properties, scattered over the Ruataniwha plains. Experience and evidence from South Island on-farm storage schemes shows an average storage depth of 5m when constructing in gravels. This assumes an ability to stopbank water 2.5m above ground (similar to Upper Tukituki flood control stopbanks) and excavating 2.5m into the existing ground.

This activity would produce 45Mm^3 of excavated material to create the storage ponds and produce 37Mm^3 of surplus material, once an allowance has been made for the dam construction volumes.

HDPE (Plastic) liners would be required to seal the reservoirs due to the granular, leaky nature of the underlying gravels and soils (See figure 4). Rainfall from within each individual property catchment will not be sufficient to capture and store the necessary annual volume of water from rainfall so alternative water sources from other tributaries or infill pumping will be required. Average rainfall for this option is also marginally less than the moderate scale storage and significantly less that the large scale option.

There are currently no on-farm plains primary storage dams on the Ruataniwha plains. The dams and reservoirs require 1,800 ha's of land for infrastructure for 90Mm^3 of storage. As for the Moderate scale storage scenario, pumping or infilling from adjacent water courses or catchments will be required due to the inability to supply sufficient water within the respective catchments. The concept assumed for water supply for this option is filling from an adjacent water course or catchment, if available, or alternatively pumped from groundwater during winter for those properties without reasonable access to surface water.

This option also raises a number of additional complexities with regard to access to water, power requirements, opportunity cost of loss productive land, lining of storage structures, on-farm pressurisation and loss of environmental offset opportunities.

For the purposes of this analysis it has been assumed, as mentioned earlier, that all three scenarios require a 90Mm3 storage requirement for primary irrigation use. Both the Large scale and Moderate scale storage options can also provide for environmental, residual flow and flushing flows requirements. With respect to On-farm storage this is unlikely to be realised, as providing and coordinating sufficient volumes of water from in excess of 200 properties to various water courses is seen as impractical and an unlikely to be provided by individual landowners.

An additional option has also been considered for the On-farm Storage scenario relating to HBRC contributing a $60 million subsidy toward encouraging individual property owners to construct on farm storage. An assumption of a 50/50 subsidy basis has been applied and then a calculation made as to what area and volume of water might be stored for that level of financial commitment. This option would realise only approximately 26% of the potential of the Large Scale option, at 24 million cubic metres of storage. The relative costs and economies of scale are also evident in this scenario, when compared with the large scale option. The requirement to also provide on-farm pressurisation and potential pumped infilling to the reservoir will significantly add to annual operational costs.

The relative statistics have been summarised in Table 1 below providing a comparison between the four storage scenarios, taking account of dam size and location, rainfall, land area and value, distribution requirements, construction costs and development costs.

RWSS Storage Options				
Storage Scale	Large	Moderate	On- Farm	On- Farm with $60m HBRC funding on 50/50 basis
Site location	Ruahine Range	Rua. Foothills	Ruataniwha Plains	Ruataniwha Plains
Ave Site Rainfall (mm)	2000	1000	800	800
Dam requirements				
Assumed Storage volume (m3)	90,000,000	90,000,000	90,000,000	24,000,000
Land value / ha (Dam)	$10,000	$15,000	$25,000	
Land Reservoir area (ha's)	400	1000	1800	480
Land cost (Dam/reservoir)	$4,000,000	$15,000,000	$45,000,000	Farmer contribution
Other compensation (Dam)	$2,000,000	$5,000,000	$9,000,000	Farmer contribution
Dam unit const. Cost/m3	$1.45	$2.46	$5.00	$5.00
Dam capital cost	$130,500,000	$221,400,000	$450,000,000	$120,000,000
Distribution requirements				
Land value / ha (Dist)	$25,000	$25,000	$25,000	$0
Land Distribution area (ha's)	50	40	0	0
Land cost (Dist)	$1,250,000	$1,000,000	$0	$0
Other compensation (Dist)	$1,000,000	$800,000	$0	$0
Pressure at farm gate	yes	maybe	no	no
Pumped water infill required	no	maybe	yes	yes
Distribution cost	$150,000,000	$145,000,000	$0.00	$0.00
Power Distribution	$20,000,000	$20,000,000	$20,000,000	$10,000,000
Other costs				
Development costs	$20,000,000	$20,000,000	$20,000,000	$5,000,000
Maintenance costs	on-going pumping	pumping and pressure	on-farm pressurisation	on-farm pressurisation
HBRC Contribution	$80,000,000	$80,000,000	$80,000,000	$60,000,000
Total costs	$328,750,000	$428,200,000	$544,000,000	$135,000,000

Table 1: Dam type storage options Costs

Note the Dam unit construction cost dollar amounts used in Table 1 above correspond with a range of dam construction costs plotted on the graph below, in figure 1, as part of Tonkin & Taylors Advanced Prefeasibility work for RWSS completed in 2011.

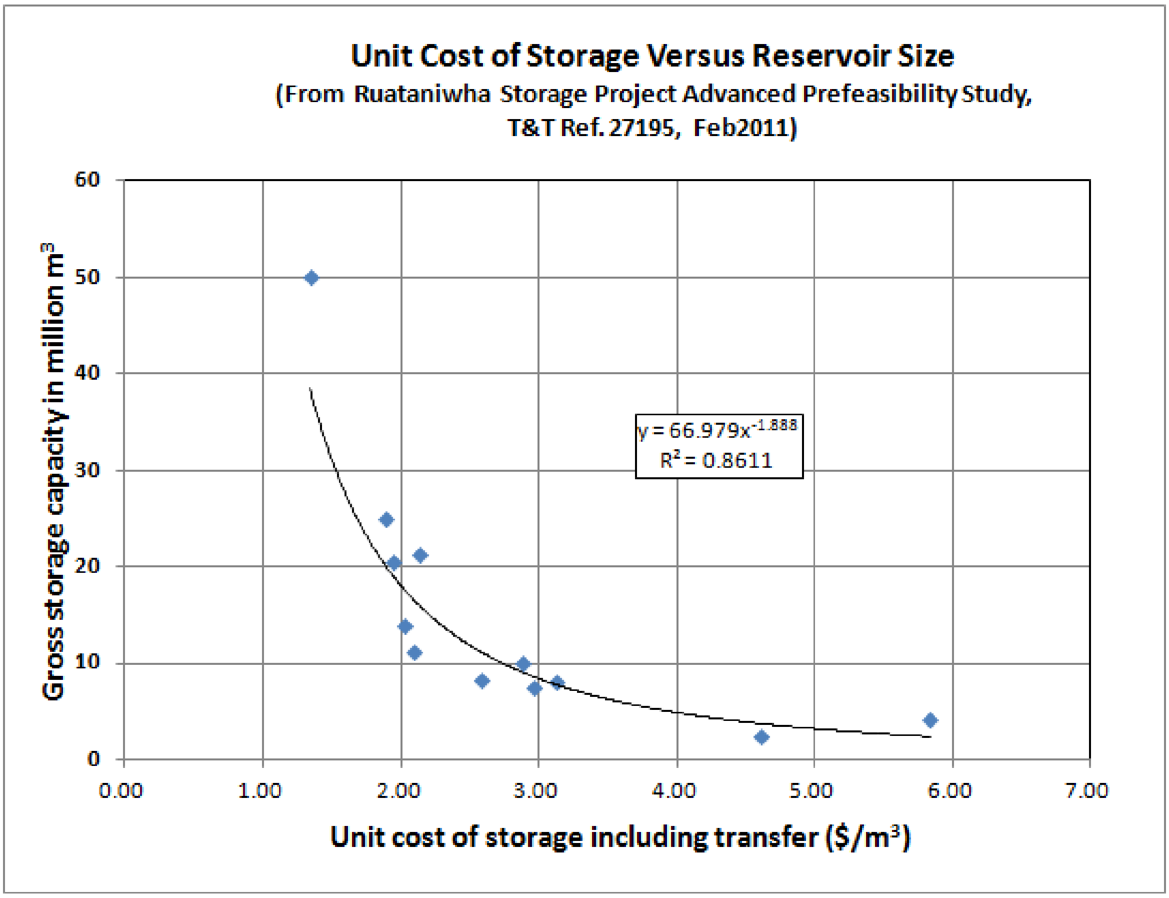


Figure 1: Unit costs of storage versus reservoir size

Impacts on Distribution costs and revenue

Large scale storage – The distribution design for the current dam option includes a combination of 30km's of open headrace canals and large diameter pipelines (Primary distribution system) and 180km's of smaller diameter pipelines and associated pumpstations (Secondary distribution system) distributing water to 209 individual farm properties at a working pressure of 3.5 bar (see figure 2). The current distribution system has a capital cost of $150M.

Moderate scale storage – The distribution scenario for this option would be similar to the Large scale storage option, utilising tributaries and streams to convey water to the Ruataniwha plains. The exception to this would be a smaller capacity primary headrace canal and pipeline feeding water to a similarly configured secondary distribution network for large scale storage. The smaller primary canal and pipe dimension results from the ability to feed smaller volumes of water from six different dam locations as opposed to one large dam.

However, this option does have more complexity with a greater number of offtakes and headrace alignment issues to resolve between the dams and the distribution system. This option also provides challenges for provision of environmental flows. The capital costs would be similar to the large scale distribution costs with an approximate saving of $5M for smaller primary headrace requirements.

On-farm (Plains) storage – This analysis has assumed no off-farm distribution related costs for on-farm storage. This position is considered very conservative as storage dams on a property by property basis will require pumping or filling from an adjacent water course and will not provide any working pressure on-farm so will necessitate on farm pumping and pressurisation.

The infrastructure and ongoing running costs for this have not been assessed but are likely to be significant, when compared with costs for large scale pumping and pressurisation. Other on-farm reticulation would be required for all of the 3 scenarios considered

<u>Impacts on primary production output</u>

The impacts on primary production output, compared against the current proposed Makaroro Storage dam are discussed in the following section. Table 1 presents a summary of the impacts on costs, loss of land and other economic impacts for the three different storage options.;

Moderate scale storage – The impact for this option is largely unaffected due to the storage dams being located off the productive land of the Ruataniwha plains irrigation zones. There would be a modest loss of production value from the additional 600 ha's required for reservoir storage on the foothill properties.

On-farm storage – Any storage on the Ruataniwha plains will impact productive land by virtue of there being no significant tracts of unproductive/ undeveloped land available for storage structures. This would then see 1,800 ha's of productive land removed from the Ruataniwha plains with an associated material reduction in production output and devaluation of farm property values. This situation will be further exacerbated by the individual farmer's inability to contribute their share of environmental water to maintain minimum flows during the very low flow periods in summer and to further assist with nutrient management requirements.

Table 2 – Summary of impacts for other storage options

	Cost	Loss of land	Other economic costs
Large scale	Forms base case	Minimal	Minimal
Medium	Increase on base case	Some	Minimal
On farm	Substantial increase on base case	Significant loss of productive land	Increased on farm costs to meet water requirements, loss of production

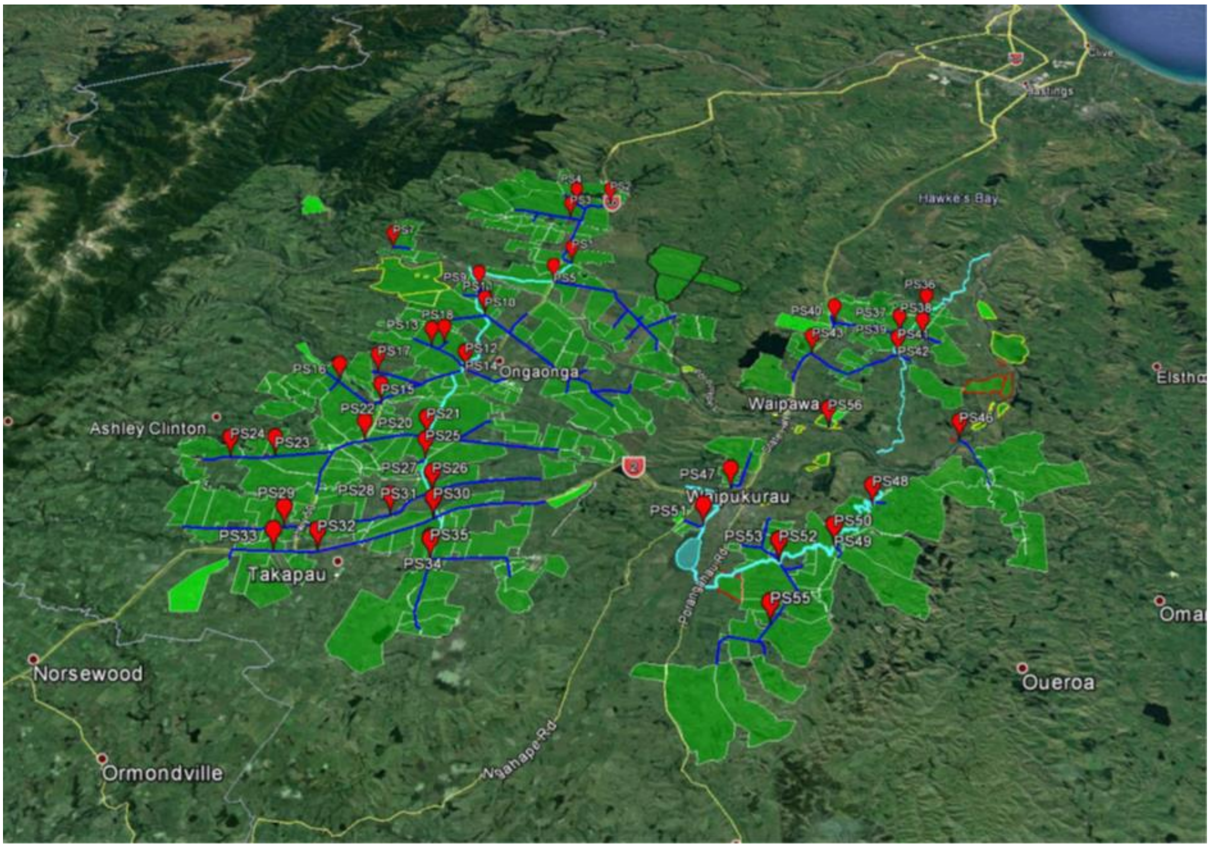
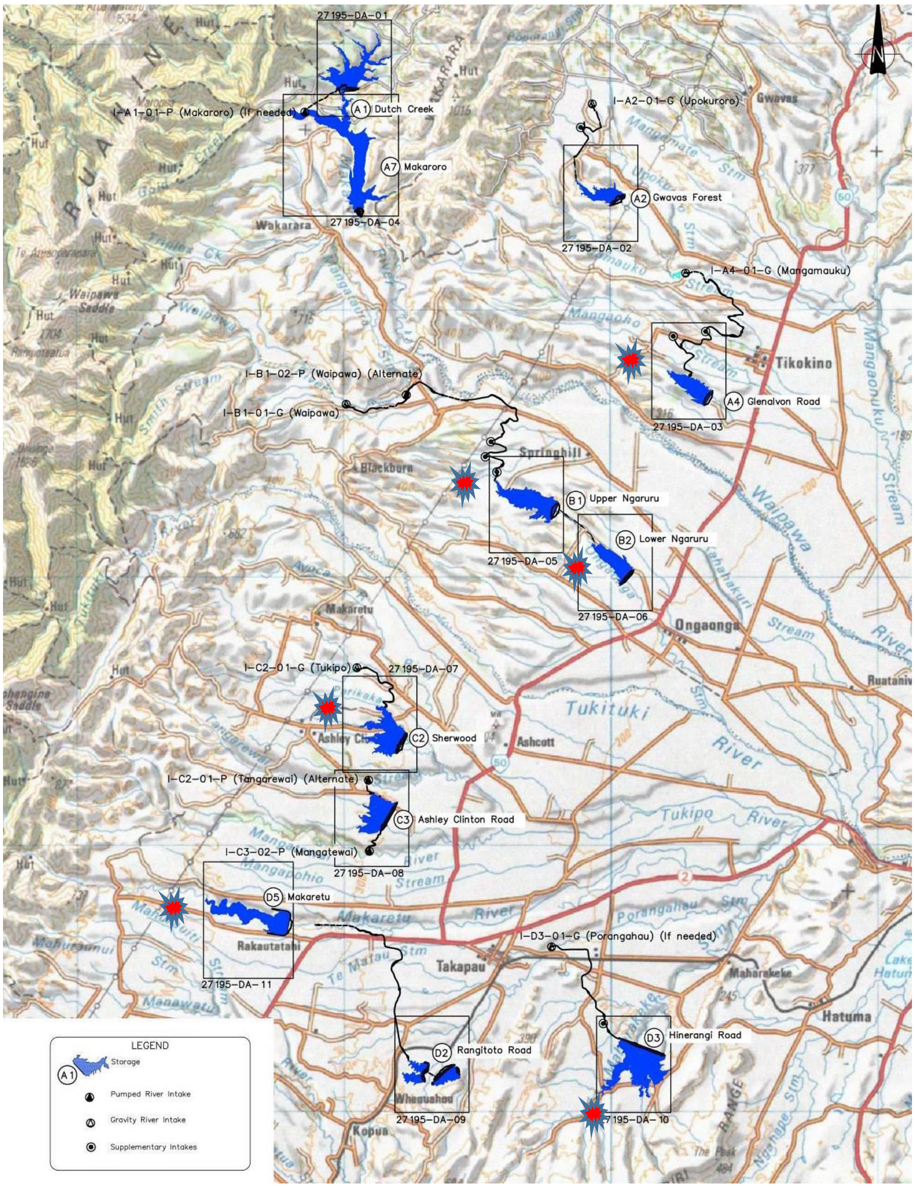


Figure 2: OHL-Hawkins Proposed Primary and Secondary Distribution Network.



Dams selected for analysis

Figure 3: Proposed Dam Sites from T&T Advanced Prefeasibility Study - 2011

Figure 4: Mayfield Hinds Irrigation – Carew Pond lining.

On Farm Storage Scenario for Zone A

This analysis assumes 10 larger scale dams to service 5,000 hectares in Zone A of the Ruataniwha irrigation footprint.
This is a more economical option when compared with individual properties catering for their own needs.
Each dam will serve 500 hectares requiring 1,500,000m3 of storage, based on 3,000m3/ha/year irrigation requirement.
The on- farm dam design allows for 2.5m of stopbank above ground and 2.5m excavated into the ground, giving a total storage depth of 5m.
30 hectares is required for a dam 5m deep, storing 1,500,000m3. A dam 550m x 550m is required for 30 hectares of storage.
The above ground storage structure is similar in scale and dimension to the Upper Tukituki Scheme stopbanks.
Rates applied to the analysis have been supplied by HBRC Engineering Section and OHL-Hawkins RWSS Pricing.

Activity	Units	Volume	Rates	Cost
Stripping	Sq. m	300,000.00	$0.60	$180,000.00
Earthworks	Cubic m.	68,750.00	$5.00	$343,750.00
topsoil, grass, harrow	Sq. m	18,000.00	$0.20	$3,600.00
Lining	Sq. m	300,000.00	$15.00	$4,500,000.00
Fencing	Lin m.	2,200.00	$18.00	$39,600.00
Surplus fill disposal	Cubic m.	680,000.00	$2.00	$1,360,000.00
Design and Supervision	%		13.00	$475,503.50
Land Value	Hectare	30.00	$25,000.00	$750,000.00
			Total Contract Cost	$7,652,453.50

Total Volume of Water Stored (m3) 1,500,000.00

Rate per Cubic Metre of Water Stored **$5.10**

On Farm Storage

The review should cover the viability of on farm storage which has been promoted as an alternative to one central dam. The reviewers need to look behind the reasons why on farm storage is used in the South Island in some cases .

Comment :

I am currently building a effluent holding pond of about 19000m3 on flat ground .We expect the cost to be $250000 which works at approximately $13.16 per m3 of storage .This is a very expensive exercise on flat ground compounded by the need to use liners. Discussions with South Island irrigators indicates very large ponds can get down to $8.00 m3 capital cost .On top of that one has to obtain a water source which for many properties may be several kilometers away to the nearest river and then to pay for consenting , piping , pumping power and general running costs . After that they need to pump pressurised water to irrigators. RWSS provides pressureised water to the gate.

Also there is a loss of productive land .

If we calculate the cost of capital for a pond at just $8.00m3 @6% =48cents m3 plus add another 6 cents m3 to pump to irrigators, ie total of 54 cents m3 plus the cost and issues of getting water into these ponds this would bring the total cost to over 65cents m3 .

Comparing this to RWSS @27.5cents which is hard enough to make work it tends to suggest that on farm storage is not viable.

Not many properties have a suitable valley to dam which could reduce the cost .One would need a "perfect" site with water flowing through it to dam to get near the cost of RWSS.

It needs to be pointed out that many of the South Island on farm dams are only for short term storage and not for providing water for a whole season..This is due to the fact that these properties were supplied with water for border dike flood irrigation and received water for say 4 out of 14 days from a community scheme. As many of these properties have been converted to pivot irrigation for improved water use they have had to provide storage for the remaining 10 days of the cycle and not the whole season.

I used to own one of these types of irrigated properties in the Waitaki Valley .

I would be happy to answer any questions in relation to the above.

Lindsay Smith

Ingleton Farms Ltd

ph 0272767517

7 Conclusions and Recommendations

7.1 Conclusions:

7.1.1 On-plain Storage comparisons:

Building on plains is being carried out successfully within the New Zealand irrigation industry.

Costs vary largely depending on the level of supply reliability risk targeted by the scheme design and operational concepts. The Rangitata ponds costs of $1-2/ cubic meter are in our opinion too low and would incur too high a risk. Our on-plain storage report dated April 2014 has assumed costs of anywhere between $3 and $7 per cubic metre, which is in alignment with the recently developed ALIS ponds. Our indicative costing for the distribution system has assumed a more conservative cost of $6 -12/ cubic metre and took an average of $9/ cubic metre.

are $5/m³ stored.

7.1.2 Case study for Distribution Options:

Storage capital costs are the most significant.

Variation of storage requirements is the key driver of costs. The volume of storage means most of the capital cost is taken up with the storage costs. Piping and pumping costs become less significant.

Smaller pumping networks have smaller capital cost but the WOL cost is almost neutral.

The pipe network and pumping costs are very much less for pumping from the river close to where irrigation water is required than for gravity fed pipes from upstream storages. The difference in WOL costs is not so significant.

Optimum Solution could be a Hybrid.

As storage is a key cost driver if the amount of storage can be reduced this will significantly reduce costs.

Smaller networks do have the flexibility of being added on to in the future with gravity fed pipe to upstream storages. This means a viable solution is a hybrid of on plains storage (minimal) with pumping with ability add extra storage and gravity pipe as demand increases. This allows for a staged development that ensures that capital spending is in line with current need.

7.1.3 Use of stock races

It is unlikely the network of stock races could be easily adapted to convey irrigation water.

Graeme Hansen

From: Graham Edmondson
Sent: Monday, 10 April 2017 4:11 PM
To: Graeme Hansen
Subject: RE: Stopbank unit rates

HI Ganz,
You got nothing better to do on a Sunday afternoon??

	Item	Unit	Awanui #4	Awanui #5	Taipo	UTT RB	Utt LB	**Adopt**
1	Stripping & stockpiling	($/m2)	$0.50	$0.80	$0.25	$0.30	$0.30	**$0.60**
2	Load,Cart,Place,Compact	$/m3	N/A	N/A	$3.00	$4.80	$3.50	**$5.00**
3	Topsoil,Sow,Harrow	$/m2	$0.15	$0.28	$0.12	$0.13	$0.15	**$0.20**
4	Fencing – 7 wire post & batten	$/m	$18					

For the above jobs (approx. $200,000 contract cost included $10-15,000 contingincy) also included:
Watercart $10,000
Haul Roads $5,000
Design, plans, contract preparation, tendering, supervision – $25,000 (13% contract price)

NOTE: Taipo was a cheep job from Gairs

Idi

From: Graeme Hansen
Sent: Sunday, 9 April 2017 2:52 p.m.
To: Graham Edmondson <Idi@hbrc.govt.nz>
Subject: Stopbank unit rates

Idi, Would you please be able to give me units rates for the following items based on your knowledge of your most recent contracts. I am pulling together detail for on-farm storage dams and I am using the same approach as if one of our stopbanks, ie; 2.5m high, 5m topwidth, 3 to 1 batters. If any doubt about rates give me a conservative figure;

1. Stripping topsoil – $/m2
2. Bulk Earthworks - $/m3 (from immediate area)
3. Topsoiling – m3 or m2?
4. Harrow & Sow - $/m2
5. Fencing – per lin m
6. Do you have a % estimate for design and supervision? 10 – 25%?
7. Anything else I have missed?

