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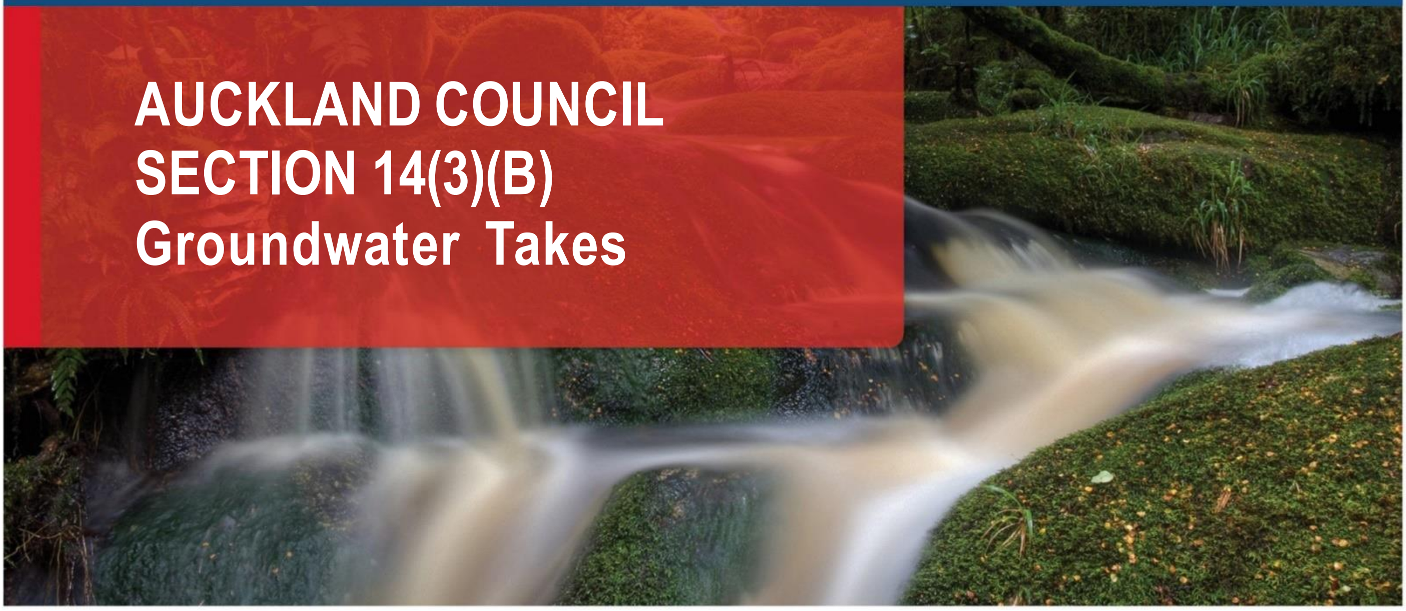
Water Management REPORT

AUCKLAND COUNCIL SECTION 14(3)(B) Groundwater Takes



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EXECUTIVE SUMMARY

Regional Councils and Unitary Authorities have a responsibility to manage water resources, including allocation of these resources. The Resource Management Act (RMA) allows for water to be taken for reasonable domestic and stock water drinking water use, provided that the use does not, or is not likely to have, an adverse effect on the environment:

(b) in the case of fresh water, the water, heat, or energy is required to be taken or used for

(i) an individual's reasonable domestic needs; or

(ii) the reasonable needs of a person's animals for drinking water,

and the taking or use does not, or is not likely to, have an adverse effect on the environment.

The National Policy Statement for Freshwater Management requires Councils to set and apply limits and to establish and operate a freshwater accounting system. The difficulty is that not all allocation can be quantified. Section 14(3)(b) takes can be difficult to quantify, as councils cannot require the measurement, recording and reporting of the take.

In some areas, Section 14(3)(b) takes could represent a substantial proportion of the total water abstraction. For example, Waikato Regional Council estimated that Section 14(3)(b) takes could represent as much as 20% of the total surface water take in the Region, illustrating the magnitude of Section 14(3)(b) takes relative to consented takes in some areas.

This project aimed to model water use that had not been consented, known as Section 14(3)(b) (or permitted) takes. An earlier version of this approach was considered to generally over-estimate Section 14(3)(b) takes. This project aimed to evaluate the previous approach, adjust the model if needed, and determine a new estimate of Section 14(3)(b) water takes.

The new approach taken did not use Agribase data, on which the previous approach had been based, as the Council no longer licence the database. Instead, stock numbers were estimated from StatsNZ data. It is recognised that the numbers will not be correct on a property-by-property basis, but they should provide a reasonable estimate over larger areas.

The estimated total water use in the Auckland Region from this revised model is as follows:

Estimated animal drinking needs (m^3/yr)	Estimated reasonable domestic drinking needs (m^3/yr)	Sum
3,598,144	153,423	3,751,567

The approach has limitations regarding stock numbers per property, assumptions about aquifers used, and the land classification. The results are summarised by aquifer management area (AMA) and should be used to indicate the magnitude of Section 14(3)(b) takes across these areas. The approach is not appropriate to be applied at a property level.

However, the results provide an indication as to the magnitude of Section 14(3)(b) takes, that can be used in estimating the total consented and unconsented takes. The model results can be used to highlight areas which require further investigation, including on the ground validation. This is important to quantify the allocation status of Auckland's aquifers, as required by the National Policy Statement for Freshwater Management.

GLOSSARY

Acronym	Meaning
ADD	Average Daily Demand (derived from total annual consumption estimates divided by 365)
APS	Agricultural Production Survey
CRS	Core Record System (Cadastral data)
DOC	Department of Conservation
FME	Feature Manipulation Engine (www.safe.com)
HPEG	High producing exotic grassland
LCDB	Land Cover Database (Landcare Research)
NPS- FM	National Policy Statement Freshwater Management
NRSI	Natural Resource Specialist Input – legacy database
OAS	Legacy Auckland bore database
PA	Permitted Activity
PDD	Peak Daily Demand (estimated highest single day consumption during the year)
RA	Rating Assessment
RMA	Resource Management Act
SAP	The SAP consents database has been in operation since 2018/19. These data are non-spatial.
SDE	Spatial Database Engine. This data base holds spatial property data.

1 INTRODUCTION

Auckland Council engaged Aqualinc Research Ltd (Aqualinc) to assess an existing model that estimates likely water use from permitted, unconsented groundwater takes within the Region. These takes are permitted by Section 14(3)(b) of the Resource Management Act (RMA), which permits the take and use of water for an individual's reasonable domestic needs; or the reasonable needs of a person's animals for drinking water, without the need to obtain a resource consent, provided that the use does not, or is not likely to, have an adverse effect on the environment. The estimates are needed to assist with meeting the requirements of National Policy Statement Freshwater Management (NPS-FM). This includes a requirement for every council to operate and maintain a freshwater quantity accounting system. The NPS-FM notes that "freshwater take" refers to all takes and forms of water consumption, whether metered or not, whether subject to a consent or not, and whether authorised or not.

The estimation of Section 14(3)(b) takes will enable the Council to more accurately determine the current allocation status of groundwater resources and fulfil their requirement to carry out the requirements of the NPS-FW.

1.1 Model Overview

The existing model was developed by a previous consultant. An assessment of the numbers generated by the model suggested it provided some unrealistic estimates.

The model attempted to identify existing bores that could be used for a Section 14(3)(b) take, then defined water use requirements based on Agribase data and LCDB (Version 4) data where Agribase data was missing. The next step was to define the likely aquifer being used, based on bore information or depth. Where there was a land parcel without a bore, that was likely to have a Section 14(3)(b) take, the shallowest aquifer was used. The next step was to allocate stock water needs to bores, and to land parcels with no bores that were likely to have a Section 14(3)(b) take. The final data are attributed to an aquifer, and the daily volumes multiplied by 365 to get an annual water take. Further details of the existing model are provided in Section 2.

