# A WAI-INU BLUEPRINT

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## ABSTRACT

**Background** Selwyn District sits in the heart of the Canterbury Plains, with a deep understanding of its ki uta ki tai “mountains to sea” Arthurs Pass to Te Waihora guardianship responsibilities. Bounded by the alpine sourced Waimakariri and Rakaia Rivers, wai sustains Councils 27 rural and urban water supplies, providing over 77% of the population with over $8.8x10^6$ $m^3$ of potable water per annum. With 8 stream/river and 45 ground water sources, asset management practice supported by targeted capacity and renewals modelling is essential.

Research has shown Selwyn’s drinking water source reliability and quality is steadily declining (nitrate levels in 11 wells is >=3 mg/L), while demand is increasing through annual 4% population increases – particularly in Lincoln and Rolleston. Previous assessments have established that $322M is required for nitrate removal (OPEX $25.6M per annum) and $10M for fluoridation (OPEX $1M per annum). These challenges require a different approach – one that was consistent, auditable, and repeatable. A fit for future framework to capture and assess these and emerging factors is needed.

## KEYWORDS

**Complexity, Consolidation, Drinking Water, One Water, Rūnanga, Scale, Wai-Inu**

## PRESENTER PROFILE

Murray England is Selwyn District Councils Water Asset Manager. He is passionate about integrating through co-design, Rūnanga wai | water values into the way Selwyn provides community water services.

Hugh Blake-Manson is an Infrastructure Advisor with Waugh Infrastructure Management based in Canterbury. A Chartered Professional Engineer with previous and current roles on the Board of Water New Zealand and IPWEA(NZ) and 30 years involvement in the water sector.

## DISCLAIMER

We wish to note that throughout this paper, we have applied an informed interpretation of Māori values, however, we do not assume cultural knowledge, nor speak for mana whenua. We acknowledge that, as this is not grounded within Te Ao Māori and tikanga, there will be limitations to our understanding, but consider it demonstrates a willingness to continue to learn, and find synergy with values, knowledge and approaches between both cultures. Through co-design with mana whenua, the One-Water Strategy will bring clarity as it is developed, with an authentic mapping of both values and knowledges, within a bi-cultural space.

# 1 INTRODUCTION

## 1.1 TE HURIHANGA WAI | THE WATER CYCLE, TE MANA O TE WAI | RESPECT FOR WATER

Water, or wai, particularly safe drinking water is a cornerstone for healthy and sustainable communities in New Zealand. Both Māori and European colonists understood this and have respectively applied their mātauranga Māori and western science based approaches to ensuring and improving water quality over time. There are many examples of significant failures, particularly in recent New Zealand history [1], with each presenting an opportunity to make positive changes.

Te Hurihanga Wai "One Water" cycle is understood in both Māori and European cultures [2, 3]. The fundamental need for safe drinking water and a duty of care is also understood by our cultures [4]. In 2017, six fundamental principles of safe drinking water were articulated [5] and began integrate these principles into drinking water suppliers risk management plans. In 2020, Government published a three-tiered hierarchy for water embodied in the Te Mana o te Wai framework [6] and encoded this into legislation [7]. It too, has six Principles informed, in part from a Te Ao Māori view. A One Water Strategy is the vehicle which supports and enables water management aligned with these principles, bicultural values and community wellbeing. This paper describes the developed of a Wai-Inu Blueprint, a key reference document supporting the co-design One Water Strategy process.

## 1.2 FIVE WATERS STRATEGY TO A ONE WATER STRATEGY

In 2009, Selwyn District Council (the Council) published its 5Waters Strategy [8]. Recognising the role and responsibilities Council had, and on the back of adoption in 2008 of their Seven Principles of Sustainbility, Council identified where intergenerational effort should be focussed to meet the environmental, social and cultural needs of the community.

The 5Waters Strategy reflected the scientific and cultural understandings of the time. Over the following decade, global and New Zealand centric change in the cultural, social and environmental landscape has occurred. Council is now, appropriately, revisiting this strategy through a co-design process with local rūnanga. A Wai-Inu | Drinking Water Blueprint is one of the key Council documents informing this process (Figure 1). Ngāi Tahu, Council and Regional Council documents, and the relationship between these will also inform the One Water Strategy.

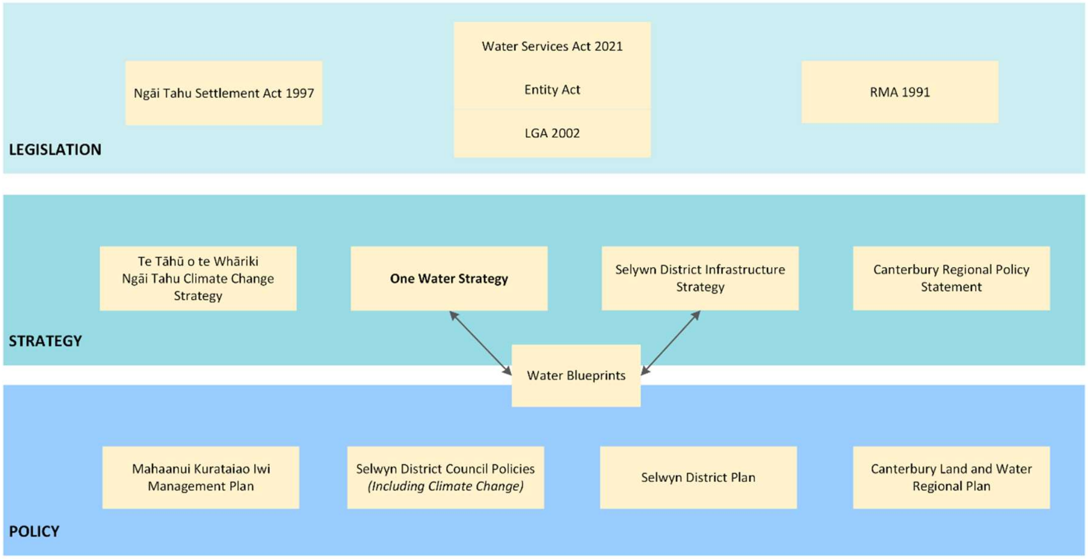


*Figure 1: Hierarchical Relationship – Ngāi Tahu, Council and Regional Council Documents*