I have rates in mind but keen to see if we agree. I have a price for land and surplus disposal.

I'm tied up on CIMs training Monday/ Tuesday so can you please email me and I will pick up at night.

Thanks Ganz

Graeme Hansen
Group Manager - Water Initiatives

Graeme Hansen

From: Craig Fletcher <CFletcher@ohlaustralia.com>
Sent: Sunday, 9 April 2017 5:26 PM
To: Graeme Hansen
Subject: Re: HDPE unit rates

Graeme,

I completed the analysis and narrative for 50 cumec just reviewing few numbers in the morning before sending through.

When it comes to liner you should take the below factors into account for your buildup,

- 1.5mm HDPE liner has a cost of $17.5m2 included for liner and placement/welding, this price fluctuates vastly depending on the shape and total area installed, welding costs are high as labour intensive cleaning cutting etc. (JV canal has one seem weld down the length utilizing the wide roles)

- liner integrity is important, must only be placed on even surface with particle size no greater than <10mm, you should allow for compacted surface preparation and grading of material (sand or alternate material 50mm thick over prepared surface) then one layer of a non woven geotextile fabric (generally allow $2.5m2 for geo) rule of thumb for larger areas to ensure you gain the design life out of liner your Pre liner preparation is similar cost to liner installed value although again heavily down to surface area and shape of storage facility.

50 yr design life Water storage ponds for the CSG market we had been constructing have an rule of thumb comparison cost of $1.4m per meg storage,

Regards

Craig Fletcher

On 09/04/2017, at 1:01 PM, "Graeme Hansen" <Ganz@hbrc.govt.nz> wrote:

> Craig, sorry to be a nuisance again but are you able to give me a per square metre installed rate for the HDPE liner you propose in the canal. I'm trying to confirm some on-farm storage costs for the RWSS review and am assuming your liner proposal for the canal would be the same as what would be used to line an on-farm dam? Or at least put me in the ballpark.
>
> Be keen on answer by end of tomorrow (Monday) if at all possible? and keen on the 50 cumec dam answer to when available.
>
> Any help appreciated.
>
> Regards Graeme

22. Advice on the proposed approach to gravel management within the reservoir, including operation costs and consent compliance, seismic risks to dam integrity, and any issues arising from future decommissioning of the dam.

1. Gravel Management

A report summarising the results of a sedimentation assessment for the RWSS project was completed by Tonkin & Taylor (Ruataniwha Water Storage Project Sedimentation Assessment, July 2012, Project No 27690.600) and peer reviewed by NIWA, as part of a suite of engineering documents related to the RWSS project feasibility and Board of Inquiry (BOI) EPA processes. The findings of this work was further reviewed and summarised in the Technical Feasibility Study report – Tonkin & Taylor, August 2012, Project No 27690.100/3. This report, section 4.2.3 Dead Storage Allowance, determined and summarised a number of key findings relative to sediment management issues, including;

1. An estimate of Sedimentation in the reservoir between 12 – 25 million m^3 over 100 years, with the upper figure known to be too conservative and the lower figure potentially unconservative,
2. A dead storage provision of 4 million m^3 has been allowed for within the dam reservoir capacity to accommodate sediment accumulation, and
3. Based on a midpoint estimate of 0.18 million m^3 (180,000m^3) of sediment infill per year, this allowance is sufficient for 22 years of accumulation.

It was considered unnecessarily conservative to ring fence the equivalent of 100 years of sediment infill within the reservoir because:

- The term which would be used for any economic or discounted cash flow analysis would be considerably less than 100 years; the tenure of resource consents would be no greater than 35 years in any case,
- The adopted approach recognises that most of the reservoir space for sediment would be available over the first decade of operation and does not preclude advances in technology and economic incentives in the future to actively manage and extract trapped bedload in the reservoir; trapped gravel in the reservoir is a resource that is likely to have increasing value in the future (especially for road construction), likely sufficient to warrant commercial extraction at some point, and
- Loss in storage beyond the 4 million m^3 set aside for sediment infill would translate into a modest reduction in drought reliability and would affect supply to a degree only in the drought events approaching the design event.

Note: the Sedimentation Assessment report also determined the impacts of interruption of sediment on various reaches of Upper Tukituki rivers and the coast and discussed a number of sediment management options.

The response and findings to these key issues has been included in the BOI consent decisions issued in June 2014. The range of specific conditions are summarised and commented on further below.

The gravel that will accumulate within the dam reservoir area has economic value for use in the roading and construction industries, both for quality and size purposes. Importantly the annual average volume of 180,000m^3 broadly aligns with volumes historically extracted from Central Hawkes Bay rivers as part of managing the Upper Tukituki Flood Control Scheme. Current extraction rates are considerably less than this volume, reflecting the lack of economic development within the area at present however this is expected to greatly improve should the scheme proceed. It is also significant that the proposed dam site domiciled in the Makaroro River will trap sediment that contributes to the Waipawa River system and will provide additional security, relief and medium term stability to the upper section of the flood control scheme.

Operational modelling for the scheme has assumed that 25% (45,000m^3) of the annual accumulation average of 180,000m^3 will be extracted from the reservoir each year. This assumption is modest, readily achievable by volume and sees the life of the dead storage provision of 4 M m^3 potentially extended to 89 years. This timeframe is considered a reasonable position based on the economic life of the project.

There is a perception that the scheme loses capacity and reliability immediately once construction is complete. This is not the case and at the estimated sedimentation rate, it would take 500 years before the dead and live storage provisions are infilled with sediment and gravel and decommissioning would need to be considered. This life is obviously further extended with an active sediment management regime in place.

The sediment accumulation delta is expected to form in the upper part of the reservoir and will therefore generally be available for extraction on a regular basis during the irrigation season, especially when water levels are low. The approach to getting access to a location in a river and extracting 50 -100,000m^3 in one effort is an approach applied to other rivers within the Hawkes Bay region.

An assessment has been made of the additional cost for extractors to remove gravel from the proposed dam, compared with current extraction at State Highway 50. There is an additional 50km round trip, with a cost of \$10/m^3 for transport to extract the annual 45,000m^3 amount. This equates to an annual cost of \$450,000 and this should be considered a potentially shared cost, on an agreed ratio, between the RWSS and Upper Tukituki FCS recognising the impediments and benefits to the respective schemes. Provision has been made within O&M budgets for the RWSS scheme for a range of consent and operational management costs, including those obligations listed in the RWSS Sediment Resource Consent Conditions section below.

Taking account of this access into the reservoir area specifically for gravel extraction has been provided for as part of land negotiations and purchasing land from Parks Peak Station (see image 1).

1.1 RWSS Sediment Resource Consent Conditions

There are a number of obligations on the scheme to manage sediment issues for the RWSS project, as defined by BOI consent decisions, particularly Schedule 11. These are summarised as follows;

1. Provide Sediment Management Plan

Engage and manage a suitably qualified and experienced Engineer to prepare a Sediment Management Plan (SMP) for certification by the HBRC Group Manager - Resource Management no less than 20 working days prior to the first complete filling of the reservoir. The plan must meet the monitoring and management approach set out in the table in Schedule Eleven of the Final Consent Conditions. The SMP shall include protocols defining:

a. Monitoring locations, methods and frequency,
b. The range of anticipated management actions which may be required over time in response to any observed changes affecting the river environment,
c. Trigger levels for implementation of management actions,
d. Liaison with HBRC engineering staff responsible for the management of the Upper Tukituki Flood Control Scheme and the Heretaunga Plains Flood Control Scheme; and
e. Appropriate SMP review and reporting timelines.

RWSS Consent Conditions - Schedule 11 – Sediment Management Plan – Monitoring and Management Approach

Task Description	Frequency
Manage a contractor to undertake cross-section/bathymetric surveys of the reservoir to monitor sedimentation and delta development.	3 yearly
Manage a contractor to undertake a cross-section survey at Makaroro River downstream of the Dam. Maximum spacing to match existing HBRC monitoring programme of 500 m and to include Burnt Bridge. In addition, measure particle size distribution of bed surface particle-size distribution to monitor armour development.	3 yearly
Manage a contractor to undertake a cross-section survey. Additional cross sections to be included for Waipawa upstream of the Waipawa/Makaroro confluence including Wakarara Road Bridge and Pendle Hill Bridge (1 km upstream) with maximum spacing of 500 m. Additional cross section for the UWI.	3 yearly
Manage a contractor to undertake a cross-section survey at existing cross sections on Waipawa/Tukituki Rivers downstream of SH50 locations	3 yearly
Manage a contractor to undertake cross-section surveys at existing cross section Coast locations	3 yearly
Develop a morphological model for Tukituki River basin including Waipawa and Makaroro Rivers.	On going
Engage contractors to respond to degradation of channel at Burnt Bridge (if required). *Refer Section 2.6.2 in the RWSS Technical Operations and Maintenance Scope of Works – December 2015 document.*	As required
Engage contractors to respond to degradation of channel at Wakarara Road Bridge (not likely, contingency only). *Refer Section 2.6.2 in the RWSS Technical Operations and Maintenance Scope of Works – December 2015 document.*	Annually

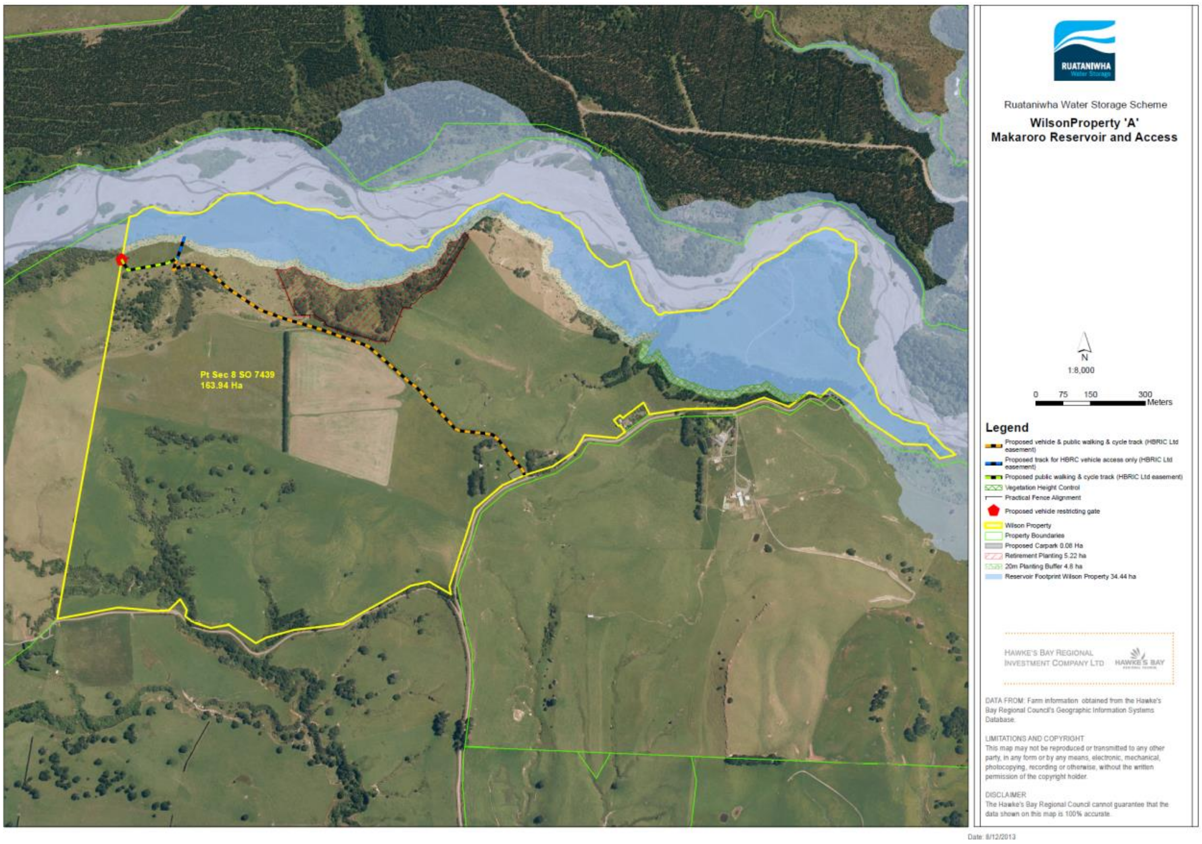


Image 1 – Reservoir access provision – Parks Peak station

2. <u>Seismic Risks to Dam integrity</u>

2.1 Seismic Stability of the Region

The region in which the scheme is to be constructed is seismically active with the potential for severe earthquake shaking and fault rupture.

The technical feasibility for the project was determined by Tonkin & Taylor, (Ruataniwha Water Storage Project Technical Feasibility, August 2012, Project No 27690.100/3), with GNS involved in the engineering geotechnical investigations. The design criteria for the works are based on the New Zealand Society on Large Dams (NZSOLD:2000) Dam Safety Guidelines and the Building (Dam Safety) Regulations 2008. These provide guidance on dam design and construction practice including the assessment of flood and seismic hazards. The design will also require consent under the New Zealand Building Act.

GNS[1] identified specific fault rupture displacement sources with potential to impact on the proposed reservoir site. For the scheme's dam site (the "A7 - Makaroro" dam site) the fault rupture displacement source is identified as the Mohaka Fault. The Mohaka Fault trace crosses the body of the reservoir and passes approximately 600 m upstream from the dam site.

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1 GNS Science Consultancy Report 2010/121, August 2010. Spectra and compilation of fault data for Central Hawke's Bay Water Augmentation Scheme.

The Mohaka Fault has a recurrence interval of 700 – 1830 years (average c. 1125 years). The last rupture event on the fault is believed to have occurred c. 300 years ago.

GNS[2,3,4] completed a series of investigations and assessments of the potential for rupture of the primary Mohaka Fault trace and possible secondary fault displacements. Summarised key findings include:

1. Primary fault rupture along the main active fault is not likely to occur in the site area ("site area" interpreted to mean the as-built footprint of the dam and appurtenant structures) albeit that the dam site would experience severe shaking,
2. No evidence for active secondary faulting has been encountered in the investigation trenches targeting candidate features. The possibility of secondary faulting in the dam site in places not investigated cannot be discounted, and
3. The magnitude of secondary displacements in the dam site, should these occur, could be up to 0.5 m for a single event.

The Wakarara Fault is also present within approximately 4.0 km of the dam site. Data from the fault south of Wakarara suggest that there have been 1 - 2 fault movements during the last 10,000 - 14,000 years.

The investigations undertaken by GNS targeted the most likely "candidate" features for secondary faulting and as industry recognised specialists their findings are considered robust. Consistent with best dam engineering practice the dam foundation excavations will be mapped by the Contractor to verify conditions during construction.

The investigation processes completed by Tonkin & Taylor and GNS, along with the NZSOLD guidelines defined the Operational Basis Earthquake (OBE) and Maximum Design Earthquake (MDE) values for the dam, based on the High Potential Impact Classification (PIC) of the site. This is the highest classification in the Guidelines and the design is based on this rating. Performance requirements are as per NZSOLD guidelines for the MDE where safe retention of the reservoir under the Maximum Design Earthquake (MDE) is achieved and essential structural elements must remain serviceable and be repairable.

Notwithstanding this, the Principals Requirements and Resource Consent documentation from the outset of the scheme has required the dam structure to be capable of accommodating a 0.5 m vertical displacement without failure. This is considered an appropriate design rule given the seismic environment and regardless of whether any secondary fault features (active or otherwise) are identified in the foundation or not.

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[2] GNS Science Consultancy Report 2011/117, July 2011. The A7 Makaroro River dam site. Phase 1: Initial site evaluation for active deformation.

[3] GNS Science Consultancy Report 2011/300, December 2011. A7 Makaroro River dam site – Phase 1B: Updated active fault and surface rupture displacement hazard and acceleration response spectra reassessment.

[4] GNS Science Consultancy Report 2013/68, July 2013. A7 Makaroro River dam site – Phase 1C: Field characterisation of possible fault displacement.

2.2 Left Abutment Dilated Rockmass

An area of the left abutment adjacent to the proposed dam site was visually assessed during feasibility to be a zone of dilated, potentially unstable rock. Subsequent abseiling survey of the rock mass by engineering specialists of the Contractor, as part of the tender design process, concluded that the rock mass does not appear dilated to an extent that would inhibit dam construction and that “normal” scaling (the scraping and removal of loose weathered rock from the surface layer) operations would be expected as part of construction.

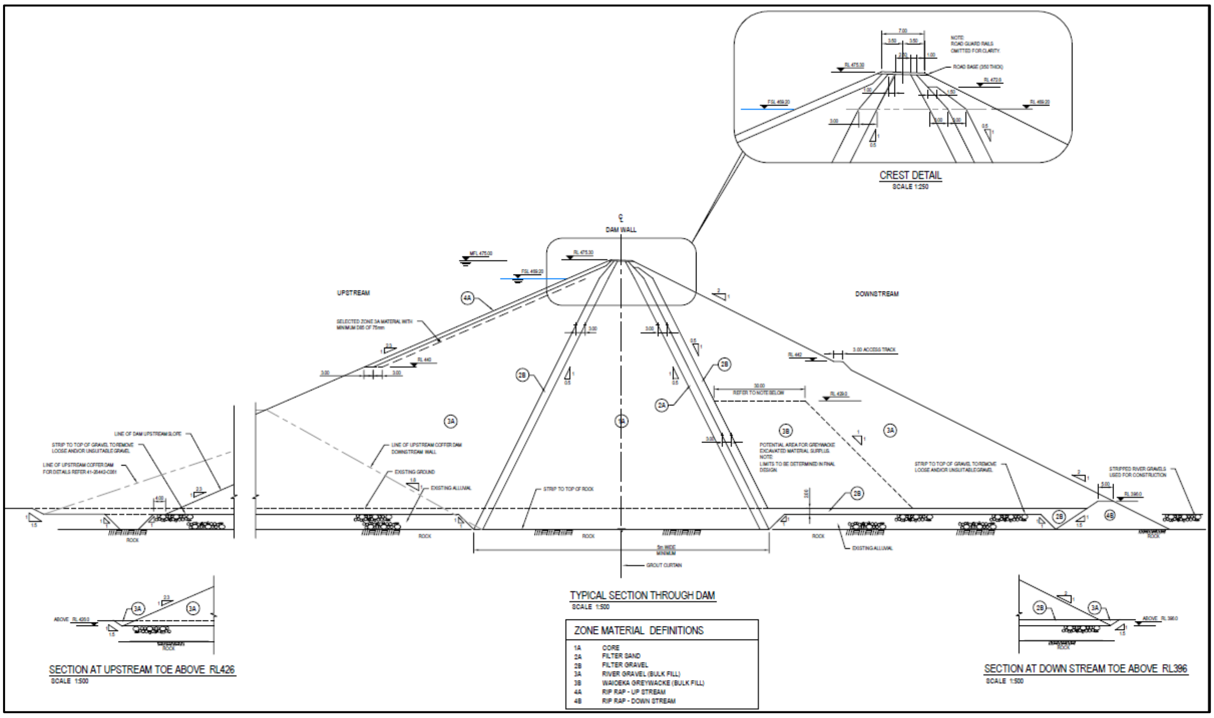
The proposed design has re-aligned the dam axis to intercept this area. This is a logical design decision in relation to the natural contours of the abutment.

2.3 Suitability of Location

The construction area for the site of the Makaroro Dam, was defined for the Contractor in accordance with HBRIC’s Resource Consent Application for the RWSS. The Contractors proposed design has logically progressed from the Tonkin & Taylor Application Design, with due consideration to additional geotechnical information gathered during the tender period, and includes:

- Central core rockfill dam (CCRD) – the proposed CCRD has taken account of the design requirements, seismic environment (refer Section 2.5) and the available soil and rock materials (refer Section 2.6). The design allows for up to 0.5m vertical movement on fault rupture in the event of an earthquake, and hence is considered the safest dam type for the location,
- Alignment of the dam axis – the proposed design includes a downstream re-alignment from that of the application design to better suit topographical and geotechnical considerations. In particular the left abutment is aligned to fit with topographic contours in the area of the left abutment dilated rockmass. This has been achieved due to the additional site investigation works undertaken by the contractor during the tender phase, which has dealt with this specific issue.
- Left bank intake tower and conduit – Locating the intake tower and water supply conduit onto and within the left abutment is consistent with the application design arrangements. Positioning the intake further away from the right abutment slip area is considered safer from a seismic and intake operation point of view than the original application design arrangement.

2.4 OHL -Hawkins Dam Design



A number of design criteria have been set to ensure that there is increased seismic safety for the RWSS dam. These are described below:

- The CCRD core and filters are wide and the proposed freeboard is appropriate for this design compared to other dams in similar seismic environments which is a conservative approach,
- Reshaping the foundation profile between the river channel and the terrace is proposed, to remove sharp angles and changes in grade in the foundation. This reshaping would address potential adverse settlement/movement of the core under static and seismic loading, and reduce the potential associated with cracking of the core,
- The selection of this dam type allows for the protection of shear movement up to 0.5 m in a fault or splinter fault within the footprint of the dam, and
- The ability of the core to accommodate seismic movements and deformations is a key aspect of the design of this dam. The core provides “flexibility” of the dam body to accommodate fault shear displacements caused by faulting in the footprint of the dam during a seismic event. Upstream and downstream filter zones are provided and which will act as “crack stoppers” and filters against erosion of the core respectively.

2.5 Ability of Proposed Design to withstand Seismic Events

The Contractor has appropriately applied an analysis for the Maximum Design Earthquake (MDE) which indicates that more rigorous techniques need to be applied to confirm the dam’s performance in a MDE seismic event. This is consistent with expectations given the seismic loads to be withstood by the dam. Semi-empirical methods to assess seismic deformations of the dam under the MDE are included in the Contractors design memorandum.

Appropriately and for the purpose of detailed design the Contractor recognises and has allowed for a more sophisticated analysis of the dam (beyond the semi-empirical methods) to include assessment of seismic inputs and material properties.

2.6 Availability of Source Materials

The proposed design identifies the material zones and quantities required within the body of the dam[5]. The central core and supporting shoulders represent approximately 28% and 57% of the total dam volume respectively.

For the central core (Zone 1A Core) the contractor has proposed the use of mudstone/siltstone materials, locally referred to as "Papa", to construct a low permeability and plastic core in the dam body. The plastic core provides "flexibility" of the dam to accommodate fault shear displacements caused by faulting in the footprint of the dam during a seismic event. Upstream and downstream filter zones are provided which respectively will; act as "crack stoppers" to seal cracks on the upstream side of the core, and a filter against erosion on the downstream side of the core.

The Contractor has assessed reserve volumes of the Papa within the project boundary to exceed the volume required for the core. Papa materials which have plastic behaviour meeting defined limits will be acceptable within the core. Papa materials which are non-plastic and "non-cohesive" are un-acceptable within the core as these materials are vulnerable to internal erosion.

3. Decommissioning Dam

3.1 Reasons for decommissioning dams

Decommissioning of a dam may occur because the dam has outlived its usefulness, or it requires rehabilitation works which are too expensive to undertake or will render the dam uneconomic. Other reasons for decommissioning might be if the dam is becoming increasingly unsafe, at which point removal may be the most prudent option.

A dam may outlive its usefulness by becoming silted up (Marmot Dam, Oregon, USA)[6], and stopped producing electricity or delivering water (in the case of the RWSS).

Safety concerns have been the most common reason for dam removals. Dams age at different rates and in different ways, depending on a variety of circumstances and therefore decommissioning requirements are considered on a case by case basis.

A decision to decommission a dam should be based on the careful evaluation of a wide range of alternatives to resolve issues associated with dam safety, high rehabilitation costs, high operation and maintenance costs, environmental effects, sedimentation issues, and long-term function and ownership.

In some cases full removal may be necessary to resolve critical issues, while in other cases partial removal may provide a satisfactory long-term solution.

