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Rotorua Water Source Assessment – Stage 1

Rotorua Lakes Council

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Rotorua Water Source Assessment – Stage 1

Prepared for

Rotorua Lakes Council

August 2019

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Quality Control Sheet

TITLE	Rotorua Water Source Assessment – Stage 1
CLIENT	Rotorua Lakes Council
VERSION	Final
ISSUE DATE	13 August 2019
JOB REFERENCE	T01673400
SOURCE FILE(S)	T01673400R001.docx

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Executive Summary

This study considered present water usage in the four water supply areas in the Rotorua caldera, each serviced by a consented spring take. Estimates were made to predict demand in 2048, based on Housing Accord "medium" population projections.

Consideration is given to the implications of abstraction limits contained in Regional Plan Change 9, including whether the Regional Council decides to impose the limits or to re-consent the takes at current levels.

In both cases (and in the range in between), it is seen that there will be a shortfall that will have to be met by developing new sources of water, particularly in the Central and Eastern supply areas, where existing sources are over allocated. If new consents are given at current levels, only supplementary supplies will be needed; however, if PC9 limits are rigorously imposed, substantial new sources will be required. Additional hydrological and ecological investigations will be required to justify maintaining existing take levels from the Utuhina and Waipa catchments for the Central and Eastern supply areas.

Current surface water sources for the Western and Hamurana water supply areas have surplus allocable water available subject to resource consent and access to the source for short to medium term requirements. The capital costs of transferring this "available" water to the areas of demand in the Central and Eastern areas need to be compared against other options, and long-term supply requirements. A small quantity of water is also consented, and infrastructure installed, to take water from Hemo Springs until 2025. This is conveniently located close to the demands in the Eastern and Central Water supply zones.

Development of groundwater is raised as an option, which would be useful as a supplementary source with good water quality characteristics. Significant investigation costs and risks exist for locating and developing potential groundwater source areas.

However, if a large new source is required, the likely option will be to take and treat water from Lake Rotorua as a single source, located in close proximity to the additional demand. Potential site locations and water quality investigations are required to progress this option further.

RLC needs to fully consider demand management options to limit future demands, including peak demand management from storage buffering, water conservation and leakage control programmes. At current unidentified water use levels, these measures have the potential to provide significant improvements to the water availability. Ongoing and additional flow monitoring activities will be essential to achieve these potential improvements.

All options will have planning, cost and cultural implications that will need to be explored further and addressed.

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1.0 Introduction

Rotorua Lakes Council has five existing water sources (four active) supplying the Rotorua caldera basin. Resource consents are in place for all sources, of which the consent for Taniwha Springs has already expired and the others will be expiring between 2024 and 2026.

The city is expecting continued population growth (infills, new subdivisions) and consequent increased water demand for the foreseeable future and is looking ahead to replacing existing consents when they expire and providing for future water supply needs.

The purpose of this assessment was to identify constraints to reconsenting and to identify potential future sources to supplement and/or replace the existing. PDP was engaged by the Manager, Infrastructure Planning of RLC in June 2019 to undertake Stage 1 which is a high level (desktop) demand and water source options assessment. It is expected this work will feed into more detailed stages of the overall project. A workshop was held on 18 July 2019 to discuss the findings; this report summarises those and includes some points arising from the workshop.

2.0 Existing Sources

Information relating to existing water usage and predicted future demands is summarised in Table 1.

The four existing water sources that supply the Rotorua caldera each supply a distinct area around Lake Rotorua. See Figure 1 showing water supply areas, water sources and major pipelines and storages. The largest supply area, Central, is supplied from Karamu-Takina Spring and is currently consented to supply up to 36,369 m^3/day to central Rotorua. The other three areas are also supplied from spring sources. RLC holds a fifth consent for a water take at Hemo Spring that it currently does not use but which is consented for 2,230 m^3/day.

The Ngongotaha / Western supply area is supplied from Taniwha / Te Waro Uri Springs and this water take is in the process of acquiring a consent renewal. Consents for the other takes all expire in 2024 or 2026.

Existing water demand figures have been calculated from flowmeter data supplied by RLC. This daily data shows the total water take and maximum instantaneous take each day from June 2013 to June 2018. It is noted that the peak day take is generally about 1.5 times the average daily take, however the water taken over the peak day is considered the critical scenario for consent limits. For the purpose of this exercise, the peak day demand over this 2013-18 five-year period is the figure stated for present peak day take in Table 1.

The exception to this is in the Hamurana/Kaharoa supply, where for one day in five years, the daily take was greater than the consent due to a burst water pipe and already high-water demand. Also shown in the table is the 99% percentile high water demand. This allows events such as a pipe burst to be removed from the peak flow data. It should also be noted however, that even a 99% percentile high water demand was exceeded 19 times over the course of 5 years.

3.0 Future Demand Projections

3.1 Demand Projections

In 2018 RLC developed draft masterplan documents for each of its four urban water supply areas, Central, Ngongotaha, Eastern and Hamurana. In these documents the predicted future population of each supply zone is considered for two scenarios. A high unrestrained growth forecast provided by a BERL paper was considered unrealistic by RLC staff as Rotorua has not achieved similar growth patterns in the past. Instead, a medium growth forecast from the Rotorua Housing Accord produced by the Ministry of Housing and Urban Development based on expected building consent numbers has been used in this report to predict water requirements to 2048.

Several further scenarios were presented considering water use and conservation strategies into the future. These included maintaining the status quo situation, aggressive water demand management through leakage and pressure reduction, and the introduction of urban metering. The RLC master planning documents predict the peak daily water demand to 2048 for each of these scenarios. As a conservative approach, the status quo scenario was adopted to predict the future peak daily water demand.

The starting point on the growth forecast charts in the Master Plan documents is based on the peak day water demand figures from 2017 only. PDP considers that it is better to use data from more than one year due to the potential for climatic variations. For this reason, the estimated 2048 demand in the tables has been calculated using the growth rate predicted in the Master Plan documents but starting from the peak daily demand over the years 2013–2018 taken from flow data provided by RLC.

This method was used for three of the urban water supply schemes: Central, Eastern and Ngongotaha. As Hamurana Spring supplies both Hamurana Scheme (an urban scheme) and Kaharoa (a rural scheme), a slightly different method was adopted to develop a water demand prediction. The growth in the Hamurana scheme was predicted in the Hamurana Master Planning document, but not Kaharoa. For this study, it was assumed this rate of growth for Kaharoa would be equal to the rate of growth in the Hamurana scheme. This is likely to be conservative given the current policy to not increase the overall allocation to a property if the property is subdivided. This allowed a 2048 peak daily total water demand from Hamurana Spring to be approximated.

Table 1: Existing Sources and Future Demands

Service Area	Hamurana / Kaharoa	Western	Eastern	Central	Central
Source	Hamurana Spring	Taniwha Springs	Waipa Spring	Karamu-Takina Spring	Hemo Spring
Consents					
Consent Number	20231	61175	65465	20057	65756 (RLC)
Abstraction Limit (m^3/d)	3,200	7,340	9,504	36,369	2,230
Abstraction Limit (l/s)	45	115	110	420	31
Expiry Date	01/10/2026	25/08/2018	31/01/2024	01/10/2026	31/12/2024
Present water usage					
Average Take (m^3/d) [1]	2,250	3,000	4,700	22,600	0
Peak Day Take (m^3/d) [2]	3,198 [3]	4,240	8,400	31,000	0
Peak Day Take(99%ile) (m^3/d)[4]	3,080	4,121	7,100	30,100	0
Peak Take as % of Limit	103%	58%	88%	85%	0%
Predicted 2048 usage (Housing Accord, status quo water use scenario)					
Peak Day Take (m^3/d)	4,600	6,000	10,750	38,500	
Peak Day Take as % of Present Limit	144%	82%	113%	106%	

Notes:

1. *Average Daily take from 2013 – 2018 daily flow data supplied by RLC.*
2. *The maximum recorded daily take between 2013 – 2018.*
3. *A daily take of 3,296 m^3 occurred on the 23 October 2016 as a result of a burst pipe. The second highest take was 3,198 m^3/d and is used as peak day in the table.*
4. *The 99% Percentile Daily Take from 2013 – 2018 daily flow data supplied by RLC. Each 99% percentile high water demand was exceeded 19 time over the length of the data.*
5. *It can be seen that in most cases, present consented limits would be insufficient to meet peak demand in 2048.*

3.2 Demand Management

- Buffering

  Provision of network storage is identified as potential means of reducing peak demands. These can only be assessed if peak demands are known. Currently these are only measured at Karamu Takina.