## 1.3 THE WAI MĀORI | FRESHWATER OF SELWYN DISTRICT

Selwyn District is located in Te Wai Pounamu | South Island, on the east coast of New Zealand. It has many similarities with rural and urban South Island east coast communities, and can be considered a touchstone on emerging issues and how they could be addressed. Council's jurisdiction extends over 6,550 square kilometres ($km^2$) of land with diverse geographical and geological areas. Council has three significant rivers, the Rakaia, Waimakariri on its flanks and the Selwyn through its centre. The rohe of Te Rūnanga o Taumutu incorporates Selwyn District, whileTe Rūnanga o Ngāi Tūāhuriri have a very strong relationship to the area and historic catchment and flow of the Waimakariri.

Council manages 27 water supplies with a current footprint of 807 $km^2$ (Figure 2) or 12.3% of the total land area. This is significant considering 20% of the District is Crown alpine estate. Council provides drinking and stock water to 77% of the population (Table 1).

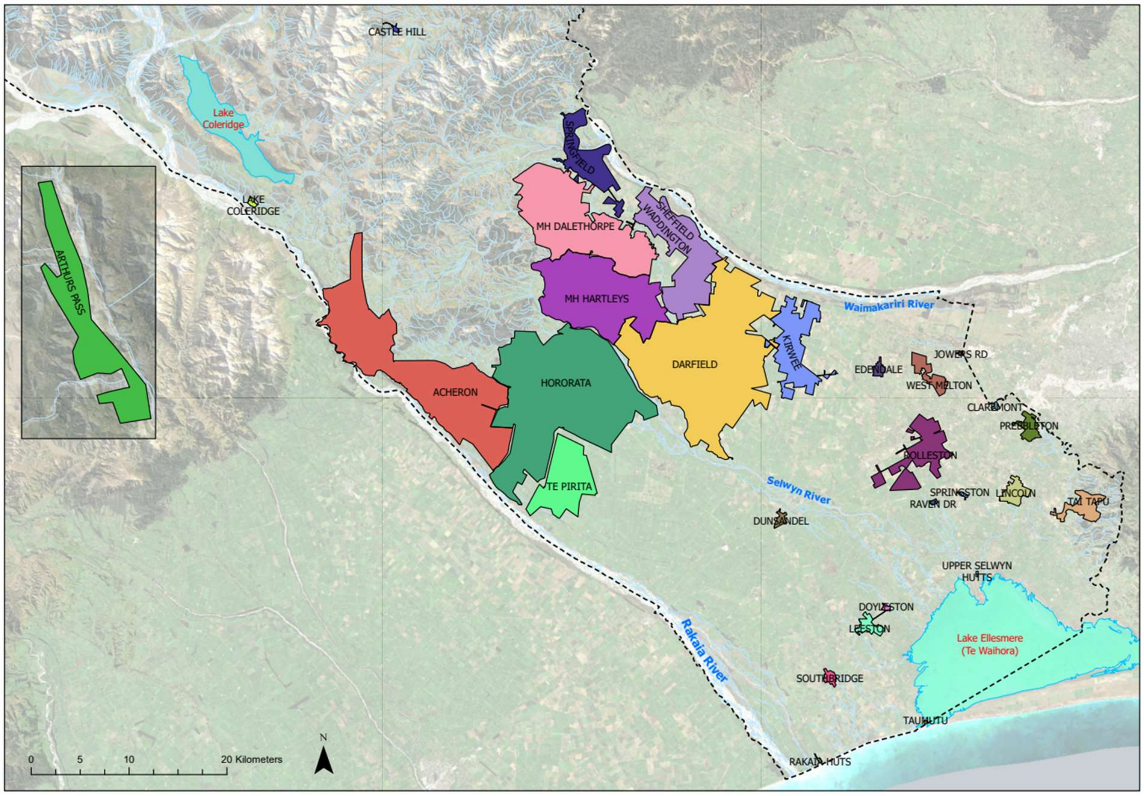


*Figure 2: Location of Council Drinking Water Supplies*

Interspersed between Councils supplies are 3,695 other drinking water sources [9] amongst intensive agricultural land use areas. Te Waihora | Lake Ellesmere is located at the lowest geographic part of the district . This is considered a “food basket” particularly for Rūnanga, but suffers from degraded water quality, impacting on cultural connections.

| **Financial & Economic** | **Quality / Quantity** |
|---|---|
| \$387 per 200 m$^3$ | 45 wells/bores, 8 river/surface takes |
| Replacement Value \$440M (2021) | Treatment (filtration, UV, chlorination) |
| \$31.95M maintenance/upgrades (5 years) | 8.8 Mm$^3$ water supplied annually |
| 27 supplies, 807 sq. km. coverage | Rohe of Te Taumutu Rūnanga |
| 1,356 km pipes, 19,874 connections | Te Waihora \| Lake Ellesmere at base |
| Average mainline pipe age of 17 years | Population 71,500 with 4% annual growth in |
| 99.3% water meter coverage (mechanical) | Lincoln, Rolleston, Darfield & Prebbleton |
| **Assets & Infrastructure** | **Cultural / Social** |

*Table 1: Key Drinking Water Supply Attributes*

### 1.4 WATER TREATMENT

Council has ultraviolet light treatment for all sources (27), cartridge filtration (10 sources), chlorination (nine online, 12 on-demand). It is in the process of seeking a chlorine exemption under s58 of the Water Services Act (the Act) [7]. No allowance has been made in any treatment infrastructure including buildings for possible cyanobacteria and/or nitrate removal, associate waste product disposal, and/or fluoride dosing.

