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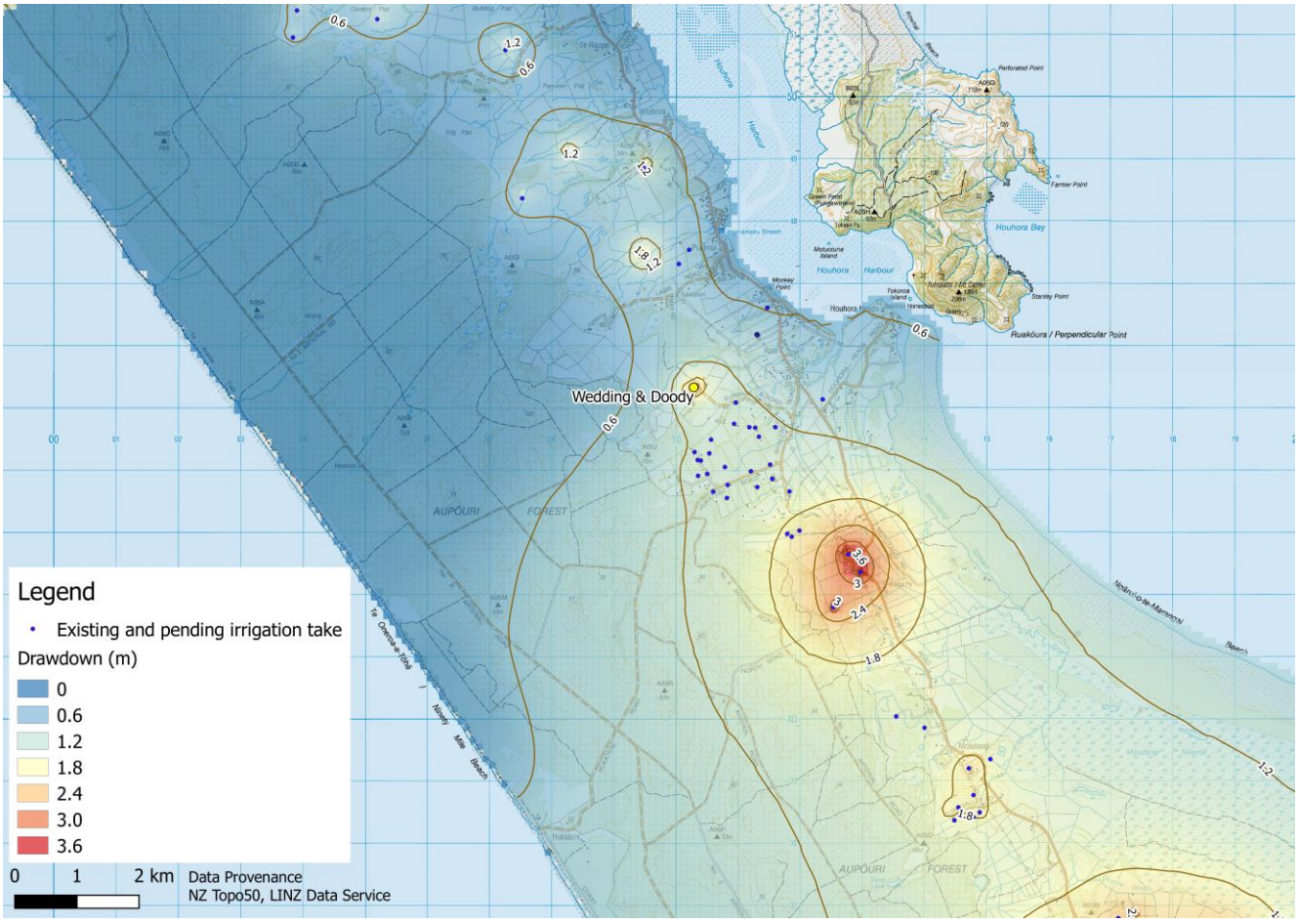
Irrigation Water Take Consent

Resource Consent Application & Assessment of Environmental Effects

DIANE WEDDING AND MARTIN DOODY

WWA0053| Rev. 2

10 August 2018



Irrigation Water Take Application

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Contents

1. Introduction

This document and attachments comprise a Resource Consent Application and an Assessment of Environmental Effects associated with a water take permit for irrigation of a 95-heactares Total Orchard Area at 173 Burnage Road, Houhora.

The background details of this application using Northland Regional Council's (NRC) "Application for Resource Consent" form is provided in **Appendix A**. Further details of various items where marked on the form are provided in the **Section 2**.

1.1 Report Structure

The report comprises:

- **Section 2** – a description of the proposed activity and suggested consent conditions;
- **Section 3** - background details of the application;
- **Section 4** – an assessment of environmental effects;
- **Section 5** – an assessment of cultural effects;
- **Section 6** - an assessment of statutory considerations;
- **Section 7** – a discussion of the notification process;
- **Section 8** – a discussion consideration of consultation; and
- **Section 9** – summary and conclusions.

2. Description of Proposed Activity

2.1 Location

Figure 1 provides a map of the project area. The property is located at 173 Burnage Road, Houhora. An existing bore is also located at this property.

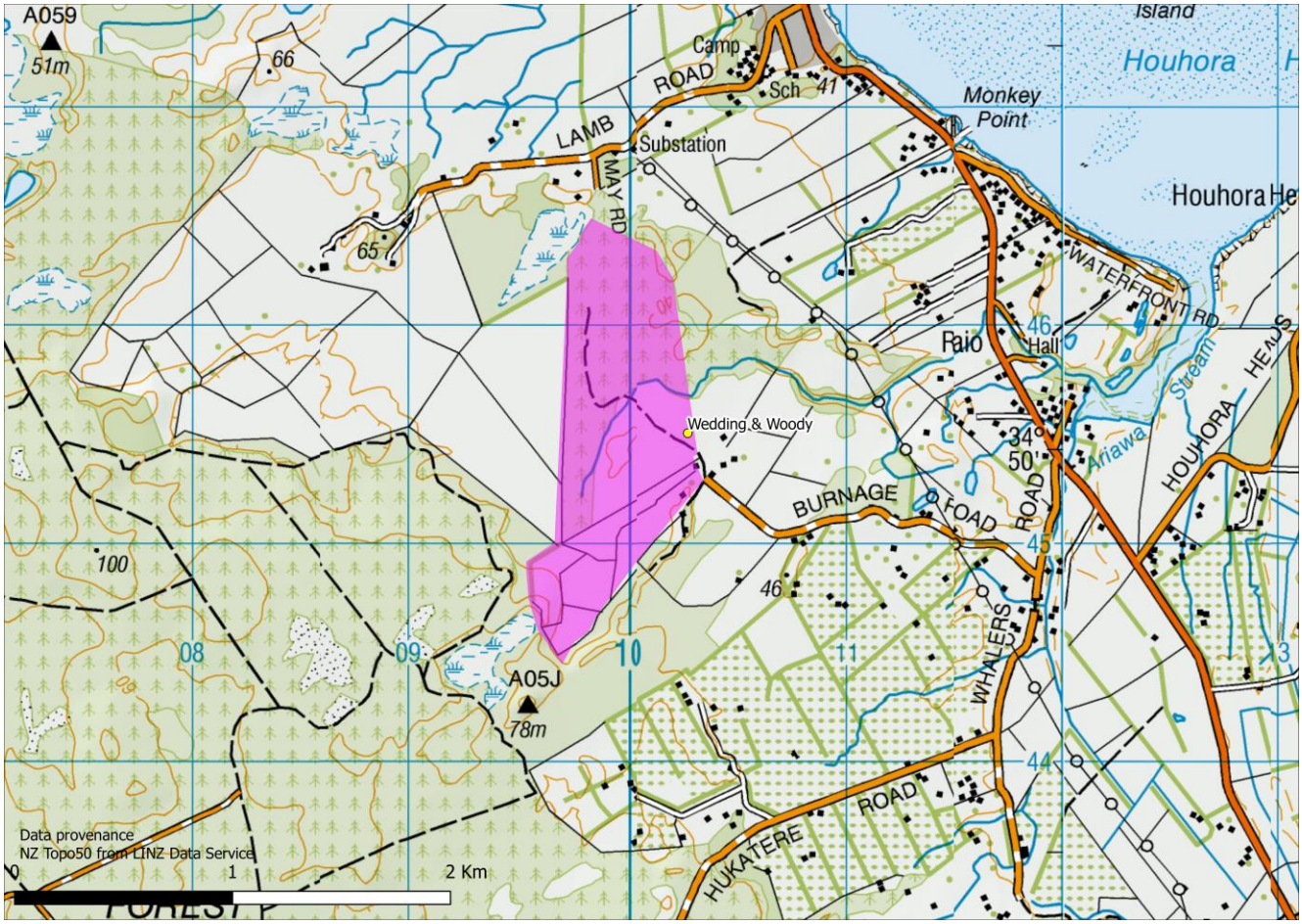

Figure 1. Project locality map.

2.1 Description of Proposed Activity

The resource consent application for Wedding and Doody is to take and use groundwater for a new 95 ha orchard development. The groundwater take will be exercised from October to April, in accordance with the following volumes:

- Maximum daily volume of 2,375 m^3/day; and
- Maximum annual volume of 304,000 m^3/yr.

The current bore on the property is unlikely to support the full orchard development on its own (**Table 1**), hence an additional bore will need to be drilled as the orchard matures.

Table 1. Bore details of the proposed application.

Bore ID	Easting	Northing	Depth (m)	Diameter (mm)	Depth of casing (m)	Screened Interval (mBGL)	Static Water Level (mBGL)	Aquifer
AUT.039838.01.01	1610293	6145503	76.5	100	73	73.5-76.5	0.8	Aupouri Shellbed

The maximum daily volume has been calculated at 25 m^3/ha/day over the Total Orchard Area, in accordance with the decision made in the Motutangi-Waiharara Water User Group (MWWUG) decision[1].

The maximum annual volume has been calculated from the canopy area, which for this orchard (given the topographic and existing building constraints) is 80% of the Total Orchard Area or 76 ha[2]. The maximum annual volume has been calculated on the basis of 400 mm/annum, which is consistent with the Council Officers' recommendation in the MWWUG Hearing. This irrigation requirement is adequate to meet up to a 1 in 10 years drought requirement (**Section 0**).

2.1.1 Consent Duration, Lapse and Review

A consent duration of 30 years is sought subject to a lapse period of 5 years from commencement of consent, and review conditions have been proposed for the purposes laid out in **Section 2.2**.

2.2 Proposed Consent Conditions

This section contains the proposed conditions for the water permit sought by the Applicant.

Water Extraction Volumes

1. The rate of take shall not exceed the limits set out as follows:
   (a) Maximum daily volume of 2,375 m^3/day (being any 24 consecutive hours); and
   (b) Maximum annual volume of 304,000 m^3/annum (being 1 July to 30 June).

Notification of Irrigation

2. The Consent Holder shall advise the Council's assigned Monitoring Officer in writing when irrigation is to commence for the first time each season, at least five days beforehand.

Metering and Abstraction Reporting

3. The Consent Holder shall install a meter to measure the volume of water taken, in cubic metres, from each production bore. Each meter shall:
   (a) Be able to provide data in a form suitable for electronic storage;
   (b) Be sealed and as tamper-proof as practicable;
   (c) Be installed at the location from which the water is taken; and

[1] The maximum daily volume can also be calculated on the basis of 41.6 m^3/day per canopy hectare (4.16 mm irrigation system capacity) on the basis of a peak daily soil requirement of 3.74 mm/day per canopy hectare and allowing for 10% system losses in delivery and application.
[2] The maximum annual volume can also be calculated on the basis of approximately 96 days at full daily volume, which is equivalent to approximately 400 mm/year. In practice the maximum daily rate will only be required on consecutive days during the peak of summer and when this coincides with drought.

