



**Strategic Water Study into the Supply
and Demand Options for the Four Main
Catchments within the Gisborne
District**

Community Irrigation Fund Grant No. 10/03

Prepared for Gisborne District Council

Report No H13000/3

October 2013



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EXECUTIVE SUMMARY

Limitation to this study: Data and information for this study was primarily provided by the Gisborne District Council (GDC). Where other data or information has been used, the sources have been referenced accordingly. It is acknowledged that the available reliable data for surface water and groundwater resources within the study area is limited. To complete this study Aqualinc has estimated the necessary information on the available water resources where information was unavailable. In this estimation process, the assumptions made have been conservative. The assumptions made are clearly stated within the report at the relevant sections. Due to these assumptions and insufficient available data, the findings of this report should be considered as preliminary and used with appropriate care and caution. As new knowledge becomes available and information on the water resources improves, the findings and conclusions in this report should be revised.

The purpose of this study is to make strategic assessments of the current and future state of the water resources for the four main catchments within the Gisborne District (GD). The study assesses the present and potential future (for next 50 years) requirements for water in these catchments, the availability of surface and groundwater resources to meet this demand, and identifies appropriate mechanisms and options to address water availability and management in the catchments where water shortfalls have been identified.

Sustainable strategies to improve water availability for the benefit of the social and economic growth in the district have been identified. The findings of this project provide important information and greater confidence for the long term planning of water supplies for the district. The four catchments that have been included in this study are:

- Greater Waipaoa catchment;
- Uawa Catchment;
- Waiapu Catchment; and
- Other catchments: North Coast catchments including Karakatuwhero, Awatere and Wharekahika are all considered as a single catchment.

The total study area covers a land area of approximately 6,000 square kilometres (km²): Greater Waipaoa 2,928 km² (48.7% of the study area), Uawa 560 km², Waiapu 1,736 km² and other catchments 783 km². The study area represents approximately 72% of the land area in the GD. For the purposes of this study the Greater Waipaoa catchment has been divided into nine water resource zones (WRZ) based on surface water catchments, population and current water demands. The other three catchments, due to relatively limited information available, have been assessed as separate but single WRZs.

The key features of the study area include:

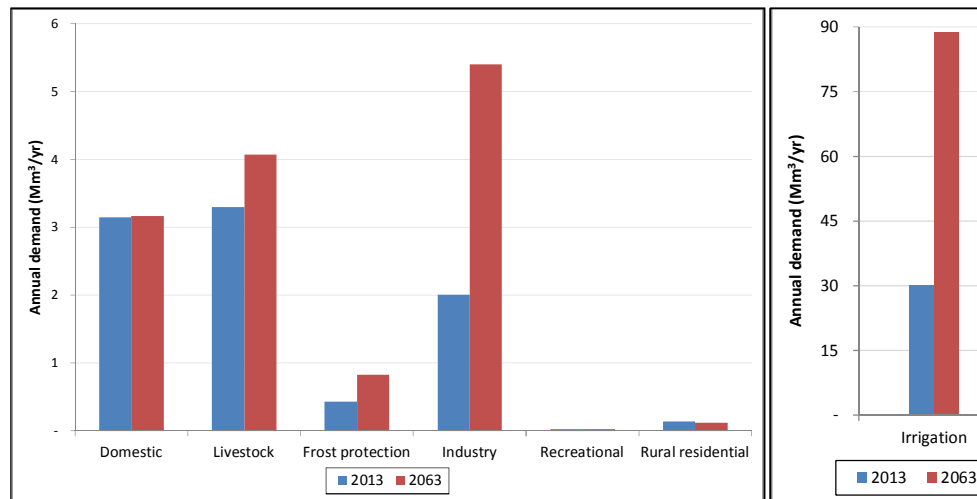
- The 2013 total population of the four catchments is approximately 35,000, which represents approximately 75% of the total population of the GD. The population in the Greater Waipaoa catchment is 25,700. It is predicted that the population demographics will not significantly change over the next 50 years.

- Gisborne District Council (GDC) reticulates water to urban areas in and around Gisborne City. This reticulated area falls within both the Greater Waipaoa and Other catchments. This supply services the water needs of approximately 25,000 people.
- GDC currently supplies water to 700 commercial and industrial operations; all of which are located within Gisborne City boundary.
- The current irrigated agricultural area in the study area is approximately 6,000 ha.
- The total irrigated area of horticulture is approximately 4,500 ha, 60% of which is in vegetable production.

Water Demand

The projected water demands from this study indicate that:

- Demand for water in the study area is projected to increase from the current level of 39 Mm³/yr to 102 Mm³/yr by 2063. This represents a 160% increase over the 50 year planning period. The distribution of this growth in water demand by use is shown below. This growth is dominated by irrigation demand. Sensitivity analysis indicates that the demand could be as high as 132 Mm³/yr (238% increase) by 2063, if there is sustained high population and industrial growth, and increased demand for irrigation water.



Distribution of water demand

- The total water demand in the Greater Waipaoa catchment is 36 Mm³/yr. This represents 92% of the demand for the whole study area.
- Domestic water demand (both on a reticulated and non-reticulated basis) is projected to remain relatively constant at 3.1 Mm³/yr.
- Water demand for commercial and industrial uses is predicted to increase from 2 to 5.4 Mm³/yr by 2063.
- It is likely that the principal driver for an increase in water demand for the GD will be irrigation.
- Agriculture and horticulture industries are economically very important sectors in the district; they currently use 30 Mm³/yr, which represents 77% of water used in the study area. This volume is predicted to increase to 89 Mm³/yr (87% of water

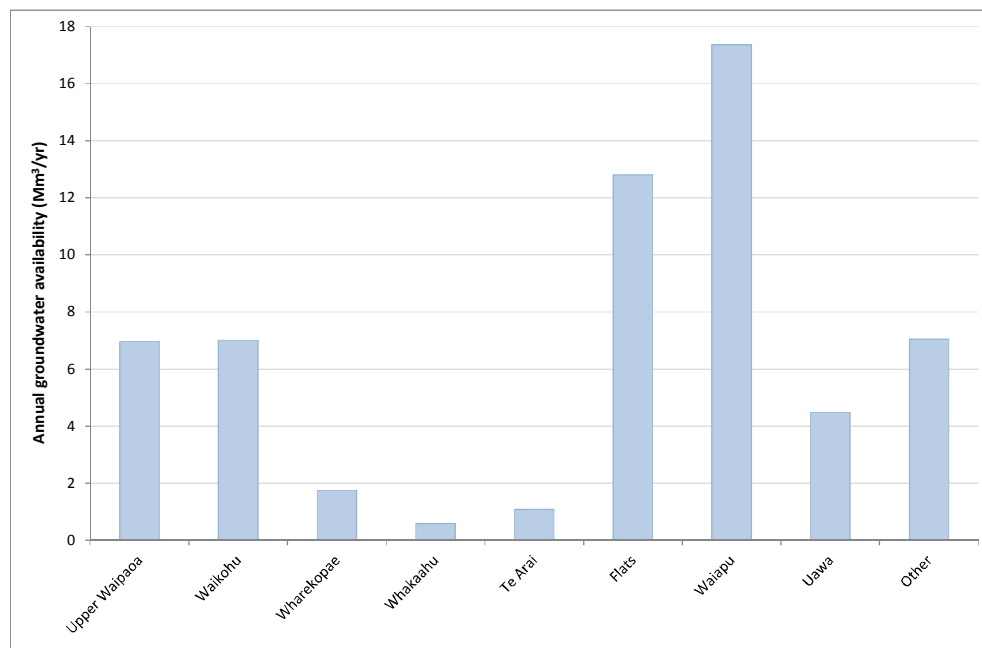
use) by 2063. This increase in use is partly to maintain market share by irrigating more area. However, it is also expected that annual irrigation application depths will increase to respond to higher soil water deficit, due to the effects of climate change.

- Water demand for frost protection is predicted to increase slightly as more growers will use water for frost protection to improve the quality of their products. However, the predicted warm weather patterns forecasted for the district will result in less frost during critical times.
- Livestock water demand will increase from current level of 3.3 to 4.1 Mm³/yr by 2063.

Resource Availability

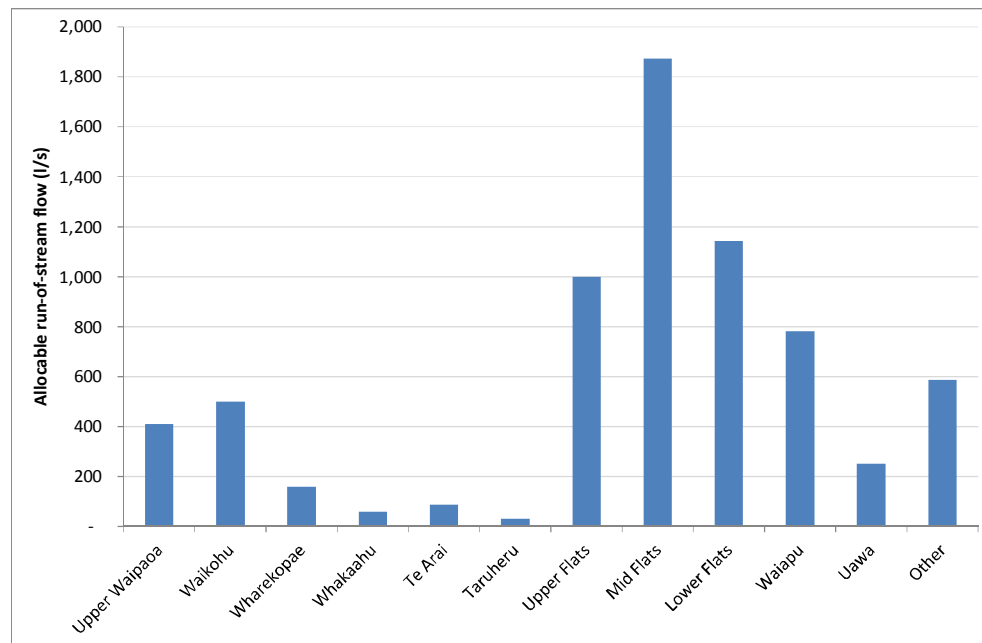
The key findings with regard the assessment of water resources available in the study area indicate that:

- Total current annual water availability from run-of-stream flows, groundwater and reservoirs is approximately 135 Mm³/yr. Due to climate change, however, it is predicted that this available resource will reduce to 130 Mm³/yr by 2063.
- Approximately two thirds of the total water resources available are within the Greater Waipaoa catchment (88 Mm³/yr).
- Groundwater availability in the study area is approximately 59 Mm³/yr. This component represents 44% of the total water resource available.
- Groundwater availability by WRZs is presented below. Note that WRZs in the Poverty Bay Flats area (Taruheru, Upper Flats, Mid Flats and Lower Flats) are combined and presented as the “Flats” category. This was necessary because with current available data, it is not feasible to determine the available groundwater resource for each WRZ separately.



Groundwater availability by WRZ

- The available data on run-of-stream flow is limited for the study area. Estimated average daily water available based on extrapolation of available data is approximately 595,000 m³/d (6,883 l/s), as presented for each WRZ below.



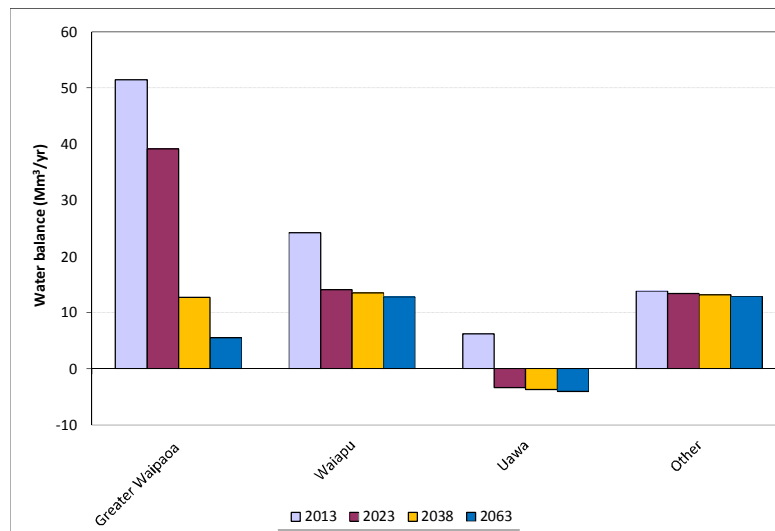
Run-of-stream availability by WRZ

- Storage reservoirs are currently estimated to contribute approximately 10.7 Mm³/yr to meet water demand.
- Harvesting and storage of winter stream flows could potentially contribute more than 1,300 Mm³/yr to water supplies. However, there are a number of challenges to overcome to realise this potential.
- Rooftop rainwater harvesting is not a major contributor to meeting water demand in the GD area; it currently only accounts for less than 1.5% of the supply.

Water Resource Sustainability

The assessment of sustainability of water resources completed in this study indicates:

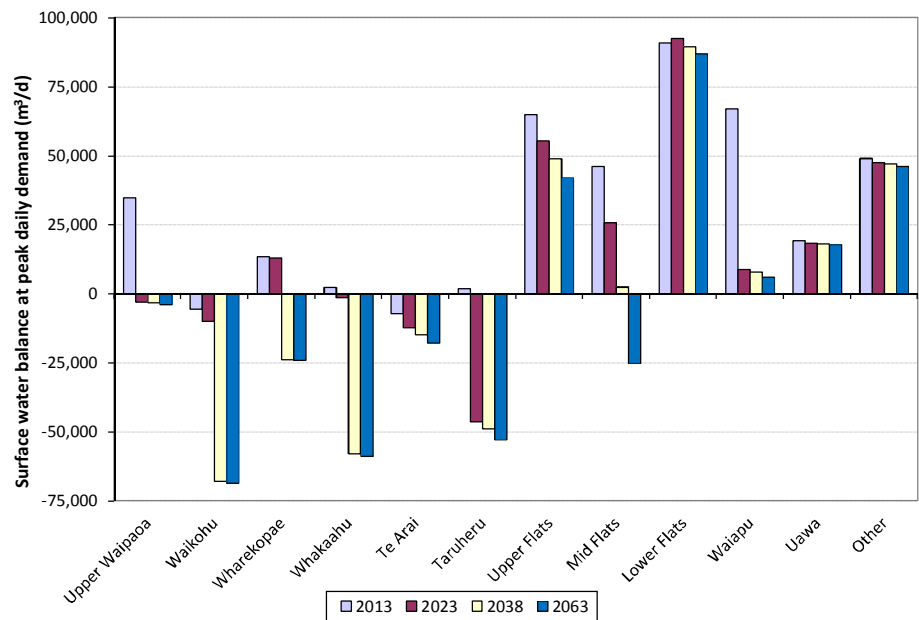
- The annual water balance completed over the whole study area shows a positive water balance of at least 27 Mm³/yr over the entire planning period, up to year 2063. The water balance is positive for three of the four catchments as shown below, however, it is predicted that there is not sufficient water resources to meet the future growth in the Uawa catchment. The water balance at this large scale is of limited value as it masks the spatial and temporal variation in demand and supply as well as differences between water sources. More relevant discussion on the water balances by WRZ and source types are presented in the following sections.



Water balance by four catchments

Surface water

- The current contribution of water from surface water resources to meet current demand is estimated to be 56% (76 Mm³/yr).
- The demand of the GDC reticulation water supply is approximately 4.5 Mm³/yr. This is met by surface water, primarily from the Te Arai WRZ using three storage reservoirs.
- The current average daily allocable run-of-stream water available for the entire study area is estimated to be 595,000 m³/d. This average quantity is predicted to reduce with time to 573,000 m³/d by 2063, due to climate change.
- The current daily peak demand met from run-of-streams is 218,000 m³/d. This is predicted to increase to 627,000 m³/d by 2063, which is greater than the water available from run-of-stream water.
- Using the current level of water allocations the daily surface water balance, at peak demand for the 12 WRZs is produced below. This shows that the daily surface water balances are negative and cannot meet the current peak demand in the Te Arai and Waikohu WRZs. All of the WRZ in the Greater Waipaoa catchment apart from Upper and Lower Flat WRZ will have a negative surface water balances due to projected demand over the next 50 years.
- GDC predominately uses the Te Arai WRZ to source water for their reticulated water supply. It is predicted that by 2063 the peak daily demand from the GDC water supply system will exceed the allocable surface water resources by 18,000 m³/d.

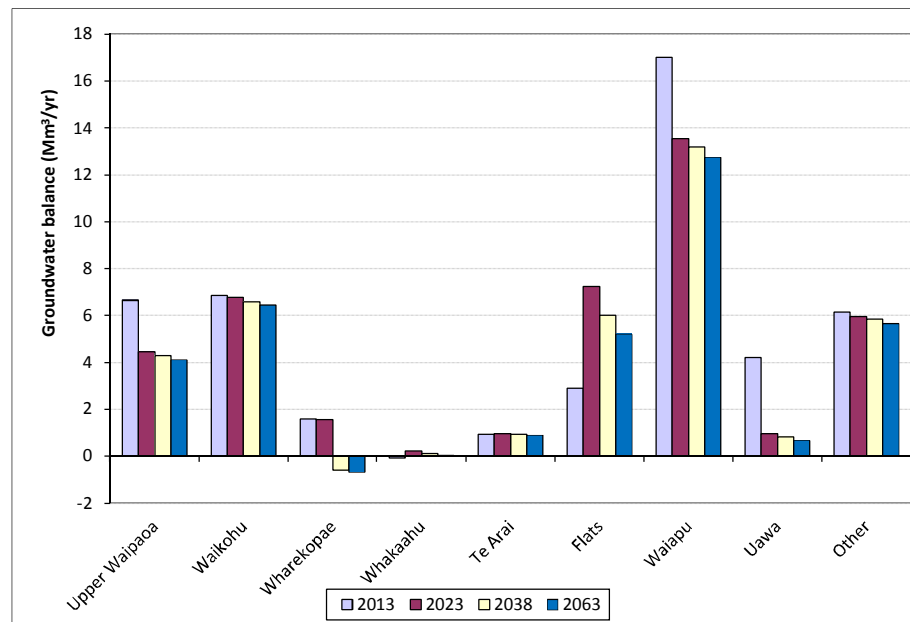


Run-of-stream water balance by WRZ, based on daily peak demand and supply

- It should be recognised that the available flow data to complete this supply/demand analysis for each WRZ is limited. The available water resources used in this assessment have been calculated with a degree of conservativeness. It is conceivable that higher volumes of water may be available from the surface water if in-stream minimum flow requirement (IMFR) studies are completed.

Groundwater

- The annual groundwater balance for the entire study area is positive, with an annual net balance of over 35 Mm³/yr for the entire planning period.
- Based on the assumed allocable groundwater resource and under the current allocation regime, the groundwater resource in the critical Poverty Bay Flats WRZs shows a positive water balance. However, the uncertainty associated with the sustainable allocation limits from the aquifers in this area is high. Therefore, GDC need to thoroughly understand the aquifer and recharge characteristics to be able to determine the defensible long-term sustainable allocation limits in this zone.
- The groundwater balance in the Poverty Bay Flats will increase in the short-term as a result of a predicted reduction in agriculture land use, and associated water use, in and around the urban areas. However, the water availability will incrementally reduce due to an increase in water demand by industries.
- If within a coastal WRZ the water balance shows the groundwater volumes zone to be approaching its sustainable limit, it is possible that saltwater intrusion could occur. Under this scenario regular monitoring of groundwater levels is necessary.



Groundwater balance by WRZ

Storage Reservoirs

- Current contribution of water to the total water demand from storage reservoirs is 8%. Nearly all of this storage capacity is part of the GDC water reticulation system.
- There is considerable potential for harvesting winter surface flows; over 1,300 Mm³/year. However, storage is often a technically and environmentally challenging prospect, so significant constraints need to be overcome to realise this storage potential.
- Low flows occur in surface waters during the summer, and with climate change the summer flows are predicted to reduce further. As a result of this it is likely that the supply pressures on surface water resources will increase. It is important that seasonal summer water takes, such as irrigation, investigate the feasibility of storage to improve their supply reliability.

All of the above projections in this study are based on most likely outcomes of medium growth of population and economic development and associated land use changes. However, there is a potential for a higher rate of growth and development. If higher growth rates (i.e. population by an additional 10%, industry demand by another 30%, irrigation by 30% and livestock by 20% over the medium growth by 2063) occur in the medium to long term, the run-of-stream supply is unsustainable for most of the WRZs around Gisborne City.

Recommendations

- GDC should undertake a detailed strategic water planning exercise in each of the WRZs, where water resources have been identified as being under considerable pressure. These studies are necessary to ensure that water is not limiting social and economic growth of the zone. The WRZ that should be further studied include Taruheru, Mid Flats and Te Arai WRZs.

- GDC should evaluate the current preference and desirability for water sources for large takes in water stressed WRZs. This study needs to identify whether alternative sources would be more appropriate for the long-term sustainability of the water resource in WRZs.
- GDC must improve current information on water resources by:
 - Conducting IMFR studies on high demand streams to determine sustainable allocation limits.
 - Collection of water quality data to identify the temporal variations in the water quality which may limit the available resources.
 - Measure daily flow data in all key catchments.
 - Determine the sustainable yields for aquifers, particularly for the high use aquifers in the Poverty Bay Flats.
- GDC should design and implement a more strategic approach to water allocation for the district. This should include consideration of the likely future demand by use, type and source, and through the consenting process reserve resources to meet these demands, if appropriate.
- GDC should actively promote or require the use of winter flow harvesting, particularly for irrigation supplies for market gardening, frost protection, and possibly municipal water supplies from catchments other than Te Arai.

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- Brendon McQuaid, OPAC

LIST OF ABBREVIATIONS

| | |
|-----------------|---------------------|
| d | day |
| ha | hectare |
| km ² | square kilometres |
| l/s | litres per second |
| m | metre |
| mm | millimetre |
| m ³ | cubic metre |
| Mm ³ | million cubic metre |
| WRZ | water resource zone |
| yr | year |

LIST OF ACRONYMS

| | |
|------|--|
| GD | Gisborne District |
| GDC | Gisborne District Council |
| GIS | Geographic Information System |
| IMFR | In-stream minimum flow requirement |
| MALF | Mean annual low flow |
| NIWA | National Institute of Water and Atmosphere |

GLOSSARY

| | |
|--|--|
| Annual water balance | Difference between available annual water resources and annual water use for an area or water resource zone (ie, availability of demand) |
| Instream minimum flow requirement (IMFR) | Minimum flow required to sustain freshwater ecosystems and the human livelihoods and wellbeing that depend on these ecosystem |
| Mean annual low flow | The average of the lowest flow measured in a river or stream each year. |
| Peak daily demand | The maximum daily water demand for a use type, eg. domestic daily water use can vary and generally it peaks in the summer months. |
| Run-of-stream | River or stream flows that can be abstracted directly without storage |

1 INTRODUCTION

Gisborne District Council (GDC) is undertaking a strategic water study in conjunction with local stakeholders designed to develop a long term water sustainability plan to effectively and efficiently manage water allocation in areas of high water demand. The study involves assessing the likely potential future requirements for water in the district, the availability of current and future surface and groundwater resources to meet this demand, and additionally identifying appropriate mechanisms to manage future water use within the resources available.

This report outlines the water resource demand for the current status, and predictions for the next 10, 25 and 50 years, this is assessed against the resource availability on the same time basis. Additionally sustainable strategies are identified, where appropriate, to improve the water allocation and/or resource available for the benefit of the social and economic growth in the district. The findings of this project provide valuable information and a greater confidence for long term water supply planning in the district. The four main catchments within the region have been included in this study, they are:

- Greater Waipaoa catchment;
- Uawa Catchment;
- Waiapu Catchment; and
- Other Catchments: North Coast catchments including Karakatuwhero, Awatere and Wharekahika (considered as a single area).

This work is partially funded through a grant from the Ministry for Primary Industries through Community Irrigation Fund, grant 10/03.

1.1 Environmental Benefits of Project

The key focus of this project is to ensure the future sustainable management of the fresh water resources for the Gisborne District (GD). At present some water resources in the district may be close to over-allocated and hence the (often undetermined at this time) minimum in-stream environmental flow is being breached. To proactively manage the water resource GDC staff and the Gisborne Fresh Water Advisory Group need to be know the current and future demand for water for abstractive purposes and the associated level of impact that these demands may have on the protection of in-stream values. The information generated by this project, on the region water demand and matching resource available, given assumptions on allocation, will facilitate the establishment of sustainable allocation limits that are future-proofed.

This assessment will also enable GDC to consider if changing water demand in the future can be met from existing water resources with minimal investment in large-scale infrastructure or if there is a need for considerable investment to enhance water availability in periods of low flow. This decision on necessary investment has direct consequences on the ramifications and potential growth of the region due to the minimum flows that will be set for waterways to ensure that the desired environmental bottom lines are protected.

1.2 Previous Studies

There are a number of previous studies that have been completed in regard to different aspects of growth and water related issues of the Gisborne district. The relevant reports have been reviewed to gather relevant information for this current study. The relevant reports reviewed are listed in Appendix A of this document.

GDC, in conjunction with Lincoln University (part-funded by Envirolink) has completed the River Values Assessment System method for seven values in the Gisborne Region (irrigation, native birds, native fish, natural character, potable water, salmonid angling, and swimming). The preliminary assessments for potable water has identified that the Te Arai River in the Waipaoa Catchment has a national significance mainly because that is the principal water supply for Gisborne city (LU, 2012a). The irrigation assessment identified that the rivers in the Waipaoa catchment have regional significance primarily due to the catchment having the majority of irrigable land in the district, and the catchment supports significant activity in other parts of the economy through processing and flow-on economic impacts (LU, 2012b).

1.3 Objectives

The two project objectives are:

- Development of demand/supply scenarios of the water resources of each area given predicted changes in; land use (horticultural, agricultural, forestry), population, community expectations of water quality and climate.
- Identification of areas where community and/or economic development may be enhanced by greater access to water resources.
- Identification of areas and when the projected demand for water may exceed the capacity to provide the in-stream/intrinsic values identified for these areas.
- For those areas within the catchments where demand or required reliability could not be met with existing water resources, options will be identified for increasing supply and/or reliability.

1.4 Information and Data Sources

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

- Digital maps of water study areas (regional, catchment boundaries, water study areas and dams);
- Water consent and water use records;
- Population census and growth projections;
- Current and potential dam locations;
- Stream flow monitoring records;
- In-stream habitat studies;

- Groundwater investigations;
- Soil maps;
- Rainfall isohyets;
- Climate Change studies; and
- Livestock estimates by catchments.

1.5 Planning

This study used the current situation or latest available data to predict the potential situation in 10 years (2023), 25 years (2038), and in 50 years (2063). The current and projections for water use, demand, and availability have been based on available data, design parameters, published information on population growth and assumptions. This information is summarised in Appendix B.

1.6 Report Outline

The purpose of this report is to present the results, conclusions and recommendations on the strategic water study for the demand and supply in the four major catchments of the Gisborne District for the next 50 years (2063).

The structure of this report is:

- Chapter 2 outlines the study area and selection of the Water Resource Zones (WRZ);
- Chapter 3 describes the water demand assessment for different requirements, including impact of climate change on the demand and supply;
- Chapter 4 presents the assessment of the current and future water resource;
- Chapter 5 describes the water balance completed for the study area, catchments and water resource zones;
- Chapter 6 lists the potential future water strategies for the study area;
- Chapter 7 includes the conclusion and recommendations of this study.

The detailed analyses and supplementary findings are contained in 12 Appendixes. These are:

- Appendix A: Summary of relevant water reports reviewed
- Appendix B: Assumptions and design parameters used in the study
- Appendix C: Domestic water demand
- Appendix D: Livestock water demand
- Appendix E: Irrigation water demand
- Appendix F: Frost protection requirement
- Appendix G: Rural residential water demand
- Appendix H: Allocable surface water flows
- Appendix I: Winter flow harvesting using reservoirs
- Appendix J: Summary of water resources
- Appendix K: Water balances
- Appendix L: Sensitivity analysis of design parameters by catchment

2 STUDY AREA

The study area encompasses the four main catchments in the Gisborne District. These catchments are:

- Greater Waipaoa catchment;
- Uawa Catchment;
- Waiapu Catchment; and
- Other: North Coast catchments including Karakatuwhero, Awatere and Wharekahika (considered as a single area). The reason for consideration of these catchments as a single area is due to limited availability of information for the areas.

The map of the Gisborne District as a whole and four study catchments are illustrated in Figure 2-1 and Figure 2-2, respectively. The study area covers a land area of approximately 6,000 km², which covers 72% of the region and 75% of the region's population lives within the study area. Nearly a half of the study area falls within the Greater Waipaoa catchment. Table 2-1 lists the area breakdown of the catchments.