## 2 WAI-INU | DRINKING WATER BLUEPRINT METHODOLOGY

The Wai-Inu | Drinking Water Blueprint was developed within a five step assessment process. These steps are i) Understanding the Principles, ii) Developing a Framework, iii) analysing the data, iv) Data visualisation and v) Applying the knowledge. The process focussed on recognising iwi concerns, identifying and obtaining insight into current and emerging risks to provision of safe drinking water. A precautionary or conservative approach was taken to identiyfing and assessing risks proportional to the supplies scale and complexity as specified in Acts Purpose [7].

The assessment of Councils drinking water supplies covered four areas – quality, quantity, resilience and finance + energy.

### 2.1 STEP ONE – UNDERSTANDING THE PRINCIPLES

#### 2.1.1 THE INTERSECTION OF SIX PRINCIPLES AND THE IWI MANAGEMENT PLAN

It is at the intersection (Figure 3) of the six principles and regional & locally defined values such Iwi and Asset Management Plans where respect for water and a duty of care must be applied and addressed.

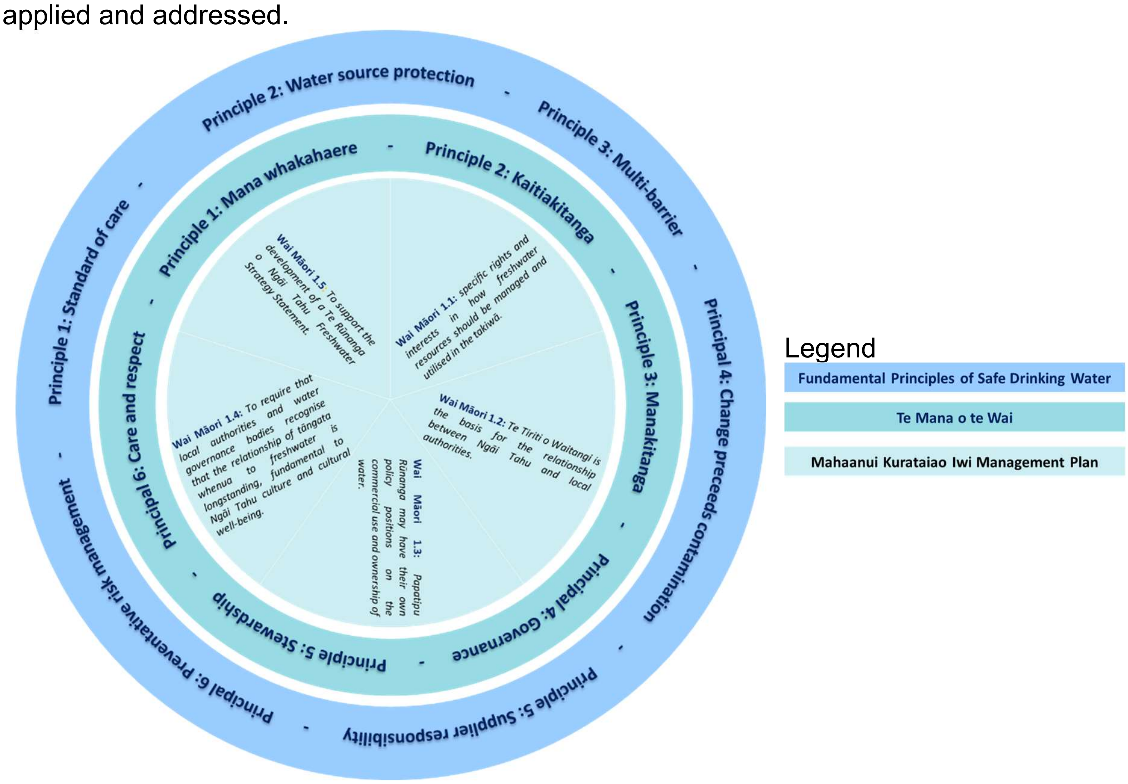


*Figure 3: Intersection of Six Principles and the Ngāi Tahu Iwi Management Plan*

Iwi have expressed concern with the pan-national application of the principles: "*Te Mana o te Wai is now so prescriptive … this has become a pakeha tool"* [10]. Our preliminary view is that within the rohe intersection between principles and knowledge systems occurs at many points (Figure 4). A clearer understanding will be developed through the co-design One Water Strategy process.

