Environment Waikato Technical Report 2007/47

A Model for Assessing the Magnitude of Unconsented Surface Water Use in the Waikato Region:

– Permitted activities under the Waikato Regional Plan
– S14(3)(b) activities under the Resource Management Act

www.ew.govt.nz
ISSN 1172-4005 (Print)
ISSN 1172-9284 (Online)

Environment Waikato
REGIONAL COUNCIL

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4 September 2007

Document #: 1219787

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Acknowledgements

The Waikato Regional Council would like to thank Bob Rout for his comments on this report. The council would also like to acknowledge NIWA for the development of the River and Environment Classification used in this report and the following district councils who provided information and water use data for the seven rural water supply schemes used in this report:

- Franklin District Council
- Thames-Coromandel District Council
- Otorohanga District Council
- Rotorua District Council.

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Executive summary

The Waikato Regional Council has developed a model for predicting the peak summer permitted and s14(3)(b) surface water use. The Waikato Regional Council needs this model to effectively manage water allocation and establish whether there are, or are likely to be adverse effects on the environment. The model takes the number of animals and people within a catchment and multiplies these figures by determined rates of use for key animal types and individual's domestic needs based on water use estimates from published information, commonly used estimates or local information. The model's accuracy was tested against measured water use data from seven rural water supply schemes in the region.

Water use for dairy farming was found to have the most influence on model predictions. This was not surprising due to the high density of dairy cows in the region and the large volumes of drinking water required by lactating cows and the large volumes of water required for dairy shed operations.

The relative water demand from permitted and s14(3)(b) activities in relation to the allocable flow was assessed in 202 catchments. In 35 of the catchments more than 50 percent of the allocable flow is taken for these activities alone, and in 16 of these the use exceeds the allocable flow. When consented authorised water takes are included with the permitted and s14(3)(b) takes, there are 77 catchments with more than 50 percent of the allocable taken and of these, in 41 catchments the use exceeds the allocable flow.

If intensification of dairying continues, the amount of animal drinking water required will for the most part increase without restrictions due to the high priority it is afforded by s14(3)(b) of the RMA. In many catchments this may result in nearly all the allocable flow being utilised solely for s14(3)(b) animal drinking water purposes. In these catchments capping the permitted use at 15 m^3/d as required by the Waikato Regional Plan will do little to relieve the situation where water use exceeds the allocable flow. Additional policy would be needed to control water take effects.

The high level of permitted and s14(3)(b) water use in a number of catchments in the region exposes a limitation in the manner the RMA provides animal drinking water as right via s14(3)(b) and s30(4)(f) without consideration of the directly linked activities such as dairy shed operations. A solution may be to constrain the number of animals per catchment that can receive water as of right. The number of animals and the water demand for associated activities such as shed operations should not be allowed to exceed the available supply of suitable freshwater. A policy of this nature will, as a consequence, limit the ability for animal intensification in large parts of the region where the permitted and s14(3)(b) use including water allocated by resource consent is close to, or exceeds, the allocable flow. This will provide a better balance between the number of animals in each catchment and the availability of water to help secure supply and protect minimum flows.

Units

cows/ha	cows per hectare
ha	hectare
l/s	litres per second
l/d	litres per day
l/ha	litres per hectare
l/person/d	litres per person per day
l/cow/d	litres per lactating cow per day
l/cattle/d	litres per beef cattle per day
l/sheep/d	litres per sheep per day
l/deer/d	litres per deer per day
m^3	cubic metres
m^3/cow/d	cubic metres per cow per day
m^3/d	cubic metres per day
m^3/km/d	cubic metres per kilometre per day
SU/ha	Stock unit per hectare

1 Introduction

With increased land use intensification the cumulative amount of water taken, without need for resource consent, for animals may now be significant relative to other water uses and may endanger environmental bottom lines. Section 14(3)(b) of the Resource Management Act 1991 (RMA) allows fresh water to be taken or used for – an individual's reasonable domestic needs; or the reasonable needs of an individual's animals for drinking water – provided the taking or use does not, or is not likely to, have an adverse effect on the environment. In addition, the Waikato Regional Plan (WRP) authorises up to 15 m^3/d of surface water to be taken or used for any other activity as a permitted activity provided there are no adverse effects on the environment. This enables the use of water for low water demand activities, which may include the operation of some dairy sheds or small industries. Activities requiring more than 15 m^3/d require a resource consent, this includes activities such as irrigation, large industries or municipal water supplies.

As the permitted and s14(3)(b) activities do not require resource consent, there is little information available about the number of, location and amount of water used by these activities. This report presents a GIS model that enables the Waikato Regional Council to effectively manage water allocation and establish whether there are, or are likely to be, adverse effects on the environment from the taking of water for permitted and s14(3)(b) activities.

Since mid 2006, Waikato Regional Council has employed a GIS model to assess the amount of surface water used by permitted and s14(3)(b) water take activities. This model was developed to supplement the Waikato Regional Council's existing surface water allocation calculator (SWAC) which is used to manage resource consents for the taking of surface water. The permitted and s14(3)(b) water use model calculates the average daily water use associated with the month of highest summer use. This month corresponds with peak use by other water users (i.e. irrigators, industries and community water supplies) and demand pressures on surface water availability. The model calculates the water use as a cumulative total within specified surface water catchments in the SWAC. The model is not intended to provide information on the amount of water used on an individual property scale.

This report details the GIS model development and provides a summary of the regional surface water use by permitted and s14(3)(b) water take activities.

2 Model development

Permitted and s14(3)(b) water uses are largely for animal drinking water, dairy shed operations, individual's reasonable domestic needs[1] and small businesses that require less than 15 m^3/d to operate. The model presented in this report identifies the spatial location of key permitted and s14(3)(b) activities in the region and calculates the total water demand based on known values of water demand for these key activities.

The model calculates the permitted and s14(3)(b) water use by multiplying the number of humans or animals in a catchment by corresponding variables relating to how much water each uses. The accuracy of the information used in the model was tested by comparing the model predictions to that measured at seven rural water supplies. The water use within these schemes is typical of what would be expected from permitted or s14(3)(b) water takes, with the added benefit that it is measured.

[1] Permitted and s14(3)(b) household water does not include water supplied by a municipal or rural water supply network. The taking of this water requires resource consent.

This section of the report presents the various sources of information that are used in the model to predict the scheme water use. The three main areas of information are:

- measured water use data for each scheme
- information relating to the number of people and animals that would use water
- information relating to the likely amounts of water being used by people and the different animals.

2.1 Rural water supply schemes and associated water use activities

The seven rural water supply schemes listed below and shown in **Figure 1** were selected because the activities within these schemes are typical of permitted or s14(3)(b) water takes occurring elsewhere in the region. The seven selected schemes are as follows.

- Pokeno (Franklin District): Water taken from two sites – ground water and spring. The supplied area includes mainly residential and lifestyle rural properties. There is very little demand for animal water requirements.
- Buckland (Franklin District): Water taken from ground water source. The supplied area includes a residential area in the township plus a primary school, some light industry and commercial areas and also several rural properties outside the town.
- Matakoki (Thames-Coromandel District): A predominantly rural supply providing water to properties in the lower Hauraki Plains on the eastern side of the Waihou River.
- Arohena (Otorohanga District): The Arohena Water Supply Scheme comprises three takes supplying three sub-schemes: the Kahorekau, Taupaki and Huirimu. This analysis is only based on the Kahorekau sub-scheme as it has the most comprehensive data available. The Arohena Rural Water Supply Scheme is primarily intended to provide water for animals although there is some domestic use. There may also be some additional water use from individual takes that will not be accounted for by the water supply scheme data[2].
- Tihiroa (Otorohanga District): Rural water supply in the Waipa catchment. There may be some additional water use from individual takes that will not be accounted for by the water supply scheme data[2].
- Mihi (Rotorua District): A predominantly rural supply adjacent to the Reporoa rural water supply.
- Reporoa (Rotorua District): A residential and rural supply. This is a restricted supply with each property receiving an allocation of water based upon land use and area. A dairy factory in the area receives a special extra allocation of water during night hours, which it stores for use during the day[3]. In this report water use records for the factory were used to isolate its use from the scheme total water use.

[2] Personal communication from Jon Fields in email (EWDOCS# 1080710) – “Please remember that farms within these areas vary from dairy to dry stock and there has been a large swing from dry to dairy. Many of the farms have bore or creek takes which I suspect are unconsented.”

[3] www.rdc.govt.nz/Our+Services/Water/Water+Supplies+at+a+Glance/Individual+Supplies.htm#8

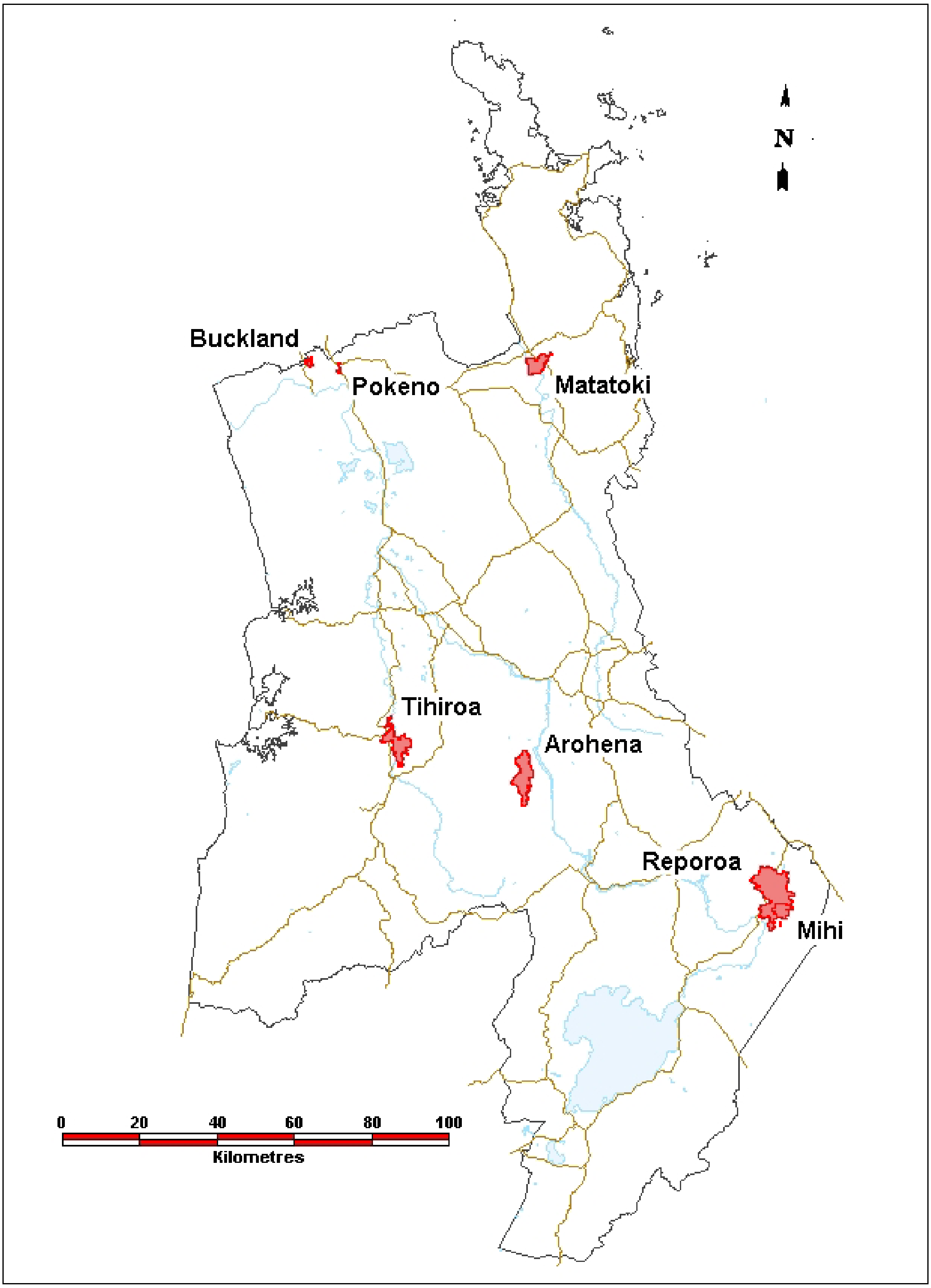


Figure 1: Location of the seven rural water supply schemes.

2.1.1 Scheme water use trends

The water use data for each scheme indicates how much water has been used to meet the demand of activities within the scheme. Water use records for the start of 2000 through to end of 2005 were collated and summarised by year and month to determine annual and seasonal demand trends (**Figure 2**). It is possible that some of the properties in each scheme may source additional water to that provided for by the scheme. A consequence of this is an under prediction by the model of the total water use within the area of the scheme.

All schemes' maximum water use is in either January or February (summer) and lowest use in June or July (winter). The seasonal variability from summer to winter is less for the two schemes dominated by domestic use (Pokeno and Buckland) compared to the other schemes which have higher levels of animal water use. All the schemes have variability in annual water use, but with a general trend of increasing use for the six years of data.

For each supply scheme the monthly average water use is given in **Figure 2**. The model is developed to calculate the typical summer high water use. In this report the typical summer high water use is taken as the month of highest use as shown in **Figure 2**. This value for each scheme is listed in **Table 1**.

Table 1: The average daily water use that occurs in the month of highest use from the data presented in Figure 2 for the seven water supply schemes.