[5] OHLHJV Ruataniwha Water Storage Scheme – Proposal from OHL-Hawkins JV, Design Memorandum 1.
[6] https://or.water.usgs.gov/projs_dir/marmot/

3.2 Dam decommissioning in New Zealand

In New Zealand, dam decommissioning is covered under the New Zealand Society of Large Dams (NZSOLD)[7] Dam Safety Guidelines 2015, specifically Section 8. The guidelines outline background on dam decommissioning, a suggested decommissioning process and considerations for design and removal. Investigation, design and decommissioning procedures are important to ensure that there is a focus on controlling the risks during the process and leaving them acceptably low on completion.

Unless emergency action is agreed by the Regional Authority as being necessary, the decommissioning of large structures in New Zealand will typically require consents under the Resource Management Act and Building Act.

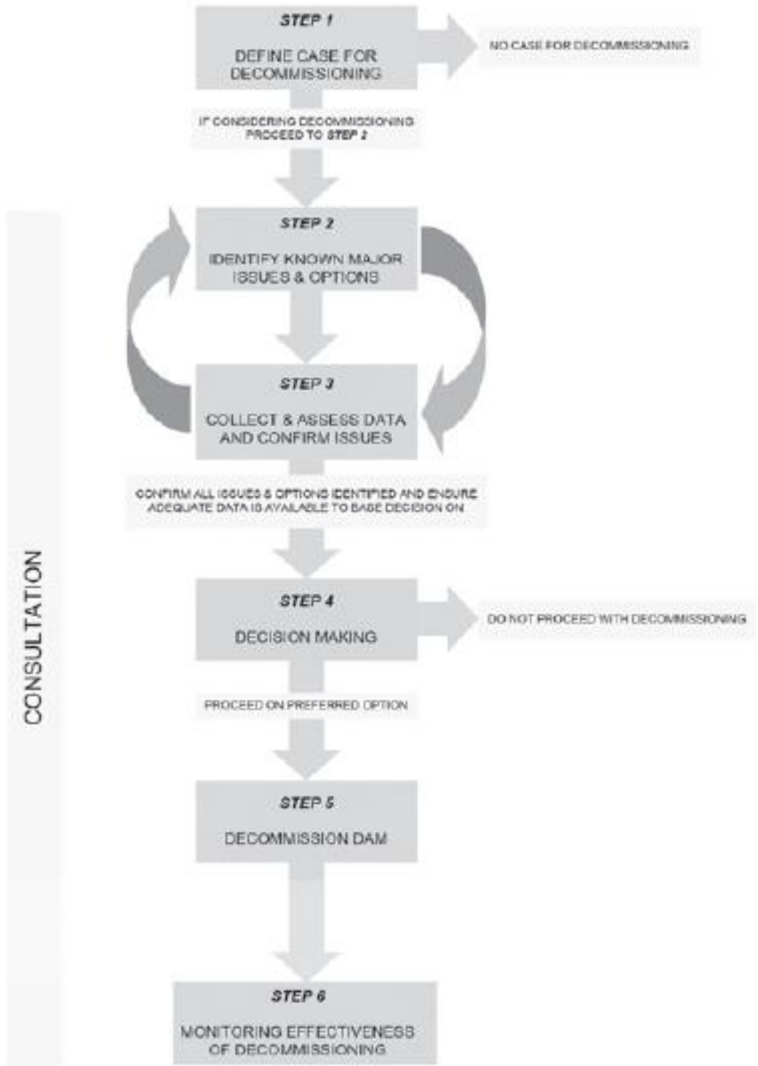
3.3 NZSOLD Dam Safety Guidelines

The Building Act and Building (Dam Safety) Regulations require dams to meet current dam safety criteria as recommended in these Guidelines. If the criteria are not met Owners would likely consider a number of questions including the following:

Decommissioning could become necessary if it was uneconomic for an Owner to complete the rehabilitation works necessary to address a dam safety deficiency. Complete removal of a dam would usually be unnecessary to satisfy current dam safety criteria and, in most cases, partial removal would be sufficient. Partial removal could include reducing the dam height or breaching the dam to permanently reduce the loads on the structure, and removing all ancillary structures (e.g. gates, pipelines, pump stations, powerhouses).

Total removal would generally only become necessary to address issues unrelated to dam safety.

[7] https://www.ipenz.nz/home/branches-and-groups/interest-groups/nzsold



3.4 Considerations for RWSS

This section will focus on the two most likely reasons for dam decommissioning for RWSS – dam safety and sediment accumulation.

3.4.1 Dam Safety:

Fifty years ago dams were built with the best engineering and construction standards at the time; however, as scientific and engineering experience has increased, so have the design criteria. In the case of the RWSS, the dam and appurtenant structures have been designed using state of the art engineering practice and so are anticipated to have a long life and be free of safety issues common in older dams. In addition, guidelines such as International Commission on Large Dams (ICOLD), Australian National Committee on Large Dams (ANCOLD) and NZSOLD provide industry practice and guidance for dam design, operation and removal.

3.4.2 Sediment accumulation

The sedimentation issue for the RWSS reservoir has been covered in Section 1 of this question response.

The important thing to note is that the dead storage zone will not affect the operation of the dam whatsoever, with the lowest intake above this dead storage zone and sedimentation occurring at the head of the reservoir, away from the dam. Loss in storage beyond the 4 Mm^3 dead storage for sediment infill would not be a significant drop in reliability, as shown in the Goldsim modelling reviews in the Technical Due Diligence Report (SMEC 2016).

There is 90.7 Mm^3 total storage in the reservoir, therefore, the unmanaged sediment load would take approximately 500 years to completely fill the dam.

3.4.3 Resource Consents and the RWSS O&M Contract.

The consents relevant to this section are covered in the Gravel Management section of this question response which briefly outlines the consents which concern sediment and gravel extraction in the reservoir. In particular, Schedule 11 (Sediment Management Plan – Recommended Monitoring and Management Approach) is the part of the resource consents which applies directly.

The O&M contract outlines the obligations of the operations and maintenance contractor. These obligations include requirements for monitoring sedimentation, extracting and raking of gravels and also the long term maintenance of the scheme. In the event that it was no longer considered economic to maintain the dam, then the option of decommissioning would be presented.

Under the O&M contract, the Contractor is responsible for compliance with Schedule 11 of the RWSS Consents.

3.5 Costs for decommissioning dams

According to the American Society of Civil Engineers (ASCE), removal costs of dams have increased to around 10 – 20% of the dam construction cost. Dam repair estimates and actual total removal costs for 10 case studies[8] (Baraboo, Clyde, Kennebec, Milwaukee, Pleasant, Santa Fe, and Willow Rivers, Souadabscook Stream, and Cold and Whitestone Creeks) showed on average that decommissioning cost approximately 37% of the average repair cost.

In some cases the costs for decommissioning can be much larger than this, but this is generally for concrete dams with hydroelectric facilities and in particular, those dams where reservoir sediment contain heavy metals and toxic contaminants.

As the RWSS dam is a rockfill dam with no hydroelectric facility (at present), nor an upstream source for pollution, it is unlikely that the removal of the RWSS dam would be in this category.

[8] American Rivers, Paying for Dam Removal (A guide to selected funding sources), October 2000.

The decommissioning of the dam is a task similar to the long term capital replacement works of the dam. Decommissioning is a decision taken when it no longer becomes economic to repair or maintain the dam. The O&M contracts provide a mechanism to properly operate and maintain all of the scheme components, so that decommissioning is not a required option under normal circumstances. There is currently no money set aside for decommissioning directly. However, it is planned to have a fund for unforeseen circumstances, which could include options for decommissioning.

To estimate costs for a fund which could cover the potential decommissioning of the RWSS and also to estimate an annual allocation set aside for decommissioning, two methods were applied:

1. Firstly the ASCE factor for removal costs of 10 – 20% was taken and the higher value of 20% used. As the dam capital cost is approximately $130 M, this gave a dam removal cost of $26 M, and
2. the second method was to take the volume of the dam ~2 Mm^3 and apply a rate for bulk earthworks with transportation ($15/$m^3$) to estimate a removal cost. This gave a dam removal cost of $30 M.

If funding is put aside for 100 years for the cost of the dam removal and assuming a long-term retail deposit rate of 5%, and the $30m decommissioning costs are increased by an assumed 2% annual inflation rate, then this amounts to approximately $83,000 per year.

Tonkin+Taylor

Memo

To:	James Palmer Graeme Hansen (HBRC)	Job No:	27690.970
From:	David Leong (T+T)	Date:	17 March 2017
Subject:	RWSS Review – Response to Issue 24 Relating to Makaroro Water Balance		

1 Introduction

This memo has been prepared in response to Mr Riden's request for further information and analysis in relation to Issue No. 24 regarding the Makaroro catchment water balance and flow yield. It is in three parts:

a. Response to Mr Riden's enquiry in his email of 20 Feb 2017 and follow-up brief of circ. 28 Feb 2017 (filename *PeerReviewRWSS4.doc*) concerning the rainfall and water balance analyses completed for the Feasibility Study. The response provided is based on the available information and state of knowledge at the time of the Board of Inquiry (BoI) process

b. Consideration of new information available since the BoI process, i.e. data from the reinstated Makaroro at Burnt Bridge flow recording site; the comparative rainfall analysis by HBRC as recently requested by Mr Riden; and investigative work on the losing reaches on the Waipawa and Tukituki Rivers, all culminating in an updated catchment water balance assessment

c. Consideration of the recent due diligence on RWSS hydrology completed for Crown Irrigation Investments Ltd (CIIL) and an institutional investor, and its implications, including how this work and associated reservoir modelling effectively renders the water balance issue academic to a large extent (supersedes it).

2 Response to Mr Riden's brief

A challenge has been issued by Mr Riden to provide the detailed information and analysis that supports the Tonkin & Taylor Ltd (T+T) estimate of the mean reservoir inflow of 200 million m^3 per annum. Mr Riden refers specifically to the water balance analysis that T+T carried out as part of the scheme Feasibility Study and how it is not possible to arrive at such a figure through such an analysis.

Much of the information sought can be gleaned from the T+T memo titled *Development of a Synthetically Extended Makaroro at Burnt Bridge Flow Record* by Candice band and David Leong dated 14 November 2011 (29 pages), which Mr Riden has a copy of. The key result from the water balance analysis is reproduced as Table 1 below, which indicates a mean flow at the proposed dam site (Makaroro A7) of 6,090 litres per second, equivalent to an annual inflow volume of 192.2 million m^3 and a mean catchment runoff of 1723 mm p.a.

Table 1 Tukituki River Catchment: water balance analysis (from T+T, 2011)

	Catchment parameters		**Mean annual catchment rainfall**		**Water balance calculations**		
Site	Calculated catchment area (km²)	Mean flow (for full record period) (l/s)	Calculated catchment rainfall (mm)	Adjusted catchment rainfall (mm)	Mean annual runoff (mm p.a.)	Annual rainfall loss (mm p.a.)	Adjusted annual rainfall loss (mm p.a.)
Makaroro at Burnt Bridge	121	6140	2001		1602	399	
Makaroro at Burnt Bridge, using 1941-70 rainfall map	121	6140		2220	1602	617	
Makaroro A7 dam site (inferred*)	111.5	**6090***	2036	**2280**	1723	571	**557**
Makaroro between dam site and Burnt Bridge	9.4	320*	1570		964	606	
Omakere at Fordale	54	870	1163		512	651	
Otane at Glendon	24	158	850		205	645	
Tukituki at Red Bridge	2454	44750	1221	**1240**	576	645	**664**
Tukipo at SH50	85	1530	1397	**1425**	571	826	**854**
Waipawa at RDS	681	14800	1386	**1440**	686	700	**754**
Tukituki at Tupairu Rd	770	15240	1232	**1270**	624	608	**646**
Tukituki at Shag Rock	1939	35590	1229	**1250**	579	650	**671**

Essentially, Mr Riden believes that the mean annual rainfall figure that T+T has used for the Makaroro catchment is too high.

As explained in the T+T (2011) memo, the catchment mean annual rainfall was initially calculated using the rainfall map generated by HBRC based on NIWA's virtual climate station network (VCSN) database. Attachment 1 to this memo shows the detail of this calculation for the Makaroro River upstream of the Burnt Bridge flow site. GIS tools were used to measure areas and rainfall volumes. The catchment-wide mean annual rainfall was determined to be 2001 mm p.a. above Burnt Bridge, and 2036 mm p.a. above the Makaroro dam site.

However, from experience, we find that there is a tendency for certain rainfall maps to underestimate the actual rainfall at higher elevations (e.g. mountain ranges) where there are very few raingauges. Indeed, our analysis of historical rainfall records for the Parks Peak raingauge in the Ruahine Ranges near the headwaters of the Makaroro River indicated a mean annual rainfall of around 2800 mm. This is significantly higher than the 2100 mm shown in the rainfall map generated from the VCSN for the raingauge location, and is higher than the highest contour value in the map of 2300 mm p.a.

Therefore, the initially estimated value of 2001 mm p.a. was checked against the New Zealand Meteorological Service's (NZMS) published map of rainfall normals for 1941 to 1970 at 1:250,000 scale. Attachment 2 to this memo shows the detail of this calculation for the Makaroro River upstream of the Burnt Bridge flow site. The rainfall contours in the map go up to 3200 mm p.a. at the headwaters of the Makaroro (note that the contour intervals above 1600 mm p.a. are: 2000 mm, 2400 mm, 2800 mm and 3200 mm p.a.). Based on this map catchment-wide mean annual rainfalls of

2220 mm and 2280 mm were determined for the catchment above Burnt Bridge and the dam site respectively.

Estimates of the catchment mean annual rainfall from the NZMS map was preferred over the VCSN map because the latter clearly underestimates rainfall at the higher elevations of the catchment relative to actual recorded data. NIWA freely admits that the network's predictions have greater uncertainty in mountainous areas. Further detail of this bias was provided in the rebuttal evidence of David Leong (dated November 2013). Table 2 below is from Paragraph 3.12 of the evidence and shows the extent of the underestimation i.e. between 526 mm and 670 mm at Parks Peak, and between 262 mm and 443 mm at Moorcock.

Table 2 Rainfall near the headwaters of the Waipawa/Tukituki catchment: comparison of real versus virtual climate station means (from Leong rebuttal evidence, 2013)

Station Name or VCS Agent Number	Mean rainfall over 30 years, 1976 – 2005 (mm p.a.)	Rainfall difference: Real minus Virtual (mm p.a.)	Rainfall difference: Real minus Virtual / Real (%)
[1] Parks Peak	2768	-	-
27430	2242	526	19.0
28928	2098	670	24.2
27865	2256	542	19.6
[2] Glenwood	2113	-	-
29417	2229	-117	-5.5
29426	1905	208	9.8
[3] Moorcock	2395	-	-
27330	1952	443	18.5
31011	2133	262	10.9

Notes:
1. **Parks Peak data exists from 1990, and was extended to 1976 via correlation with Smedley Met**
2. **Glenwood data exists from 1985, and was extended to 1976 via correlation with Brentwood**
3. **Moorcock data exists from 1987, and was extended to 1976 via correlation with Brentwood**

The catchment flow yield is equal to the mean annual runoff, which, in the absence of flow records can be computed as the difference between the catchment-wide mean annual rainfall and the rainfall losses. From the preceding catchment-wide rainfall of 2280 mm p.a. for the Makaroro above the dam site was established. For the rainfall losses, a figure of 557 mm p.a. was estimated based on the inverse relationship with mean annual rainfall inferred from the output of NIWA's Water Resources Explorer (WRENZ) web-based tool. The relevant graph which shows the relationship was attached to the peer review report by David Painter (June 2012) and is reproduced as Figure 1 below.

The resulting mean annual runoff was therefore estimated at 2280 – 557 = 1723 mm.

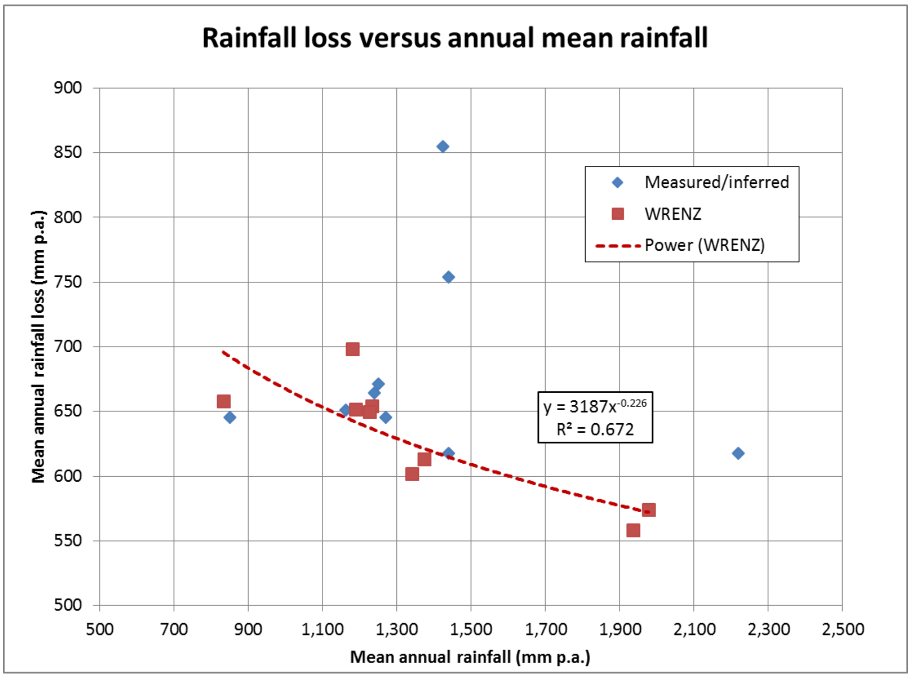


Figure 1 Inferred relationship between annual rainfall loss and the catchment-wide mean annual rainfall (from rebuttal evidence of Leong, 2013)

Arguably, a higher rainfall loss of around 615 mm p.a. could have been equally inferred based on the "measured" (rather than "WRENZ") runoff figures. However, the WRENZ-based data points showed much less scatter around the fitted relationship, and was preferred.

Furthermore, and as elaborated in the T+T (2011) memo, using a different and largely independent calculation method based on reviewing and synthetically extending the Makaroro at Burnt Bridge flow record, a long term mean flow of 6.68 m^3/s was estimated for the period 1968 to 2010. This translated to a mean flow of 6.36 m^3/s at the dam site which is equivalent to an average annual runoff depth of 1799 mm and mean annual flow volume of 201 million m^3. Given a mean annual rainfall of 2280 mm, the inferred rainfall loss would then be 2280 – 1799 = 481 mm p.a., which is closer to 557 mm p.a. than 615 mm p.a.

Whichever the case, the calculation illustrates the nature of the uncertainty in the estimate, which is why the estimate of the long term mean flow at the dam site of 6.36 m^3/s was said to be reliable to within ±10% (refer to Paragraph 2.2 of David Leong's evidence-in-chief), i.e. mean inflow volume estimated to be between 180 and 220 million m^3 per annum.

3 Information available and investigations post-BoI

3.1 Makaroro at Burnt Bridge new flow record

After a break of 20.2 years, the Makaroro at Burnt Bridge was re-established as a fully-rated flow recording site on 23 July 2011 (it previously ceased recording flows on 30 April 1991). The recorded mean flow from 23 July 2011 to 10 January 2017 is 6.21 m^3/s. The equivalent mean flow at the dam site is estimated to be 5.91 m^3/s, or 186 million m^3 p.a.

Over the same period, the mean flow recorded at Tukituki at Tapairu Road (used as an "indicator" site) is 15.565 m^3/s, compared with its long term mean flow (1987 to 2016) of 15.32 m^3/s. Making a simplistic adjustment for variance in the shorter record period and assuming similar flow ratios between the two sites, a corresponding long term mean flow of 6.11 m^3/s is estimated for the Makaroro at Burnt Bridge (i.e. 6.21 x 15.32/15.565 = 6.11). The equivalent long term mean flow at the dam site is 5.83 m^3/s, or 184 million m^3 (see Table 3 later). This estimate is about 8% lower than using the synthetically extended Burnt Bridge record (6.36 m^3/s) and about 4% lower than the catchment water balance estimate (6.09 m^3/s) from the Feasibility Study.

3.2 HBRC rainfall comparison

Under separate cover, HBRC has furnished information on the mean annual rainfall as requested by Mr Riden as part of the current response to Issue 24 of the RWSS Review. Of particular interest is the comparison between the observed mean annual rainfall at the raingauges in the Tukituki catchment operated by HBRC and the corresponding estimates from both the Landcare (1950 -1980) and NIWA (1981 – 2010) maps. The comparison confirms the systematic and severe underestimation of the mean annual rainfall in the headwaters of the Tukituki catchment by the rainfall maps. For example, the Landcare map underestimates Parks Peak rainfall by 736 mm (28%) and Moorcock rainfall by 501 mm (21%), while the NIWA map underestimates Parks Peak rainfall by 307 mm (12%) and Moorcock rainfall by 522 mm (20%).

Interestingly, and also of relevance for water balance analysis of the larger downstream catchments, is the over-prediction of the mean annual rainfall by both maps for the lower rainfall areas in the catchment. For example, the Landcare map overestimates Tapairu Road rainfall by 268 mm (41%), while the NIWA map overestimates by 153 mm (23%). Therefore, water balance analyses using the map values of mean annual rainfall would under-predict the runoff and flow yield from the upper parts of the Tukituki catchment and over-predict the runoff contribution from the mid and lower sub-catchments.

In overall terms, the discrepancy between observed and map estimates of the mean (or median) annual rainfall is significantly larger in the Landcare map compared with the NIWA map.

3.3 Waipawa and Tukituki losing reach investigations

In the first half of 2015, HBRIC commissioned an investigation on the losing reaches on the Waipawa and Tukituki Rivers in relation to their potential use to convey scheme water to downstream areas from the Makaroro Dam. The investigation included installing six temporary sites at strategic locations on the Waipawa and Tukituki Rivers to monitor water levels continuously over a 2 month period over February and March 2015.

One of the conclusions from that study is relevant to the current catchment water balance issue. That is, the indications from the flow assessments, including historical concurrent gaugings, were that the Waipawa reach has a net loss, after baseflow recovery downstream of the losing reach, of around 0.2 to 1.0 m^3/s at the RDS flow recording site (equal to 10 to 50 mm p.a. of runoff) while the Tukituki reach may have no loss, to a gain of around 0.5 m^3/s (0 to 20 mm p.a. of runoff) at the Tapairu Road flow recording site. These nuances require to be taken into account when using flow records for the Waipawa at RDS and Tukituki at Tapairu Road in the wider catchment water balance.

3.4 Updated catchment water balance

The original catchment water balance from the Feasibility Study (FS) has been updated taking into account the above additional information (Sections 3.1 to 3.3). This is presented in Table 3 below. Changes from the FS water balance are indicated by red font. The numbered notes below the table provide detail on some of the changed values.

Apart from the Makaroro River, estimates of the catchment-wide mean annual rainfall are from either the NIWA VCSN map used in the Feasibility Study or the NIWA (1981 – 2010) map used by

HBRC recently, and have not been adjusted to account for the discrepancies compared with observed values at raingauges.

Table 3 Tukituki River Catchment: updated water balance analysis for Makaroro catchment

	Catchment area and mean flow		Mean annual rainfall	Water balance calculations		
Site	Calculated catchment area (km²)	Observed (or inferred*) mean flow (l/s)	[1] Calculated catchment rainfall (mm)	Mean annual runoff (mm p.a.)	Annual rainfall loss (mm p.a.)	Adjusted annual rainfall loss (mm p.a.)
Makaroro at Burnt Bridge (1979 – 1990, unadjusted)	121	6140	[2] 2220	1602	617	
Makaroro at Burnt Bridge (2011 – 2016, normalised to 1987 to 2016)	121	6110	[2] 2220	1595	625	
Makaroro A7 dam site	111.5	**5830***	[2,3] 2275	1650	625	
Makaroro between dam site and Burnt Bridge	9.4	280*	1570	945	625	
Omakere at Fordale	54	870	1163	512	651	
Otane at Glendon	24	158	850	205	645	
Tukituki at Red Bridge	[4] 2464	[5] 44505	[6] 1149	570	579	
Waipawa at RDS	[4] 687	[5] 14970	[6] 1357	688	669	[7] **619**
Tukituki at Tupairu Rd	[4] 760	[5] 15830	[6] 1194	657	537	[7] **557**

Notes:
1 Unless noted otherwise, the rainfall estimate is from the NIWA VCSN map used in the Feasibility Study.
2 Adjusted rainfall estimate taking into account increased rainfall at higher elevations per NZMS 1941- 70 map.
3 Original value from Feasibility Study was a rounded figure of 2280 mm p.a. This figure more precise.
4 Catchment areas from latest HBRC (2017) estimate per the information provided as part of Issue 24.
5 Mean flow used for these sites is the naturalised mean flow per the information provided as part of Issue 24.
6 Rainfall value for these sites is from latest HBRC (2017) estimate based on the NIWA (1981 -2010) map.
7 The adjusted rainfall loss for Waipawa at RDS allows for 50 mm p.a. loss through its losing reach, while the adjusted rainfall loss for Tukituki at Tapairu Road allows for 20 mm p.a. net gain from the Waipawa.