Table 2-1: Land areas of the study catchments

| Catchment | Area (km²) | % area |
|------------------|------------------------------|---------------|
| Greater Waipaoa | 2,928 | 48.7% |
| Uawa | 560 | 9.3% |
| Waiapu | 1,736 | 28.9% |
| Other | 783 | 13.0% |
| Total | 6,007 | |

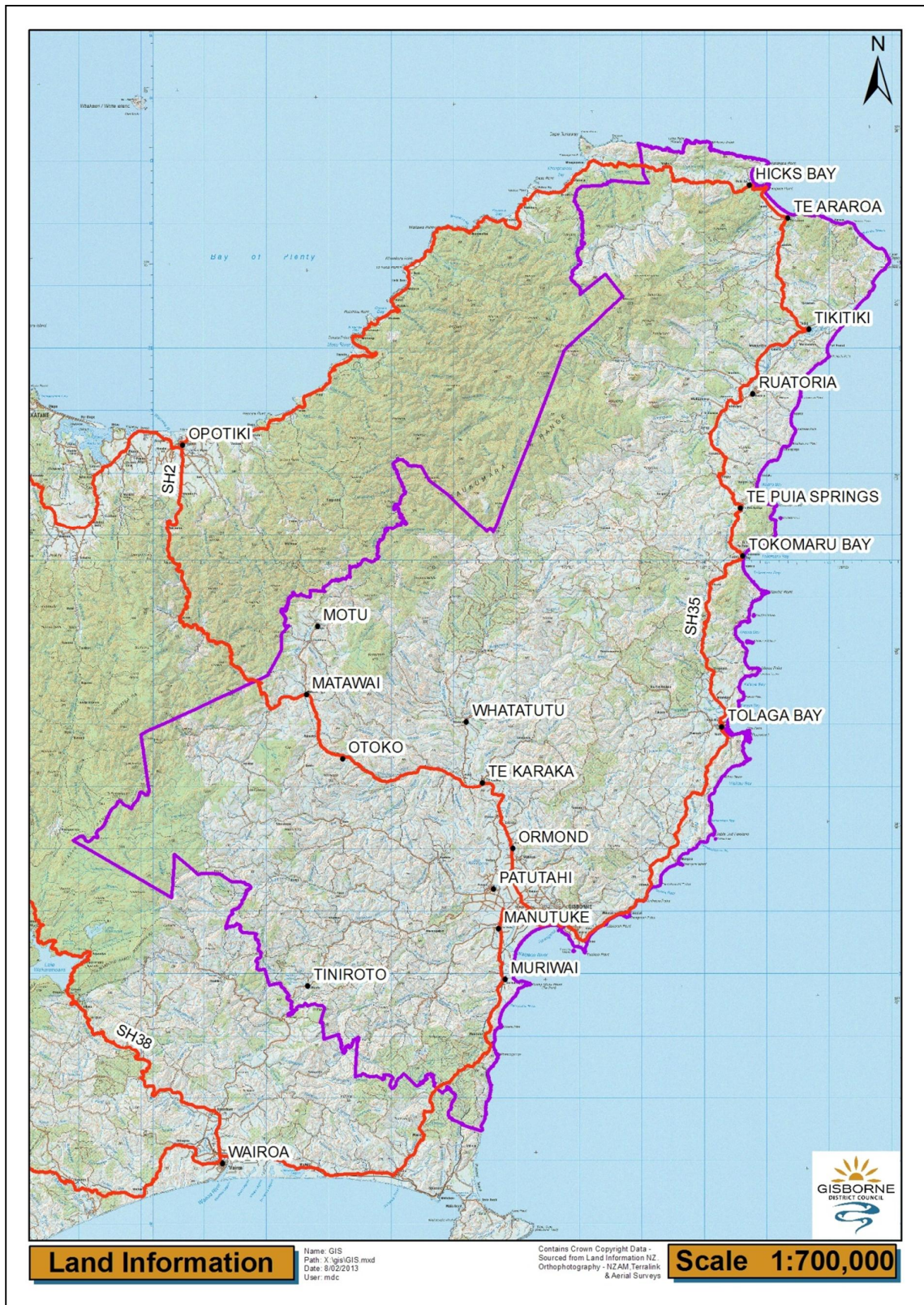


Figure 2-1: Gisborne District Land Area

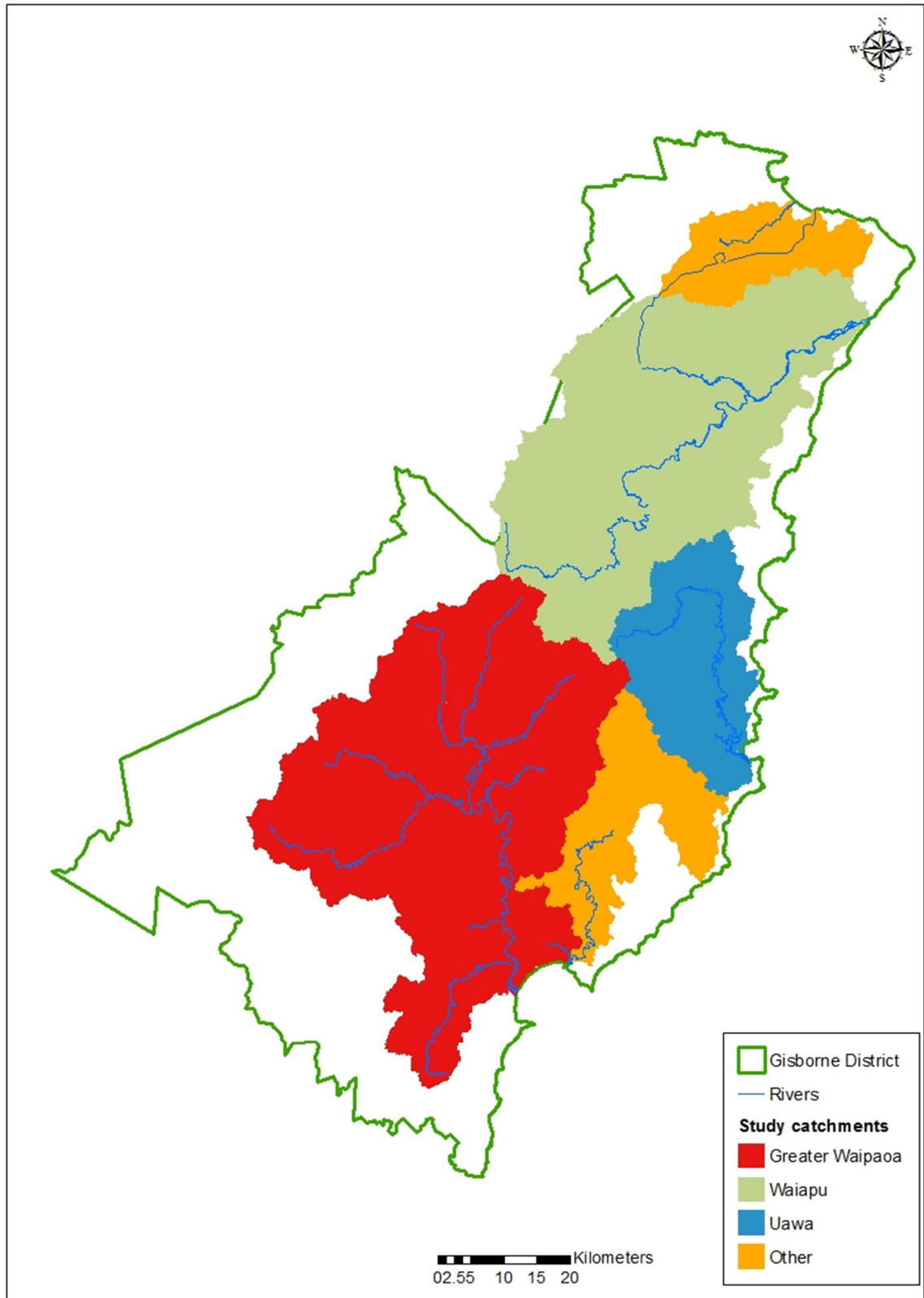


Figure 2-2: Four study catchments

2.1 Water Resource Zones

For the purpose of the study, the Greater Waipaoa catchment has been divided into nine Water Resource Zones (WRZ). This was possible as there are sufficient data and information available on a spatial basis for this catchment. However, the availability of data and information for the other three catchments are limited. Therefore, those three catchments were studied as single WRZs.

The selection of nine WRZ in the Greater Waipaoa catchment was based on criteria of:

- Surface water catchments;
- Population distribution; and
- Current water demand.

Groundwater aquifer boundaries were not considered for the WRZ selection as the current knowledge of the groundwater system was not adequate. Table 2-2 shows the land areas of the nine WRZ in the Greater Waipaoa catchment. The zone areas range from 47 km² for Lower Flats (in the Poverty Bay Flats) to 1,001 km² in Waikohu catchment.

Table 2-2: Water Resource Zones in the Greater Waipaoa catchment

| | Water Resource Zone | Area (km²) | % area |
|---|----------------------------|------------------------------|---------------|
| 1 | Lower Flats | 47.3 | 1.6% |
| 2 | Mid Flats | 229.2 | 7.8% |
| 3 | Taruheru | 88.0 | 3.0% |
| 4 | Te Arai | 216.2 | 7.4% |
| 5 | Upper Flats | 90.5 | 3.1% |
| 6 | Upper Waipaoa | 819.4 | 28.0% |
| 7 | Waikohu | 1,001.8 | 34.2% |
| 8 | Whakaahu | 118.3 | 4.0% |
| 9 | Wharekopae | 317.6 | 10.8% |
| | Total | 2,928 | |

The smaller WRZ, particularly Upper, Mid and Lower Flats (in the Poverty Bay Flats), Taruheru and Te Arai reflects the high water use within smaller land areas. The population density is also comparatively higher in these zones. Other zones are generally considered as more rural land uses, focused on agriculture and forestry. The selection criteria of the larger WRZs was primarily based on surface water catchments. The WRZs are illustrated in Figure 2-3.

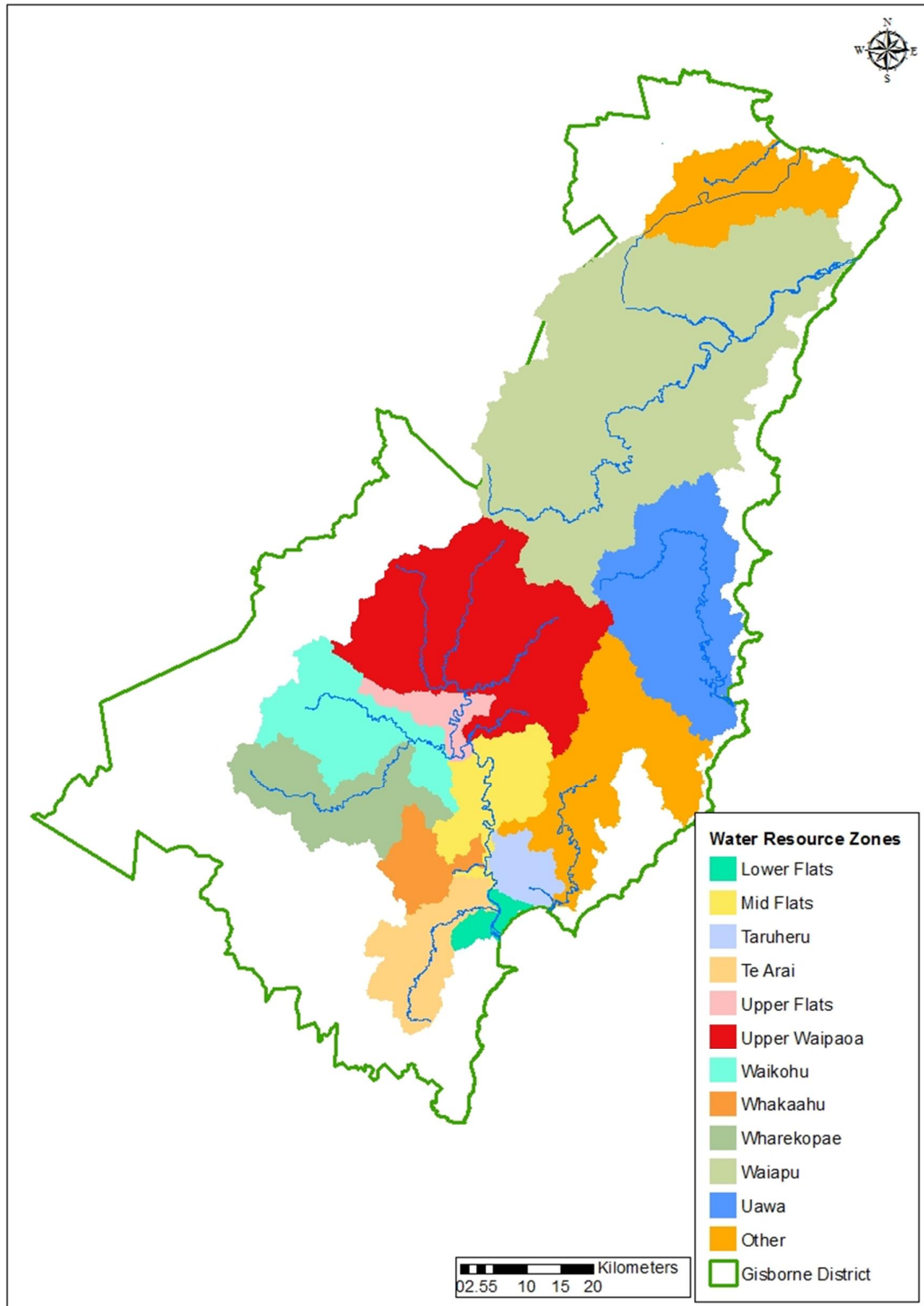


Figure 2-3: Water Resource Zones

3 DEMAND ASSESSMENT

The current and future water demands assessments for each WRZ is presented in this section. The main factors that impact on the consumptive demand for water, such as population trends and changes in land uses have been analysed to determine the future water demand. The main body of text in this section presents a description of the design parameters used and a summary of the key findings. The detailed results are presented in the appendices.

3.1 Water Demand Categories

To determining the water demand the following water use categories are used:

- i) Domestic consumption (i.e. household water consumption) with two sub-categories:
 - Reticulated (supplied) ; and
 - Non-reticulated (sourced on-site).
- ii) Industrial and commercial use.
- iii) Agriculture ó water consumption is determined for the following sub-categories:
 - Livestock, inclusive of drinking water for all stock including rural residential units and dairy shed wash-down requirements. Dairy shed wash-down requirements are not permitted as of right under the RMA, so these must comply with permitted volumes under Regional Water and Land Plan;
 - Irrigation based on the following:
 - ó Pastoral;
 - ó Horticultural; and
 - ó Arable.
 - Frost protection;
 - Rural residential; water demand for non-commercial agricultural activities (excluding domestic component and livestock demand) such as irrigation of gardens, shelter belts, part-time horticulture and plant nurseries.
- iv) Recreational (such as demands for bowling greens, sports fields, swimming pools etc.).

Note that geothermal water (>30°C), which is treated as a separate resource from cold groundwater, and is not included in this study.

Water demands for fire fighting are not considered for this assessment as it is difficult to quantify. It is considered that GDC measured consumption volumes already included all the uses including fire fighting and water losses in the reticulation system. Therefore, the values used in this study based on the GDC supplied data on actual overall consumption have already included these minor volumes.

3.2 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 flow rate over a 12 month period, expressed as cubic metres per day (m^3/d).

3.3 Climate Change

Climate change is a highly complex phenomenon that depends on interactions between many natural processes in atmosphere, land and ocean, and anthropogenic activities. It has shown to be difficult to predict the full-scale of the impacts of climate change, in part because future human activities cannot be accurately predicted.

NIWA (2012) has completed an assessment on the impact of climate change on the future water resources in the Gisborne District. Our current study has taken these findings and other relevant climate change studies (Kenny, 2001; MfE, 2004; O'Connell and Hargreaves, 2004) into account in determining the likely future water demands.

The key findings of the NIWA (2012) study that is relevant to this study are:

- Future hydrological conditions will be different from the past;
- The size of available water resources are likely to more variable and harder to predict;
- Rainfall in the current wetter winter-spring period will be less (due to stronger westerly winds), and slightly higher precipitation in summer and early autumn (due to weaker westerly winds);
- Higher air temperatures are expected throughout the year;
- Drought conditions are likely to be more frequent and more severe ;
- Crop water requirements will be higher;
- A general trend in the decline in surface water flows will occur, this will be least pronounced in summer and most pronounced in winter;
- Floods that occur will be more extreme;
- The average annual low flows will be slightly lower, though the decreases are too small to warrant changes in planning at this time; and
- Groundwater recharge from land will be reduced, though river-based recharge is not likely to change.
- The estimated average seasonal river flow reductions for the Waipaoa River at Kanakanaia in 2030-2049 period as compared to 1980-1999 are:
 - Summer: -3.5%
 - Autumn: -2.8%

- Winter: -20.9%
- Spring: -17.2%

The impact of climate change on agriculture will be both positive and negative. Warmer weather will lengthen growing seasons and increased concentrations of atmospheric CO₂, this will act like an atmospheric fertilisation. However, it is likely that average reduction in available surface water and groundwater, and higher potential evapotranspiration will increase the crop water requirements. Increased demand for water for irrigation and other purposes (e.g., domestic, and recreational uses) will enhance the competition for available water resources.

To account for climate change effect on the available surface water resources it is assumed reductions of 1%, 2% and 3.5% in the current average availability will occur by 2023, 2038 and 2063, respectively. This is considered as a reasonable assumption as water demand is primarily higher in the summer months. The effect of higher reduction in water availability in winter is not significant as the demand is less. It is also assumed that sustainable yield from groundwater aquifers will gradually reduce to 5% by 2063, due to the decrease in land surface recharge. The assumed increase in crop water demand is 5% by 2063.

3.4 Domestic Water Demand

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

- Population census - 2006;
- The rate of change in the population increase is based on GDC population predictions for period of 2006 to 2051 (GDC, 2011). The predictions were extrapolated to 2063 as required in this study.
- Average daily per capita consumption rates for water are estimated by GDC (Appendix B).
- Peak daily water consumption has been increased by a factor of 1.4 to account for higher individual demand (primarily garden irrigation) and seasonal population increase due to tourism.

3.4.1 Population Growth

Population growth for each WRZ has been estimated based on the GDC's data (GDC, 2011). These estimates represent a medium growth scenario (medium fertility, medium mortality and medium migration) and 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 these effects on water demand.

The total residential population in the study area in 2013 is approximately 35,000 and this is estimated to remain reasonably constant throughout the study period (Table 3-1). The data shows that over 60% of the current population in the study area (21,100 of 35,100) lives in Taruheru WRZ. Figure 3-1 graphically illustrates the population growth expected. The predictions indicate that population in the Gisborne urban area

will slightly increase, concurrently rural de-population will occur resulting in a net flat line for the predicted change in population within the study area by 2063.

Table 3-1: Summary of population growth

| Water Resource Zone | Population | | | |
|--|---------------|---------------|---------------|---------------|
| | 2013 | 2023 | 2038 | 2063 |
| Upper Waipaoa | 453 | 448 | 435 | 440 |
| Waikohu | 275 | 272 | 264 | 267 |
| Wharekopae | 274 | 271 | 263 | 266 |
| Whakaahu | 439 | 435 | 422 | 426 |
| Te Arai | 638 | 632 | 613 | 619 |
| Taruheru | 21,133 | 21,392 | 20,942 | 21,368 |
| Upper Flats | 726 | 719 | 697 | 704 |
| Mid Flats | 1,221 | 1,233 | 1,209 | 1,233 |
| Lower Flats | 558 | 564 | 552 | 564 |
| Total for the Greater Waipaoa Catchment | 25,717 | 25,966 | 25,397 | 25,887 |
| Waiapu | 2,044 | 2,024 | 1,963 | 1,983 |
| Uawa | 1,113 | 1,102 | 1,069 | 1,080 |
| Other | 6,244 | 6,244 | 6,057 | 6,119 |
| Total | 35,118 | 35,336 | 34,486 | 35,069 |

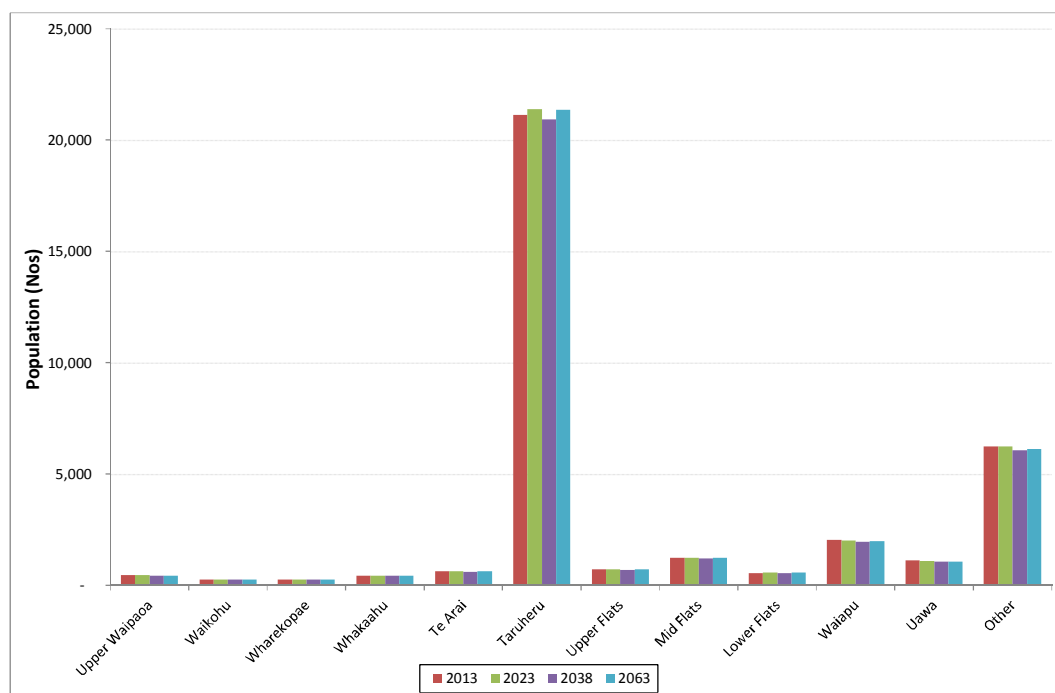


Figure 3-1: Population projection for WRZs

3.4.2 Domestic Demand

Domestic water consumption has been assessed separately for reticulated and non-reticulated supplies for each WRZ based on the population growth predictions presented in Section 3.4.1.

The average daily water consumption data for reticulated supply was supplied by GDC (Appendix B). Appendix C tabulates the estimated consumptive demand for domestic water for each WRZ in 2013, 2023, 2038 and 2063. It is assumed the number of reticulated supply connections within the urban areas in the future would only increase slightly.

Figure 3-2 shows that, consistent with population growth data, domestic water demand (expressed as a daily average demand) will increase slightly (1.2%) in the WRZs dominated by urban usage. The estimated average total consumption for the study area is approximately 8,600 m³/d, of which 6,670 m³/d (77%) is supplied through GDC reticulated supply (Appendix C).

The domestic non-reticulated supply is inclusive of supplies from rooftop rainwater, tankered water and groundwater takes. However, no data is available to determine the contribution from each category.

This analysis assumed that the GDC reticulated supply area will gradually increase in the future. As a result of that non-reticulated supply demand will reduce by approximately 9% within the study horizon.

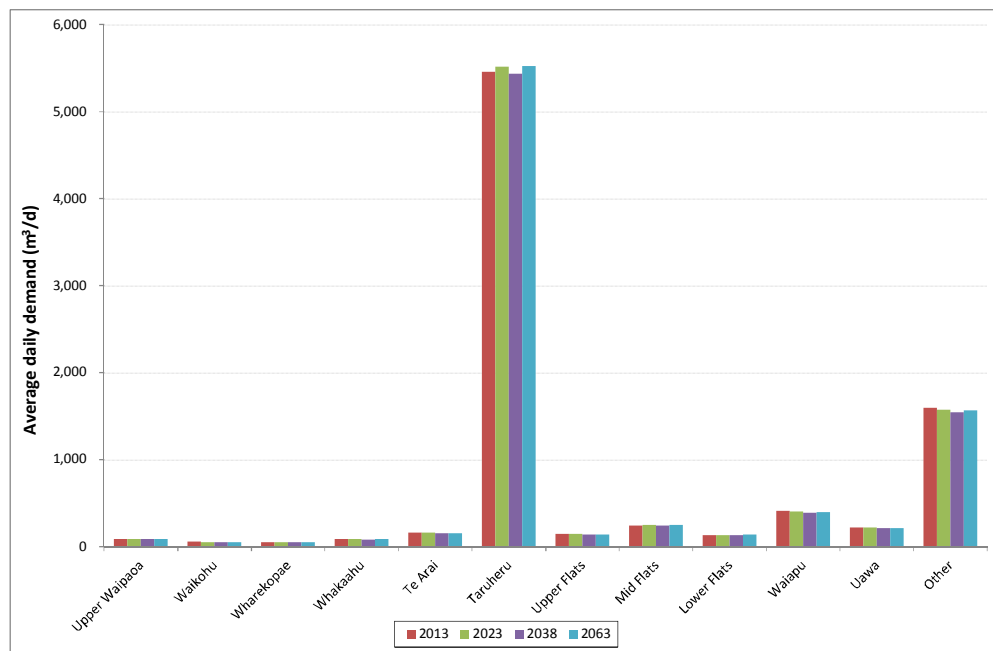


Figure 3-2: Average daily domestic water demand for WRZs

The peak daily demand (m³/d), which assumed to be 1.4 times of the average is presented in Figure 3-3. The annual demand (m³/y) for the WRZs is determined by annualising the daily volume is shown in Figure 3-4. The resulting total annual domestic water demand for the study area is 3.1 Mm³/y in 2013. The estimated current annual consumption within the Greater Waipaoa catchment is 2.3 Mm³/y. The highest

annual water demand will occur in the most populated WRZ Taruheru that is nearly 2 Mm³/y (Appendix C).

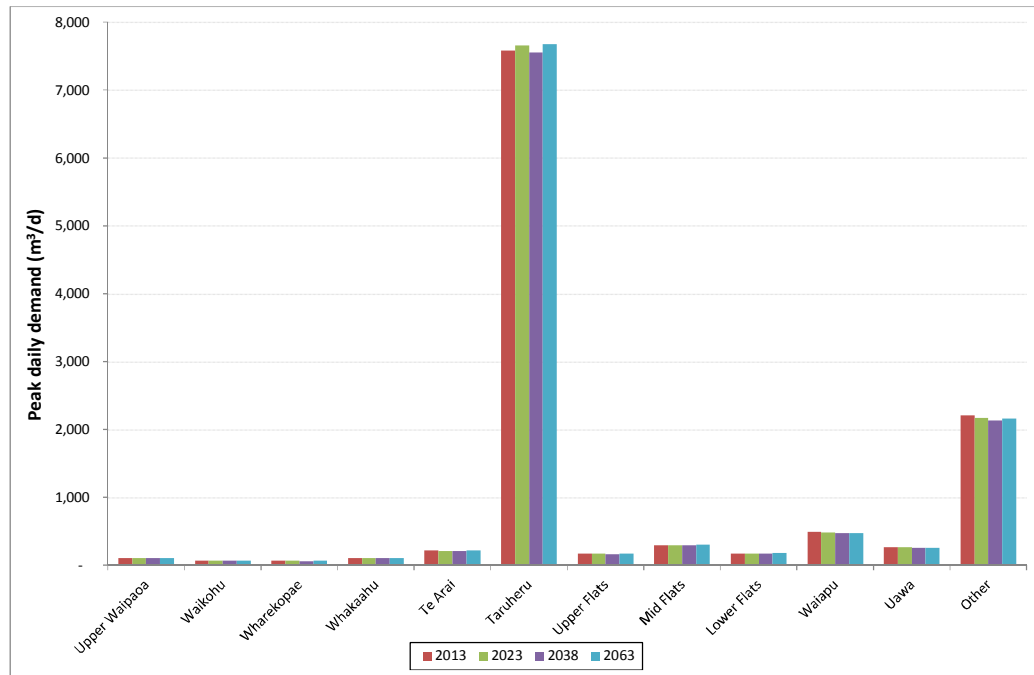


Figure 3-3: Peak daily domestic water demand for WRZs

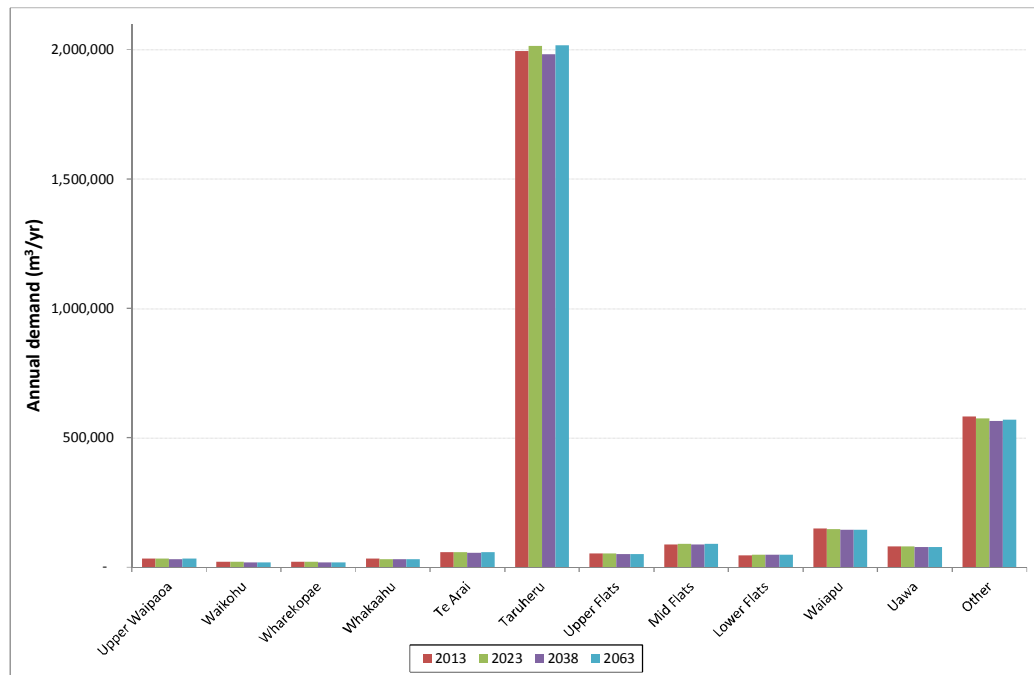


Figure 3-4: Annual domestic water demand for WRZs

3.5 Agriculture Water Demand

Data from the 2006 Census showed that 18.3% of the Gisborne District population is employed in agriculture, forestry or fishing. This percentage is higher than the

national average of 12.8% (NZ Statistics, 2012). These statistics indicate that agriculture is one of the key economic and employment drivers for the region. Irrigated agriculture generally consumes a significant proportion of the available water resources in a region

The GDC consent database shows that there are currently 161 consented water takes (surface water 65 and groundwater 96) within the study area. More than 90% (147) consents are allocated for agricultural purposes, primarily for irrigation. There are 58 surface water consent takes for irrigation, of which 29 (50%) take water from the Waipaoa River. The purposes of the take for the 147 agriculture consents are listed below;

- Irrigation
 - Pasture - 10
 - Vegetable - 26
 - Fruit - 97
 - Arable - 8
 - Nursery - 3
 - Mix crops - 1
- Frost protection - 2

It shows that 93% of the consented takes are for irrigation of horticulture-related crops (vegetables and fruit). Note that some of the above takes may utilise the water for multiple activities such as stock water, domestic use as well as irrigation.

GDC estimate shows that the consented irrigated land area in the study area is approximately 6,000 ha. This consented irrigated area should only be considered as a ball park estimate, and the actual area irrigated may be less. In addition, the irrigated area particularly for vegetables and arable crops varies from year to year due to factors such as change in lease lands, crop rotations, and economic influences. The total consented area irrigated from the surface water takes is estimated to be approximately two thirds of the total area or 3,900 ha. The estimated composition of the irrigated area by percentage is:

- Horticulture
 - Vegetable 45%
 - Fruit 31%
- Pasture 9%
- Nursery 1%
- Arable 14%

3.5.1 Livestock

Water is an essential component for livestock farming. Water is required for stock water drinking as well as activities associated with processes such as cooling of milk and yard cleaning (for dairy cattle, piggeries and broiler poultry).