1.2 Model Redevelopment

The model methodology was modified based on an assessment of the existing model. The major modification was to remove any use of Agribase data, as Auckland Council no longer hold a licence for the dataset. Other modifications include:

- Using agricultural statistics data from the Agricultural Production Survey (APS) (Ministry for the Environment, 2017). These data provide counts and densities of livestock numbers derived from the Agricultural Production Survey census final results for 2017, with beef and dairy cow, sheep and deer numbers over relatively large areas (polygons of approximately 345 km^2.)
- Refining calculated takes, based on estimated stock water use.
- Only including reasonable domestic water needs if there was a bore identified that listed domestic as a use.
- Refining the approach to assigning takes to aquifers, and assigning to aquifer management areas (AMAs).
- Using LCDB Version 5, which was updated in 2018/19, relative to LCDB Version 4 (2012/13) which was previously used.

Details of the re-developed model are given in Section 3.

2 ASSESSMENT OF 2019 MODEL

2.1 Background

The existing model was developed in 2019 by a third-party consultant, within the FME software operating environment[1]. A draft memo (herein "the memo") dated September 2019 documented the model build and the original FME scripts were also available. We used the memo and scripts to determine the logic behind the model, as is described below. The scripts were labelled AA, BB, etc., each performing a specific task, to calculate outputs that were then used by subsequent scripts.

2.2 Defining Likely Source of Water

The first step of the approach was to define any existing bores that could be used for a Section 14(3)(b) take. Script AA was used to produce *ALL_BORES_THINNED_TO_14_3_B*. The 2019 memo stated that if a property had a consent to take water, it was assumed that it did not have a Section 14(3)(b) take as well.

The method used all the groundwater take bore information held in the static GIS dataset *PUBLICATION_MASTER_OAS_ALL_BORES* (the council's master Natural Resource Specialist Input (NRSI) legacy database of wells), and applied a range of text filters and spatial filters across it. This attempted to remove any bores that either had a water take consent (and therefore not a permitted activity under S14(3)(b), but an activity which has been consented under the RMA), were not in use, or had usage that was not domestic or animal drinking water.

It was necessary to join the bore database to the water take consents and application NRSI records because OAS information is held in the GIS database, rather than the NRSI database. To do this, "All Bores" was first joined to consented water takes or consents in application (*OAS_APPL_W_TAKES and OAS_CONS_W_TAKES)* based on the Bore_ID, and these were rejected if the Bore_ID was present across all three. If not, then the bore was considered as potentially a Section 14(3)(b) take.

The remaining bores were filtered further to remove any:

- Expired, never drilled, or decommissioned bores. Also where Works_decription included "SEAL", suggesting that the bore had been decommissioned.
- Where the activity status was clearly not for drinking water (e.g. geotechnical, research, etc)
- Where the consent status was cancelled, surrendered, withdrawn, replaced, no longer required, superseded, or accepted for processing
- Where the site name suggested it was for monitoring, testing or dewatering
- Where land use suggested monitoring
- Where the purpose included activities that were unlikely to be drinking water (e.g. geotechnical, monitoring, etc)
- Where the site name, land use, or bore use included quarrying or irrigation.

This filtering reduced the original 11891 records to 5079 records which might represent Section 14(3)(b) takes. The memo states that there is the possibility that some bores may be duplicate records: this appears to be a duplication with bores that are already identified as Permitted Activity (PA) bores, and identified in the PA database. Based on this, any bores that are within 0.5m between the two datasets

[1] See https://www.safe.com/

were removed from the dataset. The method then compares the output from this process (spatially) with *PUBLICATION_MASTER_OAS_APPL_W_*TAKES (application in process for a water take, filtered for bores only), and *PUBLICATION_MASTER_OAS_CONS_W_TAKES* (consented water takes, filtered for groundwater only).

This left 4806 bores which could be potentially bores that made use of Section (14)(3)(b) .

There was a final step in the 2019 memo regarding testing if bores were within the Auckland region, due to boundary changes resulting from the formation of a unitary territory (amalgamating of the seven territorial authorities and one regional authority).

The model had a final step to "add 2019 to import SAP records": These records are the consents data that are held in the SAP database, developed since 2019. This final stage took *MASTER.AC_RateAssessment* and a database called *2016_2018* (which appears to be 2016-2018 SAP records, filtered using consent description to assess if the bore has Section 14(3)(b) potential). It appeared to merge the two datasets, tested for 'Stock or domestic', mapped SAP attributes to the old bore database, and combined the output from the above(removing any 'Waiwera Road bores', which would be geothermal and therefore not utilised for drinking water under Section 14(3)(b)). The output was ALL_BORES_THINNED_TO_14_3_B.

2.3 Defining Water Use Requirements

The 2019 memo described the process of estimating agricultural water use, as per the following sections.

2.3.1 Agricultural Water Use (Script BB)

The next step in the 2019 model was to determine likely water use. Script BB produced a stockwater consumption base map (StockwaterConsumption_BaseMap), using Agribase and High-producing Exotic Grassland (HPEG) from the Land-cover Database (LCDB (Version 4)) data. There were two main parts to the process. The first was estimating the numbers of livestock; the second was defining the estimated use by each of those stock units. This script did not include estimates of domestic requirements.

2.3.2 Estimating Stock Numbers

The numbers of livestock units were based on Agribase numbers, where available. As Agribase is a voluntary database, and has missing data, the LCDB was needed to "fill in" the gaps. Consequently, where not available, it was assumed that livestock were limited to dairy cows, which were assumed to be grazed on HPEG, at a stocking rate of 2.42 cows/ha. The 2.42 cows/ha value was taken from the New Zealand Dairy Statistics (LIC, 2009), as an average for New Zealand.

However, there may be areas that are HPEG, where farming is not allowed from a planning perspective. The memo states that land zone data from the Unitary Plan base zone (*UP_Basezone*) layer was added to the *CRS_Parcel_RA_Enhanced*, to only retain areas zoned as:

- Future Urban Zone,
- Residential – Large Lot Zone,
- Residential – Rural/Coastal Settlement Zone,
- Rural – Countryside Living Zone,
- Rural – Mixed Rural Zone,
- Rural – Rural Coastal Zone,
- Rural – Rural Conservation Zone,

- Rural – Waitakere Foothills Zone,
- Rural Waitakere Ranges Zone

These farms are likely to be located where intensive farming activities are permitted by the Unitary Plan.

Then for any rural land parcels, these were intersected with the LCDB, (filtered to extract HPEG), resulting in land parcels that were identified as rural and HPEG. This land use type was used as a proxy for areas in Auckland where dairy cattle would graze in areas not covered by Agribase data.

Previous work (Aqualinc, 2015) had suggested that low producing grassland and shrub land was still used for grazing for sheep and beef, but this was not accounted for within this model. However, there do not appear to be many large areas which fall into this category, and hence this is unlikely to be an issue.

2.3.3 Estimating Stock Requirements

Having estimated the stocking rates, the model then estimated the amount of water required for each stock unit. The model used Agribase stocking numbers and multiplied them by stock water requirements (ANZECC, 2000) and (Burton, 1965)[2].

The model took the average daily demand (ADD[3]) of dairy cows in milk (70 l/d) and ADD of dairy cows dry (45 l/h/d), and averaged these values (57.5 l/h/d) to use for the drinking water requirement for all dairy cattle in the model. Given that ADD is the average use over the year (derived from total annual consumption divided by 365), while PDD is the highest single day consumption during the year, it is more appropriate to use the ADD for dairy cattle to reflect annual consumption. Averaging the dairy demand (between ADD and PDD) is not likely to be accurate. This would be especially significant to the model if a large portion of the Section 14(3)(b) takes are dairy related. For sheep drinking water requirements, the memo used the average ADD of ‘nursing ewes’ and ‘mature sheep’ but excluded lambs completely. This resulted in ADD of 6.5 l/h/d: this is higher than the ADD of sheep (including lambs) from the multiple source analysis in (Aquas and Aqualinc, 2007) which gives an ADD of 3 l/h/d.