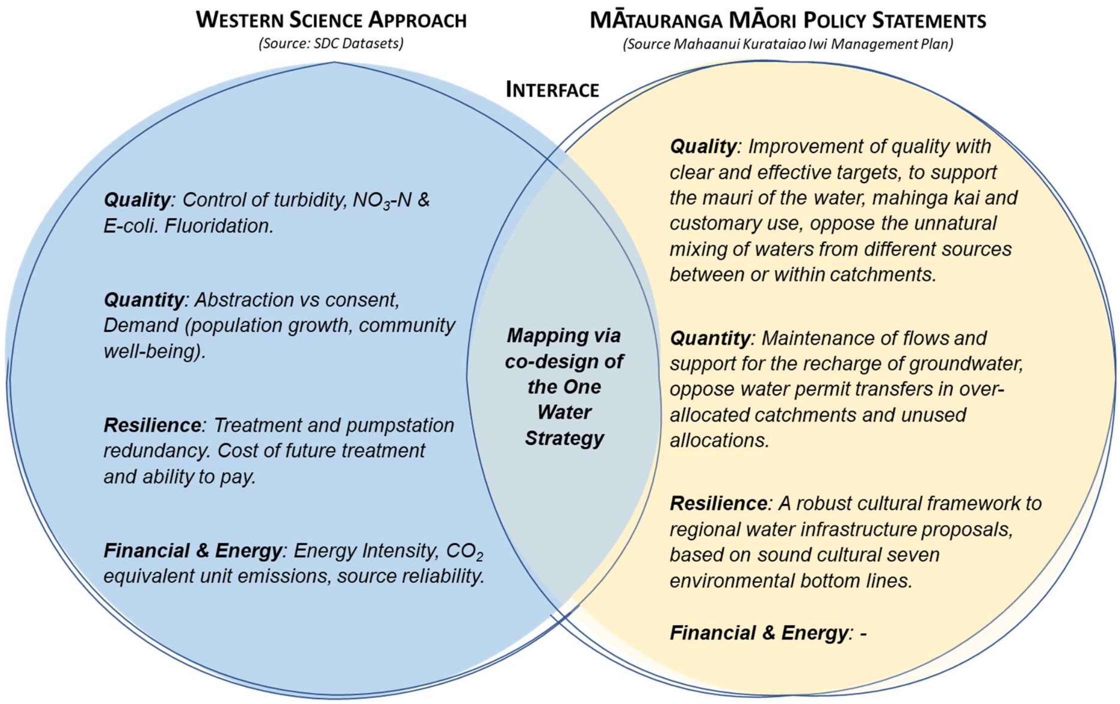


*Figure 4: Knowledge Systems Interface – Western Science and Mātauranga Māori*

### 2.1.2 NATIONAL AND REGIONAL CHALLENGES

Council faces many water related challenges. The key national challenges identified were i) meeting the assurance requirements described by the water services regulator (Taumata Arowai) and ii) preparing for transition to water service entity management. The key regional and local challenges are i) applying a duty of care approach to managing risks, ii) building a stronger authentic relationship with Rūnanga to collectively respond to water management challenges and iii) ensuring robust, low carbon emission infrastructure (capital and operational) is provided to enable resilient communities.

### 2.1.3 MULTI-CRITERIA ASSESSMENT FRAMEWORK

A multi criteria analysis (MCA) is framework populated with data relevant to the challenges identified. Appropriate selection of data and its analysis allows for identification of trends and patterns. Suitable actions can then be proposed including further more detailed analysis e.g. sensitivity modelling and actions e.g. collaboration, more effective operation of a system. A framework (Table 2) was designed with Council based on four specific water service groups: quality, quantity, resilience and finance + energy. Across these groups, 16 indicators were selected, which were collectively considered representative of Councils supplies (scale and complexity). Where possible these indicators aligned with national assessment information [11]. Four risk and response levels were established and applied to each element, which broadly described the current risk exposure and priority.

| | **Group \|** Indicator | | | |
|---|---|---|---|---|
| **Risk Level & Response** | **Quality** *E-coli events per year* [12] | **Quantity** *Volume Abstracted / consent* | **Resilience** *Infrastructure Leakage Index* [13] | **Financial & Energy** *Energy Intensity GJ/m3* [11] |
| Aware - Watch | <1 | 0-0.49 | 0-0.9 | 0-0.0002 |
| Investigate - Plan | 1-2 | 0.5-0.69 | 1-3.9 | 0.00021-0.001 |
| Programme - Respond | 3-5 | 0.7-0.89 | 4-7.9 | 0.0011-0.003 |
| Act - Deliver | >5 | >=0.9 | >=8 | >0.0031 |

*Table 2: Framework With Selected Indicators*

## 2.2 STEP TWO – DEVELOPING THE FRAMEWORK

### 2.2.1 INDICATORS

The indicators utilised (Table 3) include existing and estimated values – particularly population growth, per site NO3-N and fluoridation costs.

| **Group** | Indicators (units, year) | | | | |
|---|---|---|---|---|---|
| **Quality** | Source Nitrate-nitrogen (NO3-N) mg/L,*2008+* | Source *E-coli* MPN/100 mL *2019+* | Zone *E-coli* (MPN/100 mL) *2019+* | Source cyanobacteria *presence* | Source Turbidity (NTU) |
| **Quantity** | Use Ratio, Actual/ consent *2020/21* | Infrastructure Leakage Index (ILI) *2022* [14] | | | |
| **Resilience** | Connection Density (pers/km pipe) *2021* | Population Growth, % *2022+* | Source Climate Exposure (% drawdown) *2022* | Source+ Treatment Redundancy *(No.)* | |
| **Financial & Energy** | Energy Intensity, GJ/m3 *2021/22* | NO3-N Treatment, $(estimate) | Fluoridation $(estimate) | Operations Cost Ratio Actual/ reactive *2021/22* | Operations Cost (supply) $/property *2021/22* |

*Table 3: Indicators by Group*

### 2.2.2 DATA COLLECTION AND COLLATION

Council provided datasets, both commercially sensitive and publicly available. Information sources included: SCADA historian, 3 waters maintenance contract, drinking water quality records and national performance review information. Data covered the 2021-2022 Council financial year where relevant. Where trending was necessary e.g. nitrate-nitrogen (NO3-N), *E-coli* the entire dataset was obtained.

There are strong geographic separations for some supplies, particularly in the alpine, sub-alpine areas and Te Waihora | Lake Ellesmere areas. The five geographic areas (Alpine, Foothills, Upper Plains, Central and Te Waihora) originally established covering all 27 supplies were renamed with supplies redistributed (Table 4). This was done following a review with Council staff who identified common risks associated with geological and geographic factors.

| **Water Supply Group** | **Associated Supplies** | ***Note*** |
|---|---|---|
| Alpine | Arthurs Pass, Castle Hill, Lake Coleridge, Acheron | *Standalone supplies* |
| Foothills | Sheffield-Waddington, Springfield, Dalethorpe | Consolidation concept developed |
| Malvern | Hartleys, Hororata, Te Pirita, Darfield, Kirwee | |
| Greater Christchurch | Jowers Road, Claremont, Lincoln, West Melton (incl Edendale), Raven Drive, Rolleston, Springston, Tai Tapu, Prebbleton | |
| Greater Christchurch + | Leeston (incl Doyleston), Southbridge, Dunsandel, Upper Selwyn Huts | |
| Te Waihora | Rakaia Huts, Taumutu | *Standalone supplies* |

*Table 4: Final Groups and Associated Supplies*

## 2.3 STEP THREE – ANALYSING THE DATA

### 2.3.1 DATA ANALYSIS

Information provided in the Wai Blueprint needs to be robust with a high level of confidence and reliability. The datasets for each of the 16 indicators required assessment, removal of eroneous values and standardisation. This included use of macro / script based routines to look across large datasets (>100,000 records) and manual review. Due to the commerical sensitivity some data was derived as a ratio e.g. actual reactive maintenance cost to planned budget (Figure 5).

