AQUALINC RESEARCH LIMITED

Water Use and Availability Assessment for the Western Bay of Plenty

Prepared for Environment Bay of Plenty

Report No. H05017/1

May 2007

AQUALINC RESEARCH LIMITED

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TABLE OF CONTENTS

Page

List of Appendices:

List of Figures:

List of Tables:

LIST OF ABBREVIATIONS

EBOP	Environment Bay of Plenty
IFIM	Instream Flow Incremental Monitoring
IMFR	Instream Minimum Flow Requirement
PRWLP	Proposed Regional Water and Land Plan
TCC	Tauranga City Council
WBOP	Western Bay of Plenty
WBOPDC	Western BOP District Council
WRZ	Water Resource Zones

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EXECUTIVE SUMMARY

The Western Bay of Plenty (WBOP) sub-region is one of the fastest growing areas in New Zealand as it is a recognised ‘sunbelt’ destination, with 80% of population growth resulting from migration. Tauranga is the main urban area (70% of the sub-regional population), with smaller settlements of Te Puke, Katikati, Waihi Beach, Omokoroa, and Maketu. The study area covers a land area of approximately 2,092 square kilometres (km^2), most of which falls within the WBOP District (92.8%); the rest is within Tauranga City. The WBOPDC area is predominately rural in nature and primary land use is agriculture. The land cover of the TCC area is largely urban residential and commercial.

The regional and district councils (EBOP, WBOPDC and TCC) developed the ‘SmartGrowth’ for the strategic planning of growth in the WBOP. It contains an Action Point for EBOP to complete a strategy for water allocation to give greater confidence for long term water supply planning. Water resources in parts of the region are coming under increasing pressure to meet rising demand, and to maintain resource sustainability and environmental standards. There is a need to better understand the trends in water demand and the sustainability of water resources.

The purpose of this study is to assess the capacity of surface and ground water resources to meet projected future water demand in the sub-region over the next 50 years, and the suitability of surface and ground water quality for various uses. It also identifies the suitability of areas of land use development based on the availability of water resources, and compares these with SmartGrowth’s mapping of land use development potential.

For the purposes of this study the area is divided into 15 water resource zones (WRZ) based on SmartGrowth Management Areas and surface water catchments. Key relevant features of the area are:

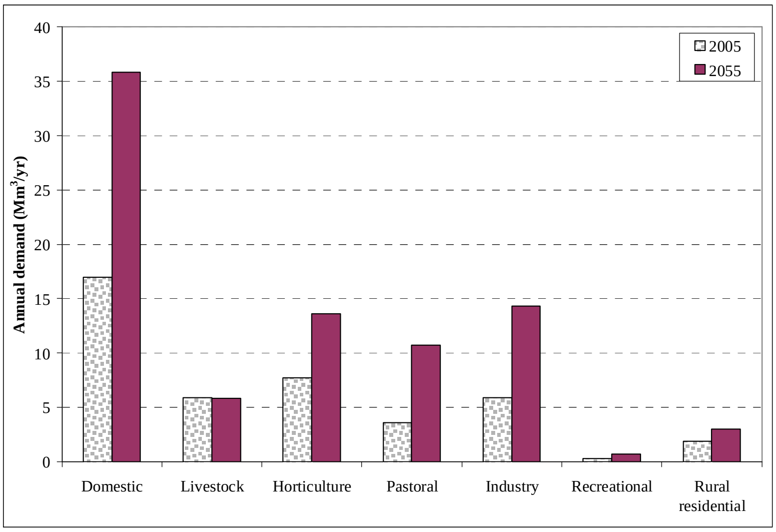
- The total population in 2005 was approximately 141,000.
- The population in TCC area is in the order of 100,000 (70% of the sub-region) who live within 7.2% of the study area.
- Reticulated water is supplied to almost all the dwellings within TCC and over 13,000 within WBOPDC. Non-reticulated supply accounts for approximately 2,700 houses.
- The area of commercial agriculture is approximately 125,000 ha.
- The total area of horticulture is approximately 10,500 ha, 71% (7,450 ha) of which is kiwifruit. Approximately 3,220 ha of the total area is irrigated.
- The area of pastoral farm is over 80,000 ha, of which only 1.26% is currently irrigated, mostly on dairy farms.

- TCC is predominately urban in nature with a large number of commercial and industrial businesses in operation.
- The area of rural residential land use (non-commercial agriculture) is estimated to be 103,000 ha.

Water Demand

The demand projections indicate:

- Demand for water in the study area is projected to increase from the current level of 41.9 Mm^3/yr to 79.2 Mm^3/yr by 2055 (an 89% increase). The breakdown of water demand by use is shown below. Sensitivity analysis indicates that the demand could be as high as 95.4 Mm^3/yr if there is sustained high population and industrial growth.



Distribution of water demand

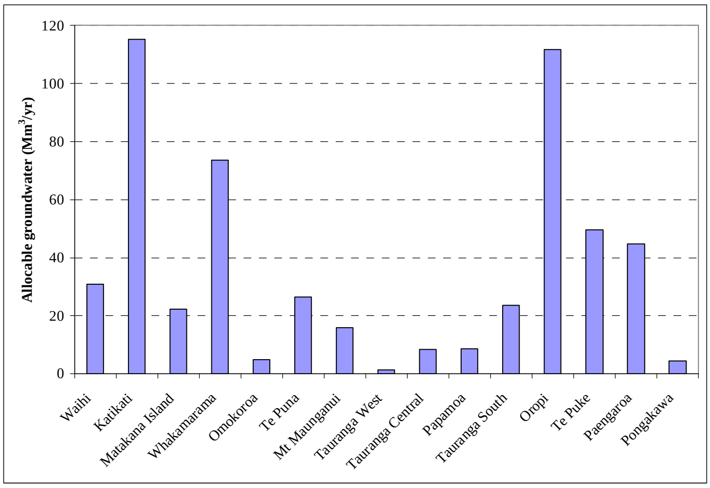
- The principal driver to increasing demand will be population growth which is projected to increase from 141,000 to 290,000 over next 50 years period (an increase of 106%, based on the medium growth scenario). The population within TCC area is projected to increase from 100,000 to 212,000 within this period.
- Domestic water demand (for reticulated and non-reticulated consumers) is projected to increase from 16.9 to 35.8 Mm^3/yr.
- Water demand for commercial and industrial use is predicted to increase from 5.9 to 11.3 Mm^3/yr by 2055. The demand from TCC reticulated supply is projected to increase by 203% (from 1.45 to 4.39 Mm^3/yr).
- The distribution of agricultural land use is predicted to change with reductions in the area of farms around Tauranga, due to conversion to urban and rural residential holds. The agriculture land area is expected to marginally increase in rural WRZs.

- Horticultural land use is predicted to remain similar to the current area; however, demand for irrigation is predicted to rise by two fold to increase profit, maintain market edge and manage effects caused by unexpected weather patterns. However, water demand for frost protection is not predicted to increase as warm weather patterns are forecasted for the region.
- Overall agricultural water demand (including livestock) will increase from current level of 17.2 to 30.2 Mm^3/yr by 2055.

Resource Availability

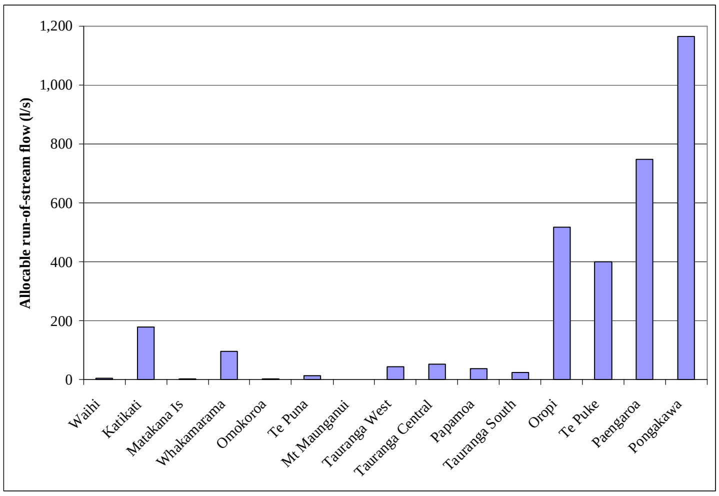
The assessment of water resources indicates:

- Total annual water availability from run-of-stream flows, groundwater and dams is approximately 646 Mm^3/yr.
- Groundwater availability is approximately 541 Mm^3/yr (84% of the total availability).



Groundwater availability by WRZ

- Available run-of-stream flow data is limited for the study area. Estimated average daily water availability using extrapolation of available data is about 284,000 m^3/d (3,289 l/s).



Run-of-stream availability by WRZ

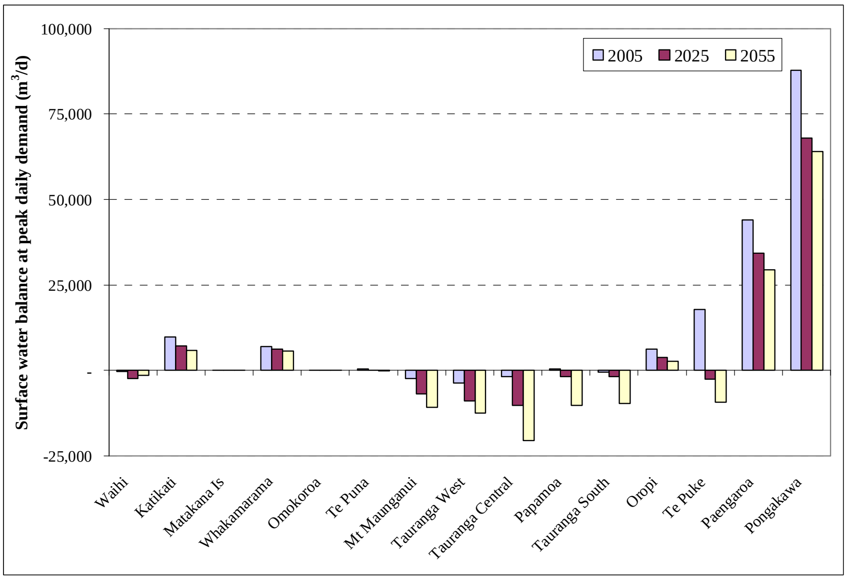
- Dams are estimated to contribute approximately 0.88 Mm^3/yr to supply.
- Harvesting of winter stream flows could potentially contribute more than 600 Mm^3/yr to water supplies; however, there are a number of issues to development.
- Rooftop rainwater harvesting is not a major contributor in the area; it accounts for less than 4% of the demand within WBOPDC.

Water Resource Sustainability
The assessment of sustainability of water resources indicates:

- The global (i.e. whole WBOP area) water balance shows that the WBOP is ‘water rich’ with a positive water balance of 566 Mm^3/yr over the planning horizon, year 2055. However, the balance masks the spatial and temporal variation in demand and water supply as well as variations between water sources.

  Surface water

  - Contribution from surface water resources is estimated to be 57%, and based on present preference for water sources could increase to 63% by 2055.
  - The average daily allocable resource is 284,000 m^3/d based on current EBOP allocation limits. The current total daily peak demand from run-of-streams is 119,000 m^3/d, with expected increase to 250,000 m^3/d by 2055. There are drought management provisions in the Regional Water and Land Plan that apply to water takes. The general approach would be to provide for human health/public safety over agricultural irrigation. The current daily peak demand for domestic and livestock is in the order of 50,000 m^3/d, and predicted increase up to 104,000 m^3/d by the planning horizon. The surface water balance at peak demand by WRZs is shown below.



Run-of-stream water balance by WRZ based on peak daily demand

- Approximately 50% of the surface water demand comes from TCC-supplied water to WRZs within and around Tauranga City. This TCC reticulated supply is sourced from the Waiorohi and Tautau Streams from Oropi WRZ, and neither of the streams have detention dams for storage.
- Surface water resources are under heavy pressure around Tauranga (at current level of allocation), and the current water balance at the peak demand is unsustainable. It is predicted that demand for surface water for TCC supply at the peak daily demand could exceed currently allocable resources by 60,000 m^3/d by 2055.
- The EBOP's current allocation limits show that it is unsustainable for TCC to continue abstracting water from run-of-stream resource only. However, IMFR studies undertaken by TCC show that there is potential for higher allocation limits from the streams that supply to TCC reticulated network.
- There is little agricultural or horticultural land use below the TCC water takes. These streams are generally in native bush catchments, or deep incised gullies, or the adjacent topography is not really suitable for high stock rates. Therefore, effect on agriculture due to TCC takes is not significant.

Ground water

- Groundwater balance for all the WRZs is positive, with global balance of over 500 Mm^3/yr over the planning horizon, year 2055.

- Recent groundwater investigation report (GNS, 2006) recommends it is only sustainable to abstract water from deeper aquifers; this can increase initial capital and operating cost of takes.
- Groundwater abstraction closer to sea can cause saltwater intrusion; therefore, regular monitoring may be required.

- Current contribution from storage dams is relatively small compared to overall water demand. There is considerable potential to increase the harvesting and storage of winter stream flows which may be developed to alleviate pressure on high demand streams, in particular streams that supply to TCC.

- While the above projections are based on medium growth and associated land use changes, there is potential for high growth rates. If higher growth rates are sustained in the medium to long term, run-of-stream supply is unsustainable for most of the WRZs. The increase in demand will have to be met from groundwater (where availability is over 500 Mm^3/yr), and/or storage supply from harvesting winter flows.

Recommendations

- EBOP should undertake a strategic water planning exercise in the high demand zones (Tauranga, Mount Maunganui and Papamoa), and the zones which these urban areas draw water from, to ensure water is not a limitation on further growth.

- EBOP should improve current information on water resources by:
  - Conducting IMFR studies on high demand streams to determine sustainable allocation limits, and include the IMFR's in the Regional Water and Land Plan via a plan change.
  - Collection of water quality data to identify the temporal variation of the available quality resource.
  - Prioritising the setting of sustainable yields for aquifers tin the Western Bay of Plenty, and include those in the Regional Water and Land Plan via a plan change.

- EBOP and TCC should work together to identify alternative sustainable water supply sources to meet predicted future high demand and improve reliability; the options include groundwater, winter flow harvesting, or other surface water sources.

- EBOP should consider and implement a more strategic approach for future water allocation, including taking into consideration likely future demand by use type and source, and through the consent process reserve resources to meet these demands.

- EBOP should improve the format of water consent database to include information such as sustainable yield from each resource/catchment, groundwater bore depth, irrigated area from each irrigation take.

- Actively promote or require the use of winter flow harvesting, particularly for irrigation supplies for market gardening, frost protection, and possibly municipal water supplies.

1 INTRODUCTION

Environment Bay of Plenty (EBOP), Western BOP District Council (WBOPDC) and Tauranga City Council (TCC) developed 'SmartGrowth' (2004) for the strategic planning of growth in the Western Bay of Plenty. The SmartGrowth contains an Action Point for Environment Bay of Plenty to complete a strategy for water allocation to give greater confidence for long term water supply planning.

Method 112A of the EBOP's (Proposed) Regional Water and Land Plan Version 9.6 (as amended by appeal resolutions) (EBOP, 2007) states that EBOP will develop a long-term water sustainability strategy in conjunction with territorial local authorities, stakeholders and the community (including representatives from commercial, industrial, horticultural and agricultural organisations) to manage future water use requirements in areas of high water demand. The strategy will:

(a) Determine the potential long-term requirement for water resources in the region according to future population growth projections, possible horticultural and agricultural land use changes, and possible industrial growth.

(b) Investigate:

   (i) Surface water and groundwater resource quantities, availability and reliability.

   (ii) Water quality, and the suitability of surface and groundwater quality for various uses.

   (iii) The capacity of those surface and groundwater resources to meet expected future water demand.

   (iv) Water resources that are likely to come under abstraction pressure.

(c) Identify appropriate mechanisms to manage future water use to ensure water is allocated in a fair and equitable manner.

(d) Integrate long-term development and the protection of the Bay of Plenty's water resources in relation to Policy 54 and 57.

(e) Identify areas in the region where:

   (i) There is a lack of water resources that may limit land use intensification or urban growth, as increased water abstraction may cause significant adverse effects on the environment.

   (ii) The area is suitable for non-consumptive uses based on the availability of water resources.

> Any changes to the Regional Water and Land Plan resulting from the Water Sustainability Strategy will be in accordance with the requirements of the First Schedule to the Resource Management Act 1991, and in consultation with the community and stakeholders.

This report outlines the water resource demand predictions for the next 50 years, resource availability and sustainable strategies for the Western Bay of Plenty Region. It forms a part of the background for the water allocation policy document, Water Sustainability Strategy, which will be prepared by EBOP to implement the SmartGrowth commitment in managing future water use requirements.

1.1 Project Objectives

The project objectives are:

- To assess the capacity of surface and groundwater resources to meet expected future water demand in the Western Bay of Plenty over the next 20 (best estimate) to 50 (potential) years, and the suitability of surface and groundwater quality for various uses. Predictions will use the current situation as a base, and will give a best estimate for the next 20 years (to 2025), and an indication of the potential situation up to 2055 (50 year period).
- To identify the suitability and unsuitability of areas in the Western Bay of Plenty of land use development based on the availability of water resources, and compare/contrast with SmartGrowth's mapping of land use development potential (based on soil type, climate and topography).

1.2 Study Area

The study area is the Western Bay of Plenty (WBOP) sub-region. This area encompasses the areas of WBOPDC and TCC as illustrated in Figure 1. The study area covers a land area of approximately 2,092 square kilometres (km^2), most of which falls within the WBOPDC (92.8%). The WBOPDC area is predominately rural in nature and primary land use is for agriculture. The land cover of the TCC area is largely urban residential and commercial.

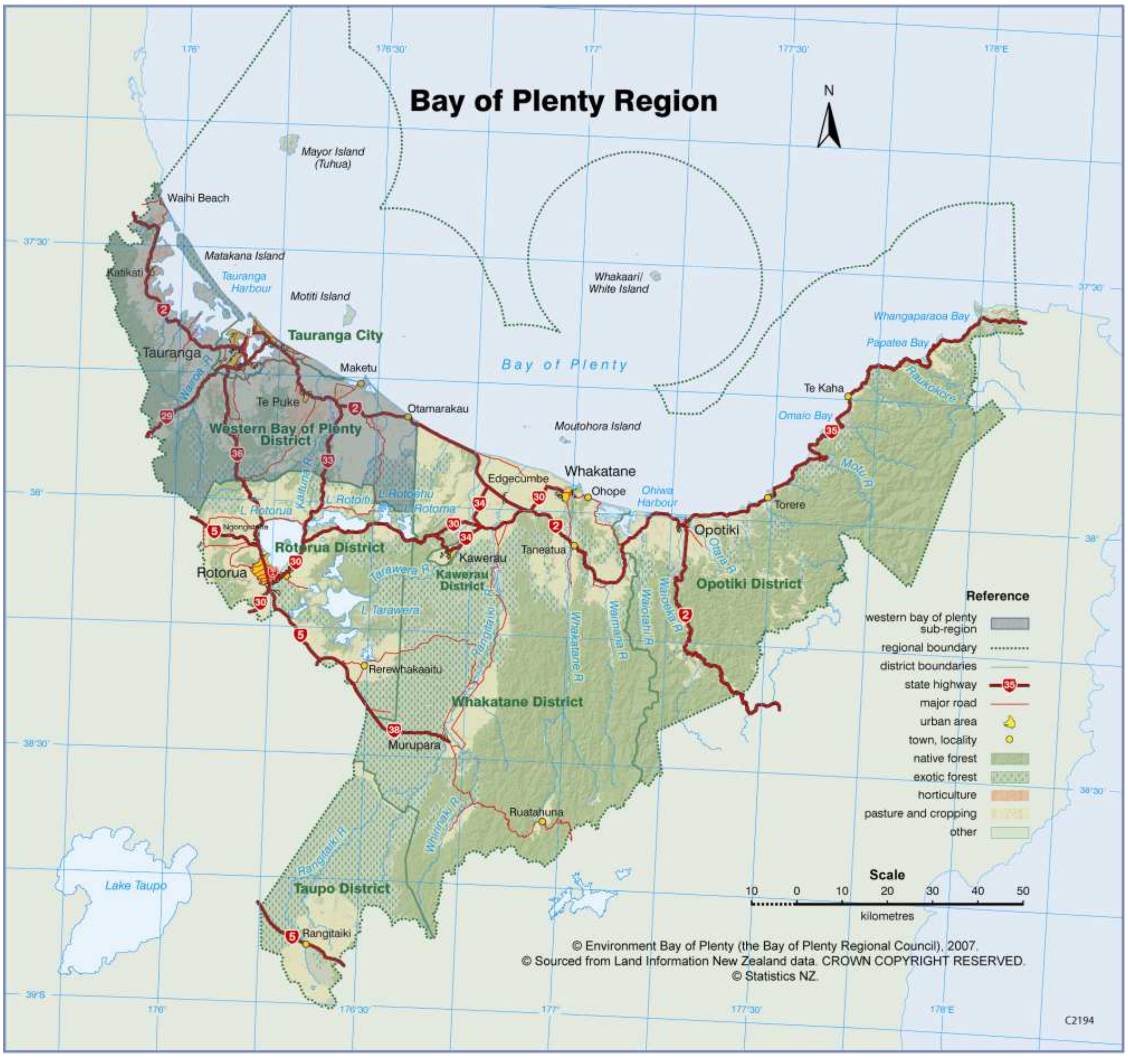


Figure 1: Study area – Western Bay of Plenty sub-region

1.3 Information and Data Sources

The SmartGrowth study has been based on a large number of research and studies of different aspects of the growth of the sub region. All the relevant reports have been reviewed to encapsulate relevant information for the current study. The main reports are listed in Appendix A.

Data used in compiling this report has been primarily supplied by EBOP, WBOPDC and TCC. This information and data are as follows:

- EBOP
  - SmartGrowth and its relevant reports (as listed in Appendix A);
  - Digital maps of water study areas (regional, catchment boundaries, water study areas and dams);

  - Land use data;
  - Water consent and water use records;
  - Population census and growth projections;
  - Dam locations and associated database;
  - Sustainable available groundwater volumes (GNS, 2006); and
  - Stream flow monitoring records.
- WBOPDC and TCC
  - Relevant sections of the district asset management plan; and
  - Water usage data, water sources and their capacities.
- MAF – agricultural census statistics for Territorial Authorities
- NZ Statistics Agricultural Production Statistics
- NZ Land Resource Inventory – soils information
- NIWA – climate and rainfall information for soil water modelling
- NZ Ministry for the Environment Climate Change studies

1.4 Planning Horizon

Predictions will use the current situation as a base, and will give a best estimate for the next 20 years (to 2025), and an indication of the potential situation up to 2055 (50 year period).

The current water use and projections have been based on a number of parameters and published information on population and land use, as listed in Appendix B.

1.5 Water Resource Zones

For the purposes of this study, the study area was divided into 15 Water Resource Zones (WRZ). The selection of zones was based on criteria of:

- EBOP surface water catchment;
- SmartGrowth Management Areas;
- Town locations;
- Population;
- Current water demand (existing water take consents and dams); and
- Isohytal maps.

The groundwater zones in the region were not considered for this analysis as data was not available at time of zoning (Note that water resource zoning was completed in August 2005, and EBOP groundwater zoning was completed in late 2006 by GNS (2006)).

The total SmartGrowth area is 2,289 km^2. However, the areas covered by the sea have been omitted for this Water Sustainability Strategy study; this results in a total area of 2,092 km^2. Table 1 lists the 15 water resources zones by names, in descending order from north to south. The zones range in area from 11.6 km^2 for Omokoroa to 407.5 km^2 for Oropi.

Table 1: Water resource zone areas

	Water Resource Zone	Area (km^2)	Total (%)
1	Waihi	56.0	2.7%
2	Katikati	251.2	12.0%
3	Matakana Island	65.4	3.1%
4	Whakamarama	305.9	14.6%
5	Omokoroa	11.6	0.6%
6	Te Puna	17.1	0.8%
7	Mt Maunganui	23.6	1.1%
8	Tauranga West	28.4	1.4%
9	Tauranga Central	21.2	1.0%
10	Papamoa	34.7	1.7%
11	Tauranga South	40.9	2.0%
12	Oropi	407.5	19.5%
13	Te Puke	188.5	9.0%
14	Paengaroa	351.4	16.8%
15	Pongakawa	289.1	13.8%
	Total	**2,092.3**	**100.0%**

Eight smaller zones (Matakana Island, Omokoroa, Te Puna, Mt Maunganui, Tauranga West, Tauranga Central, Papamoa and Tauranga South) are identical to the SmartGrowth Management Areas. Apart from Matakana Island, the population density in all these zones is higher; therefore, water demand will be greater. Other zones are generally regarded as more rural in nature, with land use focused on traditional primary production of agriculture and forestry. The zoning criteria of larger zones, Waihi, Katikati and Te Puke, were largely based on surface water catchments and SmartGrowth Management Areas. Kaimai and Paengaroa Management Areas are significantly larger and each of these areas has been divided into two zones based on water catchment boundaries. The WRZs are shown in Figure 2.

Figure 2: Water Resource Zones

2 LAND USE ASSESSMENT

Land use patterns within the study area are highly varied. Land cover in and around Tauranga City is predominately commercial and urban residential. The seaboard WRZs (Waihi, Mt Maunganui and Papamoa) provide commercial resources for tourism industry. Land use in other WRZs is predominately rural agriculture, mainly horticulture and dairying. Details of the current land use distribution of the WRZs are listed in Appendix C.

SmartGrowth (2004) indicates that high quality, versatile soils are a relatively scarce and finite resource within the sub-region and it is important to use them wisely to succeed in competitive agricultural markets. The Resource Management Act 1991 and regional and district plans include provisions for sustainable land management and guide future land use decisions. Although versatile soils should be considered and protected where appropriate, they remain just one of many factors influencing development suitability and urban growth options.

SmartGrowth (2004) also identifies the future urban growth areas in the region, as illustrated in Figure 3.

SmartGrowth has further identified the potential commercial, industrial and agricultural growth areas within the sub region. In this study, these land use capabilities have been used to assess the future water demand and availability of resources for various uses.