Estimates of the mean annual rainfall loss from the updated catchment water balance above fall in a significantly tighter range (between about 550 mm and 650 mm, excluding for Tukipo at SH50) compared with the Feasibility Study. A constant value of 625 mm p.a. has been adopted for the Makaroro catchment.

It is noted that the slightly low figures for Red Bridge and Tapairu Road may be related to residual underestimation of the rainfall at the headwaters of their catchments. In the case of Tapairu Road, the flow gain from the Waipawa losing reach may be greater than estimated (i.e. more than 20 mm p.a. equivalent).

4 Due diligence for CIIL and Institutional Investor

4.1 Background

In 2016, Crown Irrigation Investments Ltd (CIIL) and an Institutional Investor conducted a range of technical due diligence processes on the RWSS, including this specific issue due to constant challenge. There was a particular focus on the reservoir inflows and associated hydrological reliability of the scheme, resulting in additional investigations being carried out for HBRIC between June and August 2016.

The findings from those investigations are directly relevant to the current matter.

The basic issue identified by Institutional Investor's peer reviewer was the difference between the flows that were being recorded at the reinstated Makaroro at Burnt Bridge and the corresponding flow predictions based on correlations (with the Tukituki at Tapairu Road flow record) developed during the Feasibility Study. Because the recorded mean flow at Burnt Bridge (and therefore at the dam site) was lower than the predicted mean flow using the Tapairu Road-based proxy, there was a concern regarding the effect on the scheme's supply reliability and ability of the reservoir to refill.

This issue was investigated in detail during the due diligence process. The email correspondence included in Attachment 3 provide the outcomes and conclusions from the investigation.

4.2 Key findings

The key findings from the due diligence investigations are summarised below:

- By using flow correlations that utilise both the recent (2011 to 2016) and older (1987 to 1991) Burnt Bridge flow data, the full record (1968 to 2016) mean flow for Burnt Bridge from the Feasibility Study was shown to be overestimated by 3.9%, i.e. 6.45 m^3/s versus 6.71 m^3/s. The overestimation was greater at 7.3% if 1991 to 2016 were used as the base period, i.e. 6.39 m^3/s versus 6.89 m^3/s
- By using just the recent (2011 to 2016) Burnt Bridge flow data, the full record (1968 to 2016) mean flow for Burnt Bridge from the Feasibility Study was shown to be overestimated by 5.5%, i.e. 6.39 m^3/s versus 6.71 m^3/s. The overestimation was greatest at 10.3% if 1991 to 2016 were used as the base period, i.e. 6.18 m^3/s versus 6.89 m^3/s.
- The original Feasibility Study inflows were higher (overestimated) when flows were greater than about 7 m^3/s, slightly higher (slightly overestimated) when flows were between about 3.5 and 4.5 m^3/s, but slightly lower (slightly underestimated) when flows were lower than about 3 m^3/s.
- The reduction in overall mean flow, however, did not translate to a similar reduction in the flow yield of the Makaroro Dam and reservoir. The critical reservoir drawdown period is typically between November and May during the drier years. The wetter periods of the year and the wetter years do not govern drought performance.
- A strong positive correlation was found between the lowest simulated reservoir level and the November to May mean flow. Based on this correlation, a slight improvement (not degradation) in the drought performance of the scheme may be expected relative to the result using the synthetically extended flows from the Feasibility Study.

This extract from an email written by the peer reviewer (Damwatch email dated 27 June 2016) best sums up the situation:

"*In a nutshell this analysis shows that including or adopting the 2011-16 correlation between Tapairu Road and Burnt Bridge flows does not appear to translate into a reduction in the flow yield of the Makaroro Dam.*

The differences in flows duration curves for option A (1987-91 correlation period) and option C (2011-2016 correlation period) in the 3.5 to 4.5 m3/s and less than 3 m3/s ranges may reflect changes in the regulatory minimum flow and consented take volumes in the Tapairu Road Water Allocation Zone between the two correlation periods or this in combination with decadal scale climate variability. The differences in the two datasets offset what might otherwise be a reduction in the modelled dam flow yield because maximum drawdown in dry years is driven mainly by the magnitude of inflows in the irrigation season and in the drier years Option C has slightly higher irrigation season flows than Option A.

I think we can say that the question I raised has been answered and that the identified variability does not adversely affect the predicted reservoir yield. It is likely therefore that if a dam inflow dataset based on Option C were run through the Goldsim model, the reliability of irrigation supply to farm gate would be similar to the existing results for Option A."

This effectively closed out the issue for potential investors.

4.3 Revised reservoir and scheme reliability modelling

Further to the peer reviewer's last comment above, the model which simulates the operation of the scheme (the RWSS "Goldsim" model) was re-run using the revised inflows based on correlation with the recent Burnt Bridge data. The modelling runs were completed in-house by HBRC. Results from the simulations do indeed show slightly better scheme reliability when the updated inflows (with lower overall mean flow) are used instead of the original Feasibility Study inflows. This is demonstrated by Table 4, which shows the modelled curtailment volumes on a year by year basis resulting from inadequate inflow, and by Table 5, which summarises the overall volumetric reliability. (NB: Option A uses the original Feasibility Study inflows while Option C uses correlations from just the recent Burnt Bridge data 2011 – 2016).

For example, in the second worst drought on record (the 1997/1998 growing season), by using the updated inflows (with lower overall mean flow) the volumetric shortfall is 15.00 million m^3 (for Option C) compared with 15.69 million m^3 based on the Feasibility Study inflows (Option A). The improvement is more dramatic in the 2012/2013 season, whereby the modelled shortfall for Option C is 7.59 million m^3 compared with 11.47 million m^3 for Option A.

Table 4 RWSS – modelled annual curtailment volume (from modelling by HBRC, August 2016)

	Annual Curtailment from Dam Shortages		
Flow Scenario	A	B	C
Unit:	GL	GL	GL
1973	4.95	4.95	4.95
1974	0.00	0.00	0.00
1975	0.00	0.00	0.00
1976	0.00	0.00	0.00
1977	0.00	0.00	0.00
1978	0.00	0.00	0.00
1979	0.00	0.00	0.00
1980	0.00	0.00	0.00
1981	0.00	0.00	0.00
1982	0.00	0.00	0.00
1983	16.64	16.64	16.64
1984	0.00	0.00	0.00
1985	0.00	0.00	0.00
1986	0.00	0.00	0.00
1987	0.00	0.00	0.00
1988	0.00	0.00	0.00
1989	0.00	0.00	0.00
1990	0.00	0.00	0.00
1991	0.00	0.00	0.00
1992	0.00	0.00	0.00
1993	0.00	0.00	0.00
1994	0.00	0.00	0.00
1995	0.00	0.00	0.00
1996	0.00	0.00	0.00
1997	0.00	0.00	0.00
1998	15.69	15.45	15.00
1999	0.00	0.00	0.00
2000	0.00	0.00	0.00
2001	0.00	0.00	0.00
2002	0.00	0.00	0.00
2003	0.00	0.00	0.00
2004	0.00	0.00	0.00
2005	0.00	0.00	0.00
2006	0.00	0.00	0.00
2007	0.00	0.00	0.00
2008	0.00	0.00	0.00
2009	0.00	0.00	0.00
2010	0.00	0.00	0.00
2011	0.00	0.00	0.00
2012	0.00	0.00	0.00
2013	11.47	7.59	7.59

Table 5 RWSS – Modelled overall volumetric reliability (from modelling by HBRC, August 2016)

Total Ordered/Delivered/Curtailment Statistics (41 years)				
Flow Scenario	Total Ordered	Total Delivered	Curtailment	Percentage (Curtailed/Ordered)
	GL	GL	GL	%
A	3282	3228	54	1.66%
B	3282	3232	50	1.52%
C	3282	3233	49	1.50%

5 Conclusions

Some weight was given to the catchment water balance analysis during the Feasibility Study because of the uncertainty in the older historical flow record for the Makaroro River. Done properly, such an analysis leverages the available hydrometric data (rainfall and flow records) for the wider Tukituki catchment (not just the Makaroro) to confirm if the recorded mean flow is of the correct order or if an adjustment is required.

However, as has become patently clear, there can be equally significant uncertainties in applying this approach, particularly in estimating the catchment-wide mean annual rainfall. In this regard, rainfall comparisons recently provided by HBRC in response to Mr Riden's request conclusively show that both the Landcare (1950 - 1980) and NIWA (1981 – 2010) rainfall maps systematically underestimate the catchment rainfall at the headwaters of the Tukituki catchment, including nearly all of the Makaroro catchment. At the same time though, the HBRC rainfall information supports the Feasibility Study estimates for the Makaroro catchment.

Given that there is now a significantly more reliable flow record for the Makaroro River, albeit of a shorter duration (2011 – 2016), it is possible to make an estimate of the long term mean flow directly from this record that can be accorded considerably more weight than the estimate from catchment water balance. The recorded mean flow from 23 July 2011 to 10 January 2017 is 6.21 m^3/s. By using the Tukituki at Tapairu Road as an indicator site, the adjusted long term mean flow (for the period 1987 to 2016) for the Makaroro at Burnt Bridge is now estimated at 6.11 m^3/s.

This is equivalent to a mean flow at the dam site of 5.83 m^3/s and an annual inflow volume 184 million m^3. This mean flow estimate is about 8% lower than using the synthetically extended Burnt Bridge record (6.36 m^3/s) and about 4% lower than the catchment water balance estimate (6.09 m^3/s) from the Feasibility Study.

However, the reduction in overall mean flow does not translate to a similar reduction in the flow yield of the Makaroro Dam and reservoir. This is because the Feasibility Study flows appear to have been overestimated during medium to high flows and slightly underestimated during low flows. The upshot is that there is in effect a slight improvement (not degradation) in the drought performance of the scheme relative to the pre-BoI simulations using the Feasibility Study inflows.

Encl.

Attachment 1	Calculation of the catchment-wide mean rainfall for the Makaroro at Burnt Bridge using HBRC's rainfall map based on NIWA's VCSN data
Attachment 2	Calculation of the catchment-wide mean rainfall for the Makaroro at Burnt Bridge using New Zealand Meteorological Service's (NZMS) published map of rainfall normals for 1941 to 1970 at 1:250,000 scale
Attachment 3	Email correspondence from due diligence process related to reservoir inflow and scheme reliability

17-Mar-17
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ATTACHMENT 1

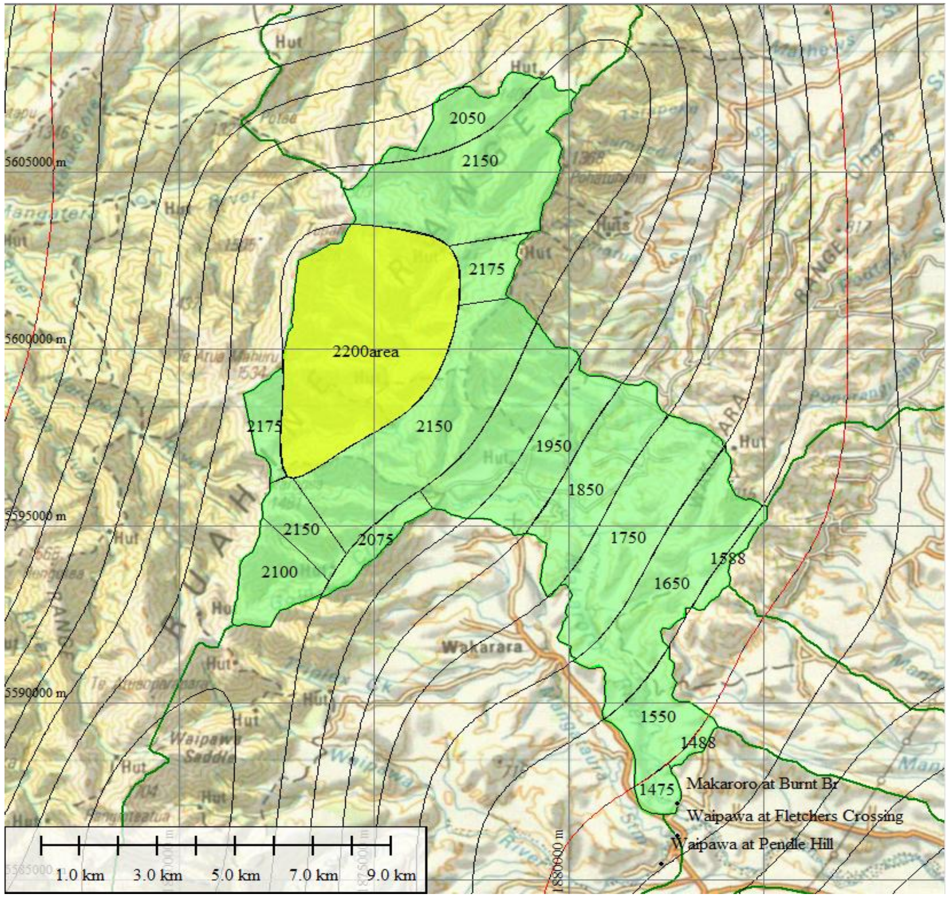
Makaroro site		122km²	
Average annual rainfall map (mm) 1979-1990			
Rainfall (mm)	Area (km²)	Area(m²)	Volume (m³)
1475	1.161	1161000	1712475
1488	0.524	524000	779712
1550	4.382	4382000	6792100
1588	1.08	1080000	1715040
1650	10.825	10825000	17861250
1750	10.944	10944000	19152000
1850	8.123	8123000	15027550
1950	6.294	6294000	12273300
2050	7.2	7200000	14760000
2075	2.063	2063000	4280725
2100	4.176	4176000	8769600
2150	2.92	2920000	6278000
2150	15.373	15373000	33051950
2175	2.026	2026000	4406550
2175	2.591	2591000	5635425
2150	14.198	14198000	30525700
2050	3.604	3604000	7388200
2200	23.42	23420000	51524000
Totals>	120.904	120904000	241933577

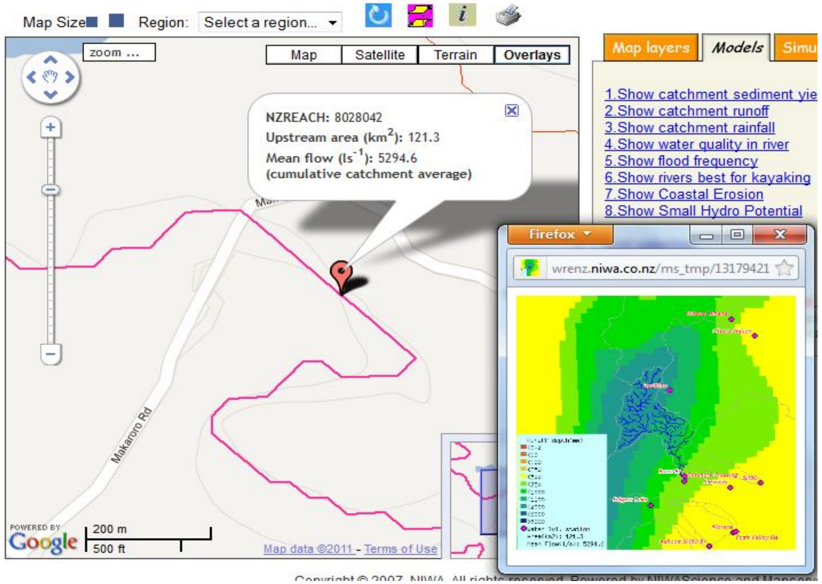
Average catchment rainfall (m	2001.04

Catchment area check		
Measured catchment area	121	km²
Reported catchment area	122	km²

WRE, other parameters*		
Catchment area	121.3	km²
Mean annual rainfall	1935.8	mm
Mean flow	5294.6	l/s

*See screenshots below




Map Size
Region: Select a region...
Map
Satellite
Terrain
Overlays
NZREACH: 8028042
Upstream area (km2): 121.3
Mean flow (ls-1): 5294.6
(cumulative catchment average)
Makaroro Rd
200 m
500 ft
Map data ©2011 - Terms of Use
Map layers
Models
1.Show catchment sediment yie
2.Show catchment runoff
3.Show catchment rainfall
4.Show water quality in river
5.Show flood frequency
6.Show rivers best for kayaking
7.Show Coastal Erosion
8.Show Small Hydro Potential
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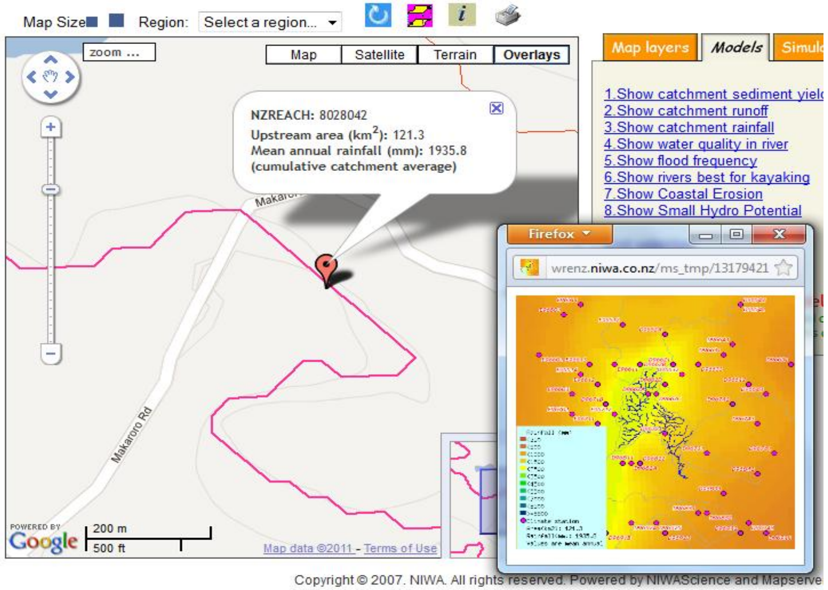
Map Size
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Map
Satellite
Terrain
Overlays
NZREACH: 8028042
Upstream area (km2): 121.3
Mean annual rainfall (mm): 1935.8
(cumulative catchment average)
Makaroro Rd
200 m
500 ft
Map data ©2011 - Terms of Use
Map layers
Models
1.Show catchment sediment yiel
2.Show catchment runoff
3.Show catchment rainfall
4.Show water quality in river
5.Show flood frequency
6.Show rivers best for kayaking
7.Show Coastal Erosion
8.Show Small Hydro Potential
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ATTACHMENT 2

Makaroro site 122km²

Average annual rainfall map (mm) 1941-1970

Rainfall (mm)	Area(m²)	Volume (m³)
3200	3676461	11764675.2
3000	15453409	46360227
2600	31620869	82214259.4
2200	18307144	40275716.8
1500	13203593	19805389.5
1350	3467818	4681554.3
1800	35290511	63522919.8
Totals>	121019805	268624742

Average catchment rainfall (m	2219.68

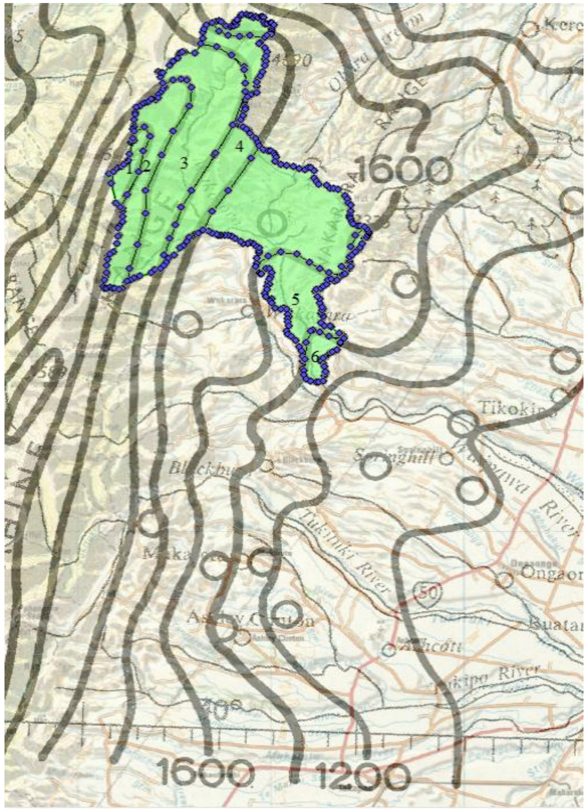
Catchment area check

Measured catchment area	121	km²
Reported catchment area	122	km²

WRE, other parameters*

Catchment area	121.3	km²
Mean annual rainfall	1935.8	mm
Mean flow	5294.6	l/s

*See screenshots below



ATTACHMENT 3

David Leong

From:	Graeme Hansen <Ganz@hbrc.govt.nz>
Sent:	Wednesday, 22 June 2016 5:51 PM
To:	Grant Pechey; Tony Harker; Alasdair Keane (keane.associates@xtra.co.nz); Rob Waldron; David Leong; Dunlop, Chris
Subject:	RE: Technical Due Diligence - hydrology inflow query

Hi Tony/ Alasdair, I attached below the results from David Leong's work with respect to the hydrology review work completed, alongside data and processing detail undertaken by HBRC and HBRIC, as requested by Damwatch.

Once you have had an opportunity to review and consider the findings it may be appropriate to have further discussions directly with David, or our wider team as necessary.

I will leave it to you to come back to us as to the next steps and trust the attached information meets with your req uirements.

Regards Graeme

Hi Grant and Graeme

I have completed the work requested below. I have checked the output, and the resulting plots and flow values seem to be correct . However, will double check once more to after I send the data to make sure.

Hourly flows in TIDEDA have been exported to csv files and will be sent separately – about 10 MB for each scenario. Note that the data starts on 22 May 1968. Grant, please remember to truncate the earlier data from May 1968 to December 1971 if you wish to run your simulation from 1972 onwards.

There are three scenarios or options for the Makaroro flow record at Burnt Bridge:

- Option A – the original feasibility data, based on Burnt Bridge (BB)/Tapairu Road (TR) correlation between May 1987 and April 1991 for generating the synthetic BB data from May 1991 onwards from TR data, and this includes the period from July 2011 to May 2016, even though real BB data exists for this period.
- Option B – this dataset uses the BB/TR correlation for the full period of overlapping data available, i.e. May 1987 to April 1991 and July 2011 to and May 2016, for generating synthetic BB data from May 1991 to July 2011. Unlike Option A, this record adopts the real data from the BB gauge for the period July 2011 to May 2016.
- Option C - this dataset uses the BB/TR correlation from the latter period of overlapping data only, i.e. July 2011 to and May 2016, for generating synthetic BB data from May 1991 to July 2011. Unlike Option A, but similar to Option B, this record adopts the real data from the BB gauge for the period July 2011 to May 2016.

The full record mean flows for each option (from 1968 to 2016):

- Option A mean flow 1968 to 2016 = 6.707 m3/s
- Option B mean flow 1968 to 2016 = 6.446 m3/s (i.e. 3.9% lower than Option A)
- Option C mean flow 1968 to 2016 = 6.338 m3/s (i.e. 5.5% lower than Option A)

The differences are greater if mean flows from the period from May 1991 to May 2016 are compared, the reason being the record for all three scenarios from May 1968 up to April 1991 are exactly the same.