	Pokeno	Buckland	Matatoki	Arohena	Tihiroa	Mihi	Reporoa
Peak usage (m^3/d)	174	189	930	724	870	496	3196[4]

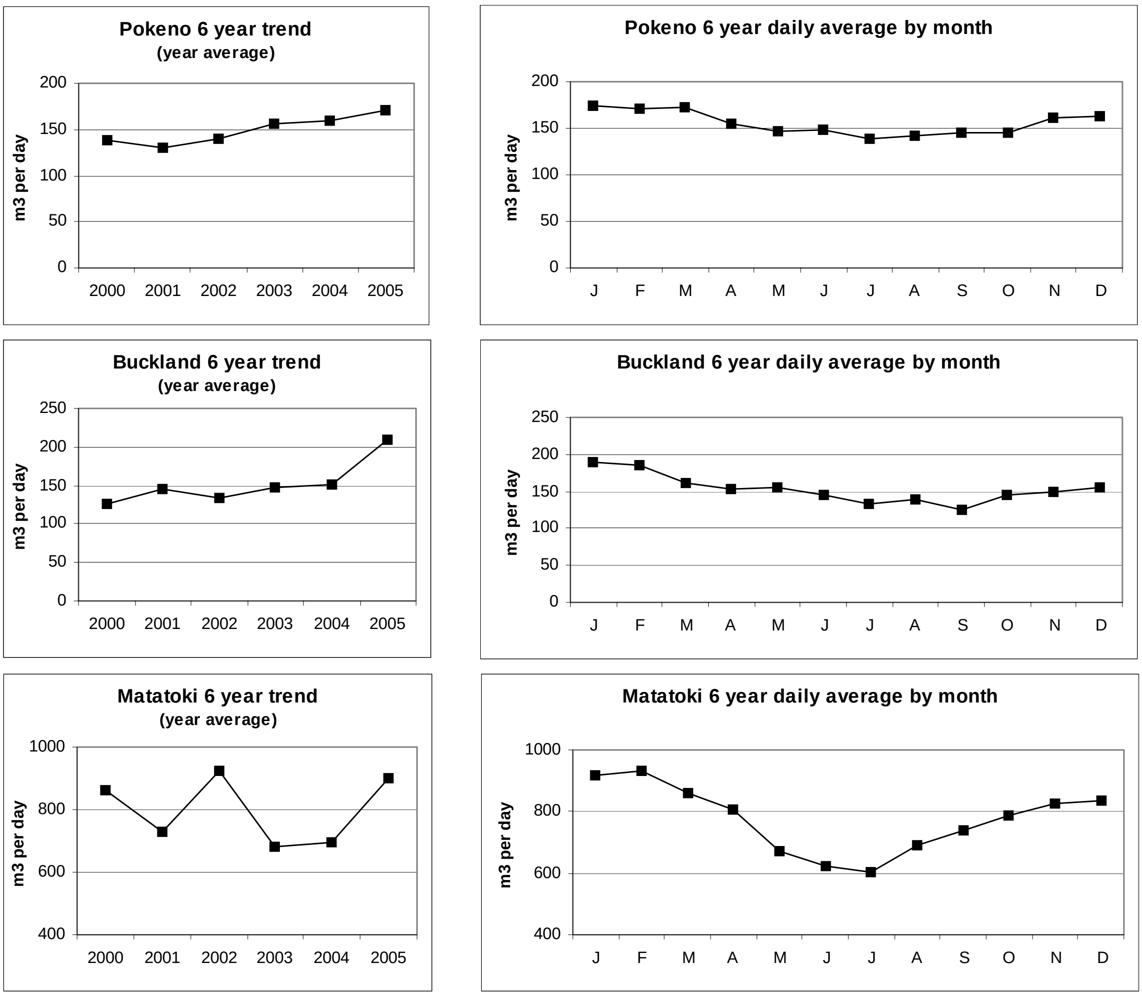


Figure 2: Average annual water use and monthly average water use from 2000 to 2005 for the seven water supply schemes in units of cubic meters per day.

[4] This is the scheme use excluding what is taken for the dairy factory.

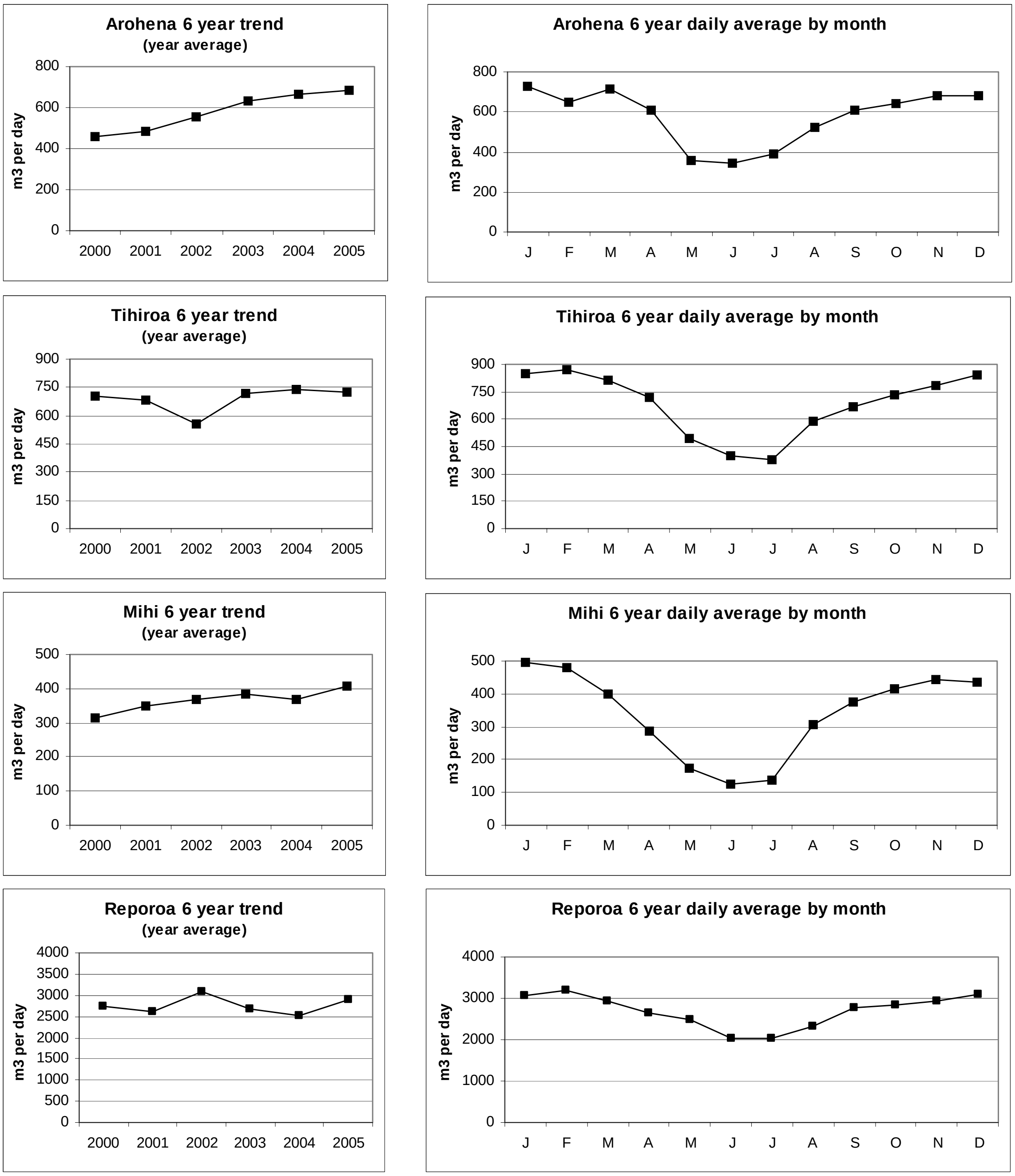


Figure 2: ***Continued*****: Average annual water use and monthly average water use from 2000 to 2005 for the seven water supply schemes in units of cubic meters per day.**

2.1.2 Scheme water use activities

The main activities that require water in the seven supply schemes are detailed below. These activities tend to be focussed around domestic water needs, animal drinking water and dairy shed operation. Details about what water is used for within the seven schemes needs to be spatially available for areas outside the schemes, as the ultimate outcome of the model is to calculate water use across the region.

2.1.2.1 Scheme population and number of properties

Population

The number of people living in an area is an important driver for calculating the amount of water required for domestic purposes. This covers drinking water, sanitary requirements and some outside uses such as gardening and car washing. The population values for the seven schemes were supplied by Drinking Water New Zealand (DWNZ)[5]. This Government sponsored organisation measures the water quality of community water supply schemes (rural and urban) across New Zealand. DWNZ records the population of every New Zealand supply scheme[6]. However, DWNZ population values are only available for supply schemes and not for areas in between supply schemes. To simplify population estimates across the region, the model utilises a default population density of 2.8 people per property. This default value of 2.8 is the average density for the seven schemes based on the DWNZ population record (**Table 2**).

Another possible population information source is the national Census 2001[7]. However, the census data was not used as its smallest unit of area (the census mesh block) is larger than a number of the smaller supply schemes, and did not match the boundaries of the supply schemes or the hydrological catchment boundaries for the rest of the region.

Number of properties

The numbers of properties in each scheme was determined using the Core Record System (CRS) from Land Information New Zealand's property database[8]. Some properties overlapped the scheme area and it was not possible to determine whether these properties draw water from the supply scheme or not. In this analysis if more than 50 percent of a property area lay within the scheme it was assumed to be taking water from the scheme (**Table 2**).

Table 2: Population and property numbers.

	Pokeno	Buckland	Matatoki	Arohena	Tihiroa	Mihi/Reporoa
Population[5]	520	610	150	120	400	1060
Number of properties (CRS)	163	223	117	36	67	421
Population per property	3.2	2.7	1.3	3.3	6.0	2.5

Note: Population statistics for Mihi and Reporoa were only available as a combined total. Mihi scheme has 35 properties and Reporoa 386 properties.

The model calculates the supply scheme and catchment population by multiplying the number of properties in the CRS property database by the average property-population density of 2.8.

2.1.2.2 Scheme animal numbers and water demand

The type and number of animals in an area is an important factor when calculating the amount of water used for animal drinking and dairy shed operations.

[5] Drinking Water New Zealand Supplies by Territorial Authority (http://www.drinkingwater.org.nz/supplies/Supplies.asp)
[6] Drinking Water New Zealand defines a community supply scheme as a water supply for 25 or more people for more than 60 days of the year.
[7] Whilst the 2006 Census was undertaken in March 2006, the data was not yet available for purchase by the Waikato Regional Council from Statistics New Zealand.
[8] This property layer is essentially a join of the LINZ CRS parcels and Valuation data (As supplied from District Valuation Roll) extracted from the EW LAND application. It allows users to access and use the non spatial District Valuation Roll data within GIS applications.

The model uses four broad animal type classifications: dairy cows, beef cattle, deer and sheep. The number of animals per farm property is available from Agribase[9] and is summarised in **Table 3**. The data reported in Agribase is dependent on information provided by farmers and there can be missing information for some farms. A check of the data in **Table 3** was made to see if the number of stock reported was realistic for the size of the farmed area in each scheme. The stock numbers in **Table 3** were standardised to stock units (SU) equivalents per hectare of farmed land. Stock unit conversion factors given by Environment Waikato (2001) were used. For the schemes in **Table 3**, excluding Pokeno and Buckland, the SU/ha ranged between 16 and 21 (equivalent to 2.4 to 3.0 dairy cows/ha). These stock units per hectare are typical of the "mid-range of dairy farms" in the Waikato region according to Environment Waikato (2001).

Other animal types (for example horses, pigs and chickens) have not been specifically accounted for in this report as they either use less water or there are relatively fewer of these animals in the region. These animals are included if they exist in the seven water supply schemes under the generic category of 'other uses and leakage'.

As shown in **Table 3** and **Figure 3** there is an overall dominance of dairy cows in most of the schemes. The exceptions are the Pokeno and Buckland supplies which are mainly for domestic purposes and the Arohena scheme which has large numbers of sheep, beef cattle and deer.

Table 3: Total animal numbers for the seven schemes from Agribase[9]

	Pokeno	Buckland	Matatoki	Arohena	Tihiroa	Mihi	Reporoa
Dairy cows	0	0	3874	5335	4197	2641	16403
Beef	78	67	668	2907	68	113	486
Deer	0	0	0	2434	0	0	173
Sheep	17	86	367	7153	16	17	97

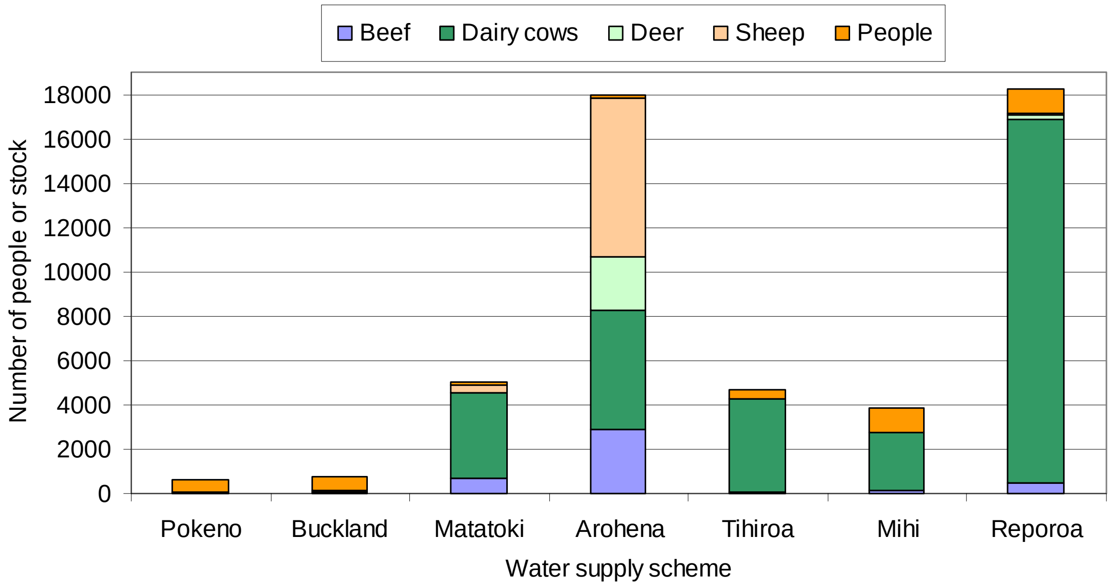


Figure 3: Domestic population from Table 2 and animal numbers from Table 3 for the seven schemes.