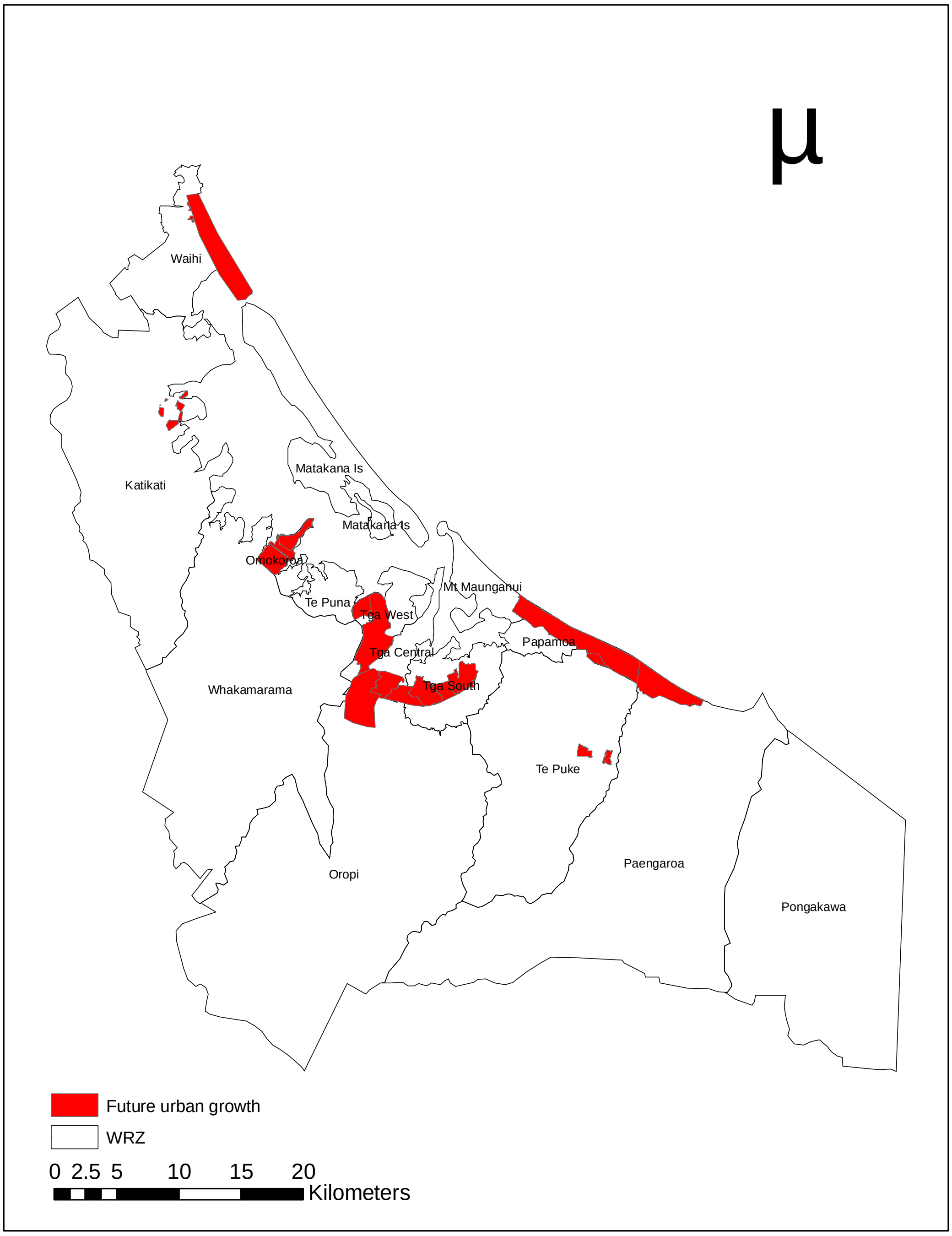


Figure 3: Projected future urban growth areas

3 DEMAND ASSESSMENT

This section presents the current and future water demands assessment for each WRZ. The main factors that impact on consumptive demand such as trends in population growth and land use types have been analysed to determine the water demand. The main body of text presents summaries of the key findings, with description of parameters and detailed results in the accompanying appendices.

3.1 Approach and Parameters

The following sub-sections outline the approach and parameters adopted for the study.

3.1.1 Water Demand Categories

The approach to determining demand is based on the following water use categories:

i) Domestic consumption (i.e. household water consumption) with two sub-categories:
   - Reticulated; and
   - non-reticulated.

ii) Industrial and commercial use.

iii) Agriculture – water consumption required for the following sub-categories:
   - Livestock (inclusive of stocks in rural residential units and dairy shed requirements, however, note that dairy shed requirements are not permitted as of right under the RMA, so must comply with permitted volumes under Regional Water and Land Plan); and
   - Irrigation based on the following:
     – Pastoral;
     – Horticultural, including frost protection; and
     – Arable.
   - Rural residential; water demand for non-commercial agricultural activities (excluding domestic component and livestock demand).

iv) Recreational irrigation (such as for bowling greens, sports fields etc.).

v) Forest demand.

The discussion of demand excludes geothermal water (>30ºC), which is treated as a separate resource from cold groundwater.

3.1.2 Demand Units

Water demand and supply values are presented as:

- Annual demand; the mean annual demand expressed as cubic metres per year (m^3/y) and million of cubic metres per year (Mm^3/y);
- Average daily demand; the average daily demand expressed as cubic metres per day (m^3/d); and
- Peak daily demand; the peak daily expressed as cubic metres per day (m^3/d).

3.2 Climate Change

Recent research in New Zealand and overseas shows that climate change is occurring and that future changes are inevitable. Further, variations in climate between years can have a strong influence on agriculture production (Kenny, 2001; MfE, 2004). Future climate changes are predicted to increase the frequency and intensity of known climate-related risks and hazards such as floods, droughts, windstorms. As an example, by 2030, the chance of flooding may increase by twofold over current frequency; and by 2070 by four times (O'Connell and Hargreaves, 2004).

NIWA have developed a model for EBOP to predict climate parameters such as temperature and rainfall (NIWA, 2003). The model predicts that mean annual temperature in Bay of Plenty could increase by about 0.80° C and 1.8° C by the 2030 and 2080, respectively. The mean annual rainfall is projected to decrease in Tauranga area by about 8% by 2030, but no further drying is expected between 2030-80. The model forecasts that summer rainfall would return to near the current climatology by 2080. However, within the same horizon autumn and winter are projected to be wetter than the current, with drier spring seasons. In addition the model shows reduced return periods of heavy rainfall are likely by 2080.

In general, a warmer climate will have benefits for production of subtropical fruits such as avocados and citrus. There will be both costs and benefits for temperate fruits such as kiwifruit and apples, depending on location. Generally, wine grapes will benefit if it is irrigated.

To date, detailed studies on the possible effects of climate change have only been carried out on kiwifruit and apples. It is likely that climate change will have beneficial effects on pasture production over coming decades. Higher atmospheric concentrations of carbon dioxide will increase photosynthesis (the so-called 'carbon-fertilisation' effect), allow for more efficient use of available water and improve pasture growth rates, particularly with temperate pasture (MfE, 2004).

Arable cropping is a relatively small contributor to the WBOP region economy. Year-to-year variations in climate can have significant impacts on production. A poor growing season combined with poor market conditions can have significant adverse effects. Arable farmers have developed a strong capacity to adapt to climate variability, and it is likely that this adaptive capacity will be needed in the future with the increasing influence of climate change.

In determining the future water resource demand for agriculture, the potential climate change effects have been taken into account along with the SmartGrowth predictions.

3.3 Domestic Water Demand

The domestic water demand for each WRZ is based on the following parameters:

- 2001 population census and SmartGrowth's residential development time line (SmartGrowth (2004) page 23 - Figure 9) to determine estimates for year 2005 and 2025.
- The growth rate of the SmartGrowth's residential development time line for period of 2046 to 2051 was extrapolated to determine the 2055 population.
- Per capita consumption rates as listed for TCC and WBOPDC in Appendix B.

3.3.1 Population Growth

Population growth of each WRZ has been estimated based on the SmartGrowth (2004) medium growth scenario for each management area. It was assumed that the medium growth scenario (medium fertility, medium mortality and medium migration) represents the most probable long-term growth outcome. The sensitivity analysis in Section 5.2 addresses the possibilities of lower and higher population growth rates and their effects on demand for water resources.

The total residential population in WBOP sub region in the base year 2005 is approximately 141,650 and estimated to increase up to 210,800 (149%) by 2025 and 290,000 (205%) by 2055 (Table 2). Figure 4 graphically illustrates that population growth in Omokoroa WRZ is exceptionally high (718%). The high projected population growths in Tauranga West, Tauranga Central, Tauranga South, Mount Maunganui, and to some extent Papamoa, would result in high density populated WRZs.

Table 2: Summary of population growth (SmartGrowth, 2004)

Water Management Zone	Population		
	2005	**2025**	**2055**
Waihi	3,614	6,096	9,691
Katikati	7,354	10,161	13,208
Matakana Is	324	444	612
Whakamarama	4,387	5,477	5,798
Omokoroa	2,240	8,620	16,080
Te Puna	2,540	2,990	3,162
Mt Maunganui	20,408	28,111	35,800
Tauranga West	29,497	38,105	41,630
Tauranga Central	20,964	36,585	55,660
Papamoa	13,716	26,248	44,541
Tauranga South	15,412	22,228	34,243
Oropi	5,844	7,297	7,736
Te Puke	8,777	10,790	13,348
Paengaroa	3,866	4,495	4,986
Pongakawa	2,706	3,153	3,506
Total	**141,650**	**210,800**	**290,000**

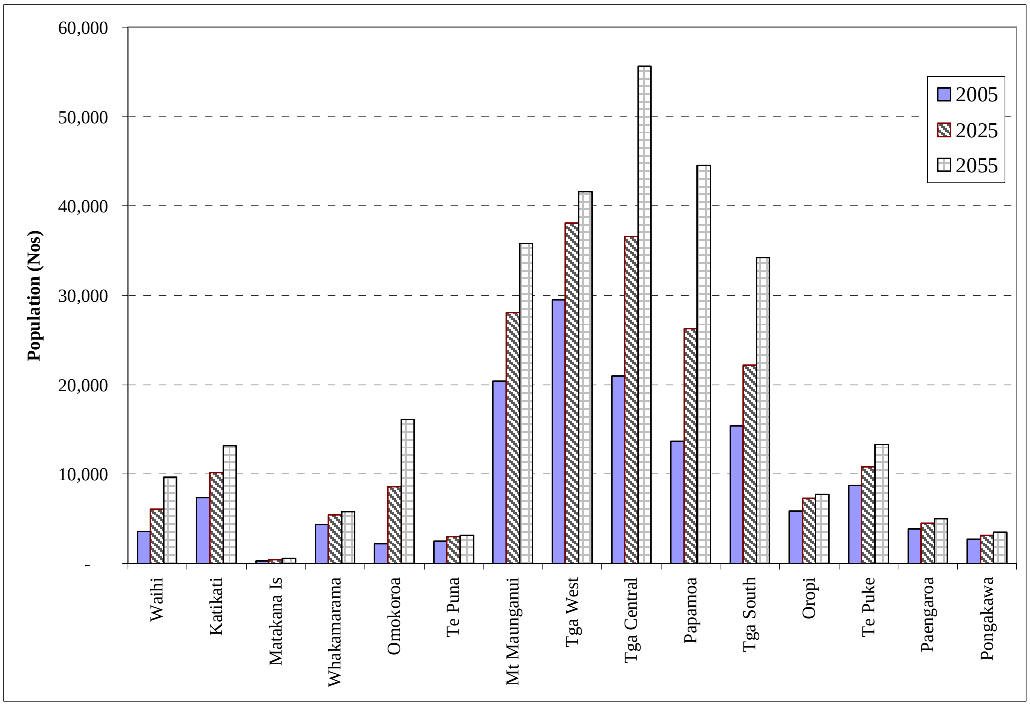


Figure 4: Population projection for WRZs

3.3.2 Domestic Water Demand

Based on population growth predictions presented in Section 3.3.1 and water use data supplied by WBOPDC and TCC, the domestic water consumption has been assessed for reticulated and non-reticulated supplies for each WRZ. Appendix D lists the estimated consumptive demand for 2005, 2025 and 2055. District Councils are expected to increase the number of reticulated supply connections in the future, and urban areas are likely to be completely supplied from municipal connections.

Figure 5 shows that, in line with population growth, domestic water demand (expressed as daily demand) will significantly increase in urbanised WRZs. Tauranga Central average daily demand will increase from the current level of 7,337 cubic metres per day (m^3/d) to 19,481 m^3/d (265%) by 2055. Omokoroa, Waihi, Papamoa and Tauranga South demand also will increase by over 200% for the same period (Appendix D).

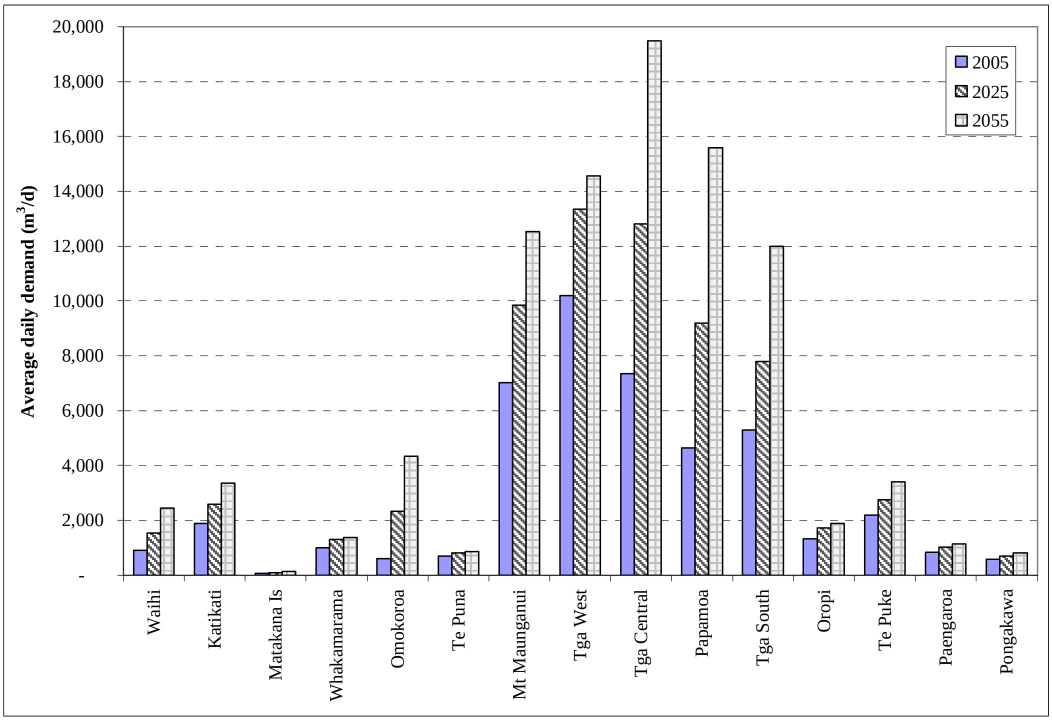


Figure 5: Average daily domestic water demand for WRZs

The peak daily demand (m^3/d) and annual demand (Mm^3/y) for the WRZs are presented in Figure 6 and Figure 7, respectively. The highest annual water demand will occur in the most populated WRZs in 2055: Tauranga Central (7.5 Mm^3/y), Papamoa (6.0 Mm^3/y), Tauranga West (5.6 Mm^3/y), Mt Maunganui (4.9 Mm^3/y) and Tauranga South (4.6 Mm^3/y) (Appendix D).

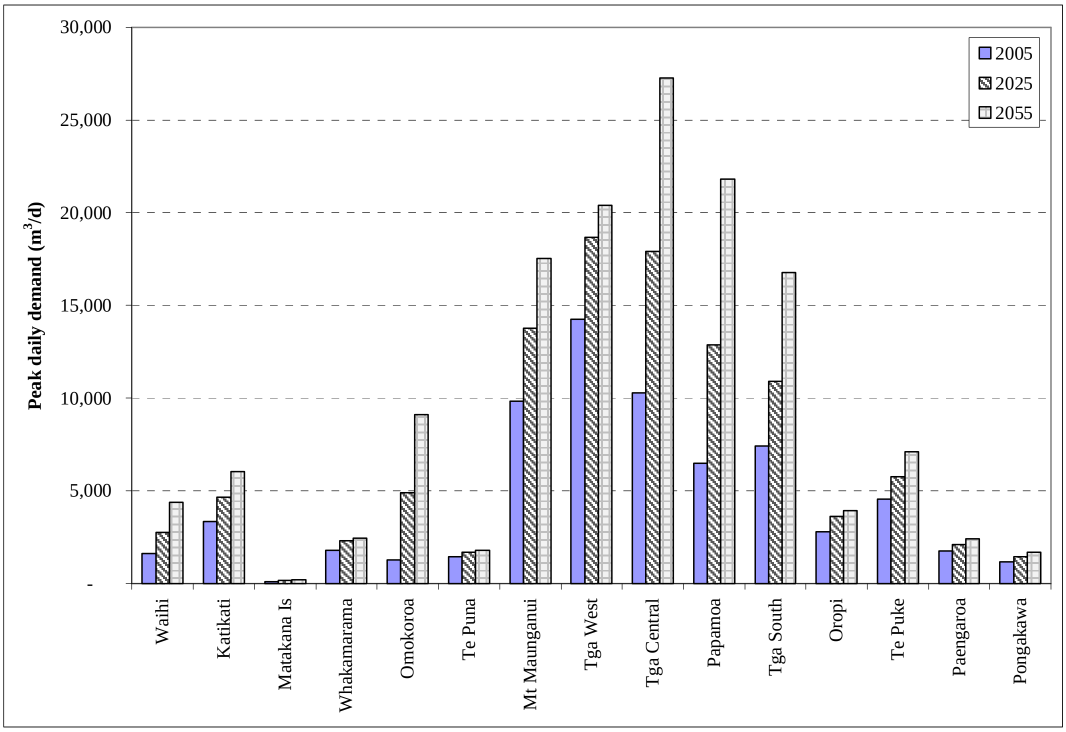


Figure 6: Peak daily domestic water demand for WRZs

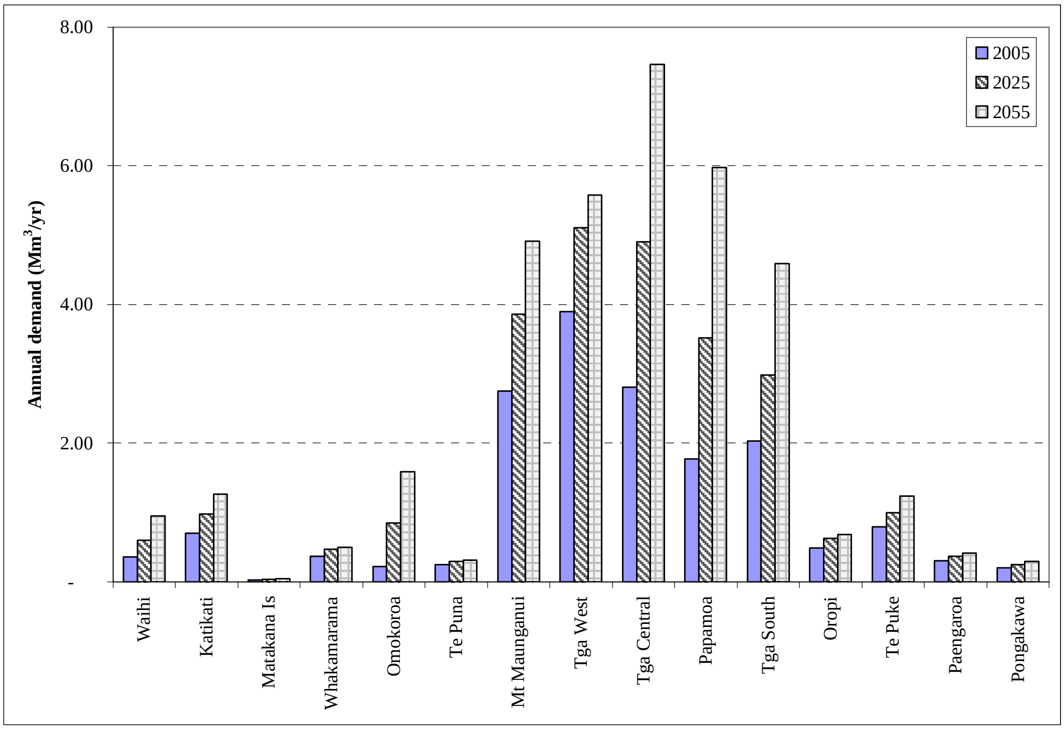


Figure 7: Annual domestic water demand for WRZs

3.4 Agriculture Water Demand

Agriculture is one of the key economic sectors in the sub-region and consumes a significant proportion of water resources. NZIER (2002) identified that of the 55,700 people employed in the area, 10.3% or 5,700 work in the agricultural sector. This is higher than the national average of 7.5%, and makes agriculture the regions second most important employer, after the retail trade.

The EBOP consent database shows that there are currently 620 consented water takes (surface water 181, groundwater 439 excluding geothermal water takes[1]) within the study area. The purposes of the take for 461 consents are known and listed below; the activities of 159 (620 - 461) takes are unclear.

- Orchard irrigation and frost protection - 309
- Horticulture - 128
- Pastoral - 11
- Greenhouse - 2
- Recreational - 11
- Other/unclear - 159

It shows that approximately 69% of the consented takes are for horticulture-related irrigation. Note that some of the above takes utilise water for multiple activities such as irrigation, stock water and domestic use. In addition there is evidence of land use change from pasture to horticulture, and forestry to pasture within the study area, however, no data is currently available,

The area of irrigated land is not collected in EBOP's consent database for the resource consents of take and use of water for irrigation. For this reason it was necessary to use New Zealand Statistics data (NZ Statistics, 2004) that shows that there are approximate 4,292 ha of irrigated land area in the study area. In the absence of information on irrigated areas for each WRZ, SmartGrowth percentage irrigation distribution for different activities over BOP region was used to estimate the irrigated and crop areas. The estimated composition of percentage irrigated areas is;

- Horticulture 75%
- Dairy pasture 22%
- Other pasture 1.5%
- Arable 1.5%

[1] Geothermal water is >30^{0} C

SmartGrowth recognises the importance of agriculture for the growth of the sub-region to create and sustain employment. However, some selective interventions are required from authorities to control the land use changes from agriculture to other uses such as rural residential use (McKinlay, 2002). The NZIER (2002) also concludes that "*the relative importance of agriculture depicted in our input-output analysis has relevance to long-term regional policy-making. Considered in tandem with the strong population growth that is projected for the region, we could expect competition in terms of land use to become increasingly pertinent. Continued strength and growth in the agricultural industry means it is likely to compete with residential and commercial interests seeking to accommodate and service a burgeoning population. It may be that that policy measures will be needed in order to protect the agricultural industry's ability to remain an important driver of economic growth in the region.*"

3.4.1 Livestock

For livestock farming, water is required for consumptive use as well as activities associated with processes such as milk cooling and yard cleaning (for dairy cattle, piggeries and broiler poultry).

Appendix G presents predicted trends in livestock numbers in each WRZ, based on recent trends given in SmartGrowth research. It shows that numbers for most stock categories, except dairy, are likely to decline over the next 50 years due to agricultural sector trends and the expansion of rural residential land use. The sector trend in recent years has been towards larger farms with higher stock numbers and conversion to different stock types to improve scale of economy and profitability. This requires amalgamation of farms, often with the purchase of adjacent properties. However, the relatively high land costs in areas closer to Tauranga, in part due to rural residential demand, limit the options for increasing farm unit profits. Dairy farming generates the highest profit margin for livestock farming per unit area as presented in Appendix H.

Figure 8 illustrates the annual livestock water demand growth trend per WRZ. The daily, peak and annual demands are presented in Appendix I. It shows that the demand is unlikely to significantly change. The demand in urban areas is expected to decrease and in rural WRZs is likely to marginally increase, especially in Te Puke, Paengaroa and Pongakawa.

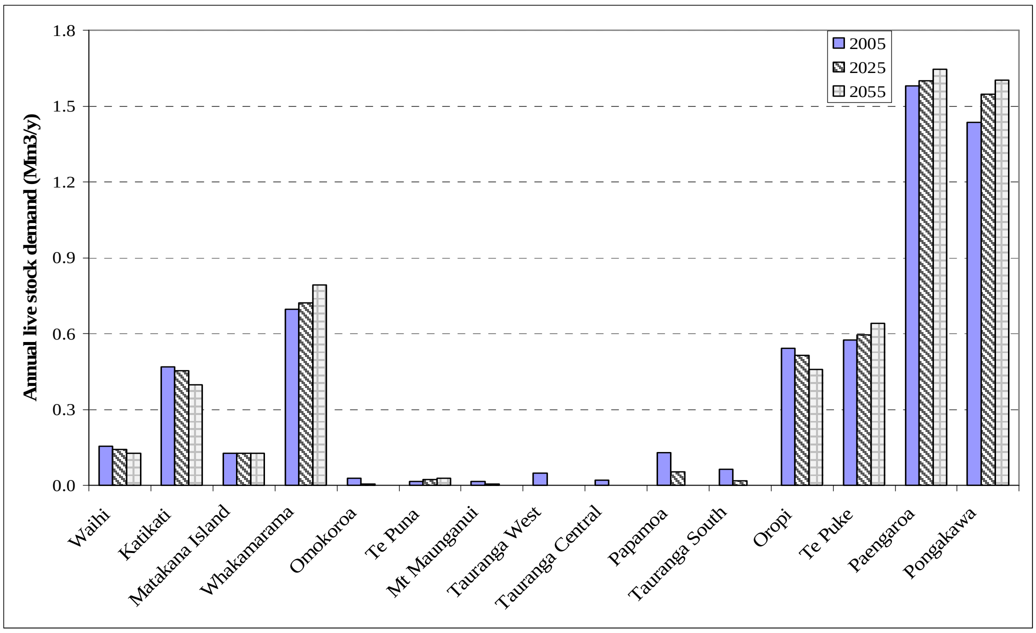


Figure 8: Annual livestock water demand by WRZs

3.4.2 Irrigation Demand

This study adopted a soil water balance approach to determine the irrigation demand. This was achieved with a soil moisture model to calculate daily water balances for a 30 year period. Key inputs to the model are rainfall, crop type, soil waterholding characteristics, potential evapotranspiration and irrigation efficiency and management. In addition to soil water content, outputs generated from the computer model include irrigation and drainage depths (mm/d). Appendix E presents a detailed description of the model, key input parameters and outputs.

Daily soil moisture levels were modelled for a 30 year period from 1975 to 2004, to determine the extent and frequency of drought days and irrigation demand.

The key input parameters were:

- Rainfall. Daily rainfall at Tauranga (supplied by NIWA) and adjusted for other WRZ based on isohytal maps.
- Potential Evapotranspiration (PET). Daily PET at Tauranga (NIWA).
- Crop. Principal crops in the sub region were modelled: kiwifruit, pasture, vegetable, avocado, grapes, stone fruits. Irrigation regimes and crop factors used for the region are listed in Appendix F.
- Soils. As different soil series are prominent in each WRZ, different series were modelled for each zone (Newsome et al., 2000). The soil series and their profile available water classes are described in Appendix F.

- Irrigation. Irrigation scenarios were; non-irrigation to determine drought frequencies, and various combinations of application depth and frequency (matched to soil type and typical irrigation system types).
- Soil moisture trigger for irrigation. Coefficients are given in Appendix F. These coefficients are assumed to be reasonable value for sprinkler systems under field conditions.
- The irrigation season for each crop is given in Appendix F.

The irrigation water demand for different uses is described in the following three sections. Future land use changes can be governed by a large number of factors; therefore sensitivity analysis (Section 5.2) was conducted to identify the effect of different rates of change of land use on water resources.

3.4.3 Horticulture

The Western Bay sub region is already the world leader in kiwifruit production, a significant producer of avocados, as well as having clear potential for other horticultural products (McKinley, 2002). The MAF Agricultural Census indicates that there are approximately 10,500 ha of horticulture within the study area of which kiwifruit is 71% (7,450 ha). As indicated above, it is estimated that there are currently approximately 3,220 ha of horticultural irrigation (orchard, field, nursery and greenhouse). The breakdown of irrigated crops includes the following:

- 2,290 ha kiwifruit;
- 440 ha avocado;
- 175 ha pipfruit;
- 60 ha field vegetables;
- 25 ha greenhouses; and
- 230 ha other orchard crops.