Appendix D presents estimated livestock water demand values used for this study; these values were adopted from Aqualinc (2007). The predicted trends in livestock numbers in each WRZ are also included in this Appendix. This data shows that stock numbers for most categories, except dairy, are likely to decline over the next 50 years due to sector trends and the expansion of rural residential land use. It is predicted that dairy cow numbers can increase from current estimate of 7,000 to 24,000 within the study horizon. The trends in recent years have been towards larger farms and conversion to different stock types to improve scales 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 urban areas, in part due to rural residential demand, limit the options for increasing farm profits.

Figure 3-5 illustrates the annual livestock water demand growth trend in each WRZ. The daily, peak and annual demands are presented in Appendix D. The estimated total current annual demand is approximately 3.3 Mm³/yr of which 1.2 Mm³/yr (36%) is within rural catchments east of Gisborne. The demand can increase to 4.1 Mm³/yr in 2063. The demand in urban areas is expected to decrease, and in rural WRZs is likely to increase.

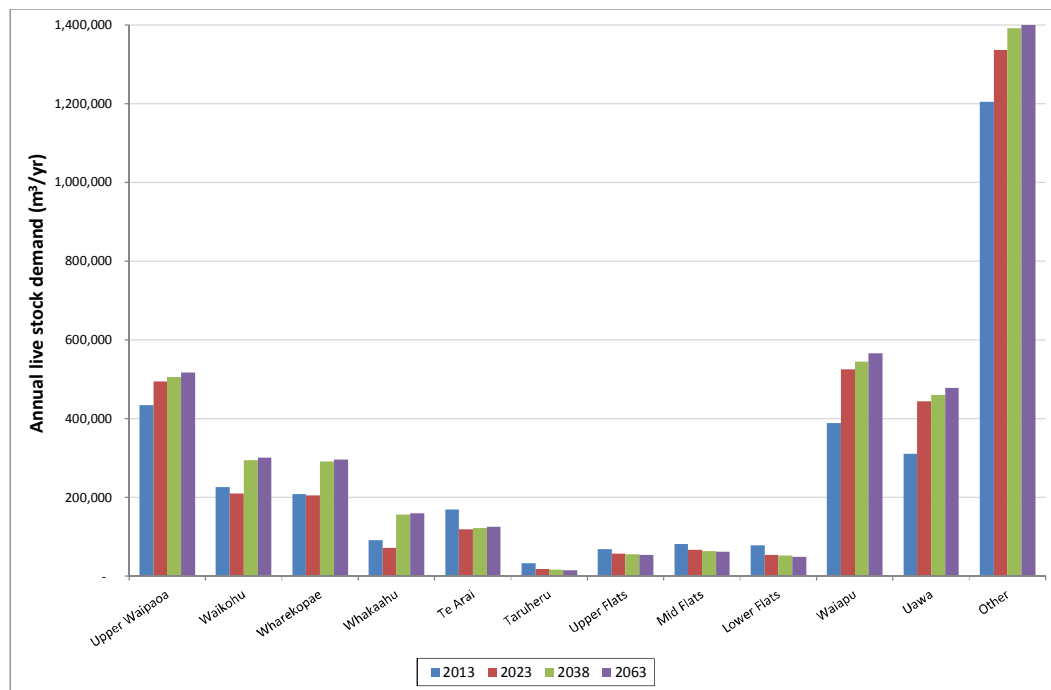


Figure 3-5: Annual livestock water demand by WRZs

3.5.2 Irrigation Demand

The irrigation demand data for this study was adopted from the Irrigation Guidelines for the Poverty Bay Flats area (Aqualinc, 2012a). It is assumed that these values are reasonably representative for the whole study area. It is recognised that the irrigation demand would vary throughout the GD due to the difference in climate. However, there is very little irrigation occurring outside of the Poverty Bay Flats as shown in Figure 3-6.

Aqualinc (2012a) provides the average irrigation demand (mm/y) for a range of soil types and soil depths. The irrigation guidelines values are for well managed and well watered crops. This current study has adopted the average 70th percentile irrigation demand for all the soil categories presented in Aqualinc (2102a). The use of the 70th percentile can be considered as "high-end" average demand and as such is a somewhat conservative value. The irrigation demand values are presented in Appendix E.

As NIWA (2012) predicted crop water requirements would be greater in the future, it is assumed that irrigation demand will increase by 1%, 3% and 5% relative to current demand by 2023, 2038 and 2063, respectively.

Appendix E presents the potentially irrigable areas in each WRZ based on land slope. The potentially irrigated areas are areas where the slopes are less than 7°. Slopes higher than this likely be susceptible to surface run-off and challenges for irrigation equipment. Within the potentially irrigated areas there could be some small, isolated land parcels, and areas at higher elevations where annual rainfall is higher and it is probably not economical to irrigate these areas. In addition, some areas can be too small in size to realistically consider for commercial irrigation. It is important that sufficient irrigable area lies within a close proximity to the water supply location/s to allow the economical delivery of water for irrigation. Therefore, the pragmatic irrigable area can be significantly less than the values given in Appendix E. Appendix E also presents the estimates of irrigated areas for the four different time horizons used in this study.

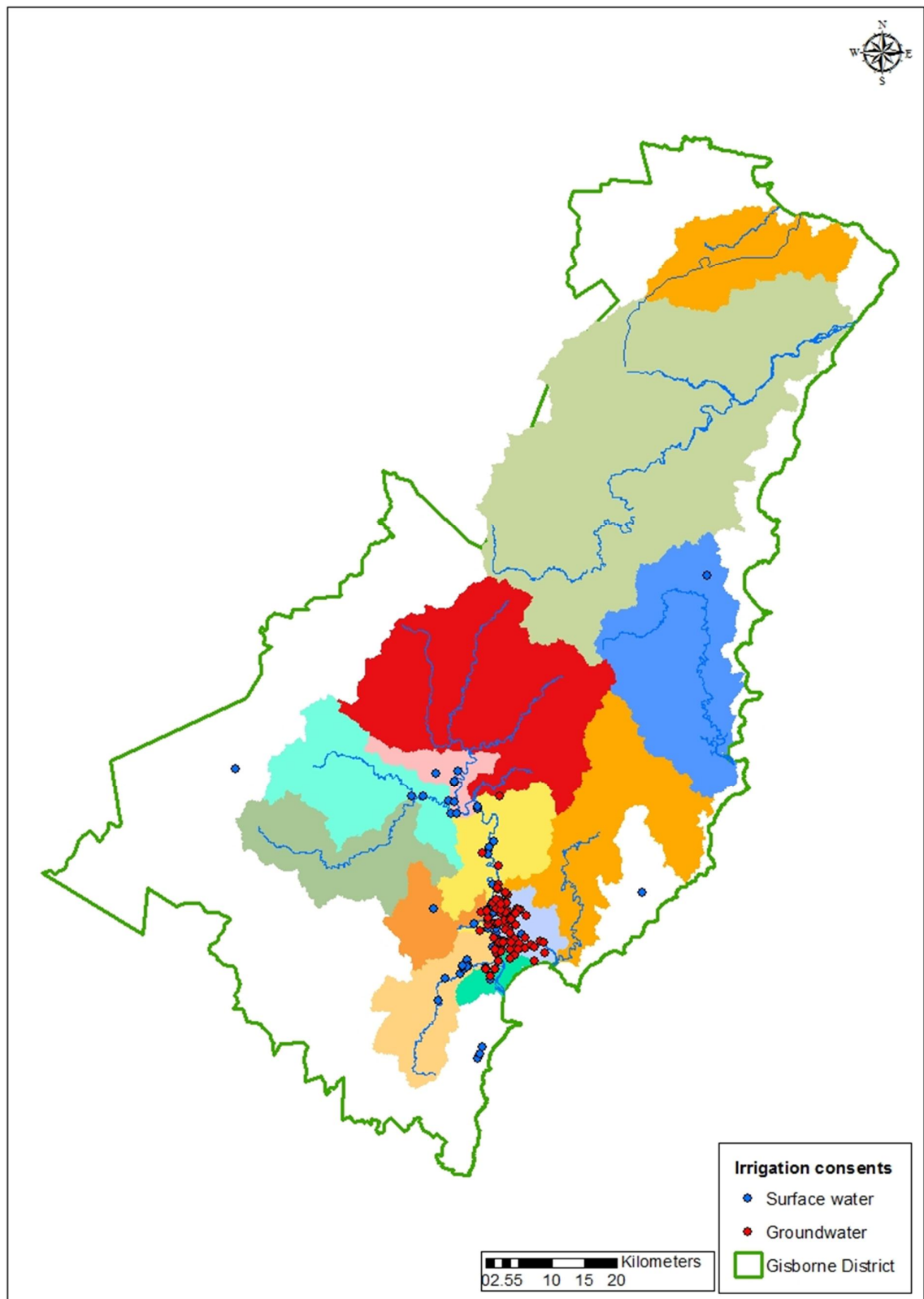


Figure 3-6: Location of Irrigation consents within the Gisborne District

Appendix E shows the estimated irrigated areas and the annual water demand for different crops. The total current irrigation water demand of the study area is approximately 30 Mm³/yr, of that 21.5 Mm³/yr is for vegetable irrigation. It is

expected that the demand for irrigation will significantly increase to 58, 82 and 89 Mm³/y by 2023, 2038 and 2063, respectively. The majority of the demand is due to dairy expansion and vegetable irrigation. Other than direct financial benefits, irrigation development is seen as a means to improve the capital value of the farm. Land that is developed for irrigation has a premium value associated with reliability of water supply, which is seen as a key factor in improving production and returns and reducing risks associated with production losses during summer droughts, frequency of which predicted to increase due to climate change.

3.5.3 Frost Protection

Frost damage to crops can be an issue in the study area in the autumn and spring periods. There are only two water take consents issued for frost protection of crops. However, it is possible that there are other water takes for frost protection under consents that are issued for multi-purposes such as irrigation and frost protection, but only listed as for irrigation.

NIWA's ground frost data shows there is on average 33 days/yr of frost in Gisborne city (NIWA, 2013). This was determined using data from 1981 to 2010. However, frost days between August and October are limited to 11 days. NIWA (2012) reports that climate change is likely to result in warmer winters and reduce the frequency of frost. MfE (2013) also predicts frosts are likely to become rare in Gisborne. On the other hand new horticulture areas would likely to use water for frost protection to increase the quality of the product. Therefore, it is conservatively assumed that number of orchards that use water for frost protection will gradually increase to 14 farms (from two) within the study area by 2063, however, the frequency that they use water will decrease due to less frost days (Appendix F).

The details of the water consumption for frost protection is presented in Appendix F. It is estimated that the current water use is approximately 431,000 m³/yr and this will increase to 823,000 m³/yr by 2063. However, frost protection does not generally occur in the summer months when river flows are low. Therefore, it is unlikely that frost protection take would affect the peak surface water take available.

3.6 Industrial and Commercial Water Demand

There are currently 700 commercial and industrial connections to the GDC water reticulation system. These include services such as schools and hospitals. These 700 commercial and industrial connections, on an annual average basis account for approximately 37% of the total GDC reticulated supply. A summary of supplies through the GDC water reticulation system by WRZ is given in Table 3-2. There are also three consented consumptive water takes for industrial purposes from groundwater within the study area.

Table 3-2: A summary of current commercial and industrial water demands supplied through municipal reticulated supply

| WRZ | Annual water demand (m ³ /yr) |
|---------------------------------|--|
| Te Arai | 3,262 |
| Taruheru | 1,898,933 |
| Lower Flats | 3,262 |
| Total (m³/yr) | 1,905,456 |

As outlined in Section 3.4.1, population in the Gisborne district is not predicted to grow within the 50 year period of study. Therefore, it is unlikely that growth in the commercial and industrial sectors would be significant over this time-frame. However, there is potential for strategic developments options by utilising district's climate and natural resources. The district already produces and processes vegetable and fruits, and there is potential for further growth. The vegetable and horticulture industry has expressed their desire to expand the industry (Crone D., GDC, *pers. comms.*). The study has taken these factors into account, and assumed that such developments (ie, processing) would primarily occur around the city due to easy access to the necessary services (eg, transport, electricity). It is predicted that water demands in the WRZ around the city will increase from current 2 to 5.4 Mm³/yr by 2063, ie, approximately 170% increase in water demand. It is possible that development in dairy industry can be considerable within the study horizon. It is predicted that dairy numbers can increase by 250%, and water demands for both stock water and shed use are included under the livestock demands in Section 3.5.1.

Petroleum industry can be another potential and emerging sector in the district that needs water for its operations. GDC has already issued a permit for oil exploration. However, the water demands for exploration and production are dependent on many local factors such as geology. It is not possible to determine accurate water demands at this stage as no prior operations in the district. It is estimated that there would be approximately 100 exploration wells within the study area, with an average four hydraulic fractures per well. The parameters used for this assessment based on estimates provided by TAG Drilling (Doyle J., *pers. comms.*), and past reports (MBIE, 2013). A summary of parameters and water demand estimates are presented in Appendix G. The listed water demand figures are the average annual demands.

Table 3-3 lists the annual water demand for industrial and commercial water use by WRZ. The annual data does not include seasonal demand variations so caution must be shown when this data is used. Table 3-3 demonstrates that the industrial and commercial consumption of water in the district is primarily high around the urbanised areas. The total estimated current use is approximately 2 Mm³/yr, that is largely consumed (96%) within Taruheru WRZ. It is predicted that water demand for industrial and commercial within the GDC reticulated supply area will increase by approximately 2.5 Mm³/yr. It is possible that the industries would obtain consents to develop their water resources to meet some water demands. Assuming that the industries expect GDC to supply a half of the new water demands, GDC would require increasing the current average industrial supply of 1.9 Mm³/yr by 66% to meet the demand.

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

Table 3-3: Estimates of commercial and industrial water demand by WRZ

| WRZ | Annual water demand (m ³ /yr) | | | |
|---------------------------------|--|------------------|------------------|------------------|
| | 2013 | 2023 | 2038 | 2063 |
| Upper Waipaoa | | 150,000 | 150,000 | 150,000 |
| Waikohu | | 70,000 | 70,000 | 70,000 |
| Wharekopae | | 70,000 | 70,000 | 70,000 |
| Whakaahu | | 30,000 | 30,000 | 30,000 |
| Te Arai | 3,262 | 104,892 | 106,523 | 106,523 |
| Taruheru | 1,937,183 | 2,324,619 | 2,905,774 | 2,905,774 |
| Upper Flats | | 270,000 | 520,000 | 520,000 |
| Mid Flats | | 500,000 | 750,000 | 750,000 |
| Lower Flats | 64,762 | 250,000 | 250,000 | 250,000 |
| Waiapu | | 300,000 | 300,000 | 300,000 |
| Uawa | | 100,000 | 100,000 | 100,000 |
| Other | | 150,000 | 150,000 | 150,000 |
| Total (m³/yr) | 2,005,206 | 4,319,512 | 5,402,297 | 5,402,297 |

3.7 Recreational Water Demand

Water is required for a range of recreational activities associated with urban development, such as swimming pools, irrigation of bowling greens and sports fields etc. The sports facilities are generally commensurate with population growth. 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.

Current GDC records show that there are 36 connections from the GDC for recreational supply. It is unlikely that number of recreational facilities would be significantly increased as the predicted population growth is negligible. However, to be conservative and account for effects of global warming, it is assumed that total water use would be increased by 20% by 2063.

In addition to GDC supply water, there are a number of recreational water uses in the nature reserves. However, no detailed information is available to accurately quantify the volumes and take locations. These takes are considered to be small and not included in this analysis. It is expected that conservative estimates made for the other water consumptions will compensate this exclusion.

As listed in Table 3-4, the combined annual fresh water take for recreational use is less than 23,000 m³/yr, and that can be expected to increase to approximately 27,500 m³/yr by 2063.

Table 3-4: Estimates of recreational water demand by WRZ

| WRZ | Annual water demand (m ³ /yr) | | | |
|---------------------------------|--|---------------|---------------|---------------|
| | 2013 | 2023 | 2038 | 2063 |
| Upper Waipaoa | | | | |
| Waikohu | | | | |
| Wharekopae | | | | |
| Whakaahu | | | | |
| Te Arai | 1,518 | 1,518 | 1,518 | 1,518 |
| Taruheru | 21,397 | 23,537 | 24,714 | 25,949 |
| Upper Flats | | | | |
| Mid Flats | | | | |
| Lower Flats | | | | |
| Waiapu | | | | |
| Uawa | | | | |
| Other | | | | |
| Total (m³/yr) | 22,915 | 25,055 | 26,232 | 27,467 |

3.8 Rural Residential Water Demand

Rural residential (or lifestyle blocks) are small rural sections 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 included in Section 3.5.1. There is an additional 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 land may be used intensively, the majority of rural-residential blocks are likely to have lower and less intensive water demand than commercial livestock farms and horticultural units.

The accurate estimates of the number of rural lifestyle blocks are not available by WRZs. To be conservative, it is assumed that all the households in non-reticulated areas consume water for some activities such as irrigation. It is assumed that average size of a lifestyle block is 2 ha. As domestic and stock water demands are not included in this assessment there could be a large 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 m³/d/ha rate, rural residential annual water demand for 2013 is 273,000 m³/yr and estimated to decrease to 250,000 m³/yr by 2063 due to decline in number of lifestyle blocks. Water demands by WRZs are given in Appendix H.

3.9 Forestry Water Demand

Forests have a water demand in the sense that they reduce the amount of surface run-off to surface waters and groundwater recharge due to higher interception losses as compared with pasture land uses. However, forests can also help reducing high flow events by reducing surface run-off and increasing groundwater recharge in high slope areas; high surface run-off and erosion is a current problem in the district (MAF, 2007). This increased recharge would release water steadily to increase surface water flows in rivers and streams over a period (ie, increased base flows rather than a few high flows) that is more useful for the district.

The planted forest area has steadily increased since 1970s through to 1990s in the district as shown in Figure 3-7 (Source: NZ Stat data from 1920-21 to 2012). However, there is no significant increase in forest area over the last decade. The current forest area is approximately 150,000 ha, which is about 25% of the study area. Therefore, it is unlikely that the forestry area would significantly increase in the future.

Based on the above facts, it is assumed that future water demand for forestry is not likely to be significantly different from the current levels.

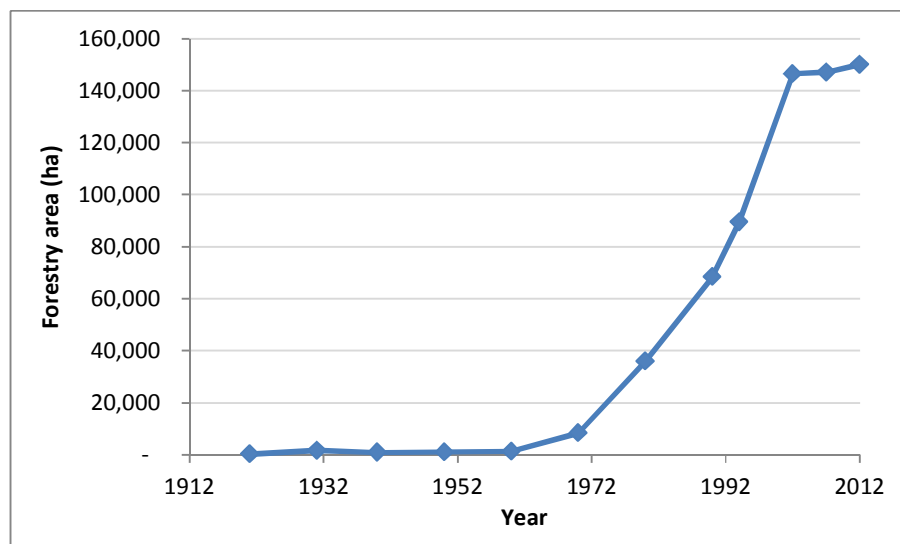


Figure 3-7: Planted forest area in the Gisborne District (Source: NZ Stat data)

3.10 Summary of Water Demand

This section presents the summary of current water demand by category (Section 3.1) for the four catchments and projections in demand for 2023, 2038 and 2055. While this provides a useful indication of trends of change in demand over the study period, it does not show the pressures associated with the local demand on specific water resources. This is assessed in further detail in Section 5, which presents the water balance for each WRZ.

3.10.1 Greater Waipaoa Catchment

Table 3-5 present a summary of current and projections for water demand in the Greater Waipaoa Catchment. The key points to note from this summary for this catchment are;

- Domestic demand for water remains around 2.35 Mm³/yr during the next 50 years.
- Current domestic demand accounts for 6.5% of the total water use in the catchment, however, it will reduce to 3% by 2063.
- Agricultural demand is the highest water demand in the catchment and represents approximately 88% of the total water demand.
- Current irrigation demand is just below 30 Mm³/yr, and this will continue to increase by over 39 Mm³ by 2063.
- Total demand in the catchment will increase from 36 to 79 Mm³/yr in 2063, ie, more than double the current demand.

Table 3-5: Summary of current and projected water demand by demand category currently and for next 10, 25 and 50 years for the Greater Waipaoa Catchment

| Demand category | 2013 | | 2023 | | 2038 | | 2063 | |
|--------------------------|---------------------|--------------|---------------------|--------------|---------------------|--------------|---------------------|--------------|
| | Mm ³ /yr | % | Mm ³ /yr | % | Mm ³ /yr | % | Mm ³ /yr | % |
| Domestic | | | | | | | | |
| Reticulated | 1.95 | 5.4% | 1.96 | 4.1% | 1.98 | 2.7% | 1.99 | 2.5% |
| Non-reticulated | 0.39 | 1.1% | 0.40 | 0.8% | 0.35 | 0.5% | 0.37 | 0.5% |
| Subtotal | 2.35 | 6.5% | 2.37 | 5.0% | 2.33 | 3.2% | 2.37 | 3.0% |
| Agriculture | | | | | | | | |
| Livestock | 1.39 | 3.8% | 1.29 | 2.7% | 1.56 | 2.1% | 1.58 | 2.0% |
| Irrigation | 29.90 | 82.7% | 39.11 | 82.2% | 63.22 | 86.6% | 69.13 | 87.7% |
| Frost protection | 0.43 | 1.2% | 0.94 | 2.0% | 0.98 | 1.3% | 0.82 | 1.0% |
| Subtotal | 31.72 | 87.7% | 41.35 | 86.9% | 65.76 | 90.0% | 71.54 | 90.7% |
| Industry | 2.01 | 5.5% | 3.77 | 7.9% | 4.85 | 6.6% | 4.85 | 6.2% |
| Recreational | 0.02 | 0.1% | 0.03 | 0.1% | 0.03 | 0.0% | 0.03 | 0.0% |
| Rural residential | 0.08 | 0.2% | 0.08 | 0.2% | 0.07 | 0.1% | 0.07 | 0.1% |
| Total | 36.17 | | 47.59 | | 73.03 | | 78.86 | |

3.10.2 Waiapu Catchment

Current and future predicted water demands for the Waiapu Catchment is given in Table 3-6. This summary shows:

- The overall water demand (0.57 Mm³/yr) in this predominately rural catchment is less than 2% of the Greater Waipaoa Catchment (36 Mm³/yr).

- Domestic demand is met from non-reticulated supply only and accounts for 26% of the total water demand. There is no current commercial irrigation in the catchment. However, it is expected that there will be significant irrigation demand in the future to counter climate change effects and increase market share. Annual irrigation demand can be around 10 Mm³/yr that represents 90% of the total catchment demand.
- Livestock demand will increase from 0.4 to 0.6 Mm³/yr by 2063.

Table 3-6: Summary of current and projected water demand for the Waiapu Catchment

| Demand category | 2013 | | 2023 | | 2038 | | 2063 | |
|--------------------------|---------------------|--------------|---------------------|--------------|---------------------|--------------|---------------------|--------------|
| | Mm ³ /yr | % | Mm ³ /yr | % | Mm ³ /yr | % | Mm ³ /yr | % |
| Domestic | | | | | | | | |
| Reticulated | 0.00 | 0.0% | 0.00 | 0.0% | 0.00 | 0.0% | 0.00 | 0.0% |
| Non-reticulated | 0.15 | 26.3% | 0.15 | 1.4% | 0.14 | 1.4% | 0.14 | 1.3% |
| Subtotal | 0.15 | 26.3% | 0.15 | 1.4% | 0.14 | 1.4% | 0.14 | 1.3% |
| Agriculture | | | | | | | | |
| Livestock | 0.39 | 68.6% | 0.52 | 5.1% | 0.55 | 5.2% | 0.57 | 5.2% |
| Irrigation | 0.00 | 0.0% | 9.32 | 90.3% | 9.53 | 90.4% | 9.78 | 90.4% |
| Frost protection | 0.00 | 0.0% | 0.00 | 0.0% | 0.00 | 0.0% | 0.00 | 0.0% |
| Subtotal | 0.39 | 68.6% | 9.84 | 95.4% | 10.08 | 95.5% | 10.35 | 95.6% |
| Industry | 0.00 | 0.0% | 0.30 | 2.9% | 0.30 | 2.8% | 0.30 | 2.8% |
| Recreational | 0.00 | 0.0% | 0.00 | 0.0% | 0.00 | 0.0% | 0.00 | 0.0% |
| Rural residential | 0.03 | 5.1% | 0.03 | 0.3% | 0.03 | 0.3% | 0.03 | 0.3% |
| Total | 0.57 | | 10.32 | | 10.55 | | 10.82 | |

3.10.3 Uawa Catchment

A summary of current and projected water use in the Uawa Catchment is presented in Table 3-7. The key points to note from this summary table are:

- The total water use within this rural catchment is low at less than 1 Mm³/yr, however, projected to increase to 11 Mm³/yr within the planning horizon.
- The highest future water demand will be for agriculture and accounts for 98%.

Table 3-7: Summary of current and projected water demand for the Uawa Catchment

| Demand category | 2013 | | 2023 | | 2038 | | 2063 | |
|--------------------------|---------------------|--------------|---------------------|--------------|---------------------|--------------|---------------------|--------------|
| | Mm ³ /yr | % | Mm ³ /yr | % | Mm ³ /yr | % | Mm ³ /yr | % |
| Domestic | | | | | | | | |
| Reticulated | 0.00 | 0.0% | 0.00 | 0.0% | 0.00 | 0.0% | 0.00 | 0.0% |
| Non-reticulated | 0.08 | 12.3% | 0.08 | 0.8% | 0.08 | 0.8% | 0.08 | 0.7% |
| Subtotal | 0.08 | 12.3% | 0.08 | 0.8% | 0.08 | 0.8% | 0.08 | 0.7% |
| Agriculture | | | | | | | | |
| Livestock | 0.31 | 47.1% | 0.44 | 4.4% | 0.46 | 4.4% | 0.48 | 4.5% |
| Irrigation | 0.25 | 38.2% | 9.51 | 93.7% | 9.70 | 93.7% | 9.89 | 93.6% |
| Frost protection | 0.00 | 0.0% | 0.00 | 0.0% | 0.00 | 0.0% | 0.00 | 0.0% |
| Subtotal | 0.56 | 85.3% | 9.96 | 98.1% | 10.16 | 98.1% | 10.37 | 98.2% |
| Industry | 0.00 | 0.0% | 0.10 | 1.0% | 0.10 | 1.0% | 0.10 | 0.9% |
| Recreational | 0.00 | 0.0% | 0.00 | 0.0% | 0.00 | 0.0% | 0.00 | 0.0% |
| Rural residential | 0.02 | 2.4% | 0.02 | 0.2% | 0.02 | 0.1% | 0.02 | 0.1% |
| Total | 0.66 | | 10.15 | | 10.35 | | 10.56 | |

3.10.4 Other Catchments

A summary of water use for the combined other catchments in the study area (ie, not summarised in Sections 3.10.1 to 3.10.3) is given in Table 3-8. The main points are:

- The total water demand will increase from 1.8 to 2.2 Mm³/yr by 2063. However, this occurs over a 70,000 ha area.
- Agriculture water demand is expect to increase from 1.2 (67% of the total demand) to 1.5 Mm³/yr.

Table 3-8: Summary of current and projected water demand for the Other Catchments

| Demand category | 2013 | | 2023 | | 2038 | | 2063 | |
|--------------------------|---------------------|--------------|---------------------|--------------|---------------------|--------------|---------------------|--------------|
| | Mm ³ /yr | % | Mm ³ /yr | % | Mm ³ /yr | % | Mm ³ /yr | % |
| Domestic | | | | | | | | |
| Reticulated | 0.48 | 26.9% | 0.50 | 24.0% | 0.51 | 24.0% | 0.52 | 23.8% |
| Non-reticulated | 0.09 | 5.0% | 0.08 | 3.7% | 0.06 | 2.6% | 0.05 | 2.4% |
| Subtotal | 0.57 | 31.9% | 0.58 | 27.7% | 0.56 | 26.7% | 0.57 | 26.2% |
| Agriculture | | | | | | | | |
| Livestock | 1.20 | 67.2% | 1.34 | 64.4% | 1.39 | 65.8% | 1.45 | 66.5% |
| Irrigation | 0.00 | 0.0% | 0.00 | 0.0% | 0.00 | 0.0% | 0.00 | 0.0% |
| Frost protection | 0.00 | 0.0% | 0.00 | 0.0% | 0.00 | 0.0% | 0.00 | 0.0% |
| Subtotal | 1.20 | 67.2% | 1.34 | 64.4% | 1.39 | 65.8% | 1.45 | 66.5% |
| Industry | 0.00 | 0.0% | 0.15 | 7.2% | 0.15 | 7.1% | 0.15 | 6.9% |
| Recreational | 0.00 | 0.0% | 0.00 | 0.0% | 0.00 | 0.0% | 0.00 | 0.0% |
| Rural residential | 0.02 | 1.0% | 0.01 | 0.7% | 0.01 | 0.5% | 0.01 | 0.5% |
| Total | 1.79 | | 2.08 | | 2.12 | | 2.18 | |

4 RESOURCE AVAILABILITY ASSESSMENT

This section presents a summary of the estimates of water availability within the study area based on available data. The source of data includes previous water studies, flow records, and existing reservoir and water take consents. Water resources within the study area include both surface and groundwater. In addition to these resources, rainfall from rooftop runoff is also harvested, principally for domestic consumption in non-reticulated areas. The volume of water available, as compared to the size of a resource must be cognisant of GDC's current allocation rules and extraction limits for the different water resources.