Risk levels for each indicator were established against national criteria where possible, including the Drinking Water Standards 2022, Council policy and Water New Zealand National Performance information .

| Risk Level & Response | | | | | | |
|---|---|---|---|---|---|---|
| Aware - Watch | <1 mg/L | 0-0.49 | 0-0.9 | >90 | 0-0.0002 | >=0.25 |
| Investigate - Plan | 1-3 mg/L | 0.5-0.69 | 1 - 3.9 | 60-89 | 0.0002-0.001 | 0.26-0.5 |
| Programme - Respond | 3-5.65 mg/L | 0.7-0.89 | 4 - 7.9 | 30-59 | 0.0011-.003 | 0.51-1.0 |
| **Act - Deliver** | **>=5.66 mg/L** | **>=0.9** | **>=8** | **0-29** | **>=0.0031** | **>0.75** |
| Drinking Water Supply | Quality<br>Source nitrate-nitrogen (NO3-N) | Quantity<br>Ratio (m3 actual\|consented) | Infrastructure Leakage Index (CARL/UARL) | Resilience<br>Connection Density (persons/km main) | Financial & Energy<br>Energy Intensity GJ/m3 | Ratio (reactive/planned) |
| Dunsandel | **6.4** | 0.41 | 2.2 | 64 | 0.0022 | 0.20 |
| Edendale | **6.1** | 0.62 | 3.6 | 54 | **0.0032** | 0.09 |
| Jowers Rd | 2.4 | 0.20 | **9** | 131 | 0.0028 | 0.16 |
| Claremont | 1.21 | 0.39 | 1.3 | 93 | 0.0023 | 0.04 |
| Lincoln | 1.78 | 0.33 | 1.2 | 118 | 0.0009 | 0.24 |
| West Melton + (Johnson Rd) | 1.95 | **0.90** | 3.6 | 76 | 0.0021 | 0.24 |
| Raven Drive | 1.34 | 0.10 | 0.4 | 63 | **0.0045** | 0.05 |
| Rolleston | **7** | 0.19 | 1.2 | 112 | 0.0013 | **5.23** |
| Springston | 1.85 | 0.59 | 3.5 | 203 | 0.0020 | 0.12 |
| Tai Tapu-Otahuna | 0.29 | 0.58 | 0.8 | 42 | 0.0025 | 0.26 |

*Figure 5: Multi-criteria Analysis by Risk Levels (Sample)*

### 2.3.2 SCALE AND COMPLEXITY

The Acts Purpose includes identification and management of risks to provision of safe drinking water in proportion to the supplies scale and complexity. Indicators included to reflect this including treatment redundancy and connection density (persons/km pipe).

## 2.4 STEP FOUR – DATA VISUALISATION

The data was presented for analysis using commonly available software – Excel in particular to ensure access was available to staff.

## 2.5 STEP FIVE – APPLYING THE KNOWLEDGE

The co-design One Water Strategy process (underway) will provide essential informattion to allow for further necessary evolution of this Blueprint.

# 3 RESULTS OVERVIEW, ANALYSIS AND DISCUSSION

## 3.1 RESULTS OVERVIEW

### 3.1.1 EUROPEAN AND MĀTAURANGA MAORI SYSTEMS

An iwi-Council One-Water strategy co-design process is underway. Recognising this, mapping the European scientific approach to holistic Mātauranga Māori knowledge was taken as far as possible without appropriating Te Mana o Te Wai values. The data collated here will be used in future dialogue.

### 3.1.2 RESULTS ANALYSIS

Analysis is provided for all supplies combined and the Greater Christchurch + group.

### 3.2 WATER SUPPLY GROUP DISCUSSION

The distribution of indicators values reflects supplies and their sources diverse geological and geographic areas along with construction and operations practices.

### 3.2.1 ALL SUPPLIES

Within this group are 29 townships, with two supplied by another township (Edendale and Doyleston). Some supplies did not have all information available. In particular turbidity information was not available for six supplies. This was not considered significant as these were all deep ground water source.

Where there were multiple wells or sources for a supply, the highest value for that indicator was taken e.g. NO3-N, 95$^{th}$ percentile – 6.7 mg/L is taken from one well. Given the diverse geographic spread and location of supplies, a wide range of values were recorded (Table 5).

| **Group** | **All Water Supply Group Indicators** | 5th percentile | 50th percentile | 95th percentile |
|---|---|---|---|---|
| **Quality** | Source nitrate-nitrogen (NO3-N) mg/L | 0.1 | 1.2 | 6.7 |
| | Source E - coli (2019+) | 0.0% | 1.0% | 87.0% |
| | Zone E - coli (2019+) | 0.0% | 1.0% | 14.5% |
| | Source Turbidity (2021/22) | 19.3% | 98.3% | 100.0% |
| **Quantity** | Ratio (m3 actual/consented) | 0.05 | 0.43 | 1.08 |
| | Infrastructure Leakage Index (CARL / UARL) | 0.45 | 1.7 | 9.75 |
| **Resilience** | Connection Density (persons/km main) | 3.1 | 70.2 | 230.6 |
| | Growth | 0.50% | 0.50% | 3.50% |
| **Finance & Energy** | Energy Intensity GJ/m3 | 0.0001 | 0.0023 | 0.0082 |
| | Ion NO3-N Treatment $(Capex) | $- | $6,310,000 | $41,535,000 |
| | Fluoridation Treatment $(Capex) | $128,250 | $285,000 | $5,073,000 |
| | Ratio (reactive/planned) work | 0.02 | 0.26 | 6.64 |
| | Opex ($/connection) | 121.6 | 632.1 | 7875.9 |