SmartGrowth research shows apart from the rapid urban development areas (Tauranga, Mt Maunganui, Omokoroa and Papamoa), the horticulture industry in other WRZs is expected to be competitive with demand for rural residential land use. However, land close to urban centres is likely to be converted to residential use due to attractive commuting distances to cities. It is also likely that the distant rural and less economically versatile agriculture land, (some of the 3,491 vacant lands (SmartGrowth)) will be converted into more profitable horticulture use such as kiwifruit (Appendix H). As 62% of the land within the study area is categorised as highly or moderately versatile (Appendix H), despite climate change warnings of adverse impacts on future growth of the industry in the region, further expansion is expected in horticulture. As described above, the forecasted drier spring and summer weather will increase demand on water resources for irrigation. In addition, growers are likely to utilise irrigation as a means to increase the income per unit area, sustain crop quality and to gain market edge. The predicted drier weather (Kenny, 2001; MfE, 2004; NIWA, 2003) would decrease the ground frost and will be an advantage to the horticulture industry.

Appendix L lists the projected change (%) in irrigated areas for different crops by WRZ over the next 50 years. Although the exact future land use area for horticulture is somewhat uncertain, as the current irrigated area is only 32% of the total horticulture land use it is expected that the percentage of water uses within the industry will increase within the study horizon.

3.4.4 Pastoral Irrigation

Figure 9 illustrates the distribution of the principal categories of pastoral farms (5) within the region. It highlights the high concentration of dairying on the south-eastern WRZs (Te Puke, Paengaroa and Pongakawa). SmartGrowth research suggests that the region has competitive advantage (within NZ) in pastoral faming, especially dairying. Furthermore, climate change will have beneficial effects on pasture production over coming decades. As irrigation will be important to improving financial sustainability of pastoral farming it is expected that demand for water will increase.

Appendix L shows the estimated irrigated areas and Appendix M lists annual water demand for pastoral farm irrigation. There are currently over 80,000 ha of pastoral farming of which less than 2% is irrigated. Current irrigation water demand is approximately 3.6 Mm^3/y and this is expected to increase to 9.7 and 10.7 Mm^3/y by 2025 and 2055, respectively.

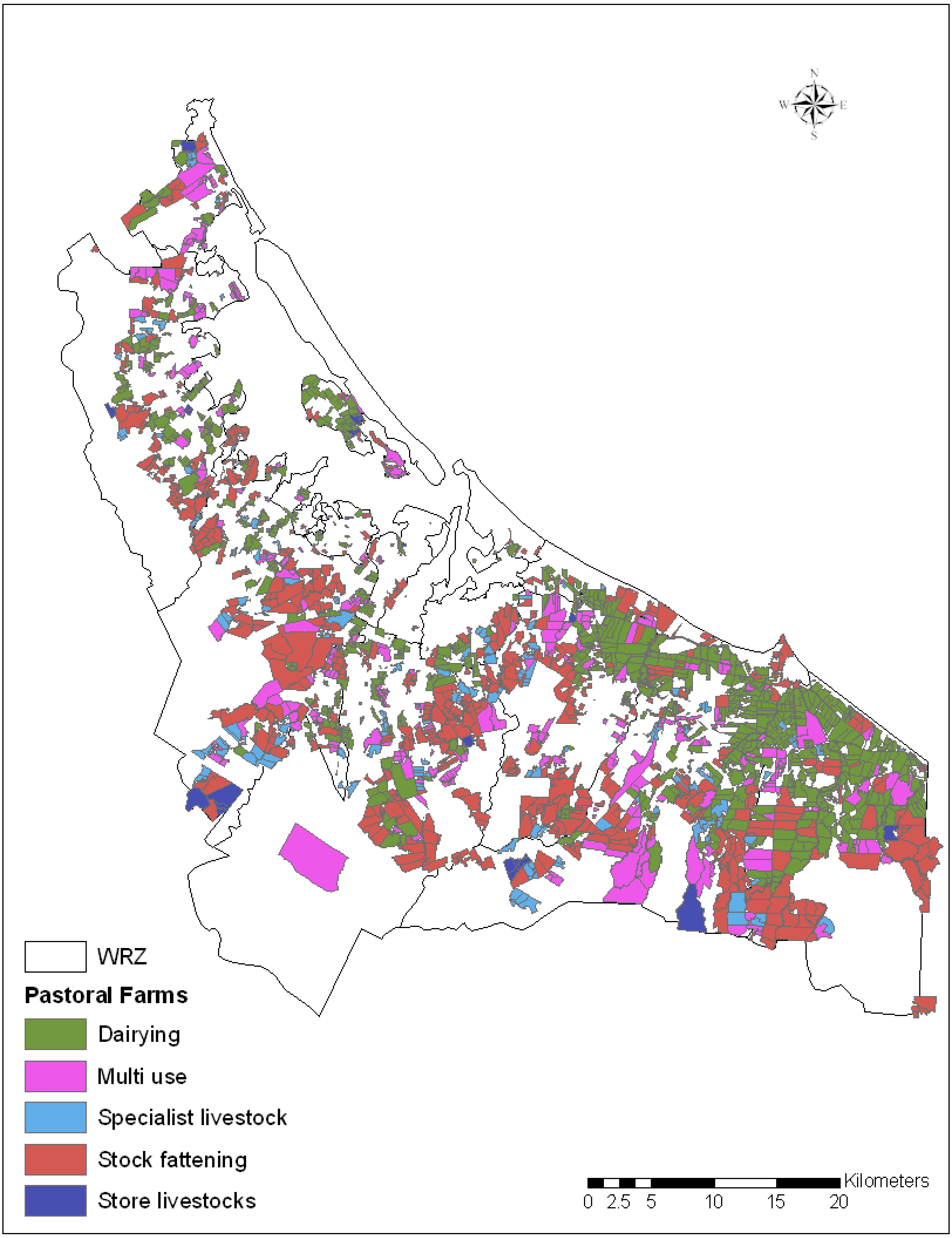


Figure 9: Distribution of pastoral farms

3.4.5 Frost Protection

Frost is an issue in the study area in the winter months and the growers, especially kiwifruit growers use different techniques for frost protection. Actual area of land use that uses water as a frost protection mechanism is unknown. Most of the larger orchards use wind (fans and helicopters) against frost and large percentage of farmers who grow green kiwifruit (over 80% of total kiwifruit area) do not have frost protection systems (per comm. Shane Max, Zespri NZ).

In the absence of reliable statistics, it is assumed that annual water demand for frost protection is equivalent to 15% of kiwifruit irrigation demand by WRZ. The water demand for frost protection is included within irrigation demand in Appendix M. A recent climate change study in the Bay of Plenty Region (Kenny, 2006) shows that warmer winters would reduce frequency of frost at inland and higher elevations in the future. On the other hand new kiwifruit areas would likely to use water for frost protection to increase the quality of the product. Therefore, it is predicted that percentage of water demand will remain unchanged for next 50 years.

3.5 Industrial and Commercial Water Demand

There are currently 2,350 commercial and industrial connections to the TCC reticulation system. These account for approximately 70% of the Tauranga Central WRZ water use. There are also 22 consented consumptive water takes (15 groundwater and 7 surface water takes) for industrial purposes within the study area. As the EBOP consent database does not show the purpose of some consented water takes, it is likely that the actual number of consented industrial takes is higher.

Appendix N shows the SmartGrowth predictions of industrial growth in the WBOP sub region as measured by employment. These figures present a reasonable indication of the industrial growth within the sub region. Further, it is expected that reasonable industrial development (employment) is necessary to meet the predicted population growth.

Although most large water takes such as industrial takes have water measuring devices installed, only a small number of takes currently are monitored. The actual water use information is collected by the consent holder and currently stored on hard copy files. The records are not reported to the EBOP, therefore, they are not included in EBOP databases. For that reason the information was not available for the WSS study. However, Aqualinc and EBOP are currently looking at ways to improve the water take information collected and stored.

In the absence of annual water consumption data for the commercial and industrial activities, average daily use for TCC supplies and consented maximum daily rates for other takes was used to calculate water demand. Table 3 and Figure 10 show industrial water demand by WRZ. However, the assumptions and estimates used in this assessment should be viewed with caution, as they exclude seasonal demand variations. Furthermore, water demand for high growth areas (commercial and industrial) can be a significant percentage of the total demand.

It should be noted that water demand in Paengaroa WRZ is dominated by one consent (Affco Meat Works consent number 20194-1) with a daily maximum of 27,271 m^3 (actual water use records were unavailable). Annual water use based on a five day working week and a 50 week year is 6.8 Mm^3, which is equivalent to five times the Tauranga city water use[2].

[2] Affco Meat Works also holds two discharge consents (treated effluent at 6,500 m^3/day and cooling water at 0.345 m^3/second). As the actual discharge data is not available, it is estimated that 15,000 m^3 of water is returned to the catchment daily. Therefore, net take (from consent 20194-1) of 12,271 m^3/day is used for this study.

Table 3: Estimates of commercial and industrial water demand

Water Management Zone	Annual demand (m^3/year)		
	2005	**2025**	**2055**
Consented takes			
Waihi	56,250	80,000	100,000
Katikati	227,000	400,000	450,000
Matakana Is	-	-	-
Whakamarama	6,000	15,000	25,000
Omokoroa	-	5,000	10,000
Te Puna	55,675	125,000	150,000
Mt Maunganui	5,750	10,000	10,000
Tauranga West	47,675	100,000	150,000
Tauranga Central	65,000	75,000	75,000
Papamoa	50,000	85,000	110,000
Tauranga South	88,750	150,000	150,000
Oropi	1,137	30,000	50,000
Te Puke	795,500	1,750,000	2,500,000
Paengaroa	3,090,000	3,090,000	3,090,000
Pongakawa	-	5,000	10,000
Consented total	**4,488,738**	**5,920,000**	**6,880,000**
TCC reticulated supply			
Mt Maunganui	33,531	55,000	75,000
Tauranga West	10,789	400,000	850,000
Tauranga Central	1,400,794	2,400,000	2,600,000
Papamoa	3,653	10,000	15,000
Tauranga South	1,732	350,000	850,000
TCC supply total	**1,450,500**	**3,215,000**	**4,390,000**
Grand total	**5,906,163**	**9,110,000**	**11,270,000**
Note: TCC currently source water for its reticulated supply from Oropi WRZ, and are planning to take water also from Te Puke WRZ in the future.			

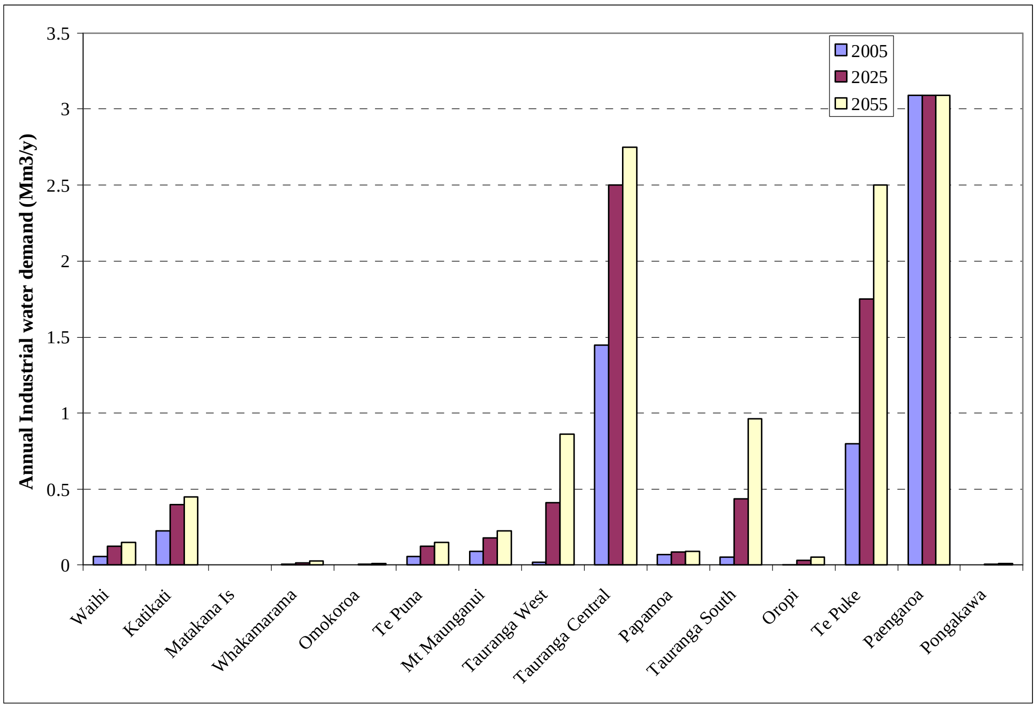


Figure 10: Estimated commercial and industrial water demand for WRZs

Based on the above growth criteria, annual demand is projected to increase from current 5.9 Mm^3/y to 11.3 Mm^3/y by 2055. Figure 10 shows that water demand for the smaller rural WRZs is relatively low. While the demand for the Tauranga city WRZs is expected to increase due to population growth, water demand in zones like Te Puke will increase to cater for increases in agriculture product processing industries.

Sensitivity of water balances to variations in industrial demand (along with other uses) is presented in Section 5.2.

3.6 Forestry Water Demand

Forests are generally not irrigated in New Zealand. However, forests have a water 'demand' (in the sense that they reduce the amount of run-off and groundwater recharge), comparable with pasture and tussock land uses. Estimation of this future water demand from afforestation was estimated to account for its potential impact on the water balance of each water resource zone. Studies on this effect of afforestation on water yield have been made worldwide, including case studies in New Zealand.

EBOP has conducted water balance modelling and statistical analysis to distinguish the effect of changing vegetation cover in the catchment on water flows in the Tarawera River, as distinct from those reductions resulting from the decline in regional rainfall (Pang, 1993). A significant change in vegetation has occurred in the catchment since the mid-1960s. The main vegetation changes are the result of large-scale exotic plantations, the regrowth of native forest, and reversion of areas from bare ground to scrub and native vegetation. When combined with a regional rainfall decline over the past three decades, the effect on water flows in the Tarawera River has been significant. Compared with the annual mean flow for the period 1949-1963, the annual mean flow at Awakaponga decreased by 13% for the period 1964-1983, and by 25% for the period 1984-1992 (Pang, 1993).

A recent research paper (Zhang et al., 2001) assembled results from paired catchment and single catchment water balance studies from around the world to assess the impact of increased afforestation on evapotranspiration (ET) and catchment yield. The paper proposes a simple model based only on average annual rainfall (Figure 11). For the purposes of this study, it has been assumed that this water demand (or reduction in water availability) occurs constantly throughout the year. In reality, there could be some seasonal variation in this demand, peaking at times of maximum ET. Refinement of this assumption would require detailed rainfall-runoff modelling, which was outside the scope of this study.

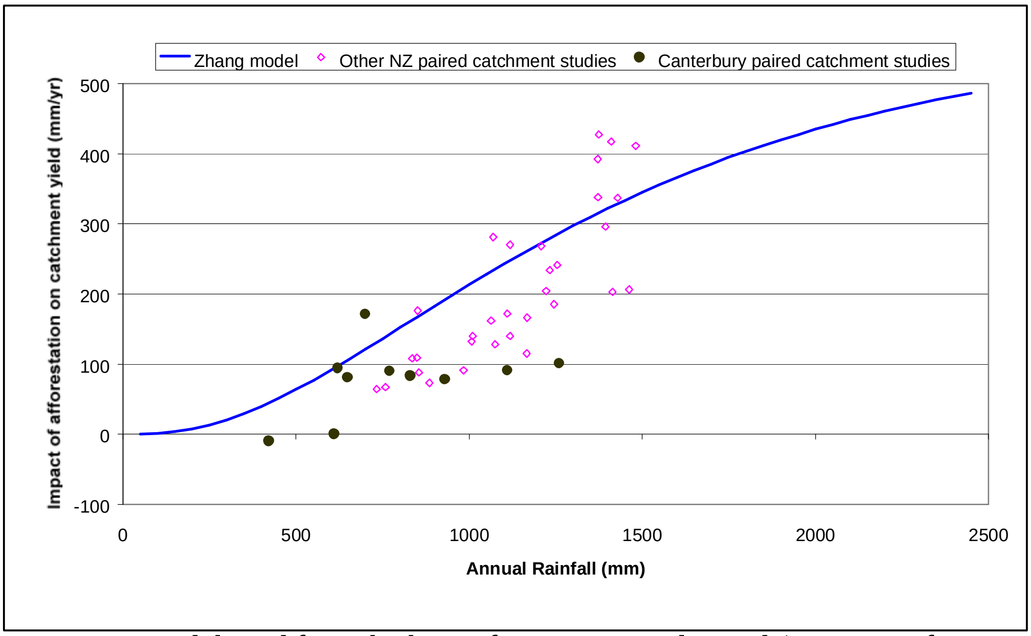


Figure 11: Model used for calculating forestry water demand (Courtesy of Morgan et al., 2002)

There are a few undeveloped large land blocks at upper ranges which can be used for forest plantation (Figure 12). These lands in Katikati and Whakamarama are covered by Kaimai National Forest and it is not likely to be potential commercial forests. The undeveloped land blocks in Oropi and Te Puke can be native forest, scrub or wetland. However, parts of these lands in hills could be prospective lands for future forests. Table 4 shows the potential water demand from new forests by WRZs, however, note that the land area shown in Table 4 should be viewed with caution as the areas are estimates only. It should be also borne in mind that the estimate area of new forestry planting is dependant on external factors, such as central government's climate change policy, economic performance of the forestry industry, and relative financial benefits of grazing.

Table 4: Summary of forestry demand results

Water Resource Zone	Estimated area of new forestry planting (ha)	Estimate of average annual rainfall (mm)	Water demand from new forestry (ℓ/s)
Oropi	5,000	2,200	713
Te Puke	2,000	2,000	270

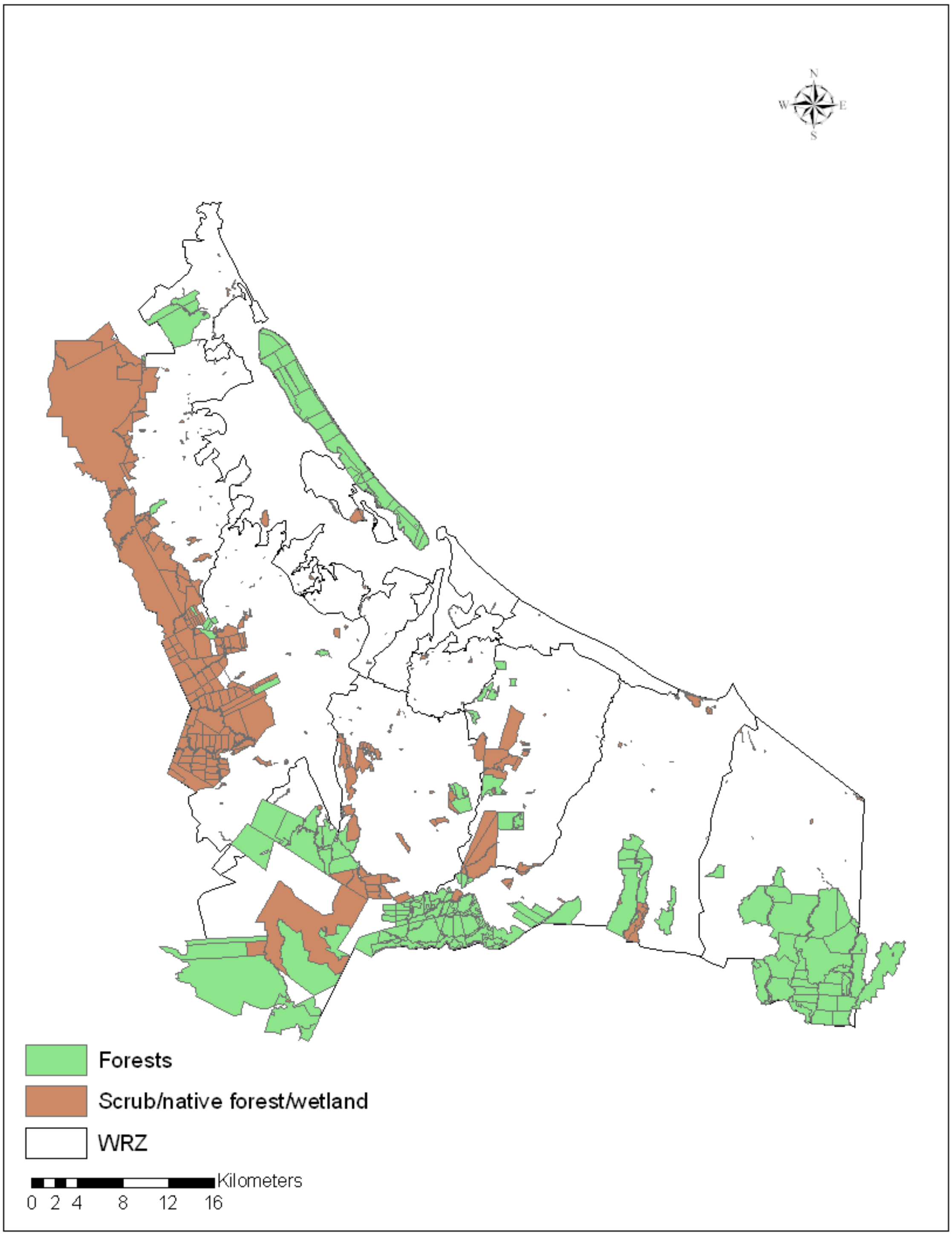


Figure 12: Distribution of forests, native forest, scrub and wetlands

3.7 Recreational Water Demand

Water is required for a range of recreation activities associated with urban development, such as swimming pools, irrigation of bowling greens and sports fields etc. Water demand is expected to increase commensurate with population growth and increase in demand of recreational activities.

Current EBOP records show that 35 water take consents have been issued for recreational purposes: bowling greens and playing fields (8), golf courses (3) and swimming pools (24). In addition it is possible that some recreational facilities use water from TCC reticulated supply, however, data is not available to verify such takes. EBOP consent records show that 14 swimming pool takes use geo-thermal water that temperature is greater than 30^0 C is treated as a separate resource from cold groundwater. The combined annual fresh water take for recreational use is less than 275,000 m^3/yr. Assuming that the increase in sports facilities is commensurate with population growth, annual water take can be expected to increase to approximately 500,000 m^3/yr by 2055. However, this assumption should be viewed with caution, as it excludes the possibility of new high demand recreational activity. But in general recreational irrigation demand is considered a relatively small component of total water demand.

3.8 Rural Residential Water Demand

Rural residential are rural plots for which the primary land use is for residency. The domestic water demand component of the rural residential is included in the predictions of domestic water demand. Water demand for livestock is also included in Section 3.4.1. There is water demand for a range of other non-commercial activities such as irrigation of gardens, shelter belts, part-time horticulture and plant nurseries. While some plots may be used intensively, the majority of plots are likely to have lower and less intensive water demand than commercial livestock farms and horticultural units.

SmartGrowth literature shows that even though there is a considerable demand for rural lifestyle blocks, it has slowed steadily over the last five years. It is considered that the decline in rural subdivision in the last few years is a function of good economic times for rural producers and of fewer subdivision opportunities available under the Proposed WBOP District Plan rules. The total number of properties used solely for residential purposes rose from 8.2% to 42.7% following subdivision. Research further shows that 85% of those properties subdivided into lots of less than 0.5 hectare. Most of the new rural residential household would be a result of subdivision and not expect to generate significant additional water demand. It is estimated that there will be around 5% increase in new rural residential developments by 2055. Table 5 lists the EBOP estimates of current rural residential land areas by WRZ. It also shows the estimated areas for 2025 and 2055.

As domestic and stock water demands are not included in this assessment there could be seasonal variation in this demand, peaking at times of maximum evapotranspiration. However, for simplicity it has been assumed that water demand occurs constantly throughout the year. Based on a 0.05 m^3/d/ha rate, rural residential annual water demand for 2005, 2025 and 2055 is 1.88, 1.91 and 1.97 Mm^3/yr, respectively. Water demand categorised under rural residential within urban areas is expected to decline as a result of intensification of residential units. Demand in rural zones (Whakamarama, Oropi, Te Puke, Paengaroa and Pongakawa) is expected to increase by approximately 20%.

Table 5: Estimated rural residential areas

Water Management Zone	Rural residential area (ha)		
	2005	2025	2055
Waihi	1,051	1,104	1,104
Katikati	2,400	2,520	2,646
Matakana Is	1,800	1,800	1,800
Whakamarama	31,886	36,669	40,336
Omokoroa	4,116	3,087	1,544
Te Puna	2,446	0	0
Mt Maunganui	0	0	0
Tauranga West	103	0	0
Tauranga Central	354	0	0
Papamoa	3,468	1,387	0
Tauranga South	5,663	0	0
Oropi	17,709	20,897	21,941
Te Puke	10,790	12,948	13,595
Paengaroa	8,617	10,168	10,676
Pongakawa	12,568	13,825	14,516
Total	**102,971**	**104,404**	**108,158**

3.9 Summary of Water Demand

Table 6 present a summary of current water demand and projections for 2025 and 2055. The domestic non-reticulated supply is inclusive of supplies from rooftop rainwater and tankered water of 0.14 Mm^3/yr in 2005 and 0.12 Mm^3/yr in 2055.

The key points to note in comparison of annual demand for the principal demand categories are:

- Domestic demand will increase from 16.97 to 35.81 Mm^3/yr
- Domestic demand will increase as a proportion of total demand from 40.2% to 44.9%
- Agricultural demand will increase by approximately 13 Mm^3/yr due to high irrigation demand that includes frost protection
- Industrial demand will increase from 5.9 to 11.3 Mm^3/yr.

Table 6: Summary of water demand – current and projections

Demand category	2005		2025		2055	
	Mm^3/yr	**%**	**Mm^3/yr**	**%**	**Mm^3/yr**	**%**
Domestic						
Reticulated	15.67	37.1	24.81	39.0	34.77	43.6
Non-reticulated	1.30	3.1	1.02	1.6	1.04	1.3
Subtotal	**16.97**	**40.2**	**25.84**	**40.6**	**35.81**	**44.9**
Agriculture						
Livestock	5.91	14.0	5.81	9.1	5.83	7.3
Horticulture	7.70	18.2	10.90	17.1	13.60	17.1
Pastoral	3.60	8.5	9.70	15.2	10.70	13.4
Subtotal	**17.21**	**40.7**	**26.41**	**41.5**	**30.13**	**37.8**
Industry	5.90	14.0	9.10	14.3	11.30	14.2
Recreational	0.28	0.7	0.42	0.7	0.50	0.6
Rural residential	1.88	4.5	1.91	3.0	1.97	2.5
Total	**42.24**		**63.68**		**79.71**	
Note: Non-reticulated supply is comprised of supplies of rooftop and tankering. Horticulture includes the frost protection demand.						

It should be noted that the summaries above are an overview of total water demand for different consumption. While this provides a useful indication of trends of change in demand over the study horizon, it does not show the pressures associated with local demand on specific water resources. This is assessed in further detail in the discussion on water balance in Section 5.1.2.

Table 7 presents a summary of water demand projections (2005 to 2055) by water source, which assumes current levels of access to water resources. It shows that the majority of the increase in demand will be from surface water. The surface water demand is predicted to increase from 23.9 to 50.1 Mm^3/yr. The increase in demand is predominately for the TCC municipal supply. As discussed in Section 5 the increase in demand from surface water will be unsustainable within most WRZs. The projected allocation increase from groundwater is in the order of 61% by volume over the study horizon.