[9] The Waikato Regional Council obtains information on the number and type of animal on each farm in the Waikato Region from the AgriBase database. AgriQuality New Zealand Ltd (formerly MAF Quality Management) developed, and now maintains, AgriBase. The AgriQuality AgriBase is maintained through regular contact with farmers and property updates from Quotable Value New Zealand.

2.1.2.3 Scheme ‘other’ water use and reticulation leakage

Within each scheme there will be ‘other’ water uses associated with activities not accounted for by the four animal types and domestic use. Examples of these activities include:

- truck washing
- businesses using water for production and cleaning
- small scale glass house operations
- dust control.

Water is also lost from pipes. Factors influencing the level of leakage include:

- operating pressure
- age of system
- location of pipes in relation to other infrastructure
- corrosive nature of water
- mechanism for identifying leaks and time to responded.

Water used for other uses and water lost to leaks is difficult to quantify and has been grouped into one generic classification in the model.

2.2 Review of likely domestic household and animal water requirements

The following is a review of information supporting the amounts of water that people and animals use as applied in the model.

2.2.1 Domestic household requirements

General household annual water requirements are between 185 to 300 l/person/d. This provides enough water to cover all drinking and sanitary needs as well as reasonable outdoor use including car washing and some lawn irrigation.

The Ministry of Health recommends that households sourcing their own water (i.e. rain water) allow for an average requirement of 300 l/person/d (MoH, 2006). A recent study measured household water use for 12 residential homes on the Kapiti Coast (Heinrich, 2007). The average annual use was 185 l/person/d and ranged from an average winter use of 168 l/person/d to 204 l/person/d during summer. This study found little seasonal variability in indoor water use. However, outdoor water use was three times more during summer than winter. The Department of Building and Housing (DBH) is reviewing the Building Code (DBH, 2007). As part of this review the DBH produced a discussion document which recommends a supply of 250 l/person/d to meet the needs of building occupants. This requirement is largely based on the study of the 12 Kapiti Coast homes.

The Pokeno and Buckland water supply networks are primarily for household requirements and support very few farm animals (**Table 3).** Dividing the summer water use in **Table 1** (remove minor stock component) by the number of people in each scheme gives Pokeno an average summer peak month rate of 260 l/person/d and Buckland 240 l/person/d. These rates for Pokeno and Buckland include distribution losses so the actual use at the household will be less.

2.2.2 Animal water requirements

There is a lack of definite information about animal drinking habits which raises uncertainty when calculating animal water requirements (Fleming, 2003). Animal water use is often represented as the average and peak use. However, no reference is given to determine if the average use is the average annual use (includes summer and winter) or if it is the average daily use which represents the amount of water required for animal wellbeing, i.e. dry periods during summer. In Fleming (2003) the average daily use is put forward as a reasonable basis for design. This report assumes that the referenced average values in Fleming (2003), ANZECC (2000) and MAF (2004) are the water requirements for animal wellbeing during critical times such as dry summer. If this assumption is incorrect, the report will underestimate the amount of water used for animal drinking water. It is these average values that are referred to when estimating the daily amount of water used by animals in the model. The peak use given in Fleming (2003), ANZECC (2000) and MAF (2004) is determined from the average use, but adjusted so that it represents the actual rate of use as water is often taken for 3 to 12 hours each day and not over 24 hours as for the average (Fleming, 2003).

2.2.2.1 Dairy cows

Dairy cow water requirements are divided into two components:

- drinking water provided for under s14(3)(b) of the RMA
- dairy shed water use provided as a permitted activity via the WRP for up to 15 m^3/d.

Drinking water

A large number of reports reference the amount of drinking water required by lactating dairy cows (Fleming, 2003; NZSFA, 2007; MAF 2004). They all indicate a rate of around 70 l/cow/d. This rate is provided as a reasonable standard for design and planning purposes on a farm. According to Rout (2003) the rate of 70 l/cow/d is the likely maximum requirement that will generally only occur rarely and does not represent the average use per day that is expected over a monthly or seasonal basis. Rout (2003) in his review of drinking water requirements found there was little recent information measuring the amount of water used by cows in New Zealand. Most of the research was from the 1970s and early 1980s. One of these studies was at Ruakura in the Waikato where the average use in the month of highest use was approximately 40 l/cow/d.

The intake of water from cows is highly dependent on a number of factors, including size of the animal, milk yield, quantity of dry matter consumed, temperature and relative humidity of the environment, temperature of the water, quality of the feed and moisture content of the feed (Looper and Waldner, 2002). It is likely that since these studies in the 1970s and early 1980s water requirements have increased due to intensification of farming and optimising of milk production. However, there is little information to ascertain the current water use of cows under current farming practices.

Dairy shed water

As well as drinking water, dairy farms rely on water for the operation of the milking shed. Water is used to cool milk, clean equipment and wash down bails and other areas (Fleming, 2003). Fleming (2003) and NZSFA, (2007) recommend 70 l/cow/d as the water requirement for dairy sheds. The value of 70 l/cow/d is used as a design value for the construction or set up of dairy sheds to ensure adequate water is available.

Rout (2003) reviewed available information relating to dairy farm water requirements for the Auckland Regional Council (ARC). The ARC utilised a guideline value of 70 l/cow/d for dairy shed operations (based on a milking season of 260 days). From the information gathered **(Table 4**), Rout (2003) concluded that 70 l/cow/d was a conservative upper limit, though there may be some exceptions where demand is higher. Rout recommended caution when using generic values to represent shed water requirements as there is considerable variability from farm to farm. More specific research is needed to understand requirements for dairy shed activities, as well as the additional washing water requirements due to the recent introduction of feed pads by many farmers.

Table 4: Summary of non-drinking water requirements for dairy farms from Rout (2003).

Purpose	Water requirement l/cow/d	Comments
Udder wash	10 to 20	Uncertainty in how many farms wash udders prior to milking.
Milk cooling	40 to 50	Non-consumptive if reused for shed wash. Volume of water is highly dependent of the amount of milk being cooled.
Plant wash	3.5 to 5.5	
Yard wash	20 to 80	Most variable and difficult component to quantify.
Feed pad wash	unknown	Similar to water requirement to yard wash, but frequency of washing is unknown.
Likely range of total use	45 to 100	Depends of degree of recycling, excludes feed pad washing.

Combined cow drinking and shed water requirements

A recent study of nine dairy farms in the Hamilton Basin and Hauraki Plains provides useful information about total annual farm water requirements – drinking and shed water (Aquas, 2006). The nine farms receive water from local rural water supply schemes. Six farms had an ‘alert’ system for early detection of water loss. None used feed pads.

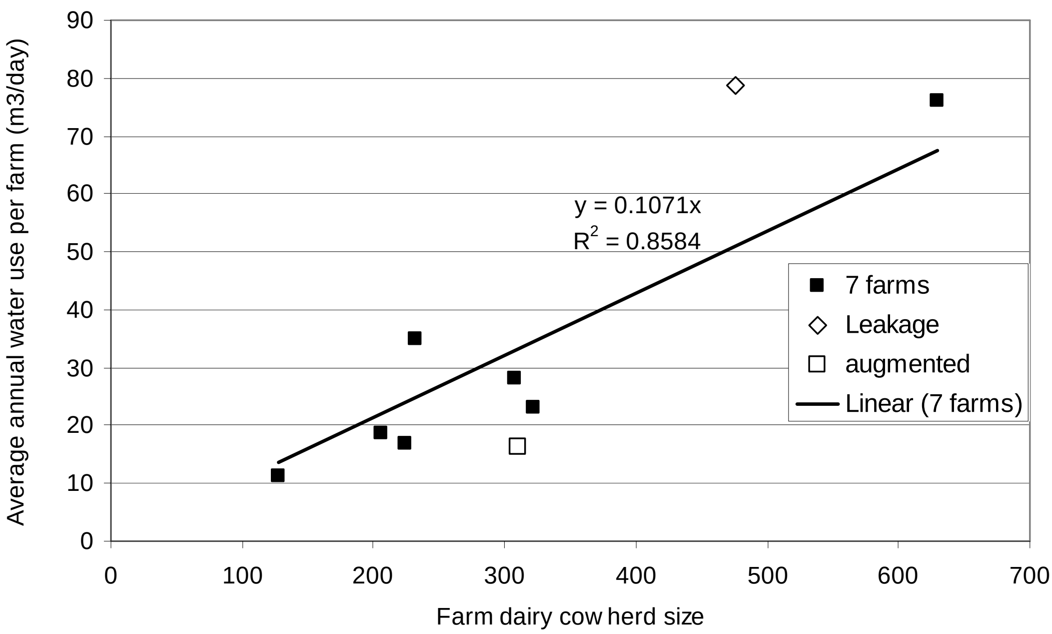


Figure 4: Nine farms with measured water use from the Hamilton Basin and Hauraki Plains, data from Aquas (2006).

The measured annual water use from the nine farms and information on animal numbers enables an assessment of the annual average water requirement for drinking and shed operations. In this analysis two farms were excluded from the dataset shown in **Figure 4.** One farm (◇) had a large amount of leakage due to a pipe failure, so the measured water use was not solely attributed to typical farm use. The other (□) had a secondary water supply source that was not measured, so the measured component under-represents actual use. For the seven farms in **Figure 4** the line of best fit gives a dairy cow annual average water requirement of 0.1071 m^3/cow/d (107 l/cow/d).

To provide insight into the likely summer use from these seven farms, the annual average daily rate has been multiplied by the ratio of average annual use (m^3/d) to highest month of water use (m^3/d) for the five supply schemes dominated by dairy cows (Section 2.1). The Pokeno and Buckland schemes were excluded as there are no dairy cows in these schemes. The ratio of annual average use to summer peak use for the five schemes was 1.3 (range of 1.2 to 1.5). Scaling the 0.1071 m^3/cow/d from **Figure 4** gives a summer peak rate of 0.140 m^3/cow/d.

The above calculation of water use for the seven farms is based on measured use at the farm gate. The measured use will include any leakage losses after the measurement point. As a result it is likely that the actual amount of water consumed by cows and used in the dairy shed will be less than 0.140 m^3/cow/d.

2.2.2.2 Beef

Beef water requirements will vary according to a number of factors including body weight, age and feed intake. ANZECC (2000), MAF (2004) and Fleming (2003) provide an average water requirement for beef cattle of 45 l/cattle/d.

2.2.2.3 Sheep

According to ANZECC (2000) mature sheep on green pastures use 3 l/sheep/d and Fleming (2003) references 3 l/sheep/d for breeding ewes. There are higher rates of use referenced, but these tend to be for peak use by sheep or lactating ewes on dry feed or dry pastures (ANZECC, 2000; MAF, 2004).

2.2.2.4 Deer

Deer water requirements can vary widely according to species, body weight, age, sex, climatic conditions, type of diet, and feed intake (DINZ, 2007). Information from DINZ (2007) shows that for an ambient temperature of 20ºC the average drinking requirements are 4 l/deer/d (range from 0.5 to 10 l/deer/d (**Table 3 in Appendix A**)). Scaling the water requirements up to account for the high summer requirement for an air temperature of 30ºC gives an average deer drinking water demand of 7 l/deer/d.

2.2.2.5 Other use and leakage

Other use

The water used by 'other' activities cannot be calculated in the same manner as for people and animals as there is little information available determining the locations or quantity of water used by these activities. It is assumed that the amount of water taken for these activities will be relatively small compared to the amounts taken for dairy cows, beef cattle, sheep, deer and domestic use.

Water taken for these activities is collectively accounted for in the model under the category of other use and leakage. The amount under this category is determined as the difference between the scheme measured water use and that modelled while accounting for dairy cows, beef cattle, sheep, deer and domestic use. This is determined in Section 2.3.1 of this report.

Leakage

The total water use measured for the seven schemes will include the component that is not utilised, but lost to leakage between the point of abstraction and the end point where it is required. The amount of scheme leakage will be highly variable and difficult to quantify. Some of the reported variability in leakage amounts is due to the manner in which it is reported, often as a percentage of total scheme input (OFWAT, 2005). For example, during times of increased water use (i.e. summer) the leakage volume may remain constant, but when reported as a percentage of total use it will appear as if there is less leakage than in times of lower water use (i.e. winter). The International Water Association recommends the reporting of water loss in a more meaningful and standard way, such as based on the length of scheme network (m^3/km/d) (OFWAT, 2005). In the calculation of the permitted and s14(3)(b) water use the water lost to leakage is represented in the model as a percentage of the total water used. This is simply due to there not being enough information relating to each properties' length of water reticulation pipe.

Reported losses for water supply networks in New Zealand and internationally is reported to be between 5 and 30 percent of the total amount of water reticulated (HCC, 2007; OFWAT, 2005). The measurement of water use in 12 residential homes in the Kapiti Coast found that leakage accounted for four percent of total household water use (Heinrich, 2007).

There is little information available to ascertain the level of leakage within farm properties. Some insight into the level of leakage is possible by assessing the measured water use for the dairy farms discussed in Section 2.2.2.1 of this report. All the farms would have some degree of leakage that was not identified and is assumed to be expected when taking water. However, one farm presented in **Figure 4** had a large leak that went undetected for some time. The leakage from this farm was in the order of 20 to 35 percent of the farm's expected total annual water use. The water loss from this farm accounts for between 5 and 10 percent of the total annual water use of all the farms combined.