- Water Conservation and Leakage Control

  Currently un-accounted water losses account for approximately 21% of the total demand across the whole network. Assuming that these levels are maintained at 21%, this will account for nearly 12,000 m^3/day. If demand management options such as leakage control studies, demand monitoring and water conservation programmes could reduce this to 10% of the total demand, then this is equivalent to the entire Taniwha Supply or nearly three times the Hemo Supply.

3.3 Further Work Required

- Daily demands for buffering – outflow measurement at Tarawera Reservoirs (Eastern Zone), Henderson Reservoir (Western Zone), and Kaharoa Reservoir (Hamurana Zone)

4.0 Water Availability – Potential Scenarios

4.1 Current Allocation Rules

4.1.1 Plan Change 9 Requirements

"Region-wide Water Quantity - Proposed Plan Change 9 to the Bay of Plenty Regional Natural Resources Plan" (PC9) is currently going through an appeals process, which is expected to be completed well before the current consents are due to expire.

PC9 has a policy (WQ P10) to 'generally decline' new consent applications in fully allocated catchments, but this does not apply to renewals for existing consents (WQ P12). However, the plan change does include a policy (WQ P3) to phase out over-allocation through various methods.

PC9 has a policy (WQ P5) that sets interim allocation limits until permanent limits are set through sub-regional plans for each Water Management Area. PC15 will apply in the case of the Rotorua lakes WMA. The allocation limits are based on 10% of 7-day Q_5 low flow for each river or stream.

A further policy (WQ P11) is to 'generally grant' applications to take and/or use surface water or groundwater where the rate of consented take will not exceed the interim limits.

4.1.2 Applicability of the Current PC9 Limits

In developing its future strategy, RLC could consider a range of scenarios, ranging from BoPRC approving replacement consent applications at the present abstraction rates to BoPRC requiring abstraction rates not exceeding the limits in Policy WQ P5.

In the tables in the following section, the scenarios at either end of the range are presented – i.e. existing takes reconsented or increased up to allocable flow at one end (Table 3) vs existing takes reduced to allocable flow at the other (Table 4) – but RLC's applications and the final decisions by BoPRC may lie somewhere in between.

The existing allocation methodology that PC9 is based on is consistent with policy in other areas around the country and national policy directives from the Ministry of the Environment, notwithstanding that local watercourse limits will vary from catchment to catchment.

Many of the 7-day Q_5 figures are based on limited information and flow data and should not necessarily preclude the interim limits from being increased in future. Many Q_5 figures are for the surface catchments of streams as a whole, and more data is needed to establish their relationship to the spring takes under consideration.

The current PC9 Limits have been set at historical flow measurement sites. These sites have different levels of applicability to the providing an appropriate measure of the effect at the take sites. Also, in some cases, the length of record used to assess the water allocation may be very limited with a high uncertainty of the selected value.

It is recommended to consider the following investigations to refine and improve the water take limits as outlined in PC9 or included in the consent limits;

Utuhina (Central Zone Source)

- Synthetically generate naturalised flows at the site to determine effects at the point of take (worst case location).
- Ongoing Flow monitoring at site(s) desirable for future improvements
- Assess effects on fish passage and trout spawning from the lake to the point of take

Waipa (Eastern Source)

- Generate naturalised flows using RLC water use records, flow monitoring records and Puarenga flow records if possible.
- Assess effect on dilution of Geothermal inflows in Whakarewarewa

- Ongoing flow monitoring at site(s) desirable for future improvements.
- Quantify effects on local aquatic habitat.

Hamurana

- Reinstate the flow monitoring site to ensure naturalised flow can be assessed with RLC flow records.
- Quantify effects on local aquatic habitat.
- Assess effects on lake circulation (as completed for the Awahou)

Awahou

- Ongoing flow monitoring at site(s) desirable for future improvements.

4.2 Effect of Climate Change

Current NIWA predictions:

- Slight increase in Annual Rainfall (0-1%); possible higher intensity rainfall.
- Changes in seasonal rainfall distribution – Autumn 1-2% increase, Spring possible decrease.
- Possible increase in EVT losses (50-100mm/year) which could have an impact on runoff and groundwater recharge.
- Overall, uncertainties are higher than predicted changes.

Conclusions:

- No major changes are currently expected to 2048.
- However, it is important to monitor water use and availability to understand what changes are occurring.

4.3 Potential Spring/Stream Sources

4.3.1 Summary of Planning Constraints

Implications of PC9 limits (and PC15 when enacted).

Utuhina and Waipa catchments are already over allocated under PC9 limits.

Takes from springs in these catchments are already in excess of PC9 limits (10% of 7-day Q_5).

Takes will be subject to minimum stream flows (90% of 7-day Q_5) under the PC9 framework.

Onus is on RLC as applicant to demonstrate that adverse effects are acceptable.

There are information gaps in hydrological, ecological and cultural effects.

Once PC9 is beyond appeal, replacement consent applications will be a controlled activity. BOPRC must grant consent i.e. they cannot be refused, but the authorised take volume and flowrate may be reduced.

4.3.2 Requirements for Additional Sources - Overview

Potential sources for ongoing and future water supplies include the existing spring sources. Tables 3 and 4 contain information relating to the existing consented takes in relation to their water supply area. These scenarios are considered desirable for RLC to maintain to minimise the costs for additional infrastructure.

Table 5 contains information relating to potential additional sources.

The conclusion from Table 3: Potential Sources – Existing Allowances (PC9 Limits Not Applied) is that approximately two thirds of the predicted shortfall in Central and Eastern water supply areas can potentially be largely addressed by using the Hemo consent.

The conclusion from Table 4: Potential Sources – PC9 Limits Fully Applied is that demands in Hamurana and Western will be within the PC9 limits and will be consented to meet the demands.

However, the predicted demands for Central and Eastern will far exceed what will be consented and new sources will be required in the long term for both demand profiles considered.

Surplus allocable flow from Hamurana and Taniwha Springs could be used as supplements but would not be sufficient to make up the Central and Eastern deficits. It should be noted that this is unlikely to be sufficient in the long-term scenario.