(d) Have an accuracy of +/-5%.

The Consent Holder shall, at all times, provide safe and easy access to each meter installed for the purposes of undertaking visual inspections and water take measurements.

4. The Consent Holder shall verify that the meter required by Condition 3 is accurate. This verification shall be undertaken prior to 30 June:

   (a) Following the first taking of water from each production bore; and

   (b) At least once in every five years thereafter.

   Each verification shall be undertaken by a person, who in the opinion of the Council's Compliance Manager, is suitably qualified. Written verification of the accuracy shall be provided to the Council's assigned Monitoring Officer by 31 July following the date of each verification.

5. The Consent Holder shall, using the meter required by Condition 3, keep a record of the daily volume of water taken from each production bore in cubic metres, including all nil abstractions.

6. If the instantaneous rate of taking is equal to or greater than 10 litres per second, then the water meter required by Condition 3 shall have an electronic datalogger for automatic logging of meter data. A copy of the electronic data records shall be forwarded to Council's assigned Monitoring Officer by the 7th of the following month, and immediately on written request from the assigned monitoring officer.

7. The Consent Holder shall measure, and keep a record of, the static water level in each production bore at least once each month. This measurement shall be taken at least eight hours after cessation of pumping. The Consent Holder shall also monitor electrical conductivity at least once a month during any irrigation season when the bore is in use.

8. A copy of the records required to be kept by Conditions 5, 6 and 7 for the period 1 July to 30 June (inclusive) shall be forwarded each year to the Council's assigned Monitoring Officer by the following 31 July. In addition, a copy of these records shall be forwarded immediately to the Council's Compliance Manager on written request. The records shall be in an electronic format that has been agreed to by the Council.

   Advice Note: If no water is taken during the period 1 July to 30 June (inclusive) then the Consent Holder is still required to notify the Council's Monitoring Manager in writing of the nil abstraction. Water use record sheets in an electronic format are available from the Council's website at www.nrc.govt.nz/wur.

9. Easy access for a water level probe shall be provided and maintained at the production bore wellhead to enable the measurement of static water levels in the bore.

Water Use Efficiency

10. The Consent Holder shall prepare an Irrigation Scheduling Plan (ISP) that outlines how irrigation decisions will be made. The ISP shall be prepared by a suitably qualified and experienced person and submitted to the Council's Compliance Manager for written approval. The ISP shall, as a minimum, address:

    - Water balance and crop water requirements;
    - Subsurface drainage; and
    - Overall irrigation strategy.

    For each irrigation area, the ISP should include:

    (a) A description of how water requirement for each irrigation cycle is calculated;

    (b) Method(s) for assessing current soil moisture levels;

    (c) Method(s) for assessing potential evapotranspiration (PET) and rainfall to date;

    (d) Assessment of other inputs such as effluent irrigation and effect on irrigation requirement;

    (e) Soil moisture target to be maintained in each zone by irrigation;

(f) How measured data will be used to assess irrigation requirements over the next irrigation cycle; and

(g) A description of proposed method(s) for remaining within consent limits at each borehole or group of boreholes.

Advice Note: The ISP seeks to ensure that an irrigation efficiency of a minimum 80% is achieved.

11. The Consent Holder shall not exercise this consent until the ISP required by Condition 10 has been certified by the Council's Compliance Manager.
12. The ISP certified in accordance with Condition 11 shall be implemented prior to the first irrigation season, unless a later date has been approved in writing by the Council's Compliance Manager.
13. The Consent Holder shall, within six months of the first exercise of this consent, undertake an audit of the irrigation system and the ISP described in Condition 10 using a suitably qualified and experienced person. The irrigation system audit shall be prepared in accordance with Irrigation New Zealand's "Irrigation Evaluation Code of Practice" (dated 12 April 2010), including recommendations on any improvements that should be made to the system to increase water efficiencies. The results of the audit and its recommendations shall be submitted in writing to the Council's assigned Monitoring Officer within one month of the audit being undertaken. A follow-up audit shall occur at five yearly intervals throughout the term of this consent, with a focus on the efficiency of water use.
14. The Consent Holder shall, within three months of notification in writing by the Council's Compliance Manager, implement any recommendations of the audit referred to in Condition 13.
15. The reticulation system and components shall be maintained in good working order to minimise leakage and wastage of water.
16. here shall be no significant ponding of irrigated water within any irrigated area, or significant runoff from either surface or subsurface drainage to a water body, as a result of the exercise of this consent.

Review Condition

17. The Council may, in accordance with Section 128 of the Resource Management Act 1991, serve notice on the Consent Holder of its intention to review the conditions annually during the month of June for any one or more of the following purposes:
    (a) To deal with any adverse effects on the environment that may arise from the exercise of the consent and which it is appropriate to deal with at a later stage; or
    (b) To review the allocation of the resource.

    The Consent Holder shall meet all reasonable costs of any such review.

Lapsing Condition

18. This consent shall lapse on the **30 June 2023**, unless before this date the consent has been given effect to.

    Advice Note: An application can be made to the Council in accordance with Section 125 of the Act to extend the date after which the consent lapses. Such an application must be made before the consent lapses.

EXPIRY DATE: 30 June 2048

3. Background Information

3.1 Site Conditions

3.1.1 Soils

There is no Landcare Research S-map soil data available for this site, however there is Fundamental Soil Layer information, pre-dating S-Map, which describes the soil around the property as having slow permeability densipan podzol[3],weakly developed sandy recent soils[4], brown soils[5] which occur in places where summer drought is uncommon, and Mesic organic soils[6] which is moderate decomposed peat. These soils display the following properties:

- ***Physical properties*** – Densipan podzol are commonly cemented or compacted B horizons which relates to the slow permeability of the soil and its limited root depth, there is extreme limitations for arable use. Sandy recent soils occur on young land surfaces generally having deep rooting and high plant – available water capacity. Brown soils are relatively stable topsoils with a well-developed structure. Mesic organic soils occur in areas of wetlands or under forests which produce acidic litter, with low bulk density, bearing strength and thermal conductivity but high total available – water capacity.
- ***Chemical properties*** - Densipan podzol are highly acidic which secondary clays and minerals strongly differentiate with depth. Densipan podzol have generally low natural fertility while sandy recent soils have high natural saturation with high base saturation. Brown soils have low to moderate base saturation. Part of Mesic organic soils have mineral material but is dominated by organic matter.
- ***Biological properties*** – Densipan podzol have generally low biological activity while sandy recent soils have a continuous cover of vascular plants. Brown soils are associated with high biological activity (earthworms are prominent). Organic soils have restricted biological activity of organisms due to the anaerobic conditions, leading to a slow decomposition rate.

3.1.2 Geology

The property is underlain by the Aupouri Aquifer – an extensive sequence of sand, peat and shellbed that covers an area of approximately 79,000 ha extending from Ahipara in the south to Ngataki in the north. The aquifer is underlain by older low permeability Cenozoic and Mesozoic age basement rocks.

Fine sand is the dominant sediment within the Aupouri Aquifer, which vary in thickness from a few meters near the hard rock boundaries to over 100 m in some places. The sand sequence is interspersed with multiple discontinuous layers of alternating iron pan (sand stone), clay and peat, which reside across the entire peninsula typically in the upper portion of the aquifer. These deposits are associated with ancient wetlands.

The aquifer is underlain to the east by volcanic basement rocks that outcrop forming Mount Camel. These rocks most likely extend at some depth across the subsurface of the Aupouri Peninsula together with greywacke, argillite and indurated conglomerate deposits of the same age.

3.1.3 Hydrogeological Interpretation

The surficial sand deposits generally become progressively younger, unconsolidated and mobile towards the west. These younger sands have higher permeability than the sands in the east, which tend to be more weathered and contain cemented iron pans close to the surface.

[3] https://soils.landcareresearch.co.nz/describing-soils/nzsc/soil-order/podzol-soils/
[4] https://soils.landcareresearch.co.nz/describing-soils/nzsc/soil-order/recent-soils/
[5] https://soils.landcareresearch.co.nz/describing-soils/nzsc/soil-order/brown-soils/
[6] https://soils.landcareresearch.co.nz/describing-soils/nzsc/soil-order/organic-soils/

With increasing depth, the presence of shell-rich sands increases, which is important from a water yield perspective as the shellbeds typically have significantly higher hydraulic conductivity (ability to transmit water) than the finer sands. The shellbed is the target aquifer for orchard irrigation water and typically resides at depths from 70 – 140 m below ground level.

All the basement rocks in the area are known to be low permeability.

3.1.4 Irrigation Requirements

The peak water requirement is 41.6 m^3/day per canopy hectare, which is equivalent to 4.16 mm per day. The irrigation requirement was simulated on a daily basis with the Soil Moisture Water Balance Model (SMWBM) using historical rainfall and evaporation data from 1957 to 2016. The simulation results are portrayed statistically on a monthly basis in **Figure 2**, which is a box and whisker plot showing the monthly median, lower quartile (25th percentile), upper quartile (75th percentile) and minimum and maximum recorded monthly values. The graph shows the seasonal irrigation profile and likelihood of water requirements each month.

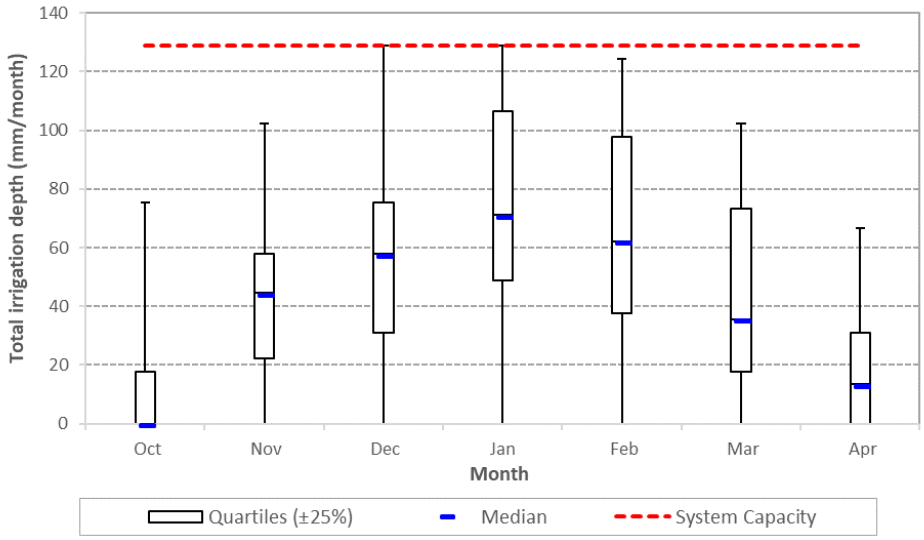

Figure 2. Simulated monthly statistical irrigation profile.

During the irrigation season, the rate of application will remain the same, but the number of days between irrigation events will increase during the shoulders of the season (i.e. typically in spring and autumn), which is exemplified in the monthly statistics shown in **Figure 2**.

Table 3 provides information on the frequency of monthly irrigation requirements and the number of days irrigation is likely required. The 1-year recurrence interval represents the typical monthly requirements and indicates that on average irrigation will not be required in October and April, and between November and March will vary from 18 mm to 47 mm per month.

In a 10-year drought year, the irrigation requirement for the season is likely to approximately 400 mm, with peak monthly totals up to approximately 120 mm, hence the amount of water being applied for is adequate to fully meet the requirements up to the 10-year drought.

Table 2. Frequency of monthly and annual irrigation requirements (mm) and days of irrigation [days].