*Table 5: All Supplies – Percentile Analysis Across 13 Indicators*

Mapping the number of incidences at risk level enables Council to consider, as a high level where it should focus its effort. Supplies which fall into the “Programme-Respond” and “Act-Deliver” levels require more focus. In this case – 21% the data points or range fall in the “Act-Deliver” response level Table 6. Should these levels occur multiple times in one supply, then a duty of care and precautionary approach should be applied. More detail analysis would follow – refer s 3.2.5.

| | | Risk Level and Response | | | |
|---|---|---|---|---|---|
| **Group** | **All Water Supply Group Indicators** | Aware-Watch | Investigate-Plan | Programme-Respond | **Act-Deliver** |
| **Quality** | Source nitrate-nitrogen (NO3-N) mg/L | 12 | 2 | 11 | **4** |
| | Source E - coli (2019+) | 11 | 7 | 1 | **9** |
| | Zone E - coli (2019+) | 9 | 18 | - | **1** |
| | Source Turbidity (2021/22) | 15 | - | - | **6** |
| **Quantity** | Ratio (m3 actual/consented) | 17 | 5 | 3 | **4** |
| | Infrastructure Leakage Index (CARL / UARL) | 9 | 14 | 2 | **4** |
| **Resilience** | Connection Density (persons/km main) | 12 | 6 | 4 | **7** |
| | Growth | 17 | 5 | 3 | **4** |
| **Finance & Energy** | Energy Intensity GJ/m3 | 4 | 16 | 1 | **8** |
| | Ion NO3-N Treatment (CAPEX) | | 4 | 10 | **14** |
| | Fluoridation Treatment (Capex) | 16 | 5 | 4 | **3** |
| | Ratio (reactive/planned) work | 13 | 3 | 6 | **5** |
| | Opex ($/connection) | 6 | 4 | 13 | **4** |
| | | 141 (39%) | 46 (15%) | 75 (25%) | 64 (21%) |

*Table 6: All Supplies – Risk Level and Response Analysis Across 13 Indicators*

### 3.2.2 ALPINE GROUP SUPPLIES

Arthurs Pass, Castle Hill, Lake Coleridge and Acheron have similar water quality, reliability, geological and geographic characteristics. Energy intensity was very low as these supplies operate under gravity. Both routine and intensive flood events affect these supplies. In May 2021 a flood event caused significant and exceptional damage to the Acheron intake and bulk conveyance system. Climate related events are anticipated to increase the frequency and intensity of source water turbidity due to (landslips, erosion and more frequent flooding) and damage to critical intake and treatment infrastructure. This flood event also damaged the Hartleys treatment plant – refer below.

### 3.2.3 FOOTHILLS GROUP SUPPLIES

Rural water supplies including Dalethorpe, Springfield and Sheffield are subject to instream seasonal flow and quality changes. Streambed cyanobacteria coverage and seasonal duration are becoming more common with no current treatment process in place e.g. no activated carbon system to manage this should it migrate through the treatment infrastructure into the distribution zone. There are high leakage rates and a targeted programme to reduce leakage. At the same time abstraction has exceeded the consented take and consent renewal will be needed within five years for Dalethorpe, (Hartleys and Hororata - Malvern Group) unless and potentially even if leakage is reduced. The energy intensity in these schemes is high given the need to pump water up and across hill country.

### 3.2.4 MALVERN GROUP SUPPLIES

Extending north-south across the district, these supplies have deep groundwater (Darfield, Kirwee, Te Pirita) and surface water sources (Hartleys and Hororata). Hartleys, which has a treatment plant in the Selwyn River has been subject to inundation due to exceptional flood events in the past two years.

Of note are the historic high levels of groundwater NO3-N in Darfield and Kirwee sources. While within the New Zealand Drinking Water Standards maximum acceptable value (MAV), at NO3-N levels of 5 mg/L it is incumbent, on Council given their duty of care responsibilities to consider mitigation options including at source treatment and/or alternative sources. Both Darfield and Kirwee, which were reliant on onsite wastewater treatment systems, now have access to a reticulated wastewater network.

Accelerated growth is expected in these townships which will increase demand and facilitate investigation of additional drinking water treatment barriers. This is premised on larger communities having a wider demographic profile and greater need for higher quality, safe drinking water. For example fluoridation could benefit cohorts within supplies that expanding or high deprivation rates [15].

### 3.2.5 GREATER CHRISTCHURCH AND "+" GROUP SUPPLIES

The Greater Christchurch + group of 15 supplies are located in the plains area of Selwyn District. Leakage ratios vary significantly, and connection density is very high given the urban communities (Table 7). Reactive to budgeted operations work is generally low, though the 95$^{th}$ percentile range indicated that unplanned, reactive work is equal to 50% of the programmed budget. NO3-N levels in some supplies have been progressively increasing, with the higher levels recorded in Rollestons sources. These sources are combined and pumped from a post treatment reservoir to consumers.