Table 7: Water demand (Mm^3/yr) by source and demand category

	Groundwater		Surface water		Total	
Demand category	**2005**	**2055**	**2005**	**2055**	**2005**	**2055**
Domestic	3.71	7.29	13.12	28.4	16.83	35.69
Livestock	5.61	5.68	0.3	0.15	5.91	5.83
Horticulture	4.08	6.99	3.62	6.61	7.70	13.60
Pastoral	1.89	5.5	1.71	5.2	3.60	10.70
Industry	0.84	1.64	5.06	9.66	5.90	11.30
Rural residential	1.88	1.97			1.88	1.97
Total	**18.00**	**29.08**	**23.93**	**50.14**	**41.93**	**79.22**
Note: Domestic demand excludes rooftop rainwater harvesting, but includes tankered supply as it is extracted from Council (TCC & WBOPDC) reticulation via hydrants.						

4 RESOURCE ASSESSMENT

Water resources within the study area include both surface and groundwater. This section presents a summary of current estimates of water availability, based on previous studies, flow records, existing dams and water take consents. It also takes into consideration EBOP's current and proposed criteria for allocation of surface flows. In addition to these resources, rooftop runoff is also harvested principally for domestic consumption in non-reticulated areas.

4.1 Surface Water

4.1.1 Run-of-stream

The study area encompasses 53 surface water catchments and/or catchment systems as shown in Figure 13, along with consented takes from surface water sources (streams and dams). Chapter 5 of the EBOP's (Proposed) Regional Water and Land Plan Version 9.6 (as amended by appeal resolutions) (EBOP, 2007) outlines the Council's current policies in relation to water quantity and allocation. Based on the policies, for the purposes of assessing long-term resource availability a maximum allocable limit of 10% of Q_5[3] has been adopted. This value is the default water allocation regime until a scientific instream minimum flow requirement (IMFR) is set. As EBOP has not set IMFRs in WBOP, the report uses the default. However, TCC have undertaken studies to determine the scientific IMFRs, and these indicate the allowable allocation could be increased up to 25% of Q_5 from the Waiari Stream.

There are 11 monitored surface water bodies within the study zone (Iremonger and Stringfellow, 2001). The allocable surface water resource within each WRZ is estimated based on available data. For WRZs where data is unavailable estimates are based on the available information in nearest WRZs and rainfall data. As shown in Appendix P, these estimates are conservative and on this criterion some WRZs are currently over-allocated.

[3] Q_5 – the 7 day low flow which has 20% probability of occurring in any one year (one in five year return period). A 7 day low flow is defined as the minimum of annual mean flow for any 7 consecutive days.

Table 8 lists run-of-stream water availability and consented allocations per WRZ calculated from specific yields (Appendix P). Based on the above allocation criterion, total allocable resource is 3,290 ℓ/s, which is equivalent to daily and annual volumes of 284,256 m^3 and 103.8 Mm^3/y respectively. The cumulative allocated rate of current consents is 2,102 ℓ/s or in the order of 60% of the allocable take rate. Note that water availability figures represent the availability at the end of the catchments and the consented allocation is the cumulative takes for the WRZ. Actual allocation rate/volumes within individual stream reaches will be different.

Table 8: Run-of-stream water availability and consented allocations

Water Resource Zone	5-year low flow (ℓ/s)	Allocable flow (10% x 5-year low flow) (ℓ/s)	Consented allocation (ℓ/s)
Waihi	45	5	9
Katikati	1,803	180	188
Matakana Is	20	2	3
Whakamarama	973	97	46
Omokoroa	20	2	8
Te Puna	134	13	18
Mt Maunganui	0	0	98
Tauranga West	444	44	38
Tauranga Central	523	52	8
Papamoa	369	37	2
Tauranga South	257	26	10
Oropi	5,175	518	1,137
Te Puke	3,998	400	414
Paengaroa	7,488	749	100
Pongakawa	11,645	1,165	21
Total	**32,894**	**3,289**	**2,102**

Note that TCC takes water from two streams in the Oropi WRZ, Tautau Stream (37,273 m^3/d) and Waiorohi Stream (54,533 m^3/d). The TCC is also planning to meet the future demand with a water take from the Waiari Stream, which is in Te Puke WRZ. The location of the actual resource use has been taken into consideration for the water resource sustainability (Section 5).

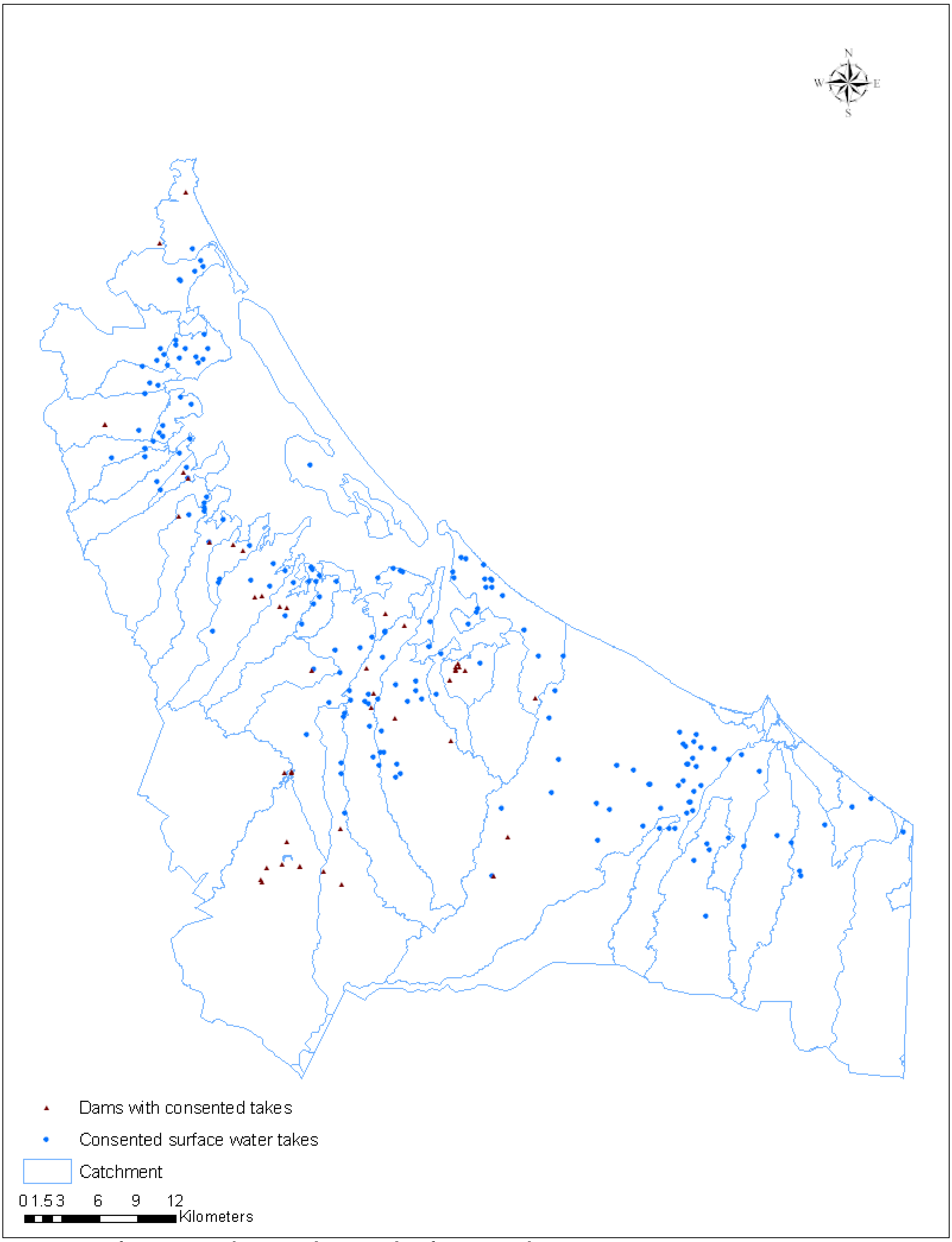


Figure 13: Surface water catchments and consented surface water takes

4.1.2 Dams

The EBOP consent database shows that there are 45 dams within the study area. It is possible that there are other small non-consented dams within the study area. Storage volumes of these small dams are assumed to be insignificant and many of these dams were possibly constructed prior to the Resource Management Act (RMA) (1991) for farm and stock water supplies. The consented dams are predominately for irrigation and TCC municipal supply with a combined volume of about 163,000 m^3 (Table 9).

Table 9: Summary of consented dams

Water Resource Zone	Number of dams	Estimated volume (m^3)	Est. total contribution from dams (m^3/yr)
Waihi	2	7,200	38,753
Katikati	5	7,500	40,368
Whakamarama	11	35,000	188,386
Te Puna	3	8,000	43,059
Tauranga West	1	5,700	30,680
Tauranga Central	3	12,900	69,433
Tauranga South	7	31,500	169,547
Oropi	13	54,900	295,497
Total	**45**	**162,700**	**875,728**

The storage volume or the area of the consented dams is unknown for most of the dams. The volume of the dams has been calculated on the basis of average surface area of 2,000 m^2 times 1.5 m depth. The volume per dam (i.e. water utilised for consumptive use) was calculated as 50% of the estimated storage volume. The estimated annual contribution from dams is based on consented volumes.

It is recommended that the storage volume of consented dams to be recorded in the EBOP consent database.

4.1.3 Harvesting Winter Flows

There is potential for further off-stream harvesting and storage of winter flows within some catchments. Table 10 presents a summary of estimated harvest potential based on winter median flows. It shows a theoretical total volume of 1,254 Mm^3/y. However the actual harvest potential is likely to be considerably lower than this value due to technical, environmental and economic constraints. Therefore, based on a 50% harvest potential (abstracted volume) is 627 Mm^3/y, a significant figure in comparison to predicted demand.

Table 10: Estimated winter surface water harvest potential

Water Resource Zone	Est. mean specific winter flow of WRZ ($l/s/km^2$)	Median discharge (l/s)	Total volume (Mm^3/yr)	Harvest potential (Mm^3/yr)
Waihi	10	420	7	3
Katikati	51.1	9,628	150	75
Matakana Island	10	654	10	5
Whakamarama	48	11,018	171	86
Omokoroa	5	58	1	0
Te Puna	12	205	3	2
Mt Maunganui	20	472	7	4
Tauranga West	20	568	9	4
Tauranga	35.8	568	9	4
Papamoa	10	347	5	3
Tauranga South	8	327	5	3
Oropi	55.3	16,901	263	131
Te Puke	54.5	7,699	120	60
Paengaroa	48.4	12,760	198	99
Pongakawa	87.7	19,008	296	148
Total		**80,635**	**1,254**	**627**

4.2 Groundwater

Groundwater resource availability estimates for this study have been obtained from a recently completed groundwater study by Geological and Nuclear Science Ltd (GNS, 2006). The study has estimated shallow and deep groundwater recharge rates. However, it considers allocable groundwater from shallow groundwater as zero, as surface water flow will probably be reduced by pumping of shallow aquifers. Therefore, it recommends considering only deep groundwater for allocation provided that abstraction does not affect baseflow and saltwater intrusion.

As mentioned above, the study area consists of 2,092 km^2, however, the GNS study has covered only 1,695 km^2. The area, 397.1 km^2 not covered in the GNS study are part of Paengaroa WRZ and the full area of Pongakawa WRZ. In the absence of data from groundwater studies, it is assumed that allocable groundwater within this area (397.1 km^2) equates to 1% of annual rainfall based on similar previous studies (Aqualinc, 2004; Aqualinc, 2006). Table 11 lists the estimated allocable groundwater by WRZ based on the GNS study and 1% of annual rainfall.

Table 11: Summary of allocable groundwater resources and consented groundwater takes

	Water Resource Zone (WRZ)	Consented groundwater (Mm^3/year)	Total allocable groundwater (l/s) [1]	1% of rainfall over gross area (l/s) [2]	Annual allocable groundwater (Mm^3/year)	WRZ Area (km^2)	Specific annual allocable groundwater (m^3/year/km^2)
1	Waihi	4.8	978		30.8	56.0	550,754
2	Katikati	2.4	3,655		115.3	251.2	458,854
3	Matakana Island	0.1	707		22.3	65.4	340,917
4	Whakamarama	10.6	2,335		73.6	305.9	240,760
5	Omokoroa	0.5	151		4.8	11.6	411,393
6	Te Puna	0.6	841		26.5	17.1	1,550,981
7	Mt Maunganui	1.2	502		15.8	23.6	670,808
8	Tauranga West	0.9	41		1.3	28.4	45,527
9	Tauranga Central	1.2	264		8.3	21.2	392,785
10	Papamoa	0.6	273		8.6	34.7	248,300
11	Tauranga South	1.0	745		23.5	40.9	574,144
12	Oropi	0.9	3,546		111.8	407.5	274,427
13	Te Puke	7.2	1,569		49.5	188.5	262,441
14	Paengaroa	7.4	1,374	47.9	44.8	351.4	127,574
15	Pongakawa	3.2	-	137.5	4.3	289.1	15,000
	Total	**42.6**	**17,166**	**185.4**	**541.4**	**2,092.3**	

Notes: Detail calculations are given in Appendix R.

[1] Allocable groundwater rates are based on GNS study (2006) that has not covered a part of Paengaroa WRZ, and the full area of Pongakawa WRZ.

[2] The allocable groundwater for areas that were not covered by GNS study was estimated using 1% of annual rainfall over gross area.

The GNS groundwater study shows that the estimated groundwater volume within 1,879 km^2 is 4,429 Mm^3; note that GNS study area is less than this study area (GNS, 2006). Whilst the GNS report acknowledges that the maximum volume (4,429 Mm^3) may be withdrawn, such withdrawal is not recommended due to significant environment effects. Therefore, allocable groundwater rates have been estimated using recharge into deep aquifers.

Table 11 shows that allocable groundwater within the study area is 17,351 ℓ/s or 541 Mm^3/year, which is approximately 12% (541 / 4,429%) of the groundwater volume in the area. However, quality of the groundwater in some areas can be unsuitable for some purposes such as drinking.

The last column of Table 11 shows the specific allocable groundwater (allocable volume per square kilometre) by WRZ. Allocable resource in Te Puna is over 1.5 $Mm^3/yr/km^2$ that is mainly due to higher estimated deep groundwater recharge for 'Te Puna Area' catchment. The specific allocable groundwater volume in Tauranga West WRZ is the lowest at 45,500 $m^3/yr/km^2$. Note that estimates for Paengaroa and Pongakawa WRZ are conservative. The Pongakawa estimate is based on 1% of rainfall over the WRZ. It is expected that a groundwater study of the WRZ that is similar to GNS study would give a higher allocable resource estimates than in Table 11.

Table 11 shows that the current consented annual groundwater volume is 42.6 Mm^3/year. However, the available data is insufficient to estimate the aquifer depths that current takes abstract water from. It is assumed that some of the takes are from shallow groundwater aquifers. It is recommended that EBOP further investigate the takes from shallow bores in association with GNS study (GNS, 2006) to evaluate the effect of takes on baseflows and saltwater intrusions.

It is recommended that the depth of groundwater bores to be recorded in the EBOP bore database and consent database.

4.3 Rooftop Water Harvesting

For many rural and non-reticulated town households, rooftop water harvesting is the primary source of water, due to availability, cost and quality of alternative supplies. It is estimated that domestic water demand for 650 households within WBOPDC is supplied from rooftop storage (Gareth Hall, Duffill Watts, Tauranga pers. comm).

The proportion of domestic water consumption supplied from rooftop storage is a key issue in the prediction of future water balances, as discussed in Section 5. Generic estimates of water harvest potential based on an average roof area (200 m^2), storage capacity (22,500 litres), rainfall (Tauranga Airport data) and average daily consumption (200 ℓ/p/d) indicates that rooftop harvest would meet household water demand for approximately 95% of the time. During times of drought, water is supplemented by tankered supplies. Generally the tanker water is extracted from Council (TCC & WBOPDC) reticulation supply via fire hydrants.

It has been estimated that the current rooftop rainwater harvesting and tankered supply contributes approximately 142,000 m^3/yr. It is difficult to predict the future use of rooftop harvesting within the sub-region; however, for this assessment it is assumed that the amount would remain unchanged over the next 50 years.

Possible future considerations are:

- Water tanks will continue to be installed in rural areas, where there is not a suitable or reliable source of surface or groundwater.
- The impact of public health concerns about quality of rooftop water supplies.
- It may be used as a supplementary supply in urban areas i.e. to supplement a limited municipal supply, as proposed for new subdivisions in some areas of the New Zealand.
- Tanks may be required for stormwater attenuation on some new developments.
- The cost of connection to municipal networks may be an incentive to continued use.
- It may not be suited to higher density urban development, due to lower catchment area, water quality and constraints on tank installation and lower convenience etc.

4.4 Tankered Water Supply

Tankering of water for domestic consumption is common in the rural areas during summer droughts and reflects on local issues to do with water availability and distribution. The comments below outline some of these issues and the quantities of water involved. However, it should be borne in mind that tankering is not a water source as generally water is extracted from Council (TCC & WBOPDC) reticulation via hydrants but merely a temporary distribution method (Gareth Hall, Duffill Watts, Tauranga pers. comm).

The Excell Corporation is the largest supplier of tanker water in the district. Their monthly tanker water supply data for the period of April 2005 to February 2007 shows that they distribute 148 m^3/month on average, with peak supply of 420 m^3/month to rural communities (Phil Millership, Excell Corporation pers. comm).

Other small tanker suppliers also operate within the study area. Therefore, it is not possible to calculate the exact tanker water usage, however, it is estimated that average monthly volume is less than 200 m^3/month.

4.5 Wastewater Reuse

Greywater recycling or tertiary treated and sanitized wastewater can be reticulated in separate systems back to houses for onsite re-use for watering gardens and toilet flushing. Based on typical domestic water use, savings would be in the order of between 15-20%. However, there are operational, public health and social issues associated with domestic wastewater recycling and to date the practice has been adopted only to a minor extent.

Overseas, particularly in arid zones, treated wastewater is utilised for municipal irrigation (Ormiston and Floyd, 2003). Within the study area TCC currently use recycled wastewater to irrigate Omanu golf course, TCC Domain and Sulphur Point.

Systems have also been developed in New Zealand for domestic level recycling, for example, ECO Wastewater Recycling System (2005). However, given the relatively low seasonal demand and cost of reticulation, such applications are unlikely to be economical in the short to medium term in New Zealand.

4.6 Summary of Water Resources

Table 12 lists the summary of water resources by WRZ. Total allocable resources (excluding winter harvesting of stream flows) are on the order of 646 million cubic metres per year, the majority of which (84%) is groundwater. Run-of-stream contributes to 16% of the water resource in the study area and the balance from dams. The allocable resource in Katikati and Oropi WRZs is over 100 Mm^3/yr due to the relatively high availability of groundwater.

Table 12: Summary of water resources

Water Resource Zone	Allocable resource (Mm^3/yr)			
	Groundwater	**Run-of-stream**	**Dams**	**Total**
Waihi	30.84	0.14	0.04	**31.02**
Katikati	115.26	5.69	0.04	**120.99**
Matakana Is	22.30	0.06	-	**22.36**
Whakamarama	73.65	3.07	0.19	**76.91**
Omokoroa	4.77	0.06	-	**4.83**
Te Puna	26.52	0.42	0.04	**26.98**
Mt Maunganui	15.83	-	-	**15.83**
Tauranga West	1.29	1.40	0.03	**2.72**
Tauranga Central	8.33	1.65	0.07	**10.05**
Papamoa	8.62	1.16	-	**9.78**
Tauranga South	23.48	0.81	0.17	**24.46**
Oropi	111.83	16.32	0.30	**128.45**
Te Puke	49.47	12.61	-	**62.08**
Paengaroa	44.83	23.61	-	**68.44**
Pongakawa	4.34	36.72	-	**41.06**
Total	**541.36**	**103.73**	**0.88**	**645.97**
%	**84%**	**16%**	**<1%**	

While the above table shows the total quantity of allocable resources under current estimates of water availability and allocation rules, what is important is the spatial distribution of these resources and matching the source to current and projected demand. The following sections look more closely at trends in water balances, and more specifically at the sustainability of resources to meet the SmartGrowth predictions of land use changes.

5 WATER BALANCE

The purpose of this section is to assess water availability against the resource demand for SmartGrowth predictions over the next 20 and 50 years. The water balance is important as it indicates whether there is significant imbalance. The following sections present a series of water balances over the planning horizon to show trends in overall water balance of the WBOP area (global), within WRZs and most importantly by water source. The water balance is calculated as the water availability from allocable resource (groundwater and surface water) minus demand on the resource(s). Sensitivity analysis has been applied to evaluate the impact of potential variations to the projected water demand values.

5.1.1 Global (WBOP) Water Balance

The current total water resource demand is in the order of 42.24 Mm^3/yr which is predominately supplied from allocable water resources (the rooftop rainwater harvesting accounts for less than 0.4% of the global demand). Approximately 64% of demand is met from surface water resources (including dams), and the balance from groundwater. The demand for water from allocable resources (assuming current levels of rainwater harvesting are maintained) is projected to double by 2055.

The global water balance provides an overview of the resource sustainability for the sub-region over the planning horizon. Figure 14 shows that the global water balance of allocable water resources versus demand at current and future demand (2025 and 2055). It shows that the annual water balance over the study area as a whole is currently positive at approximately 600 Mm^3, but will progressively decline as the demand rises and be the equivalent of 566 Mm^3 by 2055. It shows that the water balance for the study area is strongly positive, both currently and within the planning horizon. However, it is a broad scale assessment which does not show the variation, both spatial and temporal, in supply and demand. For example, the irrigation demand is seasonal and occurs over a relatively short period (Dec – Mar), and is therefore limited by take rate and minimum stream flow requirements of surface water resource. In addition, the global water balance does not highlight the preference for water sources to match specific water quality requirements. For instance, on a particular day while there may be water available for abstraction at a quality suitable for irrigation, the quality from that source may unsuitable for potable water supply.

Note that effects due to change in forestry have not been included in the water balance as its effects on different water bodies (surface water, shallow groundwater and deep groundwater) are difficult to assess within the scope of this study. However, it is likely that the effect on any particular water resource may be insignificant.

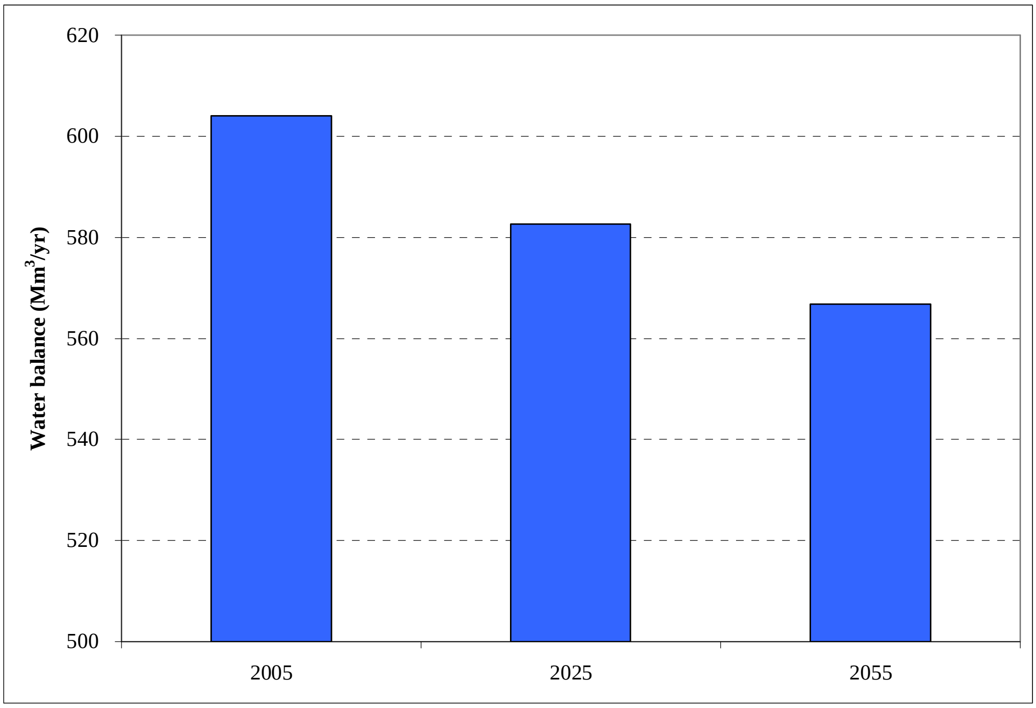


Figure 14: Global water balance

5.1.2 Water Balance by Water Resource Zones

The water balance by WRZ provides a reasonably clear picture of the water sustainability, as it is based on a smaller spatial dimension and the balance over the demand versus resource availability of each zone. TCC current water demand is predominately met with supplies from Waiorohi and Tautau Streams, located in Oropi WRZ. The Council also plans to abstract water from Te Puke WRZ (Waiari Stream) in the future. Therefore, in this water balance it is assumed that a reasonable proportion of available surface water resource in Oropi and Te Puke WRZs are available for Tauranga WRZs. The transfer of resource between WRZs is described in Appendix S.

Figure 15 shows the annual water balance (Mm^3/yr) over the study planning horizon for the 15 WRZs. Appendix S lists details of the water balance by WRZ; it shows that most of the WRZ are water rich. However, resources in Tauranga West are under pressure and water balances are declining in the other Tauranga WRZs over next 50 years. The increasing domestic demand shows that water supply is unsustainable in the longer term.

As discussed above, the WRZ water balance is only indicative of overall trends as it does not show the impact of demand growth on water sources and its sustainability. Therefore, the following sections look at water balances by resource.

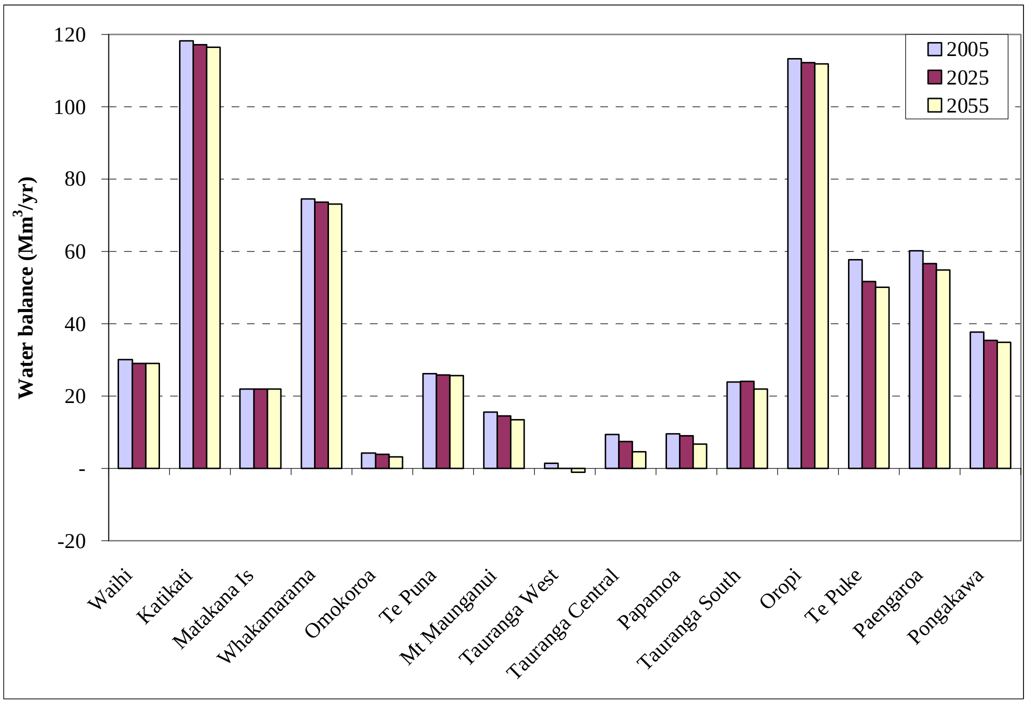


Figure 15: Water balance by WRZ

5.1.3 Surface Water Balance

The annual allocable run-of-stream flows within the study area are in the order of 104 Mm^3/yr (Section 4.6), the equivalent of approximately 284,000 cubic metres per day. The resource demand from the run-of-streams is generally highest during summer months when flow levels are low.