4.3.3 Taniwha Consent

The take from Taniwha Spring is currently being reconsented. It is proposed that this source will continue to supply the Ngongataha area and also provide for an emergency supply to Koutu (in Central area). The proposed graduated take is shown in Table 2:

Table 2: Taniwha Spring Consent - Proposed 5 Yearly Graduated Take and Maximum Daily Take

Year	Consent Quantity Requested (m^3/d)		
	Ngongotaha	Koutu	Total (rounded)
Commencement of Consent (2018) – 30 June 2023	4,400	2,000	6,400
1 July 2023 - 30 June 2028	4,500	2,100	6,500
1 July 2028 - 30 June 2033	4,500	2,100	6,600
1 July 2033 - 30 June 2038	4,600	2,200	6,800
1 July 2038 - 30 June 2043	4,700	2,300	7,000

Notes:

- *Ngongotaha will be the primary supply area;*
- *Koutu is the secondary supply area and will be supplied in the event of emergencies (natural events, pipeline failures or other unplanned for circumstances) including as a temporary measure, when overall demand is high and cannot be reasonably or sustainably met by any other sources.*

Table 3: Potential Sources – Existing Limits Allowed (PC9 Limits Not Enforced)

Service Area	Hamurana / Kaharoa	Western	Central	Central	Eastern
Source	Hamurana Spring	Taniwha Springs	Karamu-Takina Spring	Hemo Spring	Waipa Spring
Catchment	Hamurana	Awahou	Utuhina	Waipa	Waipa
Present consented take (m^3/d)	3,200	7,340	36,369	2,230 (RLC) + 3,170 (Red Stag)	9,504
Predicted 2048 take (peak day) (m^3/d)	4,600	6,000	38,500	<< Included	10,750
Allocable flow (10% of 7-day Q_5)	19,600	12,000	10,065	3,715	3,715
Expected new consent (m^3/d)	4,600 Required take consented	7,000 ## Required take consented	36,369 Existing take reconsented	2,230 Existing take reconsented #	9,504 Existing take reconsented
Shortfall (m^3/d) *			2,131		1,246
Surplus available for elsewhere (m^3/d) **	15,000	5,000			

Notes:

** Shortfall = 2048 peak day less new consent, ** Surplus = Allocable flow less new consent*

Issues:

 # Hemo Spring is in the same catchment as Waipa Spring, which is over-allocated in terms of PC9 limits. There are two consented takes from Hemo totalling 5,400 m^3/d, of which RLC does not currently use its 2,230 m^3/d. It is likely that BOPRC will <u>not</u> consider increasing RLC's consented take, and there is a <u>risk</u> that the quantity could be reduced, even in this favourable scenario.

Subject to current proposal (see Table 2 above)

Table 3 Conclusions:

- Existing surplus of 21,000 m^3/day are potentially available from Hamurana and Taniwha Springs. RLC need to consider the cost of developing and operating trunk infrastructure versus the available alternatives
- Hemo consent renewed at current take would be able to make up shortfall in Central.
- Shortfall in Eastern will need to be addressed from a new source.
- RLC will need to consider the cost benefits of developing a smaller take at Hemo in the short term versus a longer term consent risks and lower risks other consent options

Table 4: Potential Sources – PC9 Limits Fully Enforced

Service Area	**Hamurana / Kaharoa**	**Western**	**Central**	**Central**	**Eastern**
Source	Hamurana Spring	Taniwha Springs	Karamu-Takina Spring	Hemo Spring	Waipa Spring
Present consented take (m^3/d)	3,200	7,340	36,369	2,230	9,504
Predicted 2048 take (peak day) (m^3/d)	4,600	6,000	38,500	<< Included	10,750
Allocable flow (10% of 7-day Q_5)	19,600	12,000	10,065	3,715	
Expected new consent (m^3/d)	4,600 Required take consented	7,000 # Required take consented	10,065 Consented to allocable limit	0 Allocable limit of 3,715 applies to Waipa and Hemo together	3,715
Shortfall (m^3/d) *			28,435		7,035
Surplus available for elsewhere (m^3/d) **	15,000	6,000			

Notes:

** Shortfall = 2048 peak day less new consent, ** Surplus = Allocable flow less new consent*

Issues:

 # Subject to current proposal (see Table 2 above)

Table 4 Conclusions:

- Significant shortfalls in Central and Eastern will need to be addressed from a new source or sources.
- RLC to consider the risks of obtaining takes in excess of the PC9 limits
- Surplus allocable flow from Hamurana and Taniwha Springs could be used as supplements but would not be sufficient to make up the Central and Eastern deficits in the long term.
- Existing surplus of 21,000 m3/day potentially available from Hamurana and Taniwha Springs. RLC need to consider the cost of developing and operating trunk infrastructure versus the available alternatives

Table 5: Potential New Spring/Stream Sources

Sources	Mawae Spring	Ngongotaha Springs / Stream	Paradise Valley (Te Waireka) Springs	Waiteti Stream	Fairy/Rainbow Springs	Waiohewa Stream	Mangorewa River
Potential Service Area	Central	Western	Central / Western	Western	Central / Western	Eastern	Kaharoa
Planning constraints	Rule WQ R11 - Discretionary Activity due to over-allocation. Policy WQ P10 recommends to generally decline an app for primary allocation. No s104(2A) (RMA) benefits.	Rule WQ R11 - Discretionary Activity due to over-allocation. Policy WQ P10 recommends to generally decline an app for primary allocation. No s104(2A) (RMA) benefits.	Rule WQ R11 - Discretionary Activity due to over-allocation. Policy WQ P10 recommends to generally decline an app for primary allocation. No s104(2A) (RMA) benefits.	No s104(2A) (RMA) benefits.	Rule WQ R10 - Restricted Discretionary - discretion for BOPRC is limited. Policy WQ P11 recommends to generally grant an app for available primary allocation. No s104(2A) (RMA) benefits.	Rule WQ R10 - Restricted Discretionary - discretion for BOPRC is limited. Policy WQ P11 recommends to generally grant an app for available primary allocation. No s104(2A) (RMA) benefits.	Rule WQ R10 - Restricted Discretionary - discretion for BOPRC is limited. Policy WQ P11 recommends to generally grant an app for available primary allocation. Cross catchment issues - cultural concerns? Cross district issues? No s104(2A) (RMA) benefits.
Flow availability							
Surface water body	Utuhina	Ngongotaha		Waiteti	Waiowhiro	Waiohewa	Mangorewa
Estimated 2016 Q_5 (l/s)	1165	937		840	245	220	5450
Allocable flow (l/s) (10% Q_5)	116.5	93.7		84	24.5	22	545

Table 5: Potential New Spring/Stream Sources

Sources	Mawae Spring	Ngongotaha Springs / Stream	Paradise Valley (Te Waireka) Springs	Waiteti Stream	Fairy/Rainbow Springs	Waiohewa Stream	Mangorewa River
Allocated Flow (2016) (all users) (l/s)	420.9	140		6.5	3.6	3	171
Remaining allocation (2019)	-304.4	-46.3		78	21	19	374
Network Connection Requirements							
Length of main (m)	100 to existing WTP	4000 to Henderson	4500 to Henderson 3500 to Central Rd	4500 to Henderson	1300 to Henderson		11000 to Kaharoa
Comment	Close to Karamu Takina; in Utuhina catchment which is already over-allocated. For discussion - is it worth investigating further?	Springs at / near the Hatchery, 1130 Paradise Valley Rd; in Ngongotaha catchment which is already over-allocated. For discussion - is it worth investigating further?	Limited information; more required to decide whether to take further. BUT - in Ngongotaha Stream catchment which is already over-allocated.	Possible spring or surface water takes - worth further investigation.	Possible small take here. Existing allocation understood to be to local commercial operators.	Geothermal contamination? (Stream source in Hell's Gate area.)	Possible supply to Kaharoa, which would partly free up Hamurana Spring for other areas. A site would need to be identified and feasibility assessed.

5.0 Potential Lake Rotorua Sources

5.1 Site

Any abstraction of water from Lake Rotorua and its associated treatment plant will ideally need to be located close to the target service area and away from active geothermal areas and associated contaminants.

Potential areas would be near Kawaha Point, which could service Central and Western, and Holdens Bay, which could service Eastern and Central. Other possibilities that may be considered in future when demand requires it could be the Hamurana and Mourea areas.

5.2 Planning Constraints/Opportunities

No limits are defined in the BOPRC 2016 allocation report (still subject to sustainability assessment).

No net take (i.e. in theory all water taken from the lake ends up back there) makes this an attractive option.

Total take will be less than 10% of minimum lake outflow.

More drought resilient (not prone to minimum flow fluctuations).

Information gaps in lake water quality (treatment requirements), site availability, cultural effects (e.g. lake bed or shore disturbance).