Average Recurrence Interval	Oct	Nov	Dec	Jan	Feb	Mar	Apr	Annual
1 yr	0 [0]	23 [6]	31 [7]	47 [11]	40 [10]	18 [4]	0 [0]	250 [60]
2 yr	0 [0]	44 [11]	58 [14]	69 [17]	62 [15]	36 [9]	16 [4]	307 [74]
4 yr	18 [4]	58 [14]	76 [18]	107 [26]	98 [24]	74 [18]	31 [7]	369 [89]
5 yr	18 [4]	62 [15]	76 [18]	107 [26]	98 [24]	80 [19]	40 [10]	382 [92]
10 yr	31 [7]	76 [18]	104 [25]	117 [28]	116 [28]	84 [20]	50 [12]	401 [96]
100 yr	53 [13]	102 [25]	124 [30]	129 [31]	124 [30]	100 [24]	64 [15]	545 [131]

Table 3 provides the orchard water balance under dryland and irrigated conditions and **Figure 3** shows the mean monthly seasonal breakdown of this data. The data represents the mean annual water balance components from the 59-year simulation. It is evident that under the irrigated orchard profile, soil moisture content typically resides at a higher status (which is the intention) during summer, and surface runoff, sub-soil drainage, soil evaporation and canopy interception all increase.

However, avoidable losses due to surface runoff have not change appreciably, and the additional runoff that has occurred is due to rainfall excess rather than too much irrigation, demonstrating that the irrigation applications of 4.16 mm/day are efficient.

Table 3. Summary of average annual water balance components under irrigated and unirrigated profiles (mm/yr unless specified otherwise).

Annual Average	Dryland	Irrigated
Average Soil Moisture Content (mm)	92	104
Sub-Soil Drainage	452	522
Surface Runoff	93	105
Soil ET	467	547
Canopy Interception	179	284
TOTAL	1,191	1,458

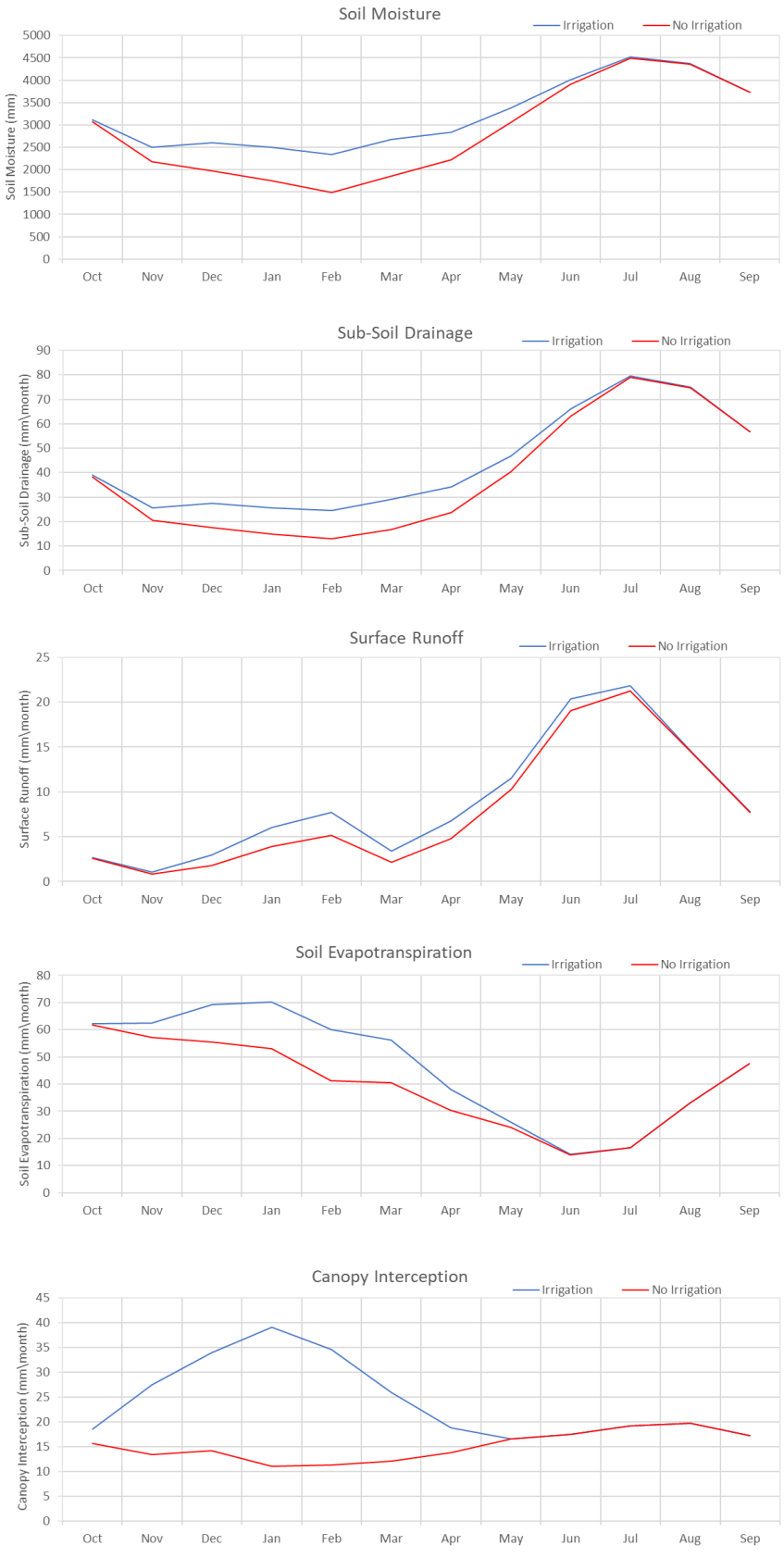

Figure 3. Comparison of water balance components.

3.2 Neighbouring Bore Information

There are 99 bores registered within the NRC database within a 2 km radius of the Wedding site (**Figure 4**). Statistics on the 99 bores are as follows:

- 91 are active, three are inactive, and four are pending and one has no information attached.
- The bores range in depth from 0 m to 118.2 m with an average of 54.6 m.
- 76 bores have information attached in terms of the purpose of the bores:
  - Two are for commercial water supply;
  - Two are for private water supply;
  - Three are for domestic and irrigation;
  - Four are for stock use;
  - Four are for domestic and stock;
  - 13 are for monitoring;
  - 23 are for domestic purposes; and
  - 25 are for irrigation

There are nine proposed bores within the pending Te Raite Station consent (OPUS, 2018) three of which are within the Hourora allocation zone. There is also one proposed bore within the pending Evans Orchard consent (WWA, 2018) to the north, and another pending consent application for Mathews at Pukenui to the east of the site. These pending consent applications have been included in the allocation assessment in **Section 3.3.3**.

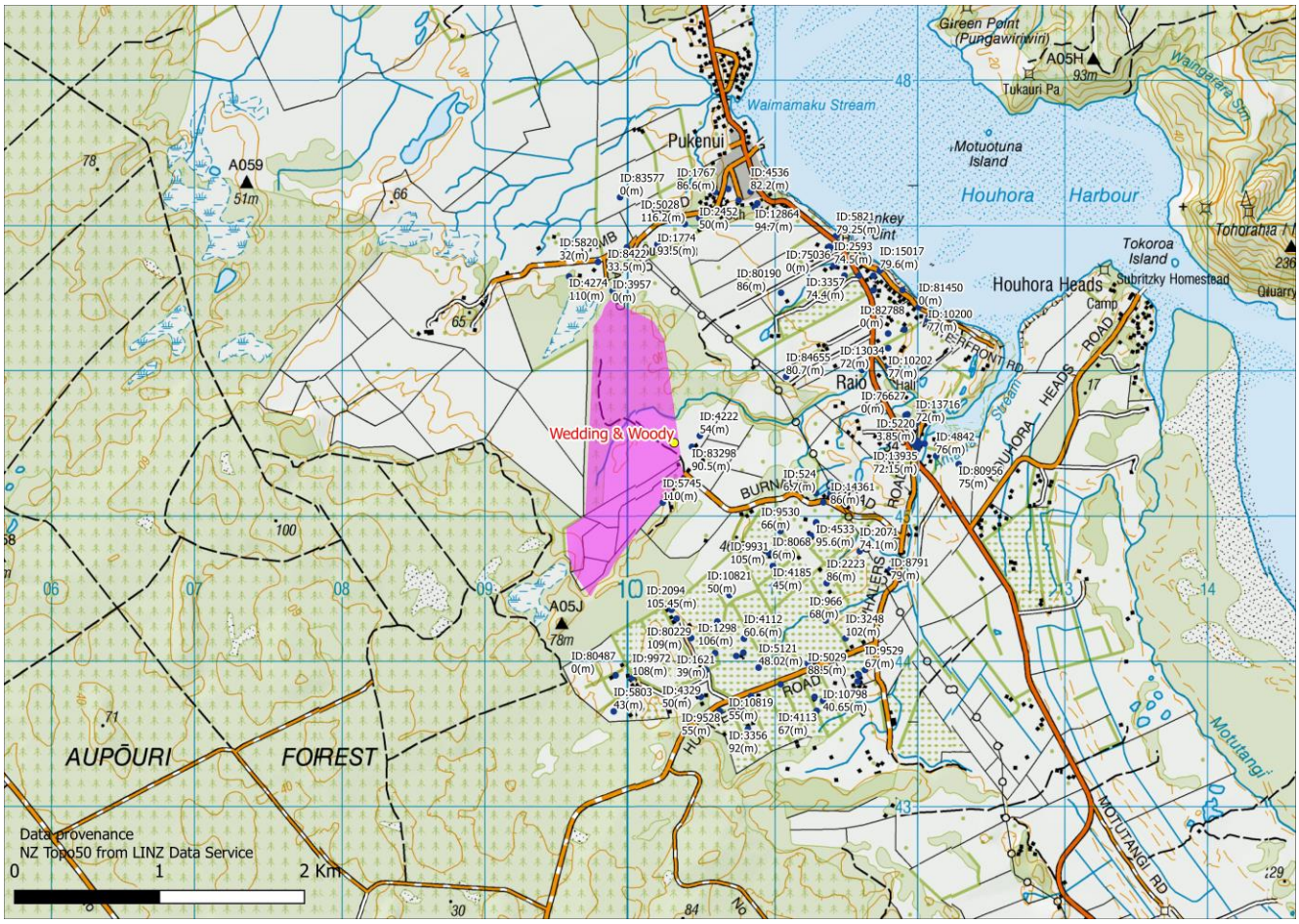

Figure 4. Neighbouring bores within 2 km radius.

3.3 Relevant Statutory Documents

3.3.1 Section 104(1)(b) of the RMA

Schedule 4 of the RMA requires that when applying for a resource consent for any activity an assessment of activities against the matters in any relevant provisions of a statutory document referred to in s104(1)(b) of the RMA must be provided. These matters are described below and **Section 6** provides an assessment against the relevant documents.

The documents referred to in Section 104(1)(b) of the RMA are:

- a national environmental standard;
- other regulations;
- a national policy statement;
- a New Zealand coastal policy statement;
- a regional policy statement or proposed regional policy statement;
- a plan or proposed plan;

The following section provides details of the relevant Regional Planning provisions, while assessment of which documents listed is above are relevant is provided in **Table 4.**

Table 4. Summary of relevance of Section 104 statutes.