The current total daily peak demand from streams is 119,000 m^3/d, and expected increase to 250,000 m^3/d by 2055. The estimated daily peak domestic demand at year 2005 and 2055 are 48,281 and 103,818 m^3/d, respectively. The average daily allocable resource (284,000 m^3/d) is higher than the current demand over the planning horizon. However, the allocable resource during some drought days can be lower than the average volume of 284,000 m^3/d.

As shown in Figure 16, the water balance at peak demand for most of the WRZs is currently negative and will come under increasing pressure due to growth in demand in the future. It should be noted that this analysis is based on a limited number of available flow statistics for the study area and extrapolation to estimate allocable resource by WRZ. This analysis has not taken the resource consumed by non-consented takes (reasonable use and permitted activities)[4] into account.

[4] The take and use of groundwater where the quantity does not exceed 35 m^3/day, and surface water quantity does not exceed 15 m^3/day per property are considered to be permitted activities. Use of water for fire-fighting and reasonable individual domestic needs is allowed under reasonable use criteria (EBOP, 2005).

Although most of these non-consented takes occur in rural areas, where water balance is relatively higher than urban WRZs, the actual water balance can be lower than that shown in Figure 16. Current knowledge shows surface water takes from Oropi and Te Puke WRZs for TCC supply will be unable to sustain future growth in water demand.

The allocable resource was estimated as 10% of Q_5 (this is the default allocation limit in the (Proposed) Regional Water and Land Plan unless an IMFR has been set through scientific investigation). On this allocation basis some streams are over-allocated. As an example, the current allocable rate from the Waiari Stream is 302 ℓ/s and current allocation is 416 ℓ/s. As TCC and WBOPDC are planning to apply for further take from the stream, the allocated rate can rise to 763 ℓ/s or 252% of the allocable rate. However, TCC have conducted an IMFR study for the Waiari Stream. It shows that the allocable rate can be increased to 754 ℓ/s and indicates that future IMFR studies may increase the allocable surface water resource in the WBOP.

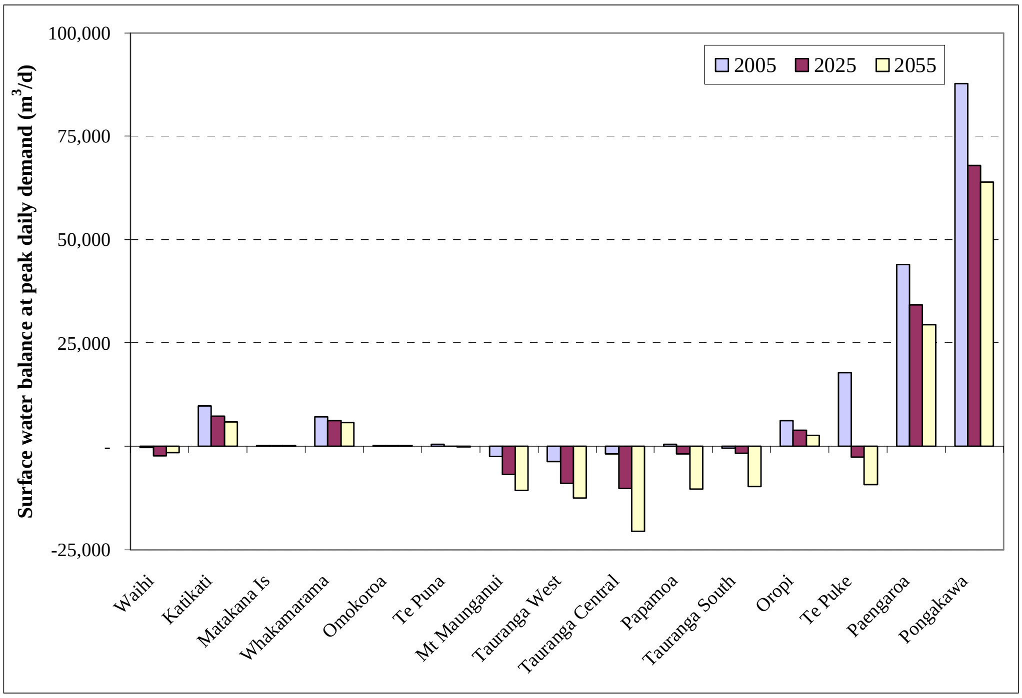


Figure 16: Run-of-stream water balance by WRZ based on peak daily demand

Sustainability of the TCC's water resource is important for future growth. This analysis shows that based on current EBOP allocation limit (10% of Q_5) it is unsustainable to continue to depend on current surface water resources to meet future demand. However, current knowledge of the available resources is limited in the spatial and temporal context. Current TCC takes from Waiorohi and Tautau Streams do not have detention dams for storage. Therefore, it is important to conduct a detailed analysis to identify daily allocable resource from each source and suitability of water quality for potable supply to identify the resource capacity. However, as shown in the next section, there are large volumes of allocable groundwater resource available in the WRZs around Tauranga City; therefore, it is recommended that TCC also investigate the options of extracting groundwater and/or harvest winter high flows for future demand. As shown in Section 4.1.3, the potential annual harvesting winter flow within the study area is in the order of 627 Mm^3/yr.

5.1.4 Groundwater Balance

As described in Section 4.2, the annual allocable groundwater within the study area is 541 Mm^3/yr, which is more than five times the currently allocable surface water. The current groundwater resource demand is approximately 18 Mm^3/yr or 3.3% of the allocable resource. As growth in the region is predominately predicted to occur within and around Tauranga City, and TCC do not currently use groundwater as a resource to meet its domestic, industrial and recreational demands, it is unlikely that the resource demand would significantly increase in the future. It is estimated that groundwater demand would increase up to 29 Mm^3/yr by 2055.

Figure 17 shows the groundwater balance by WRZ and the details are listed in Appendix S. This analysis is based on allocated resource and it is likely that a significant volume is also used by non-consented takes (reasonable use and permitted activities). These non-consented takes are predominately occurring in rural areas. As shown in Figure 17, the groundwater balance of all rural WRZs is strongly positive and non-consented takes are not expected to exert pressure on the resource. The groundwater balance for the Pongakawa WRZ shows negative balance in the future. However, as mentioned in Section 4.2, the allocable resource of the WRZ is estimated using a conservative method of 1% of rainfall. While actual allocable groundwater resource may be significantly higher, until water availability volume is known there should be caution in allocation of addition resource.

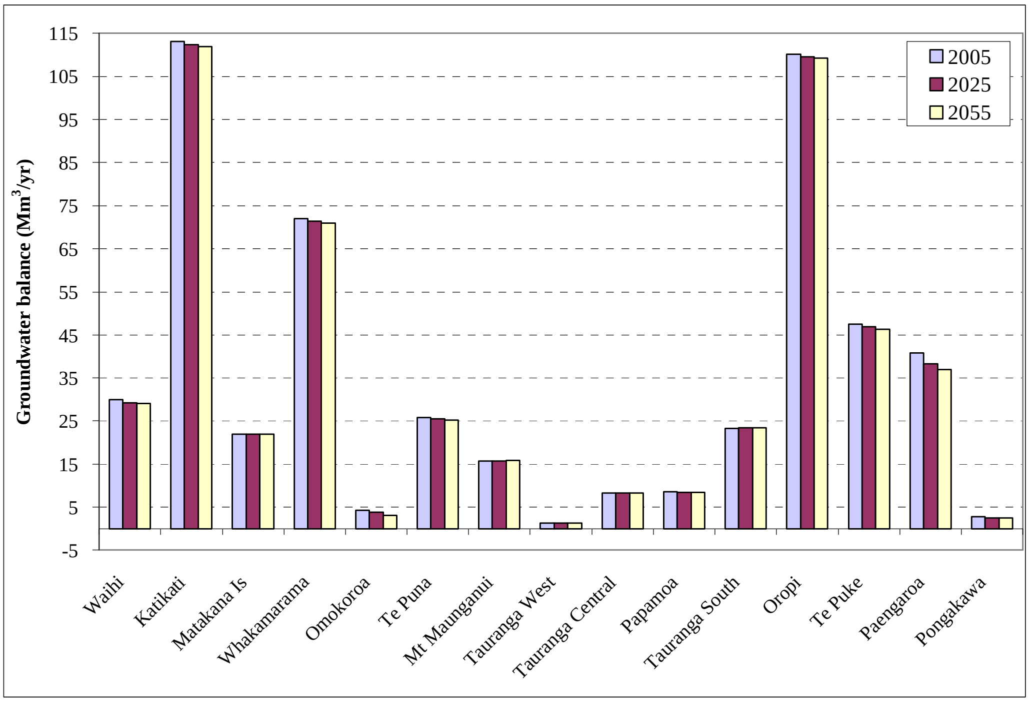


Figure 17: Groundwater balance by WRZ

5.1.5 Dams

As described in Section 4.1.2, the estimated total water resource contribution from existing consented dams is in the order of 0.87 Mm^3/yr. In addition, there are non-consented takes from dams for reasonable stock and domestic use and permitted activities. There is considerable potential for the development of dams with water harvesting to off-stream storage. In theory, there is potential to increase water availability by several magnitudes (Section 4.1.3).

5.2 Sensitivity Analysis

The assessment of future resource demand in the preceding sections is based on SmartGrowth (2004) studies on population projections, and on development predictions for different sectors. However, these predictions are based on a series of assumptions on trends in land use and industrial development. Water balances and resource sustainability were tested for sensitivity to variation in these projections and variability of the assumptions.

While there are a multitude of possible combinations of variables, a relatively simple two scenarios approach was adopted for this analysis. It is assumed that population growth of the region would be the key dynamic rationale of the industrial development and land use changes. It is likely that high population growth will pose greater pressure for rural residential subdivision and therefore water demand development of other industries.

The two simple scenarios used in the analysis are the likely lower and upper limits (referred to as 'low growth' and 'high growth' respectively) to demand sensitivity, as listed in Table 13.

Table 13: Parameters adopted for demand sensitivity

Demand category	Low growth	High growth
Population	Reduced population due to slower growth rate: -7.5% at 2025 -15% at 2055	Higher population due to faster growth rate: +7.5% at 2025 +15% at 2055
Livestock	Following reduction in demand due to lower stock numbers: -10% at 2025 -20% at 2055	Following increase in demand due to higher stock numbers: +10% at 2025 +20% at 2055
Rural residential	Following reduction in demand due to less numbers of blocks: -7.5% at 2025 -15% at 2055	Following increase in demand due to high number of blocks: +7.5% at 2025 +15% at 2055
Industry	Demand half current projections	Demand double current projections
Irrigation[#]	Demand half current projections	Demand double current projections
[#] The growth scenario represents the irrigation demand, which is not a representation of increase or decrease in agricultural land area.		

The global demand would decrease from 79 (with medium growth rate) to 63 Mm^3/yr by 2055 for the low growth scenario. The high growth scenario shows that demand could increase to 95 Mm^3/yr.

Figure 18 shows the global water balance for the study area for different demand scenarios. The effect of change demand on overall water balance is insignificant in the context of high positive water balance of the sub-region. However, as shown in 5.1.3, surface water in most of the WRZs is under pressure and the water balance for most of the WRZs around Tauranga is negative. Therefore, the sensitivity of the surface water resource for different demand growth scenarios and higher allocation rates is described in the following section.

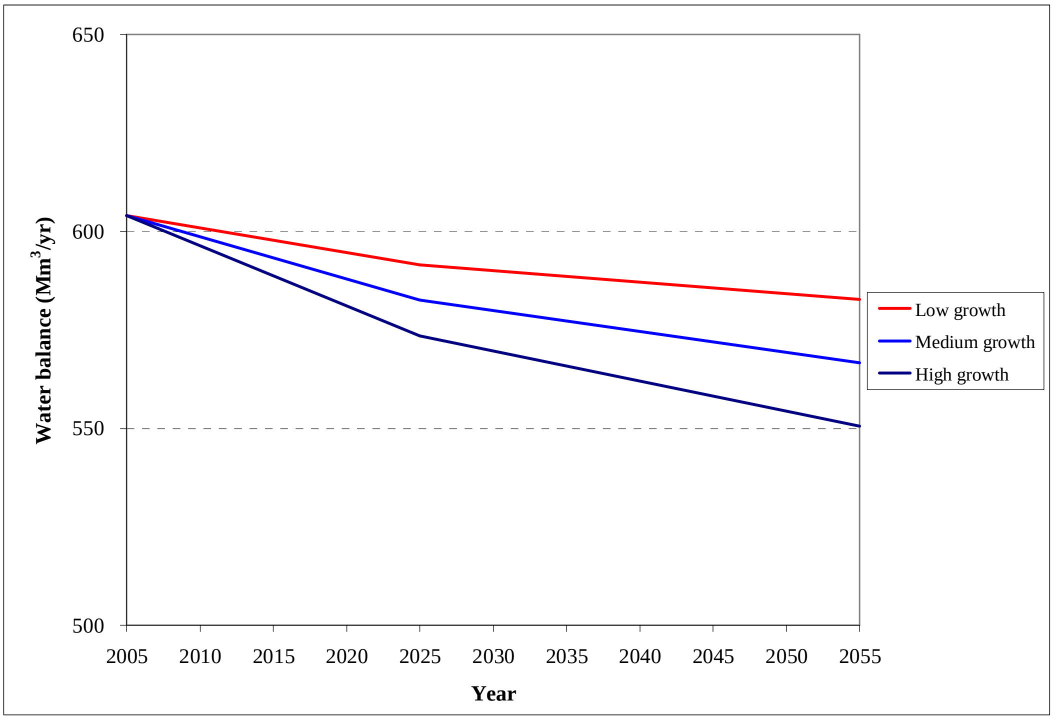


Figure 18: Global water balance for different growth scenarios

5.2.1 Surface Water

Higher allocation limit - 20% of Q_5

The surface water balance conducted as shown in 5.1.3 is based on the current allocation limit of 10% of the Q_5 from the run-of-stream. EBOP (2007) requires that scientifically accepted ecological assessment methods such as Instream Flow Incremental Monitoring (IFIM) be used to determine the flow requirements to sustain aquatic life. EBOP intends to conduct the IFIM studies in the future, and it is probable that the IFIM findings would increase allocable resources in some streams. Figure 19 shows the surface water balance with increased allocable resource of up to 20% of Q_5. This analysis is based on nominal growth predictions, i.e., not based on low and high growth rate scenarios.

By comparison with Figure 16 (with 10% Q_5), the water balance has improved in Figure 19. However, it shows that even with the increased allocation limit the surface water resource in WRZs around Tauranga will reach the sustainable limits within the planning horizon. That shows that the run-of-stream resources are under high pressure at peak demand.

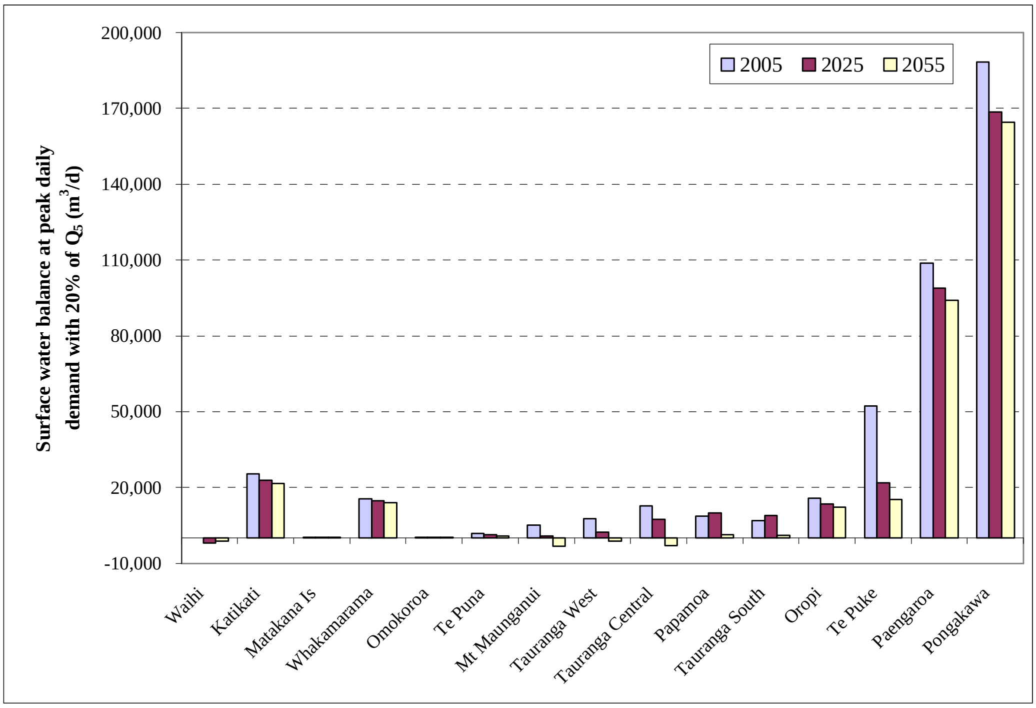


Figure 19: Surface water balance with increased allocable limit from streams to 20% Q_5

Demand scenarios

Figure 20 shows the surface water balance at daily peak demand for the growth scenarios described in Table 13. The water balance is based on current allocation limit of 10% Q_5 for run-of-stream sources. As shown above, the surface water balance with SmartGrowth demand predictions will decline to approximately 33,000 m^3/d, within the study area by 2055. High growth will greatly increase the rate of decline of the allocable surface water resources, due to higher population growth and increased industrial and irrigation demand. It is estimated that the daily peak water balance for the high growth demand will exceed current water surface supplies by 21,000 m^3/d at the end of the planning horizon, a clearly unsustainable situation. Note that this analysis does not incorporate resources from harvesting winter flows.

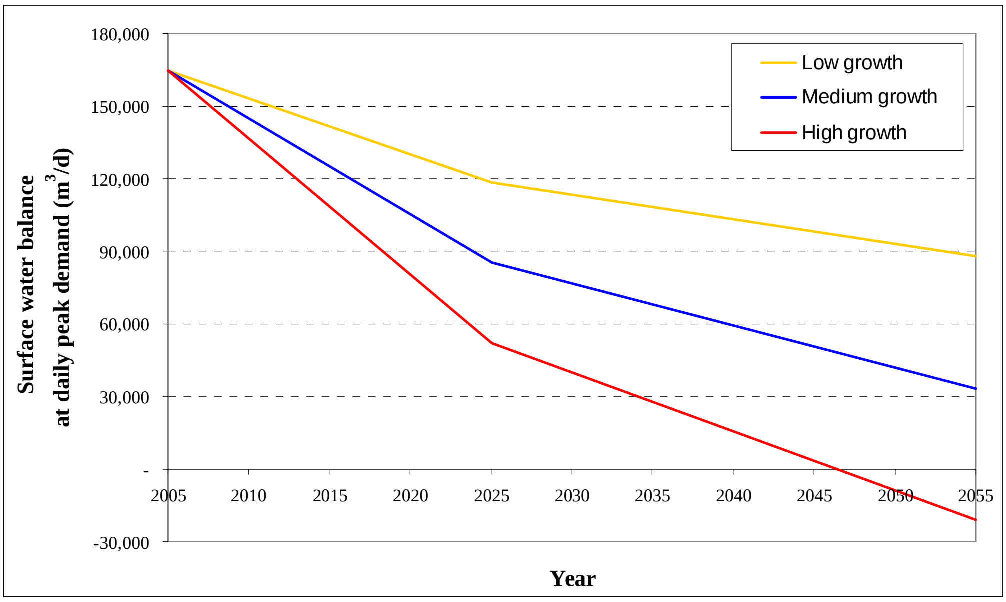


Figure 20: Surface water balance at daily peak demand for various growth scenarios

As discussed above, the global water balance masks the variation of spatial demand and allocable resource between WRZs. Figure 21 and Figure 22 show the water balance for low and high growth scenarios, respectively. The interesting feature here is the resultant water balance at low growth scenario also shows that Te Puke surface water resource will be under unsustainable stress.

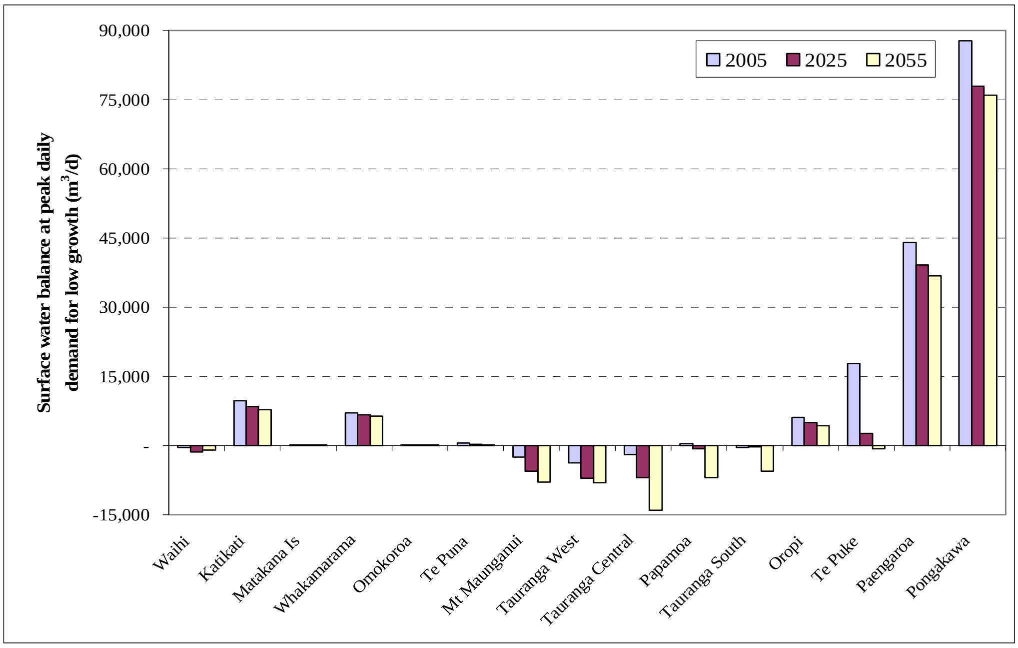


Figure 21: Surface water balance at daily peak demand for low growth scenario by WRZ

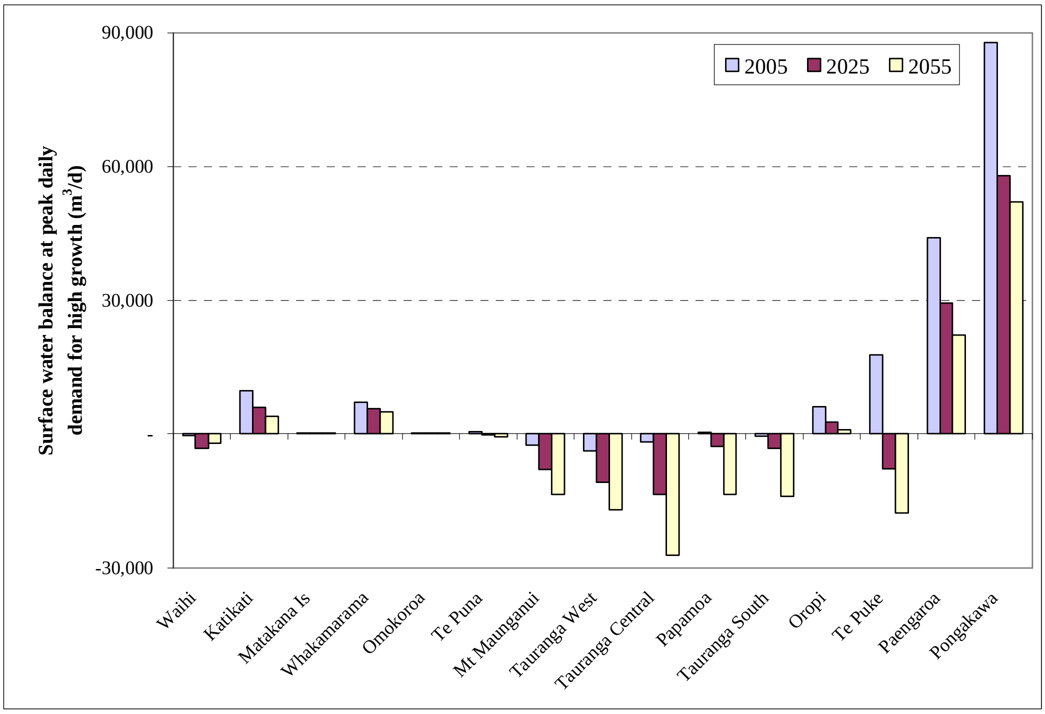


Figure 22: Surface water balance at daily peak demand for high growth scenario by WRZ

6 WATER RESOURCE SUSTAINABILITY FOR SMARTGROWTH DEVELOPMENT

This section discusses the suitability of areas in the WBOP to meet the SmartGrowth's mapping of land use development potential and sustainability of water resources. This discussion is based on the findings of the preceding sections of future resource demand for SmartGrowth development, available resources and water balance by source. It also discusses the water resource as a constraint to development, nature of the constraint, scale and intensity.

6.1 Sustainability of Water Resources

The primary purpose of the RMA is to '*promote the sustainable management of natural and physical resources'*. RMA (1991) requires each regional council to prepare and implement a regional policy statement. EBOP's (Proposed) Regional Water and Land Plan Version 9.6 (as amended by appeal resolutions) (EBOP, 2007) sets out the approach to meeting this statutory requirement and obligations related to sustainability of water resources. In line with statutory requirement, EBOP, WBOPDC and TCC have included an action point for SmartGrowth to complete a strategy for water allocation in WBOP sub-region to give greater confidence for long term water supply planning.

Allocable water resource limits are based on criteria of acceptable environmental effects of water takes. Estimates of allocable water vary with time due to improved knowledge of the resource and understanding of environmental effects. There are gaps in current knowledge of the resources, especially high use surface water streams that supply water to TCC municipal takes (Waiorohi Stream and Tautau Stream). EBOP is planning to conduct 'Instream Minimum Flow Requirement' (IMFR) studies in the future to determine flows necessary to maintain environmental values, while having regard to social, economic, cultural and environmental benefits and costs. The current allocable limits are based on a conservative default limit of 10% Q_5 until scientific IMFRs are determined. Groundwater allocation is generally determined by the long term effect on water levels. EBOP has recently completed a groundwater study (GNS, 2006) for a large part of the study area to determine the sustainable allocation limits of the resource.

Under the RMA and EBOP consent processes, rules have been established for access to different water resources based on use category and level of demand. Reasonable use allows access for domestic and livestock consumption as long as effects on the water source are minor. The EBOP threshold for groundwater and surface water are 35 and 15 m^3/d, respectively (for details refer to EBOP (2007)).