Estimated stock requirements in the BoPRC (Bay of Plenty Regional Council) drinking water report (Aqualinc, 2015) were noted as average day demand (ADD) and/or peak day demand (PDD) as provided by multiple sources. A comparison of the different rates is given in Table 1.

The Auckland (2019) model then used a value of 2.42 dairy cows per hectare (for areas without AgriBase data), with a reference to (LIC, 2009)[4].

2.3.4 Aquifer Assignment (Script CC)

Where bores had been identified, it was necessary to determine the likely aquifer that bores were abstracting from, as there are areas of the Auckland Region where there is more than one aquifer (vertically). Script CC was developed to assign an aquifer name to each bore (identified in AA).

The original input *PUBLICATION_MASTER_OAS_ALL_BORES* bores dataset (which was used to produce *ALL_BORES_THINNED*) doesn’t have complete information on aquifer geology or name. If this information was entered for a bore, then it was used, and spatial queries were only performed on records with no original aquifer information available.

To do this, CC overlaid *ALL_BORES_THINNED_TO_14_3_B* with an *AquiferArea* layer. The model also gave each bore a CRS Parcel ID called *VALREFERENCE* which was used to aggregate multi-part farms in later steps. The memo does not cover the detail, but the script also used SAP PA records and

[2] The memo refers to “*Stock Drinking water profiles generated from National Water Quality Management Strategy Oct 2000, Primary Industries — Rationale and Background Information”.* The original source is a book by (Burton, 1965).
[3] By definition, ADD is the average use over the year (derived from total annual consumption divided by 365), while PDD is the highest single day consumption during the year.
[4] Note (LIC, 2009) references 2.83 cows/ha.

PA records from an old bore database, and added them to the *ALL_BORES_THINNED_TO_14_3_B* data.

Table 1: Estimates of stockwater use (Aqualinc, 2015 and Auckland Memo).

	BoPRC estimates used by Aqualinc (2015)		Auckland (2019 memo) estimates
Stock type	**Average daily demand (ADD) (l/head/day)**	**Peak daily demand (PDD) (l/head/day)**	**Average daily demand (l/head/day)**
Dairy cattle: Milking cow	45	70	57.5
Beef cattle: Mature beef cattle, herd replacement stock and bulls	30	55	45
Sheep: Ewes, hoggets and rams	3	4.5	6.5
Deer: Hinds and stags (all ages)	6	12	6
All other large stock	30	55	30-45
All other small stock	3	4.5	3

According to the memo, the layer *AquiferArea* contains 4 main attributes: (from coarsest to finest resolution)

1. AQUIFERGEOLOGY
2. AQUIFERGROUPNAME
3. AQUIFERNAME
4. SUBAQUIFERNAME

Not all these attribute values contained data, which necessitated a workaround to obtain aquifer information for all 14(3)(b) bores. Keyword searches were undertaken to establish *AQUIFERGEOLOGY*. The attribute *AQUIFERGROUPNAME* was searched for:

1. Kaawa
2. Sand
3. Volcanic
4. Waitemata
5. Greywacke
6. Any geothermal aquifers are excluded from this script

Where a matching result occurred, the *AQUIFERGEOLOGY* attribute was updated within the *AQUIFERAREA* feature class.

It then assigned the aquifer, in order of preference, as follows:

1. Assign aquifer based on bore log information from the bore record.
2. Assign aquifer based on spatial location and [Total depth] bore attribute.
3. Assign aquifer based on spatial location and default to shallow if there was no depth information (cheaper to drill).

Associated Depth	Geological Unit
Shallow (<150m)	Kaawa, Sand, Volcanic
Deep (>150m)	Waitemata, Greywacke

The output is *PA_Bores*, with aquifer information included in the attributes.

2.3.5 Calculating Site Water Needs (Script DD)

This section in the memo discussed that there is no record of many bores in the Auckland region, and the issue that this posed to the model. Farms without a documented bore were identified by the fact that Agribase and/or the LCBD4 data showed they have a requirement for stock water, but there was no record of a bore on the property. The "farms without known bores" had water use calculated, based on likely stocking numbers and water requirements, divided between dairy cows and dry stock. In Section 2.6.2.1 of the memo, the table suggested dairy cows would use 57.5 l/d, and beef cattle 45 l/d. In the original calculations, the model used 70 l/d for dairy cattle. This methodology was altered (by request of Auckland Council's Coastal and Water Allocation team) moving to allow for a split between dairy (milking) and dry stock values, instead of applying the dairy cattle water quantities for all cattle.

As bore depth was unknown for the assumed bores, there was a series of steps followed to assign each farm to an aquifer:

1. If farm overlaid 1 single aquifer = assign this aquifer
2. If farm overlaid 1 deep and 1 shallow aquifer = assign the shallow aquifer
3. If farm overlaid 2 or more shallow aquifers = assign sand aquifer if it exists, otherwise alphabetically
4. If farm overlaid 2 or more deep aquifers = assign alphabetically

The script appeared to differ to what was described in the memo. DD tagged land parcels from cadastral (CRS) data with rural land use from the unitary plan zones (*ZONENAME)*. It used *B_Bore_w_aquifer* (from CC), to identify land parcels and dwellings with a bore. It then added in data from the *StockwaterBasemap* and average household count (from Meshblock data) to calculate *SiteWaterNeeds* for sites with bores.

2.3.6 Total Groundwater Take Allocation (Script EE)

This fifth script brought together all the intermediate datasets that had been calculated and applied them to the filtered bore dataset. The memo stated that layers *B_Bore_Aquifer*, *Site_Water_Needs*, and *BaseZone* (CRS parcels attributed with Unitary Plan (UP) information) were intersected and *EE_GroundwaterTakes_143b_bores* was the output. This layer has domestic and stock water usage calculated for land parcels, applied to the filtered bores.

This output water needs for parcels with bores. It used *SiteWaterNeeds*, which had been generated from CRS parcels and *B_Bore_w_Aquifer*, to generate *E_GroundwaterTakes_143b_bores* as the output.

The script also output data for sites with no bores: it took the *StockwaterConsumptionBasemap*, identified HPEG, added site water needs, aquifer, and number of dwellings from *CRS_Parcels*. It then tested to see if there was a bore identified on that property, and eliminated it, if there was. The output was *FarmParcelsNoBores*.

2.3.7 Total Water Needs (Script FF)

This script aggregated the results from earlier outputs, and output an excel file summary of bore data aggregated by:

1. AQUIFERGEOLOGY
2. AQUIFERGROUPNAME
3. AQUIFERNAME
4. SUBAQUIFERNAME

The memo noted that the Agribase data model allowed for multipart polygons. These multipart polygons are a single database record with multiple polygons. To avoid double-counting when the polygons are disaggregated, the total stock count was divided by the total area of the individual polygon and spatially apportioned as a percentage of the total multipart polygon area.

The memo described that, to avoid double-counting of stock numbers derived from Agribase, where multiple bores exist on a single Agribase polygon, the total stock number was divided by the sum of bores located within the Agribase polygon. When using the LCDB stocking rate proxy method, polygon area * 2.83 stock units * 57.5l per day, was used to establish water usage where no Agribase data exists.