4.1 Surface Water

4.1.1 Run-of-stream

Figure 4-1 shows the surface water catchments and current surface water consents. There are 58 surface water consents within the study area. These takes are predominately in the Poverty Bay Flats area.

GDC currently does not have a Regional Water and Land Plan that stipulates the regional policies for surface water allocation. Section 4.1.4 discusses potential policies that GDC could employ in the future. However, in the absence of this information, the current study has used GDC information on low flows in streams and the current allocation limits set for different rivers, to determine the resource availability.

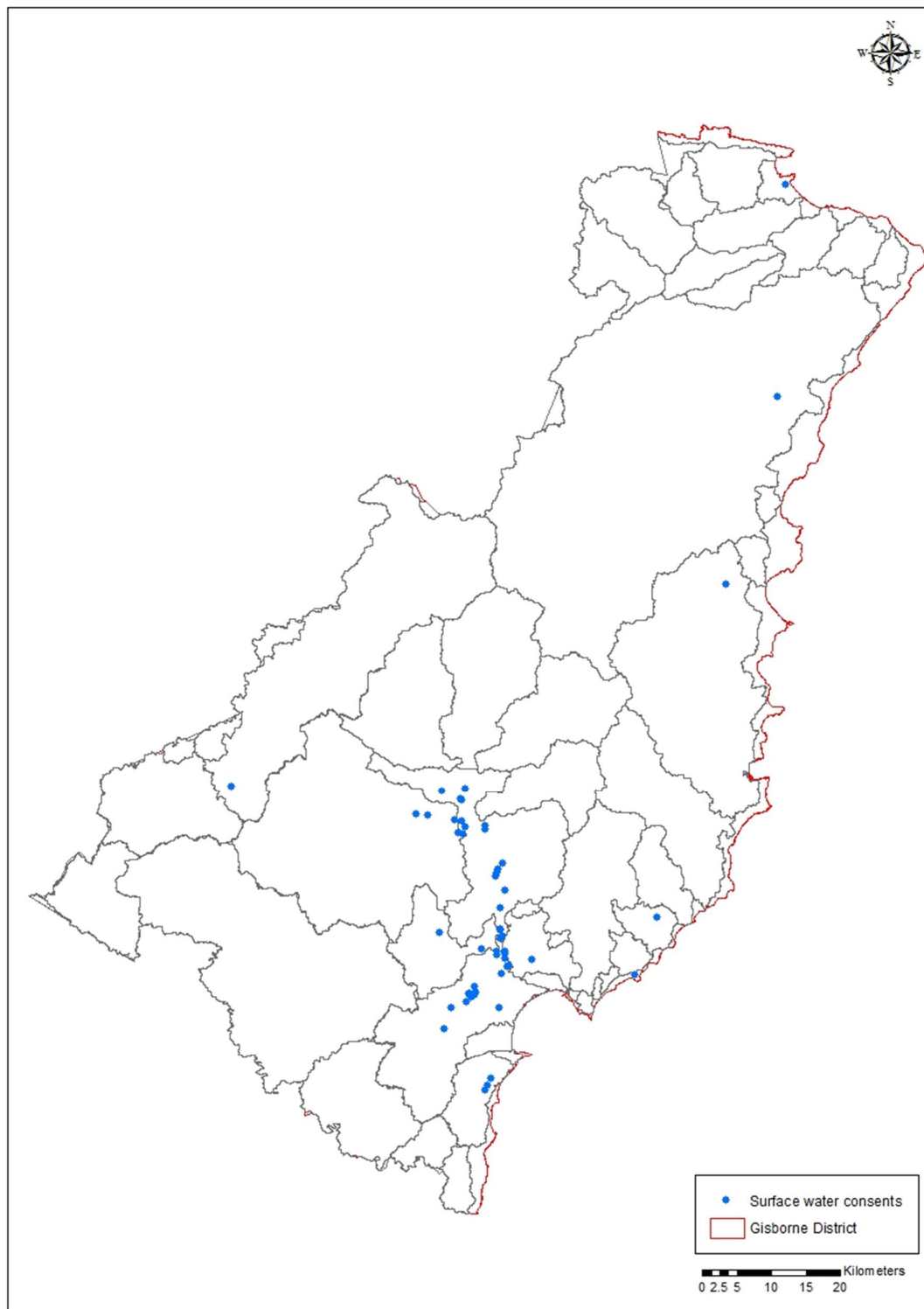


Figure 4-1: Consented surface water takes and surface water catchments

Low flow limits are available for 10 rivers in the study area. Not all of these values have been determined using the in-stream minimum flow requirement (IMFR) method. When studies have not been completed the allocable flow is typically set to 50% of mean annual 7 day low flow value (MALF). The allocation of water within an allocable flow volume should not be interpreted that water will always be available

to use, drought conditions can result in surface flows dropping below critical trigger levels, and restrictions on takes will be imposed on consent holders.

There are four monitored surface water bodies within the study zone with long term flow records. The allocable surface water resource within each WRZ is estimated based on available data. For WRZs where data is unavailable, estimates of the mean annual low flow (MALF) are based on the available information in the nearest WRZs and adjusted based on average annual rainfall. As shown in Appendix I, these estimates are necessarily conservative to offset the absence of reliable data for these WRZs.

Table 4-1 lists MALF and the run-of-stream water availability and the current consented allocations in each WRZ calculated from specific yields (Appendix I). Based on the above allocation criterion, total allocable resource for the Greater Waipaoa Catchment is 5,263 ℓ/s , which is equivalent to daily volumes of 454,723 m^3/day . The cumulative allocated rate of current consents for the Greater Waipaoa Catchment is 2,873 ℓ/s or in the order of 55% of the allocable take rate. It should be recognised that water availability figures for a catchment represent the availability at the bottom end of the catchments and the consented allocation is the cumulative takes for all consents in the catchment. Actual allocation rates and available volumes within individual stream reaches may be different. In addition there are specific consent conditions such as stipulated minimum flow level only above which the consent can abstract water; such specific conditions are not considered for this analysis.

Table 4-1: Run-of-stream water availability and consented allocations currently in 2013

| Water Resource Zone | MALF (l/s) | Allocable flow (l/s) | Allocated flow (l/s) |
|--|------------|----------------------|----------------------|
| Upper Waipaoa | 819 | 410 | 0 |
| Waikohu | 1,002 | 501 | 373 |
| Wharekopae | 318 | 159 | 0 |
| Whakaahu | 118 | 59 | 13 |
| Te Arai | 173* | 86 | 144 [#] |
| Taruheru | 62 | 31 | 13 |
| Upper Flats | 2,000* | 1,000 | 442 |
| Mid Flats | 5,746* | 1,873 | 1,864 |
| Lower Flats | 6,033 | 1,144 | 24 |
| Total for the Greater Waipaoa Catchment | | 5,263 | 2,873 |
| Waiapu | 1,562* | 781 | 8 |
| Uawa | 504 | 252 | 40 |
| Other | 1,174* | 587 | 0 |
| Total | | 6,883 | 2,921 |
| <p>* These MALF are estimated at the bottom of the catchment using MALF estimates at the flow recorder station</p> <p>[#] Notes for allocated flows from the Te Arai River:</p> <ul style="list-style-type: none"> • Stated 144 l/s excludes a consent granted for frost protection (55 l/s) as that can only be used in the months of September and October, which falls outside the high take summer period. • There are 9 consents totalling 109.8 l/s have 'low flow rights'. They can take water until the flow at Pykes Weir reaches 140 l/s whereby water can then only be taken at the discretion of the Environmental Services Manager. • 1 consent is limited to take water from September to November 15 (30 l/sec). • 1 consent is limited to when the flow is above 140 litres per second at Pykes Weir (5 l/sec). | | | |

Note that GDC takes water from Te Arai WRZ and Mangapoike catchment for their reticulation supply. Therefore, for the purpose of the assessment of water resource sustainability (Section 5) it is assumed that water is transferred to WRZ that use water, and the amount is a resource available for that WRZ. Based on the current assessment criteria, run-of-stream resource for the Te Arai WRZ is highly over-allocated.

As discussed in Section 3.3, it is assumed that available water resources in 2023, 2038 and 2063 will be less than 1%, 2% and 3.5%, respectively of the values given in Table 4-1 for 2013 due to climate change.

4.1.2 Reservoirs

GDC utilise three storage reservoirs for their reticulation supply: Clapcott, Williams, and Sang. Two of these dams are located in the Te Arai catchment and the other is out of the study area in Mangapoike catchment. These three dams have a combined storage capacity of 3.76 Mm³. Due to emptying and filling for domestic consumption it is assumed that total supply capability of these dams are three times greater than the

storage capacity. It is assumed that the volumes used for this study represent the net volumes after water supply infrastructure network loss, which is estimated to be 15%.

There are a few other small reservoirs within the study area used primarily for irrigation and stock water (e.g., Paroa Station reservoir in Tolaga Bay and Lane Brothers reservoir in Whangara). However, specific details of these reservoirs are not available. It is probable in a regional scale study such as this that the storage volumes of these small reservoirs are insignificant and many of these reservoirs were possibly constructed prior to the Resource Management Act (RMA) (1991) for farm and stock water supplies. It is recommended that the details of the reservoirs including location and storage volume of the consented reservoirs and that are used under permitted activities be determined by GDC.

Water and Soil Division of the Ministry of Works and Development has conducted an irrigation investigation in Poverty Bay Flats in 1986 (MWD, 1986). This investigation included exploring the potential sites for storage reservoirs. While they identified 21 potential locations, detailed studies were not conducted. However, it is reported that many of the identified sites do not appear particularly attractive. Sediment inflows were identified as a primary impediment for most of the potential sites.

4.1.3 Harvesting Winter Flows

There is potential for further off-stream harvesting and storage of winter flows within some catchments. This analysis used a simple mean winter flows to determine the harvesting potential, and a summary of this analysis is presented in Table 4-2. The detailed analysis is given in Appendix J. This work shows a theoretical total volume of 4,459 Mm³/yr could be harvested. However, the actual harvest potential is likely to be considerably lower than this value, due to technical, environmental and economic constraints of constructing the storage infrastructure required. Based on a 30% harvest of the potential abstracted volume (ie, 30% x 4,459 Mm³/yr), 1,338 Mm³/yr could be harvested from winter flows.

Table 4-2: Estimated winter surface water harvest potential

| Water Resource Zone | Estimated mean specific winter flow of WRZ (l/s/km ²) | Total volume (Mm ³ /yr) | Harvest potential (Mm ³ /yr) |
|---------------------|---|------------------------------------|---|
| Upper Waipaoa | 20 | 254.9 | 76 |
| Waikohu | 20 | 311.6 | 93 |
| Wharekopae | 20 | 98.8 | 30 |
| Whakaahu | 20 | 36.8 | 11 |
| Te Arai | 16 | 53.8 | 16 |
| Taruheru | 15 | 20.5 | 6 |
| Upper Flats | 17 | 23.9 | 7 |
| Mid Flats | 16.9 | 60.1 | 18 |
| Lower Flats | 15.0 | 11.0 | 3 |
| Waiapu | 87.0 | 2,349.1 | 705 |
| Uawa | 49.4 | 430.6 | 129 |
| Other | 66.3 | 807.9 | 242 |
| Total | | 4,459 | 1,338 |

4.1.4 Water Harvesting Rules

GDC does not, at present, use specific rules for water harvesting, rather GDC use minimum flows and water allocation limits for surface water bodies that ensures sufficient flows are left in the water body for ecological, recreational and other water uses. This primary allocation block can be considered as Block allocation. However, further allocation can be made while protecting river flow in-stream values and other water uses, once the catchment appears to be fully allocated.

The additional blocks for water harvesting can be specified as B and C blocks. These allocation blocks are in line with approaches used by other regional councils (eg. ECan, Waikato Regional Council, Otago regional Council). The allocation blocks can be in the form suggested in Table 4-3. There may be a need for testing these proposed allocation blocks for appropriateness in GDC rivers.

Table 4-3: Proposed allocation regimes

| Block | Minimum Flow | Allocation limit |
|-------|-------------------------------|-----------------------------|
| A | Habitat flow | MALF - minimum habitat flow |
| B | 1:1 flow sharing above MALF | MALF×0.3 |
| C | 1:1 flow sharing above 2×MALF | MALF×0.7 |

The 1:1 flow sharing helps rivers retain their natural flow variability and would ensure that the values of other water users are protected. 1:1 flow sharing means that only half of any flow in excess of the minimum flow (i.e. MALF for B-Block water and

2×MALF for C-Block water) is available for abstraction, the remaining water must remain in the river.

4.2 Groundwater

Sustainable yields of groundwater have not been determined by GDC for the aquifers in their region. However, previous studies (NIWA, 2009) indicate the allocable resources for the Poverty Bay Flats WRZs (Taruheru, Upper Flats, Mid Flats and Lower Flats) is 12.8 Mm³/yr. However, GNS (2012) showed that groundwater elevations in some of the Poverty Bay Flats aquifers (Makauri Gravel and Matokitoki Gravel aquifers) are decreasing over the longer term. This possibly indicates the current levels of abstractions are unsustainable or recharge dynamics are changing. Barber (1993) estimated that average volume of water flowing through the Makauri Gravel aquifer is 1.3 Mm³/yr, which is significantly lower than the current consented total annual allocation from the aquifer (7.2 Mm³/yr). This shows that the current understanding of the aquifer system is poor and that further work is urgently required.

In the absence of data from groundwater studies, it is assumed that allocable groundwater within other all aquifers (i.e., other than the Poverty Bay Flats aquifers) equates to 0.5% of annual rainfall for the entire WRZ area. This assumption is highly conservative. Similar previous studies have used 1% of annual rainfall for area to calculate the groundwater resources (Aqualinc, 2004; Aqualinc, 2006). However, these studies had nearby aquifers of which sustainable yields have been determined so that the estimates (using rainfall) could be verified against the determined values. As no detailed studies are available for the study area, the use of 0.5% of the annual rainfall is considered appropriate for this study. It is also a reasonable assumption given that quality of the groundwater is not considered in this assessment and there are known quality issues in some areas. Table 4-4 lists the estimated allocable groundwater by WRZ.

The groundwater resources reported in Table 4-4 are assumed to be from deeper aquifers. Water from shallow groundwater should not be considered suitable for high flow uses such as irrigation and industrial uses. This is because surface water baseflow will probably be reduced and saltwater intrusion can occur from pumping of these wells connected to shallow aquifers near the coast. Therefore, it recommends only deeper groundwater should be allocated provided that the abstraction does not affect baseflow in surface water and cause any saltwater intrusion.

As discussed in Section 4.1.1 under run-of-river resource availability, it is assumed that available groundwater resources will be reduced by 1.5%, 2.5% and 5% in 2023, 2038 and 2063, respectively, due to reduced recharge as a result of lower rainfall and elevated evaporation due to the effects of climate change.

Table 4-4: Summary of allocable groundwater resources and consented groundwater takes

| WRZ | WRZ area (km ²) | Estimated average annual rainfall (mm/yr) | Estimated current annual allocation (m ³ /yr) | Total allocable groundwater based on previous studies (m ³ /yr) | 0.5% rainfall over the gross area (m ³ /yr) | Annual allocable groundwater (m ³ /yr) |
|---------------|-----------------------------|---|--|--|--|---|
| Upper Waipaoa | 819.4 | 1,700 | 3,120 | | 6,964,593 | 6,964,593 |
| Waikohu | 1,001.80 | 1,400 | 0 | | 7,012,364 | 7,012,364 |
| Wharekopae | 317.6 | 1,100 | 0 | | 1,746,668 | 1,746,668 |
| Whakaahu | 118.3 | 1,000 | 296,400 | | 591,699 | 591,699 |
| Te Arai | 216.2 | 1,000 | 45,600 | | 1,080,942 | 1,080,942 |
| Taruheru | 88 | 1,200 | 5,917,920 | 7,167,600 | n.a. | 12,800,000 |
| Upper Flats | 90.5 | 1,100 | 900 | | n.a. | |
| Mid Flats | 229.2 | 1,100 | 709,200 | | n.a. | |
| Lower Flats | 47.3 | 1,100 | 539,580 | | n.a. | |
| Waiapu | 1,736.00 | 2,000 | 0 | | 17,360,193 | 17,360,193 |
| Uawa | 560 | 1,600 | 0 | | 4,480,318 | 4,480,318 |
| Other | 782.9 | 1,800 | 0 | | 7,046,450 | 7,046,450 |
| Total | | | 7,512,720 | | | 59,083,228 |

4.3 Rooftop Water Harvesting

Rooftop water harvesting is the primary source of water for many rural and non-reticulated households due to availability, cost and quality of alternative supplies. The actual number of households that use rooftop water harvesting is unknown. It is assumed that only 50% of non-reticulated households use rooftop water harvesting, and the rest use groundwater bores to abstract water. It is acknowledged that the actual number of household using roof water harvesting may be higher than 50%, however, in the absence of better data this conservative assumption is more appropriate.

Previous studies (Aqualinc, 2007) shows that generic estimates of water harvest potential based on an average roof area of 200 m², storage capacity of 22,500 litres and average daily consumption of 200 ℓ/p/d (assumed as non-reticulated consumption for this study) would meet annual household water demand for approximately 95% of the time. During times of drought, water is supplemented by tankered supplies.

It has been estimated that the current rooftop rainwater harvesting and tankered supply contributes approximately 355,000 m³/yr. It is difficult to predict the future use of rooftop harvesting within the region; however, for this assessment it is assumed that the 50% households that are not supplied with the reticulated supply will continue to use roof water over the next 50 years.

Possible future considerations are:

- Rainwater harvesting 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 for irrigation of garden and lawns i.e. to supplement a limited municipal supply, as proposed for new subdivisions in some areas of the New Zealand.
- The cost of connection to municipal networks may be an incentive to continued using rainwater harvesting.

4.4 Tankered Water Supply

Tankering of water for domestic consumption is common in the rural areas during summer droughts and reflects water availability and distribution issues. However, tankered water is not a water source as it is generally extracted from GDC reticulation via hydrants or from other surface water sources.

There are no estimates available on tankered supply and the volumes can vary significantly between years depending on rainfall. It is estimated that average annual volume of tankered water is approximately 30,000 m³/yr. As this volume is use over a large spatial areas, its impact is not significant. Therefore, tankered water supply is not considered further in this assessment.

It is recommended the GDC collects data from tanker suppliers who operate within the district to improve the overall understanding of water use within the district.

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). 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

A summary of current water resources by WRZ is presented in Table 4-5. The total current allocable resources over the study area (excluding winter harvesting of stream flows) is approximately 135 Mm³/yr, the majority (48%) is from the run-of-stream source. Groundwater contributes to 44% of the water resource in the study area and the balance is from reservoirs.

The future water resources for 2023, 2038 and 2063 are presented in Appendix K.

Table 4-5: Summary of water resources

| | Annual allocable resource (Mm ³ /yr) | | | |
|---|---|---------------|-------------|--------------|
| | Groundwater | Run-of-stream | Reservoirs* | Total |
| Upper Waipaoa | 6.96 | 3.88 | | 10.84 |
| Waikohu | 7.01 | 4.74 | | 11.75 |
| Wharekopae | 1.75 | 1.50 | | 3.25 |
| Whakaahu | 0.59 | 0.56 | | 1.15 |
| Te Arai | 1.08 | 0.82 | 0.23 | 2.12 |
| Taruheru | 12.80 | 0.29 | 7.33 | 45.73 |
| Upper Flats | | 9.46 | | |
| Mid Flats | | 17.72 | | |
| Lower Flats | | 10.82 | 0.11 | |
| Waiapu | 17.36 | 7.39 | | 24.75 |
| Uawa | 4.48 | 2.38 | | 6.86 |
| Other | 7.05 | 5.56 | 3.01 | 15.61 |
| Total | 59.1 | 65.1 | 10.7 | 134.9 |
| % | 44% | 48% | 8% | |
| * GDC current water demand is mainly met with reservoir storage takes from Te Arai WRZ. As the resources are allocated it is assumed these water resources are available within WRZs that the resources are consumed: Taruheru, Other and Lower Flats. The amounts are allocated for the WRZs based on their average consumption. | | | | |

While the Table 4-5 shows the total quantity of allocable resources based on current estimates of total water resource available and under current allocation rules, it is important that the spatial distribution of these available resources is matching to the source of the demand. The following Section 5 look more closely at trends in water balances by WRZ, and specifically at the sustainability of resources to meet the future predictions due to land use changes.

5 WATER BALANCE

The previous two sections of this report summarised the water demand and resource availability. The purpose of this section is to assess the water availability against the resource demand predictions over the next 10, 25 and 50 years. This water balance assessment is important as it indicates whether there is significant imbalance between demand and supply.

The following sections present a series of water balances over the planning horizon to show trends in overall water balance of the study area (global), catchments, 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 in the components to the outcome of projected water balance.

5.1.1 Global Water Balance

The current total annual water resource demand for the total study area is in the order of 39 Mm³/yr which is supplied from the current allocable water resources, which is 135 Mm³/yr. Rooftop rainwater harvesting accounts for less than 1.5% of the total demand of the study area. Approximately 56% of the demand is met from surface water resources (including reservoirs), and the balance from groundwater. The demand for water from allocable resources is projected to increase to 102 Mm³/yr by 2063 with the allocable water resource being 130 Mm³/yr.

The global annual water balance provides an overview of the sustainability of resource for the region over the 50 year planning horizon. Figure 5-1 shows that the annual balance for the difference between the allocable water resources less the demand at current and future demand (2023, 2038 and 2063). It shows that the annual water balance over the study area as a whole is currently positive at approximately 96 Mm³, but will progressively decline as the demand rises and available resources reduce due to effect of the climate change, the difference being 27 Mm³ by 2063. It should be also noted that most of the allocable resource estimates are conservative. Thus it indicates that the overall water balance for the study area is strongly positive, both currently and within the 50 year planning horizon. However, this is only a broad scale assessment which does not show the variation, on either a spatial and temporal scale in supply and demand. For example, the irrigation demand is seasonal and occurs over a relatively short period (Nov ó Mar), and is therefore limited by the consented take rate and minimum stream flow requirements of the surface water resource. In addition, the global water balance does not highlight the preference for water sources to match any 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.

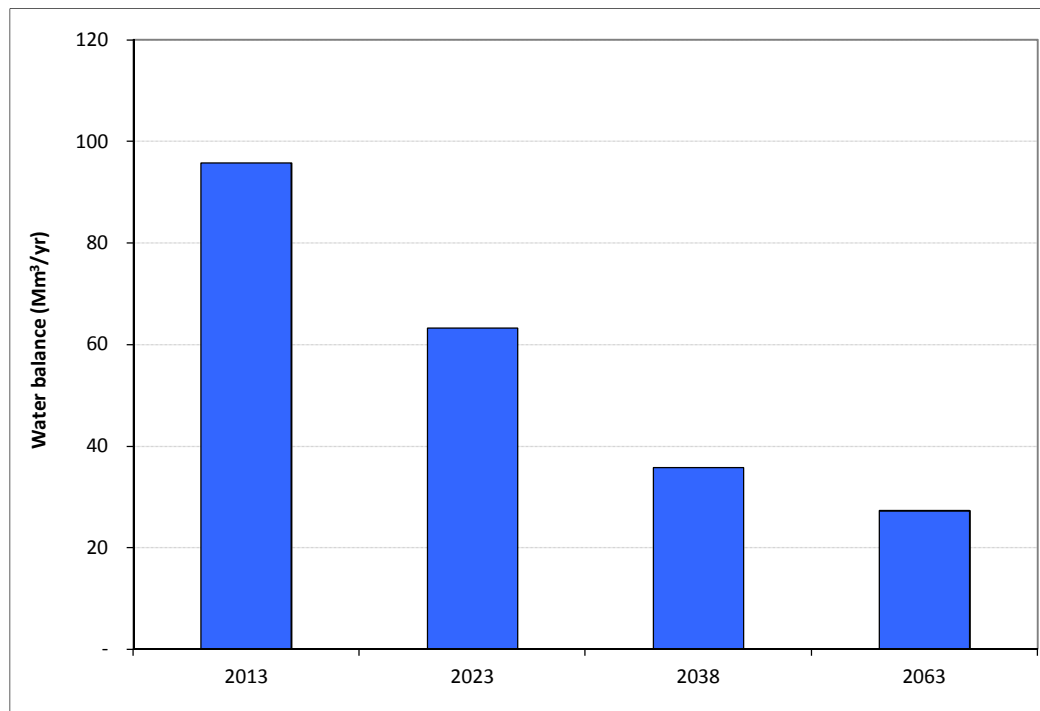


Figure 5-1: Global water balance; available water resource – demand on an annual basis

5.1.2 Water Balance by Catchments

The study assesses the water demand and availability for four catchments: Greater Waipaoa, Waiapu, Uawa, and combined other catchments. The water balance presented in this section describes the status of the water sustainability for these four catchments.

Figure 5-2 shows the annual water balance (Mm³/yr) over the 50 year study planning horizon for the four catchments. Appendix L lists details of the water balance by catchment. Three catchments (Greater Waipaoa, Waiapu and other combined) show positive water balance over the study horizon. However, the availability of water can be a constraint to potential development in the Uawa catchment. The net resources in the Greater Waipaoa catchment are also declining at an average rate of nearly 1 Mm³/yr over next 50 years.

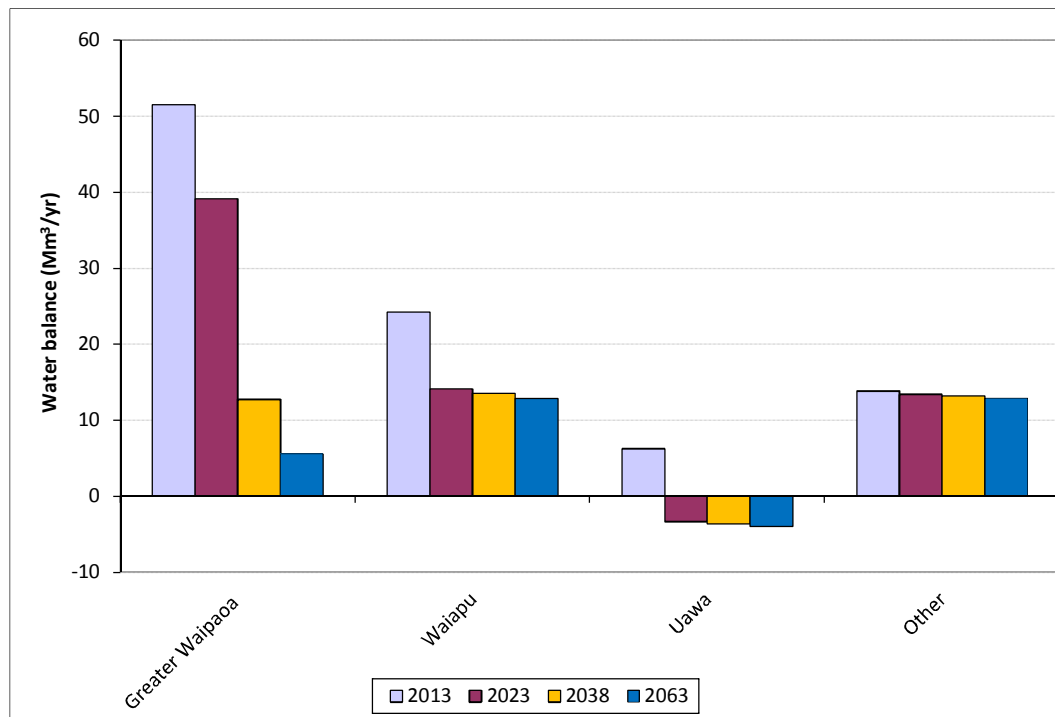


Figure 5-2: Water balance by catchments

5.1.3 Water Balance by Water Resource Zones

The water balance by WRZ provides a truer picture of the water sustainability, as it is based on a smaller spatial dimension and the net balance between demand and resource availability is for each WRZ. GDC current urban water demand is predominately met with water supplied from Te Arai WRZ and Mangapoike catchment. Therefore, in this water balances it is assumed that the resources source from Te Arai WRZ have been transferred to the WRZs that consume water; in other words GDC sourced water from Te Arai is not considered as available within Te Arai WRZ.

Figure 5-3 shows the annual water balance (Mm^3/yr) over the 50 year study planning horizon for the WRZs. Appendix L lists details of the water balance by WRZ; it shows that four WRZs in the Greater Waipaoa have a net positive water balance. However, the resources in Waikohu, Whararekopea, Whakaahu, Te Arai, Taruheru and Uawa WRZ will be a limitation for the future growth and the net water balances is declining, and predicted to have a negative water balance by 2063. The increasing demand, primarily for irrigation and industries, and declining available water resources mainly due to climate change effect shows that water supply is unsustainable in the longer term in these WRZ.

As discussed above, the WRZ water balance is only indicative of overall trends as it does not show the impact of demand growth on particular water sources and its relevant ability to meet the project demand over the next 50 years, Therefore, the following sections look at the net water balances by resource.