Based on the above criteria and rules, the maximum sustainable development of water resources is achieved when cumulative takes (rates and/or volumes) are equal to the allocable resource. The allocation of takes beyond this threshold will have adverse effects on the environment and/or the ability to sustain water levels (in the case of groundwater). The preceding water balance analysis forms the basis for the discussion of resource sustainability below. While demand levels are generally similar to consented takes, they also include non-consented water use.

The following subsections present a summary of sustainability of water resources within the study area, based on the preceding assessment of demand and resource availability.

6.1.1 Surface Water Takes

As shown in Figure 16, the water balance at peak demand for the WRZs in and around Tauranga City is currently negative and predicted to further decline with projected high growth. The demand on the resource within WRZs in the north of the study area (Waihi to Omokoroa) is not high compared to southern WRZs. The water balance in most of these WRZ is positive. The surface water demand for Tauranga WRZs mainly comes from domestic and industrial demands, which occur all year around; the demand in southern WRZs (Oropi, Te Puke, Paengaroa and Pongakawa) is predominately for seasonal irrigation.

The SmartGrowth prediction shows that the highest growth is likely to occur around Tauranga City with high density population growth. The TCC abstracts water for its reticulated supplies from surface water resources, whereas the predominant source for the WBOPDC supply is groundwater. A high proportion of current TCC supply is used to meet the essential domestic demand and is expected to more than double within the next 50 years. Therefore, it is important to assess the sustainability of the water supply to TCC as it is vital to the development of the sub-region.

As indicated in Section 4.1.1, the allocable resource from surface water has been estimated using limited available data for number of streams. This data has been used to conservatively extrapolate the resource availability for the whole WRZ. As mentioned above, no flow data is available for the two streams that currently supply water to TCC (Waiorohi Stream and Tautau Stream). The surface water balance shown in this report is for peak daily demand that is more likely to occur in summer drought months where resource demand is at its highest and the stream flow levels are low. The analysis shows that sustainable limits have been exceeded during the peak demand with current allocation limits.

TCC is planning to abstract water from the Waiari Stream for its future demands. The maximum current allocable limit from the stream is 302 ℓ/s and with the proposed take the consented rate will be increased up to 763 ℓ/s. However, TCC have conducted an IMFR study for the Waiari Stream. The study shows that allocable rate can be increased to 754 ℓ/s.

As mentioned above, it is important to meet the TCC demand and to maintain the resources at sustainable capacity. This can be achieved with improved understanding of the resources. It is recommended that IMFR studies be conducted for streams that TCC currently take (Waiorohi Stream and Tautau Stream) and intend to take water from in the future, to determine the sustainable limits.

Climate change can affect the nature of stream flow in the future. Therefore, it is recommended that TCC look into alternative water resources and means to meet future growth; these include harvesting winter flows and groundwater which is available in abundance in the area.

6.1.2 Groundwater Takes

As indicated in Section 5.1.4, the groundwater balances for the demand projections are not likely to come under pressure within the study horizon for all the WRZs. The exception is Pongakawa; resource availability here is based on a conservative estimate and it is expected that the available volume may be higher.

The groundwater quality data indicate that quality remains unchanged over time for most of the wells (GNS, 2006). One shallow well suggests tracers of saltwater intrusions. The recent GNS groundwater study recommends use of deeper groundwater only for the abstractions. Shallow groundwater takes can affect the baseflow of streams and may cause saltwater intrusion near the coast. Although groundwater abstraction is generally more expensive than surface water, the abundance of resource throughout the study area provides reliable supply throughout the year.

6.1.3 Harvesting Winter Flows and Dams

As shown in Section 4.1.3, the theoretical harvest potential of winter flows is over 1,200 Mm^3/yr and the practical volume can be over 600 Mm^3/yr. This is approximately six times more than estimated run-of-stream allocable resource under current allocation rules. The resource demand in most rural WRZs is relatively low, and harvesting winter flows may not be required to meet the predicted demands and/or economically viable. However, it is recommended to investigate the options for winter flow harvesting in catchments from Whakamarama, Oropi and Te Puke WRZs to provide a reliable water supply to TCC.

6.1.4 Domestic Use and Rooftop Water Harvesting

The estimated water resource demand based on SmartGrowth predictions shows that nearly a half of the future demand will be for domestic potable supply. As described in Section 5.1.3 the pressure on surface water resources is extremely high due to domestic demand in urban WRZs. Therefore, it is recommended that EBOP and TCC intervene to change the traditional water use practices in Tauranga and look into introducing necessary policies and provide support to encourage using rooftop water to meet domestic demands in new residential dwellings. It may be necessary to look into elements such as land block size for storage tank installation and its health and safety. Rooftop harvesting may also assist stormwater management.

6.2 Summary

The analysis of available water resources and demand shows that there is sufficient resource available to implement SmartGrowth predicted development in most of areas. However, it cannot be achieved with current preference of surface water sources, i.e. there is high demand for surface water around Tauranga, and it cannot be met with available resource during most of the drought months.

The current knowledge of the surface water resource in terms of allocable quantity and quality need to be improved to manage it sustainably, as the demand on the resource is expected to increase significantly.

7 CONCLUSIONS AND RECOMMENDATIONS

The key findings and the conclusions of the study are:

Water Demand
The SmartGrowth demand projections indicate:

- Water demand in the study area is projected to increase from the current level of 42 Mm^3/yr to 80 Mm^3/yr by 2055. Sensitivity analysis indicates that it could be as high as 95 Mm^3/yr if there is sustained high population and industrial growth, and increase in irrigation demand.
- The key driver to increasing demand will be population growth, which is projected to increase from 141,000 to 290,000 over the next 50 years (an increase of 106%, based on the medium growth scenario).
- Domestic water demand (for reticulated and non-reticulated consumers) is projected to increase from 17 to 36 Mm^3/yr.
- Although total area of agricultural land use is not expected to significantly change, water demand is predicted to increase from 17 to 30 Mm^3/yr, of which 6 Mm^3/yr would be for livestock demand. The current percentage of irrigated area over the agricultural lands is very low (32% horticulture and 1.3% for pastoral farms); agriculture demand is therefore expected to increase.
- Horticultural irrigation area is predicted to increase from current level of 3,220 to 5,600 hectares by 2055.
- Land area of irrigated dairy pasture will increase from 940 to 2,800 hectares over the planning horizon.
- High urban growth will occur around Tauranga City, Papamoa, Omokoroa, Waihi Beach, and to a lesser extent in Te Puke and Katikati.
- Water demand for commercial and industrial use is predicted to increase from 6 to 11 Mm^3/yr by 2055. This demand from TCC's reticulated supply is projected to increase 203% (from 1.5 to 4.4 Mm^3/yr).

Resource Availability
The assessment of water resources for the study area indicates:

- Total annual allocable water resource from run-of-stream flows, groundwater and dams is approximately 646 Mm^3/yr.
- Groundwater availability is approximately 541 Mm^3/yr (84% of the total availability).
- Available run-of-stream flow data is limited for the study area. Estimated average daily water availability using extrapolation of available data is about 284,000 m^3/d (3,289 l/s).

- Dams are estimated to contribute approximately 1 Mm^3/yr to supply.
- Harvesting of winter stream flows could potentially contribute more than 600 Mm^3/yr to water supplies; however, there are a number of issues to development.
- Rooftop rainwater harvesting is not a major contributor in the area; it accounts for less than 4% of the demand within WBOPDC.

Water Resource Sustainability
The assessment of sustainability of water resources indicates:

- The global water balance shows that the area is ‘water rich’ with a positive water balance of 566 Mm^3/yr over the planning horizon. However, the balance masks the spatial and temporal variation in demand and water supply as well as variations between water sources.
- Contribution from surface water resources is estimated to be 57%, and if the present preference of water sources continues it can go up to 63% by 2055.
- Approximately 50% of the surface water demand comes from the TCC that supplies water to WRZs around Tauranga City. This TCC reticulated supply is sourced from the Waiorohi and Tautau Streams, and neither of the streams have detention dams for storage.
- Surface water resources are under heavy pressure around Tauranga (at current level of allocation), and the current water balance at the peak demand is negative. It is predicted that surface water balance of the Tauranga WRZs can be over 60,000 m^3/d negative by 2055 (under current EBOP allocation rules). The WRZs where predicted future surface water demand will not be sustainable for year 2025 and 2055 are shown in Figure 23 and Figure 24, respectively.

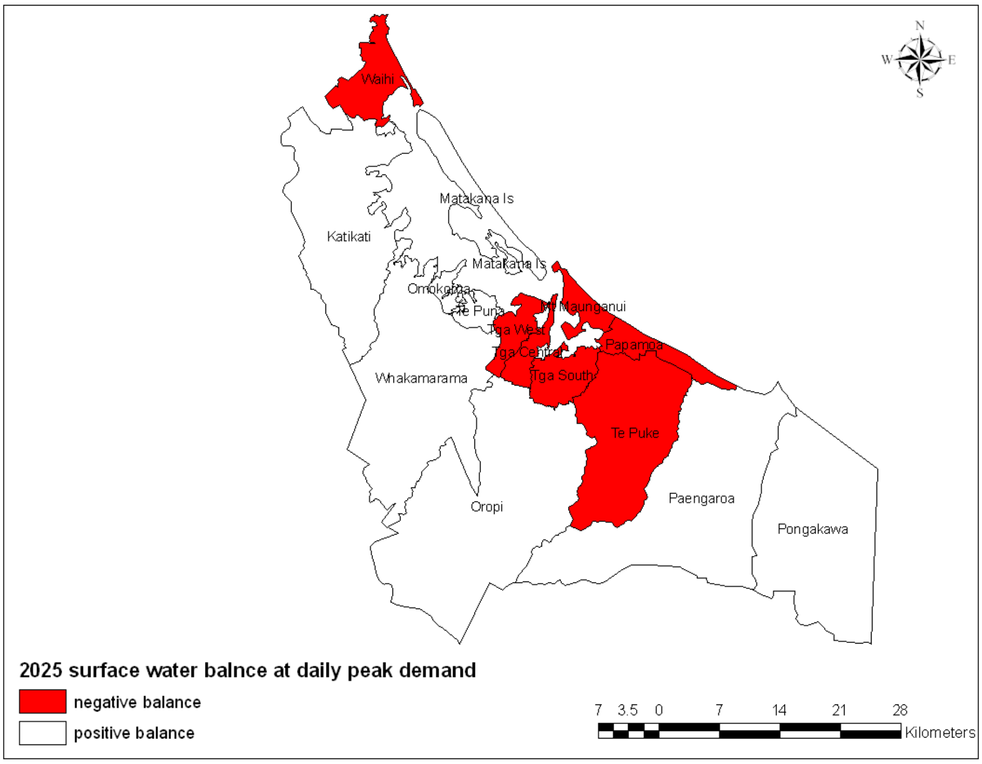


Figure 23: Surface water balance at daily peak demand for year 2025 by WRZ

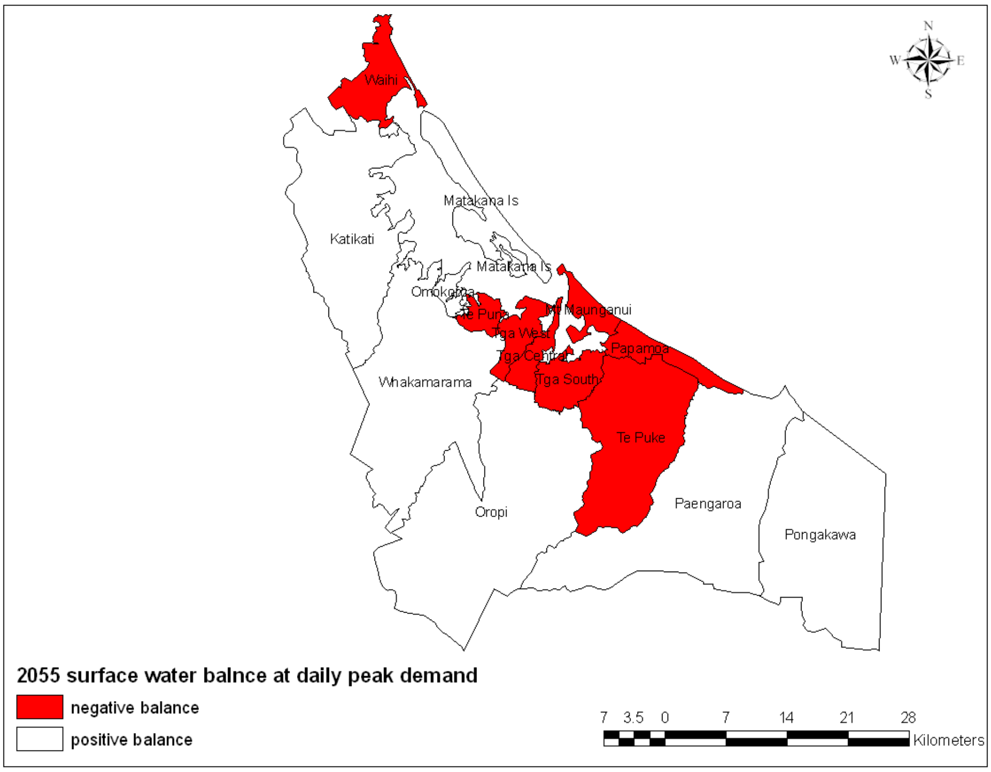


Figure 24: Surface water balance at daily peak demand for year 2055 by WRZ

- It can be unsustainable for TCC to continue abstracting water from surface water resource only.
- Alternative water resources should be used to meet TCC demand; that can include groundwater supply to new residential areas and/or harvesting winter flows.
- Based on medium population growth, the surface water demand for domestic supply will increase from 13 to 29 Mm^3/yr in Tauranga.
- Groundwater balance for all the WRZs is positive, with global balance of over 500 Mm^3/yr over the planning horizon.
- A recent groundwater investigation report (GNS, 2006) recommends it is only sustainable to abstract water from deeper aquifers; this can increase initial and operating cost of takes.
- Groundwater abstraction closer to the sea can cause saltwater intrusion; therefore, regular monitoring will be required.
- Current contribution to overall water demand from storage dams is relatively small. There is considerable potential to increase the harvesting and storage of winter stream flows, which may be developed to alleviate pressure on high demand streams, in particular streams that supply to TCC.
- While the above projections are based on medium growth and associated land use changes, there is potential for high growth rates. If higher growth rates are sustained in the medium to long term, run-of-stream supply is unsustainable for most of the WRZs. The increase in demand will have to be met from available groundwater over 500 Mm^3/yr, and/or storage supply from harvesting winter flows.

Recommendations

- ***Improve knowledge of water resources***: Water resources in the high demand zones (Tauranga, Mount Maunganui and Papamoa) is currently under pressure during drought months and will come under increasing pressure within the study planning horizon, year 2055. The analysis of water balance shows that availability of water will be a constraint to achieve SmartGrowth development plans with current practices and preferences of the water source for large takes. To ensure that water is not a limitation to further growth, there is a need for strategic planning of water management within these zones. Accurate information is vital to conduct the strategic planning; however, at present there is a significant gap in the knowledge on high use surface water resources. The planning authorities in the region need to utilise resources to gain the knowledge of the spatial and temporal variation of the allocable resource. It is required to conduct IMFR studies for high demand streams to determine sustainable allocation limits. In addition, water quality data need to be collected to identify the temporal variation of available quality resource.

- ***TCC alternative supply options:*** The sustainability of the water supply for TCC reticulated supply is a critical water management issue. The TCC source water only from run-of-streams. This is a constraint to supply reliability with inadequate quantity (based on current allocation limits) to meet the demand during low flows and quality issues in heavy rainstorms. EBOP and TCC should work together to identify alternative sustainable supply sources to meet the predicted future high demand; the options can include many groundwater supplies to local areas of the wells, winter flow harvesting and other surface water sources.

- ***Need for better strategic planning:*** Better use of resource can also be achieved by strategic planning of the consent process. The current consent process is largely based on allocation of water on a 'first in line' approach. This process does not differentiate between users on economic, social or public health criteria. A more strategic basis for future allocation may take into consideration likely future demand by use type and source, and through the consent process reserve resources to meet these demands. This may be achieved by limiting consent durations so that it may be reallocated to higher value (economic and/or social) after a specified future date.

- ***Promote alternative supply options for agriculture sector:*** Agriculture and horticulture is a key driver of the economic growth of the sub-region. It is predicted that some of the surface water takes for irrigation and frost protection could come under pressure within the planning horizon, due to high population growth and irrigation demand. As mentioned above, there is considerable potential to develop small scale harvesting of winter flows, which are particularly suited to irrigation supplies for market gardening, and may be necessary to supply water for frost protection. This may be more actively promoted in areas of high demand as an alternative to current run-of-stream.

- ***Integrate groundwater information:*** GNS's groundwater resources report specifies the sustainable groundwater yield by catchment. It is recommended that EBOP integrate this information with water take resource consent database to avoid over allocation of resources. However, note that no allocable resource from shallow aquifers (GNS, 2006).

REFERENCES

Aqualinc (2004): Water Demand Forecasting; Part A: North Auckland Region. Prepared by Aqualinc Research Ltd for Auckland Regional Council.

Aqualinc (2006): Water Demand Forecasting; Part B: South Auckland Region. Prepared by Aqualinc Research Ltd for Auckland Regional Council.

EBOP, 2007. (Proposed) Regional Water and Land Plan Version 9.6 (as amended by appeal resolutions). Environment Bay of Plenty Regional Council, Whakatane.

ECO Waste Water Recycling Systems Ltd (2005): www.wastewater-recycling.co.nz

GNS (2006). Groundwater Resources in the Tauranga Area – Report No. 2006/79. Prepared by Geological and Nuclear Science Ltd for Environment Bay of Plenty.

Iremonger, S.D. and Stringfellow, M.A. (2001): Environmental data summaries. Environment Bay of Plenty, Environmental report 2001/01.

Kenny, G. (2001): Climate Change: Likely Impacts on New Zealand Agriculture. Ministry for the Environment as part of the New Zealand Climate Change Programme.

Kenny, G. (2006): Biotic Effects of Climate Change in the Bay of Plenty. Prepared for Environment Bay of Plenty by Earthwise Consulting Limited with contributions from Willie Shaw, Wildland Consultants Limited.

Landcare (2002): Land versatility for food and fibre production and urban use in the Information Area of the western Bay of Plenty subregion. Prepared for the SmartGrowth consortium**.**

McKinlay (2002): Western Bay Of Plenty Smartgrowth Study - Economic and Demographic Projections and Analysis for Phase 2: Research Part 3 Possible Future Economic Activity: An Economic Scan. Report to SmartGrowth Bay of Plenty. Prepared by McKinlay Douglas Limited.

MfE (2004): Preparing for climate change – A guide for local government in New Zealand. Report prepared by Ministry for the Environment New Zealand Climate Change Office.

Morgan, M., Bidwell, V., Bright, J. et al (2002): Canterbury Strategic Water Study, Lincoln Environmental Report No. 4557/1. Prepared for Ministry of

Agriculture & Forestry, Environment Canterbury and Ministry for the Environment.

Newsome, P.F.L., Wilde, R.H. and Willoughby, E.J. (2000): Land resource information system spatial data layers. Landcare Research NZ Ltd.

NIWA (2003): The Climate of the Bay of Plenty: Past and Future? Prepared for Environment Bay of Plenty by NIWA. Client Report: AKL2003-044.

NZIER (2002): Western Bay of Plenty SmartGrowth study Phase 2: Economic drivers and determinants. Report to SmartGrowth Bay of Plenty. Prepared by NZ Institute of Economic Research (Inc.)

NZ Statistics (2004): www.stats.govt.nz

O'Connell, M. and Hargreaves, R. (2004): Climate change adaptation – Guidelines on adapting NZ's built environment for the impact of climate change. BRANZ Study report 130 (2004).

Ormiston, AW and Floyd, RE (2003): The ARC manual of alternative wastewater treatment and disposal systems – On-site wastewater disposal from households and institutions. Draft Technical Publication 58. Auckland Regional Council.

Pang, L. (1993): Tarawera River Flow Analysis, Environment Bay of Plenty Environmental Report 93-2, 102pp.

SmartGrowth (2004): The Western Bay of Plenty Sub-Region 50-year Strategy and Implementation Plan.

Zhang, L., Dawes, W.R., Walker, G.R. (2001): Response of mean annual evapotranspiration to vegetation changes at catchment scale. *Water Resources Research* **37**:701-708.

Appendix A: Summary of relevant water reports

The bibliography below lists reports reviewed during the study.

Alan Bickers Management Services (2003): Development industry perceptions.

Bedford, R. and Dharmalingam (2002): Growth in Population and Households in the Western Bay of Plenty: a 50 Year Forecast. Population Studies Centre, Waikato University.

Bedford, R. Western Bay SmartGrowth Region: A Summary of the Population, Labour Force and Household Projections. University of Waikato.

Boffa Miskell Ltd (2003): Intensification Scenario Testing.

Harrison Grierson Consultants Ltd (2002): Rural Issues Background Report.

Herbst, P. (2004): A Regional Formula for the estimation of peak floods in the Bay of Plenty Region. Environment Bay of Plenty, Operation Publication 2004/06.

Hill Young Cooper Ltd (2002): Residential Intensification: Policy Paper, May 2002, in Association with Tauranga District Council.

McLeay, C. (2002): Contextualising Tauranga: Towards an understanding of the 'Consumer City' and SmartGrowth. Department of Geography, University of Waikato.

MOH (2004): Register of community drinking-water supplies in New Zealand 2004. Ministry of Health.

NIWA (2003): Minimum flow report for the Tauranga area. NIWA Client Report HAM2003-043, prepared for Environment Bay of Plenty.

NZ Statistics (2004): Changing land use patterns – The Agriculture Industry.

Phizacklea, D. (2002): Land Capacity. Tauranga City Council.

Shepherd, T.G. and Jessen, M.R. (2002): Land versatility for food and fibre production and urban use in the Information Area of the Western Bay of Plenty Subregion. Landcare Research Contract Report: LC0102/114.

SmartGrowth - Smart Space project team (2003): Smart Space.

Smith, J. and Briggs, P. (2002): Economic drivers and determinants. NZ Institute of Economic Research (Inc.).

Tauranga City Council and Western Bay of Plenty District Council (2001): Development Trends 2001.

Appendix B: Assumptions and parameters

The study has adopted a number of assumptions and parameters in the determination of water demand, water availability and water balances. In some cases these were necessary due to limitations on data availability; in others, to time constraints. Listed below is a summary of the assumptions and parameters adopted and where relevant the rationale.

1. Planning horizons

The year 2005 was adopted as the study base year, with a planning horizon of 50 years (2055) and intermediate horizon of 20 years (2025). In adopting 2005 as the base year, it was necessary to update the relevant data sets to establish a best estimate of current status. This was based on the following assumptions:

- Population census - 2001; updated based on recent growth figures
- Ag census - 2002; assumed to have remained constant
- Consents - 2002; no major changes assumed.

2. Seasonal population

The following provisional estimates of percentage increases over resident population during the summer months (Dec-Feb) for the eastern seaward WRZs were used in assessment of domestic water demand;

WRZ	Summer increase
Waihi	35%
Katikati	15%
Mt Maunganui	30%
Tauranga West	20%
Tauranga Central	20%
Papamoa	20%
Tauranga South	20%

3. Average daily demand

- Per capita consumption for domestic demand is based on current reticulated supply information from TCC and WBOPDC:

WRZ	Consumption (ℓ/c/d)
Waihi	260
Katikati	260
Matakana Island	260
Whakamarama	270
Omokoroa	270
Te Puna	270
Mt Maunganui	350
Tauranga West	350
Tauranga Central	350
Papamoa	350
Tauranga South	350
Oropi	260
Te Puke	260
Paengaroa	260
Pongakawa	260

- Non-reticulated supply: No data available. An average daily demand of 200 ℓ/c/d was assumed. The lower rural demand is attributed to lower unaccounted water, losses, and absence of other uses associated with reticulated systems i.e. commercial and industrial use.