2.3 Model development – for the seven water supply schemes

The calculation of water use in the seven rural water supply schemes is simply a multiplication of the number of humans or animals by corresponding variables relating to how much each of these use. The permitted and s14(3)(b) predicted water use for each scheme is calculated using **Equation 1**,

$$\begin{aligned} SMU = {} & (Prop * PopD * DomWU) + (PopDC * DCWU) + (PopBF * BFWU) \\ & + (PopDR * DRWU) + (PopSH * SHWU) + leak/other \qquad \textbf{\textit{Eq. 1}} \end{aligned}$$

Where;

SMU	is the scheme measured water use per day (m^3/d)
Prop	is the number of properties in the scheme
PopD	is the number of people per property (constant of 2.8)
DomWU	is the amount of domestic water use per person (m^3/person/d.
PopDC	is the number of dairy cows
DCWU	is the amount of water used per dairy cow per day (m^3/cow/d)
PopBF	is the number of beef cattle
BFWU	is the amount of water used per beef cattle per day (m^3/beef/d)
PopDR	is the number of deer
DRWU	is the amount of water used per deer per day (m^3/deer/d)
PopSH	is the number of sheep
SHWU	is the amount of water used per sheep per day (m^3/sheep/d)
Leak/other	is the amount used by other uses/animal or lost via leaks.

The fixed variables in the model are the number of properties within the scheme, average population per property (2.8) and the number of animal per scheme (**Table 5**). The independent variables relate to: the amount of water required by both humans, by each of the four animal types, and for other unaccounted water use and scheme leakage. The domestic (*DomWU)* and animal *(DCWU, BFWU, DRWU, SHWU*) water use were set in the model at the rates given in **Table 6** and are representative of reasonable water requirements for each activity. The leakage rate was set at zero as this is the most uncertain variable and by doing so enables the assessment of how well the domestic and animal water use variables account for the measured water use.

Table 5: Fixed variables used in Equation 1 for the calculation of water use for each water supply scheme.

	Pokeno	Buckland	Matatoki	Arohena	Tihiroa	Mihi	Reporoa
Number of properties (*Prop*)	163	223	117	36	67	35	386
Average population per property (*PopD*)	2.8	2.8	2.8	2.8	2.8	2.8	2.8
Dairy cow # (*PopDC*)	0	0	3874	5335	4197	2641	16403
Beef # (*PopBF*)	78	67	668	2907	68	113	486
Deer # (*PopDR*)	0	0	0	2434	0	0	173
Sheep # (*PopSH*)	17	86	367	7153	16	17	97

Table 6: Independent variables used in Equation 1 for the calculation of water use for each water supply scheme.

Unit	Summer daily demand litres/unit/day
Dairy cow in lactation (*DCWU*)	140*
Beef (*BFWU*)	45
Deer (*DRWU*)	7
Sheep (*SHWU*)	3
Domestic per person (*DomWU*)	300

Note:

*Includes cooling, cleaning of equipment and wash down of bails and other areas ~ 70 l/cow/d based on Section 2.2.2.1.

2.3.1 Results

The permitted and s14(3)(b) model, without accounting for other uses or leakage, calculated approximately 80 percent of the measured water use for the seven schemes (**Figure 5**). The model results have a mean error of -11 percent and an absolute mean error of 20 percent. The log normalised modelled data have a Pearson correlation coefficient (r) of 0.87 and are statistically significant, p of 0.01. Even though there will be wide variation in the water demand for each animal unit as given in **Table 6** (depending on factors including: species, body weight, age, sex, climatic conditions and feed intake), the statistical relationships indicate that the values given in **Table 6** largely account for water use across the seven schemes. However, they tend to be an under estimate.

The amount of water used by other activities and lost to leakage is largely unknown for the seven schemes, other than being part of the measured water use. The other use and leakage was accounted for in the model by scaling up the results for all seven schemes until the modelled water use more closely matched the measured. An improved fit was achieved by increasing all the results by 20 percent (**Table 7** and **Figure 5**). For the seven schemes the modelled results accounting for other use and leakage have a mean error of only 7 percent, a mean absolute error of 15 percent. The log normalised modelled data have the same Pearson correlation coefficient (r) of 0.87 and remains statistically significant, p of 0.01.

Table 7: Modelled and measured summer high water use.

	Pokeno	Buckland	Matatoki	Arohena	Tihiroa	Mihi	Reporoa
Measured usage (m^3/d)	174	189	930	724	870	496	3196
Modelled usage (m^3/d)	168	228	806	1136	776	485	3172
Percent difference	-3%	21%	-13%	57%	-11%	-2%	-1%

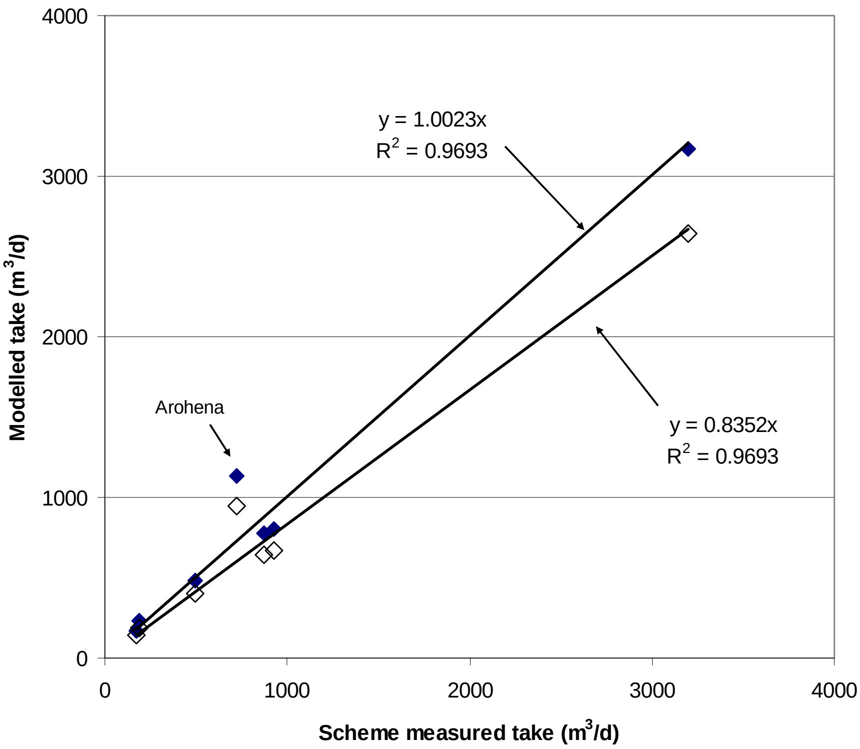


Figure 5: Modelled and measured summer high water use for the seven schemes, without accounting for leakage (◇) and accounting for leakage (◆).

The greatest difference between modelled and measured water use is for the Arohena Scheme where the model calculates 57 percent more water use than was measured. This difference may be due to some farms sourcing water directly from streams or ground water rather than from the scheme. This was also noted by staff operating the scheme[2]. This observation is also supported by **Figure 6** which shows that the measured water use for the Arohena scheme is smaller than would be expected for a scheme of its extent. The measured water use in the Arohena catchment is equivalent to 180 l/ha, whereas the other six schemes have an average water use of 345 l/ha. However, if it is assumed that the measured water use is correct and accounts for all water use in the catchment, this would mean that the model parameters are incorrect. Of all the schemes Arohena has the greatest number of sheep, beef and deer (**Figure 3**). The amount of calculated water use by these three animal types in the model has less validation per scheme than for domestic and dairy cow use. As a result, it is unlikely that the model is overestimating the domestic and dairy cow component, which means that it may be overestimating the sheep, beef and deer component. To test this and calculate a closer match to the measured use, the amount of water required by the sheep, beef and deer was reduced. However, a close match could not be achieved without reducing the sheep, beef, deer and leakage values to zero. Even under this unrealistic scenario, the modelled water use by cows and people alone exceeded the measured use by seven percent. From this it is reasonable to assume that the observations of staff at the scheme are correct and some water is not sourced from the scheme supply. As a result it is not necessary to modify the model to match the measured use for Arohena.

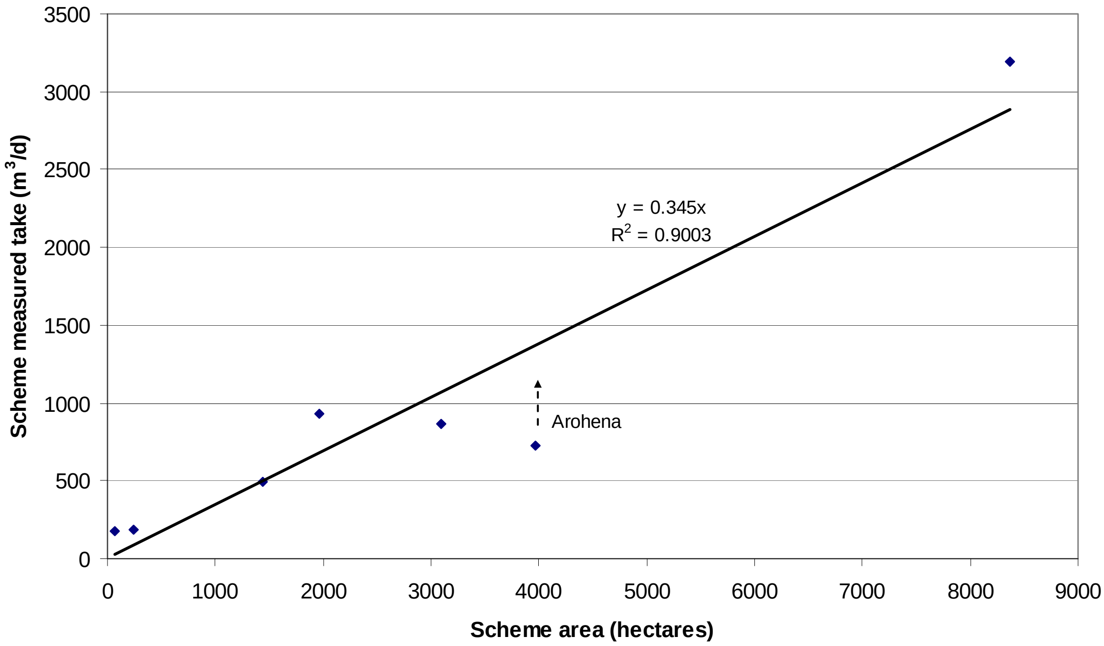


Figure 6: Scheme measured water take and size of the scheme area.

2.3.2 Sensitivity

Sensitivity analysis was performed on the model to identify the degree of influence the input parameters relating to water use have on the modelled results for the seven schemes. Parameters which have a high degree of influence on modelled results need to be accurately accounted for in the model. Any errors in these parameters can have corresponding large errors in the modelled output.

The calculated water use is highly influenced by the parameters relating to dairy cows, people and leakage (**Figure 7**). For example, changing the amount of cow water use by 50 percent has a corresponding change of 31 percent of the total modelled water use of the schemes. Whereas, changing the amount of water use for beef cattle by 50 percent only has a corresponding change of 1.5 percent. The high influence of cows and people on the model results is not unexpected as they are dominant by number across the seven schemes (**Figure 3**) and dairy cows also require the most water out of all the animal types (**Table 6**).

The high influence of cows, people and leakage on total modelled water use means that a good prediction of the scheme water use can be achieved by using these three variables alone *(DCWU*, *DomWU and leak/other)*. However, it is important to include the other animal types as there are catchments outside the seven schemes which are dominated by beef cattle, deer or sheep.

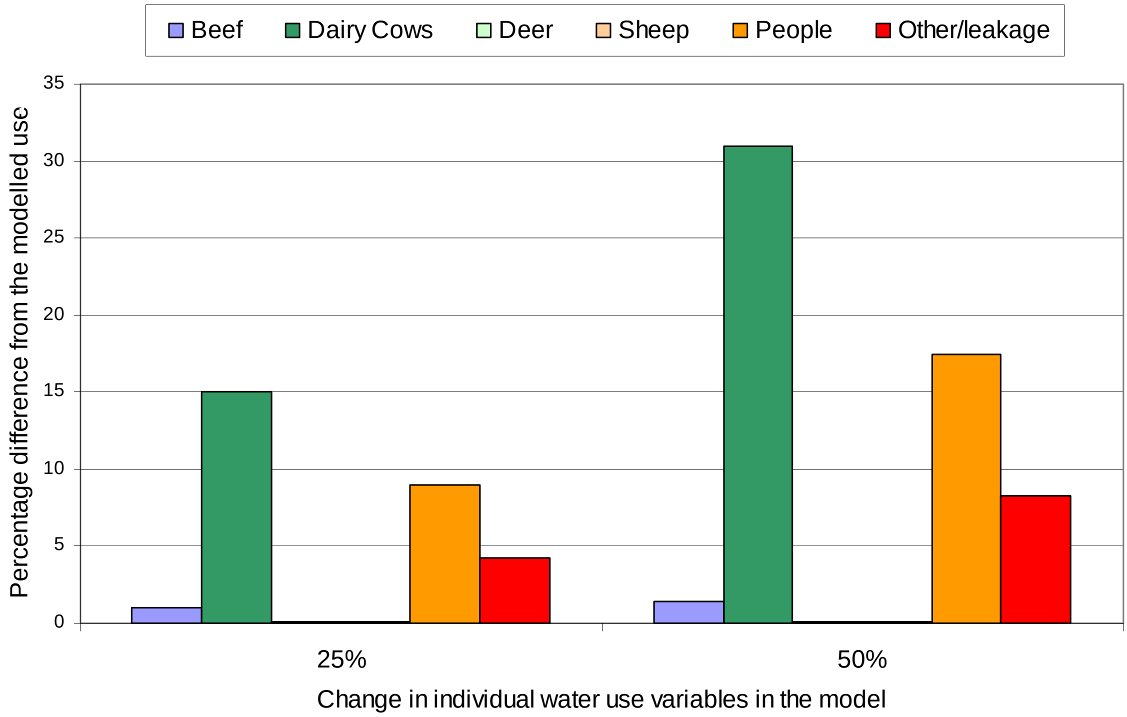


Figure 7: Sensitivity of the model's calculated permitted and s14(3)(b) water use for the seven supply schemes due to either a 25 or 50 percent change in water use for either people or each animal type.