Daily volume totals were summed and multiplied by 365 to obtain annual extraction amounts. Units were converted from litres to cubic metres for a final output attribute called **Annual_Water_Take (Cubic Metres).**

It appears that the script combined *FF_14_3_B_Bores_Raw* (which appears to be the same information as *EE_ GroundwaterTakes_143b_bores*) with *FarmParcelsNoBores*, to give a final output, aggregated by aquifer.

The final datasets were *SiteWaterNeeds* (where there was a Section 14(3)(b) bore identified) and *FarmParcelsNoBores* (where there was no Section 14(3)(b) bore).

2.4 Data Issues

2.4.1 Agribase

There were found to be several issues with Agribase data that affected the previous attempts to estimate Section 14(3)(b) water use:

- There were multiple duplicate polygons. Overlying polygons had new farm IDs, and were probably not easy to identify.
- The dates of records varied, from 1999 to 2015. Inevitably, there will have been changes in land use and stock numbers between the earlier dates and 2016, when this dataset was generated.
- One multi-part polygon was AK0001, which is Department of Conservation (DOC) estate land. This accounted for 33,914ha of land, and was exploded into 190 individual properties. The total stock numbers were then distributed between each of the individual properties. This is unlikely to have reflected the actual stock distribution across DOC land.
- Some results appear anomalous, for example, one 11 ha farm had 90 beef cows identified on Agribase, implying a very high stocking rate.

2.5 Issues With Results

The following are broad issues identified with some of the results.

2.5.1 Script BB – Water Needs

- As previously described, the stock water requirements may not be realistic, though it is acknowledged that the actual stock water use will always be an estimate. The extent to which this will affect the numbers depends on the overall stock numbers.
- Only dairy cattle were attributed to non-Agribase polygons, and sheep and beef were not included on HPEG. There is virtually no mapped low producing grassland and given there is substantial sheep and beef farming across the region, it is reasonable to assume that this is on HPEG

2.5.2 Script DD – Site Water Needs (No bores)

Assessment of the outputs from DD suggested there were some anomalies:

- Included residential, commercial, and industrial areas under the identified *ZoneName* (derived from the Unitary Zone). Some polygons also had stock water needs identified.
- Some of these were residential polygons but had no domestic water needs identified.

The reasons for these anomalies were not investigated in detail.

2.5.3 Script EE – Water Needs (With bores)

There appeared to be numerous anomalies in the output of *Farm_Parcels_No_Bores*. These included no identified water use for land parcels where water use would have been expected, and vice versa. Issues included:

- Total water use under _total_water_needs_per_site did not appear to be correct. That is, _stock_drinking_water plus _domestic_water_needs did not add up to _total_water_needs_per_site.
- Some polygons had a domestic requirement of zero even when CRS_Parcels indicated a dwelling should be present and vice versa.
- The StockwaterConsumptionBasebmap appeared to have overlapping polygons, probably carried through from Agribase. These may have been carried through to FarmParcelsNoBores.
- There were some areas of HPEG that were not covered by FarmParcelsNoBores or SiteWaterNeeds.

The reasons for these anomalies were not investigated in detail.

3 NEW APPROACH

3.1 Introduction

There had been queries about the numbers derived from the existing approach. A new approach was developed, still using FME, redeveloping the scripts with new assumptions and inputs as necessary. A key difference was that Auckland Council no longer hold a licence for Agribase. The new approach used agricultural census data to estimate animal drinking water use, which on a broad scale should accurately reflect stock numbers.

The previous approach assumed every land parcel had a dwelling. The new approach uses rating assessment data to identify land parcels with a dwelling. It also assumes a standard number of people at each dwelling, rather than relying on census data.

3.2 New Approach

3.2.1 Script A

Script AA, to extract bores that had a possible Section 14(3)(b) take, was redeveloped to simplify the approach. There are two main components.

3.2.1.1 Refining the bores from the master database and old consents database

Similar to the original approach, the OAS consent information was used (old bore database). The OAS_ALL_BORES data are filtered by activity description, bore use, site name, purpose, and land use, in order to create a subset that are not industrial, mining, water quality, etc, and could be Section 14(3)(b) bores. The final step of the initial processing is to assign an attribute, according to Bore_Use_Category description, such that the records are marked as 'Drinking/Non specified', 'NonDrinking', or blank (if the bore activity status was identified as being backfilled, decommissioned or never drilled, no Bore_Use_Category is entered). No bores are removed, but the non drinking bores are not used to estimate water use.

Separately, the consents data is processed (bore and water take consents), to remove any cancelled or surrendered consents. The databases *CONS_W_BORES* and *CONS_W_TAKES* are assessed and any cancelled or surrendered water take consents are dropped. The bore data from *OAS_ALL_BORES* is then joined with the outputs from the consented takes and *PA_BORES*, and *PA_TAKES*. If a bore is identified within the consent data as being a bore with a consent to take water, it is marked as a 'No" in the _RMA_S42_3_b field. That is, if there is a matching ID that is a consented water take, it is removed from possible Section 14(3)(b) bores.

The bores are then tested spatially against the output from the *OAS_ALL_BORES* output, and if any bores with a consent to take water are within 0.5m of each other, it is assumed that these are the same bore. In this case, the bore is given an indicator that it is not a Section 14(3)(b) bore. The remaining bores are given an indicator that they may be Section 14(3)(b) bores, but only if they also have a bore use category of Drinking or Not specified.

3.2.1.2 Identifying bore installation consents and abstraction consents

The SAP consents database has been in operation since 2018/19. Prior to this, these data were non-spatial and maintained by different regional offices. To deal with these data, the script reads spatial Auckland property data from the SDE, and retains the property ID.

Separately, there is a manual download of SAP records from NewCore (consents data), to which the script adds new attributes: Bore_consent_status, and Bore_DataSource (which is identified as SAP). In order to extract bore permits that may have been to drill bores that could be Section 14(3)(b) drinking water bores, the script assesses whether there are words such as stock, domestic, drinking or residential in the application detail field (Bore_Use_Category). If the test passes, then the consent is identified as having a possible Section 14(3)(b) bore, and the bore use category is given as Drinking/Non-specified. The consents that do not pass this test, are further tested for non-drinking water uses, such as investigation, industry, etc. If they pass this test, they are identified as non-drinking water; otherwise they are identified as possibly being Section 14(3)(b) bores, and identified as Drinking/NonSpecified.

The SAP records are then merged with the Auckland property data, based on the property ID, such that the bore consents data have spatial properties. The polygons are then used to test whether processed bores from Section **Error! Reference source not found.** overlap with the bore consent polygons. If so, then the bores will be marked as consented bores to avoid double-counting. All unmatched polygons are then converted to inside points with SAP attributes, and added to the processed bore database.

The output is a geodatabase file: *AA_Filtered_OAS_ALL_BORE*

The processing logic is shown diagrammatically in Figure 1.