Iwi concerns and aesthetic concerns of the public about drinking lake water into which treated wastewater Has been discharged.

5.3 Treatment Considerations

Lake water will require more treatment than water from spring sources. The following will be addressed:

Algae

- Trophic Level Index (TLI) consistently >4 (i.e. Eutrophic).
- High algae biomass likely, particularly at shallow depths in summer
- Risk of cyanobacteria and related cyanotoxins

Arsenic (and other contaminants of geothermal origin)

- Elevated arsenic concentration (but can be removed effectively)

Aluminum and turbidity unlikely to be problematic

Pathogenic Organisms

- Combined UV and chlorination proposed for disinfection

5.4 Further Work Required for Lake Rotorua Source

Investigation to identify suitable sites and select the best option(s).

Water sampling at proposed location(s) to identify a complete suite of parameters for potable water.

Consideration of type of intake, whether from the lake itself or a gallery on shore.

Conceptual treatment design and costing of options.

Consideration of disposal of waste streams.

Engage with tangata whenua to ascertain cultural values, attitudes and requirements.

Engage with the ratepayers of Rotorua about aesthetic concerns.

Consider network integration requirements.

6.0 Sources in Other Lakes

Taking water from other lakes was considered but was not given high priority. The same cultural concerns and treatment issues will apply and generally long pipelines will be required to take the water where it is needed.

Possibilities for further consideration:

- Investigating constructing a new source on Lake Okareka and/or Tarawera to provide a supply to local residential areas. This would enable water that is presently being pumped from the Eastern area to Okareka to be used in the Eastern area itself.
- A brief assessment into the possibility of taking water from Lake Okataina to supply the Eastern area could be worthwhile (or quickly rule it out).
- A source in Lake Rotoiti could be considered for supply to the Mourea area if a public water supply is ever to be provided there.

7.0 Potential Groundwater Sources

Figure 3 shows the geological formations around and beyond Lake Rotorua and indicates potential areas for groundwater investigation. These are not the only possibilities, but PDP groundwater specialists consider them to be good initial options for further investigation. Additional discussion of other potential groundwater source locations is provided below.

7.1 Considerations for Groundwater Source

7.1.1 Yields

Depending on the overall demand to be serviced by groundwater, the ability to obtain sufficient yields will be uncertain and will require confirmation following intrusive investigations. Individual bores can be expected to be able to yield of the order of up to 20 l/s to 40 l/s (1,730-3,500 m^3/day) for bores in the Mamuku Geological formation to the west and north of Rotorua.

Pilot bore investigations will be required to confirm potential yields and interference effects at proposed locations and may guide the site selection process.

A number of bores will be required for any option including groundwater – this number, and the total cost of bore drilling / installation, will depend on the yield required and the yield able to be obtained at each location.

A number of bores have been developed in the Huka formation lake sediments close to the Lake to the east of the city and in the vicinity of Ngongotaha. Maximum yield from these bores are limited to several hundred cubic metres per day (< 2 l/s).

7.1.2 Water Quality

Groundwater has the potential to produce good quality source water requiring little treatment – e.g. similar quality to springs but with improved security regarding microbiological contaminants.

There is the possibility of elevated iron and manganese in some locations, plus potential geothermal contaminants. Groundwater quality is generally good in the Mamaku Formation and is the source of existing spring takes.

Shallow bores adjacent to the lake are anticipated to provide similar water quality risks and issues to a lake water supply.

Groundwater quality in Mamuku Formation aquifers to the east of Lake Rotorua is likely to be similar to the west, but with some potential for geothermal contamination (based on the presence of hot groundwater bores in some locations).

7.1.3 Other Considerations

With any groundwater supply, upfront investment is required to carry out intrusive investigations to prove the concept. These are relatively costly and are required in order to confirm whether suitable quantity and quality can feasibly be obtained.

Groundwater is generally favoured over spring takes from a community/iwi point of view. The consultation pathway is likely to be relatively more straightforward than for spring takes.

However, consideration will still need to be given to the effects of groundwater abstraction on existing groundwater users and spring flows. Scientific consensus is that even deep aquifers are essentially part of a closed hydrological system within the Lake Rotorua catchment and groundwater abstraction can affect spring discharges, depending on the proximity of abstraction to the springs. Groundwater takes in some locations may have little effect on spring flows and instead intercept groundwater which would otherwise discharge to the lake. Consideration would be given to whether groundwater sources are required to complement existing spring takes and the possibility of interference.

7.2 Potential Investigation Areas

Refer to Figure 3. Two potential sites/areas for bore fields are shown in the Awahou and Paradise Valley. These areas are not exhaustive but represent locations for initial consideration based on potential yield and water quality criteria.

Potential investigation area delineation was based on the following:

- Geological formation – Mamaku Formation ignimbrite is favoured over Huka Formation lake sediments (T&T, 2012);
- It is preferred to drill directly into Mamaku Formation rather than through unconsolidated cover deposits;
- Elevation – depth to groundwater can be great at high elevations. Drilling at lower elevations is favourable, while avoiding areas with lacustrine sediment cover;
- Proximity to existing network infrastructure and supply zones.

Bores in the Awahou area would supplement the Western/Ngongotaha water supply area, while bores in Paradise Valley could supplement either Central or Ngongotaha or both.

Awahou area is preferable over Paradise Valley area due to easier access and proximity to existing roading infrastructure to access. However, it is a greater distance from increases in demand in the Eastern and Central areas.

It may be possible to locate bore fields east of Lake Rotorua to supplement the Eastern water supply area. There are a large number of private bores already in existence at lower elevations near the lake. However, this area was not included for initial consideration owing to the low yields obtained to date and the same potential water quality risks as a lake supply.

There is an area of exposed Mamaku Plateau Formation ignimbrite east of Lake Rotorua, which could be explored for groundwater supply potential. There are currently few bores drilled in this area. It is noted that the catchment (i.e. recharge zone) to this area is limited in extent, meaning the sustainable yield from bores in this area may be correspondingly limited. The ignimbrite in this area is exposed at elevations of greater than 400 mRL, meaning that production bores would likely need to be deep in order to obtain sufficient submergence.

7.3 Planning Constraints/Opportunities

Allocation limits are not currently defined/set in the Rotorua Lakes area.

RLC would have to demonstrate a take is 'sustainable'. BOPRC may have alternative views based on its approach elsewhere in BOP.

Localised effects on surface flows would need to be assessed (possibly reduced from existing surface water takes but yet to be defined).

Application would be assessed under Rule WQ R10 - Restricted Discretionary. If RLC determine water is available using Schedule 15 methodology, discretion for BOPRC is limited.

There are no s104(2A) (RMA) benefits.

May have lesser effects on tangata whenua values than other options.

7.4 Further Work Required for Groundwater Sources

There are information gaps in site / yield availability / quality / cultural effects.

- Bore field locations will have to be refined.
- Pilot bore investigations will be required to confirm potential yields and quality at proposed locations.
- RLC will have to undertake extensive work to demonstrate a particular take is 'sustainable' and assess its effects on surface water flows.
- RLC will have to engage with tangata whenua to ascertain cultural values, attitudes and requirements.
- RLC will have to engage with BOPRC to confirm its approach to consenting groundwater abstraction for municipal purposes in this area.