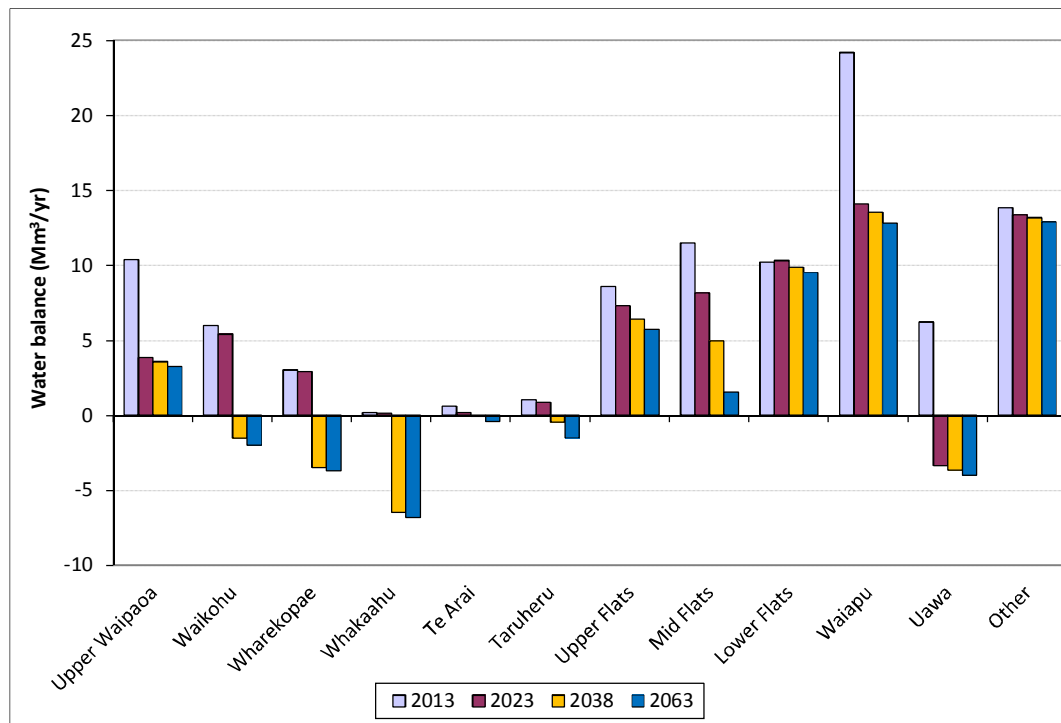


Figure 5-3: Water balance by WRZ

5.1.4 Surface Water Balance

The daily allocable run-of-stream flows within the study area is approximately 6,883 litres per second (l/s) (Section 4.1.1), or 595,000 m³/day. It is predicted that this allocable resource will decline in the future due to climate change effects of less rainfall and higher evaporation to 574,000 m³/day by 2063. The demand for the water from the run-of-streams is generally highest during summer months when flow levels are at their lowest.

The current total daily peak demand from streams is 219,000 m³/d, and this demand is expected to increase to 628,000 m³/d by 2063. Irrigation takes account for the highest demand in the study area. The estimated daily peak irrigation demand at year 2013 and 2063 are 213,000 and 616,000 m³/d, respectively. The current average daily allocable resource of 595,000 m³/d is higher than the current peak demand, however, less than the predicted demand over the 50 year planning horizon. This negative water balance will be further worsen during some summer drought periods when the actual resource available will be lower than the average 595,000 m³/d.

As shown in Figure 5-4, the daily water balance given peak demands and at minimum in-stream ecological flows for some WRZs is currently negative and will only come under increasing pressure due to a growth in demand and reduced available resources in the future. All the WRZ in the Greater Waipaoa catchment except that are in the Poverty Bay Flats are unable to sustain any growth in water demand. Therefore, the water users in these WRZ will need to source water from groundwater or develop storage to supplement shortfalls. This analysis has not taken the resource consumed by non-consented takes (reasonable use and permitted activities) into account. However, such takes should not be significant.

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. Thus a conservative approach has been adopted in estimating the allocable resources. It is possible that if IMFR studies are completed in the future more allocable resource may be available in some WRZ.

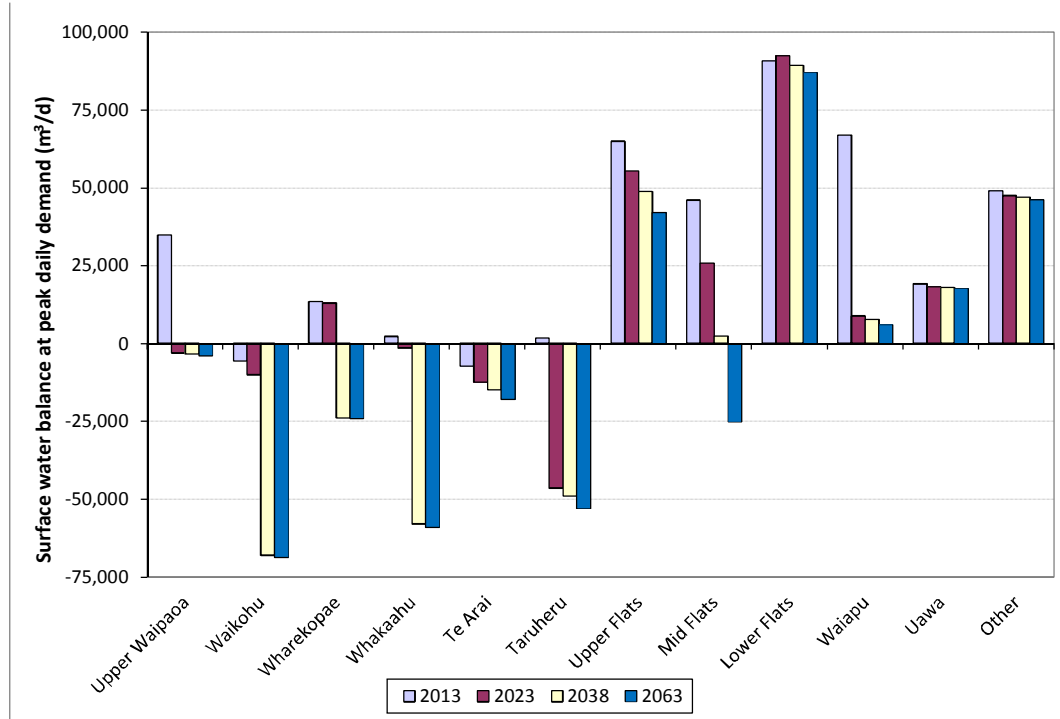


Figure 5-4: Run-of-stream water balance by WRZ based on peak daily demand

5.1.5 Groundwater Balance

As described in Section 4.2, the current annual allocable groundwater resource within the study area is 59 Mm³/yr. This accounts for approximately 44% of the total current allocable resources in the study area. The current groundwater resource demand is approximately 13 Mm³/yr or 22% of the allocable resource. As the growth in the region is predominately predicted to occur within and around Gisborne City, groundwater resources around the city may come under increased demand in the future.

Figure 5-5 shows the groundwater balance by WRZ and the details are listed in Appendix L. The aquifer system below the Poverty Bay Flats area spreads over many WRZs, therefore, they were combined into one zone, called Flats for this water balance assessment.

This analysis is based on current allocated resource and it is likely that a significant volume is additionally used by non-consented takes (reasonable use and permitted activities). These non-consented takes are predominately occurring in rural areas. As shown in Figure 5-5, the groundwater balance for most rural WRZs is strongly positive and non-consented takes are not expected to exert excessive pressure on the groundwater resource.

The current groundwater balance for the Flats shows a positive balance. It is predicted that the groundwater balance will increase in short-term due to reduction in agriculture use in and around the urban areas, however, higher water demand for industries will then reduce the net water availability by 2063.

While this assessment is primarily based on ōball parkö allocable values, GNS (2012) shows that based on groundwater level data, current groundwater use in the Flats may be unsustainable. However, Aqualinc (2012b) questioned the methodology used by GNS (2012) in coming to this conclusion. Thus, there is considerable uncertainty associated with the sustainability of the groundwater resource in the Flats WRZ. It is therefore recommended that GDC should adopt a very cautious approach until accurate allocable water volumes can be determined.

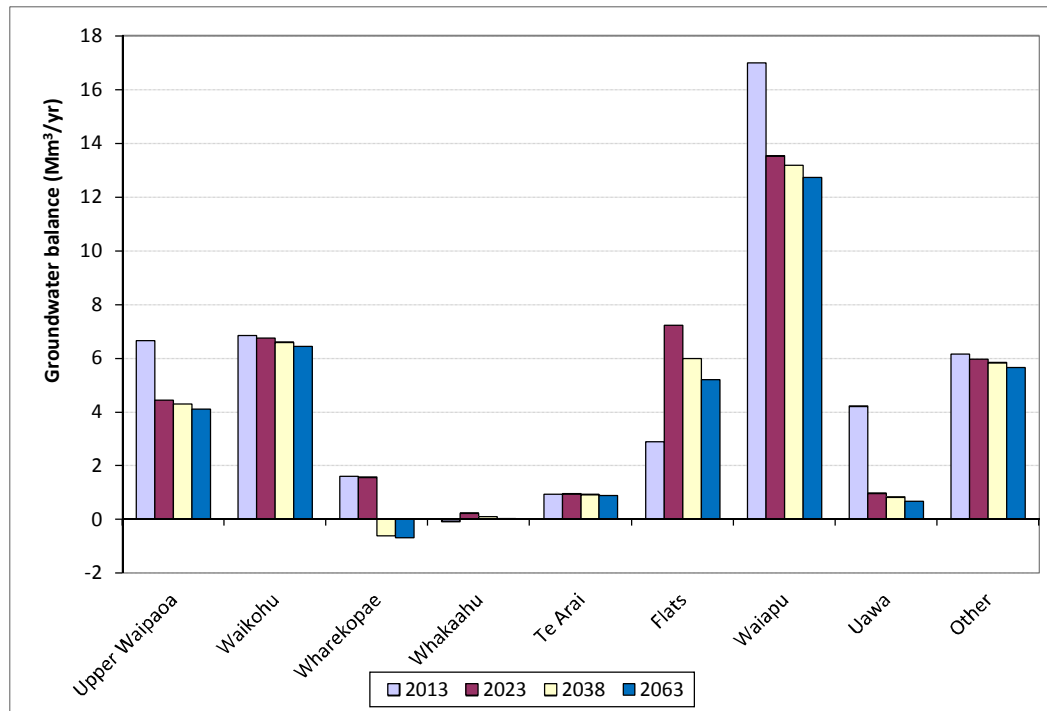


Figure 5-5: Groundwater balance by WRZ

5.1.6 Reservoirs

As described in Section 4.1.2, the estimated total water resource contribution from existing consented reservoirs is in the order of 10 Mm³/yr (supply volume). In addition, there are some non-consented takes from reservoirs for reasonable stock and domestic use and permitted activities. There is considerable potential for the development of reservoirs utilising winter water harvesting to off-stream storage. In theory, there is good potential to increase water availability through such an option (Section 4.1.3).

5.2 Sensitivity Analysis

The assessment of future resource demand in the preceding sections is based on population projections, and predictions of development scenarios for different water-use sectors. These predictions are based on a series of assumptions on the trends in land use and industrial development and uncertainty in these predictions exists. The water balances assessments and sustainability of resources were tested for sensitivity to variation in the projections and variability of the associated assumptions.

While there are a multitude of possible combinations of design variables, a relatively simple two scenarios approach was adopted for this sensitivity analysis. The two simple scenarios used in the analysis are the likely lower and upper limits (referred to as 'low growth' and 'high growth' respectively) in demand sensitivity, as listed in Table 5-1. For simplicity it is assumed that the predictions made for 2023 are reasonably valid, therefore, sensitivity analysis is carried out for 2038 and 2063 predictions.

Table 5-1: Parameters adopted for demand sensitivity

| Demand category | Low growth | High growth |
|-----------------|---|---|
| Population | Reduced population due to slower growth rate: -5% at 2038 -10% at 2063 | Higher population due to faster growth rate: +5% at 2038 +10% at 2063 |
| Livestock | Following reduction in demand due to lower stock numbers: -10% at 2038 -20% at 2063 | Following increase in demand due to higher stock numbers: +15% at 2038 +30% at 2063 |
| Irrigation | Following reduction in irrigated area: -10% at 2038 -20% at 2063 | Following increase in irrigated area: +15% at 2038 +30% at 2063 |
| Industry | Following lower demand for industrial water use: -15% at 2038 -30% at 2063 | Following increased industrial demand: +15% at 2038 +30% at 2063 |

The demand over the whole study for water would decrease from 102 (with medium growth rate) to 82 Mm³/yr by 2063 for the low growth scenario. The high growth scenario requires demand increase to 132 Mm³/yr by 2063.

Figure 5-6 shows the water balance for the study area for the three different demand scenarios. The effect of the change in demand for the high growth indicates that the limitation of available water can be a major restriction to elevated growth in the district. As shown in Section 5.1.4 and 5.1.5, both surface water and groundwater in some WRZs is under pressure and the water balance for some of the WRZs is negative or nearly zero. Therefore, the sensitivity of the available water resource for

different demand growth scenarios is described in the following sections. The sensitivity analysis plots for the four catchments are presented in Appendix M.

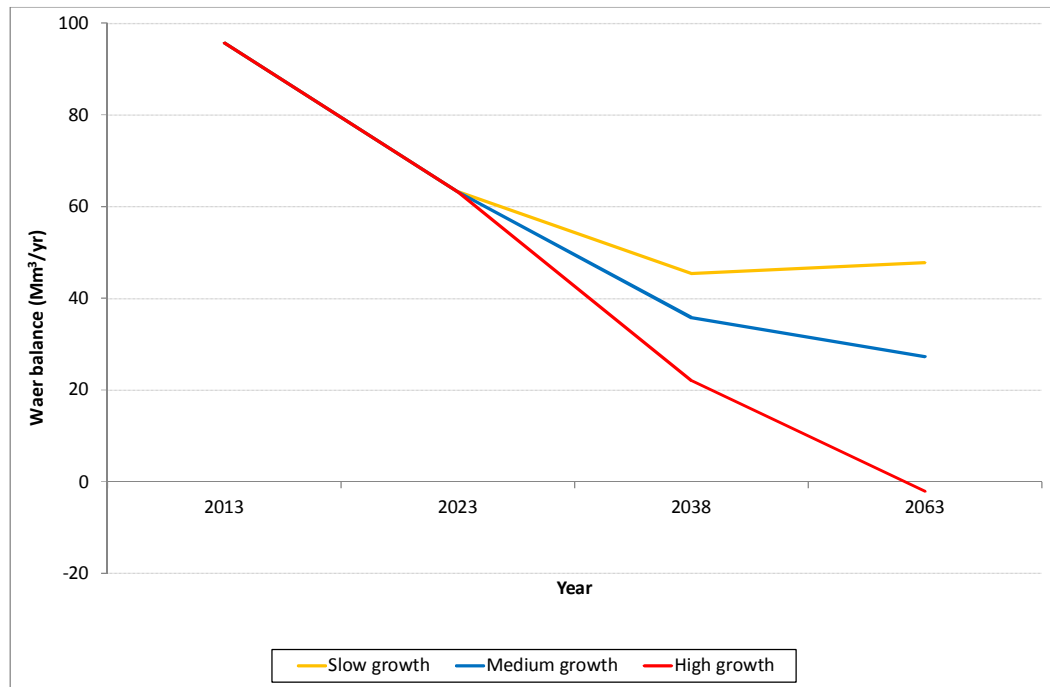


Figure 5-6: Global water balance for different growth scenarios

5.2.1 Surface Water

As discussed previously in Sections 5.1.1, the annual global water balance masks the true difference between demand and allocable resource on a spatial and temporal basis in WRZs. Therefore, to provide a reasonably clear picture of the water sustainability at the correct scale it is important to assess the outcome of this analysis at the smaller spatial dimension of the WRZ. Figure 5-7 and Figure 5-8 show the water balance for low and high growth scenarios, respectively for each WRZ. The surface water resource balances in rural WRZ in the Greater Waipaoa catchment are negative for the low growth area indicating the resource is already under significant pressure. The interesting feature here is the water balance for the Mid Flats WRZ where positive balance for the low growth scenario changes to high negative water balance with the higher growth scenario showing that the growth rate is highly sensitive to water balance in the WRZ. As with the previous water balance analysis harvesting winter flows is not incorporate into the available resource.

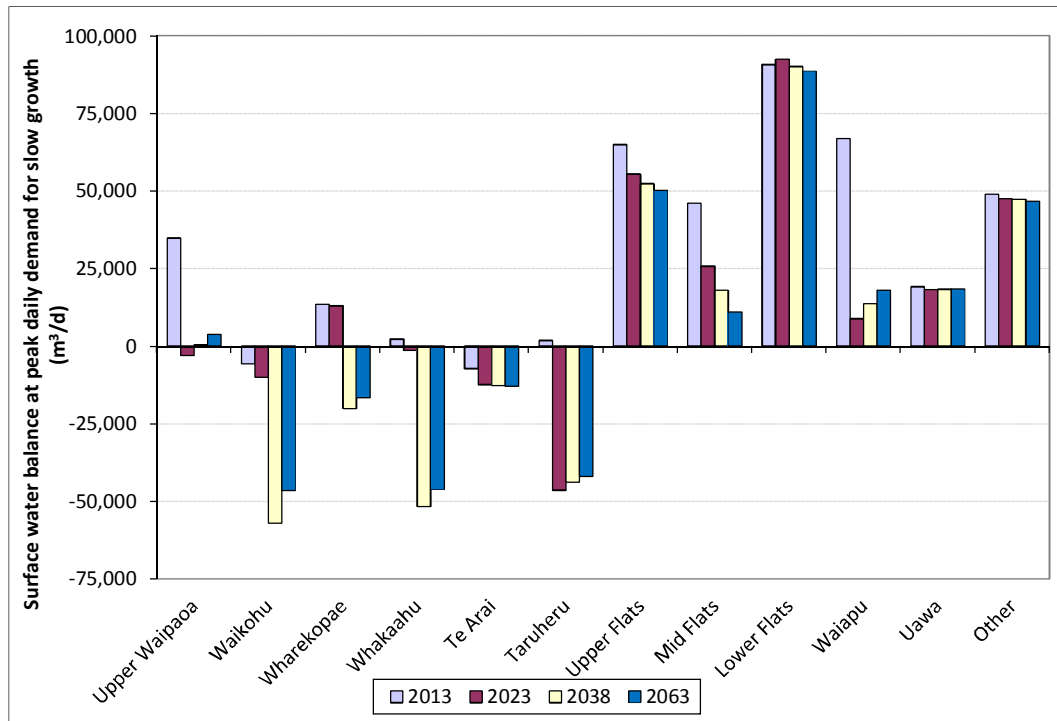


Figure 5-7: Surface water balance at daily peak demand for low growth scenario by WRZ

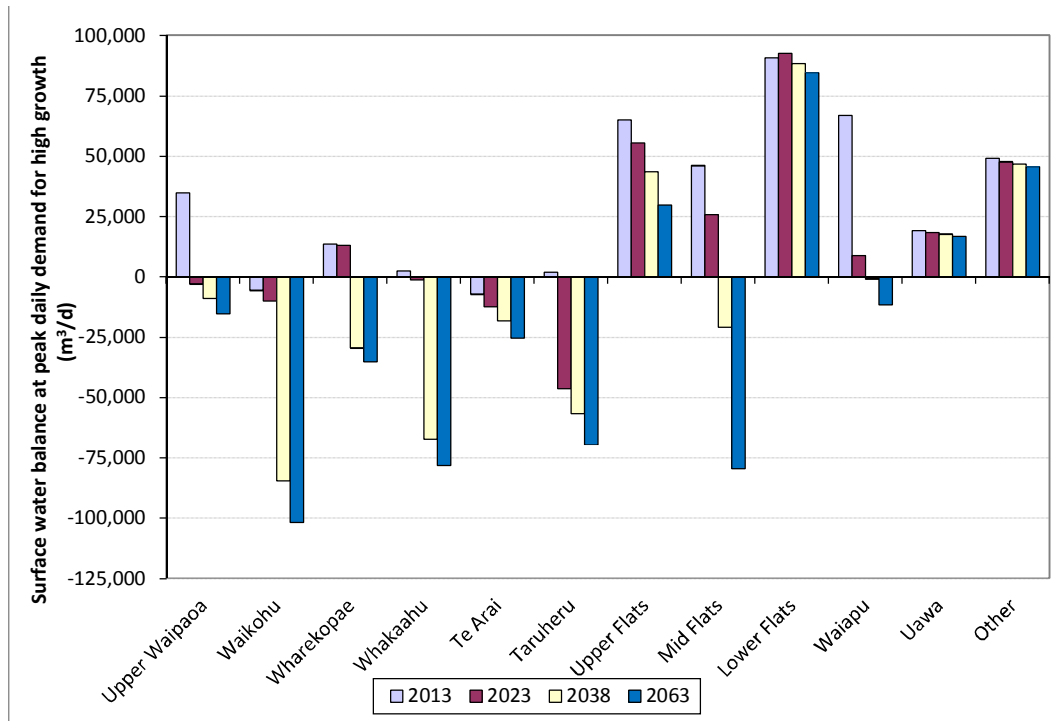


Figure 5-8: Surface water balance at daily peak demand for high growth scenario by WRZ

5.2.2 Groundwater

As discussed in Section 5.1.5, although the groundwater balance for the Poverty Bay Flats WRZ under the medium scenario is positive that associates with high uncertainty. The intensive agriculture and horticulture land uses in this area are two of the important economic sectors for the Gisborne district. These sectors are heavily dependent on reliable supply of groundwater from the Poverty Bay Flats aquifers. Therefore, it is important to assess the resource sustainability for low and high growth scenarios to identify any potential issues in the future.

Figure 5-9 and Figure 5-10 show the annual groundwater balance for low and high growth scenarios, respectively. This shows that the net groundwater resource of the Poverty Bay Flats WRZ can be approaching zero under the high growth scenario by 2063. Therefore, it is important that GDC improve their understanding of these aquifers so they can confidently and sustainably manage the sustainable allocation of this groundwater resource in the future.

The groundwater resource is also under heavy pressure in Wharekopae and Whakaahu WRZ. However, as mentioned in Section 4.2, the allocable resource of the WRZ is estimated using a conservative method of 0.5% of rainfall. While actual allocable groundwater resource may be significantly higher, until water availability volume is confidentially known prudent caution should be used in the allocation of any addition resource.

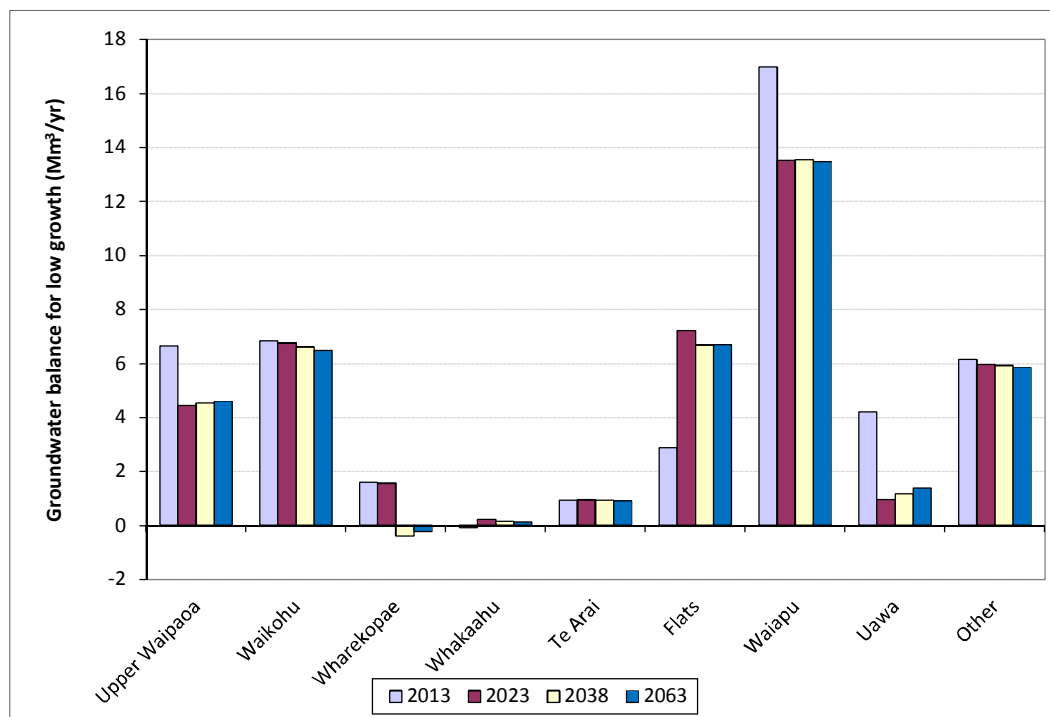


Figure 5-9: Annual groundwater balance for low growth scenario by WRZ

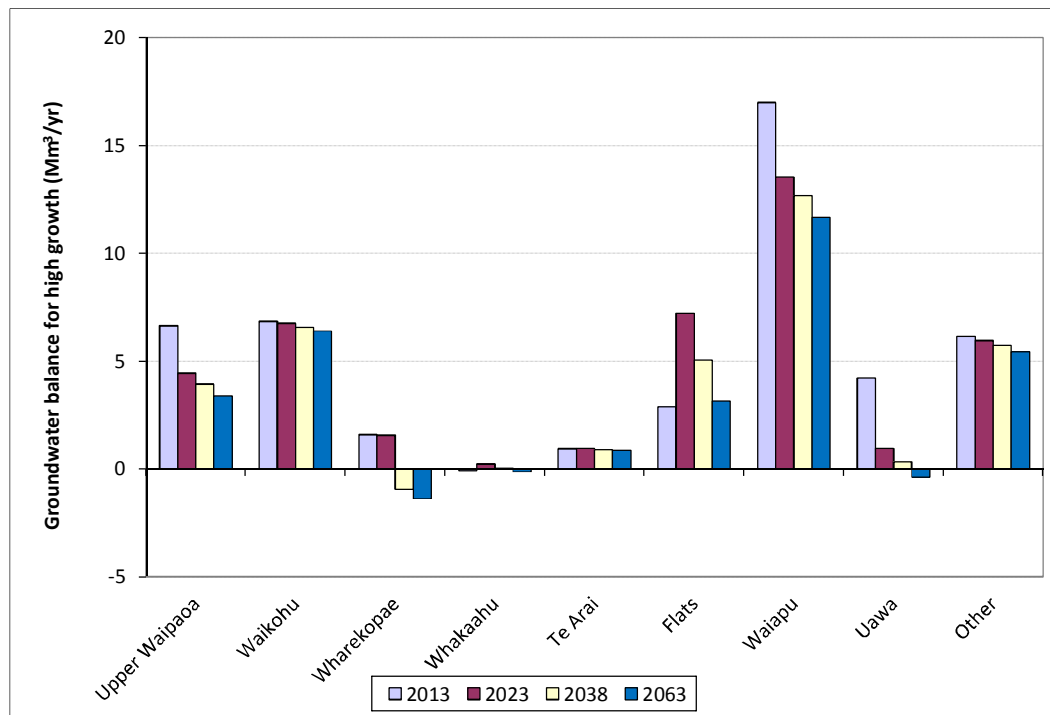


Figure 5-10: Annual groundwater balance for high growth scenario by WRZ

6 STRATEGIES TO MEET FUTURE WATER DEMAND

The preceding assessments showed that water balances in some WRZs are negative over the planning horizon primarily due to the predicted high water demand from irrigation and industrial growth. Under these scenarios the surface water resource will be more stressed than the groundwater resource. The main reason for this is that the direct run-of-stream water sources generally tend to be the cheaper, thus that is generally the 'first-choice' for water users. Direct run-of-stream sources require lower capital infrastructure and the pumping requirement is limited to lifting the water to the area to be irrigated and providing sufficient pressure for the irrigation equipment. However, run-of-stream sources are sometimes less reliable and susceptible to the allocable flow limits and restrictions during periods of low flow.

The analysis undertaken showed that the ratio of the groundwater used to resource available is currently lower than the same ratio for surface water. Therefore, in the future more water users will need to source their water from groundwater rather than from direct run-of-stream sources. However, groundwater sources (particularly deep groundwater sources) require a reasonable amount of capital infrastructure (drilling of a borehole and the installation of relatively expensive submersible pumps) and the pumping costs are higher. Groundwater sources are generally more reliable than direct run-of-river abstractions as the aquifers essentially provide storage that allows buffering in a low recharge year.

There is a significant potential for harvesting and storage of winter surface flows within some catchments. The theoretical potential is over 1,000 Mm³/yr, which equates to 10 times the predicted total water demand within the study area. Water

harvesting requires significant capital infrastructure in the form of storage dams, intake structures and spillways. Additionally, high winter flow events are required to fill the storages and insufficient stored water volumes can result following dry winters.

Figure 6-1 and Figure 6-2 show the results of the surface water balance at peak demand, and the groundwater on an annual balance for 2063 data, respectively. Figure 6-1 illustrates that surface water resources would be unable to meet the demand in the Greater Waipaoa Catchment at peak times. This is generally during the summer months when surface flows are at their lowest. However, Figure 6-2 shows that water is available from the groundwater resource in all the WRZ apart from Wharekopae WRZ; note that the available groundwater volume from the Wharekopae WRZ is estimated using conservative assumptions. Therefore, Gisborne district should look into encouraging and utilising more groundwater resources where possible. This strategy would also help to alleviate potential issues regarding management and monitoring of a heavily allocated resource and improve the in-stream intrinsic values of surface water bodies.

However, as previously discussed run-of-stream sources generally tend to be the cheapest to develop and use, thus the balance between the economics of using run-of-stream water and overall better water resource usage for the district of using groundwater sources should be carefully assessed in the strategies developed.

Table 6-1 outlines a summary of water resources and development options based on 2063 water balances by WRZ. It is recommended, based on economic factors, that when development potentials are assessed, the run-of-stream options are first considered and then followed by groundwater and storage.