| Group | Greater Christchurch + | 5$^{th}$ percentile | 50$^{th}$ percentile | 95$^{th}$ percentile |
|---|---|---|---|---|
| **Quality** | Source nitrate-nitrogen (NO3-N) mg/L | 0.4 | 1.2 | 5.7 |
| | Source E – coli (2019+) | 0.2% | 1.0% | 2.7% |
| | Zone E – coli (2019+) | 0.0% | 3.0% | 8.6% |
| | Source Turbidity (2021/22) | 0.0% | 0.0% | 99.0% |
| **Quantity** | Ratio (m3 actual/consented) | 0.07 | 0.41 | 0.48 |
| | Infrastructure Leakage Index (CARL/UARL) | 1.16 | 2.3 | 8.42 |
| **Resilience** | Connection Density (persons/km main) | 62.0 | 140.6 | 177.7 |
| | Growth | 0.50% | 1.50% | 2.30% |
| **Finance & Energy** | Energy Intensity GJ/m3 | 0.0016 | 0.0020 | 0.0026 |
| | Ion NO3-N Treatment $(Capex) | $- | $6,310,000 | $11,358,000 |
| | Fluoridation Treatment $(Capex) | $57,000 | $285,000 | $1,482,000 |
| | Ratio (reactive/planned) work | 0.13 | 0.20 | 0.48 |
| | Opex ($/connection) | 245.4 | 412.8 | 746.1 |

*Table 7: Greater Christchurch + Percentile Analysis Across 13 Indicators*

Of the 15 supplies, 11% of indicator values fall in the highest risk level (Table 8). Population growth is both a significant benefit and challenge for Council. It requires robust, rapid infrastructure planning. At the current growth rate, and geographic direction the urban boundaries of Rolleston and Lincoln may be within five kilometres of each other within 10 years.

| | **Greater Christchurch + Indicators** | **Risk Level and Response** | | | |
|---|---|---|---|---|---|
| **Group** | | Aware-Watch | Investigate - Plan | Programme-Respond | **Act-Deliver** |
| **Quality** | Source nitrate-nitrogen (NO3-N) mg/L | 3 | 9 | - | **3** |
| | Source E - coli (2019+) | 6 | 7 | 1 | **-** |
| | Zone E - coli (2019+) | 4 | 9 | - | **1** |
| | Source Turbidity (2021/22) | 8 | - | - | **2** |
| **Quantity** | Ratio (m3 actual/consented) | 11 | 3 | - | **1** |
| | Infrastructure Leakage Index (CARL/UARL) | 3 | 10 | - | **2** |
| **Resilience** | Connection Density (persons/km main) | 9 | 4 | 2 | **-** |
| | Growth | 6 | 4 | 1 | **4** |
| **Finance & Energy** | Energy Intensity GJ/m3 | 1 | - | 12 | **2** |
| | Ion NO3-N Treatment (CAPEX) | - | 7 | 2 | **1** |
| | Fluoridation Treatment (Capex) | 8 | 2 | 2 | **1** |
| | Ratio (reactive/planned) | 10 | 3 | 1 | **1** |
| | Opex ($/connection) | 4 | 7 | 2 | **2** |
| | | 73 (40%) | 65 (36%) | 23 (13%) | 20 (11%) |

*Table 8: Greater Christchurch Water Supplies + Risk Level and Response Analysis Across 13 Indicators*

This group includes the major townships and with the highest year on year urban and commercial growth. The major townships in this group were West Melton (Edendale), Rolleston, Lincoln and Prebbleton. Beyond these, Dunsandel, Southbridge, Leeston (Doyleston) and other supplies or less than 100 persons reside.

NO3-N levels in Rolleston sources have steadily increased over the past decade with one of four sources in a consolidated well field above 5.65 mg/L. NO3-N levels have been observed to reduce as well flushing and demand increases. As the largest township with the highest consistent growth rate, it is incumbent on Council to consider source options including at source treatment and/or alternative sources.

### 3.3 SIGNIFICANT EMERGING CHALLENGES - FLUORIDATION AND NITRATE (NO3-N) REMOVAL

Ensuring provision of safe drinking water requires that all parts of the water suppliers business demonstrate a mature risk management approach. Te Mana o Te Wai, the fundamental principles of safe drinking water and Councils strategic asset management approach require that a future thinking approach is demonstrated. An assessment was undertaken to identify alternative water source, treatment and distribution infrastructure which could address emerging source water quality issues, water demands particularly in the supplies with significant growth.. This was focussed on the Greater Christchurch Group "+" (Figure 6).