Statute	Relevance	Requirement of Statue
National Environmental Standards	There are no national environmental standards that are applicable to the proposed activity.	None
Resource Management (Measurement and Reporting of Water Takes) Regulations 2010	This regulation applies to a water permit that allows fresh water to be taken at a rate of 5 litres/second or more and is consumptive. Therefore, this regulation is relevant for this water take consent.	In summary, the regulations require permit holders to keep records that provide continuous measurement of the water taken under a water permit, including water taken in excess of what the permit allows. These records are to comprise measurements of the volume of water taken each day (in cubic metres) or each week (if approved by the Regional Council), and must be in an appropriate format for auditing, and in a form suitable for electronic storage. The regulations also specify the required accuracy of any metering device (to within ±5% of the actual volume taken if from a full pipe (e.g. bore)).
National Policy Statement for Freshwater Management 2014	The following objectives and policies of the NPS are relevant to this proposal: *Water Quality* • Objectives A1, A2, andA4. • Policies A2, A3, and A7. *Water Quantity* • Objective B2, B3 and B5. • Policies B2 to B6. *Integrated Management* • Objective C1. • Policies C1 and C2.	*Water Quality* • Objective A1 seeks to safeguard the life-supporting capacity, ecosystem processes and indigenous species including their associated ecosystems of fresh water, in sustainably managing the use and development of land, and of discharges of contaminants. • Objective A2 required that the overall quality of fresh water within a region is maintained or improved while improving the quality of fresh water in water bodies that have been degraded by human activities to the point of being over-allocated. • Objective A4 seeks to enable communities to provide for their economic well-being, including productive economic opportunities. • Policies A2, A3, and A7 are considered relevant to this application and give effect to Objectives A1, A2, A4. *Water Quantity* • Objective B2 seeks to avoid any further over-allocation of fresh water and phase out existing over-allocation. • Objective B3 seeks to improve and maximise the efficient allocation and efficient use of water. • Objective B5 seeks to provide for communities' economic wellbeing within freshwater quantity limits. • Policies B2 to B6 are considered relevant to this proposal. *Integrated Management* • Objective C1 seeks to improve integrated management of fresh water and the use and development of land in whole catchments,

Statute	Relevance	Requirement of Statue
		including the interactions between fresh water, land, associated ecosystems and the coastal environment. • Policies C1 and C2 are relevant to this application and give effect to Objective C1.
Regional Policy Statement for Northland	The Regional Policy Statement (RPS) was made operative on 9 May 2016. The RPS provides a broad direction and framework for managing Northland's natural and physical resources. These include land, water, air, soil, minerals, plants, animals and all built structures. The following Objectives are considered relevant to this proposal: • Objective 3.2, 3.3, 3.5, and 3.10. The following Policies give effect to the above Objectives, and therefore are considered relevant to this application: • Policy 4.3.2, 4.3.3.	• Objective 3.2 seeks to maintain and improve water quality for human use and ecological health. • Objective 3.3 seeks to safeguard the flows and flow variability required to maintain water's life-supporting capacity, for ecological processes, and to support indigenous species. • Objective 3.5 requires that the region's resources are sustainable managed in a way that is attractive for business and investment that will improve the economic wellbeing of the region and its communities. • Objective 3.10 requires efficient use and allocation of common natural resources with a particular focus on maximising the security and reliability of supple for users. • Policy 4.3.2 requires regulatory methods to avoid over-allocation of region-wide ecological flows and water levels. • Policy 4.3.3 requires the allocation and use of water efficiently within allocation limits.
Regional Plans	The Proposed Regional Plan for Northland (pRPN) sets out policies and rules for how Northland's water, soil, air and coast are used and was publicly notified on 6 September 2017 and closed for submissions on 26 March 2018. The pRPN will replace the Regional Water and Soil Plan for Northland (RWSPN), which has been operative since 28 August 2004. At present, the rules in both these plans have legal effect, with weight given to whichever plan has the more restrictive rule for the same activity if there is a conflict between the two plans, or the later plan if no submissions were received on certain aspects. Both plans address groundwater abstractions that have the potential to adversely affect the environment. However, there are no specific aquifer allocation limits set in the RWSP. The following objectives and policies of the pRPN are considered relevant to this proposal: • Objective F.0.1. • Policy D.2.2. • Policy D.2.5. • Policy D.4.5. • Policy D.4.13. • Policy D.4.17. • Policy D.4.18.	From the pRPN: • Objective F.0.1 seeks to manage the use, development, and protection of Northland's natural and physical resources which enables people and communities to provide for their social, economic and cultural well-being while 1. sustaining the natural resources to meet the reasonable foreseeable needs of future generations, 2. safeguarding life-supporting capacities of water, and 3. avoiding, remedying, or mitigating adverse effects on the environment. • Policy D.2.2 requires that regard is had to the social, cultural, and economic benefits of the proposed activity when considering resource consents. • Policy D.2.5 requires an authority to have regard to community and tangata whenua values • Policy D.4.5 seeks to maintain overall water quality. • Policy D.4.13 seeks to achieving freshwater quantity related outcomes and inn particular manage the taking, use, damming, and diversion of fresh water so that (with relevance to this application) saline intrusion in, and land

Statute	Relevance	Requirement of Statue
	• Policy D.4.20. • Policy D.4.23. The following objectives and policies of the RWSPN are considered relevant to this proposal: • Objective 7.4. • Objective 10.4.1. • Policy 10.5.1. • Policy 10.5.2. • Policy 10.5.4. • Policy 10.5.7. • Policy 10.5.9	subsidence above, aquifers is avoided (amongst other things). • Policy D.4.17 considers allocation limits for aquifers and requires rules and applications to meet allocation limits • Policy D.4.18 concerns conjunctive surface water and groundwater management. • Policy D.4.20 requires the reasonable and efficient use of water for irrigation and sets requirements for a resource consent application to take water for irrigation purposes. • Policy D.4.23 From the RWSPN: • Objective 7.4 requires the maintenance or enhancement of water quality of natural water bodies. • Objective 10.4.1 maintains the sustainable use and development of the region's groundwater resources while avoiding, remedying, or mitigating actual and potential adverse effects on groundwater quantity and quality. • Policy 10.5.1 seeks to ensure the sustainable use of resources by avoiding takes that exceed recharge. Saltwater intrusion, reduced groundwater quality, significant drawdown, and adverse effects on surface water resources can arise where takes exceed recharge. • Policy 10.5.2 recognises that aquifers are at risk in certain circumstances and that adverse effects on water quality should be avoided. • Policy 10.5.4 seeks that groundwater allocations take into account reduction in recharge that may occur in time. • Policy 10.5.7 requires the Northland Regional Council to consider effects of a groundwater take and use on surface water bodies. • Policy 10.5.9 seeks to avoid, remedy or mitigate any ground subsidence as a result of groundwater takes, use or diversion, where this is likely to cause adverse flooding, drainage problems, or building damage.

3.3.2 Activity Status

The activity status of the proposed activity under both the RWSPN and pRPN is considered a discretionary activity – details of this conclusion are summarised in **Table 5.**

Table 5. Summary of activity status against Regional Plan Provisions.

Plan	Relevant Rules	Comment
RWSPN	Rule 25.03.01 of the plan states that "The taking, use or diversion of groundwater from an aquifer, and any associated discharge of groundwater onto or into land or into water, which does not meet the requirements of the permitted, controlled or non-complying activity rules is a discretionary activity." In essence, the discretionary activity rule is for takes that are not for domestic or stock watering purposes (Rule 25(A)) and exceed the permitted activity thresholds (Rule 25.01.01) of a daily volume of 10 m3/d and instantaneous rate of 5 L/s per bore.	Under this plan and until such time as the equivalent provisions within the Proposed Regional Plan for Northland (pRPN) are no longer contested, the proposed activity would be considered Discretionary Activity.
pRPN	Rule C.5.1.10 states that the taking and use of fresh water is a discretionary activity unless it is one of the following: 1) a permitted activity under C.5.1.1 'Minor takes – permitted activity', or 2) a permitted activity under C.5.1.2 'Temporary take for road construction or maintenance – permitted activity', or 3) a permitted activity under C.5.1.3 'Water take from an off-stream dam – permitted activity', or 4) a permitted activity under C.5.1.4 'Water take from an artificial watercourse – permitted activity', or 5) a permitted activity underC.5.1.5'Water take associated with bore development, bore testing or dewatering – permitted activity', or 6) a controlled activity under C.5.1.6 'Replacement water permits for registered drinking water supplies - controlled activity', or 7) a controlled activity under C.5.1.7 'Takes existing at the notification date of the plan - controlled activity', or 8) a restricted discretionary activity under C.5.1.8 'Supplementary allocation – restricted discretionary activity', or 9) a discretionary activity under C.5.1.9 'Takes existing at the notification date of this plan – discretionary activity', or 10) a non-complying activity under C.5.1.11 'Water take below a minimum flow or water level-non-complying activity', or 11) a non-complying activity under C.5.1.12 'Water take that will exceed an allocation limit - non-complying activity', or 12) a prohibited activity under C.5.1.13 'Water takes that will exceed an allocation limit - prohibited activity'.	The proposed groundwater take does not conform to any of the activities in listed in 1) to 10) above, and as indicated in the following **Section 3.3.3** does not exceed an allocation limit, therefore the proposed activity constitutes a Discretionary Activity under the pRPN.

3.3.3 Allocation Zones

The Aupouri Peninsula Aquifer is divided into different allocation zones for management purposes. The Wedding and Doody property sits within the Aupouri-Houhora allocation zone. The allocation limit, current level of allocation and the level of allocation should this consent (along with other pending consents) be granted, are shown in Error! Reference source not found..

The new allocation limit is based off the annual recharge being 15% of mean annual recharge, which we understand from paragraphs 111 to 118 of the Section 42 Hearing Report (Tait, 2018), is being recommended by Northland Regional Council.

Error! Reference source not found. shows that the granting for the Wedding and Doody (304,000 m^3/yr) will take the allocation status to 62% of the allocation limit. If the other proposals are granted (Anton Matthews and Te Raite Station) this will increase the allocation status to 80%.

Table 6. Aupouri Aquifer Limits[7] and Allocation Status.

Sub-aquifer	Allocation Limit [A.]		Allocation Status (Current)[B.]		Allocation Status	
					If Te Raite Station (562,500), Evans (160,000), Wedding & Doody (304,000), and Matthews (12,000) Granted	
	m^3/year	% ann. mean. recharge	m^3/year	%	m^3/year	%
Aupouri - Houhora	2,999,201	15	1,374,864	46%	2,413,364	80%

Notes:

A. Recalculated from Lincoln AgriTech (2015).

B. Current allocation includes the recently granted (June 2018) MWWUG consents, which equated to 329,370 m^3/year in the Motutangi zone.

[7] According to NRC's allocation maps at http://gis.nrc.govt.nz/LocalMaps-Viewer/?map=895e0785f7054d47b10a72edc38022dc

4. Assessment of Environmental Effects

The proposed Wedding and Woody take (304,000 m^3/year), and three other ongoing applications including Anton Mathews (12,000 m^3/year), Yelavich take (52,000 m^3/year) and Robert Campbell Family trust (360,000 m^3/year) are located in the Motutangi-Waiharara Groundwater Model (MWGW) domain (WWA,2017). A further two pending applications including NE Evans Trust (160,000 m^3/year) and Te Raite Station (1170,000 m^3/year) are located in the Houhora Groundwater Model domain (WWA, 2018)

The cumulative drawdown of all current and pending applications has been evaluated using analytical methods superimposed on the drawdown profile from Tuscany Avocados and NE Evans Trust Assessment of Environmental Effects (WWA, 2018) - noting that this included the existing takes and newly granted MWWUG (Motutangi – Waiharara Water User Group) takes.

The methodology and results of the groundwater and surface water impact analysis are detailed in **Appendix B.**

4.1 Pumping Interference Effects

Drawdown due to proposed take was analysed using Theis (1935) and Feather and Williamson Solution (unpublished)[8]. A maximum drawdown ranging between of 7.0 m (Feather and Williamson) and 9.6 m (Theis) and was estimated in the deep aquifer adjacent to the pumping bore. A drawdown of 0.15 m was estimated near the pumping bore in the shallow aquifer with the Feather and Williamson Solution.