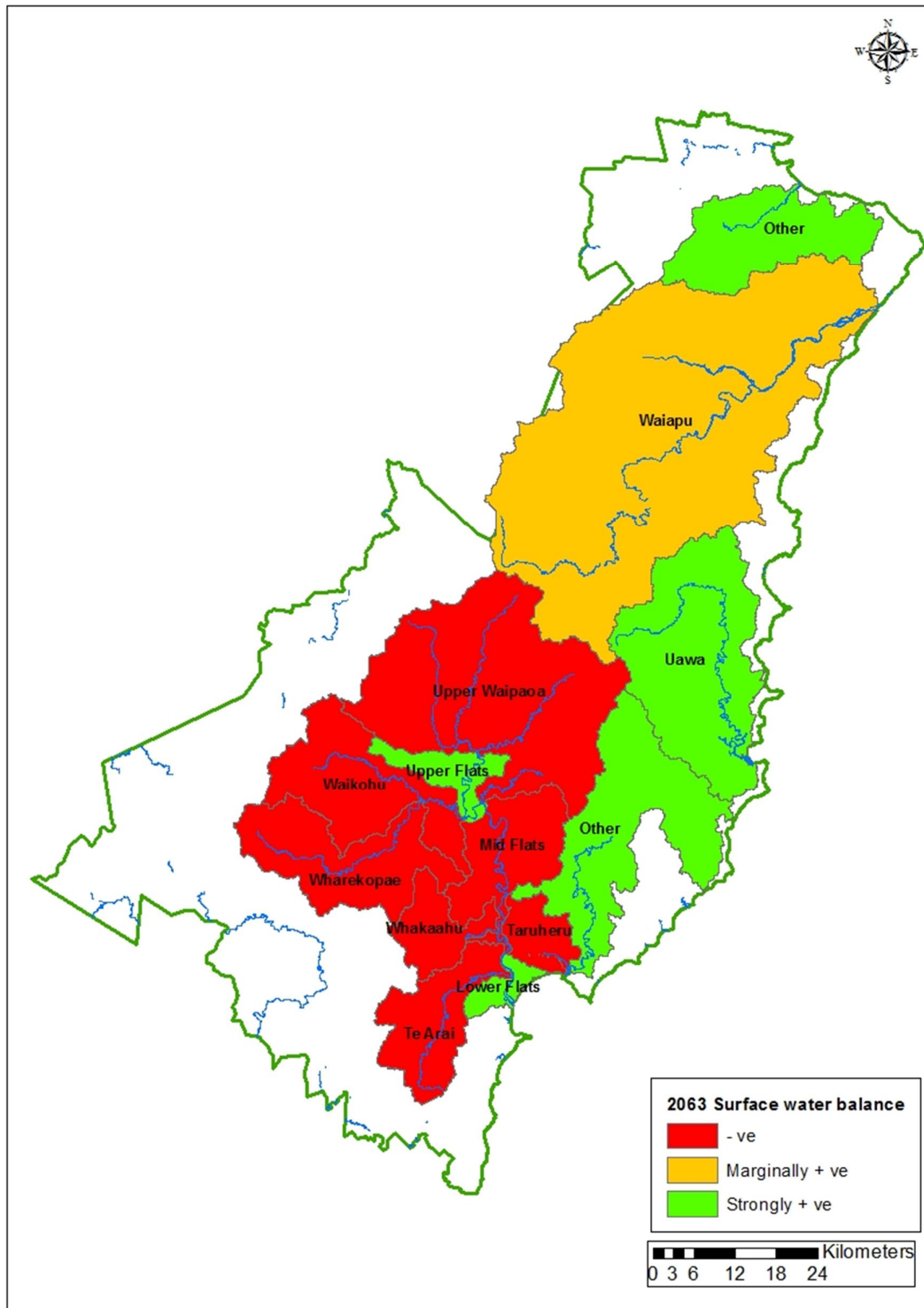


Figure 6-1: Surface water balance at daily peak demand for year 2063 by WRZ

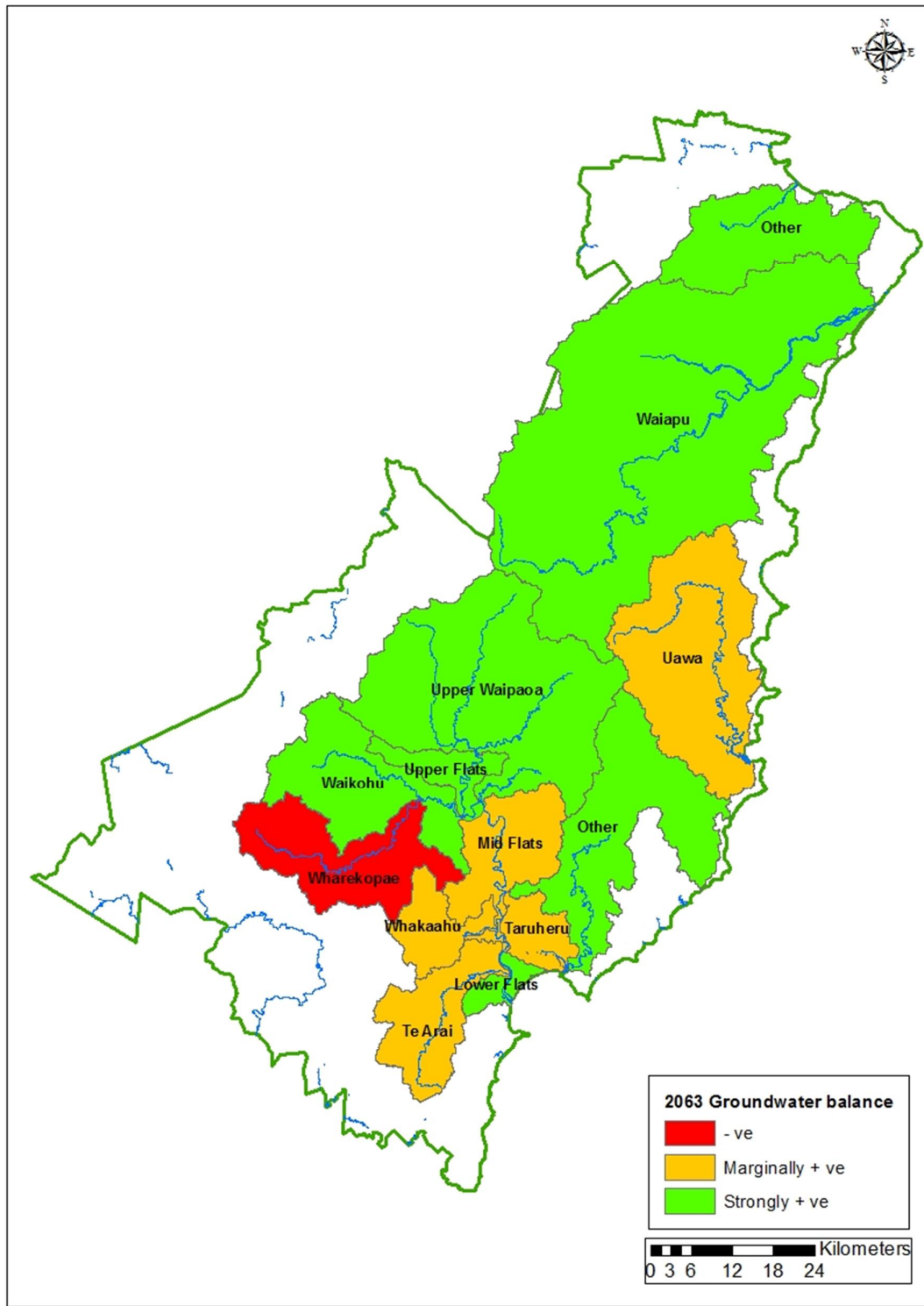


Figure 6-2: Annual groundwater balance for year 2063 by WRZ

Table 6-1: Summary of water resources and development options based on water balances in 2063 by WRZ

| WRZ | Run-of-stream | Groundwater | Storage |
|---------------|--|---|---|
| Upper Waipaoa | <ul style="list-style-type: none"> • -ve water balance • No minimum flow studies completed • Assessment based on conservative assumptions, thus more water may be available • Potential to meet some demand | <ul style="list-style-type: none"> • +ve water balance • High development potential | <ul style="list-style-type: none"> • Strong potential for winter flow harvesting |
| Waikohu | <ul style="list-style-type: none"> • High -ve water balance • No minimum flow studies completed • Assessment based on conservative assumptions, thus more water may be available • No or low potential for further development | <ul style="list-style-type: none"> • Strong +ve water balance • High development potential | <ul style="list-style-type: none"> • Strong potential for winter flow harvesting |
| Wharekopae | <ul style="list-style-type: none"> • High -ve water balance • No minimum flow studies completed • Assessment based on conservative assumptions, thus more water may be available • Potential to meet some demand | <ul style="list-style-type: none"> • -ve water balance • Potential to meet partial demand | <ul style="list-style-type: none"> • Moderate potential for winter flow harvesting |
| Whakaahu | <ul style="list-style-type: none"> • High -ve water balance • No minimum flow studies completed • Assessment based on conservative assumptions, thus more water may be available • Low potential to meet some demand | <ul style="list-style-type: none"> • Very low +ve water balance • Low potential for further development | <ul style="list-style-type: none"> • Moderate potential for winter flow harvesting |

| WRZ | Run-of-stream | Groundwater | Storage |
|-------------|--|--|---|
| Te Arai | <ul style="list-style-type: none"> • Highly over-allocated • High -ve water balance • No minimum flow studies completed • Assessment based on conservative assumptions, thus more water may be available • No potential for further development | <ul style="list-style-type: none"> • Low +ve water balance • Potential for further development | <ul style="list-style-type: none"> • Moderate potential for winter flow harvesting |
| Taruheru | <ul style="list-style-type: none"> • High -ve water balance • No minimum flow studies completed • Assessment based on conservative assumptions, thus more water may be available • No potential for further development | <ul style="list-style-type: none"> • +ve water balance • Potential for further development | <ul style="list-style-type: none"> • Low potential for winter flow harvesting |
| Upper Flats | <ul style="list-style-type: none"> • High +ve water balance • High potential for further development | <ul style="list-style-type: none"> • +ve water balance • Potential for further development | <ul style="list-style-type: none"> • Low potential for winter flow harvesting |
| Mid Flats | <ul style="list-style-type: none"> • -ve water balance • Low potential to meet some demand | <ul style="list-style-type: none"> • +ve water balance • Potential for further development | <ul style="list-style-type: none"> • Low potential for winter flow harvesting |
| Lower Flats | <ul style="list-style-type: none"> • +ve water balance • High potential to meet the demand | <ul style="list-style-type: none"> • +ve water balance • Potential for further development | <ul style="list-style-type: none"> • Low potential for winter flow harvesting |
| Waiapu | <ul style="list-style-type: none"> • +ve water balance • No minimum flow studies completed • Assessment based on conservative assumptions, thus more water may be available | <ul style="list-style-type: none"> • Strong +ve water balance • High potential for further development | <ul style="list-style-type: none"> • High potential for winter flow harvesting |

| WRZ | Run-of-stream | Groundwater | Storage |
|------------|---|---|---|
| | <ul style="list-style-type: none"> • Potential for further development | | |
| Uawa | <ul style="list-style-type: none"> • Low +ve water balance • No minimum flow studies completed • Assessment based on conservative assumptions, thus more water may be available • Potential for further development | <ul style="list-style-type: none"> • Low +ve water balance • Potential for further development | <ul style="list-style-type: none"> • High potential for winter flow harvesting |
| Other | <ul style="list-style-type: none"> • +ve water balance • No minimum flow studies completed • Assessment based on conservative assumptions, thus more water may be available • Potential for further development | <ul style="list-style-type: none"> • High +ve water balance • Potential for further development | <ul style="list-style-type: none"> • High potential for winter flow harvesting |

6.1 Alternative Strategies

GDC and stakeholders should investigate the following strategies and measures to improve the water resource availability and reliability.

6.1.1 Improve Water Use Efficiency

With the district's water resources predicted to come under severe pressures within the planning horizon, it is important that GDC and water users develop strategies to improve the water use efficiency. Some measures can include:

- Target users/takes of larger takes (e.g target 20% largest takes) and conduct water audits.
- Irrigation is the largest water use and accounts for approximately 90% of the annual demand. As this use occurs within a relative short period in the summer months, where available water resources are low, it is vital to improve the accuracy of the allocation process for irrigation and minimise inefficient water use. Irrigation water use efficiency can be improved using:
 - Allocation based on the actual currently irrigated area (i.e., not for aspirational future areas) matched to the soil and crop types.
 - Introduce telemetry water meters for large takes to monitor real-time water use.
 - Introduce heavy penalties for non-compliances.
 - Encourage the use of soil water monitoring for irrigation management.
 - Ensure that irrigation equipment is optimally matched to the soil and plant requirement so water losses are minimised.
- Target reductions of water losses from the GDC reticulation system from current level of 15% to 10% within 10 years. Conduct system water audits every two years.
- Introduce domestic water use efficiency targets, eg. 10% reduction by 2023. This can be achieved through public information programs, and school educational programs.
- Promote water re-use for landscape irrigation sourced from high water users such as factories.

6.1.2 Managed Aquifer Recharge (MAR)

MAR is becoming an attractive option to store water in underground aquifers and reuse during the periods where conventional resource availability is limited. MAR involves the artificial recharge of water into the groundwater system via infiltration or pumping mechanisms. The source of water is generally surface water during high flow periods. This method enhances the groundwater resource and relieves the over-allocation issues. However, MAR can also cause potential adverse effects due to higher groundwater levels primarily in shallow aquifers. Therefore, it is important that sufficient investigation is carried out to assess the suitability of MAR for an aquifer, and implement the process in an iterative basis of recharge-observe-analyse-modify.

7 CONCLUSIONS AND RECOMMENDATIONS

The key findings and the conclusions of this study are:

Water Demand

The results from the projected water demand for the region indicate:

- The current total population of approximately 35,000 in the study area is not expected to grow. However, it is likely that people will move from rural areas to urban areas, resulting in increased demand on an already stressed water resources in these urban areas.
- Current domestic water demand (for reticulated and non-reticulated consumers) is approximately 3.2 Mm³/yr.
- The GDC reticulated supply area will gradually increase in the future, and non-reticulated supply demand will reduce by approximately 9%.
- The key driver in the projected increasing water demand is due to an expansion of dairy farming, and to some extent horticultural and vegetable irrigation. It is predicted that the total irrigated area will increase from the current estimate of 5,900 to 15,100 hectares by 2063. The reasons for this increase include higher crop water requirements due to warmer weather, and increased irrigated areas to improve the financial benefits. The predicted total irrigation demand will increase from 30 to 89 Mm³/yr by 2063.
- The livestock water demand is projected to increase from 3.3 to 4.1 Mm³/yr by 2063.
- Water demand for commercial and industrial use is predicted to increase from 2 to 5.4 Mm³/yr by 2063. This demand increase is mainly due to expansions in vegetable and fruit processing, and emerging petroleum sectors.
- Total water demand over the study area is projected to increase from the current level of 39 Mm³/yr to 102 Mm³/yr by 2063. Sensitivity analysis indicates that the increase could be up to 132 Mm³/yr if there is sustained high population and industrial growth, and increase in irrigation demand.

Resource Availability

The assessment of water resources for the study area indicates:

- Total current annual allocable water resource from run-of-stream flows, groundwater and reservoirs is approximately 135 Mm³/yr. This is predicted to reduce to 130 Mm³/yr due to the effects of climate change.
- Two thirds of the total water resources are available within the Greater Waipaoa catchment (88 Mm³/yr).
- Groundwater availability for the study area is approximately 59 Mm³/yr which represents 44% of the total water available.
- The available flow data for run-of-stream is limited for the study area. Based on extrapolation of available data the estimated average daily water availability from this source is approximately 595,000 m³/d (6,883 l/s).

- Reservoirs are estimated to contribute approximately 10 Mm³/yr to the supply component.
- Rooftop rainwater harvesting is not a major contributor in the study area; it meets less than 1.5% of the demand within the study area.

Water Resource Sustainability

The assessment of sustainability of water resources indicates:

- The annual water balance over the entire area shows that the area is water rich with a positive minimum water balance of 27 Mm³/yr over the 50 year planning horizon. However, this balance masks the underlying spatial and temporal differences between demand and supply, as well as shortfalls between the water sources.
- Current surface water demand for the GDC reticulated supply is approximately 4.5 Mm³/yr. This reticulated supply is primarily sourced from the Te Arai WRZ using detention reservoirs for storage.
- Surface water resources are under heavy pressure in many WRZs: Upper Waipaoa, Waikohu, Wharekopae, Whakaahu, Te Arai and Taruheru. It is predicted that peak daily surface water balance for the Te Arai WRZ, from which GDC source water for their municipal supply, will be negative (-18,000 m³/d) by 2063 (based on current allocation limits).
- The annual groundwater balance for the study area is positive, with a net positive balance of over 35 Mm³/yr over the 50 year planning horizon.
- Based on the allocable groundwater resource determined and under the current allocation regime, the groundwater resource in the Poverty Bay Flats shows a positive water balance. However, the uncertainty associated with the sustainable allocation limits from these aquifers is high. Therefore, GDC need to determine the aquifer and recharge characteristics to be able to determine the defensible long-term sustainable allocation limits.
- Groundwater abstraction, primarily from shallow aquifers, closer to the sea can cause saltwater intrusion; therefore, regular monitoring in these areas will be required.
- Current contribution to overall water demand from storage reservoirs is 8%. Almost all this is from the GDC reservoirs and is used for the reticulated water supply to urban users.
- There is potential for over 1,300 Mm³/yr from harvesting of winter surface flows. However, there are significant technical, environmental and economic challenges to overcome to realise this potential.
- In highly allocated WRZ it is important that seasonal high summer takes such as irrigation use storage to improve their supply reliability. Water take restrictions due to lower summer flows and higher irrigation demands due to climate change will increase pressure on surface water resources.
- While the above conclusions are based on projected medium growth and associated land use changes, there is a potential for high growth rates. If higher growth rates are experienced in the longer term, run-of-stream supply is unsustainable for most of the WRZs around Gisborne city.

Recommendations

- ***Improve knowledge of water resources:*** Current knowledge of the water resource available in the GDC region is very limited. Water resources in the high demand zones (supplies to Gisborne urban area) are currently under serious pressure during summer low flow periods and it is predicted that this resource will come under increasing pressure within the 50 year study planning horizon (2063). The results of the water balance analysis conducted, using conservative assumptions, shows that availability of water for some WRZs (Te Arai, Waikohu, Wharekopae, Whakaahu, Taruheru and Uawa) will be a constraint to achieving the optimum economic developments, using the current irrigation and management practices and the preferences of using surface water for large takes. To ensure that water is not a limitation to further economic growth, there is a critical need for strategic planning of the water management (as discussed below) at the catchment scale. Accurate information is vital to conduct the strategic planning required; however, at present there are significant gaps in the knowledge and understanding of the water resources. These knowledge gaps include minimum flows and sustainable allocable resources from surface water, and sustainable yields from aquifers. GDC need to improve their knowledge of the spatial and temporal variations of the allocable resource. To robustly determine sustainable allocation limits IMFR studies should be completed on streams where the demands for water are high. In addition, appropriate water quality data needs to be collected to identify the temporal variation in the quality of the resource.

GDC also need to invest in gaining adequate knowledge (aquifer boundaries, sustainable yields, and aquifer parameters such transmissivity and storativity) about the groundwater resources of the region. It is very important to identify the sustainable allocation limits for the key high use aquifers. Without this critical knowledge, under allocation will restrain growth and over allocation will have detrimental environmental outcomes.

- ***GDC alternative options for reticulated supply:*** The sustainability of the water supply for GDC reticulated supply is a critical water management issue. The GDC source water predominately from one catchment. This is a constraint to the reliability of supply and has insufficient flow (based on current allocation limits) to meet the peak demands during low flows, and additionally suffers from quality issues following heavy rainstorms. GDC has emergency supply sources from other surface water sources to meet any temporary short-falls. However, the operation of these emergency takes can restrict other consented water users and adversely affect the in-stream values during low flows. Therefore, it is important that GDC identify alternative sustainable supply sources to meet potential future demands under the higher growth rate scenario (i.e., higher growth than medium growth). Higher population growth and increased industrial demand will put pressure on GDC reticulation supply already stressed under summer conditions. New resource options could include water sourced from a different catchment, preferably with a reservoir and/or groundwater supplies.

Other recommendations that should be implemented include:

- Identify storage locations that can supply reliable water for the WRZs that are currently or will become water short.

- Target users/takes of larger takes (eg. target 20% largest takes) and conduct water audits to assess water use efficiencies.
 - Allocate irrigation water based on the actual current irrigated area (ie, not for aspirational future areas).
 - Introduce telemetry water meters for large takes to monitor real-time water use.
 - Introduce heavy penalties for non-compliances.
 - Encourage the use of soil water monitoring for irrigation management.
 - Ensure that irrigation equipment is optimally matched to the soil and plant requirement so water losses are minimised.
 - Target reductions of water losses from the GDC reticulation system from current level of 15% to 10% within 10 years. Conduct system water audits every two years.
 - Introduce domestic water use efficiency targets, e.g. 10% reduction by 2023. This can be achieved through public information programs, and school educational programs.
 - Promote water re-use for landscape irrigation primarily from high uses such as factories.
 - Investigate the potential for managed aquifer recharge.
- ***Need for better strategic planning:*** Better use of resource (i.e. better value for the limited resource) can also be achieved by strategic planning of the consenting process. The current consent process is largely based on allocation of water on a -first in, first served 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 resources can be managed to meet these future demands in a more strategic approach. 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 for the Gisborne District. It is predicted that some of the surface water takes for irrigation and frost protection will come under pressure within the 50 year planning horizon. This will primarily occur due to a higher irrigation demand and reduction in allocable resource as a result of climate change effects. As mentioned previously, there is considerable potential to develop harvesting of winter flows, which are particularly suited to irrigation supplies for vegetables etc. This activity should be promoted more actively in high demand areas as an alternative to current run-of-stream takes. GDC could develop a clear allocation policy framework by introducing a multiple -Block allocation system (see Section 4.1.4) to promote winter flow harvesting, while still protecting the environmental and in-stream values of the surface water resource.

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Appendix A: Summary of relevant water reports

The bibliography below lists reports reviewed during the study.

- GDC (1998). Water management. Gisborne District Council internal memo prepared for the Planning and Regulatory Committee.
- GDC (2011a). Gisborne district alluvial area boundaries and rainfall recharge estimates. Gisborne District Council internal research report.
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- NIWA (2010b). Review of groundwater information for the Poverty Bay Aquifers. Prepared by NIWA for Gisborne District Council. Client Report: CHC2010-022, April 2010.
- NIWA (2010c). Instream habitat and flow regime requirements for the Waipaoa and Te Arai rivers. Prepared by NIWA for Gisborne District Council. Client Report: CHC2010-067, June 2010.

Appendix B: Assumptions and design parameters

In a regional wide water study such as this, a number of assumptions and various design parameters need to be chosen in the determination of the water demand and availability and to complete the water balance analysis. In some cases these were necessary due to limitations on data available. Below is a summary of the relevant assumptions and design parameters adopted and where appropriate the rationale behind their selection is also provided.

1. Planning horizons

The current year, 2013, was adopted as the study base year, with a planning horizon of 50 years (2063) and intermediate reporting intervals of 10 years (2023) and 25 years (2038). In adopting 2013 as the base year, it was necessary to update relevant data sets to establish best estimates of their current status. This was based on the following assumptions:

- Population census prepared in 2006; updated based on recent growth data
- Livestock numbers for 2011; assumed to have remained constant to 2013.

2. Average daily water demand

- Reticulated supply:
 - Per capita consumption for domestic demand is based on current reticulated supply information from GDC.
 - Average daily water consumption = 263 ℓ/c/d
- Non-reticulated supply:
 - No data available.
 - Average daily consumption assumed = 200 ℓ/c/d
 - The lower rural demand is attributed to lower unaccounted water losses that occur in a reticulated system, and the absence of other uses associated with reticulated systems i.e. commercial and industrial use.

3. Peak daily demand

- GDC data shows that peak daily demand for domestic supply is 1.4 times of average daily demand.
- This increase represents higher seasonal use (e.g. garden irrigation) and seasonal increase in population.

Appendix C: Domestic water demand

Population

| Water supply | WRZ | | | | | | | | | | | | Total |
|------------------------|---------------|---------|------------|----------|---------|----------|-------------|-----------|-------------|--------|-------|-------|---------------|
| | Upper Waipaoa | Waikohu | Wharekopae | Whakaahu | Te Arai | Taruheru | Upper Flats | Mid Flats | Lower Flats | Waiapu | Uawa | Other | |
| Reticulated supply | | | | | | | | | | | | | |
| 2013 | 0 | 0 | 0 | 0 | 484 | 19,596 | 0 | 0 | 270 | 0 | 0 | 5,026 | 25,376 |
| 2023 | 0 | 0 | 0 | 0 | 490 | 19,650 | 0 | 10 | 300 | 0 | 0 | 5,200 | 25,650 |
| 2038 | 0 | 0 | 0 | 0 | 500 | 19,750 | 0 | 25 | 330 | 0 | 0 | 5,300 | 25,905 |
| 2063 | 0 | 0 | 0 | 0 | 525 | 19,850 | 0 | 40 | 360 | 0 | 0 | 5,400 | 26,175 |
| Non-reticulated supply | | | | | | | | | | | | | |
| 2013 | 453 | 275 | 274 | 439 | 154 | 1,537 | 726 | 1,221 | 288 | 2,044 | 1,113 | 1,218 | 9,742 |
| 2023 | 448 | 272 | 271 | 435 | 142 | 1,742 | 719 | 1,223 | 264 | 2,024 | 1,102 | 1,044 | 9,686 |
| 2038 | 435 | 264 | 263 | 422 | 113 | 1,192 | 697 | 1,184 | 222 | 1,963 | 1,069 | 757 | 8,581 |
| 2063 | 440 | 267 | 266 | 426 | 94 | 1,518 | 704 | 1,193 | 204 | 1,983 | 1,080 | 719 | 8,894 |
| Total | | | | | | | | | | | | | |
| 2013 | 453 | 275 | 274 | 439 | 638 | 21,133 | 726 | 1,221 | 558 | 2,044 | 1,113 | 6,244 | 35,118 |
| 2023 | 448 | 272 | 271 | 435 | 632 | 21,392 | 719 | 1,233 | 564 | 2,024 | 1,102 | 6,244 | 35,336 |
| 2038 | 435 | 264 | 263 | 422 | 613 | 20,942 | 697 | 1,209 | 552 | 1,963 | 1,069 | 6,057 | 34,486 |
| 2063 | 440 | 267 | 266 | 426 | 619 | 21,368 | 704 | 1,233 | 564 | 1,983 | 1,080 | 6,119 | 35,069 |

Average daily water demand (m³/d)

| Water supply | WRZ | | | | | | | | | | | | Total |
|------------------------|---------------|---------|------------|----------|---------|----------|-------------|-----------|-------------|--------|------|-------|--------------|
| | Upper Waipaoa | Waikohu | Wharekopae | Whakaahu | Te Arai | Taruheru | Upper Flats | Mid Flats | Lower Flats | Waiapu | Uawa | Other | |
| Reticulated supply | | | | | | | | | | | | | |
| 2013 | 0 | 0 | 0 | 0 | 127 | 5,154 | 0 | 0 | 71 | 0 | 0 | 1,322 | 6,674 |
| 2023 | 0 | 0 | 0 | 0 | 129 | 5,168 | 0 | 3 | 79 | 0 | 0 | 1,368 | 6,746 |
| 2038 | 0 | 0 | 0 | 0 | 132 | 5,194 | 0 | 7 | 87 | 0 | 0 | 1,394 | 6,813 |
| 2063 | 0 | 0 | 0 | 0 | 138 | 5,221 | 0 | 11 | 95 | 0 | 0 | 1,420 | 6,884 |
| Non-reticulated supply | | | | | | | | | | | | | |
| 2013 | 91 | 55 | 55 | 88 | 31 | 307 | 145 | 244 | 58 | 409 | 223 | 244 | 1,948 |
| 2023 | 90 | 54 | 54 | 87 | 28 | 348 | 144 | 245 | 53 | 405 | 220 | 209 | 1,937 |
| 2038 | 87 | 53 | 53 | 84 | 23 | 238 | 139 | 237 | 44 | 393 | 214 | 151 | 1,716 |
| 2063 | 88 | 53 | 53 | 85 | 19 | 304 | 141 | 239 | 41 | 397 | 216 | 144 | 1,779 |
| Total | | | | | | | | | | | | | |
| 2013 | 91 | 55 | 55 | 88 | 158 | 5,461 | 145 | 244 | 129 | 409 | 223 | 1,565 | 8,622 |
| 2023 | 90 | 54 | 54 | 87 | 157 | 5,516 | 144 | 247 | 132 | 405 | 220 | 1,576 | 8,683 |
| 2038 | 87 | 53 | 53 | 84 | 154 | 5,433 | 139 | 243 | 131 | 393 | 214 | 1,545 | 8,529 |
| 2063 | 88 | 53 | 53 | 85 | 157 | 5,524 | 141 | 249 | 135 | 397 | 216 | 1,564 | 8,663 |

Peak daily water demand (m³/d)

| Water supply | WRZ | | | | | | | | | | | | Total |
|------------------------|---------------|---------|------------|----------|---------|----------|-------------|-----------|-------------|--------|------|-------|---------------|
| | Upper Waipaoa | Waikohu | Wharekopae | Whakaahu | Te Arai | Taruheru | Upper Flats | Mid Flats | Lower Flats | Waiapu | Uawa | Other | |
| Reticulated supply | | | | | | | | | | | | | |
| 2013 | 0 | 0 | 0 | 0 | 178 | 7,215 | 0 | 0 | 99 | 0 | 0 | 1,851 | 9,343 |
| 2023 | 0 | 0 | 0 | 0 | 180 | 7,235 | 0 | 4 | 110 | 0 | 0 | 1,915 | 9,444 |
| 2038 | 0 | 0 | 0 | 0 | 184 | 7,272 | 0 | 9 | 122 | 0 | 0 | 1,951 | 9,538 |
| 2063 | 0 | 0 | 0 | 0 | 193 | 7,309 | 0 | 15 | 133 | 0 | 0 | 1,988 | 9,638 |
| Non-reticulated supply | | | | | | | | | | | | | |
| 2013 | 109 | 66 | 66 | 105 | 37 | 369 | 174 | 293 | 69 | 491 | 267 | 292 | 2,338 |
| 2023 | 108 | 65 | 65 | 104 | 34 | 418 | 173 | 294 | 63 | 486 | 264 | 251 | 2,325 |
| 2038 | 104 | 63 | 63 | 101 | 27 | 286 | 167 | 284 | 53 | 471 | 257 | 182 | 2,059 |
| 2063 | 106 | 64 | 64 | 102 | 23 | 364 | 169 | 286 | 49 | 476 | 259 | 173 | 2,135 |
| Total | | | | | | | | | | | | | |
| 2013 | 109 | 66 | 66 | 105 | 215 | 7,584 | 174 | 293 | 169 | 491 | 267 | 2,143 | 11,682 |
| 2023 | 108 | 65 | 65 | 104 | 214 | 7,653 | 173 | 297 | 174 | 486 | 264 | 2,165 | 11,769 |
| 2038 | 104 | 63 | 63 | 101 | 211 | 7,558 | 167 | 293 | 175 | 471 | 257 | 2,133 | 11,598 |
| 2063 | 106 | 64 | 64 | 102 | 216 | 7,673 | 169 | 301 | 182 | 476 | 259 | 2,161 | 11,772 |