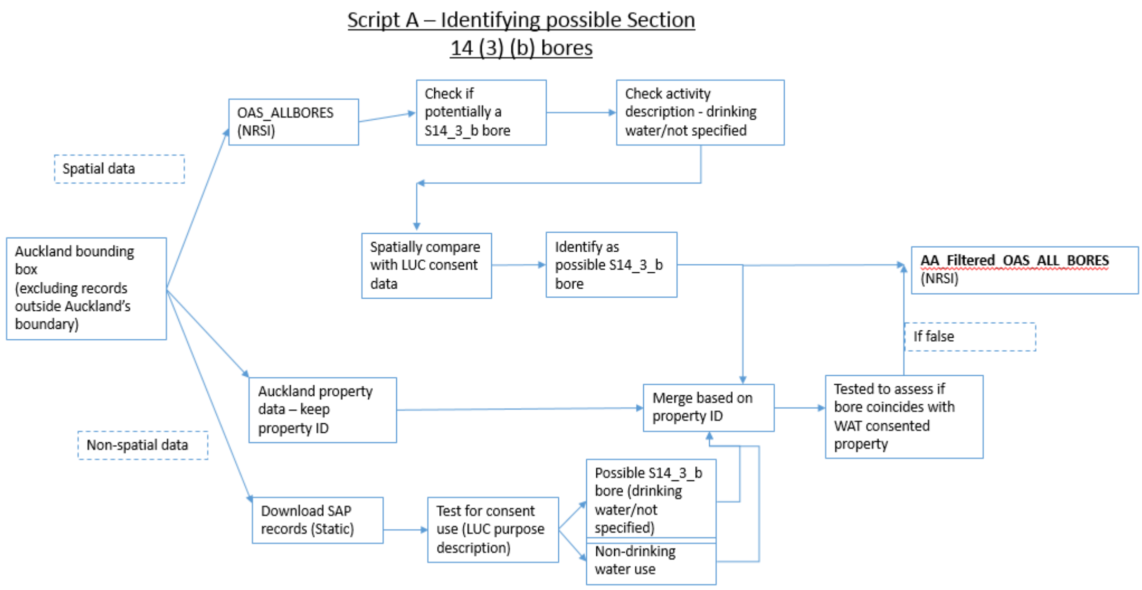

Figure 1. Processing logic for identifying potential Section 14(3)(b) bores

3.2.2 Script B – Stock and Domestic Water Use Requirements

Using the ratings assessment (*RA_Footprint*) data, the following land uses were extracted:

- 'DAIRYING'
- 'MULTI-USE WITHIN LIFESTYLE'
- 'MULTI UNIT - LIFESTYLE'

- 'STOCK FINISHING'
- 'SINGLE UNIT – LIFESTYLE
- 'VACANT - LIFESTYLE'
- 'VACANT- RURAL'
- 'MULTI-USE WITHIN RURAL'

The following were excluded based on an assumption that the water use would require resource consent:

- STORE LIVESTOCK: Assuming that livestock storage would probably be intensive stock storage, for example, for meat works, and that reasonable quantities of water would be needed, this would need a consent to take water[5].
- SPECIALIST LIVESTOCK
- MARKET GARDENS

Assuming that any HPEG on these blocks would be used to support farming, the HPEG was clipped with the RA property types listed above.

The issue then was to allocate different livestock types, and numbers to different areas. This can be used with the HPEG/RA approach, to refine the livestock numbers. To do this, the HPEG/RA layer was intersected with the Agricultural Census layer (APS data, see Section 1.2**Error! Reference source not found.**), to define the number of dairy, beef, or sheep, based on the census stock density data. By filtering out only the HPEG, this takes into account the fact that a rural property might have other land cover on parts of it, for example, forest, kanuka or arable.

The overall numbers for each census polygon could not just be applied to the farms identified across the polygon, as the numbers are an average for the whole area, not just the HPEG on properties that are identified as having a rural land use. In addition, there are numerous census polygons that extend outside of the Auckland region. As a result, the following processing had to be carried out:

- Summarise the total area of HPEG/RA properties in each census polygon, and work out the proportion of each farm relative to the area of the census polygon. The total livestock numbers can then be allocated only to the areas of HPEG on rural land uses.
- Determine the proportion of the census polygon that falls within the Auckland region, and take this into account in terms of the total livestock numbers that are attributable to the Auckland area.

Then the estimated numbers of livestock are based on, for each census area:

- (Density* total area of the census sub-polygon that falls within the Auckland Region/Total area of HPEG/RA polygons) * Area of individual properties

There are a number of small polygons that are unlikely to have livestock. Based on an arbitrary upper limit of 3 dairy cows/ha, any property that had an area of less than 0.3 ha (3,000 m^2), (i.e. one cow), was subsequently excluded.

Based on this approach, the density of dairy cows works out at less than 3/ha, which appears reasonable given the guideline values (LIC, 2009).

Poultry use was more difficult to estimate, as poultry was not included in the agricultural census data. The approach taken was to use consented discharge data, to identify poultry farms with a consent to discharge to air. Building footprint data were obtained from LINZ, and the consents and building footprints were overlaid to identify buildings where there was a poultry farm. The numbers of poultry

[5] It is unclear as to whether existing consents exclude an amount for stockwater use.

were calculated based on the building size (20 birds/m^2), and the water requirements calculated based on this.

Pig farms posed a great problem. In the absence of Agribase data, there was no simple approach to determining Section 14(3)(b) takes for these. The consents team advised that there were only two regional scale pig farms in the region, and these were well understood in terms of the location and supply aquifer for each. Apart from these, it was not possible to account for Section 14(3)(b) takes.

There was contradictory information about whether household would rely on rainwater collection or be more likely to install a bore for drinking water. Comments from the Glenbrook Kaawa S14 use memo (Stephen Crane, 2020) suggested that as few as 5% of households get their supply from bores, and so the approach taken was that domestic supply would be from rainwater, unless the property had a bore and the bore was identified as being for domestic use.

Based on average annual rainfall of 1.3m/year, and an average house roof area of 200 m^2, individual houses/properties would collect 260 m^3/year of rainwater. Based on a very general assumption of 150 l/p/day, and average of 3 people per household, yearly requirements for domestic consumption would be 164 m^3/year. There would therefore be little leeway if there was a dry year, to allow for stockwater consumption from rain water, as the majority of the collected water would be needed for household use. Therefore, it was assumed that roof water was the most likely source (in most cases) for a domestic supply, but that stock needs would require a groundwater source.

The output is the geodatabase, BB_Water_Usage_Output, plus the Water_Usage spreadsheet. Both average annual demand and peak annual demand were calculated.

The processing logic is shown diagrammatically in Figure 2.

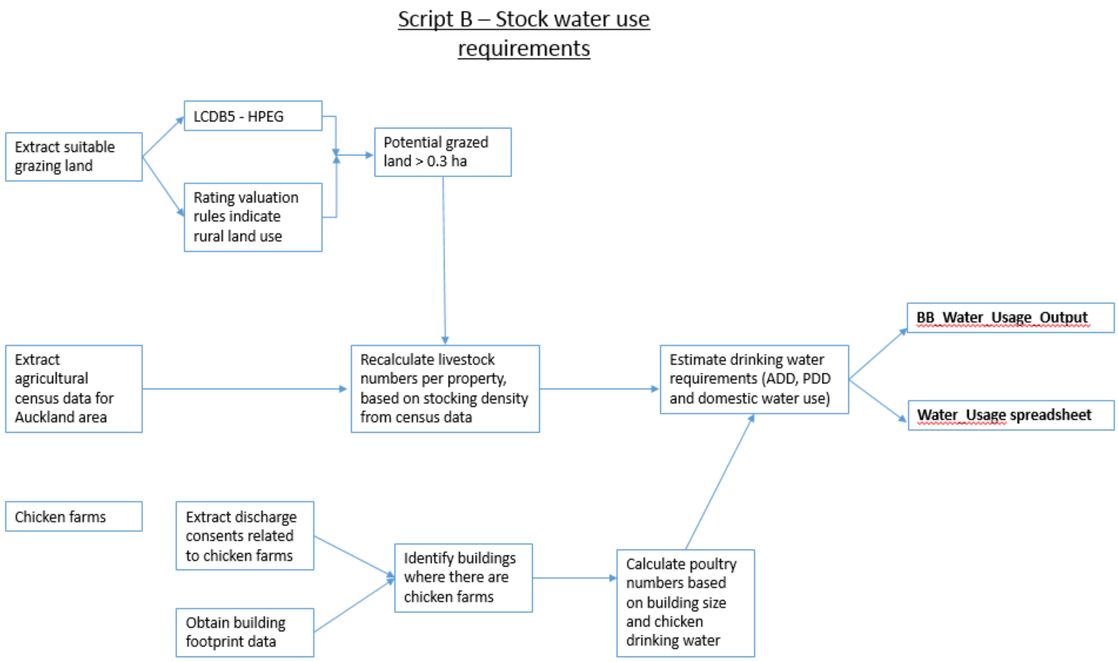

Figure 2. Processing logic for determining stock water use requirements

3.2.2.1 Future considerations

Future updates/assessments should consider the following:

- LCDB geodatabase: future updates should use either council SDE or Landcare data.
- Rating assessment data should align with live information captured in the SDE/SAP.