2.4 Model development – for the whole region

Applying the variables in **Tables 5 and 6,** the model accurately calculates the amount of surface water required by permitted activity and s14(3)(b) uses within the seven schemes.

Equation 1 and the water demand rates from **Table 6** can now be applied to the people and animal numbers for the remainder of the region. The animal numbers for the remainder of the region are sourced from Agribase. The number of people is based on an average density of 2.8 people per property. The number of properties is sourced from the CRS property database. The model was modified so it did not calculate the water demand in areas of the region where people and animals use:

- urban and/or rural water supply schemes
- ground water
- rain water.

The model was also modified to include animals not accounted for in Agribase for a recent conversion of 25,000 hectares of forest to pasture for farming purposes in the upper Waikato River catchment.

2.4.1 Areas of existing urban supply and rural supply

In the model, permitted and s14(3)(b) water requirements were not calculated for people or animals that are supplied water by a reticulated water supply scheme. Permitted and s14(3)(b) water is for an individuals' needs. The water provided by a water supply scheme does not meet this requirement and needs a resource consent. The exclusion of these areas from the model is detailed in **Appendix B**.

It is important to note that individuals within a scheme can source additional water to that provided for by the scheme for their permitted or s14(3)(b) activities. This situation is not accounted for in the model and may result in an under prediction of the amount of surface water taken for permitted and s14(3)(b) activities.

2.4.2 Properties supplied by ground water

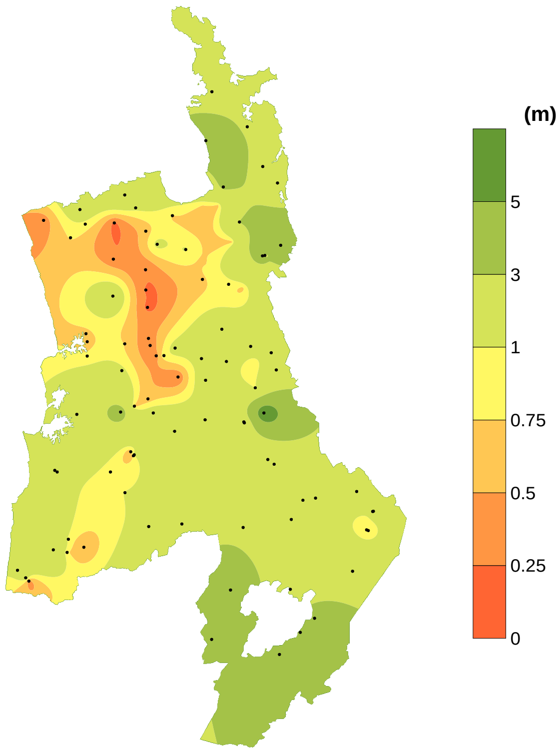
Many properties in the region use ground water rather than surface water to meet their permitted and s14(3)(b) water requirements. The model assumes that if a property has a ground water bore registered against it, then ground water was its sole source of water for permitted and s14(3)(b) water requirements. The Waikato Regional Council maintains a register of ground water bores constructed since 1988. This was used to identify ground water supplied properties.

There may be some properties where permitted and s14(3)(b) water requirements are met from both ground water and surface water. This situation is not accounted for in the model and may result in an under prediction of the amount of surface water taken for permitted and s14(3)(b) activities.

2.4.3 Properties supplied by rain water tanks

There is little information to support the likely number of houses that source their water from rainfall tanks. One study by Rout (2005) commented that 80 percent of properties in rural New Zealand use rain water for their domestic supply due to constraints on availability and quality of surface water or ground water.

In the calculation of permitted and s14(3)(b) domestic use it was assumed that for the properties without ground water bores, 1 in 5 get their domestic water from surface water and the remaining 4 in 5 from rain water tanks. The model was developed further to provide some spatial variability in the number of properties using the surface water to account for the influence of water quality. This is to take into account that if the water quality was apparently poor it was less likely to be used for domestic requirements unless there was no alternative. The model presumes that if the water quality was deemed to be ‘good’, 1 in 3 households would source their water from surface waters, and if the water was ‘poor’ this would reduce to 1 in 10 households. These ratios equate to an average ratio of 1 in 5 for the whole region. The areas of poor water quality are isolated based on a simple concept of how clean the water looks in the stream it is taken from. This assessment is based on the Waikato Regional Council Black Disk field measurements of horizontal water transparency, where a low value relates to poor water clarity. The areas of poor water quality are largely in the lowland water ways of the Hamilton Basin and Hauraki Plains (**Figure 8**). There is no information available to support the ratios selected. However, it is important to note that animal water is by far the larger user of the calculated permitted and s14(3)(b) water use. As a result, any error in this aspect of domestic demand based on water quality will have a limited impact on the cumulative calculation of water use for the catchments. This is discussed further in **Appendix C.**



c: Black Disk

Figure 8: Spatial contour plot of Black Disk (based on 5 year median values, 2001-2005), taken from Smith (2006) Figure 2c.

2.4.4 Areas with animals not accounted for in Agribase

The model was adjusted to include animals that are not represented in Agribase for a large forestry to dairy conversion in the catchment of Ohakuri Dam near Taupo. For the catchments where this conversion is occurring, the model uses a default dairy cow stocking rate of 2.8 cows/ha. Details of the catchments are given in **Appendix D**. For the conversion areas it was assumed that all the animal water is being sourced from surface water.

3 Summary of predicted permitted and s14(3)(b) surface water use in the Waikato region

The following summary is of the model results showing how much surface water is taken for permitted and s14(3)(b) water activities. The amount of water taken is calculated for the summer month with the highest use (refer to Section 2.1.1).

3.1 Regional use

The total amount of water predicted to be taken for permitted and s14(3)(b) water uses across the Waikato region is 196,600 m^3/d or 2,275 l/s. This is equivalent to the volume of an Olympic size swimming pool (2,500 m^3) being taken every 18.5 minutes.

The majority of water taken (64 percent) is for dairy cows' drinking water and dairy shed operations **(Figure 9)**. The remaining 36 percent is for the drinking requirements of the other animals, domestic use and activities included in the 'other/leakage' category.

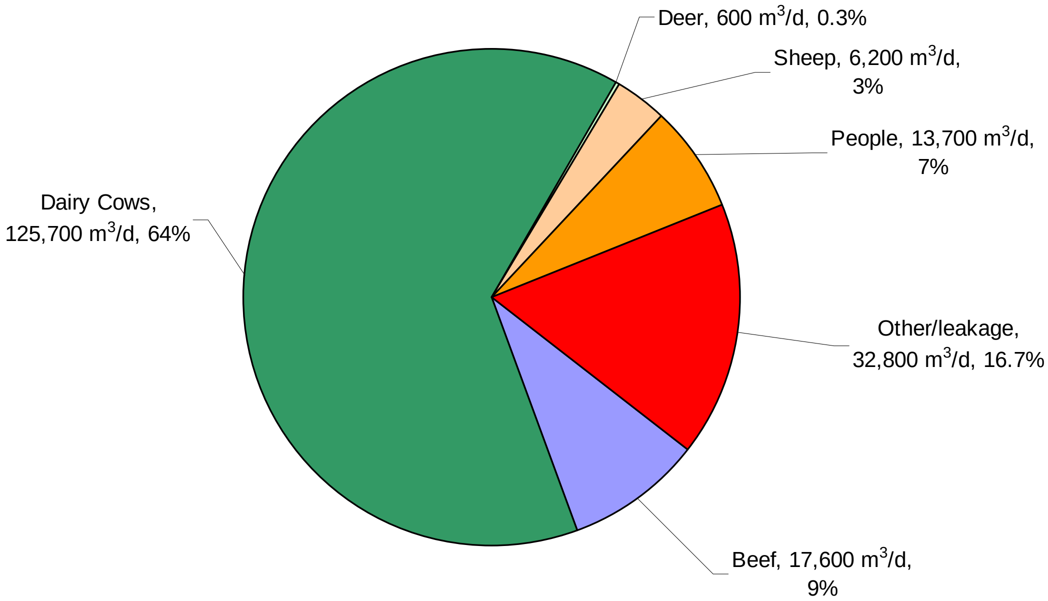


Figure 9: Distribution of permitted and s14(3)(b) water use for the Waikato region. Total use under these categories is 196,600 m^3/d.

3.2 Catchment use by daily volume

The amount of water predicted to be taken for permitted and s14(3)(b) activities has been presented for 15 catchments in the region to provide an overview of the spatial variability in water use across the region (**Figure 10**).

In the Waikato River catchment the amount of water taken for permitted and s14(3)(b) water use ranges from 4,900 m^3/d at Taupo Gates (Reids Farm) to 130,000 m^3/d at the mouth[10]. Just below the confluence of the Waikato and Waipa Rivers, the cumulative water use is 100,000 m^3/d. Half of this use comes from the Waipa catchment and the other half from the much larger Waikato River catchment up to and including Taupo. There are similar volumes (between 5,000 and 10,000 m^3/d) of water being used in the Mokau, Taupo and the much smaller Ohinemuri catchments. The volume of water taken in the Piako, Waihou[11] and Karapiro[12] catchments is between 30,000 and 40,000 m^3/d.

Within the 15 catchments there is large variation in the relative amounts of permitted and s14(3)(b) water use by the different animal and domestic requirements (**Figure 11**). However, when categorised into total animal water use and domestic water use, animal water use dominates in nearly all the catchments. In the Waikato (excluding the Taupo sub-catchment), Waihou, Ohinemuri, Tairua, Opitonui and Piako catchments dairying utilises approximately 70 percent of the permitted and s14(3)(b) water. The amount of water used by sheep and beef cattle is markedly smaller and only dominates in the Mokau and Awakino catchments, using approximately 50 percent of the water. Domestic water use dominates in the small Coromandel catchments, the Waiau, Waiomu and Kauaeranga where the use is between 50 and 75 percent of the total. Taupo is one of the few catchments with a more even distribution of use across the different animals and domestic uses.

[10] The cumulative allocation at the mouth includes water use from this point up to the head of the catchment including the Taupo catchment.
[11] Including the Ohinemuri sub-catchment.
[12] Including all the sub-catchments up to and including Taupo.

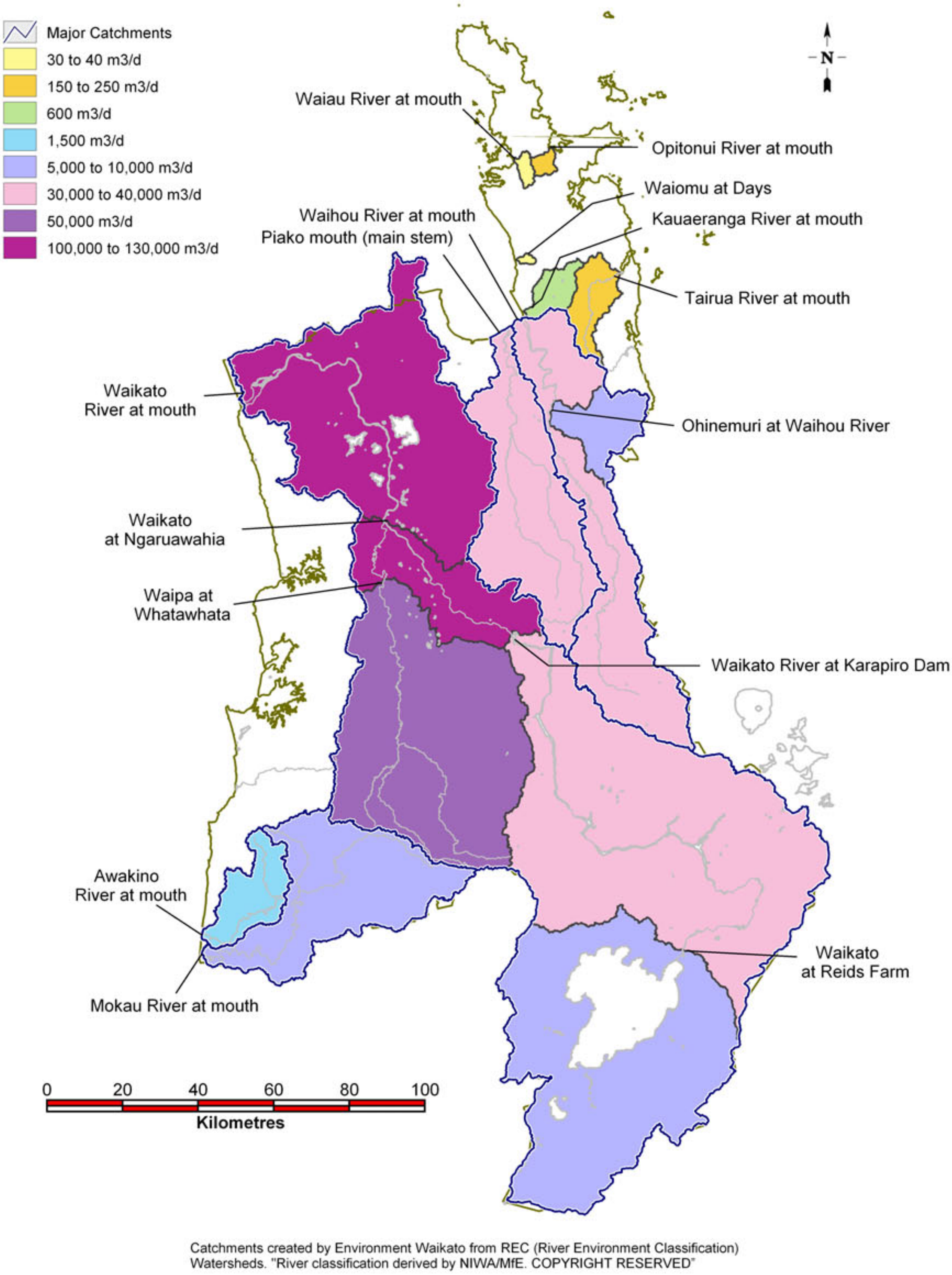


Figure 10: Daily volume of water used by permitted and s14(3)(b) takes in the Waikato for 15 selected catchments[13].