Annual demand (m³/yr)

| Water supply | WRZ | | | | | | | | | | | | Total |
|------------------------|---------------|---------|------------|----------|---------|-----------|-------------|-----------|-------------|---------|--------|---------|------------------|
| | Upper Waipaoa | Waikohu | Wharekopae | Whakaahu | Te Arai | Taruheru | Upper Flats | Mid Flats | Lower Flats | Waiapu | Uawa | Other | |
| Reticulated supply | | | | | | | | | | | | | |
| 2013 | 0 | 0 | 0 | 0 | 46,462 | 1,881,118 | 0 | 0 | 25,919 | 0 | 0 | 482,471 | 2,435,969 |
| 2023 | 0 | 0 | 0 | 0 | 47,038 | 1,886,302 | 0 | 960 | 28,799 | 0 | 0 | 499,174 | 2,462,272 |
| 2038 | 0 | 0 | 0 | 0 | 47,998 | 1,895,901 | 0 | 2,400 | 31,678 | 0 | 0 | 508,774 | 2,486,750 |
| 2063 | 0 | 0 | 0 | 0 | 50,397 | 1,905,501 | 0 | 3,840 | 34,558 | 0 | 0 | 518,373 | 2,512,669 |
| Non-reticulated supply | | | | | | | | | | | | | |
| 2013 | 33,069 | 20,075 | 20,002 | 32,047 | 11,242 | 112,201 | 52,998 | 89,133 | 21,024 | 149,212 | 81,249 | 88,914 | 711,166 |
| 2023 | 32,704 | 19,856 | 19,783 | 31,755 | 10,366 | 127,166 | 52,487 | 89,279 | 19,272 | 147,752 | 80,446 | 76,212 | 707,078 |
| 2038 | 31,755 | 19,272 | 19,199 | 30,806 | 8,249 | 87,016 | 50,881 | 86,432 | 16,206 | 143,299 | 78,037 | 55,261 | 626,413 |
| 2063 | 32,120 | 19,491 | 19,418 | 31,098 | 6,862 | 110,814 | 51,392 | 87,089 | 14,892 | 144,759 | 78,840 | 52,487 | 649,262 |
| Total | | | | | | | | | | | | | |
| 2013 | 33,069 | 20,075 | 20,002 | 32,047 | 57,704 | 1,993,319 | 52,998 | 89,133 | 46,943 | 149,212 | 81,249 | 571,385 | 3,147,135 |
| 2023 | 32,704 | 19,856 | 19,783 | 31,755 | 57,404 | 2,013,468 | 52,487 | 90,239 | 48,071 | 147,752 | 80,446 | 575,386 | 3,169,350 |
| 2038 | 31,755 | 19,272 | 19,199 | 30,806 | 56,247 | 1,982,917 | 50,881 | 88,832 | 47,884 | 143,299 | 78,037 | 564,035 | 3,113,163 |
| 2063 | 32,120 | 19,491 | 19,418 | 31,098 | 57,259 | 2,016,315 | 51,392 | 90,929 | 49,450 | 144,759 | 78,840 | 570,860 | 3,161,931 |

DRAFT**Appendix D: Livestock water demand**

The following table shows the average and peak daily water demand per head for various livestock categories. These estimates were based on Aqualinc (2007).

| Stock category | Demand (l/c/d) | | |
|----------------|----------------|---------------|------|
| | 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 | |

Estimated average distribution of stock (Aqualinc, 2007)

| | |
|---|------|
| Dairy Cows | % |
| Dairy cows and heifers (over 2 years) in milk or calf | 0.75 |
| Dairy cows and heifers (over 2 years) NOT in milk or calf | 0.03 |
| Rising 1 year old dairy heifers and heifer calves | 0.20 |
| Dairy bulls to be used for breeding | 0.02 |
| | |
| Beef cattle | |
| Adult cows and bulls | 0.45 |
| Yearlings | 0.55 |
| | |
| Sheep | |
| Ewes | 0.67 |
| Hoggets | 0.33 |
| | |
| Deer | |
| Adult deer | 0.6 |
| Yearling deer | 0.4 |

Projected change in livestock numbers by WRZ

| | | Upper Waipaoa | Waikohu | Wharekopae | Whakaahu | Te Arai | Taruheru | Upper Flats | Mid Flats | Lower Flats | Waipapu | Uawa | Other | Total |
|--------|------|---------------|---------|------------|----------|---------|----------|-------------|-----------|-------------|---------|---------|---------|------------------|
| Sheep | 2013 | 197,000 | 98,000 | 92,000 | 23,000 | 51,000 | 3,000 | 20,000 | 25,000 | 18,000 | 170,000 | 136,000 | 527,000 | 1,360,000 |
| | 2023 | 187,150 | 93,100 | 87,400 | 21,850 | 48,450 | 2,000 | 19,000 | 23,750 | 17,100 | 164,900 | 131,920 | 511,190 | 1,307,810 |
| | 2038 | 177,793 | 88,445 | 83,030 | 20,758 | 46,028 | 1,500 | 18,050 | 22,563 | 16,245 | 159,953 | 127,962 | 495,854 | 1,258,180 |
| | 2063 | 168,903 | 84,023 | 78,879 | 19,720 | 43,726 | 1,000 | 17,148 | 21,434 | 15,433 | 155,154 | 124,124 | 480,979 | 1,210,521 |
| Cattle | 2013 | 30,000 | 15,000 | 15,000 | 6,000 | 9,000 | 2,000 | 5,000 | 6,000 | 5,000 | 30,000 | 24,000 | 93,000 | 240,000 |
| | 2023 | 30,900 | 15,450 | 15,450 | 6,180 | 9,270 | 1,800 | 4,800 | 5,500 | 4,600 | 31,500 | 25,200 | 97,650 | 248,300 |
| | 2038 | 31,827 | 15,914 | 15,914 | 6,365 | 9,548 | 1,700 | 4,700 | 5,200 | 4,400 | 33,075 | 26,460 | 102,533 | 257,635 |
| | 2063 | 32,782 | 16,391 | 16,391 | 6,556 | 9,835 | 1,500 | 4,500 | 5,000 | 4,000 | 34,729 | 27,783 | 107,659 | 267,125 |
| Dairy | 2013 | 1,000 | 800 | 300 | 800 | 2,000 | 500 | 400 | 400 | 800 | - | - | - | 7,000 |
| | 2023 | 3,000 | - | - | - | - | - | - | - | - | 4,500 | 4,500 | 3,000 | 15,000 |
| | 2038 | 3,000 | 3,000 | 3,000 | 3,000 | - | - | - | - | - | 4,500 | 4,500 | 3,000 | 24,000 |
| | 2063 | 3,000 | 3,000 | 3,000 | 3,000 | - | - | - | - | - | 4,500 | 4,500 | 3,000 | 24,000 |
| Deer | 2013 | 1,000 | 2,000 | 2,000 | 1,000 | 699 | - | 200 | 200 | 124 | 2,330 | 1,864 | 7,223 | 18,640 |
| | 2023 | 800 | 1,700 | 1,700 | 800 | 600 | - | 100 | 100 | 50 | 2,000 | 1,700 | 6,500 | 16,050 |
| | 2038 | 700 | 1,500 | 1,500 | 700 | 550 | - | - | - | - | 1,800 | 1,500 | 5,500 | 13,750 |
| | 2063 | 600 | 1,200 | 1,200 | 650 | 400 | - | - | - | - | 1,500 | 1,200 | 4,000 | 10,750 |

The following table presents estimated average and peak livestock water demand

| | WRZ | | | | | | | | | | | | Total |
|---|---------------|---------|------------|----------|---------|----------|-------------|-----------|-------------|---------|---------|-----------|------------------|
| | Upper Waipaoa | Waikohu | Wharekopae | Whakaahu | Te Arai | Taruheru | Upper Flats | Mid Flats | Lower Flats | Waiapu | Uawa | Other | |
| Average daily demand (m³/d) | | | | | | | | | | | | | |
| 2013 | 1,199 | 628 | 575 | 258 | 481 | 94 | 192 | 225 | 220 | 1,065 | 852 | 3,301 | 9,088 |
| 2023 | 1,385 | 573 | 561 | 198 | 326 | 47 | 155 | 182 | 146 | 1,481 | 1,260 | 3,689 | 10,004 |
| 2038 | 1,413 | 838 | 826 | 456 | 334 | 45 | 153 | 175 | 142 | 1,537 | 1,306 | 3,842 | 11,066 |
| 2063 | 1,444 | 854 | 843 | 467 | 342 | 39 | 149 | 171 | 133 | 1,595 | 1,354 | 4,002 | 11,394 |
| Peak daily demand (m³/d) | | | | | | | | | | | | | |
| 2013 | 2,143 | 1,113 | 1,034 | 433 | 796 | 147 | 329 | 390 | 364 | 1,929 | 1,543 | 5,979 | 16,199 |
| 2023 | 2,396 | 1,041 | 1,017 | 353 | 590 | 82 | 278 | 327 | 261 | 2,504 | 2,104 | 6,550 | 17,504 |
| 2038 | 2,439 | 1,399 | 1,375 | 702 | 602 | 78 | 274 | 314 | 254 | 2,596 | 2,179 | 6,808 | 19,020 |
| 2063 | 2,487 | 1,424 | 1,401 | 718 | 614 | 68 | 267 | 307 | 238 | 2,693 | 2,258 | 7,078 | 19,554 |
| Annual demand (m³/yr) | | | | | | | | | | | | | |
| 2013 | 434,098 | 226,521 | 208,918 | 91,294 | 168,891 | 32,422 | 68,610 | 80,923 | 77,427 | 388,621 | 310,896 | 1,204,724 | 3,293,346 |
| 2023 | 495,092 | 209,318 | 204,932 | 72,101 | 119,129 | 17,220 | 56,619 | 66,373 | 53,324 | 524,979 | 444,172 | 1,335,880 | 3,599,138 |
| 2038 | 505,097 | 295,114 | 290,865 | 155,716 | 121,942 | 16,277 | 55,911 | 63,893 | 51,830 | 545,012 | 460,599 | 1,391,566 | 3,953,822 |
| 2063 | 516,157 | 301,011 | 296,897 | 159,515 | 124,758 | 14,380 | 54,454 | 62,409 | 48,556 | 566,064 | 477,800 | 1,450,023 | 4,072,023 |

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Appendix E: Irrigation

The following table summarises the consented irrigated area distribution of different crops by WRZs

| WRZ | Consented irrigated area (ha) | | | | | | | Total |
|--------------|-------------------------------|----------|--------------|------------|-----------|------------|--------------|--------------|
| | Arable | Flowers | Fruit | Mix | Nursery | Pasture | Vegetable | |
| Uawa | | | | | | | 40 | 40 |
| Waikohu | | | 14 | | 37 | 52 | 782 | 885 |
| Whakaahu | | | 28 | | | 30 | 90 | 148 |
| Te Arai | | | 137 | | | | 136 | 273 |
| Taruheru | 292 | 1 | 381 | | | 131 | 880 | 1,685 |
| Upper Flats | 240 | | 59 | | | | 90 | 389 |
| Mid Flats | 200 | | 706 | 662 | | 1 | 676 | 2,245 |
| Lower Flats | | | 122 | | | 108 | 19 | 249 |
| Total | 732 | 1 | 1,447 | 662 | 37 | 322 | 2,712 | 5,913 |

Note: For the simplicity it is assumed that water demand for flowers, mixed crops and nursery is as same as for vegetable.

The irrigation water demand values used for different crops (Aqualinc, 2012a) are listed below

| Crop | Irrigation guidelines value for the Poverty Bay Flats (mm/yr) ^{*1} | | | Estimated annual irrigation demand (mm/yr) ^{*3} | | |
|-----------|---|-----|---|--|------|------|
| | Average | Max | 70 th percentile ^{*2} | 2023 | 2038 | 2063 |
| Vegetable | 575 | 720 | 630 | 636 | 649 | 662 |
| Fruit | 307 | 310 | 307 | 310 | 316 | 322 |
| Arable | 280 | 290 | 287 | 290 | 296 | 301 |
| Pasture | 598 | 638 | 611 | 617 | 629 | 642 |

^{*1} The average values for all the soil types including different soil depths modelled in Aqualinc (2012).
^{*2} 70th percentile values were adopted for this study. These values are considered to be conservative.
^{*3} The increased demand in 2023, 2038 and 2063 represent the potential higher crop water deficit due to global warming

The following table lists the estimate of total irrigable area and current consented irrigated area by WRZ

| | WRZ | | | | | | | | | | | | Total (ha) |
|---|---------------|---------|------------|----------|---------|----------|-------------|-----------|-------------|--------|-------|-------|---------------|
| | Upper Waipaoa | Waikohu | Wharekopae | Whakaahu | Te Arai | Taruheru | Upper Flats | Mid Flats | Lower Flats | Waiapu | Uawa | Other | |
| Current irrigated area (ha) | - | 885 | - | 148 | 273 | 1,685 | 389 | 2,245 | 249 | - | 40 | - | 5,913 |
| Irrigable total area based on slopes that are less than 7 ⁰ (ha)* | 3,993 | 2,022 | 1,997 | 2,013 | 3,625 | 5,023 | 2,434 | 5,860 | 3,211 | 16,331 | 7,578 | 6,164 | 60,250 |
| * The actual irrigable area can be significantly less as these values include lands at higher elevations and some areas are small land parcels that are not economical to irrigate. | | | | | | | | | | | | | |

Estimated distribution of irrigation area for various crops by years.

| | | Irrigated area (ha) | | | | | | | | | | | | |
|-----------|------|---------------------|---------|-------------|----------|---------|----------|-------------|-----------|-------------|--------|-------|-------|--------------|
| | | Upper Waipaoa | Waikohu | Wharekopaie | Whakaahu | Te Arai | Taruheru | Upper Flats | Mid Flats | Lower Flats | Waipuu | Uawa | Other | Total |
| Pasture | 2013 | - | 52 | - | 30 | - | 131 | - | 1 | 108 | - | - | - | 322 |
| | 2023 | 1,000 | - | - | - | - | - | - | - | - | 1,500 | 1,500 | 1,000 | 4,000 |
| | 2038 | 1,000 | 1,000 | 1,000 | 1,000 | - | - | - | - | - | 1,500 | 1,500 | 1,000 | 7,000 |
| | 2063 | 1,000 | 1,000 | 1,000 | 1,000 | - | - | - | - | - | 1,500 | 1,500 | 1,000 | 7,000 |
| Vegetable | 2013 | - | 819 | - | 90 | 136 | 881 | 90 | 1,338 | 19 | - | 40 | - | 3,412 |
| | 2023 | - | 900 | - | 108 | 160 | 970 | 200 | 1,605 | 50 | - | 40 | - | 4,033 |
| | 2038 | - | 945 | - | 130 | 180 | 1,066 | 250 | 1,926 | 75 | - | 40 | - | 4,612 |
| | 2063 | - | 945 | - | 156 | 210 | 1,173 | 300 | 2,311 | 100 | - | 40 | - | 5,235 |
| Fruit | 2013 | - | 14 | - | 28 | 137 | 381 | 59 | 706 | 122 | - | - | - | 1,447 |
| | 2023 | - | 50 | - | 60 | 200 | 350 | 75 | 800 | 150 | - | - | - | 1,685 |
| | 2038 | - | 50 | - | 75 | 225 | 325 | 100 | 900 | 200 | - | - | - | 1,875 |
| | 2063 | - | 50 | - | 75 | 250 | 325 | 150 | 1,000 | 200 | - | - | - | 2,050 |
| Arable | 2013 | - | - | - | - | - | 292 | 240 | 200 | - | - | - | - | 732 |
| | 2023 | - | - | - | - | - | 275 | 270 | 200 | - | 20 | - | - | 765 |
| | 2038 | - | - | - | - | - | 275 | 300 | 200 | - | 30 | - | - | 805 |
| | 2063 | - | - | - | - | - | 275 | 300 | 200 | - | 50 | - | - | 825 |

Estimated annual water demand for different crops and years by WRZs

| | | Irrigation demand (m ³ /yr) | | | | | | | | | | | | |
|-----------|------|--|-----------|------------|-----------|-----------|-----------|-------------|------------|-------------|-----------|-----------|-------|-------------------|
| | | Upper Waipaoa | Waikohu | Wharekopae | Whakaahu | Te Arai | Taruheru | Upper Flats | Mid Flats | Lower Flats | Waipuu | Uawa | Other | Total |
| Pasture | 2013 | - | 317,720 | - | 183,300 | - | 797,844 | - | 6,110 | 659,880 | - | - | - | 1,964,854 |
| | 2023 | 6,171,100 | | | | | | | | | 9,256,650 | 9,256,650 | | 24,684,400 |
| | 2038 | 6,293,300 | 6,293,300 | 6,293,300 | 6,293,300 | | | | | | 9,439,950 | 9,439,950 | | 44,053,100 |
| | 2063 | 6,415,500 | 6,415,500 | 6,415,500 | 6,415,500 | | | | | | 9,623,250 | 9,623,250 | | 44,908,500 |
| Vegetable | 2013 | | 5,156,550 | | 567,000 | 853,650 | 5,552,820 | 567,000 | 8,426,250 | 119,700 | | 252,000 | | 21,494,970 |
| | 2023 | | 5,728,927 | | 687,204 | 1,018,080 | 6,169,183 | 1,272,600 | 10,212,615 | 318,150 | | 254,520 | | 25,661,279 |
| | 2038 | | 6,134,490 | | 840,974 | 1,168,020 | 6,920,480 | 1,622,250 | 12,497,814 | 486,675 | | 259,560 | | 29,930,263 |
| | 2063 | | 6,253,606 | | 1,028,765 | 1,389,150 | 7,760,344 | 1,984,500 | 15,288,588 | 661,500 | | 264,600 | | 34,631,052 |
| Fruit | 2013 | | 42,980 | | 86,881 | 420,897 | 1,169,547 | 180,823 | 2,168,341 | 373,128 | - | - | - | 4,442,597 |
| | 2023 | | 155,035 | | 186,042 | 620,140 | 1,085,245 | 232,553 | 2,480,560 | 465,105 | | | | 5,224,680 |
| | 2038 | | 158,105 | | 237,158 | 711,473 | 1,027,683 | 316,210 | 2,845,890 | 632,420 | | | | 5,928,938 |
| | 2063 | | 161,175 | | 241,763 | 805,875 | 1,047,638 | 483,525 | 3,223,500 | 644,700 | | | | 6,608,175 |
| Arable | 2013 | - | - | - | - | - | 896,440 | 736,800 | 614,000 | - | - | - | - | 2,247,240 |
| | 2023 | | | | | | 852,693 | 837,189 | 620,140 | | 62,014 | | | 2,372,036 |
| | 2038 | | | | | | 869,578 | 948,630 | 632,420 | | 94,863 | | | 2,545,491 |
| | 2063 | | | | | | 886,463 | 967,050 | 644,700 | | 161,175 | | | 2,659,388 |

Appendix F: Frost protection

The following table shows the assumptions adopted for the determination of water used for frost protection and associated estimates of annual water consumption for this use.

| | Upper Flats | | | Mid Flats | | | Total water use (m ³ /y) |
|------|-------------|------------------|-------------------------------|-------------|------------------|-------------------------------|-------------------------------------|
| | No of farms | No of frost days | Water use (m ³ /y) | No of farms | No of frost days | Water use (m ³ /y) | |
| 2013 | 1 | 11 | 39,600 | 1 | 11 | 352,000 | 391,600 |
| 2023 | 3 | 8 | 86,400 | 3 | 8 | 768,000 | 854,400 |
| 2038 | 5 | 5 | 90,000 | 5 | 5 | 800,000 | 890,000 |
| 2063 | 7 | 3 | 75,600 | 7 | 3 | 672,000 | 747,600 |

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Appendix G: Petroleum

The following parameters were used to estimate average annual water demands for the petroleum industry.

| | |
|------------------------------------|------------------------|
| Number of hydraulic fractures/well | 4 |
| Water demand/day/well | 50 (m ³ /d) |
| No of days of operation/well | 50 days |

| WRZ | Number of wells | Annual demand (m ³ /y) |
|---------------------------------|-----------------|-----------------------------------|
| Upper Waipaoa | 15 | 150,000 |
| Waikohu | 7 | 70,000 |
| Wharekopae | 7 | 70,000 |
| Whakaahu | 3 | 30,000 |
| Te Arai | 10 | 100,000 |
| Taruheru | 0 | - |
| Upper Flats | 2 | 20,000 |
| Mid Flats | 0 | - |
| Lower Flats | 0 | - |
| Waiapu | 30 | 300,000 |
| Uawa | 10 | 100,000 |
| Other | 15 | 150,000 |
| Total (m³/yr) | 99 | 990,000 |

Appendix H: Rural residential water demand

The following table shows the estimated annual water consumption for rural residential blocks within each WRZ. These values exclude domestic and livestock demands.

Annual demand (m³/y)

| | WRZ | | | | | | | | | | | | Total |
|---|---------------|---------|-------------|----------|---------|----------|-------------|-----------|-------------|--------|--------|--------|----------------|
| | Upper Waipaoa | Waikohu | Wharekopaie | Whakaahu | Te Arai | Taruheru | Upper Flats | Mid Flats | Lower Flats | Waiapu | Uawa | Other | |
| Average daily demand (m³/d) | | | | | | | | | | | | | |
| 2013 | 6,359 | 3,861 | 3,847 | 6,163 | 2,162 | 21,577 | 10,192 | 17,141 | 4,043 | 28,695 | 15,625 | 17,099 | 273,525 |
| 2023 | 6,289 | 3,818 | 3,804 | 6,107 | 1,993 | 24,455 | 10,094 | 17,169 | 3,706 | 28,414 | 15,470 | 14,656 | 271,953 |
| 2038 | 6,107 | 3,706 | 3,692 | 5,924 | 1,586 | 16,734 | 9,785 | 16,622 | 3,117 | 27,558 | 15,007 | 10,627 | 240,928 |
| 2063 | 6,177 | 3,748 | 3,734 | 5,980 | 1,320 | 21,310 | 9,883 | 16,748 | 2,864 | 27,838 | 15,162 | 10,094 | 249,716 |

Appendix I: Allocable surface water flows

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

| WRZ | Data for monitored sites | | | | | Estimates made for the WRZ | | | | | |
|--|---------------------------------|----------------------|--------------------------------------|------------|--------------------------------------|-----------------------------|--|------------|----------------------|------------------|---|
| | Site | Low Flow Limit (l/s) | Approx. site area (km ²) | MALF (l/s) | Specific MALF (l/s/km ²) | WRZ area (km ²) | Estimated specific MALF (l/s/km ²) | MALF (l/s) | Allocable flow (l/s) | Allocated (l/s) | Annual availability (Mm ³ /y)* |
| Upper Waipaoa | | | | | | 819 | 1 | 819 | 410 | | 3.88 |
| Waikohu | Waikohu @ Mahaki Station Bridge | 187 | 246 | | | 1,002 | 1 | 1,002 | 501 | 373 | 4.74 |
| Wharekopae | Wharekopae @ Rangimoe | 128 | 162 | | | 318 | 1 | 318 | 159 | | 1.50 |
| Whakaahu | Whakaahu @ Brunton Road Weir | 15 | 103 | | | 118 | 1 | 118 | 59 | 13 | 0.56 |
| Te Arai | Te Arai @ Pykes Weir | 150 | 77 | 68 | 0.88 | 216 | 0.8 | 173 | 86 | 199 [#] | 0.82 |
| Taruheru | Taruheru @ Tucker Rd Bridge | 10 | 39 | | | 88 | 0.7 | 62 | 31 | 13 | 0.29 |
| Upper Flats | Waipaoa @ Kanakanaia Bridge | 1300 | 2,229 | 2000 | 0.90 | 90 | 0.9 | 2,000 | 1,000 | 442 | 9.46 |
| Mid Flats | Waipaoa @ Matawhero Bridge | 600 | 2,458 | 5746 | 2.34 | 229 | 2.34 | 5,746 | 1,873 | 1,864 | 17.72 |
| Lower Flats | | | | | | 47 | 2.34 | 6,033 | 1,144 | 24 | 10.82 |
| Waiapu | Waiapu River @ SH35 Br | | 1100 | 10.1 | 0.01 | 1,736 | 0.9 | 1,562 | 781 | 8 | 7.39 |
| Uawa | Hikuwai @ No.4 Bridge | 842 | 215 | 0.18 | 0.00 | 560 | 0.9 | 504 | 252 | 40 | 2.38 |
| Other | Waimata @ Monowai | 100 | 79 | 212 | 2.68 | 783 | 1.5 | 1,174 | 587 | | 5.56 |
| Total | | | | | | | | | | | 65.1 |
| <p>* It is assumed that the annual surface water availability is only 30% of the average daily availability over the year. It is recommended to use this conservative approach in the absence of annual records and flow data for some rivers/streams.</p> <p>[#] Includes a consent (55 l/s) granted for frost protection that can only be used in the months of September and October, which falls outside the high take summer period.</p> | | | | | | | | | | | |

Appendix J: Winter flow harvesting

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

| WRZ | Data for monitored sites | | | | Estimates made for the WRZ | | | |
|---------------|---------------------------------|--|------------------------|--|-----------------------------|---|------------------------------------|--|
| | Site | Approx. area above site (km ²) | Mean winter flow (l/s) | Mean specific winter flow (l/s/km ²) | WRZ area (km ²) | Estimated mean specific winter flow of WRZ (l/s/km ²) | Total volume (Mm ³ /yr) | Harvest potential (Mm ³ /y) |
| Upper Waipaoa | | | | | 819 | 20 | 254.9 | 76 |
| Waikohu | Waikohu @ Mahaki Station Bridge | 246 | | | 1,002 | 20 | 311.6 | 93 |
| Wharekopae | Wharekopae @ Rangimoe | 162 | | | 318 | 20 | 98.8 | 30 |
| Whakaahu | Whakaahu @ Brunton Road Weir | 103 | | | 118 | 20 | 36.8 | 11 |
| Te Arai | Te Arai @ Pykes Weir | 77 | | | 216 | 16 | 53.8 | 16 |
| Taruheru | Taruheru @ Tucker Rd Bridge | 39 | | | 88 | 15 | 20.5 | 6 |
| Upper Flats | Waipaoa @ Kanakanaia Bridge | 2,229 | | | 90 | 17 | 23.9 | 7 |
| Mid Flats | Waipaoa @ Matawhero Bridge | 2,458 | 51,816 | 21.1 | 229 | 16.9 | 60.1 | 18 |
| Lower Flats | | | | | 47 | 15 | 11 | 3 |
| Waiapu | Waiapu River @ SH35 Br | 1100 | 119,638 | 108.8 | 1,736 | 87 | 2,349.1 | 705 |
| Uawa | Hikuwai @ No.4 Bridge | 215 | 13,286 | 61.8 | 560 | 49.4 | 430.6 | 129 |
| Other | Waimata @ Monowai | 79 | 6,552 | 82.9 | 783 | 66.3 | 807.9 | 242 |
| Total | | | | | | | 4,459 | 1,338 |

Appendix K: Water resource summary

The table below presents the water resource summary for difference sources over the various study periods by WRZs.

| WRZ | Annual allocable resource (Mm ³ /yr) | | | | | | | | | | | | |
|---------------|---|-------------|-------------|-------------|---------------|-------------|-------------|-------------|-------------|--------------|--------------|--------------|--------------|
| | Groundwater | | | | Run-of-stream | | | | Reservoirs | Total | | | |
| | 2013 | 2023 | 2038 | 2063 | 2013 | 2023 | 2038 | 2063 | | 2013 | 2023 | 2038 | 2063 |
| Upper Waipaoa | 6.96 | 6.86 | 6.76 | 6.62 | 3.88 | 3.84 | 3.8 | 3.74 | | 10.84 | 10.7 | 10.55 | 10.36 |
| Waikohu | 7.01 | 6.91 | 6.8 | 6.66 | 4.74 | 4.69 | 4.64 | 4.57 | | 11.75 | 11.6 | 11.45 | 11.23 |
| Wharekopae | 1.75 | 1.72 | 1.69 | 1.66 | 1.5 | 1.49 | 1.47 | 1.45 | | 3.25 | 3.21 | 3.17 | 3.11 |
| Whakaahu | 0.59 | 0.58 | 0.57 | 0.56 | 0.56 | 0.55 | 0.55 | 0.54 | | 1.15 | 1.14 | 1.12 | 1.1 |
| Te Arai | 1.08 | 1.06 | 1.05 | 1.03 | 0.82 | 0.81 | 0.8 | 0.79 | 0.23 | 2.12 | 2.1 | 2.08 | 2.04 |
| Taruheru | | | | | 0.29 | 0.29 | 0.29 | 0.28 | 7.33 | | | | |
| Upper Flats | 12.8 | 12.6 | 12.4 | 12.2 | 9.46 | 9.37 | 9.27 | 9.13 | | 58.53 | 57.95 | 57.37 | 56.59 |
| Mid Flats | | | | | 17.72 | 17.54 | 17.37 | 17.1 | | | | | |
| Lower Flats | | | | | 10.82 | 10.71 | 10.6 | 10.44 | 0.11 | | | | |
| Waiapu | 17.36 | 17.1 | 16.84 | 16.49 | 7.39 | 7.32 | 7.24 | 7.13 | | 24.75 | 24.42 | 24.08 | 23.62 |
| Uawa | 4.48 | 4.41 | 4.35 | 4.26 | 2.38 | 2.36 | 2.34 | 2.3 | | 6.86 | 6.77 | 6.68 | 6.56 |
| Other | 7.05 | 6.94 | 6.84 | 6.69 | 5.56 | 5.5 | 5.44 | 5.36 | 3.01 | 15.61 | 15.45 | 15.29 | 15.06 |
| Total | 59.1 | 58.2 | 57.3 | 56.1 | 65.1 | 64.5 | 63.8 | 62.8 | 10.7 | 134.9 | 133.3 | 131.8 | 129.6 |