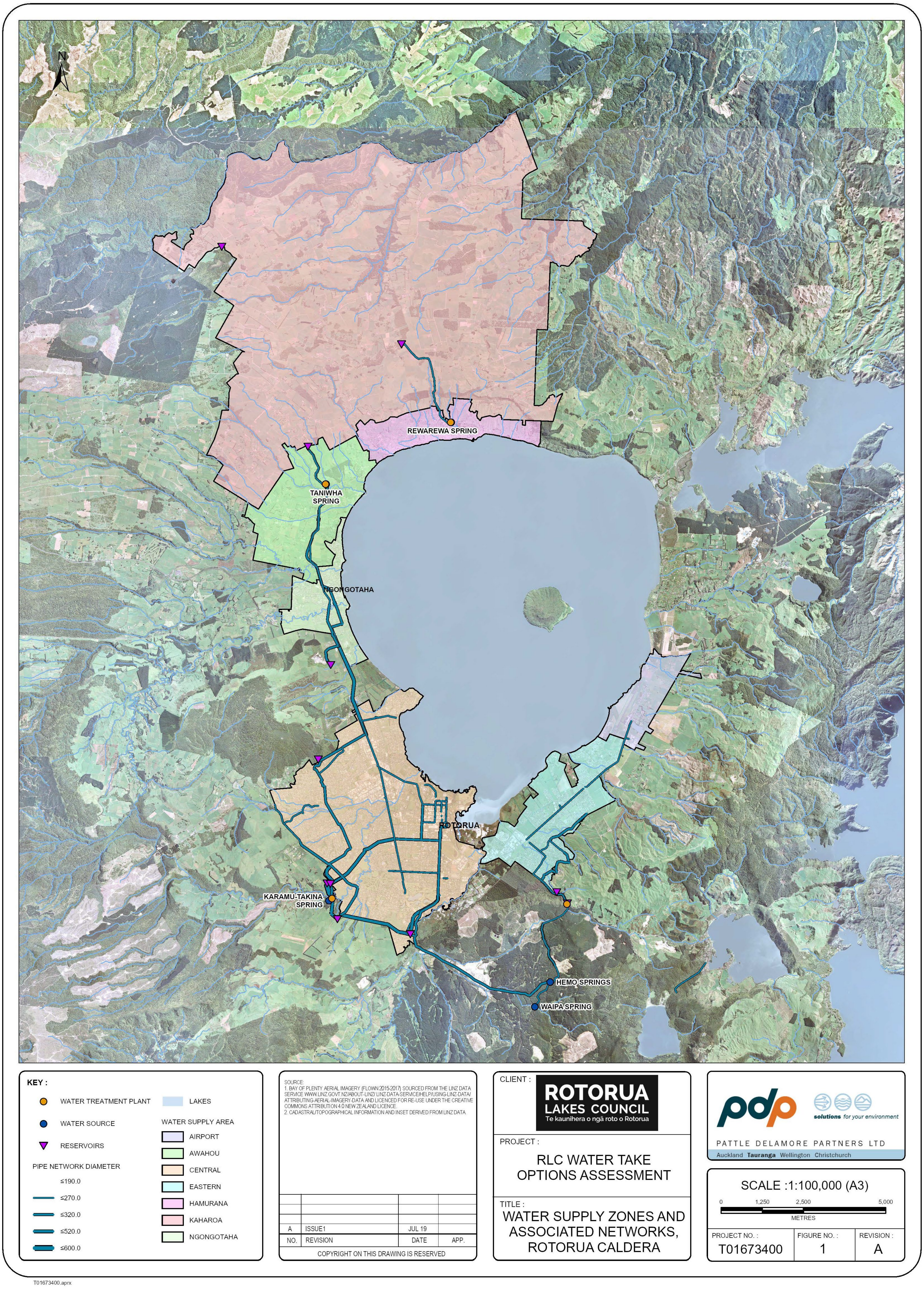

Figure 1: Water Supply Service Areas and Sources

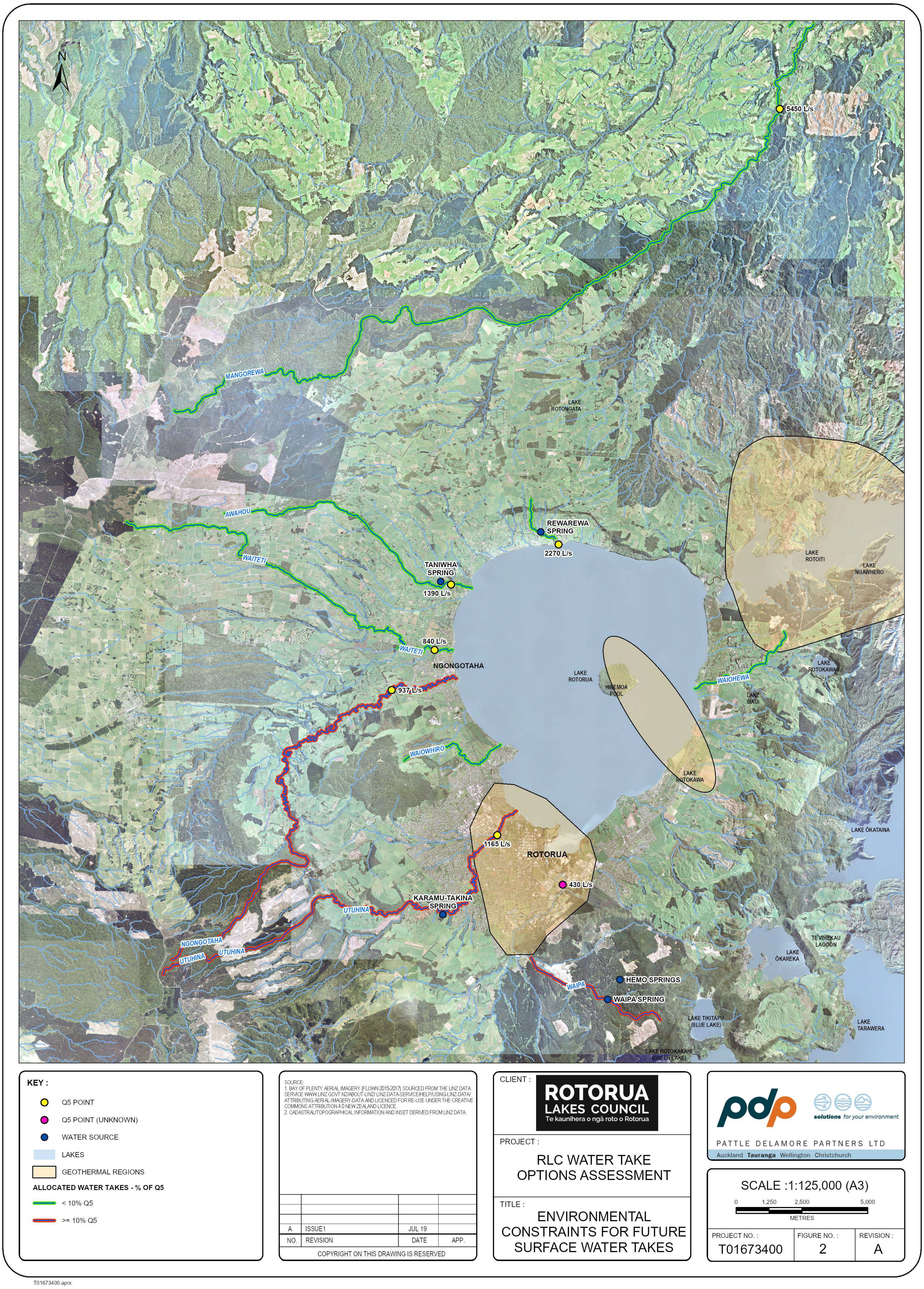

Figure 2: Environmental Constraints

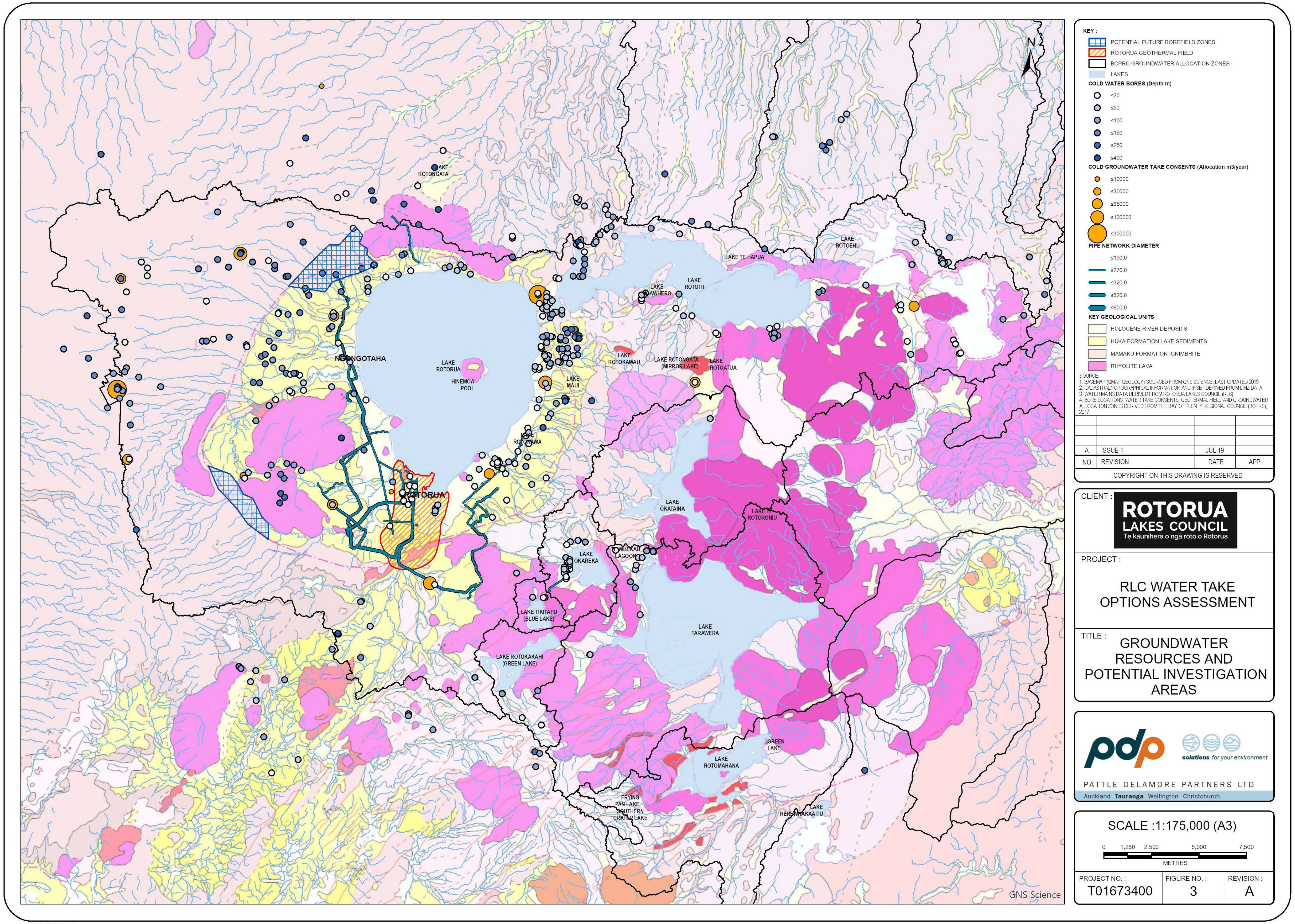

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Figure 3: Groundwater Resources