- Livestock numbers from Ministry for the Environment (2017) should be updated as more recent information becomes available.

3.2.3 Script C - Aquifer Assignment.

Script C attributes aquifers to the bores identified in A. The first step is to create the aquifer layer. The approach was similar to the previous approach taken, and was discussed with Kolt Johnson (Auckland Council Groundwater Scientist), to ensure that it took into account the likely aquifers being used. The aquifers were identified and put in depth order[6], as follows:

0 - Sand

1 - Volcanic

2 - Kaawa

3 - Waitakere Group

4 - Waitemata

5 - Greywacke

6 - Geothermal

The assumption was that where there was more than one aquifer, the Section 14(3)(b) bores would access the least deep water body, unless the bore depth was greater than 150 m, in which case it would access the deeper aquifer. The bores identified in Script A were then overlaid with the disaggregated aquifer layer, and attributed to an aquifer.

The script created a "flattened" aquifer layer, where it outputs a layer with only the shallowest aquifer. This was required for the land parcels with no identified bores, which were assumed to access only the shallowest aquifer.

The processing logic is shown diagrammatically in Figure 3.

[6] Note that order of geologic units is not consistent across the entire Auckland region, but a generalised order was chosen which would be most appropriate for use in the model.

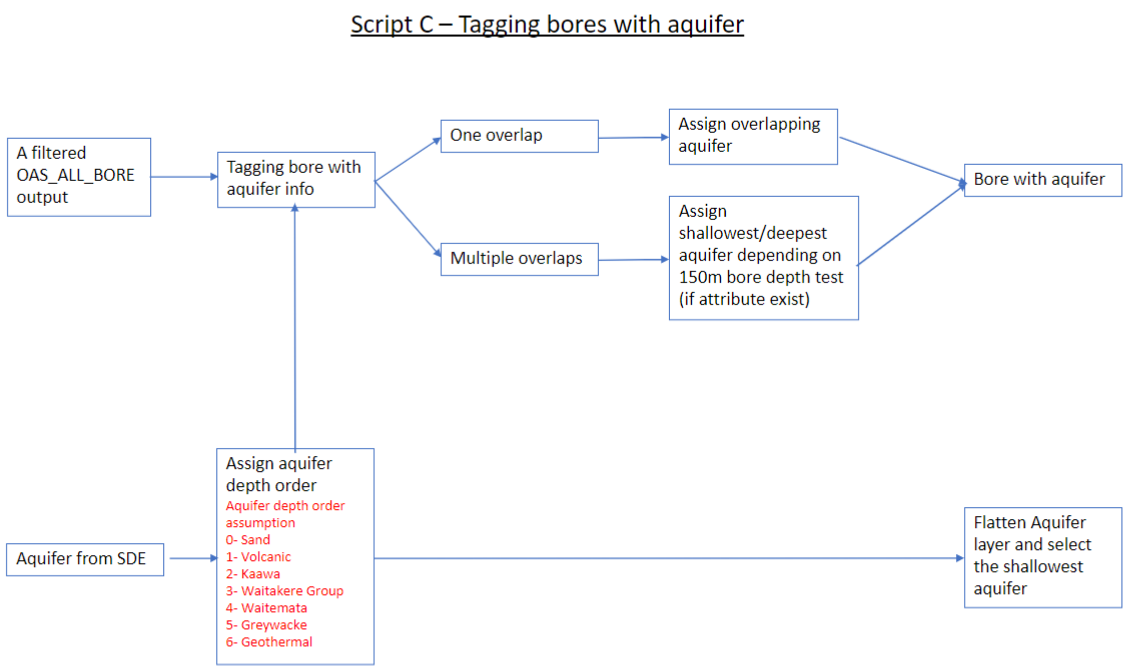

Figure 3. Processing logic followed for aquifer assignment

3.2.4 Script D - Site Water Needs.

The script takes the bores, attributed with aquifers, from CC, and allocates each bore to a local board area. The bores are intersected with the output from BB (water usage), and the bore water take calculated. The bores that are outside of HPEG/RA land parcels are tagged as being non-grazing use. For some land parcels, there is more than one bore. The bores are filtered to ensure they are being used for domestic or stock (from Script AA). The water needs for the land parcel are then "pro-rated" between the bores, including domestic needs, if the bore has been identified as a domestic take. The data are then merged with the non-pro-rata bores, the aquifer identified, and the total takes calculated for each bore.

There are numerous land parcels without a potential bore identified. In these cases, a randomised inside point of the land parcel (derived in Script BB) was used to identify a likely bore. The points were overlaid on the flattened aquifer layer, in order to identify the shallowest likely aquifer. The stock water needs were attributed to that aquifer and the results calculated.

The processing logic is shown diagrammatically in Figure 4.

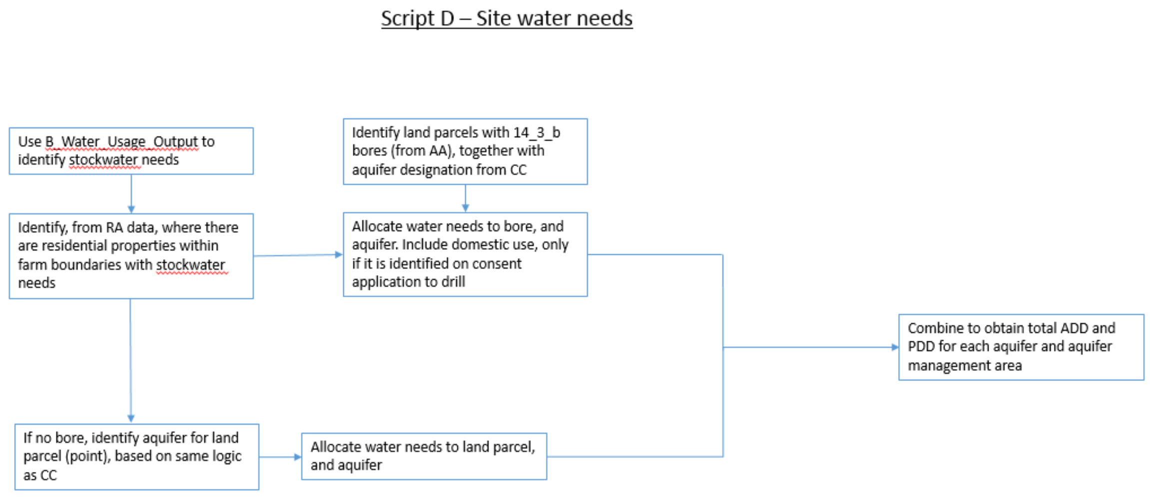

Figure 4. Processing logic for site water needs

3.3 Quality Assessment and Quality Control

A process of quality assessment and quality control was followed, in order to check that outputs were as expected, that is the code performed as expected based on the logic followed. This included:

- Manual duplication of FME processing steps, to ensure that the scripts produced the expected results. For example, determining the expected stock numbers for polygons based on the logic developed, and ensuring that the numbers were replicated in the script calculations.
- Qualitative checking of outputs to ensure that estimated numbers were realistic.
- Investigating any empty fields to ensure that there was no entry for a valid reason.
- Investigating any estimates that appeared anomalously high.

As a result of this process, the scripts were modified as needed throughout the process, until we were satisfied that the outputs were as expected.