- Option A mean flow 1991 to 2016 = 6.888 m3/s
- Option B mean flow 1991 to 2016 = 6.386 m3/s (i.e. 7.3% lower than Option A)
- Option C mean flow 1991 to 2016 = 6.179 m3/s (i.e. 10.3% lower than Option A)

Below is a visual comparison of the Flow Duration Curves for each scenario for the full record period:

- Red curve is Option A
- Blue curve is Option B
- Green curve is Option C.

Basically, relative to Option C, the original feasibility data (Option A) shows higher values (overestimation) when the flows are greater than about 7 m3/s, slightly higher values (slight overestimation) when flows are between about 3.5 and 4.5 m3/s, but slightly lower values (slight underestimation) when flows are lower than about 3 m3/s.

Finally, and as before, to obtain the dam inflow, multiply the Makaroro at Burnt Bridge flow by 0.952.

Further to my above email and our conversation this morning, I add the following further interpretation of the flow datasets:

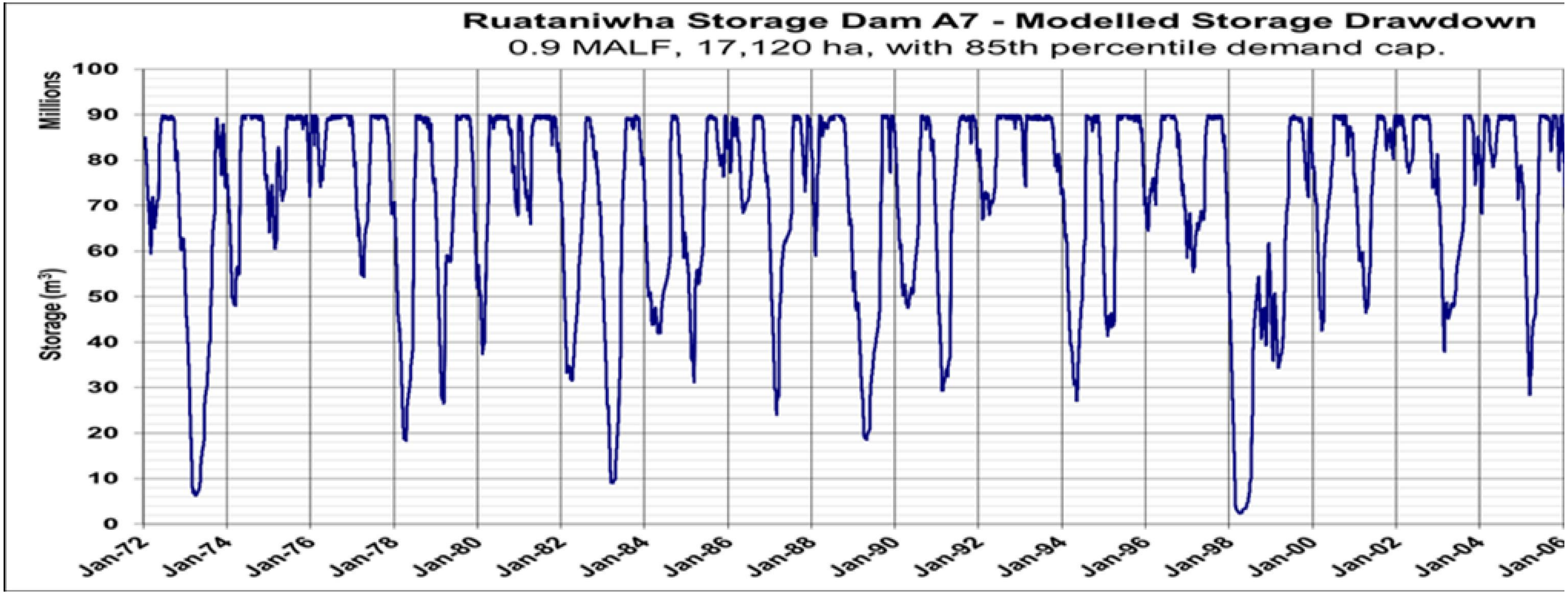
1. As expected , the maximum difference is between Options A and C. Option B demonstrates an intermediate difference. Option C implies that we give no weight at all to the earlier BB/TR flow correlation (1987 to 1991), while Option B implies equal weighting to both the earlier and latter (2011 to 2016) flow correlations. Option A is of course the original feasibility dataset that has been used to date, based only on he earlier BB/TR flow correlation, with the period 2011 to 2016 comprised of synthetic TR-based data.

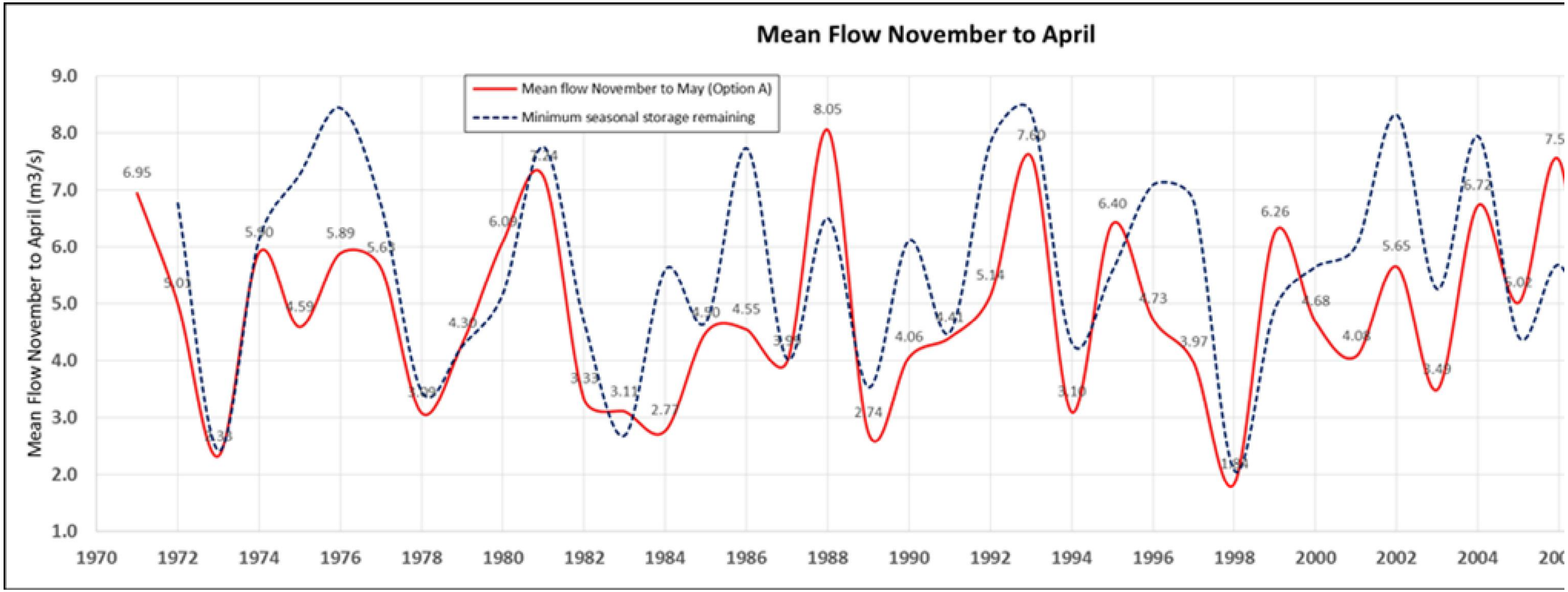
2. Assuming for the moment that Option C is the most reliable dataset, then the flow duration curve comparison below suggests that we have been overestimating flow availability during higher flow periods (when flows are > 7m3/s), slightly overestimating flow availability when the flow is between about 3.5 and 4.5 m3/s, and slightly underestimating flow availability when flows are less than about 3 m3/s.

3. The reduction in the overall mean flow indicated by Option C (relative to Option A) depends on the period of data being considered, and is 5.5% if the overall record 1968 to 2016 is considered and 10.3% if the period 1991 to 2016 is compared. Individual years show greater or lesser differences.

4. HOWEVER, the reduction in overall mean flow does not necessarily translate to a similar reduction in the water yield of the Makaroro dam and reservoir. The critical reservoir drawdown period is typically between November and May during the drier years (which put stress on the reservoir supply-demand balance). The wetter periods of the year and the wetter years do not normally govern drought performance.

5. I have done a simplistic analysis of the correlation between the mean flow from November to May each year and the lowest reservoir storage each year (as modelled during our feasibility study). The storage trajectory plot below is from page 63 (Section 4.2.8) of our Feasibility Study Report (Ref. 27690.100/3, August 2012). Taking the lowest storage each year and plotting these we get the dashed dark blue line in the lower plot ("minimum seasonal storage remaining"). The solid red line in the lower plot shows the mean flow for the 6 months November to May each year (Option A). You will see a strong correlation between the deeper troughs in the dashed blue line and red line plots. That is, the years which incur the largest storage drawdowns (critical w.r.t. drought reliability), coincide with the years with the lowest November to May inflows. These critical years are 1973, 1983, 1998 and 2008. The years 1978, 1989, 2007 and 2009 also indicate large drawdowns.





6. The table below sets out the mean flow from November to May each year for all three datasets (Options A, B and C). They rows have been colour-coded to highlight the driest years (red). The values from 1969 to 1990 are the same for each dataset, as expected. They differ from 1991 onwards. You will see a pattern in this table that reflects the flow duration comparison. That is, for the wetter seasons (November to May) as indicated by the green and light green shading, Option C has consistently lower values than Option A i.e. the feasibility study has potentially overestimated the actual flow. However, for the drier seasons as indicated by the dark orange and red shading, Option C has similar or slightly higher values than Option A i.e. the feasibility study has potentially underestimated the actual flow. For example, in the critical 1998 year, the November to May mean flow has increased from 1.839 m3/s in Option A to 2.011 m3/s in Option C. Given the positive correlation above between the magnitude of the dry year drawdown and the seasonal November to May mean flow, one may surmise that Option C may result in similar or slightly better dry year performance of the Makaroro dam and reservoir compared with the feasibility estimate (which uses Option A).

	Option A	Option B	Option C
Water years (ending June)	Nov to May Mean flow (m3/s)	Nov to May Mean flow (m3/s)	Nov to May Mean flow (m3/s)
1969	3.260	3.260	3.260
1970	5.650	5.650	5.650
1971	6.945	6.945	6.945
1972	5.007	5.007	5.007
1973	2.326	2.326	2.326
1974	5.897	5.897	5.897
1975	4.592	4.592	4.592
1976	5.886	5.886	5.886
1977	5.631	5.631	5.631
1978	3.087	3.087	3.087
1979	4.297	4.297	4.297
1980	6.089	6.089	6.089
1981	7.238	7.238	7.238
1982	3.328	3.328	3.328
1983	3.111	3.111	3.111
1984	2.773	2.773	2.773
1985	4.495	4.495	4.495
1986	4.547	4.547	4.547
1987	3.989	3.989	3.989
1988	8.050	8.050	8.050
1989	2.738	2.738	2.738
1990	4.063	4.063	4.063
1991	4.405	4.181	4.055
1992	5.140	4.862	4.717
1993	7.596	7.090	6.805
1994	3.101	3.088	3.097
1995	6.405	6.019	5.810
1996	4.733	4.601	4.521
1997	3.973	3.895	3.860
1998	1.839	1.956	2.011
1999	6.256	5.870	5.657
2000	4.684	4.407	4.330
2001	4.078	3.956	3.898
2002	5.653	5.325	5.140
2003	3.494	3.435	3.409
2004	6.724	6.332	6.019
2005	5.016	4.744	4.599
2006	7.523	6.919	6.651
2007	2.488	2.522	2.552
2008	2.993	3.000	2.999
2009	2.737	2.752	2.774
2010	4.656	4.348	4.191
2011	5.488	5.138	4.979
2012	6.736	7.023	7.023
2013	1.692	1.886	1.886
2014	6.741	5.884	5.884
2015	3.551	3.769	3.769
2016	3.042	3.605	3.579

7. To confirm the above inference, the Goldsim simulations/storage modelling should be re-run substituting the Option C dataset for the original feasibility inflow dataset (Option A).

I trust the above is clear enough and useful. I am more than happy to provide further clarifications as required and to discuss this matter with others as instructed by you.

Ngā Mihi | Kind regards,
David Leong | Senior Water Resources Engineer
BE(Hons), ME(Dist.), MIPENZ, CPEng, IntPE(NZ), RE Cat A
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From: Grant Pechey
Sent: Tuesday, 24 May 2016 9:01 a.m.
To: Tony Harker <Tony.Harker@damwatch.co.nz>
Cc: Alasdair Keane (keane.associates@xtra.co.nz) <keane.associates@xtra.co.nz>; Graeme Hansen <Ganz@hbrc.govt.nz>
Subject: Re: Technical Due Diligence - hydrology

Hi Tony,

I expect to be back in the office tomorrow. Perhaps we could schedule a call tomorrow afternoon or Thursday. Please let me know what day/time would be suitable for you and Alasdair.

I intend asking Rob Waldron to join us for the meeting. It may be helpful if Alasdair could briefly list any issues or concerns prior to our discussion. That way we can come prepared.

Regards

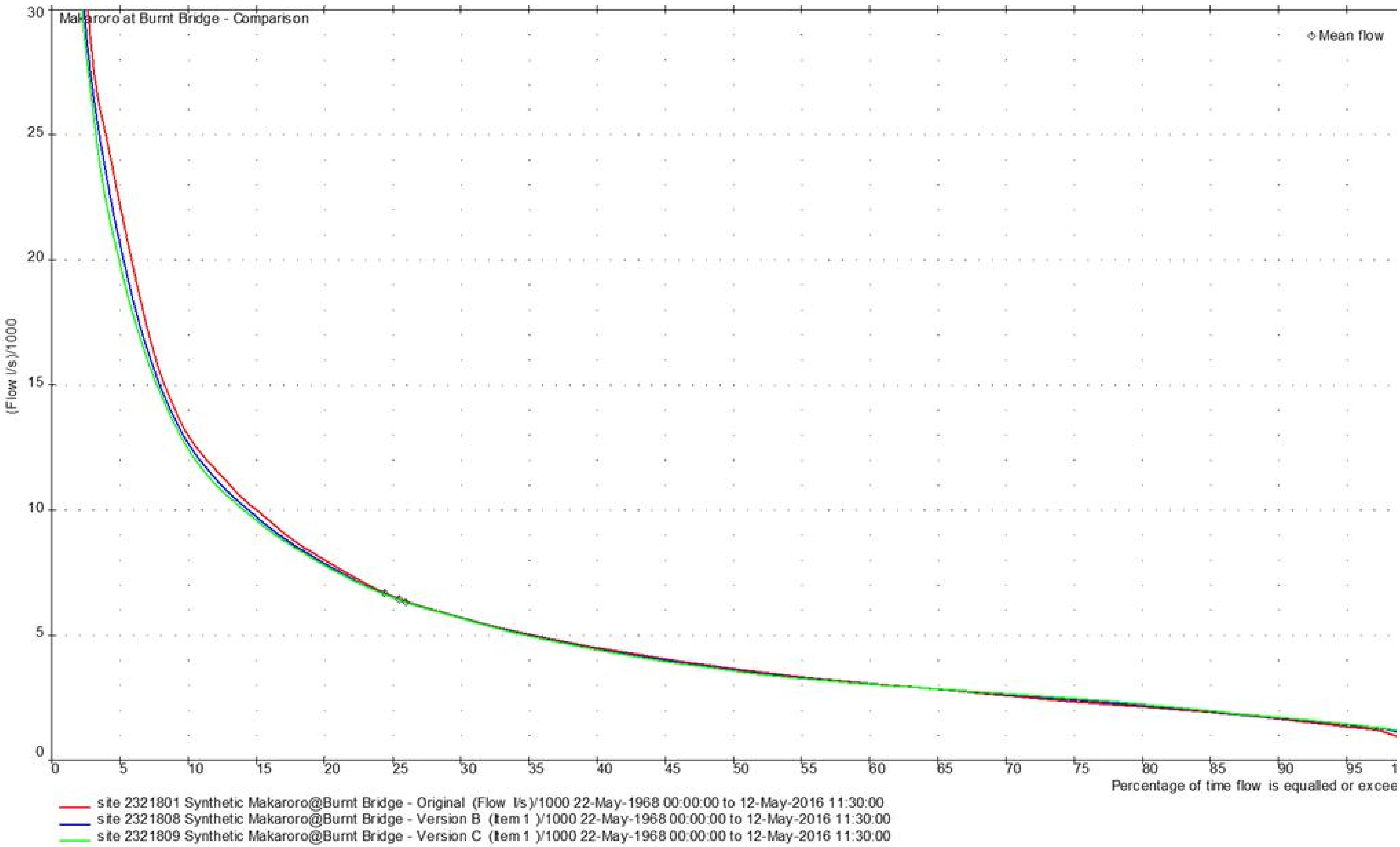
Grant Pechey
Hawkes Bay Regional Council

David Leong

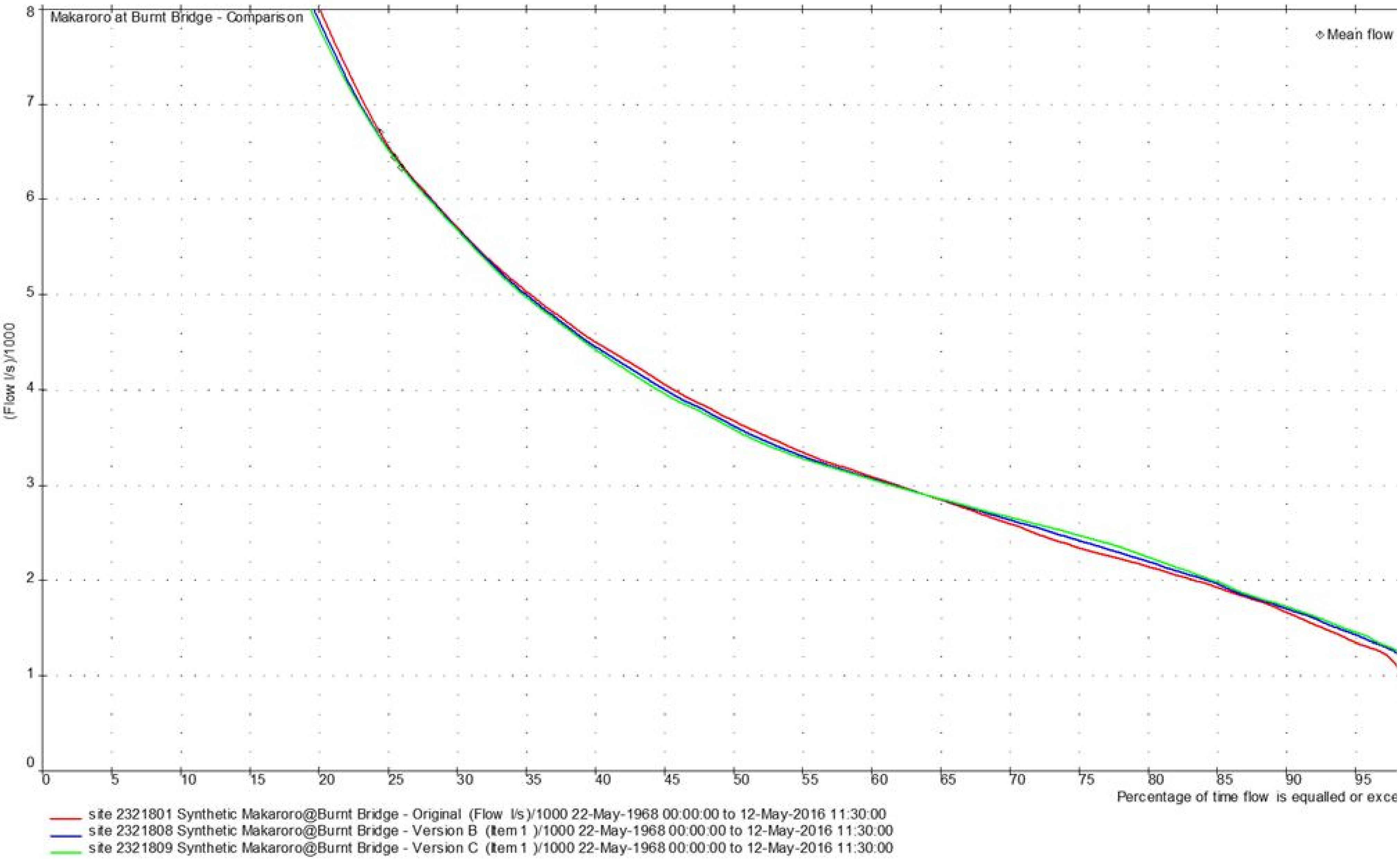
From: David Leong <DLeong@tonkintaylor.co.nz>
Sent: Wednesday, 22 June 2016 6:36 PM
To: Graeme Hansen; Grant Pechey; Tony Harker; Alasdair Keane (keane.associates@xtra.co.nz); Rob Waldron; Dunlop, Chris
Subject: RE: Technical Due Diligence - hydrology inflow query

Gentlemen,

Just noted that the flow duration curves that were referred to below weren't included in Graeme's email. Here they are:



Makaroro at Burnt Bridge - Comparison
◇ Mean flow
(Flow l/s)/1000
0
5
10
15
20
25
30
0
5
10
15
20
25
30
35
40
45
50
55
60
65
70
75
80
85
90
95
1
Percentage of time flow is equalled or excee
site 2321801 Synthetic Makaroro@Burnt Bridge - Original (Flow l/s)/1000 22-May-1968 00:00:00 to 12-May-2016 11:30:00
site 2321808 Synthetic Makaroro@Burnt Bridge - Version B (Item 1)/1000 22-May-1968 00:00:00 to 12-May-2016 11:30:00
site 2321809 Synthetic Makaroro@Burnt Bridge - Version C (Item 1)/1000 22-May-1968 00:00:00 to 12-May-2016 11:30:00



Makaroro at Burnt Bridge - Comparison
Mean flow
(Flow l/s)/1000
Percentage of time flow is equalled or exce
site 2321801 Synthetic Makaroro@Burnt Bridge - Original (Flow l/s)/1000 22-May-1968 00:00:00 to 12-May-2016 11:30:00
site 2321808 Synthetic Makaroro@Burnt Bridge - Version B (Item 1)/1000 22-May-1968 00:00:00 to 12-May-2016 11:30:00
site 2321809 Synthetic Makaroro@Burnt Bridge - Version C (Item 1)/1000 22-May-1968 00:00:00 to 12-May-2016 11:30:00

David

David Leong

To: Tony Harker
Subject: RE: Technical Due Diligence - hydrology inflow query

From: Tony Harker [mailto:Tony.Harker@damwatch.co.nz]
Sent: Monday, 27 June 2016 4:46 PM
To: Graeme Hansen <Ganz@hbrc.govt.nz>; David Leong <DLeong@tonkintaylor.co.nz>; Grant Pechey <grant@hbrc.govt.nz>; Alasdair Keane (keane.associates@xtra.co.nz) <keane.associates@xtra.co.nz>; Rob Waldron <Rob@hbrc.govt.nz>; Dunlop, Chris <Chris.Dunlop@smec.com>
Cc: Peter Amos <Peter.Amos@damwatch.co.nz>
Subject: RE: Technical Due Diligence - hydrology inflow query

Hi Graeme,

Alasdair has taken a look at the information you provided, below is his summary. We will inform of the outcome.

In a nutshell this analysis shows that including or adopting the 2011-16 correlation between Tapairu Road and Burnt Bridge flows does not appear to translate into a reduction in the flow yield of the Makaroro Dam.

The differences in flows duration curves for option A (1987-91 correlation period) and option C (2011-2016 correlation period) in the 3.5 to 4.5 m3/s and less than 3 m3/s ranges may reflect changes in the regulatory minimum flow and consented take volumes in the Tapairu Road Water Allocation Zone between the two correlation periods or this in combination with decadal scale climate variability. The differences in the two datasets offset what might otherwise be a reduction in the modelled dam flow yield because maximum drawdown in dry years is driven mainly by the magnitude of inflows in the irrigation season and in the drier years Option C has slightly higher irrigation season flows than Option A.

I think we can say that the question I raised has been answered and that the identified variability does not adversely affect the predicted reservoir yield. It is likely therefore that if a dam inflow dataset based on Option C were run through the Goldsim model, the reliability of irrigation supply to farm gate would be similar to the existing results for Option A.