[13] The amount of water use shown for each catchment is based on the cumulative allocation for the whole catchment. Discrete rivers and streams within each catchment are likely to have different allocation levels. Where a catchment is encompassed by another catchment, (e.g. the Waikato River) the allocation level for each sub-catchment is cumulative to the head of the catchment. For example the allocation for the Waikato River mouth is based on the cumulative amount of water taken from the mouth to the head of the catchment at Mt Ruapehu.

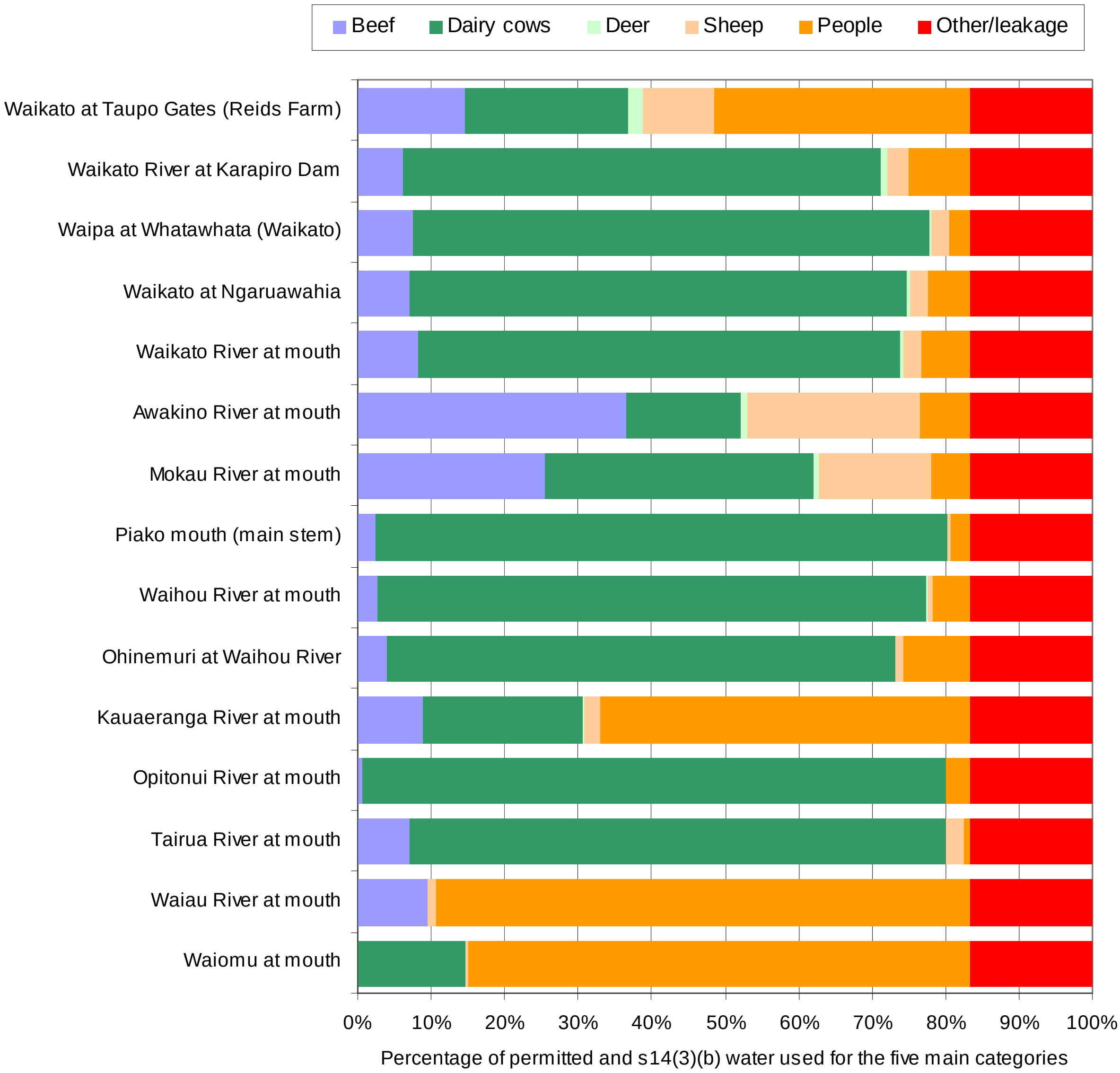


Figure 11: The relative amount of permitted and s14(3)(b) water used by the six activities listed for the 15 catchments shown in Figure 10.

3.3 Catchment permitted and s14(3)(b) use relative to the allocable flow

A useful measure of the magnitude of permitted and s14(3)(b) water demand is to compare the amount taken to the allocable flow[14]. When the amount of water taken exceeds the allocable flow there is a higher likelihood of adverse effects on the water body as well as reduced reliability of water supply. The assessment of allocation in relation to the allocable flow has been completed for 202 catchments in the region (**Figure 12**). While there are some limitations in the mapping of water demand due to the limited number and uneven distribution of stream flow monitoring sites, it does show relative pressures on catchments.

[14] Allocable flow is a measure of how much water is readily available for allocation for out-of-stream uses providing a high reliability of supply. The allocable flow in the Waikato Regional Plan is specified as a percentage of the one-in-five year low flow. Once an environmental minimum flow has been set that provides protection for the instream values, such as water quality, fish and invertebrate habitat, the difference between this value and that of the Q_5 flow is made available for allocation. This difference is termed the allocable flow.

The amount of water taken for permitted and s14(3)(b) presented in this section of the report assumes that the water is taken evenly over 24 hours of each day. In reality the water is often taken for only 3 to 12 hours of each day (Fleming 2003).

The highest allocation levels (greater than 100 percent of the allocable flow) in the region occur in the Piako and sub-catchments of the Waipa (**Figure 12**). The remainder of the Waipa catchment is between 10 and 50 percent allocated. The cumulative allocation at the mouth of the Waikato River is 8 percent of the allocable flow. The majority of the Waikato catchment from Karapiro upwards is less than 10 percent of the allocable flow. The Waihou catchment is between 10 and 20 percent allocated. However, parts of the Ohinemuri tributary are up to 100 percent allocated. For the selected Coromandel catchments the allocation level is less than 20 percent.

Of the 202 catchments assessed, the majority (120) have less than 15 percent of the allocable flow taken by permitted and s14(3)(b) activities (**Figure 14**). However, there are 32 catchments which have more than 50 percent of the allocable flow taken and of these 16 have more than 100 percent taken.

In the Piako catchment use exceeds 100 percent of the allocable flow as a result of the high density of dairy cows and large water requirements. Whereas in the sub-catchments of the Waipa the high percentage of use is due to the very low level of allocable flow. In some cases no water is available for allocation. As a result any permitted and s14(3)(b) use, no matter how small, would result in more than 100 percent being allocated.

3.4 Catchment use, including consented takes as percent of allocable flow

As well as the demand for water by permitted and s14(3)(b) activities there is also the consented taking of water for other uses such as community water supplies, irrigation and industry. These also derive water from the allocable flow. The combination of the permitted, s14(3)(b) and consented takes increases the amount of water used in the region. This combined use is shown in **Figures 13 and 15** for the 202 catchments. When consented takes are included there are 70 catchments with more than 50 percent of the allocable flow taken, of which 41 have more than 100 percent taken. A comparison of **Figures 12 and 13** and **Figures 14 and 15** clearly shows an increase in the number of catchments with high levels of allocation (greater than 50 percent). In effect, future allocation of the allocable flow in the Waikato, Waihou and Piako catchments is largely limited due to the cumulative allocation at the mouth of the respective catchments. Even though large parts of the Waikato and Waihou catchments show levels below 50 percent, further allocation is limited by the cumulative level downstream.

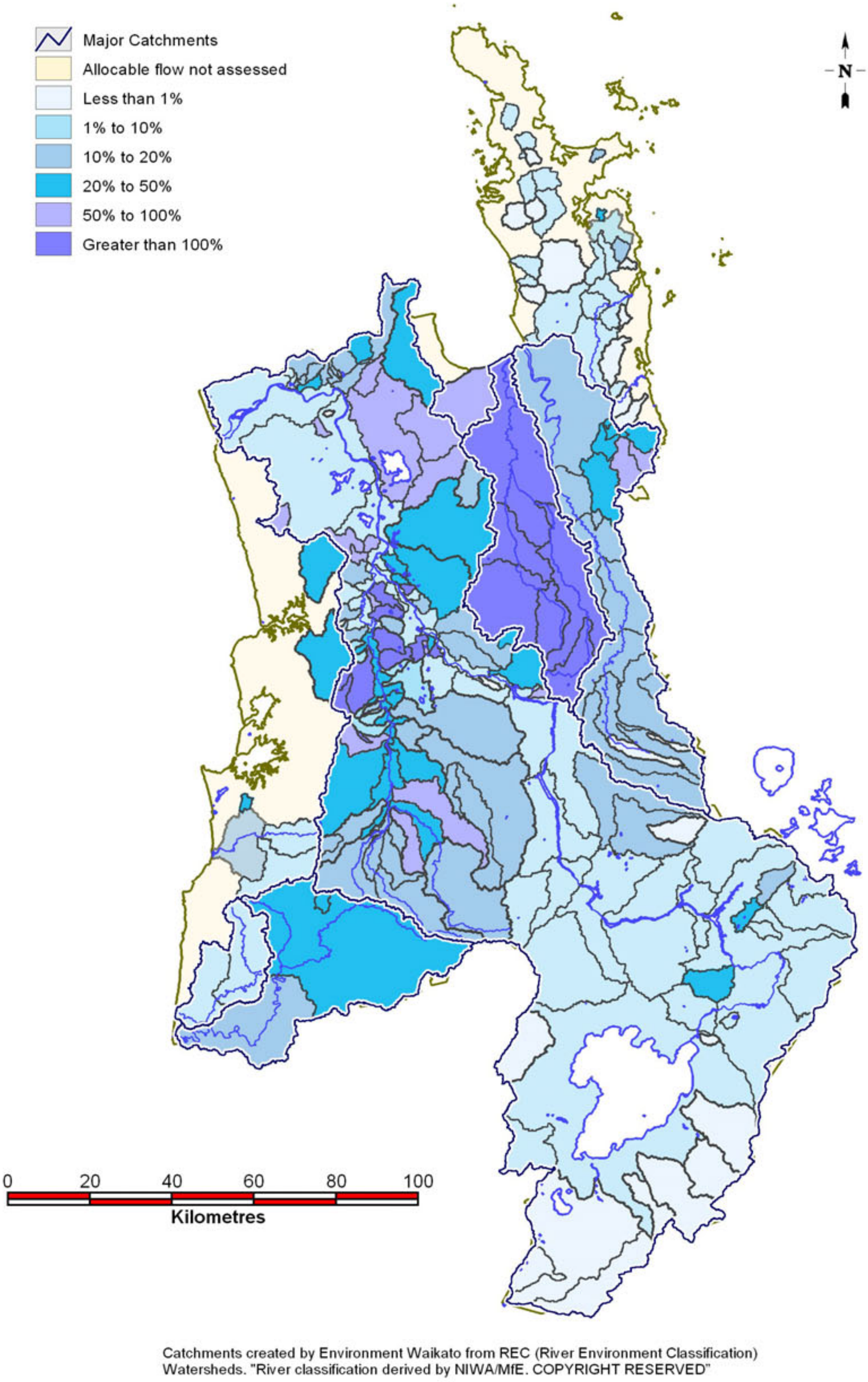


Figure 12: Permitted and s14(3)(b) water use as a percentage of the allocable flow for catchments with available flow data.