4. Peak daily demand

Peak daily demand for domestic supply was assumed as a factor of average daily demand:

WRZ	Peak/average ratio
Waihi	1.8
Katikati	1.8
Matakana Island	1.8
Whakamarama	1.8
Omokoroa	2.1
Te Puna	2.1
Mt Maunganui	1.4
Tauranga West	1.4
Tauranga Central	1.4
Papamoa	1.4
Tauranga South	1.4
Oropi	2.1
Te Puke	2.1
Paengaroa	2.1
Pongakawa	2.1

Appendix C: Land use distribution

WRZ		Waihi		Katikati		Matakana Island		Whakamarama		Omokoroa	
Area (km^2)		56.0		251.2		65.4		305.9		11.6	
Land use	Use type	Area (km2)	% use	Area (km2)	% use	Area (km2)	% use	Area (km2)	% use	Area (km2)	% use
	Multi	5.567	9.949%	35.968	14.320%	2.029	3.104%	64.551	21.104%	4.435	38.209%
	Primary	38.702	69.162%	202.305	80.546%	62.336	95.344%	218.573	71.459%	4.278	36.853%
	Storage	0.000	0.000%	0.280	0.112%	0.000	0.000%	0.104	0.034%	0.062	0.532%
	Transport	0.038	0.068%	0.092	0.037%	0.000	0.000%	0.212	0.069%	0.111	0.953%
	Community	0.159	0.285%	0.165	0.066%	0.120	0.184%	0.088	0.029%	0.064	0.548%
	Recreational	6.188	11.058%	2.078	0.827%	0.442	0.676%	8.742	2.858%	0.769	6.629%
	Utility	0.996	1.780%	0.131	0.052%	0.000	0.000%	1.191	0.389%	0.001	0.007%
	Industrial	0.098	0.175%	0.607	0.242%	0.011	0.016%	0.227	0.074%	0.013	0.109%
	Commercial	0.016	0.028%	0.067	0.027%	0.000	0.000%	0.265	0.087%	0.060	0.515%
	Residential	2.234	3.992%	2.897	1.154%	0.038	0.058%	1.702	0.556%	1.025	8.827%
	No data	1.960	3.503%	6.575	2.618%	0.404	0.618%	10.219	3.341%	0.791	6.817%

WRZ		Te Puna		Mt Maunganui		Tauranga West		Tauranga Central		Papamoa	
Area (km^2)		17.1		23.6		28.4		21.2		34.7	
Land use	Use type	Area (km2)	% use	Area (km2)	% use	Area (km2)	% use	Area (km2)	% use	Area (km2)	% use
	Multi	9.350	54.728%	2.702	11.470%	7.346	25.892%	3.683	17.390%	4.095	11.788%
	Primary	5.774	33.793%	2.591	11.000%	4.709	16.597%	3.376	15.942%	18.049	51.961%
	Storage	0.023	0.137%	0.465	1.976%	0.000	0.000%	0.005	0.022%	0.001	0.003%
	Transport	0.134	0.787%	0.229	0.972%	0.167	0.587%	0.057	0.270%	0.190	0.546%
	Community	0.070	0.408%	0.502	2.130%	0.878	3.096%	0.613	2.894%	0.128	0.368%
	Recreational	0.181	1.060%	2.791	11.847%	1.330	4.689%	2.296	10.843%	1.718	4.947%
	Utility	0.000	0.002%	0.502	2.131%	0.403	1.420%	0.221	1.045%	0.201	0.578%
	Industrial	0.200	1.171%	1.972	8.369%	0.263	0.927%	1.327	6.267%	0.003	0.009%
	Commercial	0.012	0.073%	0.303	1.286%	0.160	0.564%	0.441	2.084%	0.185	0.533%
	Residential	0.283	1.654%	7.558	32.083%	9.282	32.718%	5.684	26.839%	7.812	22.490%
	No data	1.057	6.187%	3.942	16.734%	3.833	13.510%	3.474	16.405%	2.354	6.777%

WRZ		Tauranga South		Oropi		Te Puke		Paengaroa		Pongakawa	
Area (km^2)		40.9		407.5		188.5		351.4		289.1	
Land use	**Use type**	**Area (km2)**	**% use**	**Area (km2)**	**% use**	**Area (km2)**	**% use**	**Area (km2)**	**% use**	**Area (km2)**	**% use**
	Multi	11.963	29.268%	59.648	14.639%	22.424	11.894%	42.197	12.010%	11.314	3.913%
	Primary	19.341	47.322%	271.267	66.574%	148.402	78.715%	285.678	81.308%	266.531	92.184%
	Storage	0.000	0.000%	0.101	0.025%	0.237	0.126%	0.179	0.051%	0.004	0.001%
	Transport	0.000	0.000%	0.000	0.000%	0.282	0.150%	0.398	0.113%	0.530	0.183%
	Community	0.386	0.944%	0.309	0.076%	0.370	0.196%	0.317	0.090%	0.165	0.057%
	Recreational	1.220	2.985%	43.055	10.567%	5.823	3.089%	5.115	1.456%	1.623	0.561%
	Utility	0.044	0.108%	25.602	6.283%	2.283	1.211%	0.361	0.103%	0.014	0.005%
	Industrial	0.002	0.004%	0.143	0.035%	0.392	0.208%	0.823	0.234%	0.088	0.030%
	Commercial	0.026	0.063%	0.000	0.000%	0.091	0.048%	0.204	0.058%	0.028	0.010%
	Residential	5.481	13.411%	0.254	0.062%	2.487	1.319%	2.072	0.590%	2.613	0.904%
	No data	2.409	5.895%	7.087	1.739%	5.740	3.045%	14.011	3.988%	6.219	2.151%

Appendix D: Domestic water demand

Population

Water supply	WRZ															Total
	Waihi	Katikati	Matakana Is	Whakamarama	Omokoroa	Te Puna	Mt Maunganui	Tauranga West	Tauranga Central	Papamoa	Tauranga South	Oropi	Te Puke	Paengaroa	Pongakawa	
Reticulated supply																
2005	3,072	6,619	0	1,755	2,240	2,540	19,592	28,612	20,964	12,619	14,796	2,630	7,022	967	406	123,831
2025	5,182	9,145	0	2,739	8,620	2,990	28,111	38,105	36,585	26,248	22,228	4,378	9,711	1,798	946	196,785
2055	8,237	11,887	0	2,899	16,080	3,162	35,800	41,630	55,660	44,541	34,243	5,415	12,013	2,493	1,753	275,814
Non-reticulated supply																
2005	542	735	324	2,632	0	0	816	885	0	1,097	616	3,214	1,755	2,900	2,300	17,818
2025	914	1,016	444	2,739	0	0	0	0	0	0	0	2,919	1,079	2,697	2,207	14,015
2055	1,454	1,321	612	2,899	0	0	0	0	0	0	0	2,321	1,335	2,493	1,753	14,187
Total																
2005	3,614	7,354	324	4,387	2,240	2,540	20,408	29,497	20,964	13,716	15,412	5,844	8,777	3,866	2,706	141,649
2025	6,096	10,161	444	5,477	8,620	2,990	28,111	38,105	36,585	26,248	22,228	7,297	10,790	4,495	3,153	210,800
2055	9,691	13,208	612	5,798	16,080	3,162	35,800	41,630	55,660	44,541	34,243	7,736	13,348	4,986	3,506	290,001

Average daily demand (m^3/d)

Water supply	WRZ															Total
	Waihi	Katikati	Matakana Is	Whakamarama	Omokoroa	Te Puna	Mt Maunganui	Tauranga West	Tauranga Central	Papamoa	Tauranga South	Oropi	Te Puke	Paengaroa	Pongakawa	
Reticulated supply																
2005	799	1,721	0	474	605	686	6,857	10,014	7,337	4,417	5,178	684	1,826	251	106	40,954
2025	1,347	2,378	0	739	2,327	807	9,839	13,337	12,805	9,187	7,780	1,138	2,525	467	246	64,923
2055	2,142	3,091	0	783	4,342	854	12,530	14,571	19,481	15,589	11,985	1,408	3,123	648	456	91,002
Non-reticulated supply																
2005	108	147	65	526	0	0	163	177	0	219	123	643	351	580	460	3,564
2025	183	203	89	548	0	0	0	0	0	0	0	584	216	539	441	2,803
2055	291	264	122	580	0	0	0	0	0	0	0	464	267	499	351	2,837
Total																
2005	907	1,868	65	1,000	605	686	7,020	10,191	7,337	4,636	5,302	1,327	2,177	831	566	44,517
2025	1,530	2,581	89	1,287	2,327	807	9,839	13,337	12,805	9,187	7,780	1,722	2,741	1,007	687	67,726
2055	2,432	3,355	122	1,363	4,342	854	12,530	14,571	19,481	15,589	11,985	1,872	3,390	1,147	806	93,839

Peak demand (m^3/d)

Water supply	WRZ															Total
	Waihi	Katikati	Matakana Is	Whakamarama	Omokoroa	Te Puna	Mt Maunganui	Tauranga West	Tauranga Central	Papamoa	Tauranga South	Oropi	Te Puke	Paengaroa	Pongakawa	
Reticulated supply																
2005	1,438	3,098	0	853	1,270	1,440	9,600	14,020	10,272	6,183	7,250	1,436	3,834	528	222	61,442
2025	2,425	4,280	0	1,331	4,888	1,695	13,774	18,671	17,927	12,862	10,892	2,390	5,302	982	516	97,935
2055	3,855	5,563	0	1,409	9,117	1,793	17,542	20,399	27,273	21,825	16,779	2,957	6,559	1,361	957	137,390
Non-reticulated supply																
2005	195	265	117	948	0	0	229	248	0	307	173	1,350	737	1,218	966	6,751
2025	329	366	160	986	0	0	0	0	0	0	0	1,226	453	1,133	927	5,579
2055	523	475	220	1,044	0	0	0	0	0	0	0	975	561	1,047	736	5,581
Total																
2005	1,633	3,362	117	1,800	1,270	1,440	9,828	14,268	10,272	6,490	7,422	2,786	4,571	1,745	1,188	68,194
2025	2,754	4,646	160	2,317	4,888	1,695	13,774	18,671	17,927	12,862	10,892	3,616	5,755	2,114	1,443	103,515
2055	4,378	6,039	220	2,453	9,117	1,793	17,542	20,399	27,273	21,825	16,779	3,931	7,120	2,408	1,693	142,971

Annual demand (Mm^3/d)

Water supply	WRZ															Total
	Waihi	Katikati	Matakana Is	Whakamarama	Omokoroa	Te Puna	Mt Maunganui	Tauranga West	Tauranga Central	Papamoa	Tauranga South	Oropi	Te Puke	Paengaroa	Pongakawa	
Reticulated supply																
2005	0.32	0.65	0	0.17	0.22	0.25	2.69	3.84	2.81	1.69	1.98	0.25	0.67	0.09	0.04	15.67
2025	0.53	0.90	0	0.27	0.85	0.29	3.86	5.11	4.90	3.52	2.98	0.42	0.92	0.17	0.09	24.81
2055	0.85	1.17	0	0.29	1.58	0.31	4.91	5.58	7.46	5.97	4.59	0.51	1.14	0.24	0.17	34.77
Non-reticulated supply																
2005	0.04	0.05	0.02	0.19	0	0	0.06	0.06	0	0.08	0.05	0.23	0.13	0.21	0.17	1.30
2025	0.07	0.07	0.03	0.20	0	0	0	0	0	0	0	0.21	0.08	0.20	0.16	1.02
2055	0.11	0.10	0.04	0.21	0	0	0	0	0	0	0	0.17	0.10	0.18	0.13	1.04
Total																
2005	0.36	0.71	0.02	0.37	0.22	0.25	2.75	3.90	2.81	1.77	2.03	0.48	0.79	0.30	0.21	16.97
2025	0.60	0.97	0.03	0.47	0.85	0.29	3.86	5.11	4.90	3.52	2.98	0.63	1.00	0.37	0.25	25.84
2055	0.96	1.27	0.04	0.50	1.58	0.31	4.91	5.58	7.46	5.97	4.59	0.68	1.24	0.42	0.29	35.81

Appendix E: Soil water balance model

The soil water balance is based on the following equations, for conservation of mass and daily time periods:

Inflow = Outflow + Change in Storage

$$I_t + P_t = DR_t + AET_t + (PAW_t - PAW_{t-1}) + (PAWmax_{t-1} - PAWmax_t) \quad (1)$$

Rearranging:

$PAW_t = PAW_{t-1} + P_t + I_t - AET_t - DR_t + PAW_{maxt} - PAW_{maxt}$
Where:

PAW_t	is the level of available soil moisture (mm) for day t
PAW_{t-1}	is the level of available soil moisture (mm) for day t-1
P_t	is the rainfall rate (mm/day) for day t
I_t	is the irrigation rate (mm/day) for day t
AET_t	is the actual evapotranspiration rate (mm/day) for day t
DR_t	is the rate of movement of water away from the root zone to deep drainage (mm/day) caused by PAW levels exceeding PAW_{max} for day t
PAW_{max}	is the maximum available soil moisture (mm) for day t or t-1 in the root zone

Equation 1 is used to calculate the daily soil moisture levels through the simulation period.

Available Soil Moisture

For this study the following assumptions and values were adopted:

- Profile readily available water (Praw) as the available soil moisture level. Praw is estimated from the volumetric water content difference between –10 kPa and –1500 kPa in the 0-0.4 m layer, and between –10 kPa and –100 kPa in lower layers.
- The maximum available soil moisture is the drained upper limit, in this case assumed to be the water content at –10kPa.

Evapotranspiration

Actual evapotranspiration (AET) is the effect of evaporation from the soil and transpiration from the crop. The model considers AET to be a function of the atmospheric demand for water (ET_{ref}), crop characteristics (Kc) and the soil moisture content in the crop root zone (PAW_{fac}).

$$AET = \int (ET_{ref}, PAW_{fac}, Kc) \quad (2)$$

Atmospheric demand is characterised by the evapotranspiration rate (ET_{ref}) which occurs when evapotranspiration for a reference crop (usually pasture) is limited only by the meteorological conditions. For this study ET_{ref} was estimated from daily climate data using the Penman/Monteith method.

Crop coefficients are used in the model to calculate the potential evapotranspiration (PET) for a specific crop with the following equation:

$$PET = ET * Kc \qquad (3)$$

Where Kc is a crop specific coefficient.

The rate at which a plant transpires is restricted at low soil moisture levels. There are various empirical approaches to defining the relationship between AET and soil moisture levels. The approach adopted in the model is to use a reduction factor (ET reduction factor) to define the threshold soil moisture level below which AET decreases. The ET reduction factor is the ratio of PAW to PAW_{max} (as percentage); a value is selected below which AET reduces linearly to zero. For this study an ET reduction factor of 15 was adopted.

Drainage

If the volume of water infiltrated exceeds the volume required to restore PAW to the drained upper limit, the excess is assumed to drain beyond the root zone one time step (day). The drainage volume is given by:

$$DR = PAW + I + P - PAW_{max} \qquad (4)$$

Rainfall

For this study all precipitation was assumed to be effective (infiltrated the soil).

Irrigation

The depth of water applied and timing of irrigation is determined by the irrigation rules. The rule options include:

- No irrigation
- Irrigation at a specified level of soil moisture depletion to a specified depth or soil moisture level
- Irrigation at a specified depth and return interval

For this study the rule option adopted was irrigation at a specified depth (approximately 50% of Praw) and specified return period. The return period was established by trial and error, until a solution was acceptable to the probabilistic frequency of soil moisture levels. These were a soil moisture level greater than 25% of Praw for 100% of the time and soil moisture level greater than 90% of Praw for 50% of the time.

The model takes account of the non-uniformity of irrigation applications. It uses the Christiansen's Uniformity (CU) Coefficient as the measure of application uniformity. The CU along with the application depth determines how much of the applied water is actually retained in the crop root zone, and losses to drainage. For this study a CU of 70% was adopted; this is a typical value for well managed sprinkler systems. However, it should be recognised that some systems, particularly well-designed and managed centre pivots, achieve CU values higher than 70%.

Model Outputs

The model outputs are:

- Daily AET
- Daily irrigation application depth (IRR)
- Daily drainage

Appendix F: Irrigation regimes, soils and crop factors

The following irrigation regime for representative crops were used in the soil water balance model described in Appendix E.

Crop	Irrigation season	Soil moisture trigger for irrigation	Application depth (mm)	Return period (days)	Potential rooting depth (mm)
Pasture	1 Oct to 31 Apr	50%	35	7	600
Avocado	15 Oct to 30 Mar	70%	10	2	1,000
Grapes	15 Oct to 30 Mar	70%	15	3	1,500
Stonefruit	15 Oct to 30 Mar	70%	10	2	900
Vegetables	1 Oct to 31 Apr	70%	20	4	500
Kiwifruit	15 Oct to 31 Apr	70%	10	2	900

The following soil types and profile available water classes were modelled for each WRZ.

WRZ	Soil series	PAW
Waihi	Waihi	60
	Katikati	120
Katikati	Aroha	45
	Tangatara	90
	Katikati	200
Matakana Is	Pinaki	50
Whakamarama	Otanewaihuku	35
	Waitekauri	60
	Oropi	90
	Katikati	120
Omokoroa	Katikati	200
Te Puna	Katikati	200
Mt Maunganui	Pinaki	75
Tauranga West	Katikati	120
Tauranga Central	Oropi	90
Papamoa	Katikati	200
Tauranga South	Oropi	90
Oropi	Otanewaihuku	75
	Oropi	200
Te Puke	Pongakawa	60
	Oropi	200
Paengaroa	Pongakawa	60
	Opiki	105
	Paengaroa	200
Pongakawa	Pongakawa	60
	Manawahe	120
	Paengaroa	200

The following crop factors for representative crops were used.

Month	Crop factors					
	Pasture	Avocado	Grapes	Stonefruit	Veges	Kiwifruit
September	1.0	0.6	0.3	0.3	0.4	0.5
	1.0	0.6	0.3	0.3	0.5	0.6
October	1.0	0.7	0.4	0.4	0.7	0.8
	1.0	0.7	0.4	0.4	0.8	0.9
November	1.0	0.8	0.4	0.5	0.9	1.0
	1.0	0.85	0.4	0.5	0.9	1.1
December	1.0	0.85	0.5	0.75	1.0	1.1
	1.0	0.85	0.5	0.75	1.0	1.1
January	1.0	0.85	0.7	1.0	1.0	1.1
	1.0	0.85	0.7	1.0	0.9	1.1
February	1.0	0.85	0.7	1.1	0.6	1.1
	1.0	0.85	0.7	1.1	0.6	1.0
March	1.0	0.8	0.7	1.1	0.7	0.9
	1.0	0.8	0.7	1.1	0.7	0.9
April	1.0	0.6	0.6	1.05	0.6	0.4
	1.0	0.6	0.6	1.05	0.6	0.4
May	1.0	0.6	0.4	0.9	0.6	0.4
	1.0	0.6	0.4	0.9	0.6	0.4
June	1.0	0.6	0.4	0.75	0.6	0.4
	1.0	0.6	0.4	0.75	0.6	0.4
July	1.0	0.6	0.4	0.5	0.4	0.4
	1.0	0.6	0.4	0.5	0.4	0.4
August	1.0	0.6	0.4	0.3	0.4	0.4
	1.0	0.6	0.4	0.3	0.4	0.4

Appendix G: Parameters and assumptions for agricultural water demand

The table below lists the per head, peak and average daily water demand adopted for the categories of livestock.

	Demand (l/c/d)		
Stock category	**Peak daily**	**Average daily**	**Shed**
Dairy cattle			
Milking cows	72	36	70
Dry cows	45	30	
Yearling	36.5	18	
Beef cattle			
Cows	45	30	
Yearling	36.5	18	
Sheep			
Ewes	4.2	2.1	
Hoggets	3.9	2	
Deer			
Adult	11	5.7	
Yearling	7	3.6	
Poultry /1000	45	30	
Pigs	15	10	

Projected change in livestock numbers (%).

WRZ	Period	Projected change (%)					
		Dairy cattle	Beef cattle	Sheep	Deer	Goats	Pigs
Waihi	2005-25	-8	-10	-9	-24	0	-100
	2005-55	-16	-20	-17	-61	0	-100
Katikati	2005-25	0	0	-27	-11	-49	-20
	2005-55	-7	-6	-53	-22	-100	-40
Matakana Island	2005-25	0	0				0
	2005-55	0	0				0
Whakamarama	2005-25	+6	+6	-5	-13	-38	-2
	2005-55	+23	+10	-15	-25	-58	-3
Omokoroa	2005-25	-67	-56	-100			
	2005-55	-100	-100	-100			
Te Puna	2005-25	+76	0	0	-100	0	0
	2005-55	+152	0	0	-100	0	0
Mt Maunganui	2005-25	-54	-33	-100	-100		
	2005-55	-100	-100	-100	-100		
Tauranga West	2005-25	-100	-100	-100	-100	-100	-100
	2005-55	-100	-100	-100	-100	-100	-100
Tauranga Central	2005-25	-100	-100	-100	-100	-100	-100
	2005-55	-100	-100	-100	-100	-100	-100
Papamoa	2005-25	-55	-100	-100	-100		-100
	2005-55	-100	-100	-100	-100		-100
Tauranga South	2005-25	-59	-100	-100	-100	-100	-100
	2005-55	-100	-100	-100	-100	-100	-100
Oropi	2005-25	-4	-7	-10	-24	0	0
	2005-55	-11	-22	-29	-56	0	0
Te Puke	2005-25	+5	-6	-11	-6	0	0
	2005-55	+16	-11	-22	-19	0	0
Paengaroa	2005-25	+2	-3	-5	-4	0	0
	2005-55	+6	-6	-10	-11	0	0
Pongakawa	2005-25	+8	+14	-8	0	0	0
	2005-55	+11	+21	-15	0	0	0

Appendix H: Parameters and assumptions for agricultural land change

The following table shows the revenue from different agricultural land uses (SmartGrowth).

Land Use	Gross revenue per hectare	Net trading profit after tax per hectare
Kiwifruit (green)	$35,292	$7,595
Dairy	$4182	$1,688
Sheep	$273	$348
Beef	$934	

Land use potential distribution in WBOP (Landcare, 2002) for food and fibre production:

- 32% of land is highly versatile;
- 30% of land is moderately versatile; and
- 38% of land is low versatile.

Appendix I: Livestock water demand

The following table lists the estimated livestock water demand for each WRZ.

	WRZ															Total
	Waihi	Katikati	Matakana Is	Whakamarama	Omokoroa	Te Puna	Mt Maunganui	Tauranga West	Tauranga Central	Papamoa	Tauranga South	Oropi	Te Puke	Paengaroa	Pongakawa	
Average daily demand (m3/d)																
2005	491	1,483	415	2,148	89	51	49	153	66	415	201	1,678	1,830	5,055	4,652	18,775
2025	449	1436	415	2234	21	71	20	0	0	177	58	1594	1898	5122	5012	18,507
2055	407	1274	415	2470	0	92	0	0	0	0	0	1432	2048	5273	5191	18,602
Peak daily demand (m3/d)																
2005	703	2,146	571	3,238	133	78	73	226	98	579	298	2,511	2,621	7,160	6,467	26,902
2025	643	2,069	571	3,352	29	105	27	0	0	242	80	2,377	2,707	7,245	6,967	26,414
2055	582	1,817	571	3,662	0	136	0	0	0	0	0	2,120	2,905	7,444	7,215	26,452
Annual demand (M3/yr)																
2005	0.15	0.47	0.13	0.70	0.03	0.02	0.02	0.05	0.02	0.13	0.07	0.54	0.58	1.58	1.44	5.91
2025	0.14	0.45	0.13	0.72	0.01	0.02	0.01	0.00	0.00	0.05	0.02	0.51	0.60	1.60	1.55	5.81
2055	0.13	0.40	0.13	0.79	0.00	0.03	0.00	0.00	0.00	0.00	0.00	0.46	0.64	1.65	1.60	5.83

Appendix J: Area distribution of agricultural land use (Hectares)

Land use	Waihi	Katikati	Matakana Is	Whakamarama	Omokoroa	Te Puna	Mt Maunganui	Tauranga West	Tauranga Central	Papamoa	Tauranga South	Oropi	Te Puke	Paengaroa	Pongakawa
Sheep farming		54		84			0.2					85	167	9	21
Mixed sheep and beef farming	157	453		5490	0.5	82		6	0.3	0.1	234	3520	2255	1943	1670
Beef cattle farming	385	2028	93	3736	101	232	2	287	196	532	543	3294	2968	4758	2563
Grazing other peoples stock	32	502		458	10	9		45	11	11	49	571	87	168	287
Dairy cattle farming	1026	3137	759	3023	88	92	0.1	74	47	177	294	2059	2681	8745	10452
Dairy dry stock		131		159						11		373	168	801	310
Deer farming	166	680		1896						28	94	711	461	892	214
Pig farming				87								15		10	
Goat farming		27		31								4			
Horse farming and breeding	4	6		30										7	
Alpaca / Llama farming															
Other livestock		3		5								8			
Poultry farming													4		
Beekeeping and hives															7
Emu bird farming				5								0.1	4		
Ostrich bird farming		9												4	

Land use	Waihi	Katikati	Matakana Is	Whakamarama	Omokoroa	Te Puna	Mt Maunganui	Tauranga West	Tauranga Central	Papamoa	Tauranga South	Oropi	Te Puke	Paengaroa	Pongakawa
Arable cropping or seed production		64	104		0.1								32	0.3	
Viticulture, grape growing and wine															
Fruit Growing	387	2023	33	1182	229	398	39	163	75	2	146	843	1956	2058	338
Vegetable growing		5						7					6		
Cut flowers and flower seeds	12	42		41	8				8			8	9	5	
Plant nurseries		28				14						4	105	9	
Other planted types		31													
Forestry	8	278		925		0.2			7			6563	354	3541	576
Fish, marine fish farming, hatcheries															
Lifestyle block	11	240	18	319	41	24		1	18	35	57	177	108	86	126
Native bush		0		6											
Other farm types	68	302	110	660	25	89		19	8	26	44	799	26	314	50
Unspecified	141	187		93		16					2	7	236	71	6
Total area (ha)	**2,809**	**11,035**	**1,117**	**23,925**	**507**	**966**	**41**	**607**	**370**	**821**	**1,464**	**23,984**	**14,139**	**24,100**	**19,551**

Appendix K: Estimates of area distribution of irrigated land (Hectares)

	WRZ															Total
	Waihi	Katikati	Matakana Is	Whakamarama	Omokoroa	Te Puna	Mt Maunganui	Tauranga West	Tauranga Central	Papamoa	Tauranga South	Oropi	Te Puke	Paengaroa	Pongakawa	
Dairy	30	91	22	87	3	3	0	2	1	5	8	60	78	253	302	944
Horticulture	126	671	10	385	75	130	12	54	26	0	46	269	654	653	107	3,219
Other pasture	1	4	0	16	0	1	0	1	0	1	1	12	9	11	7	64
Arable	0	20	34	0	0	0	0	0	0	0	0	0	10	0	0	64

Appendix L: Estimated agricultural irrigation demand

The following figures show the estimated irrigated land area for each crop.

WRZ	Year	Estimated irrigated agricultural land (ha)					
		Kiwifruit	Avocado	Pasture	Vegetable	Pipfruit	Other horticulture
Waihi	2005	90	17	31	2	7	9
	2025	142	27	95	4	11	14
	2055	178	34	125	5	14	18
Katikati	2005	477	92	95	13	36	68
	2025	605	116	235	16	46	81
	2055	711	137	265	19	54	91
Matakana Island	2005	7	1	22	0	1	34
	2025	11	2	30	0	1	51
	2055	11	2	30	0	1	51
Whakamarama	2005	274	53	103	7	21	28
	2025	427	82	230	11	33	43
	2055	533	102	280	14	41	54
Omokoroa	2005	53	10	3	1	4	5
	2025	21	4	0	1	2	2
	2055	18	3	0	0	1	2
Te Puna	2005	92	18	3	2	7	9
	2025	142	27	20	4	11	14
	2055	178	34	25	5	14	18
Mt Maunganui	2005	9	2	0	0	1	1
	2025	0	0	0	0	0	0
	2055	0	0	0	0	0	0
Tauranga West	2005	38	7	3	1	3	4
	2025	0	0	0	0	0	0
	2055	0	0	0	0	0	0
Tauranga Central	2005	19	4	2	0	1	2
	2025	0	0	0	0	0	0
	2055	0	0	0	0	0	0
Papamoa	2005	0	0	6	1	2	3
	2025	14	3	20	0	0	0
	2055	18	3	25	0	0	0
Tauranga South	2005	33	6	10	1	2	3
	2025	0	0	0	0	0	0
	2055	0	0	0	0	0	0
Oropi	2005	192	37	71	5	15	19
	2025	320	61	250	8	24	32
	2055	427	82	275	11	33	43
Te Puke	2005	465	89	86	12	36	57
	2025	569	109	275	15	43	77
	2055	711	137	300	19	54	91
Paengaroa	2005	465	89	264	12	36	47
	2025	711	137	825	19	54	71
	2055	1,067	205	875	28	82	107
Pongakawa	2005	76	15	310	2	6	8
	2025	124	24	860	3	10	13
	2055	142	27	960	4	11	14

Appendix M: Irrigation demand

The table below summarises the annual water demand for different agricultural uses by WRZ

Annual irrigation demand (m^3/year)

		Waihi	Katikati	Matakana Is	Whakamarama	Omokoroa	Te Puna	Mt Maunganui	Tauranga West	Tauranga Central	Papamoa	Tauranga South	Oropi	Te Puke	Paengaroa	Pongakawa	Total
Kiwifruit	2005	208,079	986,009	24,877	524,510	177,846	319,652	31,763	88,914	43,025	922	69,124	629,930	1,401,274	1,563,980	228,438	**6,298,341**
	2025	829,036	1,249,306	36,164	816,435	71,402	492,611	0	0	0	36,934	0	1,052,369	1,713,470	2,394,306	374,822	**9,066,854**
	2055	413,077	1,469,772	36,164	1,020,543	59,502	615,763	0	0	0	46,167	0	1,403,158	2,141,837	3,591,460	428,367	**11,225,812**
Avocado	2005	21,510	96,254	3,093	49,512	21,851	40,137	4,004	9,191	4,448	100	6,714	76,927	165,016	193,274	26,901	**718,931**
	2025	34,161	121,957	4,496	77,068	8,773	61,855	0	0	0	4,008	0	128,516	201,781	295,884	44,139	**982,638**
	2055	42,702	143,478	4,496	96,335	8,773	77,319	0	0	0	5,010	0	46,690	252,226	443,826	50,445	**1,171,300**
Pasture	2005	69,600	191,424	92,870	191,528	12,459	15,418	0	5,999	3,847	15,445	20,422	323,603	317,047	1,169,745	1,134,720	**3,564,125**
	2025	216,125	473,623	126,000	426,650	0	96,133	0	0	0	51,333	0	522,500	1,008,219	3,650,281	3,152,975	**9,723,840**
	2055	284,375	534,085	126,000	519,400	0	120,167	0	0	0	64,167	0	574,750	1,099,875	3,871,510	3,519,600	**10,713,929**
Vegetables	2005	5,444	27,480	0	15,323	6,219	11,076	0	2,326	1,126	23	1,888	22,168	42,993	51,620	7,009	**194,694**
	2025	8,646	34,818	0	23,851	2,497	17,068	0	0	0	924	0	37,034	52,571	79,025	11,500	**267,935**
	2055	10,807	40,963	0	29,814	2,081	21,335	0	0	0	1,155	0	49,379	65,714	118,537	13,143	**352,929**
Pipfruit	2005	10,837	51,773	1,408	27,862	9,922	17,915	1,774	4,631	2,241	48	3,585	35,159	76,239	87,804	12,429	**343,626**
	2025	17,210	65,598	2,046	43,370	3,984	27,609	0	0	0	1,931	0	58,736	93,225	134,420	20,393	**468,522**
	2055	21,513	77,174	2,046	54,212	3,320	34,511	0	0	0	2,414	0	78,315	116,531	201,630	23,306	**614,972**
Other horticulture	2005	2,159	12,486	27,588	3,992	4,211	7,972	810	922	446	11	656	14,478	33,462	37,121	4,476	**150,792**
	2025	3,429	14,730	41,113	6,214	1,682	12,286	0	0	0	457	0	24,188	45,321	56,714	7,344	**213,478**
	2055	4,286	16,686	41,113	7,768	1,402	15,357	0	0	0	571	0	32,250	53,714	85,071	8,393	**266,611**

Appendix N: Commercial and industrial growth predictions and parameters

The following table shows the SmartGrowth industrial growth predictions, as measured by employment.