Thanks and best regards,

Tony Harker
Instrumentation Group Manager

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From: Graeme Hansen [mailto:Ganz@hbrc.govt.nz]
Sent: Wednesday, 22 June 2016 8:14 p.m.
To: David Leong; Grant Pechey; Tony Harker; Alasdair Keane (keane.associates@xtra.co.nz); Rob Waldron; Dunlop, Chris
Subject: RE: Technical Due Diligence - hydrology inflow query

Thanks David and sorry about the omission.

Regards Graeme

David Leong

From:	David Leong
Sent:	Tuesday, 30 August 2016 4:11 PM
To:	Andrew Newman; Grant Pechey
Subject:	RE: Flow Scenarios ABC - Goldsim modelling outputs

Hi Andrew, Grant

Without spending time on literature research and case studies, here is my brief take on reliability of the scheme based on Grant's Goldsim modelling results:

The key results from Goldsim modelling of the scheme operation that indicate scheme reliability are summarised in two tables supplied to me. The first table (replicated below as Table 1) presents the curtailment volume on an annual basis over the 41 year modelled period 1973 to 2013 for each of the modelled flow options A, B and C. The second table (replicated below as Table 2) provides an overall summary in terms of the overall curtailment versus the volume ordered i.e. effectively the scheme's volumetric reliability. It is assumed that "curtailment" here is equal to the shortfall volume. (As an aside, it is pleasing to note that the modelled difference between flow scenarios A, B and C in terms of shortfalls has turned out exactly as I surmised in my email of 22 June 2016 based on a simple proxy using November to May mean flows.)

Shortfalls are recorded in 4 years out of the 41 years modelled which indicates a slightly better reliability than a 1 in 10 year shortfall frequency. It appears that the average annual ordered volume is about 80 million m^3. Assuming this is the ordered volume in the shortfall years (would expect the volumes to be slightly greater as these years would correspond with high demand years), the percentage shortfall would be about 6% in 1973, 21% in 1983, 20% in 1998 and 9.5% in 2013. However, taken over the entire modelled period, the average shortfall is only 1.5%.

Data on comparable schemes are not readily available and where available not easily verifiable. Below (Figure 1) is an extract from the 2016 Update of the report "Cost of Irrigation Scheme Water Supply in New Zealand" issued by Irrigation New Zealand (INZ). The INZ (2016) report is attached. A "Reliability Estimate" for each of the surveyed schemes is included in the figure below (which is the main result of the report). However, how reliability is measured or expressed in the table is not defined, only that it is in response to a one of the survey questions: "What is the reliability of the scheme?" Further, a list of the schemes and their corresponding identification numbers (ID) was purposely omitted to maintain anonymity, as a condition required by the representatives of the surveyed schemes. Despite the lack of specificity, it is probably reasonable to assume that "Reliability" in the table most likely refers to the overall volumetric reliability (viz. volume received/volume requested). Across all schemes, the median value is 95% and the average 92.3%. The upper quartile value is 98.8%. On this approximate basis, the RWSS as modelled, which has a volumetric reliability of 98.5% is at the upper quartile value (more precisely at the 74th percentile).

A 2001 report by Lincoln Environmental entitled "Reliability of Supply for Irrigation in Canterbury" prepared for Environment Canterbury (C. Robb and I. McIndoe) considers a range of criteria for measuring reliability of irrigation supply. Clearly, reliability can be defined in different ways. The Lincoln Environmental report used a two tier approach. The first tier described reliability in terms of the number of years that "sufficient" water is available, where the threshold for "sufficient" incorporated some restrictions that could be addressed by on-farm management with no significant decrease in annual profit. The second tier described reliability in terms of the frequency of a "severe" event, which would result in a significant reduction in farm profit. The thresholds for "sufficient" and "severe" are complex, and depend on severity, duration, timing, frequency and predictability of supply restrictions as well as on-farm factors such as soil type, on-farm storage, land use type and farming practices. This report is attached for your study.

Without the benefit of the detailed results for confirmation, it appears that two of the four years with a shortfall would be borderline "severe" or "low threshold" events i.e. 1983 and 1998, while the other two shortfall years would likely meet the high threshold criteria. On this basis, the scheme may be classified as having a reliability between “Reliability Option 1” and “Reliability Option 2” (refer to description below).

Reliability Option 1	-	Allocate so that every year restrictions are no more than a level that can be addressed by on-farm management with no significant decrease in annual profit.
Reliability Option 2	-	Allocate so that in 4 out of 5 years restrictions can be addressed by on-farm management with no significant decrease in annual profit, and with only 1 year in 20 subject to a severe event that causes a significant decrease in annual profit.
Reliability Option 3	-	Allocate so that in 3 out of 5 years restrictions can be addressed by on-farm management with no significant decrease in annual profit, and 1 year in 10 subject to a severe event, causing a significant decrease in annual profit.

I trust this is helpful. Happy to discuss further as required.

Cheers

Ngā Mihi | Kind regards,

David Leong | Senior Water Resources Engineer
BE(Hons), ME(Dist.), MIPENZ, CPEng, IntPE(NZ), RE Cat A
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Figure 1 Extract from INZ publication *Cost of Irrigation Scheme Water Supply in New Zealand, 2016 Update* (A. Curtis)

Table 1:

ID	Share Price ($)	Share Basis (ℓ/s, m³, ha)	On-farm Storage reqt $/ha	Annual Charge ($)	Annual Charge Basis (ℓ/s, m³, ha)	Variable Charge ($)	Variable Charge Basis (ℓ/s, m³, ha)	ℓ/s/ha	Maximum System Capacity (mm/day)	Piped or Open Channel	Continuous Supply or Roster supply	Delivery Pressure (bar)	Reliability Estimate (%)	Seasc Lim (m³/
1	$3,300	ℓ/s	–	$1,370	ℓ/s	$0.07	m³	0.60	5.2	P	CS	4	97%	–
2	$5,500	ha	–	$228	ha	–	–	0.42	3.6	OC	CS	0	95%	562
3	$5,500	ha	–	$429	ha	–	–	0.42	3.6	OC	CS	0	95%	562
4	$5,500	ha	–	$229	ha	–	–	0.42	3.6	OC	CS	0	95%	562
5	–	ha	–	$457	ha	–	–	0.42	3.6	P	CS	4	95%	562
6	$5,500	ha	–	$197	ha	–	–	0.42	3.6	OC	CS	0	95%	562
7	$15,000	ℓ/s	–	$85	ha	–	–	0.41	3.5	OC	RS	0	95%	–
7a	$15,000	ℓ/s	–	$288	ha	–	–	0.46	4	P	CS	4	95%	–
8	$5,300	ℓ/s	–	$75	ha	–	–	0.41	3.5	OC	RS	0	95%	–
8a	$3,000	ℓ/s	–	$75	ha	–	–	0.41	3.5	OC	RS	0	80%	0
9	$5	ha	–	$54	ha	–	–	0.46	4	OC	RS	0	75%	–
10	$12,000	ℓ/s	–	$182	ha	–	–	0.52	4.5	P	CS	4	95%	–
11	$4,300	ha	–	$72	ha	–	–	0.60	5.2	OC	CS	0	94%	–
12	$7,700	ℓ/s	–	$112	ha	–	–	0.52	4.5	OC	CS	0	75%	–
12a	$7,700	ℓ/s	–	$224	ha	–	–	0.52	4.5	OC	CS	0	90%	–
13	–	ha	–	$141	ha	–	–	0.41	3.5	OC	CS	0	95%	–
14a	$2,124	ha	–	$59	ha	$0.07	m³	1.16	10	OC	RS	0	99%	810
14b	$2,030	ha	–	$49	ha	$0.07	m³	0.43	3.7	P	CS	6	99%	610
15	$4,500	ha	–	$614	ha	$0.06	m³	0.40	3.5	P	CS	5	99%	–
16	$40	ha	–	$230	ha	$0.03	m³	0.41	3.5	P	CS	1.5	99%	300
17	$1,302	ℓ/s	$146.25	$765	l/s	–	–	0.45	3.9	OC	CS	0	82%	–
18a	$446	ha	–	$58	ha	–	–	0.72	6.25	OC	RS	0	99%	0
18b	$446	ha	–	$46	ha	–	–	0.50	4.3	OC	CS	0	99%	0
19a	$2,478	ha	–	$190	ha	–	–	0.96	8.3	OC	RS	0	99%	100
19b	$2,478	ha	$1,225	$190	ha	–	–	0.58	5	OC	RS	0	99%	600
20	$4,197	ha	–	–	ha	$0.22	m³	0.21	1.8	P	CS	3	85%	0
21	$2,500	ha	–	$160	ha	–	–	0.46	4	OC	RS	0	85%	0
22	–	ha	0	$91	ha	–	–	0.50	4.3	OC	CS	0	98%	0
23	–	ℓ/s	–	$529	ha	$2.58	ℓ/s	0.50	4.3	P	CS	3	70%	0
24	$1,750	ha	–	$894	ha	–	–	0.60	5.2	P	CS	4	95%	0

Notes to Table 1:

1. The blue shaded line represents a future scenario under investigation.
2. Reliability is an approximation.
3. For line 13, 22 and 23, the share price is unable to be determined as there have been no separate sales of irrigation shares.
4. For lines 18a and b, the purchaser pays the cost of getting water from the scheme infrastructure to their property.

TABLE 1 RWSS - ANNUAL CURTAILMENT VOLUME

	Annual Curtailment from Dam Shortages		
Flow Scenario	A	B	C
Unit:	GL	GL	GL
1973	4.95	4.95	4.95
1974	0.00	0.00	0.00
1975	0.00	0.00	0.00
1976	0.00	0.00	0.00
1977	0.00	0.00	0.00
1978	0.00	0.00	0.00
1979	0.00	0.00	0.00
1980	0.00	0.00	0.00
1981	0.00	0.00	0.00
1982	0.00	0.00	0.00
1983	16.64	16.64	16.64
1984	0.00	0.00	0.00
1985	0.00	0.00	0.00
1986	0.00	0.00	0.00
1987	0.00	0.00	0.00
1988	0.00	0.00	0.00
1989	0.00	0.00	0.00
1990	0.00	0.00	0.00
1991	0.00	0.00	0.00
1992	0.00	0.00	0.00
1993	0.00	0.00	0.00
1994	0.00	0.00	0.00
1995	0.00	0.00	0.00
1996	0.00	0.00	0.00
1997	0.00	0.00	0.00
1998	15.69	15.45	15.00
1999	0.00	0.00	0.00
2000	0.00	0.00	0.00
2001	0.00	0.00	0.00
2002	0.00	0.00	0.00
2003	0.00	0.00	0.00
2004	0.00	0.00	0.00
2005	0.00	0.00	0.00
2006	0.00	0.00	0.00
2007	0.00	0.00	0.00
2008	0.00	0.00	0.00
2009	0.00	0.00	0.00
2010	0.00	0.00	0.00
2011	0.00	0.00	0.00
2012	0.00	0.00	0.00
2013	11.47	7.59	7.59

TABLE 2 RWSS - OVERALL VOLUMETRIC RELIABILITY

Total Ordered/Delivered/Curtailment Statistics (41 years)				
Flow Scenario	Total Ordered	Total Delivered	Curtailment	Percentage (Curtailed/Ordered)
	GL	GL	GL	%
A	3282	3228	54	1.66%
B	3282	3232	50	1.52%
C	3282	3233	49	1.50%

From: Andrew Newman [mailto:Andrew@hbrc.govt.nz]
Sent: Tuesday, 30 August 2016 8:58 a.m.

RWSS Review – Information Requested by Colin Riden

The following information has been put together by Kathleen Kozyniak (Principle Scientist Climate & Air) and Rob Waldron (Scientist Hydrology).

Annual Rainfall

The information provided below is in response to a request, from Colin Riden to Hawke's Bay Regional Council (HBRC), for the average annual rainfall in the following catchments:

1. The catchment upstream of Tukituki River at Red Bridge
2. The catchment upstream of Waipawa at RDS/SH2
3. The catchment upstream of Tukituki River at Tapairu Road
4. The Makaroro River catchment upstream of the confluence with the Waipawa River
5. The Waipawa River catchment upstream of the confluence with the Makaroro River
6. The Waipawa River catchment upstream of Waipawa River at RDS/SH2 but downstream of the Waipawa/Makaroro confluence
7. The Makaroro above the new or old dam
8. The Makaroro below the new or old dam

Also requested are catchment areas and a single map. The request specifies Landcare's 1950-1980 climate surfaces as the source of the rainfall data and also invites alternative sources of rainfall data that HBRC believes better reflect Tukituki catchment rainfall.

Table 1 lists the catchments and their areas. Alongside each is the mean annual rainfall determined from the Landcare Mean Annual Rain Surface 1950-1980. Also presented in Table 1 is the median annual rainfall determined from national maps produced by NIWA. NIWA uses a more recent thirty-year period (1981-2010) and takes median rather than mean values, thereby avoiding the influence of extreme years.

Table 1: The catchment, the catchment area and the annual rainfall from Landcare Mean Annual Rain Surfaces 1950-1980 and NIWA Median Annual Rain 1981-2010.

Catchment	**Area (km^2)**	**Landcare Mean Annual Rain (mm) 1950-1980**	**NIWA Median Annual Rain (mm) 1981-2010**
Tukituki River upstream of Red Bridge	2463.7	1209	1149
Waipawa River upstream of RDS/SH2	687.19	1318	1357
Tukituki River upstream of Tapairu Rd	760.27	1265	1194
Makaroro River upstream Waipawa River confluence	121.97	1650	1997
Waipawa River upstream Makaroro River confluence	126.63	1781	1872
Waipawa River between RDS/SH2 and Waipawa/Makaroro confluence	438.57	1093	1032
Makaroro River upstream of dam site	111.35	1666	2049
Makaroro River downstream of dam site	10.62	1482	1468

HBRC has telemetered rainfall sites within the catchments and these, with their length of record, are presented in Table 2. The length of record is short for some sites but for the majority, it exceeds twenty years. HBRC considers rainfall data recorded at each site in the HBRC's rainfall site network (in the Tukituki Catchment and the Hawke's Bay region), to be the most representative and up-to-date rainfall data available. HBRC's rainfall data is collected, processed and archived in accordance with HBRC's ISO 9001 accredited quality assurance procedures and in line with National Environmental Monitoring Standards.

The observed mean annual rainfall and the median annual rainfall for the HBRC sites are listed alongside corresponding Landcare and NIWA estimates respectively at the same location. Differences in values are expected because the datasets cover different periods, however these are likely to be small (within 10%), particularly for sites with long records. Estimates more than 10% above and below the observed values are highlighted. The results in the table show that Landcare and NIWA values are lower than the recent history of rainfall at sites in the western ranges and typically higher for sites on the Ruataniwha Plains.

Landcare values range from 72% (Parks Peak) of the listed observed values to 141% (Tukituki at Tapairu Road). NIWA values range from 80% of observed values (Moorcock) to 123% (Tukituki at Tapairu Road).

Figure 1 displays the location of the catchments as well as the Council's telemetered rainfall sites within them. Some catchments sit within others, which makes it difficult to present all of the requested catchments clearly on a single map.

Table 2: Observed rainfall at HBRC telemetered rainfall sites and Landcare and NIWA estimates at the same location. Orange cells highlight estimates below observed values and blue cells highlight estimates above observed values. Cells are not highlighted if estimates lie within 10% of observed values. The catchment(s) where the site is located, the year recording began and the number of complete years in the rain record are also listed. Catchments are identified by the numbers listed in the request details above.

Site	**Year records began**	**No. of complete years**	**Catchment(s)**	**Observed Mean Annual Rain (mm)**	**Landcare Mean Annual Rain (mm) 1950-1980**	**Observed Median Annual Rain (mm)**	**NIWA Median Annual Rain (mm) 1981-2010**
Parks Peak	1989	23	1, 2, 4, 7	2583	1847	2479	2172
Glenwood	1985	25	1, 2, 5	2217	1880	2252	2014
Moorcock	1987	19	1, 3	2511	2010	2636	2114
Gwavas	1988	22	1, 2, 6	1144	1149	1114	1143
Ongaonga	1997	12	1, 3	700	893	703	839
Tukipo SH50	1989	24	1, 3	919	1089	907	909
Tukituki Tapairu Rd	1987	25	1, 3	656	924	659	812
Waipukurau	1997	15	1, 3	702	891	722	785
Tukituki Shagrock	1988	21	1	850	974	806	829
Te Aute Drumpeel Rd	2010	6	1	683	883	655	795
Waipoapoa	1978	25	1	1726	2109	1623	1600
Omakere	2005	11	1	1132	1340	1206	1155
Te Kaihi	1973	36	1	1213	1311	1203	1164

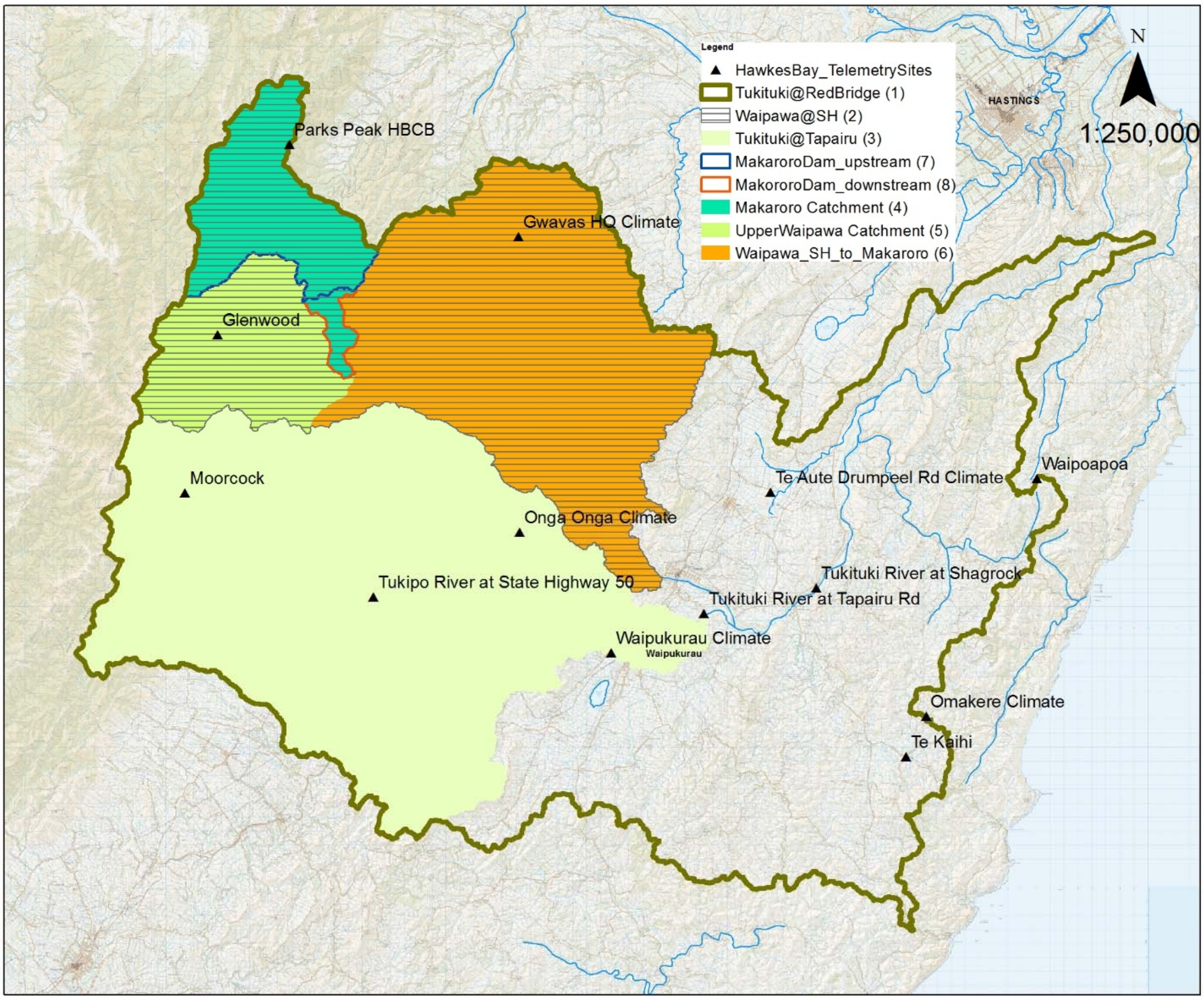

Figure 1: Catchments and telemetered rainfall sites. Catchments are identified in the legend by name and by the number (in brackets) listed in the request details above. The solid green line encompassing all other catchments represents the Tukituki River catchment upstream of Red Bridge. All catchments with a pattern of horizontal lines comprise the Waipawa catchment upstream of SH. The blue and red lines within the Makaroro catchment define the split upstream and downstream of the dam respectively.

Naturalised River Flows

The naturalised flows were requested to be confirmed for the following sites:

- Waipawa River at RDS/SH2
- Tukituki River at Tapairu Rd
- Tukituki River at Red Bridge

The naturalised flow records available for the above sites have not been updated since the Board of Inquiry into the Tukituki Catchment Proposal.

Naturalised flow statistics were presented in a report by Wilding and Waldron (2012). The full reference for this report is:

Wilding, T & Waldron, R. 2012. Hydrology of the Tukituki Catchment. Flow metrics for 17 sub-catchments. Hawke's Bay Regional Council - Resource Management Group Technical Report. EMT 12/18, HBRC Plan No. 4405.

The following tables contain naturalised flow statistics for the three required sites taken from Wilding and Waldron (2012) report.

Table 3: Waipawa River at RDS/SH2 naturalised flow statistics

Waipawa River at RDS/SH2	T1
Naturalised Flow Statistics	
Flow Record Details	
Record Type:	Naturalised (Daily Mean Flow)
Period of Record:	1969-2008

Annual Flow Statistic	Flow (L/s)
Minimum	1358
Maximum	656271
Mean	14970
Median	8991
3 x Median	26974

Mean Annual Low Flow	3009

Table 4: Tukituki River at Tapairu Rd naturalised flow statistics

Tukituki River at Tapairu Rd	T15
Naturalised Flow Statistics	
Flow Record Details	
Record Type:	Naturalised (Daily Mean Flow)
Period of Record:	1969-2008

Annual Flow Statistic	Flow (L/s)
Minimum	1307
Maximum	582126
Mean	15830
Median	9829
3 x Median	29486

Mean Annual Low Flow	2865

Table 5: Tukituki River at Red Bridge naturalised flow statistics

Tukituki River at Red Bridge	T16
Naturalised Flow Statistics	
Flow Record Details	
Record Type:	Naturalised (Daily Mean Flow)
Period of Record:	1969-2008

Annual Flow Statistic	Flow (L/s)
Minimum	2871
Maximum	2104360
Mean	44505
Median	22022
3 x Median	66067

Mean Annual Low Flow	6258

MEMO

To: James Palmer

From: Kathleen Kozyniak

Date: 6th April 2017

Subject: **RWSS REVIEW**

File Ref:

Cc:

Hi James,

Below are Colin Riden's comments regarding rainfall information provided in a previous memo and my response.

1. **In terms of rainfall HBRC appears to have taken the view that their gauges are representative of the catchment's they are in while Landcare and NIWA data is simply wrong. I am not sure that the comparisons made are apples with apples. A meteorologist is possibly required.**

   Individual rain gauges are not representative of whole catchments. Data from the gauges were used to investigate differences between datasets at point locations. The differences have implications for determination of catchment scale rainfall.

   The previous memo was not comparing apples with apples and it was stated in the memo that *"Differences in values are expected because the datasets cover different periods..."*. The memo listed the periods covered by the observed and derived datasets and the metrics used (i.e. average and median values). A comparison over identical years between Parks Peak and its nearest VCS produces greater differences (the VCS is more than 15% lower) than those presented in Table 2 of the previous memo, i.e. between Parks Peak and NIWA's 30 year climate surface.

   The rain gauge observations should not be discounted even though the records are less than thirty years. Observations over shorter periods are relevant in a number of ways. Firstly, short-term observations can improve spatial interpolation of climate variables, as noted by Tait et al (2012). Tait et al (2012) documented differences in NIWA's VCS network and Regional Council observations. The largest differences occur in complex terrain and at elevations above 500 m. The purpose of the memo was not to dismiss the datasets but to highlight that observations can add value to interpolated data. In particular, consistency in the pattern of differences is of interest, with all sites above 500 m higher than their interpolated counterparts and sites below 500 m near to or lower than their interpolated counterparts. This reflects the findings of Tait el al (2012).