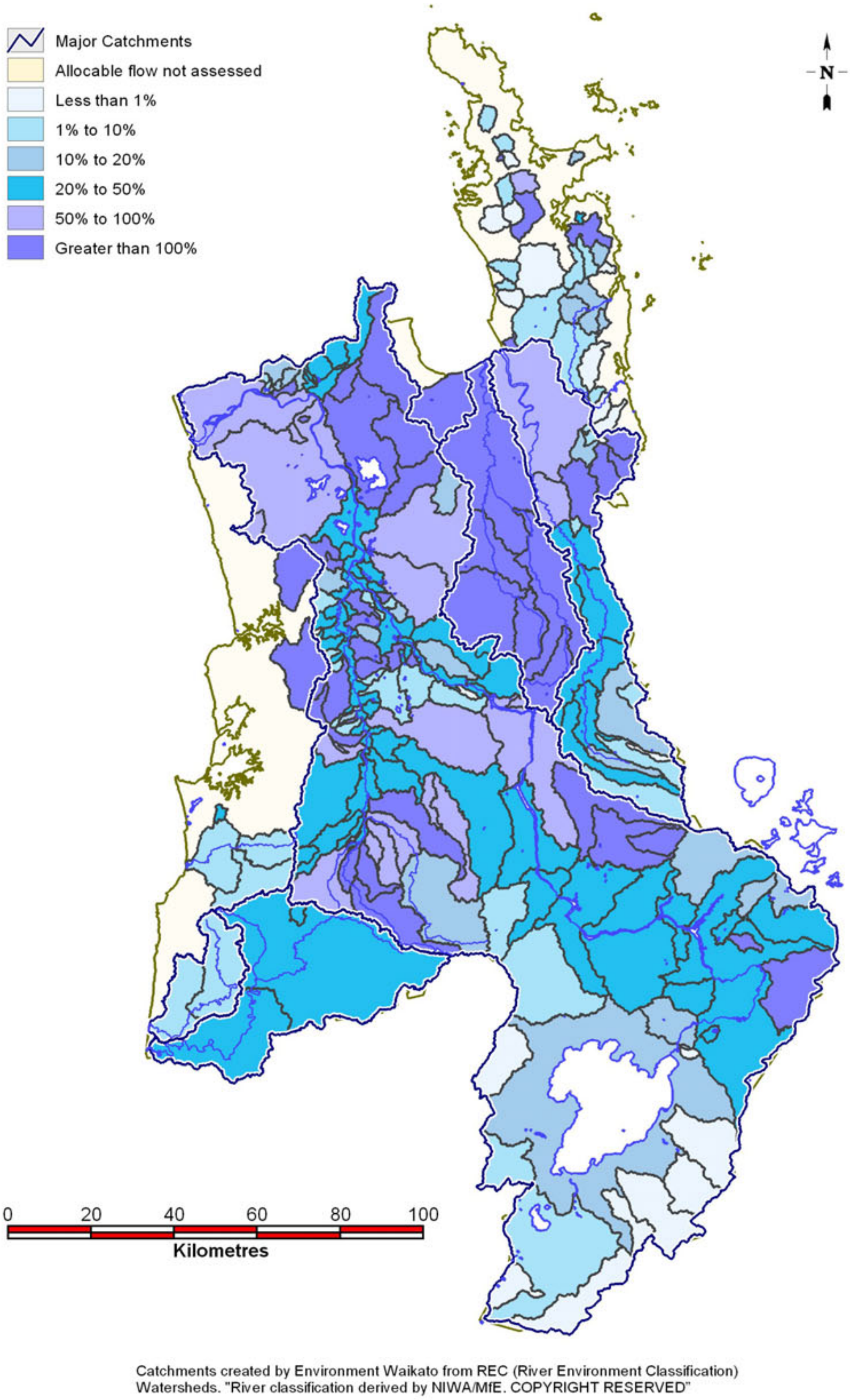


Figure 13: Permitted, s14(3)(b) and consented water use as a percentage of the allocable flow for catchments with available flow data.

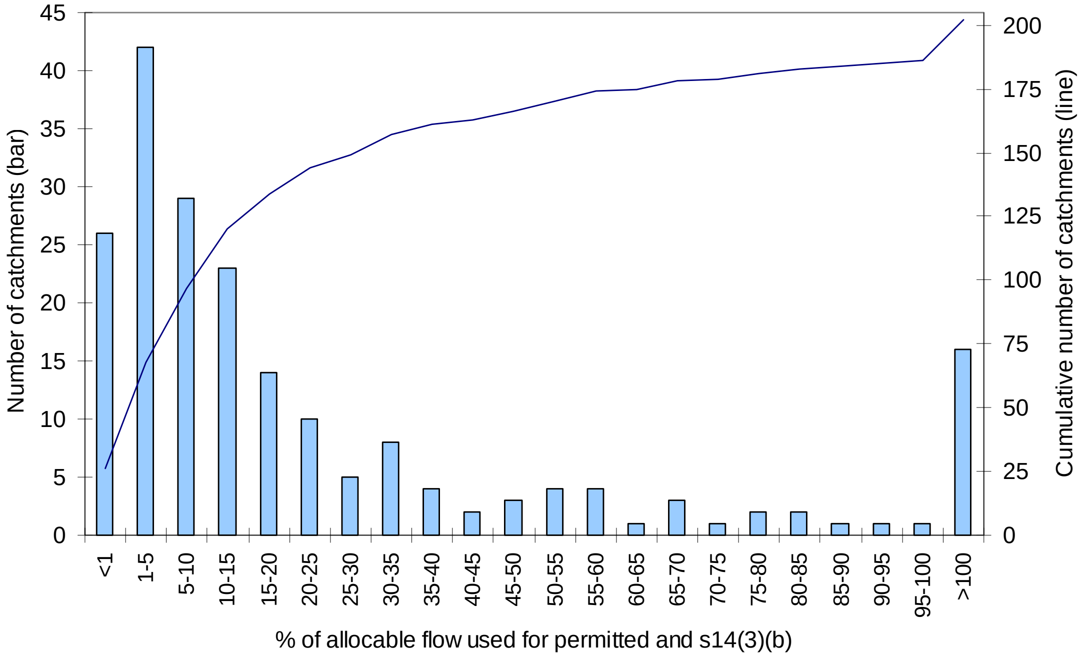


Figure 14: Histogram of permitted and s14(3)(b) water use as a percentage of the allocable flow for catchments shown in Figure 12.

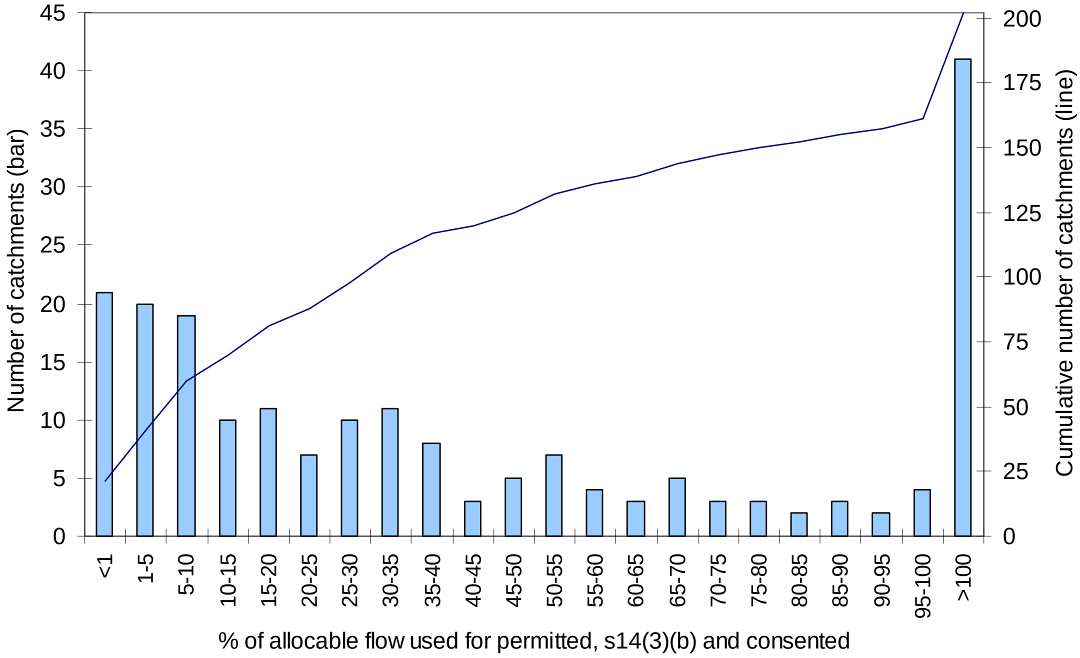


Figure 15: Histogram of permitted, s14(3)(b) and consented water use as a percentage of the allocable flow for catchments shown in Figure 13.

3.5 Over allocation and dairy shed wash-down

In catchments where the amount of water taken by permitted and s14(3)(b) activities exceeds the allocable flow[14], only the permitted water use provided for in the Waikato Regional Plan (WRP) can be easily restricted. Water used for animal and domestic drinking is provided for by right under s14(3)(b) if there are no adverse effects associated with the taking of the water. The taking of water under s14(3)(b) cannot be effected by the allocation of water for other activities according to s30(4)(f) of the RMA.

This section of the report identifies how much water is currently being taken for permitted activities, but should require consent due to the daily volume exceeding 15 m^3.

The largest use of permitted water is for dairy shed operations. The amount of water typically needed for dairy shed operations is around 70 l/cow/d (see Section 2.2.2.1). As a result, when a dairy herd has more than 215 cows, the total daily shed water is likely to exceed 15 m^3. Over 1,700 dairy farms in the Waikato have herds greater than 215 cows. These farms should have a resource consent to take any water above the permitted 15 m^3/d. However, there are only 26 resource consents currently[15] issued by the Waikato Regional Council for shed washing. It is important for dairy farm operators to know that water for dairy shed operations is not available as of right if it exceeds 15 m^3/d or if the taking of water, even if less than 15 m^3/d in conjunction with all other water takes exceeds the allocable flow.

The amount of water taken that requires consent, in addition to the permitted 15 m^3/d can be quite small, typically between 1 and 40 m^3/d, with an average of 17.4 m^3 per farm (**Figure 16**). However, the cumulative amount over a large number of farms can be quite considerable. This is shown in **Table 8** where the amount of water taken without consent in the Piako catchment is 3,200 m^3/d, 3,300 m^3/d in the Waihou catchment and 14,000 m^3/d in the Waikato Catchment. For the three catchments these amounts account for approximately 12 percent of all the water currently taken for permitted and s14(3)(b) activities.

Table 8: The amount of water allocated for dairy shed activities that may require resource consent.

Catchment	Permitted shed wash above 15 m^3/d threshold m^3/d	% of total	Total permitted + s14(3)(b) m^3/d
Piako	3,200	11%	28,500
Waihou	3,300	12%	27,800
Waikato	14,000	13%	109,200
Rest of region	500	1.6%	31,100

Note: Rounded to nearest hundred

If intensification of dairying continues the amount of water taken for drinking via s14(3)(b) of the RMA will increase for the most part without restriction due to the high priority it is afforded. In many catchments this may result in nearly all the allocable flow being utilised solely for s14(3)(b) drinking water purposes. In these catchments capping the permitted use at 15 m^3/d as required by the WRP will do little to relieve the situation where use exceeds the allocable flow. **Table 8** shows only a 12 percent potential reduction from the capping of permitted use. To ensure that the current amount of water used for s14(3)(b) activities remains within the allocable flow, the permitted activities threshold of 15 m^3/d will have to be lowered. In some catchments it may need to be zero. Resource consents would then be required for previously permitted activities to continue taking the water. Requiring a consent will not reduce the amount of water taken from the allocable flow, unless restrictions are included in the consent conditions. During times when water is not readily available, these conditions could stop water being taken for dairy shed operations to maintain minimum stream flows.

This scenario of restricted permitted water use such as for dairy shed operations highlights a limitation in the manner the RMA provides animal drinking water as right

[15] Based on a search of Environment Waikato's consent database on the 3 September 2007.

via s14(3)(b) and s30(4)(f) without consideration of the directly linked activities such as dairy shed operations. The allocation of water via s14(3)(b) needs to be constrained when these takes, in combination with directly related activities, are having or are likely to have an adverse effect on the environment. In this case it is likely that adverse affects will occur if the allocable flows are exceeded and minimum flows are compromised during summer low flows (droughts). During summer when minimum stream flows are compromised, the taking of water for dairy shed operations may have to temporarily stop due to the high demand from animals for their drinking requirement. This will limit the ability for animal intensification in large parts of the region where the permitted and s14(3)(b) use including water allocated by resource consent is close to or exceeds the allocable flow. These catchments where water use exceeds 50 percent and 100 percent of the allocable flow are shown in **Figure 13**. Maintaining current or future water use within the allocable flows of these catchments will require greater reliance on ground water as an alternative water source.

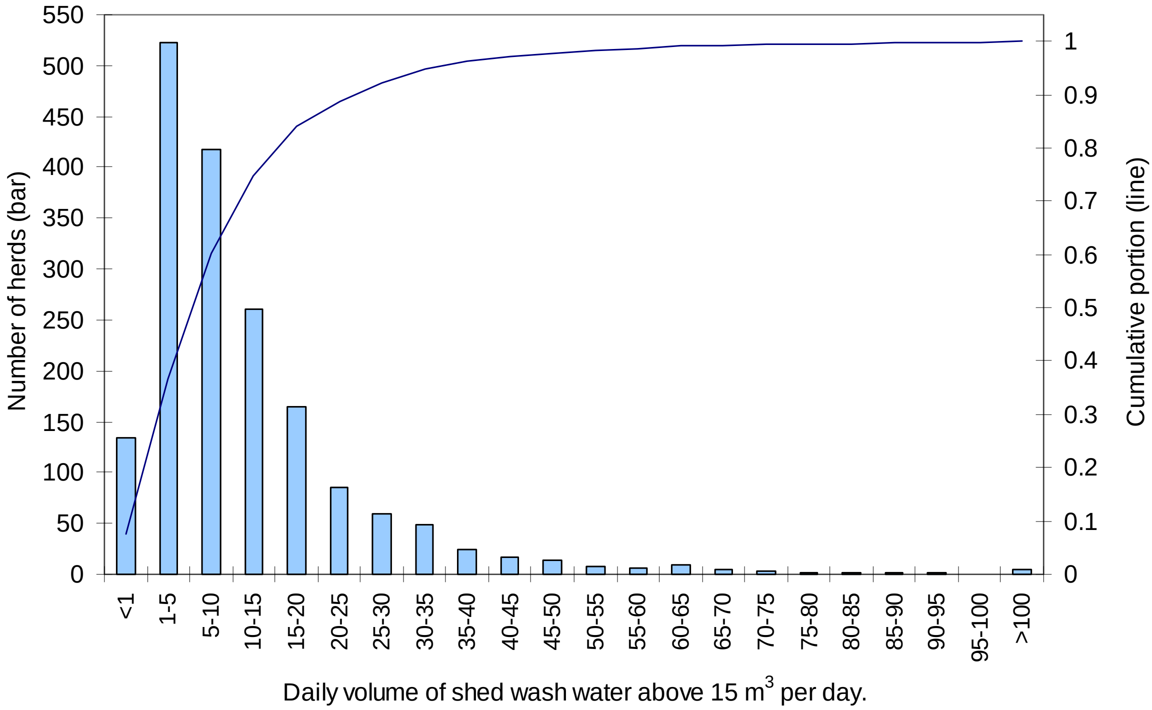


Figure 16: Number of herds in the region sourcing surface water which do not have a consent for water use greater than that provided for by the permitted activity rules in the Waikato Regional Plan. n=1787.