Appendix L: Water balance analysis

The following table shows the annual allocable flow, by source and totals, the annual demand and resulting balance for each WRZs

| Parameter | Water Resource Zone | | | | | | | | | | | | Total |
|---|---------------------|---------|------------|----------|---------|----------|-------------|-----------|-------------|---------|------|-------|---------------|
| | Upper Waipaoa | Waikohu | Wharekopae | Whakaahu | Te Arai | Taruheru | Upper Flats | Mid Flats | Lower Flats | Waipapu | Uawa | Other | |
| Annual allocable resource (m³/yr) | | | | | | | | | | | | | |
| Groundwater | | | | | | | | | | | | | |
| 2013 | 6.96 | 7.01 | 1.75 | 0.59 | 1.08 | | 12.80 | | | 17.36 | 4.48 | 7.05 | 59.08 |
| 2023 | 6.86 | 6.91 | 1.72 | 0.58 | 1.06 | | 12.61 | | | 17.1 | 4.41 | 6.94 | 58.20 |
| 2038 | 6.76 | 6.8 | 1.69 | 0.57 | 1.05 | | 12.42 | | | 16.84 | 4.35 | 6.84 | 57.31 |
| 2063 | 6.62 | 6.66 | 1.66 | 0.56 | 1.03 | | 12.16 | | | 16.49 | 4.26 | 6.69 | 56.13 |
| Run-of-stream | | | | | | | | | | | | | |
| 2013 | 3.88 | 4.74 | 1.5 | 0.56 | 0.82 | 0.29 | 9.46 | 17.72 | 10.82 | 7.39 | 2.38 | 5.56 | 65.12 |
| 2023 | 3.84 | 4.69 | 1.49 | 0.55 | 0.81 | 0.29 | 9.37 | 17.54 | 10.71 | 7.32 | 2.36 | 5.5 | 64.47 |
| 2038 | 3.80 | 4.64 | 1.47 | 0.55 | 0.8 | 0.29 | 9.27 | 17.37 | 10.6 | 7.24 | 2.34 | 5.44 | 63.82 |
| 2063 | 3.74 | 4.57 | 1.45 | 0.54 | 0.79 | 0.28 | 9.13 | 17.1 | 10.44 | 7.13 | 2.3 | 5.36 | 62.84 |
| Reservoirs | | | | | 0.23 | 7.33 | | | | 0.11 | | 3.01 | 10.68 |
| Total | | | | | | | | | | | | | |
| 2013 | 10.84 | 11.75 | 3.25 | 1.15 | 2.12 | 13.48 | 10.24 | 23.26 | 11.57 | 24.75 | 6.86 | 15.61 | 134.88 |
| 2023 | 10.7 | 11.6 | 3.21 | 1.14 | 2.1 | 13.39 | 10.13 | 23 | 11.45 | 24.42 | 6.77 | 15.45 | 133.34 |
| 2038 | 10.55 | 11.45 | 3.17 | 1.12 | 2.08 | 13.29 | 10.03 | 22.74 | 11.33 | 24.08 | 6.68 | 15.29 | 131.81 |
| 2063 | 10.36 | 11.23 | 3.11 | 1.1 | 2.04 | 13.17 | 9.87 | 22.36 | 11.16 | 23.62 | 6.56 | 15.06 | 129.65 |
| Note: For simplicity, it was assumed that the groundwater available for Taruheru, Upper Flats, Mid Flats and Lower Flats WRZs is proportional to the current resource demand, eg. the total resource for the Poverty Bay Flats, 12.8 Mm ³ /yr for 2013 was distributed for the WRZs based on current demand. | | | | | | | | | | | | | |

| Parameter | Water Resource Zone | | | | | | | | | | | | Total |
|--|---------------------|---------|------------|----------|---------|----------|-------------|-----------|-------------|---------|-------|-------|---------------|
| | Upper Waipaoa | Waikohu | Wharekopae | Whakaahu | Te Arai | Taruheru | Upper Flats | Mid Flats | Lower Flats | Waipapu | Uawa | Other | |
| Demand (Mm³/yr) | | | | | | | | | | | | | |
| 2013 | 0.47 | 5.77 | 0.23 | 0.97 | 1.51 | 12.42 | 1.66 | 11.79 | 1.35 | 0.57 | 0.66 | 1.79 | 39.19 |
| 2023 | 6.86 | 6.19 | 0.30 | 1.01 | 1.92 | 12.51 | 2.82 | 14.84 | 1.14 | 10.32 | 10.15 | 2.08 | 70.13 |
| 2038 | 6.99 | 12.97 | 6.68 | 7.59 | 2.17 | 13.76 | 3.61 | 17.79 | 1.47 | 10.55 | 10.35 | 2.12 | 96.05 |
| 2063 | 7.12 | 13.22 | 6.81 | 7.91 | 2.49 | 14.68 | 4.15 | 20.82 | 1.66 | 10.82 | 10.56 | 2.18 | 102.42 |
| Water balance (Mm³/yr) | | | | | | | | | | | | | |
| 2013 | 10.4 | 6.0 | 3.0 | 0.2 | 0.6 | 1.1 | 8.6 | 11.5 | 10.2 | 24.2 | 6.2 | 13.8 | 95.7 |
| 2023 | 3.8 | 5.4 | 2.9 | 0.1 | 0.2 | 0.9 | 7.3 | 8.2 | 10.3 | 14.1 | -3.4 | 13.4 | 63.2 |
| 2038 | 3.6 | -1.5 | -3.5 | -6.5 | -0.1 | -0.5 | 6.4 | 5.0 | 9.9 | 13.5 | -3.7 | 13.2 | 35.8 |
| 2063 | 3.2 | -2.0 | -3.7 | -6.8 | -0.4 | -1.5 | 5.7 | 1.5 | 9.5 | 12.8 | -4.0 | 12.9 | 27.2 |

The resulting water balance by catchment (Mm³/yr) is shown below

| Horizon | Catchment | | | | Total |
|---------|-----------------|---------|------|-------|-------------|
| | Greater Waipaoa | Waipapu | Uawa | Other | |
| 2013 | 51.5 | 24.2 | 6.2 | 13.8 | 95.7 |
| 2023 | 39.1 | 14.1 | -3.4 | 13.4 | 63.2 |
| 2038 | 12.7 | 13.5 | -3.7 | 13.2 | 35.8 |
| 2063 | 5.5 | 12.8 | -4.0 | 12.9 | 27.2 |

The following table shows the allocable flow for surface water and the peak flow demand by use and the resulting balance by WRZs (m³/d)

| Parameter | Water Resource Zone | | | | | | | | | | | | Total |
|--|---------------------|---------|------------|----------|---------|----------|-------------|-----------|-------------|--------|--------|--------|----------------|
| | Upper Waipaoa | Waikohu | Wharekopae | Whakaahu | Te Arai | Taruheru | Upper Flats | Mid Flats | Lower Flats | Waipuu | Uawa | Other | |
| Allocable daily volumes (m³/d) | | | | | | | | | | | | | |
| 2013 | 35,397 | 43,276 | 13,719 | 5,112 | 7,471 | 2,661 | 86,400 | 161,827 | 98,811 | 67,496 | 21,774 | 50,734 | 594,680 |
| 2023 | 35,043 | 42,844 | 13,582 | 5,061 | 7,397 | 2,634 | 85,536 | 160,209 | 97,823 | 66,821 | 21,557 | 50,227 | 588,734 |
| 2038 | 34,689 | 42,411 | 13,445 | 5,010 | 7,322 | 2,608 | 84,672 | 158,591 | 96,835 | 66,147 | 21,339 | 49,720 | 582,787 |
| 2063 | 34,158 | 41,762 | 13,239 | 4,933 | 7,210 | 2,568 | 83,376 | 156,163 | 95,353 | 65,134 | 21,012 | 48,959 | 573,867 |
| Peak daily demand (m³/d) | | | | | | | | | | | | | |
| Domestic | | | | | | | | | | | | | |
| 2013 | | | | | | 368.9 | | | | 40 | | | 409 |
| 2023 | | | | | | 418.1 | | | | 40 | | | 458 |
| 2038 | | | | | | 286.1 | | | | 40 | | | 326 |
| 2063 | | | | | | 364.3 | | | | 40 | | | 404 |
| Live stock | | | | | | | | | | | | | |
| 2013 | 643 | 334 | 310 | 130 | 239 | 44 | 99 | 117 | 109 | 579 | 463 | 1,794 | 4,860 |
| 2023 | 719 | 312 | 305 | 106 | 177 | 25 | 83 | 98 | 78 | 751 | 631 | 1,965 | 5,251 |
| 2038 | 732 | 420 | 413 | 210 | 181 | 23 | 82 | 94 | 76 | 779 | 654 | 2,042 | 5,706 |
| 2063 | 746 | 427 | 420 | 215 | 184 | 21 | 80 | 92 | 71 | 808 | 677 | 2,124 | 5,866 |
| Irrigation | | | | | | | | | | | | | |
| 2013 | - | 48,648 | - | 2,750 | 14,553 | 330 | 21,390 | 115,742 | 7,779 | - | 2,200 | - | 213,391 |
| 2023 | 36,667 | 52,269 | - | 6,292 | 19,158 | 48,694 | 29,975 | 134,389 | 5,325 | 55,733 | 2,200 | - | 390,703 |
| 2038 | 36,667 | 109,745 | 36,667 | 62,667 | 21,553 | 51,332 | 35,750 | 156,164 | 7,406 | 56,100 | 2,200 | - | 576,250 |
| 2063 | 36,667 | 109,745 | 36,667 | 63,618 | 24,498 | 55,243 | 41,250 | 181,325 | 8,322 | 56,833 | 2,200 | - | 616,367 |

| Parameter | Water Resource Zone | | | | | | | | | | | | Total |
|---|---------------------|---------|------------|----------|---------|----------|-------------|-----------|-------------|--------|--------|--------|---------|
| | Upper Waipaoa | Waikohu | Wharekopae | Whakaahu | Te Arai | Taruheru | Upper Flats | Mid Flats | Lower Flats | Waipuu | Uawa | Other | |
| Industry | | | | | | | | | | | | | |
| 2013 | - | - | - | - | - | 128 | - | - | 205 | - | - | - | 333 |
| 2023 | 750 | 350 | 350 | 150 | 500 | - | 100 | - | - | 1,500 | 500 | 750 | 4,950 |
| 2038 | 750 | 350 | 350 | 150 | 500 | - | 100 | - | - | 1,500 | 500 | 750 | 4,950 |
| 2063 | 750 | 350 | 350 | 150 | 500 | - | 100 | - | - | 1,500 | 500 | 750 | 4,950 |
| Note: GDC source water from reservoirs. No recreational and rural residential surface water takes. Forest protection takes were not considered for this peak surface water balance as those takes are limited to non-summer months. | | | | | | | | | | | | | |
| Total peak demand (m³/d) | | | | | | | | | | | | | |
| 2013 | 643 | 48,981 | 310 | 2,880 | 14,792 | 871 | 21,488 | 115,859 | 8,093 | 619 | 2,663 | 1,794 | 218,992 |
| 2023 | 38,136 | 52,932 | 655 | 6,548 | 19,835 | 49,137 | 30,158 | 134,487 | 5,403 | 58,024 | 3,331 | 2,715 | 401,362 |
| 2038 | 38,148 | 110,515 | 37,429 | 63,028 | 22,234 | 51,642 | 35,932 | 156,258 | 7,482 | 58,419 | 3,354 | 2,792 | 587,232 |
| 2063 | 38,163 | 110,522 | 37,437 | 63,983 | 25,182 | 55,628 | 41,430 | 181,417 | 8,394 | 59,181 | 3,377 | 2,874 | 627,588 |
| Peak surface water balance (m³/d) | | | | | | | | | | | | | |
| 2013 | 34,754 | -5,705 | 13,409 | 2,232 | -7,320 | 1,790 | 64,912 | 45,968 | 90,718 | 66,878 | 19,111 | 48,941 | 375,688 |
| 2023 | -3,093 | -10,088 | 12,927 | -1,487 | -12,438 | -46,503 | 55,378 | 25,722 | 92,420 | 8,797 | 18,225 | 47,512 | 187,372 |
| 2038 | -3,460 | -68,104 | -23,984 | -58,018 | -14,911 | -49,034 | 48,740 | 2,333 | 89,353 | 7,728 | 17,985 | 46,927 | -4,445 |
| 2063 | -4,005 | -68,761 | -24,198 | -59,050 | -17,972 | -53,060 | 41,946 | -25,254 | 86,959 | 5,953 | 17,635 | 46,085 | -53,721 |

The peak daily surface water balance by catchment (m³/d) is presented below;

| Horizon | Catchment | | | | Total |
|---------|-----------------|--------|--------|--------|----------------|
| | Greater Waipaoa | Waipuu | Uawa | Other | |
| 2013 | 240,758 | 66,878 | 19,111 | 48,941 | 375,688 |
| 2023 | 112,837 | 8,797 | 18,225 | 47,512 | 187,372 |
| 2038 | -77,085 | 7,728 | 17,985 | 46,927 | -4,445 |
| 2063 | -123,394 | 5,953 | 17,635 | 46,085 | -53,721 |

The following table shows the annual allocable flow for groundwater and the demand by use and the resulting balance by WRZs (m³/yr)

| Parameter | Water Resource Zone | | | | | | | | | | | | Total |
|--|---------------------|---------|------------|----------|---------|----------|-------------|-----------|-------------|--------|-------|-------|--------------|
| | Upper Waipaoa | Waikohu | Wharekopae | Whakaahu | Te Arai | Taruheru | Upper Flats | Mid Flats | Lower Flats | Waiapu | Uawa | Other | |
| Allocable annual volumes (Mm³/y) | | | | | | | | | | | | | |
| 2013 | 6.96 | 7.01 | 1.75 | 0.59 | 1.08 | | 12.8 | | | 17.36 | 4.48 | 7.05 | 59.08 |
| 2023 | 6.86 | 6.91 | 1.72 | 0.58 | 1.06 | | 12.6 | | | 17.1 | 4.41 | 6.94 | 58.20 |
| 2038 | 6.76 | 6.8 | 1.69 | 0.57 | 1.05 | | 12.4 | | | 16.84 | 4.35 | 6.84 | 57.31 |
| 2063 | 6.62 | 6.66 | 1.66 | 0.56 | 1.03 | | 12.2 | | | 16.49 | 4.26 | 6.69 | 56.13 |
| Peak daily demand (Mm³/yr) | | | | | | | | | | | | | |
| Domestic | | | | | | | | | | | | | |
| 2013 | 0.017 | 0.010 | 0.010 | 0.016 | 0.006 | 0.056 | 0.026 | 0.045 | 0.011 | 0.075 | 0.041 | 0.044 | 0.36 |
| 2023 | 0.016 | 0.010 | 0.010 | 0.016 | 0.005 | 0.064 | 0.026 | 0.045 | 0.010 | 0.074 | 0.040 | 0.038 | 0.35 |
| 2038 | 0.016 | 0.010 | 0.010 | 0.015 | 0.004 | 0.044 | 0.025 | 0.043 | 0.008 | 0.072 | 0.039 | 0.028 | 0.31 |
| 2063 | 0.016 | 0.010 | 0.010 | 0.016 | 0.003 | 0.055 | 0.026 | 0.044 | 0.007 | 0.072 | 0.039 | 0.026 | 0.33 |
| Live stock | | | | | | | | | | | | | |
| 2013 | 0.304 | 0.159 | 0.146 | 0.064 | 0.118 | 0.023 | 0.048 | 0.057 | 0.054 | 0.272 | 0.218 | 0.843 | 2.31 |
| 2023 | 0.347 | 0.147 | 0.143 | 0.050 | 0.083 | 0.012 | 0.040 | 0.046 | 0.037 | 0.367 | 0.311 | 0.935 | 2.52 |
| 2038 | 0.354 | 0.207 | 0.204 | 0.109 | 0.085 | 0.011 | 0.039 | 0.045 | 0.036 | 0.382 | 0.322 | 0.974 | 2.77 |
| 2063 | 0.361 | 0.211 | 0.208 | 0.112 | 0.087 | 0.010 | 0.038 | 0.044 | 0.034 | 0.396 | 0.334 | 1.015 | 2.85 |
| Irrigation | | | | | | | | | | | | | |
| 2013 | 0.000 | 0.000 | 0.000 | 0.592 | 0.025 | 8.398 | 0.000 | 0.610 | 0.445 | 0.000 | 0.000 | 0.000 | 10.07 |
| 2023 | 2.057 | 0.000 | 0.000 | 0.284 | 0.036 | 3.253 | 0.000 | 0.714 | 0.374 | 3.106 | 3.086 | 0.000 | 12.91 |
| 2038 | 2.098 | 0.000 | 2.098 | 0.350 | 0.042 | 3.501 | 0.000 | 0.851 | 0.527 | 3.178 | 3.147 | 0.000 | 15.79 |
| 2063 | 2.139 | 0.000 | 2.139 | 0.414 | 0.047 | 3.804 | 0.000 | 1.010 | 0.592 | 3.261 | 3.208 | 0.000 | 16.61 |

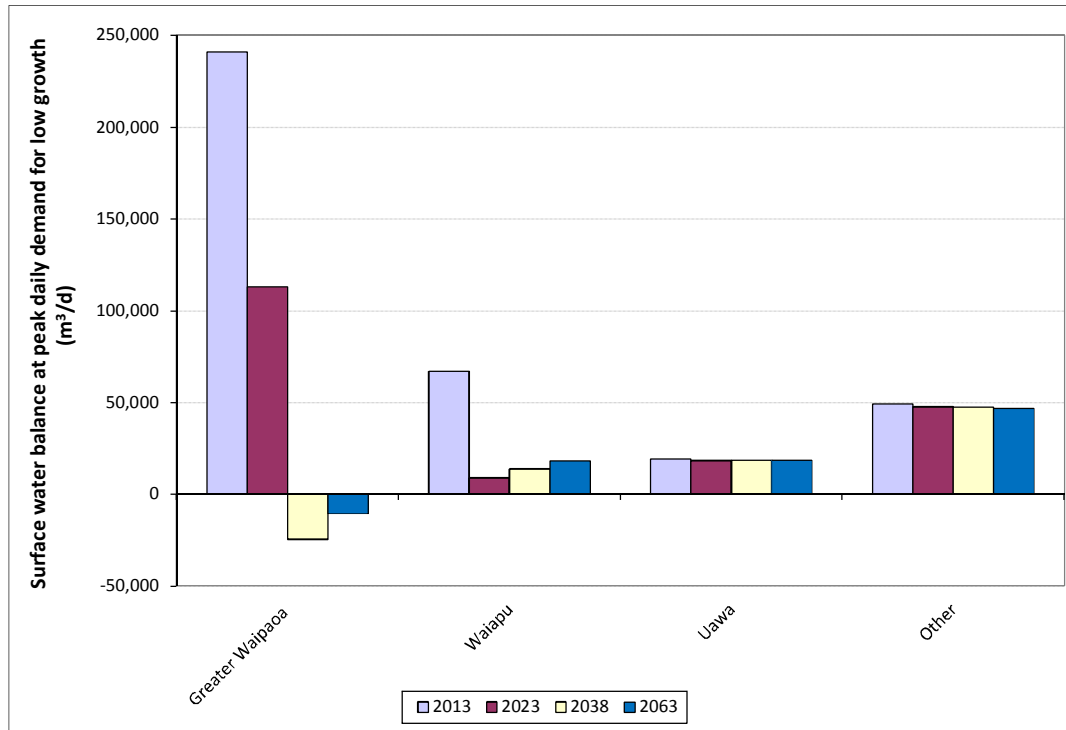
| Parameter | Water Resource Zone | | | | | | | | | | | | Total |
|--|---------------------|---------|------------|----------|---------|----------|-------------|-----------|-------------|---------|-------|-------|--------------|
| | Upper Waipaoa | Waikohu | Wharekopae | Whakaahu | Te Arai | Taruheru | Upper Flats | Mid Flats | Lower Flats | Waiaapu | Uawa | Other | |
| Industry | | | | | | | | | | | | | |
| 2013 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.038 | 0.000 | 0.000 | 0.062 | 0.000 | 0.000 | 0.000 | 0.10 |
| 2023 | 0.000 | 0.000 | 0.000 | 0.000 | 0.001 | 0.213 | 0.125 | 0.250 | 0.123 | 0.000 | 0.000 | 0.000 | 0.71 |
| 2038 | 0.000 | 0.000 | 0.000 | 0.000 | 0.002 | 0.503 | 0.250 | 0.375 | 0.123 | 0.000 | 0.000 | 0.000 | 1.25 |
| 2063 | 0.000 | 0.000 | 0.000 | 0.000 | 0.002 | 0.503 | 0.250 | 0.375 | 0.123 | 0.000 | 0.000 | 0.000 | 1.25 |
| Rural residential | | | | | | | | | | | | | |
| 2013 | 0.006 | 0.004 | 0.004 | 0.006 | 0.002 | 0.022 | 0.010 | 0.017 | 0.004 | 0.029 | 0.016 | 0.017 | 0.14 |
| 2023 | 0.006 | 0.004 | 0.004 | 0.006 | 0.002 | 0.024 | 0.010 | 0.017 | 0.004 | 0.028 | 0.015 | 0.015 | 0.14 |
| 2038 | 0.006 | 0.004 | 0.004 | 0.006 | 0.002 | 0.017 | 0.010 | 0.017 | 0.003 | 0.028 | 0.015 | 0.011 | 0.12 |
| 2063 | 0.006 | 0.004 | 0.004 | 0.006 | 0.001 | 0.021 | 0.010 | 0.017 | 0.003 | 0.028 | 0.015 | 0.010 | 0.12 |
| Total annual groundwater demand (Mm³/yr) | | | | | | | | | | | | | |
| 2013 | 0.33 | 0.17 | 0.16 | 0.68 | 0.15 | | 9.93 | | | 0.38 | 0.27 | 0.90 | 12.97 |
| 2023 | 2.43 | 0.16 | 0.16 | 0.36 | 0.13 | | 5.39 | | | 3.58 | 3.45 | 0.99 | 16.63 |
| 2038 | 2.47 | 0.22 | 2.31 | 0.48 | 0.13 | | 6.43 | | | 3.66 | 3.52 | 1.01 | 20.25 |
| 2063 | 2.52 | 0.22 | 2.36 | 0.55 | 0.14 | | 6.97 | | | 3.76 | 3.60 | 1.05 | 21.17 |
| Annual groundwater balance (Mm³/yr) | | | | | | | | | | | | | |
| 2013 | 6.64 | 6.84 | 1.59 | -0.09 | 0.93 | | 2.87 | | | 16.98 | 4.21 | 6.14 | 46.1 |
| 2023 | 4.43 | 6.75 | 1.56 | 0.23 | 0.94 | | 7.22 | | | 13.52 | 0.96 | 5.95 | 41.6 |
| 2038 | 4.28 | 6.58 | -0.62 | 0.09 | 0.91 | | 5.99 | | | 13.18 | 0.82 | 5.82 | 37.1 |
| 2063 | 4.09 | 6.44 | -0.70 | 0.02 | 0.89 | | 5.19 | | | 12.73 | 0.66 | 5.64 | 35.0 |

The annual groundwater balance by catchment (Mm³/yr) is;

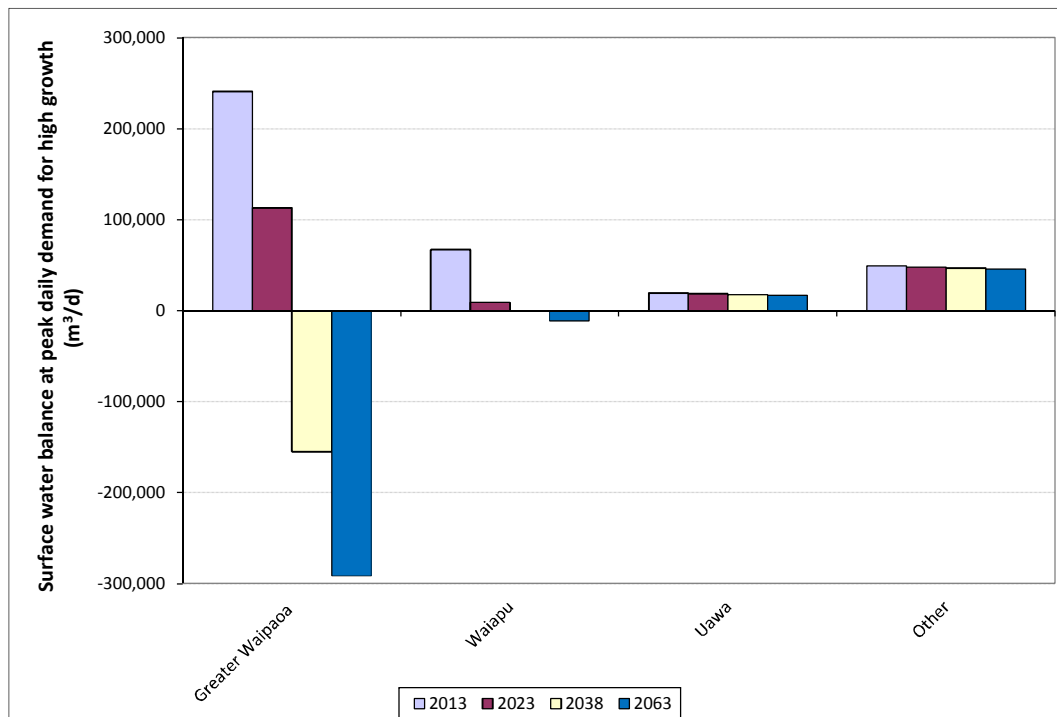
| Horizon | Catchment | | | | Total |
|---------|-----------------|--------|------|-------|-------------|
| | Greater Waipaoa | Waiapu | Uawa | Other | |
| 2013 | 18.8 | 17.0 | 4.2 | 6.1 | 46.1 |
| 2023 | 21.1 | 13.5 | 1.0 | 6.0 | 41.6 |
| 2038 | 17.2 | 13.2 | 0.8 | 5.8 | 37.1 |
| 2063 | 15.9 | 12.7 | 0.7 | 5.6 | 35.0 |

Appendix M: Sensitivity analysis by catchments

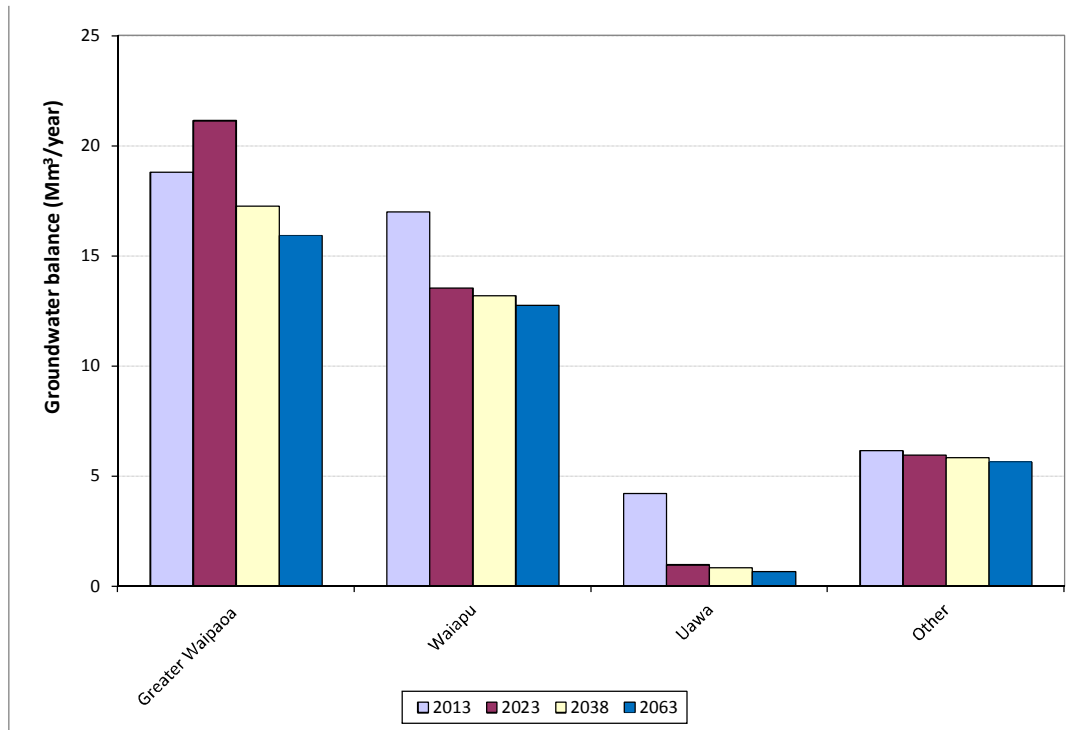
The following figures show the sensitivity analysis of the water balance analysis for low and high growth scenarios for different water resource by catchment.



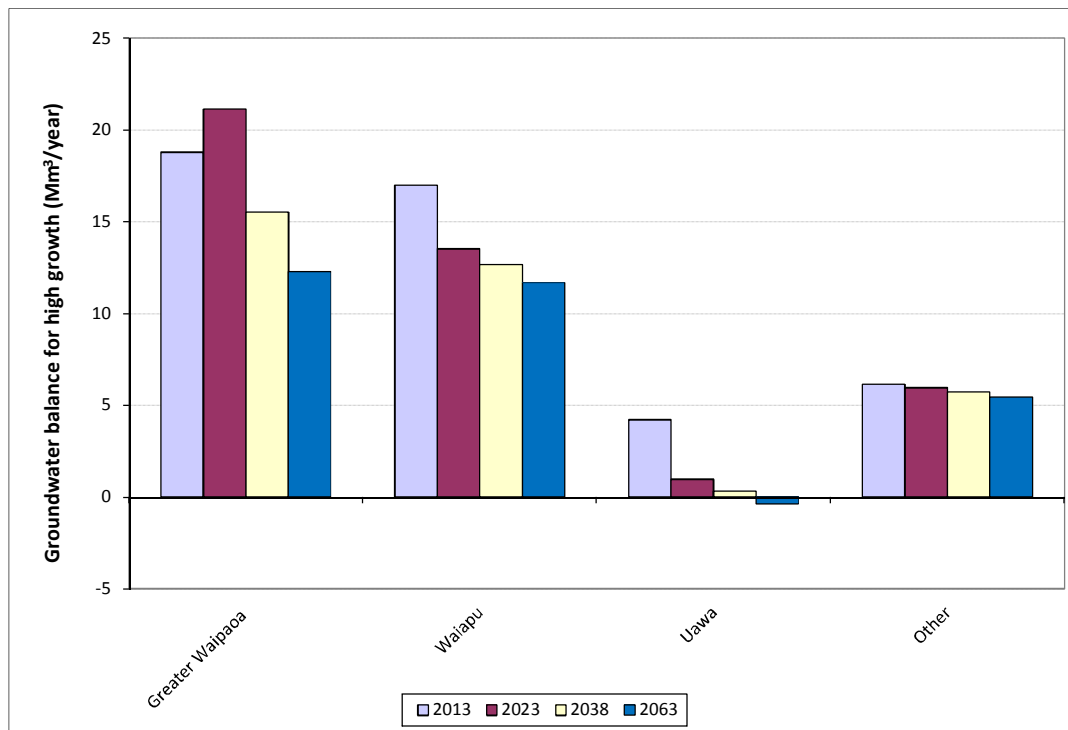
Surface water balance at peak daily demand for the low growth scenario



Surface water balance at peak daily demand for the high growth scenario



Annual groundwater balance for the low growth scenario



Annual groundwater balance for the high growth scenario