3.4 Limitations/Uncertainties

Even with this approach, there are still numerous limitations and uncertainties in the outputs.

- Animal water consumption rates (l/h/day) are an average across NZ and will be affected by climate, milking cycles, and animal species. They will also vary according the actual climatic conditions: consumption would be less during colder seasons, compared with warmer seasons. The ADD figure should allow for seasonal variation, but PDD could be used for peak water use in the summer.
- The use of census data to attribute stock numbers is very coarse, and will never be correct. It assumes that, over a polygon of up to around 345 km^2, all properties will have the same density of livestock. This cannot be true, but the data are the most recent, and most likely to be correct at a broad scale. The other issue with the data, is that it will allocate dairy cows to lifestyle blocks. Again, this is unlikely to be true. If needed, the numbers could be adjusted downwards to reflect the fact that any cows on lifestyle blocks will be drystock, but this should be considered on a case

by case basis, depending on the area/aquifer being assessed. The only solution would be to have actual livestock numbers per property, but even with Agribase data this would never be correct.

- The approach to estimating poultry numbers is very coarse, but again as good as can be achieved with the available data.
- The assumption that all land identified as being HPEG on rural land use is used for grazing livestock will over-estimate numbers on HPEG. The assumption that low producing grassland isn't used will offset this.
- Using ratings assessment data to identify properties that might be used for grazing will have limitations. For example, multi-uses within rural, may not include livestock grazing.
- The assumption is that groundwater is only taken for domestic use if there is a bore permit or information that links a bore to domestic supply. There may be other bores that are used for domestic supply, but the assumption is that there are not, and that roof water is used instead.
- There may be some Section 14(3)(b) takes that have daily volumes in excess of the Section 14(3)(b) activity volume, thus requiring a resource consent as per the Auckland Unitary Plan. The model results could be queried to provide an estimate of the scale of this issue.

4 RESULTS AND RECOMMENDATIONS

The results are tabulated in Appendix A for average daily demand (ADD m^3/year). The numbers are considerably lower than those estimated using the previous approach, and it might be useful to check sample areas, with ground-truthed data, to assess the results.

It should be noted that, although both dairy drystock and milking numbers have been calculated (both being based on the number of dairy cows on a property), we have used the milking annual demand to estimate the total, as the annual demand should include both periods when cows were in milk, and when they were dry.

4.1 Recommendations

Recommendations for further work include:

- Carry out surveys to check model results for areas against actual numbers. Given drinking water regulatory changes, including the need to register small suppliers (supplying water to more than one dwelling), there may be opportunity to gather information for multiple purposes.
- It is unclear as to whether existing consents exclude an amount for stockwater use. This should be investigated as it will potentially affect the results. It has been assumed that, if a property has an existing consent, it will not be taking water under Section 14(3)(b).

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LIC (2009): *New Zealand Dairy Statistic 2008-2009.* Livestock Improvement Corporation.

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Appendix A: Annual average demand

AMA	Estimated animal drinking needs (m^3/yr)	Estimated reasonable domestic drinking needs (m^3/yr)	Sum of domestic and stock
Albert Park Volcanic	0	0	0
Araparera Waitemata	63,604	1,201	64,805
Auckland Domain Volcanic	0	0	0
Auckland Isthmus Waitemata	0	537	537
Awhitu Sand	328,668	2,376	331,044
Awhitu Waitemata	19,374	894	20,268
Beachlands Greywacke	1,035	694	1,729
Beachlands Waitemata	611	2,202	2,813
Bombay Drury Sand	94,704	5,621	100,325
Bombay Volcanic	26,218	1,022	27,240
Bombay West Waitemata	15,593	409	16,001
Clevedon East Sand	28,119	1,559	29,678
Clevedon East Waitemata	1,234	0	1,234
Clevedon West Sand	73,594	460	74,054
Clevedon West Waitemata	3,281	281	3,562
East Coast Bays Waitemata	7,987	2,104	10,091
East Tamaki Waitemata	22,437	2,785	25,222
Franklin Southwest Waitemata	3,203	460	3,663
Glenbrook Kaawa	108,781	4,505	113,287
Glenbrook Volcanic	99,591	2,776	102,368
Great Barrier Island Greywacke	5,114	0	5,114
Great Barrier Island Volcanic	2,390	1,022	3,412
Hampton Park-Green Hill Volcanic	0	0	0
Helensville Waitemata	6,279	460	6,739
Henderson Waitakere Group	64,143	51	64,194
Henderson Waitemata	4,149	153	4,302
Hoteo Waitemata	389,816	2,427	392,243
Hunua East Greywacke	83,285	1,559	84,843
Hunua Wairoa Greywacke	125,313	4,420	129,733
Hunua West Greywacke	50,419	1,107	51,526
Kaipara Sand	320,551	4,561	325,112
Karaka Waitemata	38,156	2,274	40,430
Kaukapakapa Waitemata	83,795	1,712	85,507
Kawau Island Greywacke	0	332	332
Kumeu East Waitemata	81,914	14,385	96,298
Kumeu Waitakere Group	51,716	1,661	53,377
Kumeu West Waitemata	54,729	3,960	58,690
Lower Kaipara Waitemata	50,147	2,351	52,498

Mahurangi East Waitemata	21,489	2,564	24,053
Mahurangi Waitemata	29,008	1,840	30,847
Mahurangi West Waitemata	38,447	2,564	41,010
Makarau Waitemata	80,659	1,993	82,652
Mangere-Manurewa Kaawa	0	0	0
Manukau City Waitemata	7,614	51	7,665
Manukau North Waitemata	0	0	0
Manukau Southeast Kaawa	34,141	77	34,218
Maraetai Greywacke	13,463	852	14,315
Matakana Waitemata	43,696	4,573	48,269
Motutapu Island Greywacke	0	0	0
Mt Eden Volcanic	0	26	26
Mt Mangere Volcanic	0	0	0
Mt Richmond Volcanic	0	0	0
Mt Roskill-Mt Albert Volcanic	0	0	0
Mt Wellington Volcanic	0	0	0
Muriwai Waitemata	1,589	677	2,266
Newmarket Volcanic	0	51	51
North Head-Mt Victoria Volcanic	0	0	0
Okahukura Sand	23,087	256	23,342
Okahukura Waitemata	49,443	639	50,081
Omaha Greywacke	685	732	1,417
Omaha Sand	14,936	6,379	21,315
Omaha Waitemata	403	77	479
Onehunga Volcanic	0	0	0
Onepoto-Pupuke Volcanic	0	26	26
Orewa North Waitemata	15,442	792	16,234
Orewa Waitemata	19,572	894	20,466
Otuataua Volcanic	14,549	153	14,703
Paerata Waitemata	11,343	3,177	14,519
Pakiri Waitemata	118,822	2,070	120,892
Papakura Greywacke	16,966	1,022	17,988
Papakura Sand	10,740	1,337	12,077
Papakura West Waitemata	1,379	1,192	2,571
Paremoremo Waitemata	20,933	1,252	22,185
Port Albert Waitemata	200,528	179	200,707
Pukekiwiriki Volcanic	0	0	0
Pukekohe Central Volcanic	4,569	307	4,876
Pukekohe Kaawa	105,428	6,268	111,697
Pukekohe North Volcanic	20,309	996	21,305
Pukekohe South Volcanic	10,093	358	10,451
Pukekohe West Volcanic	41,471	818	42,289
Puketutu Volcanic	0	0	0
Rangitopuni Waitemata	78,868	2,555	81,423
South Kaipara Waitemata	538	77	614
Tawharanui Greywacke	654	1,431	2,085