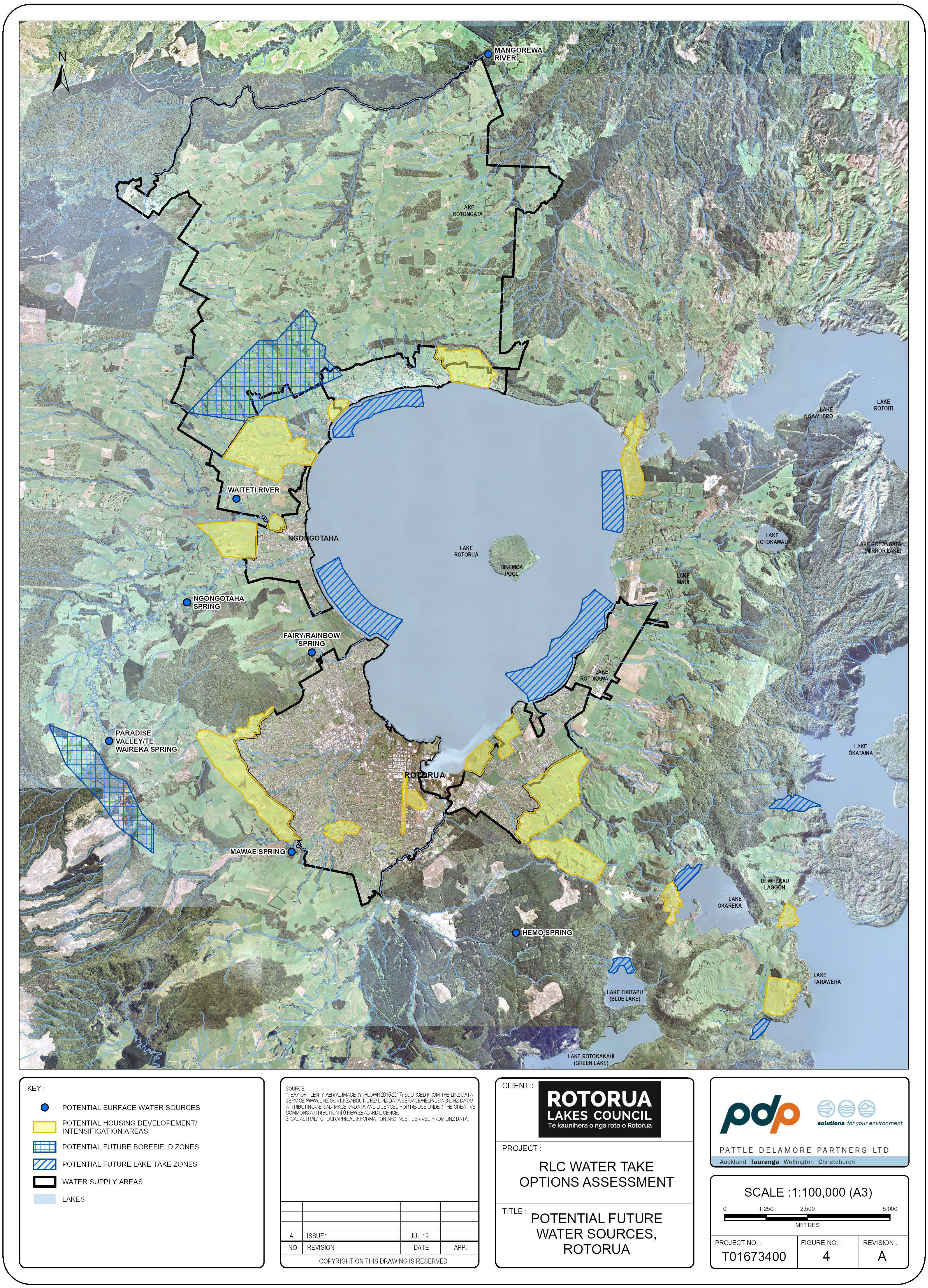


Figure 4: Potential Future Water Sources

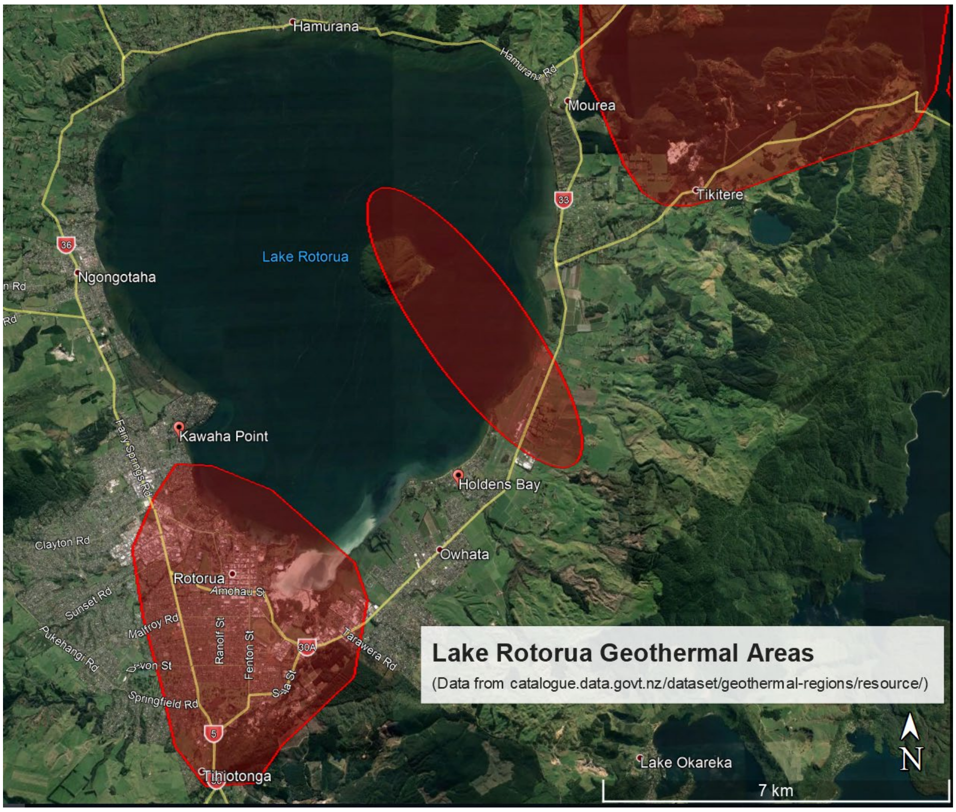
Appendix A

Notes on Lake Water Treatment

Appendix A: Notes on Lake Water Treatment

General

Geothermal areas shapefile obtained from Data NZ. Boundaries are based on a compilation of studies with geophysical and borehole data.



It is desirable to locate the intake away from geothermal and wastewater effluent discharges located at Utuhina and Puarenga streams and close to future demand /growth areas.

Intake depth will impact raw water qualities.

Expected mixing patterns inform where impact is expected from geothermal inlets and treated wastewater.

Seasonal variance will impact algae growth and potentially relative buoyancies of inlet/lake water.

Proposed take locations for this assessment were the vicinity of Kawaha Point and Holdens Bay.

Although Holdens Bay is closer to multiple geothermal areas so is likely to have more impacted water quality, if lakeside bores or galleries are to be considered the soil types should also be assessed for suitability and this site should not be ruled out due to the geothermal impact alone.

Bathymetry and Mixing

A study conducted in 2015 to advise on treated wastewater effluent disposal options included 1D and 3D modelling of the lake's mixing behaviour. SW and NE were identified as the prevailing wind directions at the Rotorua Airport weather station.

The impact of these winds on flow patterns at Kawaha Point and Holdens Bay is almost opposite. Due to geothermal areas on both sides of the Holdens Bay site, it is likely to be more impacted for a higher proportion of the time than the site at Kawaha Point.

Vertical mixing will be impacted by the relative buoyancy of the inlets.

Sites were identified due to proximity to existing urban areas and availability of existing infrastructure to limit development costs of the distribution network. It is understood that the treated wastewater effluent is discharged into the Puarenga stream and that alum dosing is currently undertaken in the Utuhina and Puarenga streams to reduce TP levels in the lake. Future urban growth is anticipated to be highest in the eastern and central zones of the township.

Combining the information about development, geothermal areas and treated wastewater, Kawaha Point seems a more suitable location. Capital costs would be expected to be similar at both sites as the same treatment processes would be required, but a lower contaminant load would result in lower operational expenses.

The cultural implications of developments at either of these sites has not been considered within the scope of this assessment.

Depth of intake should be considered in conjunction with this information to achieve optimum raw water quality.

Lake Water Quality - Existing Data

Historical water quality data has been compiled from various council records and compared to DWSNZ Maximum Acceptable Values (MAVs) and Guideline Values (GVs). Data sets compiled included a variety of date ranges and sites. The only data available from shore locations was E.coli testing completed for surveillance of recreational water standards. Other values are from sample sites towards the middle of the lake where geothermal impacts on water quality are likely to be lower due to dilution from the shoreline inlets. Planned intakes would be closer to the shore so specific testing is needed to check whether there is significant variation in water quality. Some significant determinands have also not been tested for so further sampling would be required for full assessment of treatment requirements.