The superimposition of the Feather and Williamson solution to the conservative drawdown from Tuscany and NE Evans Trust shows the proposed take will induce an additional drawdown of up to 0.4 m for neighbouring bores that are located within 2.5 km radius, with the greatest drawdown estimated for Longbeach Trust bore. For these neighbouring bores, the cumulative drawdown ranged from 0.7 m to 1.5 m (**Appendix B**).

The interference effects on existing groundwater uses considering the available drawdown of the aquifer is considered less than minor.

4.2 Surface Water Effects

As discussed in **Appendix B**, there are three surface water features that may be impacted by the proposed take:

- Unnamed drain to north (0.3 km);
- Unnamed swamp to northwest (1.1 km); and
- Unnamed swamp to southwest (0.9 km).

However, analysis indicated that the maximum potential drawdown impact in the shallow aquifer in the location of these surface water features is less than 0.3 m, which would translate to an insignificant impact within a standing or flowing water body.

Therefore, the impact on surface water due to proposed abstraction in the deep aquifer is considered less than minor.

4.3 Saline Intrusion

The risk of saltwater/freshwater interface upconing and lateral migration was in Appendix B.3.1 based on the analysis conducted in MWGM report (Section 5.2.6, WWA, 2017).

[8] Feather and Williamson Solution - a multi-layer model based on Hemker and Maas (1987) and Hunt and Scott (2007).

Due to the existence of low permeable bedrock underlying the deep shellbed aquifer, saltwater lateral migration along the base of the shellbed is a more likely mechanism of saltwater intrusion. As detailed in **Appendix B**, the proposed take is located in the central sand area. The additional drawdown is unlikely to change the potential saltwater lateral migration profile at the sentinel locations assessed from MWGW report (WWA, 2017)

The impact on saltwater intrusion due to proposed take will be less than minor.

4.4 Ground Settlement

The potential maximum ground settlement was estimated from the cumulative drawdown in **Appendix B**.

Within 1.5 km of proposed take, the estimated cumulative subsidence is 0.02 m, with a maximum drawdown of 0.31 m and 2.58 m in shallow and deep aquifer, respectively. In a rural setting, settlement effects of this magnitude (or less as would be more realistic) are less than minor for the following reasons:

- There is no sensitive urban infrastructure like water or wastewater mains or high-rise buildings to rupture or crack; and
- The changes in land surface due to farm machinery (e.g. rotary hoeing) would likely mask impacts of this magnitude (<0.3 m) if materialised.

In summary, the potential settlement effects are considered less than minor.

4.5 Water Quality

The potential risk to water quality from the leaching of fertilisers and pesticides that may be associated with horticulture is not a relevant consideration for a water take application under the current Northland Regional planning framework. With reference to the effects from horticultural sprays the Commissioners for the MWWUG water take applications stated in their Hearing Decision Report (June 2018) that:

“such are not matters that are directly engaged by the present applications for water abstraction. Accordingly, we have no present jurisdiction to consider those putative effects. If resource (or other) consent is subsequently required, then such will need to be applied for and considered at the appropriate time”.

Nevertheless, there are a range of factors that make the leaching of fertiliser and pesticides unlikely to impact water quality:

- In practice orchardists in this area tend to apply fertiliser efficiently via fertigation as part of their irrigation water using a small dosage regularly, which is driven by both the soil conditions (i.e. high permeability and lacking in nutrients) and economic considerations.
- Inefficient irrigation practice will lead to root rot, thus because orchardists will actively avoid this, excessive leaching of nutrients is unlikely.
- Both fertiliser and approved pesticides are applied in accordance with permitted activity rules within the pRPN and rules needing to be met to become certified under the AvoGreen Assured program by the Avocado Industry Council Ltd. One of the key aims is “environmental sustainability by only using sprays when required”.
- Due to the presence of significant amounts of organic matter within the shallow sand deposits, shallow groundwater is likely to be reducing. Under such conditions, nitrate concentrations are likely to be low in groundwater (consistent with available groundwater quality data) due to denitrification within the aquifer system. The presence of organic matter is also likely to substantially decrease the mobility of any pesticide compounds prone to leaching.

4.6 Consideration of Alternatives

An AEE must include a description of alternative locations or methods for undertaking an activity, if it is likely that the activity will result in any significant adverse effect on the environment.

The effects of the proposed taking and using of groundwater were assessed above as being no more than minor on the environment and less than minor on other groundwater users. As such, no alternatives have been considered for this proposal.

5. Assessment of Cultural Effects

The proposed groundwater abstraction lies within the rohe of Te Aupōuri, Ngāti Kurī, and Ngāi Takoto iwi.

According to the Te Raite Station groundwater take consent application (OPUS, 2018), the proposed take is not located within, or in close proximity to an area sensitive to the respective iwi. This has been confirmed via the 'Sites and Areas of Significance to Tangata Whenua' GIS layer on the Northland Regional Council Proposed Regional Plan planning maps, and by Te Aupōuri.

Northland Regional Council have an internal procedure where they circulate all applications to local Iwi and Maori Groups that have registered with the Council as having an interest in the area. If a local Iwi or Maori Group is considered to be affected by the effects of the proposed activity the Group must be notified as part of the consultation process.

The proposed groundwater abstraction lies within the rohe of Te Aupōuri, Ngāti Kurī, and Ngāi Takoto iwi. Consultation with these iwi has not be carried out stage based on the understanding that if physical effects of an application are less than minor, then any meta-physical (cultural and spiritual) effects would commensurately also be less than minor.

In this rohe we are aware that at least two of the three iwi groups have recently lodged applications for water takes, and we are aware of a third planning to do so. That signals that the taking of water itself is not an activity that iwi are adverse too.

Therefore, given the less than minor impact of this proposal, we do not consider iwi consultation is necessary for this application.

6. Assessment Of Statutory Considerations

Table 7 to **Table 10** provide assessments of the relevant statutory documents as were identified in **Section 0**.

Overall, this resource consent application is consistent with the objectives and policies of the National Policy Statement for Freshwater Management 2014, incumbent regional plan (RWSPN) and proposed regional plan (pRPN).

Table 7. Assessment against relevant objectives and policies for the National Policy Statement for Freshwater Management 2014.

No.	Objective / Policy	Assessment
Water Quality		
Objective A1	• Seeks to safeguard the life-supporting capacity, ecosystem processes and indigenous species including their associated ecosystems of fresh water, in sustainably managing the use and development of land, and of discharges of contaminants.	This proposal is consistent with these objectives and policies and either supports them or at the least maintains them.
Objective A2	• Required that the overall quality of fresh water within a region is maintained or improved while improving the quality of fresh water in water bodies that have been degraded by human activities to the point of being over-allocated.	
Objective A4	• Seeks to enable communities to provide for their economic well-being, including productive economic opportunities.	
Policies A2, A3, and A7	• Give effect to Objectives A1, A2, A4	
Water Quality		
Objective B2	• Seeks to avoid any further over-allocation of fresh water and phase out existing over-allocation.	This proposal is consistent with these objectives and policies.
Objective B3	• Seeks to improve and maximise the efficient allocation and efficient use of water.	
Objective B5	• Seeks to provide for communities' economic wellbeing within freshwater quantity limits.	
Policies B2 to B6	• Give effect to Objectives B2 to B5.	
Integrated Management		

No.	Objective / Policy	Assessment
Objective C1	• Seeks to improve integrated management of fresh water and the use and development of land in whole catchments, including the interactions between fresh water, land, associated ecosystems and the coastal environment.	This proposal is consistent with these objective and policies.
Policies C1 and C2	• Give effect to Objective C1.	

Table 8. Assessment against relevant objectives and policies for the Regional Policy Statement for Northland.

No.	Objective / Policy	Comment
Objective 3.2	• Seeks to maintain and improve water quality for human use and ecological health.	This proposal is consistent with this objective as it will at the least maintain water quality.
Objective 3.3	• Seeks to safeguard the flows and flow variability required to maintain water's life-supporting capacity, for ecological processes, and to support indigenous species.	The proposal is consistent with this objective as it will have a no more than minor impact on surface water resources.
Objective 3.5	• Requires that the region's resources are sustainable managed in a way that is attractive for business and investment that will improve the economic wellbeing of the region and its communities.	The proposal is consistent with this objective as it will efficiently utilise a natural resource to facilitate development of economic wellbeing.
Objective 3.10	• Requires efficient use and allocation of common natural resources with a particular focus on maximising the security and reliability of supple for users.	The proposal is consistent with this objective.
Policy 4.3.2	• Requires regulatory methods to avoid over-allocation of region-wide ecological flows and water levels.	The proposal does not exceed allocation limits, hence is consistent with this policy.
Policy 4.3.3	• Requires the allocation and use of water efficiently within allocation limits.	The proposal will use water efficiently and will not exceed allocation limits, hence is consistent with this policy.

Table 9. Assessment against relevant objectives and policies for the Proposed Regional Plan for Northland.

No.	Objective / Policy	Comment
Objective F.0.1	• Seeks to manage the use, development, and protection of Northland's natural and physical resources which enables people and communities to provide for their social, economic and cultural well-being while 1. sustaining the natural resources to meet the reasonable foreseeable needs of future generations, 2. safeguarding life-supporting capacities of water, and 3. avoiding, remedying, or mitigating adverse effects on the environment.	The proposal is consistent with this objective.
Policy D.2.2	• Requires that regard is had to the social, cultural, and economic benefits of the proposed activity when considering resource consents.	As discussed in Section 6, proposal will facilitate the economic and social benefits of both the landowner, their employees and the wider community through flow on effects of purchases made to operate and maintain the orchard.
Policy D.2.5	• Requires an authority to have regard to community and tangata whenua values	The proposal is not inconsistent with either community values, as there has been conversion to market gardening and horticulture in the area that has benefitted the community and tangata whenua through employment opportunities.
Policies D.4.5	• Seeks to maintain overall water quality	This proposal is consistent with this policy as it will not impact water quality.
Policy D.4.13	• Seeks to achieve freshwater quantity related outcomes and in particular manage the taking, use, damming, and diversion of fresh water so that (with relevance to this application) saline intrusion in, and land subsidence above, aquifers is avoided (amongst other things).	This proposal is consistent with this policy as it will avoid the saline intrusion and subsidence impacts, as discussed in **Section 4.3** and **4.4**.
Policy D.4.17	• Considers allocation limits for aquifers and requires rules and applications to meet allocation limits.	This proposal is consistent with this policy as the proposed take will not exceed allocation limits within the Aupouri-Motutangi zone.
Policy D.4.18	• Concerns conjunctive surface water and groundwater management.	This application is not inconsistent with this policy, in that the groundwater take will not adversely impact on surface water through stream depletion.
Policy D.4.20	• Requires the reasonable and efficient use of water for irrigation and sets requirements for a resource consent application to take water for irrigation purposes.	This proposal is consistent with this policy as the daily irrigation rate and annual volume are considered efficient and just meet 10-year drought requirements, but provide reduced reliability for more severe droughts.

No.	Objective / Policy	Comment
Policy D.4.23	• Requires conditions on water permits that 1) clearly define the take amount in instantaneous take rates and total volumes, including by reference to the temporal aspects of the take and use, and 2) require that the water take is metered and information on rates and total volume of the take is provided electronically to the regional council, and 3) for water permits for takes equal to or greater than 10 litres per second, require the water meter to be telemetered to the regional council, and 4) clearly define when any restrictions and cessation of the water take must occur to ensure compliance with freshwater water quantity limits set in this plan, and 5) require the use of a backflow prevention system to prevent the backflow of contaminants to surface water or ground water from irrigation systems used to apply animal effluent, agrichemical or nutrients, and 6) specify when and under what circumstances the permit will be reviewed pursuant to Section 128(1) of the RMA, including by way of a common review date with other water permits in a catchment.	The proposal is only partially consistent with this policy, as the applicants are arguing that so long as pumping data is recorded electronically and available for the council upon request, telemetry is not required. All other provisions will be met.