   Secondly, climate statistics are not necessarily stationary and for that reason climate normals are regularly updated (Arguez and Vose, 2011). Studies suggest that climate normals used as a proxy or predictor of climate in the near future are more successful when they are based on periods shorter than thirty years and even as little as five years (Huang et al, 1996; Lamb and Changnon, 1981). The purpose of the comparison was to not to determine if the climate surfaces are "wrong" but whether the derived climate surfaces reflect the recent record of rainfall at the sites.

2. **What is notable is that HBRC have no rainfall data representative of the majority of the Makaroro catchment (or most of the Waipawa above the Makaroro confluence) but are confident in to dismissing Landcare and NIWA data for the same.**

   The memo looked at point values and how they varied between datasets and not catchments. The differences have implications for the calculation of catchment rainfall. The purpose of the memo was not to dismiss the datasets but to show that observations could add value, as noted in point 1 above.

3. **The 3 mountain sites HBRC quote are not representative of their catchments. And in the case of Park's Peak the periods covered are considered not representative of longer term rainfall (from NIWA, from a recent submission to HBRC by Fred Robinson). None of which information they bothered to convey. No science and no understanding of data - just arrogance and perception management. A search of 'errors in rainfall measurement' quickly reveals that the hydrology/meteorology disciplines have serious problems with rainfall measurement accuracy often with errors from 15% to 50%.**

   Please refer to point 1 for a discussion about the length of records. Availability of long climate records is always a challenge. Not all sites used to produce the Landcare surfaces had thirty years of observations and gaps were filled by correlations with other sites (Leathwick et al, 2002).

   Climate surfaces are derived from interpolating observed data therefore they are subject to any measurement errors. Additionally there are errors inherent to interpolation methods. Spline interpolation fits a smooth surface to data and does so by allowing errors at each data point.

4. **The norm is for under measurement of rainfall, and by significant amounts. I would not dismiss Landcare or NIWA rainfall data for the RWSS irrigation zones on the basis of it being less than what HBRC sites have reported. I am surprised though by the blind faith HBRC express in their rainfall measurements.**

   I don't fully understand Mr Riden's point here. He seems to be arguing that Landcare's and NIWA's data under measure rainfall, potentially by significant amounts.

5. **There still remains an issue with Kathleen being happy to use Landcare data to advise Duncan and HBRIC 2 or 3 years ago that the Makaroro had rainfall averaging between 1400 and 2000 mm but now that information has been dismissed by a single HBRC gauge at Park's Peak giving rainfall of over 2,500 mm.**

   The purpose of the information provided to Duncan was to give an initial overview of climate in the area and potential climate change. Given the scope and timeframes of the request, the Landcare climate surfaces were, at the time, the most readily accessible raster in ArcMap for calculation of catchment climate variables. Furthermore, it was the base dataset in SimCLIM (climate change software) provided by CLIMsytems. Landcare surfaces provided consistency between present and future overviews and gave conservative estimates of rainfall, i.e. lower rainfall in dam catchment areas and higher rainfall in areas of irrigation demand. It is appropriate that parties undertaking subsequent in-depth analyses looked at all available information.

6. **I am not sure that an independent QC review of HBRC rainfall sites would pass muster in terms of either site or equipment selection. If rainfall measurement sites are like their hydrological measurement sites then maintenance may also be an issue.**

   HBRC measures rainfall in accordance with the National Environmental Standards for Monitoring.

References

Arguez, A. and Vose, R.S., 2011: The definition of the standard WMO climate normal. Bulletin of the American Meteorological Society 92(6): 699-703.

Huang, J., van den Dool, H.M., Barnston, A.G., 1996: Long-lead seasonal temperature prediction using optimal climate normals. Journal of Climate Volume 9:809-817.

Lamb, P.J. and Changnon, S.A., 1981: On the “best” temperature and precipitation normals: The Illinois Situation. Journal of Applied Meterology. 20(12): 1383-1390.

Tait, A., Sturman, J., Clark, M., 2012: An assessment of the accuracy of interpolated daily rainfall for New Zealand. Journal of Hydrology (NZ) 51(1):25-44.

Date: 2 May 2017

MEMORANDUM

FROM: Malcolm Miller, Consents Manager, HBRC;

Shane Lambert, Senior Planner, HBRC;

Tom Skerman, Economic Development Manager, HBRC

TO: James Palmer, Group Manager - Strategic Development, HBRC

SUBJECT: REVIEW OF THE RUATANIWHA WATER STORAGE SCHEME: ITEMS #17 AND #18

- **#17: Legal Advice on the status of the PC6 DIN Limits as they apply to RWSS farmers relative to other farmers in the catchment.**

- **#18: Clarification of the obligations of RWSS supplied farmers versus other farmers in the catchment to meet the requirements of Plan Change 6.**

Contents

Summary of key findings:

DIN

a) Non-RWSS farmers who are considered by the regulator HBRC to be causing or contributing to any measured exceedance in the DIN limit or target will be subject to a resource consent and conditions. HBRC could require a farm through mitigation conditions to reduce their nitrogen leaching.
b) RWSS farmers who, upon the completion of an annual assessment by the Scheme consent holder which finds that the Scheme is:
   i. a contributor to DIN exceedance, and
   ii. that the RWSS farms contribution is material to the exceedence, then

the scheme must identify the on-farm actions necessary for the consents to be managed in a manner consistent with achieving the DIN limits and targets in Table 5.9.1B by 31 December 2030. These actions must be relayed to the affected farmers and the scheme has the ability to review the farm's FEMP to reflect those changes. Under the Water User Agreement, failure to comply with the FEMP risks the suspension of the delivery of irrigation water with a continued obligation to pay for the water not-delivered. This monitoring, assessment, reporting and action (beginning with Condition 11 c)) must occur on an annual basis and commences with the supply of water by the scheme.

c) The DIN threshold exceedance for any non-RWSS farmers represents compliance limits beyond which they will be in breach of permitted activity rules (and thereby would be placed into a consenting framework). Meanwhile the DIN threshold for RWSS farmers represents a point at which a proscribed set of management actions must be undertaken. The DIN limit acts as a trigger for certain actions. The measure for those actions in terms of the scheme remaining compliant with its consents is that the RWSS is operating "in a manner consistent with achieving the DIN limits and targets in Table 5.9.1B by 31 December 2030."
d) The treatment of "in a manner consistent with achieving the DIN limits and targets in Table 5.9.1B by 31 December 2030" by HBRC is essentially the same for RWSS and non-RWSS farmers.
e) With the RWSS DIN conditions, the responsibility lies first with the scheme to comply with their conditions. Then the regulator HBRC is required to monitor compliance and hold the consent holder where it is responsible, to its conditions. The scheme can require that its users re-visit their FEMP and apply further actions and mitigations to reduce N on farm. This could be applied in seeking to reduce N loss on farms across the scheme and its contribution to DIN in stream.
f) HBRC as the regulator also has other avenues to address DIN across the catchment, including:
    i. Development of a procedural guideline to apply across all RWSS and non-RWSS farms. This would be to aid implementation of Policy TT4 nitrogen limits and targets, and could include 'material contributor' guidance.
    ii. HBRC can impose conditions on new consents from applicants where DIN is exceeded after 2020 with mitigations/actions that will help further reduce N loss on farm.
    iii. The Council could also consider a further Plan Change to re-calibrate how the regulations manage DIN and its relationship with LUC leaching rates, if it considered there was sufficient need to do so.

<u>LUC Nitrogen leaching rates.</u>

g) After 2020 non-RWSS farmer's are required to ensure their individual property or farm enterprise complies with the LUC leaching rates in PC6 in order to operate as a permitted activity, otherwise they require resource consent.
h) The scheme, by contrast, already has resource consent and through this has the ability to aggregate the natural capital leaching of its members collectively in surface water management zones. The scheme has the ability to manage any higher leaching properties towards the natural capital guidelines through the proscribed Farm Environmental Management Plan process set out in the scheme's production land use consent conditions.

Farm Environmental Management Plans.

i) Non-RWSS farmers must prepare their own FEMP by 31 May 2018. After this date updated FEMP's must be completed every three years. It is then a matter for HBRC to determine whether the farming operation is a permitted activity, restricted discretionary or non-complying based upon the LUC leaching rates in Table 5.1.9D of the Plan.

j) While RWSS farmers are required to prepare a FEMP, it is the scheme operator who manages them as a tool to ensure the scheme remains in overall compliance with its existing consent. A RWSS farmer must submit a FEMP to the scheme operator who can require changes to the FEMP to ensure overall compliance with scheme consents. Any amendments to a FEMP requires scheme approval. Each FEMP must be independently audited annually for the first 3 years following water delivery and three yearly thereafter. A failure to comply with a FEMP can result in water delivery suspension (while the payment obligation continues).

EDS-F&B-F&G submission question

i. Whether resource consent conditions relating to nitrogen leaching from RWSS-supplied farms mean that in-stream dissolved inorganic nitrogen (DIN) must be reduced to 0.8 mg/l by 2030, and whether the RWSS will be non-compliant with its consent conditions if that outcome is not achieved.

k) Regardless of whether the land use is part of the RWSS or not, the Plan (PC6) sets limits and targets for DIN of 0.8mg/l in most of the Tukituki catchment streams and rivers and these are to be met by 2030. The RWSS will need to determine the contribution their members are making to the nutrient load in a sub-catchment. It is expected that RWSS could only be responsible for their share of any exceedance. The answer to the EDS-F&B-F&G question depends on why the DIN level/target has not been met and whose actions or inaction have contributed to it not being met it. If it is the scheme, the answer then is potentially yes.

With reliance upon the legal opinion of Simpson Grierson obtained by HBRC, HBRC as the regulator would consider the RWSS to be non-compliant with its conditions:

- If leaching from RWSS-supplied farms is found to be a material contributor to exceeding DIN levels beyond 0.8mg/l by 2030, and;
- they have not taken sufficient actions to meet the requirement to be operating in a manner consistent with this target being met,

If they have taken actions and the target is not reached in 2030,

- RWSS would be compliant with their conditions but the scheme would have to continue to take management steps to further reduce nitrogen leaching if found to be a material contributor.

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1. Scope:

1.1 The response to #17 and #18 is based upon the legal advice previously procured by HBRC, HBRIC, Fish and Game/Forest and Bird/Environmental Defence Society. It also considers:

- The submission from the Environmental Defence Society, Forest and Bird, and Fish and Game New Zealand dated 25 November 2016 (the EDS-F&B-F&G letter).
- Feedback and questions from the meeting with the Community Reference Group on 30 March 2017.
- The expert planning opinion(s) and position of HBRC regulatory functions and responsibilities, assisted with their legal advice.

2. Introduction:

2.1 Items #17 and #18 are specifically the main focus of this review subject to the above scope.

2.2 This memo uses the terms 'RWSS farms' and 'Non-RWSS farms' to differentiate between the requirements of Plan Change 6 and the RWSS consent conditions on each type of farm in the Tuki Tuki catchment. RWSS farms are those farms that are signed up to the scheme and would operate under the resource consent that applies to it. Non-RWSS farms are all other farms anywhere across the whole of the Tuki tuki catchment that are not signed up to the scheme (and/or are not within its footprint) and are subject to the Plan Change 6 rules that apply to them.

2.3 It is important to state that HBRC is the regulator of both Plan Change 6 and the RWSS consents. Any legal opinion is subject to the expert opinion(s) of the regulator in applying the requirements of PC6 and consents that may (or may not) rely upon them. The planning expertise in the HBRC regulatory team has and remains pivotal in this because they have to interpret the rules and conditions and be subject to any challenge on their opinion. The same is true of Councils Compliance officers (subject to delegated approval of enforcement matters) in terms of monitoring and enforcement. Their opinion(s) cannot be directed by another party or by Councillors unless they agree with it independently. Councillors of course should and will form their own opinions, however it should be recognised that they cannot impose that opinion on the integrity of an expert who is responsible for defending that opinion if required (for example in court).

DIN limits, and LUC leaching rates.

2.4 It is noted that the question in #17 is specifically in regard to the Plan Change 6 Dissolved Inorganic Nitrogen Limits (DIN) and does not mention the Land Use Capability Class Natural Capital Nitrogen Leaching Rates (KgN/ha/year) that is also part of RRMP land production rule TT1. Review Issue #18 directs a broader clarification between RWSS farmers and non-RWSS farmers to meet all the requirements of PC6. So this will be where this and other matters discussed in the legal opinions referenced can be more specifically addressed.

3. #17 DIN

Legal Advice on the status of the PC6 DIN Limits as they apply to RWSS farmers relative to other farmers in the catchment.

3.1 The DIN limits are a measurement of Nitrogen in stream that are a specific part of the land production rule TT1 j within the RRMP, that triggers a resource consent if they are not met in rule TT1[1]. DIN limits have also been imposed as part of the resource consent conditions for the RWSS. As conditions of consent these apply as required for the consent for its duration. They are not exactly the same, and are not required to be the same.

DIN for the RWSS consent

3.2 In its final report and decision, the Board of Inquiry made the following comment on the RWSS resource consent application: " [80] By its very nature an application for a resource consent arises when an activity does not comply with the relevant rules in a plan. If it complies, the activity would mirror the Plan and constitute a permitted activity. [81] In this case the RWSS application was before the Board because the proposed scheme did not qualify as a permitted activity under PC6.' Simpson Grierson's advice to HBRC 24 July 15 - para 7-9 confirms this position.

3.3 When discussing POL TT6 (Decision making criteria – Use of production Land), the Board went on to note that *"This policy required the Board to carry out an evaluative exercise involving a range of matters, including the extent to which the DIN limits in Table 5.9.1B would be met. It did not, however, impose a rigid requirement for those limits to be mirrored by the terms of the RWSS consent."*

3.4 In its advice to HBRC, Simpson Grierson note that rule TT1(j) does not apply to RWSS farmers provided they are complying with the RWSS Consent conditions. A number of consent conditions are relevant:

Condition 11 Each year in the month of June, the consent holder shall submit to the HBRC Group Manager, Resource Management, a Scheme Operation Water Quality Monitoring Annual Report that:…

(c) Comments on DIN data collected…..in comparison to the limits and targets set out in Table 5.9.1B of the RRMP and includes an assessment of the likely contribution of the use component of the RWSS consents to any levels of DIN that exceed the limits and targets of Table 5.9.1B.

Condition 12A In the event that the assessment undertaken pursuant to Condition 11(c) above identifies that the activities authorised by the 'use' component of [the Resource Consents] are a material contributor to any exceedance of the DIN limits and targets in Table 5.1.9.B of the RRMP at the nearest downstream monitoring site….the consent holder shall:

(a) Identify specific actions required to be taken by land owners supplied by the scheme upstream from the monitoring site…….to ensure that the 'use component' of the [resource consent] is managed in a manner consistent with achieving the DIN limits and targets in Table 5.9.1B by 31 December 2030; and

[1] Whereas the LUC rates are a measurement of Nitrogen leaching to land from a farming enterprise based upon Overseer modelling. The LUC rates also have a specific part of the land production rule that triggers two progressively stricter classifications of resource consent depending on their exceedance of the rate (above or below a 30% exceedance, refer Rule TT2 condition a, and Rule TT2A).

(b) Advise the land owners referred to above of the specific actions they are required to take and to advise [HBRC] of the specific actions that the land owners have been advised they are required to take.

3.5 The conditions go on to require a review by RWSS of any RWSS farmer Farm Environmental Management Plan for land owners identified in Condition 12A - 23(g)(iv). They also allow for a review of the RWSS consents by HBRC to review the FEMP process to ensure the scheme is operating in a manner consistent with achieving the table 5.9.1B limits and targets in the RRMP by 31 December 2030 -30(d). HBRC as the regulator will be undertaking preparation of a procedural guideline to aid implementation of Policy TT4 nitrogen limits and targets.

3.6 The impact of the phrase *in a manner consistent with achieving the DIN limits and targets in Table 5.9.1B by 31 December 2030* has been the subject of considerable debate in regard to the RWSS. Part of the debate is whether compliance must be maintained after 2030 (which will also depend on whether the scheme is a material contributor, and the steps it may have taken to reduce its contribution). Simpson Grierson have provided the following advice to HBRC:

"In our opinion, the better view (and more consistent with an overall approach of maintaining and enhancing water quality) is that the DIN limits and targets and the conditions tied to them continue to apply beyond 31 December 2030. On that approach, if there is exceedance of DIN limits after 31 December 2030, HBRIC would still need to identify and require specific actions consistent with achieving the DIN limits and targets."

3.7 This provides an understanding of how the condition will be interpreted by HBRC as the regulator at that time. HBRC staff agree with this position.

<u>DIN for Non-RWSS farms</u>

3.8 For non-RWSS farmers rule TT1(j) applies as follows:

"After May 31, 2020, for farm properties of farming enterprises exceeding 4 hectares in area excluding:

(a) Low intensity farming systems; and
(b) Those that solely comprise plantation forestry (being forestry operations deliberately established for commercial purposes)

(To meet the permitted activity status as set out in rule TT1) *nitrogen leached from the land shall be demonstrated to be not causing or contributing to any measured exceedance of the Table 5.9.1B……limit for dissolved inorganic nitrogen at the downstream monitoring site nearest to the farm property or farming enterprise in the relevant mainstem or tributary of a river…"*

3.9 Non-RWSS farms that are not causing or contributing to a measured DIN exceedance meet the Permitted Activity classification; otherwise, they will fall into a Restricted Discretionary (TT2) resource consent classification and therefore would be subject to being approved or declined, and conditions imposed by HBRC.

DIN Summary for both RWSS farms and non-RWSS farms

3.10 Regional Resource Management Plan Policy TT1 directs that the Council will set limits and targets (in Table 5.9.1B) that are not to be exceeded (limits) or if exceeded (targets) are to be met by 2030. Policy TT4 seeks to ensure the Table 5.9.1B DIN limits are met in each sub-catchment by farm properties or farm enterprises in that sub-catchment but if these are exceeded after 2020 that each farm property or farm enterprise addresses the management of exceedances via resource consent processes. The wording "*in a manner consistent with achieving the DIN limits and targets in Table 5.9.1B by 31 December 2030"* reflects the intent of this Policy.

3.11 RWSS farmers must manage the DIN limits and targets in Table 5.1.9.B with reference to the Schedule 3 Production Land Use Consent conditions, whereas non-RWSS farmers must comply with the RRMP (or require resource consent).

3.12 The onus that is applied to RWSS farms (*in a manner consistent with achieving the table 5.9.1B limits and targets in the RRMP by 31 December 2030*) can also be considered to apply to non-RWSS farms.

3.13 There could be RWSS supplied farms and non-RWSS farms in the same catchment (or sub-catchment). In this scenario, if the DIN level is being achieved, all the non-RWSS farms could operate as permitted activities (and also providing they are meeting their LUC rate limits). On the other hand, if the DIN limit is being exceeded in the catchment all the non-RWSS farms will need a resource consent by 2020 (or at a later time if the limit is being met in 2020 but is exceeded at a later date). If and when consenting these, it is anticipated by interpretation that HBRC will take the same approach (*in a manner consistent with achieving the table 5.9.1B limits and targets in the RRMP by 31 December 2030.*) for non RWSS Farmers, similar in application to the RWSS consent.

3.14 In summary:

A. non-RWSS farmers who are considered by the regulator HBRC to be causing or contributing to any measured exceedance in the DIN limit or target will be subject to a resource consent and as yet unknown consenting conditions. The conditions must, reflect the matters of discretion that they are restricted to in rule TT2. The discretionary matters set out in TT2 allow consideration of actual nutrient loss in relation to the limits and targets, the state of the surface and groundwater quality, and whether reasonable and practical opportunities have been taken to reduce nutrient losses among other things. HBRC could require a farm through mitigation conditions to reduce their nitrogen leaching. There is some discretion as to how HBRC could do this.

B. RWSS farmers who, upon the completion of an annual assessment by the Scheme consent holder which finds that the Scheme is:

   a. a contributor to DIN exceedance, and
   b. that the RWSS farms contribution is material to the exceedance, then

   the scheme must identify the on-farm actions necessary for the consents to be managed *in a manner consistent with achieving the DIN limits and targets in Table 5.9.1B by 31 December 2030.* These actions must be relayed to the affected farmers and the scheme has the ability to review the farm's FEMP to reflect those changes.

Under the Water User Agreement, failure to comply with the FEMP risks the suspension of the delivery of irrigation water with a continued obligation to pay for the water not delivered. This monitoring, assessment, reporting and action (beginning with Condition 11 c)) must occur on an annual basis and commences with the supply of water by the scheme.

C. As Simpson Grierson note (para 33-34) the DIN threshold exceedance for any non-RWSS farmers represents compliance limits beyond which they will be in breach of permitted activity rules (and thereby would be placed into a consenting framework). Meanwhile the DIN threshold for RWSS farmers represents a point at which a proscribed set of management actions must be undertaken. The DIN limit acts as a trigger for certain actions. The measure for those actions in terms of the scheme remaining compliant with its consents is that the RWSS is operating "in a manner consistent with achieving the DIN limits and targets in Table 5.9.1B by 31 December 2030."

D. The treatment of "in a manner consistent with achieving the DIN limits and targets in Table 5.9.1B by 31 December 2030" by HBRC is essentially the same for RWSS and non-RWSS farmers.

4. **<u>#18 Other PC6 requirements</u>**

Clarification of the obligations of RWSS supplied farmers verses other farmers in the scheme to meet the requirements of PC6.

4.1 This section of the report focuses on PC6 issues other than DIN that are covered by the various legal opinions, and the basis on which HBRC as the regulator is looking to rely upon.

<u>Table 5.1.9D LUC Natural Capital, Nitrogen leaching rates.</u>

<u>Non-RWSS farms</u>

4.2 In addition to managing DIN limits discussed above, Policy TT4 also requires that the Table 5.9.1D LUC rates are quantified for each farm property or farm enterprise by 2018.

4.3 After 2020 non-RWSS farmer's are required to ensure their individual property or farm enterprise complies with the LUC leaching rates in PC6 in order to operate as a permitted activity. Failure to do so will trigger the requirement to apply for resource consent for production land use.

<u>RWSS farms</u>

4.4 The scheme, by contrast, has already been consented and under this resource consent it has the ability to aggregate the natural capital of its members collectively in surface water management zones. This allows the scheme to balance farmers operating beyond their LUC rates against those operating below and remain in compliance with the scheme's consent conditions. It should be noted that the scheme has the ability to manage the higher leaching properties towards the natural capital guidelines through the proscribed Farm Environmental Management Plan process set out in the scheme's production land use consent conditions.

Farm Environmental Management Plans.

Non-RWSS farms

4.5 Non-RWSS farmers must prepare their own FEMP (including nutrient budget and phosphorus management requirements) that meets the information requirements of Schedule XXII of the Tukituki Plan by 31 May 2018. After this date updated FEMP's must be completed every three years. Under this regime, the FEMPs are to be prepared in accordance with the requirements of Schedule XXII. It is then a matter for HBRC to determine whether the farming operation is a permitted activity, restricted discretionary or non-complying based upon the LUC leaching rates in Table 5.1.9D of the Plan.

RWSS farms

4.6 While RWSS farmers are required to prepare a FEMP, it is the scheme operator who manages them as a tool to ensure the scheme remains in overall compliance with its existing consent. A RWSS farmer must submit a FEMP to the scheme operator who can require changes to the FEMP to ensure overall compliance with scheme consents. Any amendments to a FEMP requires scheme approval. Each FEMP must be independently audited annually for the first 3 years following water delivery and three yearly thereafter. A failure to comply with a FEMP can result in water delivery suspension (while the payment obligation continues).

5. EDS-F&B-F&G submission 25 November 2016

5.1 This letter set out the basis of four questions supported by further information providing context to those questions. As part of Items 17 and 18 the main question is set out in a. i. at paragraph 3. This is set out in italics below and answered in relation to the legal opinions and HBRC regulatory position on them:

a. Achievement of Plan Change 6 (PC6) objectives if the RWSS proceeds, and (a related issue) the meaning of RWSS resource consent conditions relating to nitrogen pollution. Essentially, we propose that the review should consider:

i. Whether resource consent conditions relating to nitrogen leaching from RWSS-supplied farms mean that in-stream dissolved inorganic nitrogen (DIN) must be reduced to 0.8 mg/l by 2030, and whether the RWSS will be non-compliant with its consent conditions if that outcome is not achieved.