Lake Water Quality - Existing Data								
Parameter	**Ammonia (g/m³)**	**Nitrite (as NO2) (g/m³)**	**Nitrate (as NO3) (g/m³)**	**pH**	**Turbidity (NTU)**	**Total Al (g/m)**	**Total As (g/m³)**	**E.coli (cfu/100mL)**
DWSNZ MAV		**0.2**	**50**				**0.01**	**< 1**
DWSNZ GV	**1.5**			**7.0-8.5**	**2.5**	**0.10**		
Lake Rotorua Sample Value (**99th percentile, highest data set**)	1.36	0.01	0.68	7.15-8.47	11.2	0.19	0.016	34,448
Sample Location	*Site 2 Bottom (26.4 m)*	*Site 2 & 5 Discrete & Integrated (6-24 m)*	*Site 5 Discrete (23 m)*	*Site 5 Bottom (24 m) – Site 2 Integrated (6 m)*	*Site 2 Hypolimnion (15 m)*	*Site 5 Bottom (24 m)*	*Site 2 Hypolimnion (15 m)*	*Ngongotaha*
Lake Rotorua Sample Value (**90th percentile, highest data set**)	0.46	0.01	0.56	6.95-7.50	4.5	0.04	0.009	3,900
Sample Location	*As above*	*As above*	*As above*	*As above*	*Site 2 Discrete (24m)*	*Site 2 Discrete (24m)*	*Site 2 Bottom (26m)*	*As above*

The values given in the table are the highest 99^{th} percentile and 90^{th} percentile values across the sites tested for each determinand.

99^{th} percentile values for total arsenic, E.coli, turbidity and total aluminium exceeded the MAV or GVs. However, only E.coli and turbidity exceeded these values at the 90^{th} percentile. (pH low boundary was slightly below)

Elevated Al was only observed at lake bottom sites and is likely due to the alum dosing program operating in Utuhina and Puarenga streams. Turbidity and E.coli should be reduced by the proposed standard treatment and disinfection methods. Arsenic is the main contaminant of concern from this analysis and is commonly associated with geothermal activity.

Algae is an important consideration for surface water takes. Cyanobacteria data from 2018-2019 shows no exceedances of the recreational levels in Lake Rotorua. However, high nutrient inflows can also lead to non-toxic algal blooms, the removal of which will need to be addressed by the proposed treatment process.

Further sampling should be completed at both proposed sites and at a geothermal inlet to determine contaminants that may migrate into the proposed intake areas. A full testing suite will allow complete assessment of the raw water quality and likely treatment performance. The suite will include manganese and iron tests so that they can be checked against the threshold values for UV disinfection (which are lower than the respective MAVs) and will also allow assessment of hydrogen sulphide and sulphates (likely contaminants in geothermal areas) against DWSNZ GVs for taste and odour.

Sampling should be completed at the proposed intake depth and location and where possible on multiple occasions to account for seasonal fluctuations. Iron and manganese concentrations can increase at depth and algae and nutrients will fluctuate throughout the year.

If bank filtration is chosen as a potential treatment method, soil types should be assessed for suitability at the proposed intake site.