Table 10. Assessment against relevant objectives and policies for the Regional Water and Soil Plan for Northland.

No.	Objective / Policy	Comment
Objective 7.4	• Requires the maintenance or enhancement of water quality of natural water bodies.	This proposal is consistent with this objective as the effects of the take and use of the water will have no more than minor impacts on the shallow aquifer and other surface water bodies, as discussed in **Section 4.2**.
Objective 10.4.1	• Seeks to maintain the sustainable use and development of the region's groundwater resources while avoiding, remedying, or mitigating actual and potential adverse effects on groundwater quantity and quality.	Ditto above.
Policy 10.5.1	• Seeks to ensure the sustainable use of resources by avoiding takes that exceed recharge. Saltwater intrusion, reduced groundwater quality, significant drawdown, and adverse effects on surface water resources can arise where takes exceed recharge.	This proposal is consistent with this policy as the cumulative allocation in this aquifer management zone is only 11% of mean annual recharge, which is a low limit on a national scale.

No.	Objective / Policy	Comment
Policy 10.5.2	• Recognises that aquifers are at risk in certain circumstances and that adverse effects on water quality should be avoided.	This proposal is consistent with this policy in that current water quality will be maintained.
Policy 10.5.4	• Seeks that groundwater allocations take into account reduction in recharge that may occur in time.	This proposal is consistent with this policy in that the analysis assumed no rainfall for the entire 96 days of pumping.
Policy 10.5.7	• Requires the Northland Regional Council to consider effects of a groundwater take and use on surface water bodies.	This proposal is consistent with this policy as the effects of the take and use of the water will have no more than minor impacts on the shallow aquifer and other surface water bodies, as discussed in **Section 4.2**.
Policy 10.5.9	• Seeks to avoid, remedy or mitigate any ground subsidence as a result of groundwater takes, use or diversion, where this is likely to cause adverse flooding, drainage problems, or building damage.	This proposal is consistent with this policy as subsidence effects will be no more than minor in the context of a rural setting, as discussed in **Section 4.4**.

7. Notification

Section 95 sets out the decision-making steps for the determining of public notification and limited notification of applications and the timeframe Councils have for making the notification decision.

8. Consultation

Schedule 4 of the RMA requires that an AEE should identify (amongst other things) the persons affected by the activity, any consultation undertaken, and any response to the views of any person consulted.

Potentially affected parties in relation to this application could include other groundwater users and occupiers of the land within the pumping induced groundwater cone of depression.

However, it should also be noted that while it is considered good practice and “neighbourly” to undertake consultation, under Section 36A of the RMA there is no requirement for an applicant or council to undertake any consultation with any person in regard to an application.

In this case, no consultation has been undertaken with other water users and landowners because the assessment of effects and in particular the bore interference assessment provided in **Section 4.1** concludes that no other groundwater users are considered to be adversely affected by the granting of this application.

9. Summary and Conclusions

Wedding and Doody are seeking a groundwater take to facilitate the development of a 95 ha orchard at 173 Burnage Road, Houhora. The groundwater take will be exercised from October to April, in accordance with the following volumes:

- Maximum daily volume of 2,375 m^3/day; and
- Maximum annual volume of 304,000 m^3/yr.

A consent duration of 30 years is sought, subject to a lapse period of 5 years.

If granted, this consent taken with another application we are aware of, will take the allocation status for the Aupouri-Houhora allocation zone to just approximately 80% of full allocation. The activity status thus remains Discretionary.

The AEE has demonstrated that the potential adverse effects of the proposed water take and use on the environment will be less than minor, and the effects on persons will also be less than minor.

The proposal is also considered to be consistent with the relevant objectives and policies of the NPS, the RPS, the PRP, the RWSPN, and Part 2 of the RMA. The applicant considers that in light of the less than minor effects of the application, the decision made following the recent hearing for the MWWUG consent applications, the consent should proceed without public notification and be granted on a non-notified basis.

10. References

Feather and Williamson (currently unpublished). An Analytical Tool for Drawdown Analysis in Multi-Layered Aquifer Systems. (App soon to be publicly available on www.wwa.kiwi)

Hemker, C.J., and Maas, C., 1987. Unsteady flow to wells in layered and fissured aquifer systems. Journal of Hydrology, 90 (1987) 231-249.

Hunt, B. and Scott, D., 2007. Flow to a well in a two-aquifer system. Journal of Hydrologic Engineering, 12(2), 146-155.

HydroGeo Solutions, 2000. Aupouri Aquifer Sustainable Yield Groundwater Modelling Study. Consultancy report prepared for Northland Regional Council.

Lincoln AgriTech, 2015. Aupouri Aquifer Groundwater Model. Consultancy report prepared for Northland Regional Council.

SKM, 2007b. King Avocado Orchard Groundwater Take Consent Application (AEE Final). Consultancy report prepared for King Avocado Limited.

Tait, B., 2018. Allocation and use of water. Recommendations in response to submissions on the Proposed Regional Plan for Northland - Section 42A hearing report. Date: 3/07/2018. Author: Ben Tait. Version: Final.

Williamson Water Advisory, 2017. Motutangi-Waiharara Groundwater Model Factual Technical Report – Modelling. Consultancy report prepared for Motutangi-Waiharara Water Users Group.

Williamson Water Advisory, 2018a. Resource Consent Application & Assessment of Environmental Effects. Consultancy report prepared for NE Evans Trust.

Williamson Water Advisory, 2018b. Resource Consent Application & Assessment of Environmental Effects. Consultancy report prepared for Tuscany Valley Avocados Limited.

WSP OPUS, 2018. Application for Water Permit to take and use groundwater Te Aupouri Commercial Development Ltd. Consultancy report prepared for Te Aupouri Commercial Development Ltd.

Appendix A. Form A - Application For Resource Consent

The Northland Regional council application for resource consent is attached as an accompanying document.

Appendix B. Environmental Impact Analysis

B.1 Drawdown analysis

The drawdown analysis was conducted based on the peak daily groundwater take of 2,375 m^3/day, which will be applied to 95 ha development area. The drawdown was evaluated after 128-days of pumping, which equates to a total take of 304,000 m^3 at the end of the irrigation season. The drawdown effect was analysed using:

- **Theis Solution**: Analytical solution to compute drawdown in abstraction layer with a confined non-leaky condition.
- **Feather & Williamson** S**olution**: Analytical solution to compute drawdown in a multi-layer aquifer system considering elastic storage within layers.

The hydrogeological parameters of the abstraction layer were sourced from relevant pumping test data in the region, shown in **Table B1.**

Table B1. Summary of hydrogeological parameters of shellbed analysed from pumping test data.

Bore	Screen depth	Depth	Lithology	Transmissivity	Thickness	Specific storage	Leakance	Analysis method	Source
	mBGL	mBGL		m^2/day	m	m^{-1}	d	-	
King Avo1	110.5	-	Shell	305	26	$2.7x10^{-5}$	0.0003	-	Aupouri Aquifer Groundwater Model (Lincoln AgriTech, 2015)
King Avo2	110.5	-	Shell	370	17	$6.5\ x10^{-5}$	0.0003	-	
184	101	110	Shelly sand	140-340	-	-	-	-	Aupouri Aquifer Sustainable Yield Groundwater Modelling Study (HydroGeo Solutions, 2000)
SKM101b	84.5-100	100	Sand/shell	496	15.5	-	-	-	King Avocado Orchard Groundwater Take Consent Application (AEE Final) (SKM, 2007b)
SKM102b	112-122	122	Sand/shell	130	10	-	-	-	
SKM103b	114-124	124	Sand/shell	300	10	-	-	-	
SKM104b	82-94	94	Sand/shell	444	12	-	-	-	
Stanisich Pumping bore	87-101	-	Shell	485	14	-	-	Single well Jacob	Motutangi-Waiharara Groundwater Model Factual Technical Report – Modelling. (Williamson Water Advisory, 2017)
				512		-	-	Theis Recovery	
				471		-	-	Single well Jacob leaky solution	
Stanisich Monitoring bore	77-85	-	Shell	356	8	$4.4\ x10^{-3}$	-	Theis (point match)	
				138		$1.6\ x10^{-4}$	0.00183	Hantush-Jacob	
				408		$3.0x10^{-4}$	0.00135	Hantush-Jacob	
				348		$3.1x10^{-4}$	0.000736	Hantush-Jacob	

Bore	Screen depth	Depth	Lithology	Transmissivity	Thickness	Specific storage	Leakance	Analysis method	Source
	mBGL	mBGL		m^2/day	m	m^{-1}	d	-	
Honeytree Pumping bore	62-68,68-71,84-93	-	Shell	618	18	-	-	Single well Jacob	
				511		-	-	Theis Recovery	
Honeytree Monitoring bore	63-69,69-72,86-95	-	Shell	751	18	$3.0x10^{-4}$	-	Theis (point match)	
				784		$3.0x10^{-4}$	-	Cooper Jacob	
				579		$1.6x10^{-5}$	0.00015	Hantush-Jacob	
				484		$2.2x10^{-5}$	0.000284	Hantush-Jacob	
				707		$1.7x10^{-5}$	0.0000509	Hantush-Jacob	
De Bede Pumping bore	91-97	-	Shell	377	6	-	-	Single well Jacob	
				363				Theis Recovery	
				273					
			Minimum	130	6	$1.6 x10^{-5}$	$5.1x10^{-5}$		
			Median	**444**	**14**	$\mathbf{1.6x10^{-5}}$	$\mathbf{3.0x10^{-4}}$		
			Average	444	14	$5.4x10^{-4}$	$6.3x10^{-4}$		
			Maximum	784	26	$4.4x10^{-3}$	$1.8x10^{-3}$		

B.1.1 Theis Drawdown Solution

The median aquifer hydraulic property values from **Table B1** were used to represent the deep shellbed aquifer. The estimated drawdown after 128-days of pumping at various distance from pumping bore is shown in **Figure B1**. Near the pumping bore, a maximum drawdown of 9.6 m was simulated

Due to the existence of discrete low-permeable geological materials (e.g. iron pan, silt, peat), the regional aquifer is a leaky confined system, showing a progressive confinement with depth. The confined (non-leaky) condition of the Theis solution will lead to an appropriately conservative overestimation of drawdown in the deep shellbed.

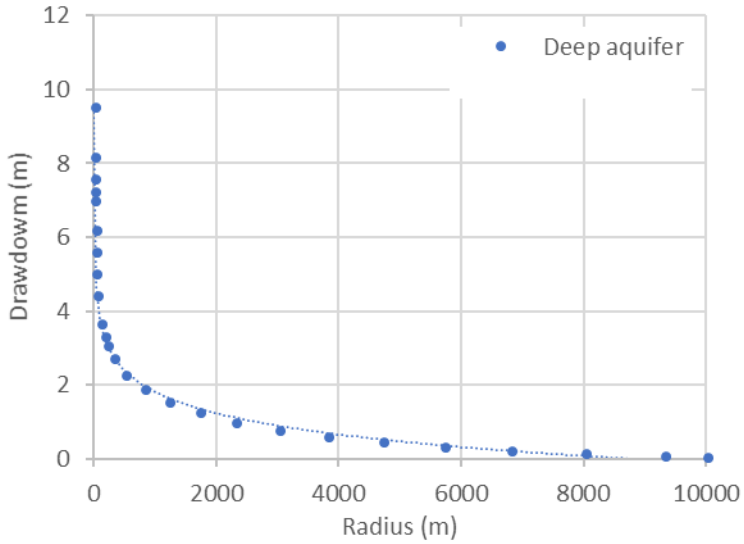

Figure B1. Calculated drawdown of abstraction layer (Theis).