Te Arai Greywacke	9,757	307	10,064
Te Henga Waitemata	265	128	393
Te Hihi North Waitemata	47,436	6,549	53,986
Te Hihi South Waitemata	7,941	920	8,861
Te Puru Greywacke	2,158	307	2,465
Te Puru Waitemata	6,820	409	7,228
Three Kings Volcanic	0	0	0
Ti Point Volcanic	391	153	544
Tomarata Waitemata	43,513	434	43,947
Waiau Pa Waitemata	44,400	3,373	47,773
Waiheke Central East Greywacke	9,922	1,635	11,557
Waiheke Central West Greywacke	3,008	5,987	8,995
Waiheke East Greywacke	6,747	0	6,747
Waiheke West Greywacke	2,010	2,257	4,267
Waimauku Waitemata	774	434	1,209
Waitakere Volcanic	11,542	715	12,258
Waitakere Waitemata	134	51	185
Waiuku Kaawa	13,424	0	13,424
Whangaparaoa Waitemata	2,239	3,040	5,280
Whitford Greywacke	5,434	3,679	9,113
Whitford Waitemata	19,416	2,474	21,890
Wiri-McLaughlins Volcanic	0	0	0
Grand total	**3,598,144**	**153,423**	**3,751,567**

AMA	Animal needs from bores	Animal needs no bores	Domestic needs from bores	Sum (m^3/year)
Albert Park Volcanic	0	0	0	0
Araparera Waitemata	18,633	44,972	1,201	64,805
Auckland Domain Volcanic	0	0	0	0
Auckland Isthmus Waitemata	0	0	537	537
Awhitu Sand	87,755	240,912	2,376	331,044
Awhitu Waitemata	19,374	0	894	20,268
Beachlands Greywacke	1,035	0	694	1,729
Beachlands Waitemata	224	387	2,202	2,813
Bombay Drury Sand	50,192	44,512	5,621	100,325
Bombay Volcanic	6,949	19,269	1,022	27,240
Bombay West Waitemata	15,593	0	409	16,001
Clevedon East Sand	8,052	20,067	1,559	29,678
Clevedon East Waitemata	0	1,234	0	1,234
Clevedon West Sand	1,743	71,851	460	74,054
Clevedon West Waitemata	2,085	1,196	281	3,562
East Coast Bays Waitemata	446	7,541	2,104	10,091
East Tamaki Waitemata	36	22,400	2,785	25,222
Franklin Southwest Waitemata	3,093	111	460	3,663
Glenbrook Kaawa	66,387	42,394	4,505	113,287
Glenbrook Volcanic	62,627	36,965	2,776	102,368
Great Barrier Island Greywacke	0	5,114	0	5,114
Great Barrier Island Volcanic	274	2,117	1,022	3,412
Hampton Park-Green Hill Volcanic	0	0	0	0
Helensville Waitemata	1,981	4,298	460	6,739
Henderson Waitakere Group	104	64,039	51	64,194
Henderson Waitemata	4,149	0	153	4,302
Hoteo Waitemata	103,088	286,728	2,427	392,243
Hunua East Greywacke	19,072	64,213	1,559	84,843
Hunua Wairoa Greywacke	48,963	76,350	4,420	129,733
Hunua West Greywacke	13,798	36,621	1,107	51,526
Kaipara Sand	145,819	174,732	4,561	325,112
Karaka Waitemata	28,802	9,355	2,274	40,430
Kaukapakapa Waitemata	8,102	75,693	1,712	85,507
Kawau Island Greywacke	0	0	332	332
Kumeu East Waitemata	9,962	71,951	14,385	96,298
Kumeu Waitakere Group	11,590	40,126	1,661	53,377
Kumeu West Waitemata	54,729	0	3,960	58,690
Lower Kaipara Waitemata	12,169	37,978	2,351	52,498
Mahurangi East Waitemata	10,457	11,032	2,564	24,053
Mahurangi Waitemata	6,504	22,503	1,840	30,847
Mahurangi West Waitemata	8,169	30,278	2,564	41,010
Makarau Waitemata	14,248	66,411	1,993	82,652
Mangere-Manurewa Kaawa	0	0	0	0
Manukau City Waitemata	7,563	50	51	7,665

Manukau North Waitemata	0	0	0	0
Manukau Southeast Kaawa	8,000	26,141	77	34,218
Maraetai Greywacke	3,972	9,491	852	14,315
Matakana Waitemata	21,245	22,451	4,573	48,269
Motutapu Island Greywacke	0	0	0	0
Mt Eden Volcanic	0	0	26	26
Mt Mangere Volcanic	0	0	0	0
Mt Richmond Volcanic	0	0	0	0
Mt Roskill-Mt Albert Volcanic	0	0	0	0
Mt Wellington Volcanic	0	0	0	0
Muriwai Waitemata	1,589	0	677	2,266
Newmarket Volcanic	0	0	51	51
North Head-Mt Victoria Volcanic	0	0	0	0
Okahukura Sand	9,891	13,196	256	23,342
Okahukura Waitemata	27,195	22,247	639	50,081
Omaha Greywacke	685	0	732	1,417
Omaha Sand	5,581	9,355	6,379	21,315
Omaha Waitemata	362	41	77	479
Onehunga Volcanic	0	0	0	0
Onepoto-Pupuke Volcanic	0	0	26	26
Orewa North Waitemata	2,213	13,229	792	16,234
Orewa Waitemata	1,298	18,274	894	20,466
Otuataua Volcanic	2,503	12,046	153	14,703
Paerata Waitemata	11,343	0	3,177	14,519
Pakiri Waitemata	30,874	87,948	2,070	120,892
Papakura Greywacke	7,551	9,416	1,022	17,988
Papakura Sand	5,541	5,199	1,337	12,077
Papakura West Waitemata	1,362	18	1,192	2,571
Paremoremo Waitemata	971	19,962	1,252	22,185
Port Albert Waitemata	5,862	194,667	179	200,707
Pukekiwiriki Volcanic	0	0	0	0
Pukekohe Central Volcanic	1,070	3,500	307	4,876
Pukekohe Kaawa	64,334	41,094	6,268	111,697
Pukekohe North Volcanic	14,057	6,251	996	21,305
Pukekohe South Volcanic	2,045	8,048	358	10,451
Pukekohe West Volcanic	22,418	19,054	818	42,289
Puketutu Volcanic	0	0	0	0
Rangitopuni Waitemata	7,460	71,408	2,555	81,423
South Kaipara Waitemata	538	0	77	614
Tawharanui Greywacke	650	3	1,431	2,085
Te Arai Greywacke	9,757	0	307	10,064
Te Henga Waitemata	265	0	128	393
Te Hihi North Waitemata	28,767	18,670	6,549	53,986
Te Hihi South Waitemata	7,798	143	920	8,861
Te Puru Greywacke	2,158	0	307	2,465
Te Puru Waitemata	1,775	5,045	409	7,228

Three Kings Volcanic	0	0	0	0
Ti Point Volcanic	117	274	153	544
Tomarata Waitemata	25,798	17,715	434	43,947
Waiau Pa Waitemata	24,180	20,220	3,373	47,773
Waiheke Central East Greywacke	1,367	8,555	1,635	11,557
Waiheke Central West Greywacke	344	2,664	5,987	8,995
Waiheke East Greywacke	0	6,747	0	6,747
Waiheke West Greywacke	816	1,195	2,257	4,267
Waimauku Waitemata	564	210	434	1,209
Waitakere Volcanic	114	11,429	715	12,258
Waitakere Waitemata	134	0	51	185
Waiuku Kaawa	7,670	5,753	0	13,424
Whangaparaoa Waitemata	2,239	0	3,040	5,280
Whitford Greywacke	4,702	731	3,679	9,113
Whitford Waitemata	6,972	12,445	2,474	21,890
Wiri-McLaughlins Volcanic	0	0	0	0
Grand total	**1,239,911**	**2,358,233**	**153,423**	**3,751,567**