Treatment Challenges / Requirements

- Algae
  - Trophic Level Index (TLI) consistently >4 (i.e. Eutrophic).
  - High algae biomass likely, particularly at shallow depths in summer
  - Risk of cyanobacteria and related cyanotoxins
- Arsenic (and other contaminants of geothermal origin)
  - Elevated arsenic concentration (but can be removed effectively)
- Aluminum and turbidity unlikely to be problematic
- Pathogenic Organisms
  - Combined UV and chlorination proposed for disinfection

Algae Removal

Treatment processes should be designed to remove entire algal cells as lysis of cyanobacteria can release increased cyanotoxins into the water. Monitoring of lake conditions and water quality can be used as a predictor for cyanobacterial blooms.

Addition of a coagulant/flocculant followed by either dissolved air flotation (DAF) or sedimentation and filtration will allow removal of cells with minimal damage and will also reduce turbidity. Some reduction of microbial determinands and arsenic may also be achieved by these processes.

Bank filtration through lakeside bore or gallery intakes may reduce algae content and turbidity of the water prior to one of these treatment processes.

It is important not to pre-disinfect the raw water as this can damage algal cells and, in the case of cyanobacteria, release significantly higher levels of cyanotoxins into the water supply.

Arsenic Reduction

Arsenic can be removed effectively using ion exchange, reverse osmosis (RO) and adsorption techniques. Treatment processes outlined for algae removal may have some reduction benefits. It is possible to divert a partial stream and mix after the treatment process to reduce the required operating volume and achieve a concentration below the MAV. RO and adsorption using granular ferric hydroxide (GFH) are the most effective removal methods and ion exchange is also rated highly. It is possible that elevated levels of dissolved silica in the water may lead to fouling of the ion exchange media which would require special attention during regeneration. Spent GFH media will require disposal to landfill. Activated alumina can also be an effective adsorbent but performance may be affected by competition with silica, fluoride, phosphate and sulphate ions.

Ultra-filtration can reduce some arsenic species with a removal efficiency up to 60%. However, pre-treatment for reduction of algae would still be recommended to prevent the filter becoming blocked and the wastewater produced from CIP process would require disposal as it would have more concentrated levels of arsenic. The applicability should also be reconsidered against test concentrations at intended intake sites. Although 50% reduction would be sufficient for the reported water quality, if the arsenic load is higher in the outer areas of the lake, there may still be exceedances after a 50-60% reduction.

If cyanobacteria are present, membrane characteristics will affect the extent to which cells trapped in the membrane can be removed during backwash. Death and lysis of the cells will result in toxin release into the water. If using direct filtration, longer filter runs will trap more cells in the filter bed than short runs, leading to release of greater amounts of cyanotoxins following cell death and lysis.

Issues / Data Gaps

- Very limited water quality data near the possible water take sites
  - Currently from middle of the lake – unlikely to be representative

  - Need complete potable water quality sampling suite at proposed locations
  - Sample near likely geothermal influences – identify other constituents / interactions (limitations) with possible treatment options
  - Need to understand the species / concentration of Arsenic in the water
- All proposed sites at risk of geothermal waters
- Treatment options will generate waste streams (including CIP waste) that will need to be disposed of to wastewater network
- Bank filtration has advantages – however need to understand the water resource (groundwater / lake water blend)

Appendix B

Groundwater – Notes from Previous Studies

Appendix B: Groundwater – Notes from Previous Studies

CH2M Beca (2005)

CH2M Beca Ltd. 2005. Taniwha Springs Water Extraction: Peer Review of Investigations into Alternatives. Technical report prepared for Rotorua District Council. 23p.

- All spring sources other than Hamurana Springs shown to have insufficient allocation available to support the required take.
- Pointed to groundwater and lake options being only viable options.
- Section 3.8 discusses the groundwater option
  - Notes bores are typically 120 – 220 m depth
  - Ignimbrite and rhyolite aquifers
  - Yields up to 20 – 40 L/s possible based on Beca experience elsewhere (Te Puke, Paengaroa)
  - Pointed towards need to install 6 – 10 bores 200 – 250 mm diameter (to meet the predicted shortfall of 210 L/s)
  - Outlined quality risk with arsenic, boron and silica possible (geothermal influence), or iron and manganese (from overlying alluvium and ignimbrite)
- Section 4 provided a weighted attribute comparison of the various options
  - Criteria based on drought reliability, implementation risks, ecological and environmental impacts, amenity impacts and costs
  - Groundwater scored highest overall and highest in all criteria other than cost
  - Followed by Mawae Spring and Lake Rotorua options (although unlikely Mawae Spring has capacity)
  - Ngati Rangiwewehi indicated in 2005 that groundwater was their preferred option from a cultural impact perspective

Tonkin & Taylor (2012)

Tonkin & Taylor Ltd. 2012. Contract 12/034: Feasibility Investigations for Alternative Water Supply Source for Ngongotaha Stages 1 & 2: Alternative source identification, scoping and shortlisting. Technical report prepared for Rotorua District Council. 16p.

- Considered the Ngongotaha supply only (with provision for emergency supply to Koutu, part of Central supply).
- Study sought options for alternative sources capable of supplying a total of 85 L/s to Ngongotaha and Koutu
- Assessed following alternative options:
  - Hamurana Springs
  - Lake Rotorua
  - Groundwater bores
  - Combination of above
- On the groundwater option (Section 4.5), reference is made to T & T (2008) desktop review of possible groundwater supply options. (Do we have this?)
- Indicated suitable source likely north of Ngongotaha around Central Road.
- Indicated 4 – 5 bores required to meet 85 L/s demand based on yields of at least 20 L/s.
- Iron and manganese risk highlighted.
- Potential SW/spring flow impacts highlighted – will likely require location-specific detailed assessment of effects.

Tonkin & Taylor (2013)

Tonkin & Taylor Ltd. 2013. Contract 12/034: Feasibility Investigations for Alternative Water Supply Source for Ngongotaha Stage 3: Feasibility Investigation. Technical report prepared for Rotorua District Council.

Section 3: Groundwater Source provides a more in-depth assessment of groundwater supply feasibility

- Mamaku Ingimbrite identified as most important water bearing formation in the area
- Generally layered in upper, middle and lower subunits, with greatest permeability in upper and lower. Middle unit is welded and flow primarily through fractures, where these occur. Fractures thought to provide water passage between upper and lower units.
- Described as a leaky aquifer.
- Awahou catchment recharge to GW thought to be in the order of 1 m^3/s.
- Water quality good at Mamaku supply bores and Taniwha Springs

Section 3.3 – assessment of water availability:

- Determined sufficient availability to supply 7,340 m^3/d (existing Taniwha consent). Offset via replacement of current spring takes.
- Recharge estimated to be 957,571 m3/day (northern + western + central) (source of estimate not stated). 35% of this is 335,150 m3/day. Up to 268,000 m3/day from western.

Section 3.4 – potential yield:

- Reviewed pump tests in Mamaku and Huka Formations from 2 bores
- Greater permeability and available drawdown in Mamaku Formation
- Concluded 20 – 25 L/s/bore likely, possibly more.

Section 3.5 – wellfield location:

- Awahou catchment, 2 – 2.5 km from Lake Rotorua, elevation around 320 – 340 m.
- Bore spacing at least 500 m.
- Other sites possible e.g. closer to Ngongotaha off SH5 but further from existing infrastructure.

Section 3.6 – Effects on springs (Taniwha)

- Rough indication of potential flow impact on spring based on assumption that 25% of GW flows to lake vs. 75% to springs.
- But acknowledges connection of GW and spring flows, suggesting up to 75% of wellfield abstraction may be borne as reduced spring flows.

Section 6 – Further investigations required for groundwater supply

- Drilling investigations proposed to confirm feasibility in terms of location, yield, quality
- Site location for new reservoir near Central Rd