B.1.2 Feather & Williamson Solution

Feather and Williamson (unpublicised) developed a solution for drawdown calculation in a multi-layer aquifer system considering elastic storage, which by coincidence was an extension of the solution by Hemker and Maas (1987) for unsteady flow to well in layered aquifer systems, and an extension of the solution by Hunt and Scott (2007) for two-layered systems. By assigning the hydrogeologic parameters and thicknesses of individual layers, drawdown is calculated for each individual layer using an inversion of Laplace transformation of the groundwater flow equation.

A 6-layer single well pumping model was setup, and the hydrogeologic parameters of Layer 1 to Layer 5 were sourced from the MWGM (WWA,2017), with the hydrogeologic parameters for the shellbed (Layer 6) taken as the median value from **Table B1**, as shown in **Table B2**.

Table B2. Hydrogeologic parameterisation in the Feather and Williamson model.

Layer	Transmissivity (m^2/day)	Horizontal hydraulic conductivity (m/s)	Vertical anisotropy (-)	Storativity (-)	Layer thickness (m)
1	140	4.05E-05	80	2.50E-01	40
2	75	3.47E-05	80	1.25E-02	25
3	60	3.47E-05	80	1.00E-02	20
4	210	3.47E-04	1	1.12E-02	7
5	18	6.94E-05	30	1.50E-03	3
6	444	3.67E-04	1	2.17E-03	14

The estimated drawdown in the deep and shallow aquifer is shown in **Figure B2**. A maximum drawdown of 0.15 m and 7 m were simulated for the shallow and deep aquifer, respectively. The calculated drawdown extent

and magnitude from Feather and Williamson Solution is less than from the Theis Solution, due to the vertical leakance simulated in the model. The drawdown estimated from Feather and Williamson Solution is considered a more realistic solution for leaky-confined aquifer systems, nevertheless the Theis Solution has value as an upper range estimate and therefore conservative approximation.

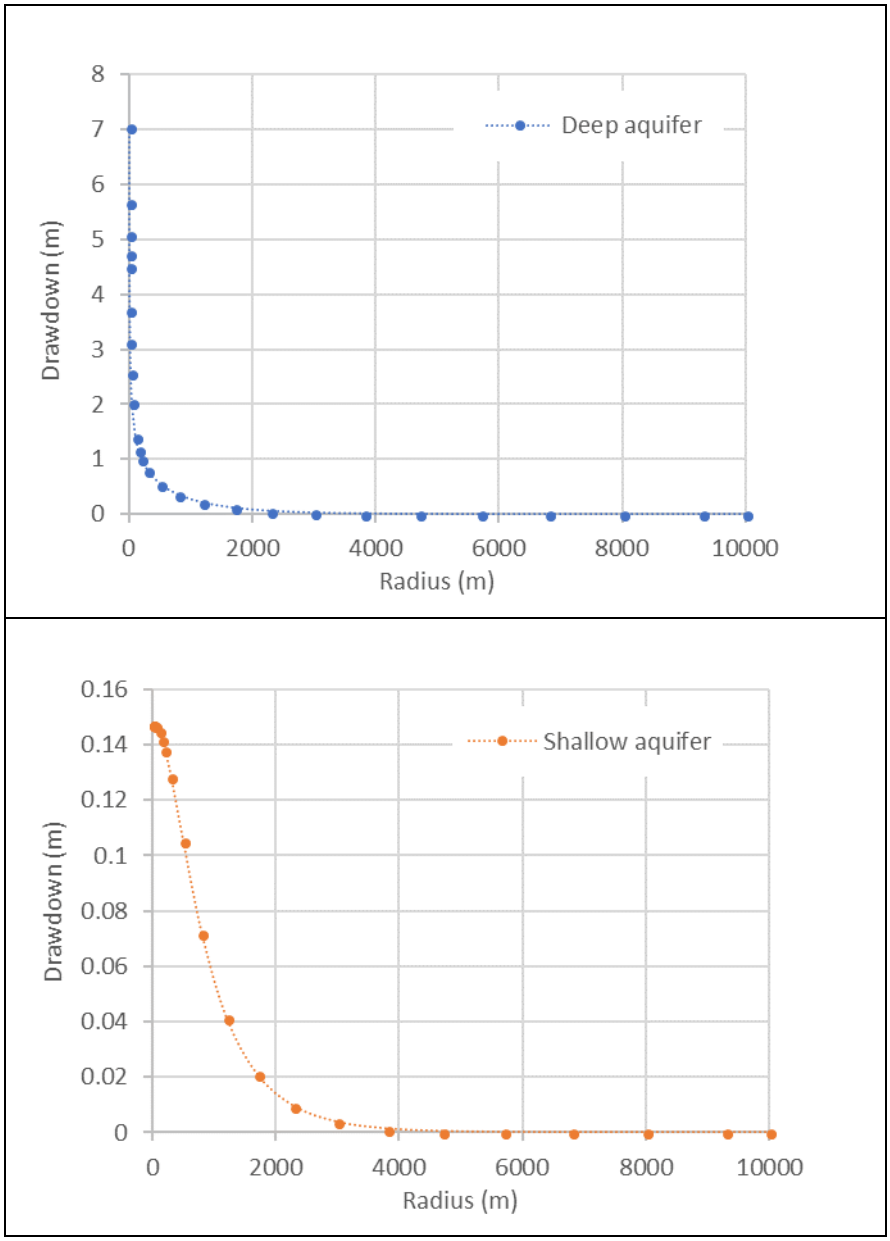

Figure B2. Estimated drawdown in deep aquifer and shallow aquifer (Feather & Williamson).

B.2 Cumulative Impact

The cumulative impact was assessed based on Wedding and Doody proposed take and other consents that are in different consenting and application stages in the region, and these are shown in **Table B3.**

Table B3. Irrigation takes included in the cumulative impact analysis.

Category	Irrigation takes	Daily rate (m^3/day)
Consented irrigation takes	Motutangi - Waiharara Water User Group Consents and other active consents	16,775*
Consent lodged	Tuscany irrigation take	375
	NE Evans Trust	1,675
	Te Raite Station	12,750
Consent in application	Anton Matthews	94
	Mate Yelavich Co Ltd	450
	Wedding and Doody	**2,375**
	Robert Campbell Family Trust	3,350

*This is retrieved from Scenario 2 MWGW (WWA,2017)

The cumulative impact was assessed by overlying the estimated drawdown from MWGW (WWA, 2017), NE Evans Trust (WWA, 2018a), Tuscany (WWA, 2018b), and simulated drawdown from the four consents in pending applications shown in **Table B3.** The drawdown profile from MWGW, Tuscany and Evans Trust together is referred as base drawdown below. The drawdown simulation selected are shown in **Table B4**, representing the conservative drawdown assessment with respect to shallow and deep aquifers.

Table B4. Selected drawdown simulation for cumulative impact assessment.

Aquifer	Base drawdown simulation	Additional drawdown
Deep aquifer - Feather & Williamson	MWGW Scenario 4c +Evan Scenario 4c +Tuscany Layer 6 Feather & Williamson drawdown	Feather & Williamson L6 drawdown
Shallow aquifer - Feather & Williamson	MWGW Scenario 2 + Evan Scenario 2+Tuscany Layer 1 Feather & Williamson drawdown	Feather & Williamson L1 drawdown

Based on the cumulative drawdown in deep aquifer shown in **Figure B3** and **Figure B4**, the drawdown was analysed at each neighbouring bore, shown in **Table B5**.

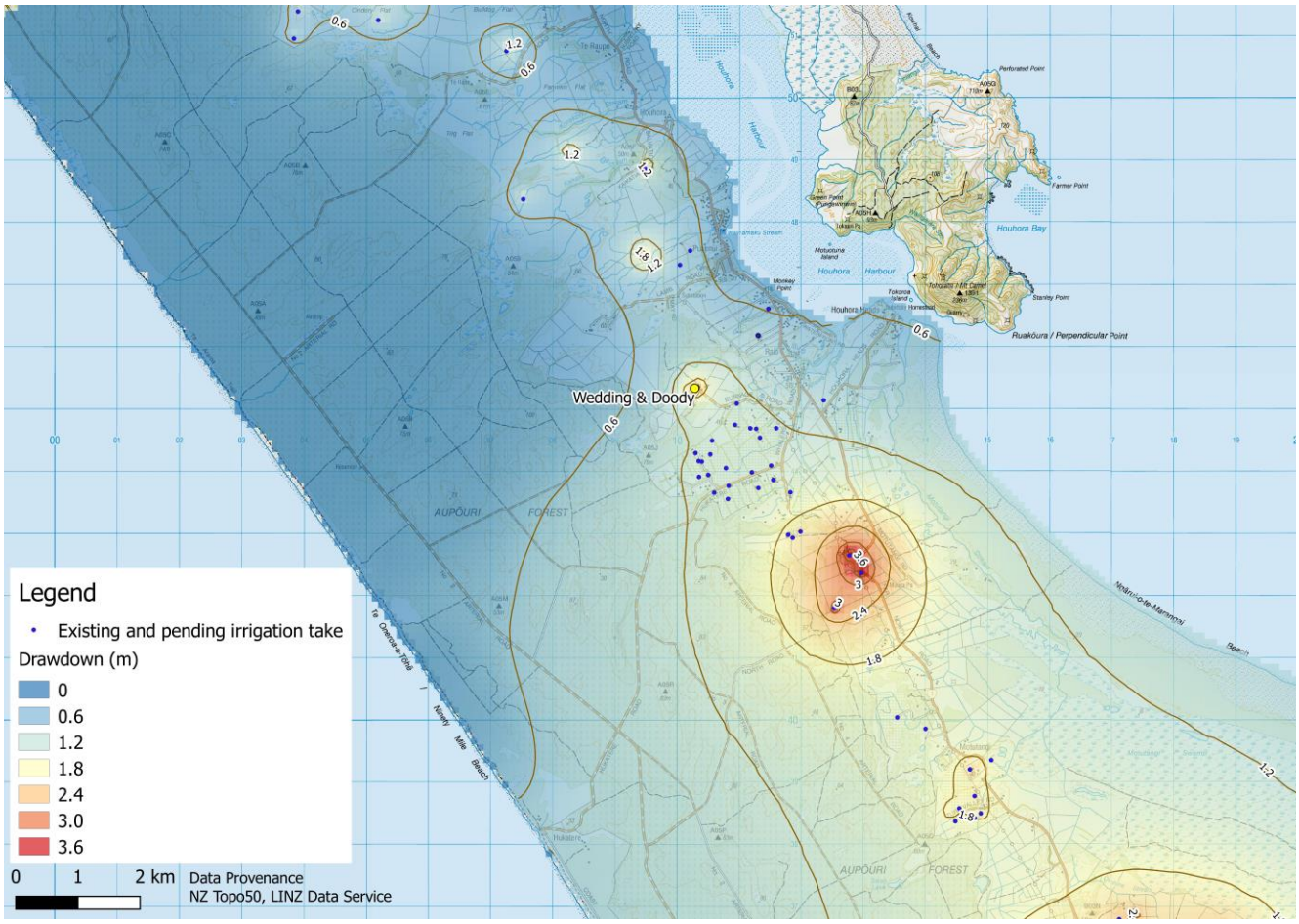

Figure B3. Cumulative drawdown of Deep aquifer – Feather & Williamson.

According to the Feather and Williamson solution, the proposed take will induce an additional drawdown of up to 0.4 m for bores that are within 2.5 km radius, as shown in **Table B5**. The greatest additional drawdown of 0.4 m was simulated at Longbeach Trust bore.