4 Conclusion

1. An assessment of cumulative permitted and s14(3)(b) surface water use in the Waikato shows that increasing land use intensification and animal numbers, particularly dairy cows, in some areas is placing stress on allocable water volumes and environmental bottom lines.
2. The Waikato Regional Council has developed a simple model to predict permitted and s14(3)(b) surface water use in the region. The model relies on spatially registered information relating to the main uses of this water, including animal types and numbers and domestic population.
3. This modelling approach to calculate permitted and s14(3)(b) water use has added considerably to council's understanding of likely water use by (1) providing information about the quantity of water used and regional distribution of this use, (2) identifying relative pressures on catchments from these takes in relation to the allocable flow, and (3) identifying activities that have the most influence on the volume of water taken.
4. It is recommended that the model's calculation of permitted water use is reassessed every 5 years, or at times when clusters of water take consents are being processed. The five year period is a reasonable timeframe over which there will be measurable and reported changes in activities requiring this water – such as stock numbers.
5. According to the model, the predicted summer permitted and s14(3)(b) water use for the entire Waikato region is 196,000 m^3/d (equivalent to 2275 l/s). The majority (64 percent) of this water is taken for dairy cow drinking and dairy cow shed operations – including wash down and milk cooling. The remaining 36 percent is for beef cattle, deer and sheep drinking water, domestic needs and water lost to leaks and other undefined uses.
6. The ecosystem health of many streams in the region is predicted to be compromised by the high level of permitted and s14(3)(b) water use.
   - Out of 202 catchment analysed, 32 have permitted and s14(3)(b) allocation levels greater than 50 percent of the allocable flow and 16 of these have allocation levels exceeding the allocable flow.
   - Including authorised consented water takes increases the number of affected catchments to the point where 70 catchments out of 202 have more than 50 percent of the allocable flow taken. In 41 of these catchments allocation levels exceed the allocable flow.
7. It is estimated that there are 1,700 dairy farms in the region which cannot meet their dairy shed water requirements (around 70 l/cow/d) within the 15 m^3 provided by the Waikato Regional Plan permitted activity for water takes. These farms have more than 215 cows. Under the provisions of the Waikato Regional Plan these 1,700 farms require resource consent to take more than 15 m^3/d for dairy shed operations. According to the Waikato Regional Council consent database only 26 farms have consent for this activity. This would require 1,700 additional resource consents for the taking of amounts typically in the order of 1 to 40 m^3/d.
8. It is important for dairy farm operators to know that water for dairy shed operations is not available as of right if it exceeds 15 m^3/d or if the taking of water, even if less than 15 m^3/d in conjunction with all other water takes exceeds the allocable flow. During summer when minimum stream flows are compromised, the taking of water for dairy shed operations may have to temporarily stop due to the high demand from animals for their drinking requirement.
9. The provision for stock drinking water in s14(3)(b) and s30(4)(f) of the RMA has enabled the largely unconstrained increase in dairy cow numbers. This has occurred without taking into account any other water take activities directly

associated with the operation of a dairy farm – such as dairy shed wash down and milk cooling – let alone other authorised takes associated with the municipal water supplies and industries such as dairy factories. This has resulted in the minimum flows and ecosystem health of many catchments being compromised due to the combined water use for animal drinking and dairy shed operations exceeding the allocable flow.

10. The high level of predicted permitted and s14(3)(b) water uses is concerning. Solutions may need to be considered such as controlling the number of animals in each catchment so that their water demand does not exceed what is available. Animals' drinking water requirements and the water demand from associated activities such as shed operations should not be allowed to exceed the allocable flow. Having controls on animal numbers will provide a better balance between the number of animals in each catchment and the availability of surface water so that the reliability of supply and protection of minimum flows are not compromised.

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Appendix A – Deer drinking water requirements

The following data and supporting words come from the Draft Deer Welfare Code following work at AgResearch Invermay for Deer Industry New Zealand.

"*1.1 Water*

General Information

(a) The daily consumption of water by deer can vary widely according to species, body weight, age, sex, climatic conditions, type of diet, and feed intake

(b) Some classes of deer will have significantly increased water requirement at certain times. For example:

(i) Adult stags during the rut

(ii) Stags post velvetting (first 24-48 hours)

(iii) Lactating hinds

(iv) Weaned deer (up to 10 days after weaning)

(v) All deer during periods of hot, dry weather.

(c) To ensure that water is always available, where used, water reticulation systems need to be inspected regularly for normal function, preferably daily during summer or extended periods of dry weather and at least weekly during winter. Where extensive grazing systems are used, depending on the size of the storage systems, less frequent inspections may be suitable

(d) Limited research has been completed to estimate the water requirements of red deer. The following recommendations have been developed from 3 winter feeding experiments with weaner deer (45-80 kg liveweight) fed on combinations of silage, concentrates and a brassica crop. The recommendations for hinds and stags are based on the comparison of the weaner data with other livestock species, with the subsequent extrapolation to mature livestock.

(e) Deer need a supply of drinking water even if feeding brassicas / spring pastures.

Table 3: The estimated daily drinking water requirements (litres per day L/day) for red deer when fed either forage (pasture, silage or a brassica crop) or a concentrate diet.

	Forage	*Concentrate*
Weaners (up to 85 kg LW)	*0.5-1.5 L/day*	*1.5-2.5 L/day*
Hinds (dry, 100-120 kg LW)	*1.5-2.0 L/day*	*3.0-4.0 L/day*
Hinds (lactating, 100-120 kg LW)	*5.5-7.0 L/day*	*8.0-10.0 L/day*
Stags (180-250 kg LW)	*3.0-4.0 L/day*	*6.0-7.0 L/day*

Assumptions made:

- *The table refers to ambient temperature up to 20ºC*
- *Forage crops refers to pasture, silage or brassicas*

- *Summer conditions: For temperatures over 20ºC the following additions should be made. Approximately 1.0 L/day should be added per 100kg LW for every 5ºC higher temperature*
- *Drinking water is assumed to be 25% and 75% of total water requirements for forage and concentrate diets respectively*
- *At low DM concentrations (under 15% DM in forages such as spring pastures or brassica crops) animals may not use additional drinking water*
- *Weaner requirements are based on a liveweight gain of 0 to 350 g/day, with the lower water requirement for the lower gain*
- *Hinds water requirements are based on a near maintenance feed requirement of 2 kg DM/day and a lactation feed requirement of approximately 4 kg DM/day*
- *For lactating hinds an additional water requirement of 1 L/kg milk produced has been added as drinking water requirements for both feeding options. This may not all be required in a forage situation due to the increase in feed intake*
- *Stag water requirements are based on a near maintenance feed requirement of approximately 4 kg DM/day*
- *The DM concentration of a forage diet is assumed to be up to 30% DM, while that of a concentrate diet is assumed to be greater than 80% DM*".

Appendix B – Removing areas of existing community supply

The most comprehensive method for removing areas of existing community water supply from the model would be to have details about which properties are supplied by each scheme. However, for many of these schemes this information was not readily available. An alternative method was used to isolate existing community supplies, this involved three steps:

1. Urban areas with scheme supplies listed by DWNZ[5] were isolated using the existing Waikato Regional Council corporate GIS feature GIS_ALL.URBAN _FOOTPRINT. The Urban footprint layer provides information on the spatial extent of these communities. This method isolates 95 percent[16] of the total Waikato population as being supplied water from an urban supply scheme. The urban areas isolated are:

   'Hamilton City' 'Tuakau' , 'Huntly' , 'Ngaruawahia' , 'Raglan' , 'Te Kauwhata' , 'Paeroa' , 'Waihi' , 'Matamata' , 'Waharoa' , 'Morrinsville' , 'Te Aroha' , 'Kawhia' , 'Otorohanga' , 'Putaruru' , 'Tirau' , 'Tokoroa' , 'Coromandel' , 'Pauanui' , 'Tairua' , 'Thames' , 'Whangamata' , 'Whitianga' , 'Cambridge' , 'Kihikihi' , 'Te Awamutu' , 'Pirongia' , 'Piopio' , 'Te Kuiti' , 'Acacia Bay' , 'Kinloch' , 'Mangakino', 'Motuoapa', 'Pukawa Bay' , 'Omori' , 'Taupo' , 'Turangi' , 'Tokaanu' , 'Wairakei Village'.

2. Smaller schemes not listed with DWNZ are not easily isolated due to insufficient information outlining which properties are in each scheme. The approach taken here is to isolate some of the consented rural supply schemes by searching the Waikato Regional Council consent database. From this database it is possible to identify how much water they are consented to take to supply the scheme. To avoid including these schemes in the model results the volume of water use was subtracted from the calculated permitted and s14(3)(b) use in the corresponding catchment. Care must be taken to subtract the correct amount as many of the schemes also provide water for irrigation and industry; these volumes should not be subtracted. Checks were also made to ensure that catchments downstream did not result in a lower total permitted water estimate due to incorrect (large) reduction values.

3. The seven water supply schemes used to develop the model were excluded based on details about the physical extent of the schemes as shown in **Figure 1**.

[16] Based on the DWNZ populations statistics the total population of the towns isolated are 281,258, out of a total reported Waikato Region population of 357,726 (http://xtabs.stats.govt.nz/eng/statsbyarea/area_main.asp).

Appendix C – Sensitivity analysis of water use parameters for domestic use

The model presumes that if a catchment's water quality was deemed to be 'good', 1 in 3 households would source their water from surface waters. If the water was 'poor' this would reduce to 1 in 10 households. These ratios equate to an average ratio of 1 in 5 for the whole region. There is little information available to support these ratios. The consequences of using these ratios were tested to identify the sensitivity of the model results to these. The test involved calculating the permitted water use for a range of ratios (1 in 2, 1 in 5 and 1 in 20) relating to the number of houses using surface water. The results were compared to the original model output and are shown in **Figure C1** for the three largest catchments in the Waikato region, the Waikato, Waihou and Piako catchments.

The 1 in 5 ratio represents the average ratio for households across the region. For all three catchments the calculated water use for the 1 in 5 ratio is less than 2 percent different than the original model. The 1 in 2 ratio represents the extreme maximum likely number of houses using surface water. This ratio results in between 4 and 10 percent more modelled water use. The 1 in 20 ratio reflects the lower extreme of expected number of houses that may use surface water for their domestic needs. The 1 in 20 ratio results in between 2 and 6 percent less water use than the original model. This analysis demonstrates that a large change in the ratio of houses using surface water does not have corresponding large changes in the modelled water use. This is primarily due to the majority of catchment water being used for animal drinking and shed operations.

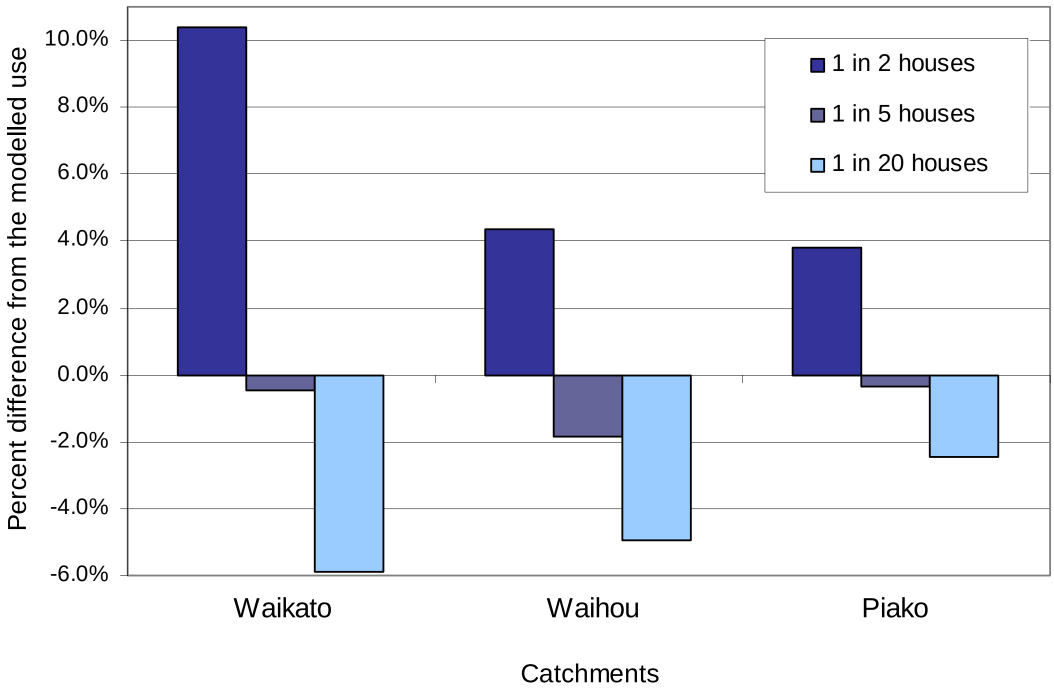

Figure C1: Percentage difference in the calculated permitted and s14(3)(b) water for three different ratios representing the number houses using surface water for domestic household use.

Appendix D – Conversion land

Table D1 lists the catchments included in the model to account for a large forestry to dairy conversion in the catchment of Ohakuri Dam near Taupo. It was assumed that the area of land being converted is stocked with dairy cows at a ratio of 2.8 cows/ha. The water usage per cow (including shed water) is 140 l/cow/d.

Table D1: Sub catchments were land is being converted from forest to pasture in the Ohakuri Dam catchment.

Catchment description	Conversion area (ha)	Animal water usage (m^3/d)	Grid reference (NZTM)	
			Easting	Northing
Orakonui at Ngatamariki	3,263	1,280	1876665	5731145
Waiwhakarewaumu Stream at Waikato River	3,800	1,490	1880661	5730429
Kereua Stream at Waikato River	1,381	540	1885135	5721005
Pueto Stream at Waikato River	11,450	4,490	1883047	5720290
Sub catchments above Ohakuri Dam	5,106	2,000	1878514	5731622
Total	**25,000**	**9,800**		