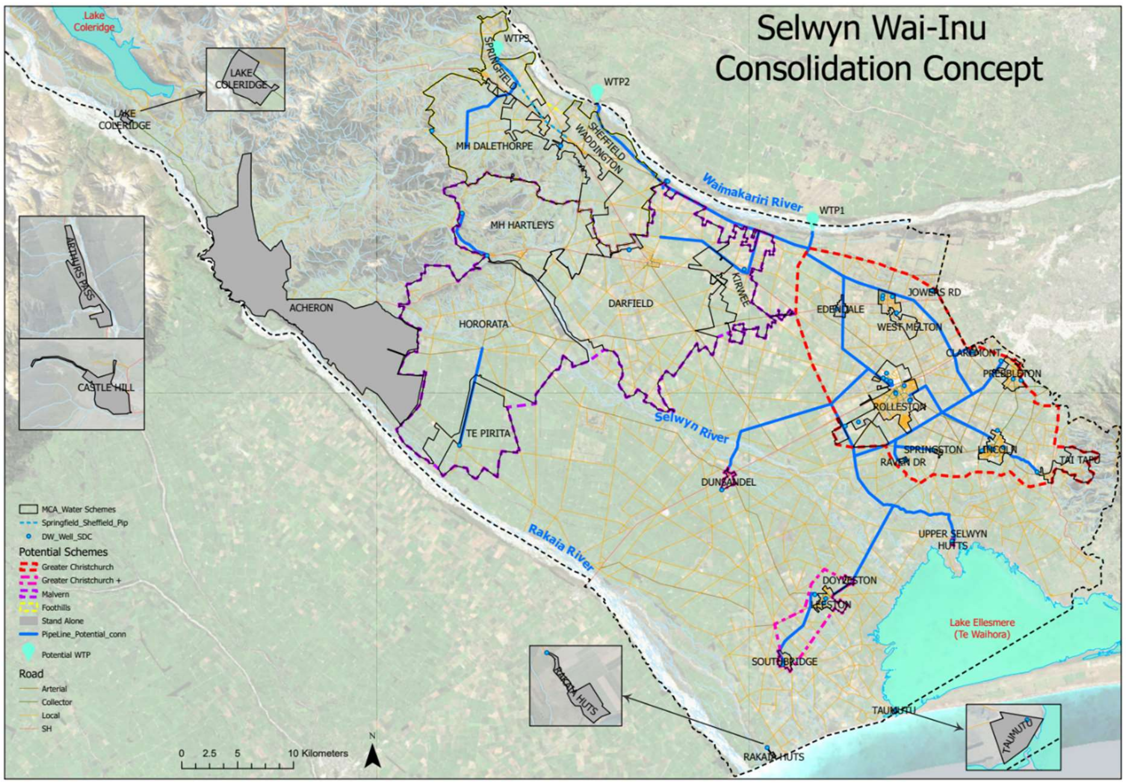


*Figure 6: Treatment and Distribution Consolidation Concept by Supply Group*

Council has obtained advice on NO3-N treatment options (Table 9) along with bulk transmission distribution pricing.

| Infrastructure Area | Notes | CAPEX ($) |
|---|---|---|
| Locations for consolidated source water take and use [16, 17] | Waimakariri sources. 0-1.0 mg/L NO3-N (modelled) | *$1M* |
| Type and estimate for nitrate-nitrogen removal [18, 19] | Membrane filtration with turbidity management. 1000 L/s (86 MLD) | $69M-$207M |
| Distribution Mains – Greater Chch and "+" [20] | 2050 demand projections. 85km PVC, 78km HDPE | $192M-$267M |
| | Total (+/-50%) | $262M-$475M |

*Table 9: Consolidation Cost Estimation (Greater Christchurch +)*

A comparison between standalone and consolidated treatment was undertaken - Table 10.

| | **NO3-N Treatment** | |
|---|---|---|
| **Cost Area** | Standalone per site | Consolidated |
| Capital ($M) | $156-$234 | $69-$207 |
| Operation & Maintenance ($M) | $8.6-$63.6 | $8.2-$12.3 |

*Table 10: Standalone vs Consolidated Cost Estimation (Greater Christchurch +)*

The consolidated capital cost is dependant on turbidity and operational NO3-N levels. Costing allow for NO3-N removal up to 1 mg/L. The wide cost range for standalone per-site capital and operations is reflective of the design and capacity to modify and/or install additional infrastructure at sites which have never been designed to allow for it. Standalone (per-site) NO3-N treatment utilises ion exchange and, like membrane filtration has a waste stream component that requires disposal. With exceptions, the Greater Christchurch groundwater sources (wells) are located near a reticulated wastewater network. Waste stream management options include removal to a reticulated network or recovery/beneficial reuse could be considered.

Per-site NO3-N maintenance and operations cost uplift include chemicals, health and safety management, energy and monitoring over 24 sources. Further detailed work would be required to increase the confidence in the cost ranges provided.

## 4 CONCLUSION

Selwyn District Councils 27 drinking water supplies are located across a wide geographic area. Source water quality has been decreasing progressively in some areas including across the Greater Christchurch supplies. Increases in demand and leakage are occurring across rural supplies. These changes have their origins in climate change, land use practices and are highlight through urban growth. Managing risks proportional to the scale and complexity of supplies must align with the principles of Te Mana o Te Wai and safe water.

Via the co-design One Water Strategy approach with Rūnanga, consideration of the linkages between the six principles of Te Mana o Te Wai, fundamental principles of safe drinking water and the Iwi Management Plan will occur. Recognising this, a western science based Wai-Inu | Drinking Blueprint has been prepared to enable Council to bring relevant information to the co-design process.

This is therefore only the start on this Wai-Inu Blueprint. As part of the journey through the co-design One Water Strategy, including face to face dialogue and sharing of ideas with Rūnanga, it will be iteratively updated to reflect the value of and respect for water.

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## GLOSSARY

| Abbreviation | Detail |
|---|---|
| *E-coli* | Escherichia coli |
| NZ DWS | New Zealand Drinking Water Standards (2022) – proposed |
| MAV | Maximum Acceptable Value |
| $NO_3$-N | The nitrogen portion of total nitrate |
| NTU | Nephelometric Turbidity Units |
| SCADA | Synchronised control and data acquisition |
| TSS | Total suspended solids (TSS) |

## TE REO MEANINGS

The following translations have been sourced from the Mahaanui Kurataiao Iwi Management Plan [21], Te Aka Māori Dictionary [22] and Te Rūnanga o Ngāi Tahu website [23]. The translations, in English, are provided within the context of this paper, and the use of te reo terms within the document.

| **Te Reo term** | **Meaning (English Translation)** |
|---|---|
| Hapū | sub-tribe, the primary pollical unit in traditional Māori society consisting of a number of whanau (collectively unite as a tribal group) |
| Ngā kaupapa | the policies |
| Ngā rūnanga | the rūnanga (*refer Papatipu Rūnanga*) |
| Ngāi Tahu | tribal group of much of the South Island |
| Ngāi Tahu rohe | the tribal boundary/area of Ngāi Tahu |
| Ngāi Tahu whānui | the wider tribal membership |
| Mana whenua | customary authority, those who have customary authority |
| Papatipu rūnanga | structural grouping overlaying hapū, 18 papatipu rūnanga within the Ngāi Tahu rohe exist to uphold the mana of their people over the land, the sea and the natural resources and appoint a tribal member to represent its interests at Te Rūnanga o Ngāi Tahu |
| Rohe | boundary, district, region, territory, area, border (of land) |
| Takiwā | region, tribal or hapū traditional territory |
| Te Rūnanga o Ngāi Tahu | governing council overseeing the tribe’s activities |
| Te Tiriti o Waitangi | the Treaty of Waitangi |
| Wai-Inu | drinking water |
| Wai Māori | freshwater |
| Whānau | extended family group, the primary economic unit of traditional Māori society |

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