The cumulative drawdown in the shallow aquifer is shown in **Figure B5**. A maximum of cumulative drawdown of 0.3 m was simulated near Wedding and Woody bore.

Table B5. Drawdown estimated for existing groundwater take locations.

Neighbouring Bore	Distance from Wedding and Woody Bore (km)	Base drawdown	Cumulative drawdown	Additional drawdown
		MWGW Scenario 4c +Evans Trust Scenario 4c+Tuscany Layer 6 Feather & Williamson drawdown	Deep aquifer - Feather & Williamson	Feather & Williamson
Longbeach Trust	0.7	0.9	1.3	0.4
Tomo Orchard Ltd	0.9	1.0	1.3	0.3
B C Smith	0.9	1.0	1.3	0.3
E J Williams	1.0	1.0	1.3	0.2
Far North Avos Limited	1.1	1.1	1.3	0.2
The Alligator Pear Partnership	1.1	1.1	1.3	0.2
Honeytree Farms Ltd	1.2	1.1	1.3	0.2
Far North Avos Limited	1.2	1.1	1.3	0.2
McLarnon	1.2	1.1	1.3	0.2
Ongare Trust	1.3	1.2	1.3	0.2
Hine & Associates Ltd	1.4	1.2	1.3	0.1
S127 change to consent for groundwater take	1.4	1.1	1.3	0.1
Brien(Hukatere Rd)	1.4	1.2	1.3	0.1
Ongare Trust	1.5	1.1	1.2	0.1
Trebcombe Limited	1.6	1.2	1.3	0.1
Trebcombe Limited	1.7	1.2	1.3	0.1
Matalaka Trust	1.7	1.2	1.3	0.1
LL & DF Rasmussen	1.7	0.5	0.7	0.1
Whispering Pines Ltd	1.7	1.2	1.3	0.1
RB Freeman	1.9	1.2	1.3	0.1
RB Freeman	1.9	1.3	1.4	0.1
McQuarrie	1.9	1.3	1.4	0.1
Brien (Lamb Rd)	2.0	1.1	1.2	0.1
Wagener Houhora Heads Properties Limited	2.1	0.9	1.0	0.1
Thomas	2.2	1.5	1.5	0.1
EJ Wagener	2.3	1.5	1.5	0.1

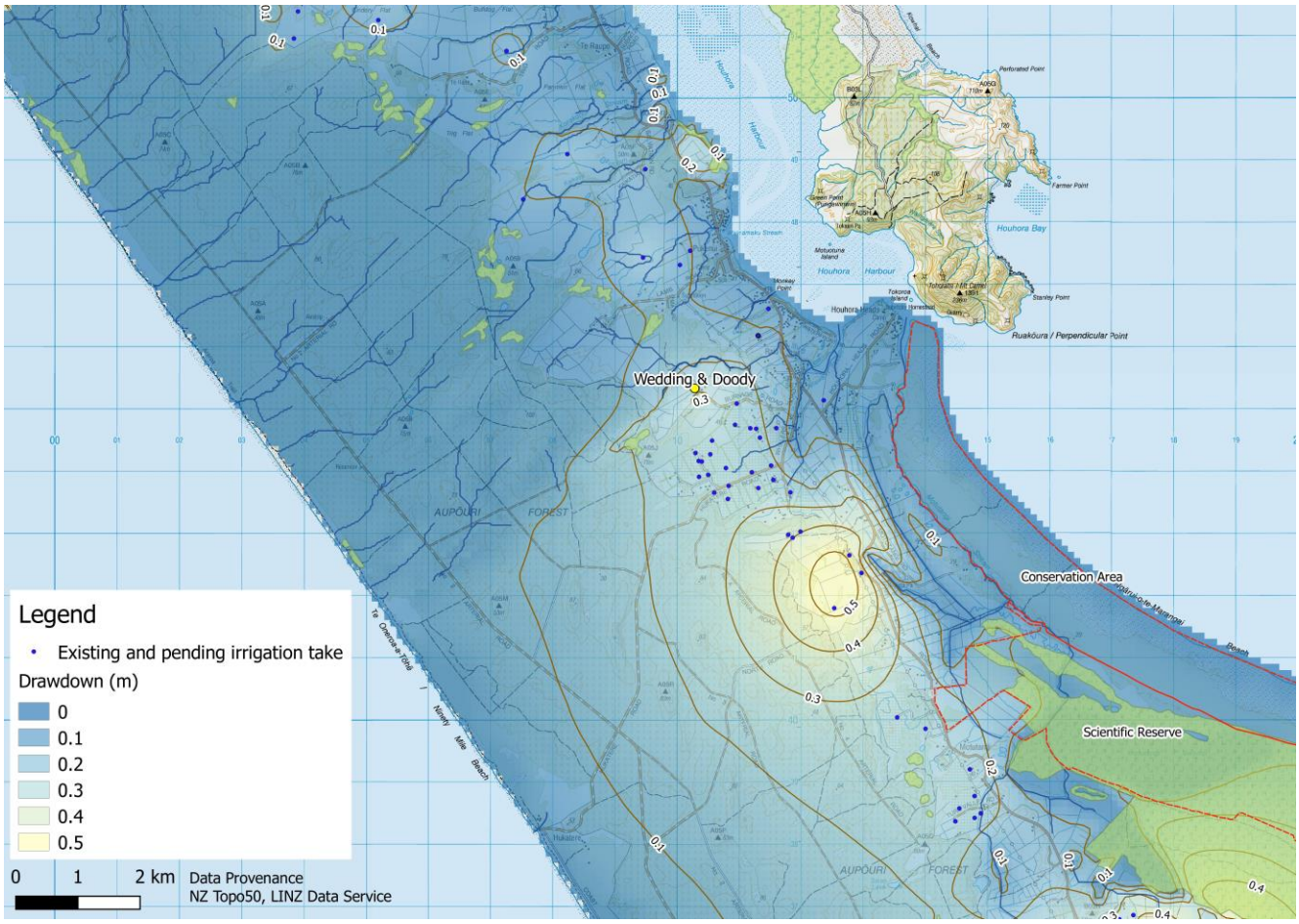

Figure B5. Cumulative drawdown in shallow aquifer - Feather and Williamson.

B.3 Surface Water Impact

The surface water features in the area adjacent to Wedding and Woody proposed bore are shown on **Figure B5** and include:

- Unnamed drain to north (0.3 km)
- Unnamed swamp to northwest (1.1 km)
- Unnamed swamp to southwest (0.9 km)

As shown in **Figure B5**, the maximum potential cumulative drawdown in the shallow aquifer is less than 0.3 m. The low permeable silty and clayey sediments impede the interaction between surface water and shallow groundwater. Drawdown in porous media would also translate to an even smaller impact within a standing or flowing water body.

Therefore, the proposed take for the deep aquifer is unlikely to pose significant impact on the surficial hydrological features.

B.3.1 Saltwater intrusion

Saltwater potential upconing and lateral migration were analysed in MWGW report (Section 5.2.6, WWA,2017) using Ghyben-Herzberg analytical solution. Due to the existence of low permeable bedrock underlying the deep shellbed aquifer, saltwater lateral migration along the base of the shellbed is a more likely mechanism of saltwater intrusion.

The proposed take is located in the central sand area. The nearest east coastline is approximate 1.9 km away from the proposed take. The simulated groundwater level at coastal sentinel location of 4 – 6 shown in Figure 42 and Figure 43 in MWGW report (Section 5.2.6, WWA, 2017) indicated an average pressure of 5 mAMSL, which is above the minimum pressure (1.9 mAMSL) to prevent the saltwater inland migration. NRC costal monitoring piezometer waterfront also had a water level ranging between 5 – 6 mAMSL from 1956 to 2016. The conservative Theis solution, shown in **Figure B4**, indicated a cumulative drawdown of less than 1.8 m at the costal location under the extremely dry condition. The proposed take is unlikely to change the potential saltwater lateral migration profile from that assessed in MWGW report (WWA,2017).

The potential impact on saltwater intrusion from proposed take is considered less than minor.

B.3.2 Ground Settlement

Groundwater settlement was calculated using the Bouwer (1977)[9] equation:

$$S_u = (P_{i2} - P_{i1})\frac{Z_1}{E}$$

where S_u = vertical subsidence (m)
$P_{i2} – P_{i1}$ = Increase in intergranular pressure due to drop of the water table
Z_1 = layer thickness
E = modulus of elasticity of the soil

The following characteristics were assumed for the aquifer:

- Porosity = 0.25
- Unsaturated water content = 0.08
- Specific weight of aquifer material (consolidated silty sand) = 20 kN/m^3 (Silty sand density ranges between 1,410 kg/m^3 and 2,275 kg/m^3[10], corresponding to specific weight of 14 kN/m^3 and 22 kN/m^3)
- Specific weight of water = 9.81 kN/m^3.

The deep shellbed material is denser and less compressible compared to the mixture of sand, silt and peat overlying above. The subsidence analysis was conducted using three separate layers representing the conceptual hydrogeological units of the sub-surface environment, and the parameter values used are shown in **Table B5**, which were selected from the elasticity values referenced in **Table B6**.

[9] Bouwer, H., 1977. Land Subsidence and Cracking Due to Ground-Water Depletion. Ground Water 15, 358–364. doi:10.1111/j.1745-6584.1977.tb03180.
[10] Density ranges for different soil types: http://structx.com/Soil_Properties_002.html

Table B5. Elasticity and depth of each zone for subsidence estimate.

Stratigraphy	Total depth	Modulus of elasticity (kPa)*
Silty sand (unsaturated zone)	5	10,000
Silty sand (saturated zone)	70	20,000
Shellbed (saturated zone)	20	50,000

* Modulus of elasticity (E) was sourced from Bouwer,1977

Table B6. Modulus of elasticity [E] for unconsolidated materials (Bouwer, 1977).

Material	E (kg/cm^2)	E (kPa)
Peat	1 – 5	98 – 490
Loose clay	10 – 50	981 – 4,903
Medium clay and silt	50 – 100	4,903 – 9,807
Dense clay and silt	100 – 1,000	9,807 – 98,067
Loose sand	100 – 200	9,808 – 19,613
Dense sand	500 – 2,000	49,033 – 196,133
Dense gravel and sand	2,000 – 10,000	196,133 – 980,665

The cumulative drawdown profile is an overlap of cone of depressions from proposed take and adjacent MWWUG takes. The drawdown magnitude around the proposed take will not attenuate as a circular pattern. Therefore, maximum cumulative drawdown was extracted within a 1.5 km radius of the proposed take, and the estimated maximum subsidence was calculated based on the cumulative drawdown profile described in **Section B2**, as shown in **Table B7**.

Table B7. Calculated subsidence (m) within 1.5 km of the pumping bore.

Scenario	Shallow aquifer - Feather and Williamson	Deep aquifer – Feather and Williamson
Drawdown (m)	0.31	2.58
Unit 1. Sand (unsatured)	7.8×10^{-5}	
Unit 2. Sand (saturated)	8.8×10^{-3}	
Unit 3. Shellbed (saturated)		8.4×10^{-3}
Maximum Cumulative	0.02	

Within 1.5 km of proposed take, the estimated cumulative subsidence is 0.02 m, with a maximum drawdown of 0.31 m and 2.58 m in shallow and deep aquifer, respectively. In a rural setting, settlement effects of this magnitude (or less as would be more realistic) are less than minor for the following reasons:

- There is no sensitive urban infrastructure like water or wastewater mains or high-rise buildings to rupture or crack; and

- The changes in land surface due to farm machinery (e.g. rotary hoeing) would likely mask impacts of this magnitude (<0.3 m) if materialised.

In summary, the potential settlement effects are considered less than minor.