Industry Grouping	% increase	
	2021	**2051**
Metal product manufacturing	113.8	391.8
Accommodation, cafes and restaurants	75.0	204.4
Wood and paper product manufacturing	41.5	93.3
Forestry and logging	27.2	70.1
Food, beverage, tobacco manufacturing	27.7	69.3
Machinery and equipment manufacturing	21.7	53.9
Mining and quarrying	5.5	14.9
Fishing	-7.8	-9.5

The following table shows the vacant potential commercial and business land areas as at 2001.

Growth area	Commercial land (ha)			Industrial land (ha)		
	Occupied	**Vacant**	**Total**	**Occupied**	**Vacant**	**Total**
Tauranga district	171.28	53.04	224.32	405.84	189.50	595.02
WBOP district	28.44	14.09	42.53	127.94	31.03	158.97
WBOP sub-region	**199.72**	**67.13**	**266.85**	**533.78**	**220.53**	**753.99**

Appendix O: Rural residential use

WRZ	Rural residential area (ha)			Annual demand (m^3/yr)		
	2005	**2025**	**2055**	**2005**	**2025**	**2055**
Waihi	1,051	1,104	1,104	19,181	20,140	20,140
Katikati	2,400	2,520	2,646	43,800	45,990	48,290
Matakana Is	1,800	1,800	1,800	32,850	32,850	32,850
Whakamarama	31,886	36,669	40,336	581,920	669,207	736,128
Omokoroa	4,116	3,087	1,544	75,117	56,338	28,169
Te Puna	2,446	0	0	44,640	0	0
Mt Maunganui	0	0	0	0	0	0
Tauranga West	103	0	0	1,880	0	0
Tauranga Central	354	0	0	6,461	0	0
Papamoa	3,468	1,387	0	63,291	25,316	0
Tauranga South	5,663	0	0	103,350	0	0
Oropi	17,709	20,897	21,941	323,189	381,363	400,431
Te Puke	10,790	12,948	13,595	196,918	236,301	248,116
Paengaroa	8,617	10,168	10,676	157,260	185,567	194,845
Pongakawa	12,568	13,825	14,516	229,366	252,303	264,918
Total	**102,971**	**104,404**	**108,158**	**1,879,221**	**1,905,375**	**1,973,887**

Appendix P: Estimates of allocable surface water flows

The table below shows the calculations of allocable run-of-stream resource availability by WRZs.

Water Resource Zone	Flow data for monitored sites						Estimate of allocable flow (l/s)			
	Site	Site No.	Site area (km^2)	5-year low flow ($l/s/km^2$)	Mean specific flow ($l/s/km^2$)	Approx. average annual rainfall of the catchment (mm)	Zone area (km^2)	Estimate of naturalised 1-in-5 year low specific yield ($l/s/km^2$)	5-year low flow Q_5 (l/s)	Allocable flow (10%) (l/s)
Waihi							56.0	0.81	45	4.5
Katikati	Kauri Pt Trib @ Tahawai	13309	2.6	0.81	17.8	1,550	251.2	7.18	1803	180.3
	Tuapiro @ Woodlands Rd	13310	39.1	8.77	49.0	2,200				
Matakana Island							65.4	0.5	20	2.0
Whakamarama	Waipapa @ Goodalls Rd	13805	8.5	5.76	57.0	2,400	305.9	3.18	973	97.3
	Mangawhai @ Omokaroa	13901	3.0	2.37	23.0	1,700				
	Wairoa above Ruahihi	14130	307.5	1.30	15.0	2,000				
Omokoroa							11.6	1.72	20	2.0
Te Puna							17.1	7.88	134	13.4
Mt Maunganui							23.6		0	0
Tauranga West							28.4	15.62	444	44.4
Tauranga Central	Kopurereroa @ SH 29 Bridge	14302	60.0	22.25	32.0	1,800	21.2	24.6	523	52.3
Papamoa							34.7	10.62	369	36.9
Tauranga South							40.9	6.27	257	25.7
Oropi	Waimapu @ McCarrolls Farm	14410	56.6	12.63	37.0	1,800	407.5	12.7	5,175	517.5
Te Puke	Raparapahoe @ U/S Drop Strc.	1114651	46.4	11.43	39.0	1,800	188.5	21.21	3,998	399.8
Paengaroa	Mangorewa @ Saunders Farm	14628	178.7	23.26	35.0	2,000	351.4	21.31	7,488	748.8
	Waiari @ Muttons	14627	71.7	42.05	56.0	2,000				
Pongakawa	Pongakawa @ Old Coach Rd	14703	54.0	80.56	137.9	1,600	289.1	40.28	11,645	1,164.5

Note: TCC surface water takes for Tauranga West, Central and South WRZs (Consent numbers, 20173 (37,273 m^3/d) and 20202 (54,533 m^3/d)) are from Oropi WRZ.

Summary of consented run-of-stream surface water takes and water availability based on 10% of Q_5.

Water Resource Zone	No. of consents	Daily allocation (m^3/d)	Allocated rate (est.) (l/s)	Estimated annual allocation (m^3/y)	Availability (l/s)	Annual availability (Mm^3/y)
Waihi	6	752	9	82,344	5	0.14
Katikati	37	16,270	188	1,781,542	180	5.69
Matakana Is	1	242	3	26,499	2	0.06
Whakamarama	15	3,939	46	431,353	97	3.07
Omokoroa	3	680	8	74,460	2	0.06
Te Puna	8	1,593	18	174,434	13	0.42
Mt Maunganui	14	8,496	98	930,312	-	-
Tauranga West	9	3,311	38	362,598	44	1.40
Tauranga Central	5	666	8	72,927	52	1.65
Papamoa	1	213	2	23,324	37	1.16
Tauranga South	6	860	10	94,174	26	0.81
Oropi	22	98,279	1,137	35,871,872	518	16.32
Te Puke	11	35,786	414	3,918,598	400	12.61
Paengaroa	37	8,653	100	947,532	749	23.61
Pongakawa	9	1,842	21	201,699	1,165	36.72
Total	**183**	**181,583**	**2,102**	**44,993,667**	**3,289**	**103.73**

Appendix Q: Winter flow harvesting

The table below lists potential harvesting of winter flows off streams.

Water Resource Zone	Flow data for monitored sites: Site	Site No.	Site area (km^2)	Mean winter flow (l/s)	Mean specific winter flow ($l/s/km^2$)	Est. mean specific winter flow of WRZ ($l/s/km^2$)	WRZ area (km^2)	Median discharge (l/s)	Total volume (Mm^3/yr)	Harvest potential (Mm^3/yr)
Waihi						10	56	420	7	3
Katikati	Kauri Pt Trib @ Tahawai	13309	2.6	75.3	29.0	51.1	251.2	9,628	150	75
	Tuapiro @ Woodlands Rd	13310	39.1	2864	73.2					
Matakana Island						10.0	65.4	654	10	5
Whakamarama	Waipapa @ Goodalls Rd	13805	8.5	714	84.0	48.0	305.9	11,018	171	86
	Mangawhai @ Omokaroa	13901	3	110	36.7					
	Wairoa above Ruahihi	14130	307.5	7196	23.4					
Omokoroa						5.0	11.6	58	1	0
Te Puna						12.0	17.1	205	3	2
Mt Maunganui						20.0	23.6	472	7	4
Tauranga West						20.0	28.4	568	9	4
Tauranga Central	Kopurereroa @ SH 29 Bridge	14302	60	2145	35.8	35.8	21.2	568	9	4
Papamoa						10.0	34.7	347	5	3
Tauranga South						8.0	40.9	327	5	3
Oropi	Waimapu @ McCarrolls Farm	14410	56.6	3130	55.3	55.3	407.5	16,901	263	131
Te Puke	Raparapahoe @ U/S Drop Strc.	1114651	46.4	2527	54.5	54.5	188.5	7,699	120	60
Paengaroa	Mangorewa @ Saunders Farm	14628	178.7	6911	38.7	48.4	351.4	12,760	198	99
	Waiari @ Muttons	14627	71.7	4170	58.2					
Pongakawa	Pongakawa @ Old Coach Rd	14703	54	4734	87.7	87.7	289.1	19,008	296	148
								80,635	**1,254**	**627**

Note:
The assessment is based on monitored winter mean flows and on the assumption that number of potential harvesting days is 180 days. As prior to and after the winter flow is generally less than the winter flow, conservatively, only 75% of the monitored values have been used.

Appendix R: Summary of groundwater resources

The table below presents a summary of information on groundwater resources by catchment and WRZ.

Water Resource Zone	Catchment	Allocable groundwater (l/s)	Estimates for catchments not covered by groundwater studies				Total allocable groundwater (l/s)	Annual allocable groundwater (m^3/year)
			Area (km^2)	Annual rainfall (mm)	1% of rainfall over gross area (m^3/y)	1% of rainfall over gross area (l/s)		
Waihi	Waiau	480.0					978	30,842,208
	Waihi Beach	498.0						
Katikati	Tuapiro	502.0					3,655	115,264,080
	Uretara	490.0						
	Te Mania	101.0						
	Tahawai	200.0						
	Ongare/Tanners Point	176.0						
	Katikati Streams	132.0						
	Te Rereatukahia	303.0						
	Waitekohe	404.0						
	Waione	129.0						
	Aongatete	686.0						
	Whatakao	532.0						
Matakana Is	Matakana Island	707.0					707	22,295,952

Water Resource Zone	Catchment	Allocable groundwater (l/s)	Estimates for catchments not covered by groundwater studies				Total allocable groundwater (l/s)	Annual allocable groundwater (m^3/year)
			Area (km^2)	Annual rainfall (mm)	1% of rainfall over gross area (m^3/y)	1% of rainfall over gross area (l/s)		
Whakamarama	Apata	260.0					2,335	73,648,333
	Oturu	45.6						
	Te Puna	0.0						
	Wainui	0.0						
	Waipapa	620.3						
	Wairoa-Ngamawahine	610.5						
	Wairoa-Ohourere	799.0						
	Wairoa-Wairoa	0.0						
Omokoroa	Waipapa	151.3					151	4,772,164
	Te Puna	0.0						
Te Puna	Te Puna Area	771.0					841	26,521,776
	Oturu	70.0						
	Wairoa-Wairoa	0.0						
	Te Puna	0.0						
Mt Maunganui	Maungatawa Area	502					502	15,831,072
Tauranga West	Otumoetai Area	4.0					41	1,292,976
	Kopurererua	37.0						
	Wairoa-Aairoa	0.0						
Tauranga Central	Tauranga City Area	80.8					264	8,327,037
	Kopurererua	47.1						
	Waimapu	136.1						

Water Resource Zone	Catchment	Allocable groundwater (l/s)	Estimates for catchments not covered by groundwater studies				Total allocable groundwater (l/s)	Annual allocable groundwater (m^3/year)
			Area (km^2)	Annual rainfall (mm)	1% of rainfall over gross area (m^3/y)	1% of rainfall over gross area (l/s)		
Papamoa	Lower Kaituna	81.5					273	8,615,994
	Waitao Area	56.1						
	Maungatawa Area	135.6						
Tauranga South	Waimapu	205.8					745	23,482,496
	Kaitemako	183.6						
	Welcome Bay Area	260.0						
	Waitao Area	95.2						
Oropi	Kopurererua	376.8					3,546	111,828,843
	Waimapu	1600.8						
	Mangorewa	27.5						
	Mangapapa/Opuiaki	1001.4						
	Omanawa	499.0						
	Kaitemako	40.7						
Te Puke	Lower Kaituna	786.0					1,569	49,470,164
	Waitao Area	669.7						
	Maungatawa Area	113.0						
Paengaroa	Lower Kaituna	922.0					1,422	44,829,346
	Maketu	24.0						
	Mangorewa	427.6						
	Not covered by GNS study		108.0	1,400	1,512,000	47.9		
Pongakawa			289.1	1,500	4,336,500	137.5	138	4,336,500
Total							**17,166**	**541,358,942**

Appendix S: Summary of water balance

The tables below list annual water supply, demand and water balances by WRZ. These tables are:

- Table 1: Water balance by WRZ
- Table 2: Adjusted water balance to meet resource transfer between WRZs (see notes above the table)
- Table 3: Surface water balance by WRZ (peak daily demand)
- Table 4: Groundwater balance by WRZ

Table 1: Water balances by WRZ

Parameter	Water Resource Zone															
	Waihi	Katikati	Matakana Island	Whakamarama	Omokoroa	Te Puna	Mt Maunganui	Tauranga West	Tauranga Central	Papamoa	Tauranga South	Oropi	Te Puke	Paengaroa	Pongakawa	Total
Annual allocable resource (Mm^3/yr)																
Groundwater	30.84	115.26	22.3	73.65	4.77	26.52	15.83	1.29	8.33	8.62	23.48	111.83	49.47	44.83	4.34	**541.36**
Run-of-stream	0.14	5.69	0.06	3.07	0.06	0.42	0	1.4	1.65	1.16	0.81	16.32	12.61	23.61	36.72	**103.73**
Dams	0.04	0.04	0	0.19	0	0.04	0	0.03	0.07	0	0.17	0.3	0	0	0	**0.88**
Total	**31.02**	**120.99**	**22.36**	**76.91**	**4.83**	**26.98**	**15.83**	**2.72**	**10.05**	**9.78**	**24.46**	**128.45**	**62.08**	**68.44**	**41.06**	**645.97**
Demand (Mm^3/yr)																
2005	0.90	2.81	0.33	2.46	0.56	0.78	2.89	4.08	4.34	2.05	2.35	2.45	4.40	8.23	3.29	**41.93**
2025	1.95	3.83	0.40	3.27	1.01	1.15	4.04	5.52	7.40	3.78	3.43	3.38	6.70	11.85	5.67	**63.38**
2055	1.98	4.45	0.41	3.78	1.70	1.38	5.14	6.44	10.21	6.18	5.55	3.78	8.36	13.66	6.22	**79.22**
Water balance (Mm^3/yr)																
2005	30.12	118.18	22.03	74.45	4.27	26.20	12.94	-1.36	5.71	7.73	22.11	126.00	57.68	60.21	37.77	**604.04**
2025	29.07	117.16	21.96	73.64	3.82	25.83	11.79	-2.80	2.65	6.00	21.03	125.07	55.38	56.59	35.39	**582.59**
2055	29.04	116.54	21.95	73.13	3.13	25.60	10.69	-3.72	-0.16	3.60	18.91	124.67	53.72	54.78	34.84	**566.75**

Note: The demand does not include the recreational demand as the current available data is not sufficient to accurately represent the distribution by WRZ. However, the recreational irrigation demand is considered a relatively small component of total water demand.

Table 2: Adjusted water balance to meet resource transfer between WRZs

Note:
Tauranga City current water demand is mainly met with surface water takes from Oropi WRZ, and they are planning to take water from Te Puke WRZ in the future (from the Waiari Stream). As the resources are/to be allocated it is assumed that part of Oropi and Te Puke water resources are available within Tauranga City WRZs and that amounts have been transferred as follows:

Current situation:
From Oropi WRZ to
Mt Maunganui = 7,500 m^3/d
Tauranga West = 7,500 m^3/d
Tauranga Central = 10,000 m^3/d
Papamoa = 5,000 m^3/d
Tauranga West = 5,000 m^3/d.

In addition, following volumes will be available from Te Puke WRZ:
Tauranga Central = 3,000 m^3/d
Papamoa = 3,500 m^3/d
Tauranga West = 3,500 m^3/d.

Parameter	Water Resource Zone															
	Waihi	Katikati	Matakana Island	Whakamarama	Omokoroa	Te Puna	Mt Maunganui	Tauranga West	Tauranga Central	Papamoa	Tauranga South	Oropi	Te Puke	Paengaroa	Pongakawa	Total
Annual allocable resource (Mm^3/yr)																
Groundwater	30.84	115.26	22.3	73.65	4.77	26.52	15.83	1.29	8.33	8.62	23.48	111.83	49.47	44.83	4.34	**541.36**
Run-of-stream-2005	0.14	5.69	0.06	3.07	0.06	0.42	2.74	4.14	5.30	2.99	2.64	3.55	12.61	23.61	36.72	**103.73**
Run-of-stream-future	0.14	5.69	0.06	3.07	0.06	0.42	2.74	4.14	6.40	4.26	3.91	3.55	8.96	23.61	36.72	103.73
Dams	0.04	0.04	0.00	0.19	0.00	0.04	0.00	0.03	0.07	0.00	0.17	0.30	0.00	0.00	0.00	**0.88**
Total - 2005	**31.0**	**121.0**	**22.4**	**76.9**	**4.8**	**27.0**	**18.6**	**5.5**	**13.7**	**11.6**	**26.3**	**115.7**	**62.1**	**68.4**	**41.1**	**646.0**
Total - future	**31.0**	**121.0**	**22.4**	**76.9**	**4.8**	**27.0**	**18.6**	**5.5**	**14.8**	**12.9**	**27.6**	**115.7**	**58.4**	**68.4**	**41.1**	**646.0**
Demand (Mm^3/yr)																
2005	0.90	2.81	0.33	2.46	0.56	0.78	2.89	4.08	4.34	2.05	2.35	2.45	4.40	8.23	3.29	**41.93**
2025	1.95	3.83	0.40	3.27	1.01	1.15	4.04	5.52	7.40	3.78	3.43	3.38	6.70	11.85	5.67	**63.38**
2055	1.98	4.45	0.41	3.78	1.70	1.38	5.14	6.44	10.21	6.18	5.55	3.78	8.36	13.66	6.22	**79.22**
Water balance (Mm^3/yr)																
2005	30.12	118.18	22.03	74.45	4.27	26.20	15.68	1.38	9.36	9.56	23.93	113.22	57.68	60.21	37.77	**604.04**
2025	29.07	117.16	21.96	73.64	3.82	25.83	14.52	-0.06	7.39	9.10	24.13	112.30	51.73	56.59	35.39	**582.59**
2055	29.04	116.54	21.95	73.13	3.13	25.60	13.43	-0.98	4.58	6.70	22.01	111.90	50.07	54.78	34.84	**566.75**

Table 3: Daily surface water balance at peak daily demand by WRZ (m^3/d)

Parameter	WRZ															
	Waihi	**Katikati**	**Matakana Island**	**Whakamarama**	**Omokoroa**	**Te Puna**	**Mt Maunganui**	**Tauranga West**	**Tauranga Central**	**Papamoa**	**Tauranga South**	**Oropi**	**Te Puke**	**Paengaroa**	**Pongakawa**	**Total**
Allocable daily volume-2005 (m^3/d)	384	15,589	164	8,411	164	1,151	7,500	11,336	14,521	8,178	7,219	9,712	34,548	64,685	100,603	**284,192**
Allocable daily volume-future (m^3/d)	384	15,589	164	8,411	164	1,151	7,500	11,336	17,521	11,678	10,719	9,712	24,548	64,685	100,603	**284,192**
Peak daily demand (m^3/d)																
Domestic																
2005							9,828	14,268	10,272	6,490	7,422					**48,281**
2025							13,774	18,671	17,927	12,862	10,892					**74,126**
2055							17,542	20,399	27,273	21,825	16,779					**103,818**
Live stock																
2005	0	180	0	87	0	0	0	226	320	1,227	73	0	379	0	41	**2,534**
2025	0	174	0	90	0	0	0	0	0	514	19	0	391	0	44	**1,232**
2055	0	153	0	98	0	0	0	0	0	0	0	0	420	0	46	**717**

Parameter	WRZ															
	Waihi	Katikati	Matakana Island	Whakamarama	Omokoroa	Te Puna	Mt Maunganui	Tauranga West	Tauranga Central	Papamoa	Tauranga South	Oropi	Te Puke	Paengaroa	Pongakawa	Total
Irrigation																
2005	770	5,691	0	1,241	0	634	0	560	191	3	175	3,570	13,860	8,687	12,793	**48,177**
2025	2,689	8,169	0	2,128	0	1,089	0	0	0	19	0	5,905	21,203	18,504	32,673	**92,379**
2055	1,884	9,512	0	2,639	0	1,361	0	0	0	24	0	7,075	25,392	23,266	36,583	**107,735**
Industry																
2005	0	0	-	0	0	0	134	43	5,603	15	7	0	2,525	11,954	0	**20,281**
2025	0	0	0	0	0	0	497	1,617	9,809	80	1,540	0	5,556	11,954	0	**31,053**
2055	0	0	0	0	0	0	677	3,417	10,809	100	3,640	0	7,937	11,954	0	**38,534**
Total peak demand																
2005	770	5,871	0	1,328	0	634	9,963	15,097	16,387	7,736	7,677	3,570	16,765	20,641	12,835	**119,274**
2025	2,689	8,343	0	2,218	0	1,089	14,272	20,288	27,736	13,474	12,451	5,905	27,150	30,458	32,718	**198,790**
2055	1,884	9,664	0	2,737	0	1,361	18,219	23,816	38,083	21,949	20,419	7,075	33,748	35,220	36,629	**250,804**
Surface water balance (m^3/d)																
2005	-387	9,718	164	7,083	164	516	-2,463	-3,761	-1,867	443	-458	6,142	17,783	44,044	87,768	**164,891**
2025	-2,305	7,246	164	6,193	164	62	-6,772	-8,953	-10,215	-1,796	-1,732	3,807	-2,602	34,227	67,885	**85,402**
2055	-1,500	5,925	164	5,673	164	-210	-10,719	-12,480	-20,562	-10,271	-9,700	2,637	-9,200	29,465	63,974	**33,388**

Table 4: Annual groundwater balance by WRZ (Mm^3/year)

Parameter	WRZ															
	Waihi	Katikati	Matakana Island	Whakamarama	Omokoroa	Te Puna	Mt Maunganui	Tauranga West	Tauranga Central	Papamoa	Tauranga South	Oropi	Te Puke	Paengaroa	Pongakawa	Total
Allocable annual volume (Mm^3/year)	30.84	115.26	22.3	73.65	4.77	26.52	15.83	1.29	8.33	8.62	23.48	111.83	49.47	44.83	4.34	**541.36**
Annual demand (Mm^3/year)																
Domestic																
2005	0.36	0.71	0.02	0.37	0.22	0.25						0.48	0.79	0.30	0.21	**3.71**
2025	0.60	0.97	0.03	0.47	0.85	0.29						0.63	1.00	0.37	0.25	**5.47**
2055	0.96	1.27	0.04	0.50	1.58	0.31						0.68	1.24	0.42	0.29	**7.29**
Live stock																
2005	0.15	0.43	0.13	0.68	0.03	0.02	0.02	0.00	0.00	0.04	0.05	0.54	0.50	1.58	1.43	**5.61**
2025	0.14	0.42	0.13	0.70	0.01	0.02	0.01	0.00	0.00	0.02	0.01	0.51	0.52	1.60	1.54	**5.63**
2055	0.13	0.37	0.13	0.77	0.00	0.03	0.00	0.00	0.00	0.00	0.00	0.46	0.56	1.65	1.59	**5.68**
Irrigation																
2005	0.23	0.74	0.15	0.68	0.23	0.34	0.04	0.05	0.03	0.02	0.08	0.71	0.51	2.15	0.01	**5.97**
2025	0.81	1.06	0.21	1.16	0.09	0.59	0.00	0.00	0.00	0.09	0.00	1.17	0.78	4.58	0.02	**10.56**
2055	0.57	1.24	0.21	1.44	0.08	0.73	0.00	0.00	0.00	0.12	0.00	1.41	0.94	5.75	0.02	**12.49**

	WRZ															
Parameter	**Waihi**	**Katikati**	**Matakana Island**	**Whakamarama**	**Omokoroa**	**Te Puna**	**Mt Maunganui**	**Tauranga West**	**Tauranga Central**	**Papamoa**	**Tauranga South**	**Oropi**	**Te Puke**	**Paengaroa**	**Pongakawa**	**Total**
Industry																
2005	0.06	0.23	0.00	0.01	0.00	0.06	0.06	0.01	0.05	0.07	0.05	0.00	0.16	0.10	0.00	**0.84**
2025	0.08	0.40	0.00	0.02	0.01	0.13	0.06	0.01	0.05	0.07	0.05	0.03	0.36	0.10	0.01	**1.35**
2055	0.10	0.45	0.00	0.03	0.01	0.15	0.06	0.01	0.05	0.07	0.05	0.05	0.52	0.10	0.01	**1.64**
Rural residential																
2005	0.02	0.04	0.03	0.58	0.08	0.04	0.00	0.00	0.01	0.06	0.10	0.32	0.20	0.16	0.23	**1.88**
2025	0.02	0.05	0.03	0.67	0.06	0.00	0.00	0.00	0.00	0.03	0.00	0.38	0.24	0.19	0.25	**1.91**
2055	0.02	0.05	0.03	0.74	0.03	0.00	0.00	0.00	0.00	0.00	0.00	0.40	0.25	0.19	0.26	**1.97**
Total groundwater demand																
2005	0.82	2.15	0.33	2.31	0.56	0.71	0.11	0.06	0.09	0.19	0.29	2.06	2.17	4.29	1.87	**18.00**
2025	1.66	2.90	0.40	3.02	1.01	1.03	0.06	0.01	0.05	0.20	0.06	2.73	2.90	6.83	2.06	**24.91**
2055	1.77	3.37	0.41	3.47	1.70	1.23	0.06	0.01	0.05	0.18	0.05	3.00	3.50	8.11	2.18	**29.08**
Groundwater balance (Mm^3/year)																
2005	30.02	113.12	21.97	71.36	4.21	25.81	15.73	1.24	8.24	8.44	23.20	109.80	47.31	40.56	2.49	**523.5**
2025	29.19	112.37	21.90	70.65	3.76	25.49	15.77	1.28	8.28	8.42	23.42	109.13	46.58	38.02	2.29	**516.6**
2055	29.08	111.90	21.89	70.20	3.07	25.29	15.77	1.28	8.28	8.44	23.43	108.85	45.98	36.74	2.17	**512.4**