5.2 Regardless of whether the land use is part of the RWSS or not, the Plan (PC6) sets limits and targets for DIN of 0.8mg/l in most of the Tukituki catchment streams and rivers and these are to be met by 2030. The RWSS will need to determine the contribution their members are making to the nutrient load in a sub-catchment. It is expected that the RWSS could only be responsible for their share of any exceedance. The answer to the EDS-F&B-F&G question depends on why the DIN level/target has not been met and whose actions or inaction have contributed to it not being met it. If it is the scheme, the answer then is potentially yes.

With reliance upon the legal opinion of Simpson Grierson obtained by HBRC, HBRC as the regulator would consider the RWSS to be non-compliant with its conditions:

- If leaching from RWSS-supplied farms is found to be a material contributor to exceeding DIN levels beyond 0.8mg/l by 2030, and;
- they have not taken sufficient actions to meet the requirement to be operating in a manner consistent with this target being met,

If they have taken actions and the target is not reached in 2030,

- RWSS would be compliant with their conditions but the scheme would have to continue to take management steps to further reduce nitrogen leaching if found to be a material contributor.

5.3 Any non-RWSS farm in the same (sub) catchment would be required to obtain consent (because DIN is above 0.8 mg/l) and would have to be taking steps/be subject to conditions to reduce nitrogen leaching if found to be a material contributor.

5.4 In summary, the scheme is required to operate and manage DIN in a manner consistent with achieving the DIN limits and targets in Table 5.9.1B by 31 December 2030. However, it will not be non-compliant with its consent conditions if that target is not achieved, providing they have demonstrated sufficient consistent actions intended to reduce their members contributions.

6. Final comments

6.1 There are some complications with DIN limits and the way they relate to the LUC leaching rates in the Plan. Nitrogen leaching, as determined through nutrient budgets can be summed across each farm property or enterprise (which can involve multiple separate land units) within each Surface water allocation zone. It is possible that a farm may be compliant with LUC requirements, but could be in a catchment that does not comply with DIN. You could also get a situation where a farm may cross the tributary catchment boundaries that DIN applies to.

6.2 If DIN is over 0.8mg/L in a tributary catchment all farm properties contributing to that will need to be part of a catchment conversation at the time. There would need to be actions taken to reduce the contribution.

6.3 The RWSS has responsibility for its members and can require changes to management practices if they are material contributors to any exceedance (12A). This would be with the intention of reducing their contribution. With changes they may not be the cause of the DIN exceedances by 2030. Others in the catchment could be the problem (and vice versa). HBRC has a separate responsibility to require non-RWSS parties to work towards achieving the 2030 target.

6.4 Whether the scheme and its water users are likely to be material contributors in the future remains to be seen, other parts of the review have provided some assessment of this. If they are, then the RWSS could then be considered non-compliant. If they and their water users in that catchment have not taken the actions that have been determined as necessary (by them and advised to HBRC) to manage their production land use "in a manner consistent with achieving the DIN limits and targets in Table 5.9.1B by 31 December 2030".

6.5 If they have taken the actions identified but have not succeeded in reducing DIN to the level in the Plan they may be determined to have complied with condition 12A and would not be in non-compliance even though the catchment is over the target. This is because condition 12A literally requires HBRIC as the consent holder to annually assess their contribution to DIN level exceedances, to identify specific actions required by landowners supplied by the scheme, and then to advise the landowners of the specific actions they are required to take. It requires these actions but it doesn't require absolute compliance with the specific DIN limit. These actions should be taken annually if required. But if by 2030 they remain material contributors to exceedances they would still have a responsibility to work on further reductions. The degree of exceedance and the state of the environment (using MCI and other indicators) would be relevant in determining the magnitude of any non-compliance.

6.6 Therefore, in regard to the RWSS DIN and LUC conditions, the responsibility lies first with the scheme to comply with their conditions. Then the regulator HBRC is required to monitor compliance and hold the consent holder where it is responsible, to its conditions. The scheme can require that its users re-visit their FEMP and apply further actions and mitigations to reduce N on farm. This could be applied in seeking to reduce N loss on farms across the scheme and its contribution to DIN in stream.

6.7 HBRC as the regulator also has other avenues to address DIN across the catchment, including:

a) Development of a procedural guideline to apply across all RWSS and non-RWSS farms. This would be to aid implementation of Policy TT4 nitrogen limits and targets, and could include 'material contributor' guidance.

b) HBRC can impose conditions on new consents from applicants where DIN is exceeded after 2020 with mitigations/actions that will help further reduce N loss on farm.

c) The Council could also consider a further Plan Change to re-calibrate how the regulations manage DIN and its relationship with LUC leaching rates, if it considered there was sufficient need to do so.

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Commentary from Malcom Miller, HBRC Consents Manager on Variation to RWSS Resource Consents

The RWSS consents that have been issued are comprehensive in covering the proposal to dam the Makaroro River and to subsequently release, convey and use the water. There have been some additions and modifications to the consent documents since the BOI decision. The consents are constructed to allow some change from the original proposal without change to the consent. There are requirements for management plans to be provided at critical stages to provide details of key aspects of the project. The management plans are to be approved by the Councils (HBRC, CHBDC and HDC) before having effect (although there is a 20 working day period for this to occur or otherwise they will default to being approved). The Councils have established a Joint group to co-ordinate this process and will engage expertise as and when required to provide technical support.

Judgement will be required along the way as to whether any changes are within "general accordance" of the consent. There is however provision for the dam design to change where it is "not generally in accordance with that document (CEMP) which meets or exceeds the relevant specified engineering design standards and is of no materially greater or different effect in relation to environmental outcomes".

The dam design has been changed. Schedule One, Condition 24 allows for such a change to be approved. This has been done by the Councils following this process but there is a need to sight and approve the final plans when they are submitted with the Construction Environmental Management Plan (CEMP). These changes cover changes to the dam structure, alignment, spillway location, construction method and diversion. Changes to the intake tower structure have not been submitted to date. There is a Supplementary Construction Environmental Management Plan to be submitted which will allow opportunity to assess any changes to this.

Further resource consents will be required for the structure to take water to supply Zone A on the northern side of the Waipawa River and also Zone M (Papanui) depending on changes. Also any plans to discharge to the Tukituki River and to take and supply a possible Zone N (Lake Whatuma area) will require resource consent. Realignment of the canal to convey water across the Ruataniwha Plains will need a change to the designation in the CHBDC District Plan.

Removal of the hydro-electric power generation component is not contrary to the resource consents. The consents allow the use of the water for hydro-electric power generation but they do not condition it.

The consented irrigation command area has increased with the issue of a second consent. This was issued in January 2016 by HBRC via a non-notified consent approval process. The consent issued in 2016 did have regard to the effects and like the original consent has conditions requiring the meeting of nutrient leaching limits and surface water quality among other matters. If other areas are to be supplied by the RWSS then a resource consent will be required unless it can be determined that the Production land use falls within the Permitted Activity Rule TT1.

An Independent Panel is required to be established in addition to the Dam Construction Expert Panel. The function of the Independent Review Panel is to report to the consent holder on the development of the dam with particular reference to ensuring safety of the dam to the consent holder at milestone stages of detailed investigations, detailed design, construction, commissioning and operation. To my knowledge this panel has not been established to date. I don't view this panel to have a "go/no go" authority. They would provide peer review of each of the milestone stages to the consent holder. It will be up to the consent holder as to how they view this independent report. There will also be scrutiny of the dam through all stages via the building consent process, and by the independent expert on the Dam Construction Expert Panel.

Judicial Review is an option available to any party. While one Judicial Review was instigated by Greenpeace to test the process followed to consent the additional Production Land use consent this was subsequently withdrawn by Greenpeace.

The proposal has gone through a rigorous consenting process via the Board of Inquiry. The BOI has incorporated (often volunteered by the applicant) a complex set of conditions to address the environmental effects of the proposal. There will be effects arising from this proposal and these have been avoided, remedied and mitigated through the conditions suite approved by the Board to the degree they considered reasonable. There was and is limited opportunity to oppose this outcome. Council's regulatory duty is to enforce the conditions of the consent. Council has been reasonably passive in this space because the activity has not been advancing.

Appendix 2: A table of the proposed major design changes as presently evident variations from the RWSS scheme from the Tonkin & Taylor Project Description, examples of potential environmental outcomes and a rough appraisal in regard to the Resource Consent Conditions.

	Major RWSS Project Design and Scheme Changes	Examples of unassessed potential difference in Environmental Effects and outcomes	Relevance to the RWSS Resource Consent	HBRC Response
1	Change in dam structure, crest width, spillway, diversion and dam alignment	While the BOI heard how the Concrete Faced Rock Filled Dam selected by experts is the most suitable construction type for this site in weighing risk including earthquake fault displacement, very high ground motions, landsliding, reservoir seiche wave overtopping; flood, dam break, downstream hazard and effects; this dam type is being no longer proposed. See T &T RWS Technical Feasibility Report.v3.30082012 Appendix Table G2 'Non cost issues'.	Any Variations from the T &T Project Description associated with Dam Infrastructure should have no materially greater or different effect in relation to environmental outcomes.	There is scope within the conditions for changes provided these are "generally in accordance" with the Project Description. There is further latitude in condition 24 through certification of the Final CEMP and SEMPs to approve a change that is "not generally in accordance with that document which meets or exceeds the relevant relevant specified engineering design standards and is of no materially greater or different effect in relation to environmental outcomes". A Joint Project Team of CHBDC HDC and HBRC staff has been established to manage the initial steps of approving Management Plans. This has included engaging an expert engineer (Trevor Matushka) to assess the change of design and certify his agreement with other engineers that "the variations meet or exceed the dam design criteria relevant to dam safety underpinning the Application Design …" as per Condition 24 a) ii. Conditions 30 to 34 in Schedule Two apply to dam safety.

				Dam integrity will be further assessed by Building Consent process. CEMP is to be lodged and must be approved via the Councils Joint Project Team. Experts to be engaged to inform this approval process.
2	Change of diversion and dam construction method and additional works	Risks to downstream environment (cement especially) and water quality sedimentation, hazards due to failure.	All changes in construction activities managed under the CEMP* & SCEMP* should be assessed to ensure they are able to meet consented performance standards and results in no greater adverse environmental effects.	I believe less cement is involved with the changed design. Conrete Faced Rockfill Dam (CFRD) v Central Core Rockfill Dam (CCRD). Regardless there is a Concrete batching SEMP to be provided. Sediment control and pH monitoring is required to avoid and control adverse effects on environment.
3a	Change in the reservoir intake structure	Effects on Reservoir flow regime, water quality and related downstream effects. (see NIWA May 2013 Reservoir Water Quality Characterisation Report) and sedimentation flows within the reservoir, effecting water storage and operational costs and the lifespan of the scheme. Stratification, algae blooms, development of toxic anoxic water are risks associated with reservoirs.	Any Variations from the T &T Project Description associated with Dam intake Infrastructure should have no materially greater or different effect in relation to environmental outcomes. The NIWA report states any change in the flow regime requires water quality remodelling.	No change has been advised to the Councils on the intake structure. This will need to be detailed with the CEMP. Effects of any change will need to be assessed at that time.

3b	A residual flow reservoir intake at a very low RL 397m level	Modelling indicates sedimentation within the first 20 years of the scheme will overwhelm this intake, restricting 'environmental' residual flows and affecting the flow regime for the scheme.	Any Variations from the T &T Project Description associated with Dam intake Infrastructure should have no materially greater or different effect in relation to environmental outcomes.	Residual flow intake location and depth will be part of the reservoir intake structure and assessed at that time if changed.
4	Proposed HBRC foundation water user agreement: involving an increase in the frequency and volume of water for flushing flows was proposed.	Reduced flows available to RWSS water users, and reduced flows to streams in Irrigation Zone A and Zone M	Effect on RWSS water users (unable to object due to clause in the RWSS water Right agreements).	A minimum number of flushing flows is required. There is nothing preventing release of additional flushing flows. The foundation water user agreement is not of relevance to the regulatory functions of HBRC. Uncertain why this would be adverse to RWSS water users.
5	Additional intake from the Waipawa River for Zone A and M	Sedimentation, and aquatic ecology, fishery effects, effects on remnant terrestrial kowhai ecological community	The varied design exceeds the design parameters and specifications relevant to the upstream intake structure underpinning the 'Application Design' and materially greater or different effect in relation to environmental outcomes.	Consent required.
6	Extension and changes to the canal alignment	Effects on existing streams, waterways and ground water flows flowing across the Ruataniwha Plains, as well as landowner operations, access and amenity, and community safety.	The varied design exceeds the design parameters and specifications relevant to the distribution infrastructure underpinning the 'Application Design' and materially greater	May affect designated route and require change. CHBDC function.

			or different effect in relation to environmental outcomes	
7	Removal of hydro-electricity generation	The Application design involved the harvesting of water for electric power generation. Major environmental and community benefit of scheme has been dropped and instead left to a possible later "retrofit. Environmental effects e.g. reservoir drawdown, and future scheme costs associated with the retrofit proposal	In their summing up of the resource consent the Board accepted that the RWSS generation of electricity will benefit the community. The Board concluded that the overall economic benefits of the scheme appear to outweigh the costs and that the scheme would constitute an efficient use of the resources involved. The proposal to instead 'Retrofit' is a variation of the RWSS resource consent.	Not sure this is material. It is consented but don't consider this has to be built or built at the same time. While this may have been a consideration in the decision the economic consequences are not material to HBRC regulatory function.
8	Significant increase in the irrigation command area (land where RWSS water can be distributed) in all consented Irrigation Zones	Significant extension on to areas with different landscape characterisation (slope, terrain, soils, hydrogeology and groundwater, microclimate, aquatic and terrestrial ecology, degree of natural character and landscape values) and effects thereof. Resource Consent variations required for materially significant difference in the piped network, in irrigation command area and the landscape characterisation, landuse enabled by irrigation and	RWSS Landuse Conditions require revision as a result of BOI and Plan Change 6 Appeal decisions. Materially greater and significant different environmental outcomes.	Consent is for production landuse and is restricted discretionary activity. Matters able to be considered are limited. Focus is nutrient management, water quality . Not to landscape, terrestrial ecology etc. A second consent has been issued to extend the command area by HBRC. This increases the command area but not the area able to

		different effect in relation to environmental outcomes.	In 2015 HBRC allowed HBRIC to apply for a non-notified resource consent application and approved the consent which has since been filed to the High Court for judicial review by GreenPeace.	be irrigated. No more water is available as a consequence. Judicial review was filed and has been withdrawn by Greenpeace by their choice. Irrigated farms covered by land use consents.
9	Additional new canal outfall into the Upper Tukituki River for the purpose of supplying water to a new RWSS Command Area "Zone N"	Effects river water flows, gravel flows and aquatic ecology. Increased risk of contamination sourced from potential algae or bacteria blooms in the RWSS Makaroro reservoir (a risk stated in the 2013 NIWA Reservoir Water Quality report). The RWSS proposes to use numerous rivers and streams for water conveyance. An outfall into upper Tukituki River will materially increase the "mixing of waters" across the sub catchments increasing spread of any contamination.	The varied design exceeds the design parameters and specifications relevant to the upstream intake structure underpinning the 'Application Design' and materially greater or different effect in relation to environmental outcomes.	Discharge of water to water is a permitted activity subject to conditions. Shouldn't include contaminants. Need for consent for structure in river. Zone N is not consented for production land use. Consent is not necessarily required if not exceeding LUC limits on a per farm basis, providing downstream DIN limit is not exceeded.
10	A new intake off the Tukituki River upstream of Waipukurau diverting Tukituki River/ RWSS water to supply 'Zone N' through Lake Whatuma into Mangatarata Stream	Changes to the river, lake and stream water characterisation, sediment and gravel flows, lake levels, flood risk, aquatic ecology and risks associated with "mixing of waters"	The varied design exceeds the design parameters and specifications relevant to the upstream intake structure underpinning the 'Application Design' and materially greater or different effect in relation to environmental outcomes.	New intake from Tukituki River would require consent.

	meeting the Tukituki River again downstream			
11	New sub-catchment 'Zone N' command area with significantly different landscape characterisation	Right back in feasibility studies "Zone N" was identified and various maps existed – through the BOI process it wasn't consented as there was some uncertainty about demand. This Zone Assessment of the type of potential landuse enabled by irrigation and effects on' landscape character'; i.e. to soils, hydrology, groundwater, aquatic and terrestrial ecology, degree of natural character and landscape values	Resource Consent variation involving of the extension of piped network, irrigation command area and types of landuse intensification enabled by irrigation on different areas of 'landscape characterisation'. RWSS Landuse Conditions require revision as a result of BOI and Plan Change 6 Appeal Decisions. E.g. The Resource Consent Conditions include the 'Trim' model which BOI disregarded.	Zone N command area is not consented for production land use. But note consent is not necessarily required if not exceeding LUC limits on a per farm basis, providing downstream DIN limit is not exceeded. TRIM is required in current consents. HBRIC is required to apply it for nitrate-nitrogen. Its application could be reviewed if necessary.

*CEMP = Construction Environmental Management Plan Construction Environmental Management Plan and *SEMP =Supplementary Construction Environmental Management Plans

Ruataniwha Water Storage Scheme (RWSS)
Resource Consents and Conditions Summary

RWSS holds 16 Resource Consents that are administered by HBRC. Of these 15 were issued by the Board of Inquiry (BOI) and one was issued later by HBRC to extend the production land use area. Since being issued by the BOI the consents have been changed by HBRC to incorporate an additional environmental health (MCI) monitoring condition. Another two resource consents and a designation are administered by Central Hawkes Bay District Council (CHBDC) and Hastings District Council (HDC).

The 16 HBRC consents provide for the following:

- Construct and maintain a dam structure in the bed of the Makaroro River
- Dam, take, divert and discharge water at the Makaroro dam location
- Construct an intake structure on Waipawa River (upstream intake)
- Divert and take water from the upstream intake structure
- Construct an intake structure on Waipawa River (downstream intake to Papanui Stream)
- Divert and take water from the downstream intake structure
- Construct, operate and maintain siphons etc. in beds of mapped rivers and streams (for pipes and races that convey water across the plains)
- Construct, operate and maintain structures in and adjacent to rivers;
- Outfall structure to Mangaonuku Stream
- Discharge of water to Managonuku Stream
- Outfall structure to Kahahakuri Stream
- Discharge of water to Kahahakuri Stream
- Production land use (for Zone A, B, C, D and E)
- Production land use (for extensions of Zone A, B, C, D and E)
- Planting and associated works within the Upper Tukituki Flood Control Scheme Area
- Beach renourishment (deposit of gravel)

The CHBDC consent is for the uses of the land associated with the storage dam, intake and outfall structures and all associated earthworks. A separate designation was approved for the primary canal route.

The HDC consent is for establishment of the Makaroro dam reservoir that is within the HDC district, and for associated activities.

Conditions are included in these consents and in a series of Schedules attached to these consents. These detail specific standards and also set out processes that must be established and followed through the construction phase and also for the ongoing operation of the dam, the release of water downstream, the supply of water for irrigation and other uses across the plains, and for production land use of properties supplied water by the RWSS. There are also conditions requiring the mitigation and offset of effects that arise due to the flooding of areas of native vegetation and habitat of flora and fauna and effects on tangata whenua values. There is a requirement for management plans to be submitted for approval at critical stages of the development and operation. The management plans are specified and their objectives are established in the conditions. Detailed management plans must be submitted for approval by the relevant Councils. (A joint working group has been established in anticipation of this requirement.) Once submitted and approved these Management Plans must be complied with. There are a variety of monitoring requirements prior to construction, during construction, upon commissioning and ongoing throughout the life of the consents.

Conditions in summary:

- Makaroro storage dam full supply level of 469.5mRL ⇔ storage capacity of 90.7 million m^3;
- Makaroro residual flow of 1.23m^3/s;
- Release of flows to maintain existing consents security of supply;
- Release of flushing flows to Makaroro, Waipawa, Tukituki river(4 x 1million m^3 if required);
- Monitoring and managing reservoir water quality;
- Eel monitoring, and trap and transfer;
- Fish screening and passage around intake structures and monitoring of effectiveness;
- Residual flow of 50l/s to be provided and retained in Papanui Stream;
- Planting to reinstate areas damaged during construction and to offset effects.
- Deposition of 3,400m^3/yr of gravel at the Tukituki river mouth subject to no nesting birds being present;
- Establishment of a Dam Construction Expert Panel;
- Establishment of an Independent Review Panel to review and report to the consent holder particularly on ensuring safety of the dam;
- Construction phase water quality monitoring;
- Cultural / accidental discovery protocol
- Establish a Kaitiaki Rūnanga (KR) to inform and identify issues through pre-construction, construction and initial operation phase.
- Establish a Construction Liaison Group (CLG)
- To report to hui, CLG;
- Provision of management plans addressing the following:
  - Construction Environment Management Plan;
  - Supplementary Construction Environment Management Plans;
    - Dam construction area;
    - Borrow areas;
    - Concrete batching;
    - Powerhouse construction;
    - Temporary coffer dams and tunnels;
    - Intake tower construction;
    - Upstream and downstream intake structure;
    - Primary distribution system headrace canal;
    - Primary and secondary distribution system and network;
    - Site office workshop facilities;
    - Construction of replacement roads ;
    - Landslip;
  - Reservoir Filling and Edge Rehabilitation Plan (RFERP);
  - Public Access & Offset Mitigation Progress Plan;
  - Construction Traffic Management Plan (CTMP).
- Fund and implement six Integrated Mitigation and Offset Approach Projects:
  - Ruataniwha Reservoir Restoration Buffer and Catchment Enhancement Zone Project;
  - Ruataniwha Riparian Enhancement Zone (River Halo Project);
  - Ruataniwha Threatened Species Enhancement Project;
  - Ruataniwha Plains Spring-fed Stream Enhancement and Priority Subcatchment Phosphorus Mitigation and Central / Southern Hawke's Bay Wide Native Fish Passage Project;
  - Old Waipawa River Bed and Papanui Stream Restoration Project;
  - Lower Tukituki Cultural Values Impact and Mitigation Project;
- Establish a Ruataniwha Biodiversity Advisory Board to advise and assist offset approach projects.

- Operational phase Management Plans:
    - Infrastructure Stormwater and Maintenance Management Plan;
    - Sediment Management Plan;
    - Reservoir Inflows, Water Level and Flow Releases;
    - Dam Safety Assurance Programme;
    - Emergency Action Plan;
    - Water Level Safety Plan;
    - Groundwater Monitoring Plan (GMP);
    - Groundwater Mounding and Drainage Monitoring Plan (GMDP);
    - Irrigation Environmental Management Plan (IEMP);
    - On-Farm Monitoring Plan.
- Monitor inflows to Makaroro dam, residual flow releases, water takes, residual flows, discharge flows;
- Dam safety conditions;
- Properties supplied by RWSS shall not exceed Tukituki LUC Natural Capital Nitrogen Leaching rates when averaged across each Surface Water Allocation Zone;
- Nitrate-nitrogen levels not to be exceeded and a management response to be initiated if concentrations are greater than 80% of the limits;
- If DIN limits are exceeded in a sub-catchment RWSS to determine if scheme members are a material contributor and if they are RWSS must identify specific actions consistent with achieving the DIN limits by 31 December 2030 and advise property owners and HBRC of these required actions;
- All RWSS supplied properties to prepare Farm Environment Management Plans (FEMP)
- “Approved maximum outputs” to be assigned to each property for phosphorus and nitrogen outputs .
- Each FEMP to be audited for first three years and every three years thereafter;
- Water quality monitoring required at 25 sites (if not being done by HBRC);
- Reporting required of aggregated Maximum Approved Outcomes”, catchment modelling, results of independent audits of FEMPs, Scheme operation water quality monitoring, analysis of monitoring data;
- Establish a Scheme Operations Liaison Group (SOLG) following commissioning for reporting on operation and environmental effects, identify issues and make recommendations (possibly leading to review of conditions);
- Review condition.