1. History

1.1 Security of supply

Greater Wellington Regional Council operates to a security of supply (reliability) standard for bulk water that requires the supply to be capable of meeting consumer demand in all but a 1-in-50 year drought. The security of supply is calculated by GWRC's Sustainable Yield Model (SYM) as a percentage annual shortfall probability (% ASP). Water supply development is planned to avoid the security of supply level rising above 2% ASP (which can be equated to a 1-in-50 year drought).

The 2% ASP standard has been Council policy since 1999. A consultant report in 2011 identified it to be a reasonable target for GWRC given the high level of reliance on run-of-river source water and the low volume of water storage. The 2% ASP standard was also identified as the most common level of service target used by water providers reviewed in New Zealand, UK, USA, Canada and Australia.

The security of supply policy of 2% ASP was reconfirmed by the Council in 2011 following consultation with the four city customers.

1.2 Population projections

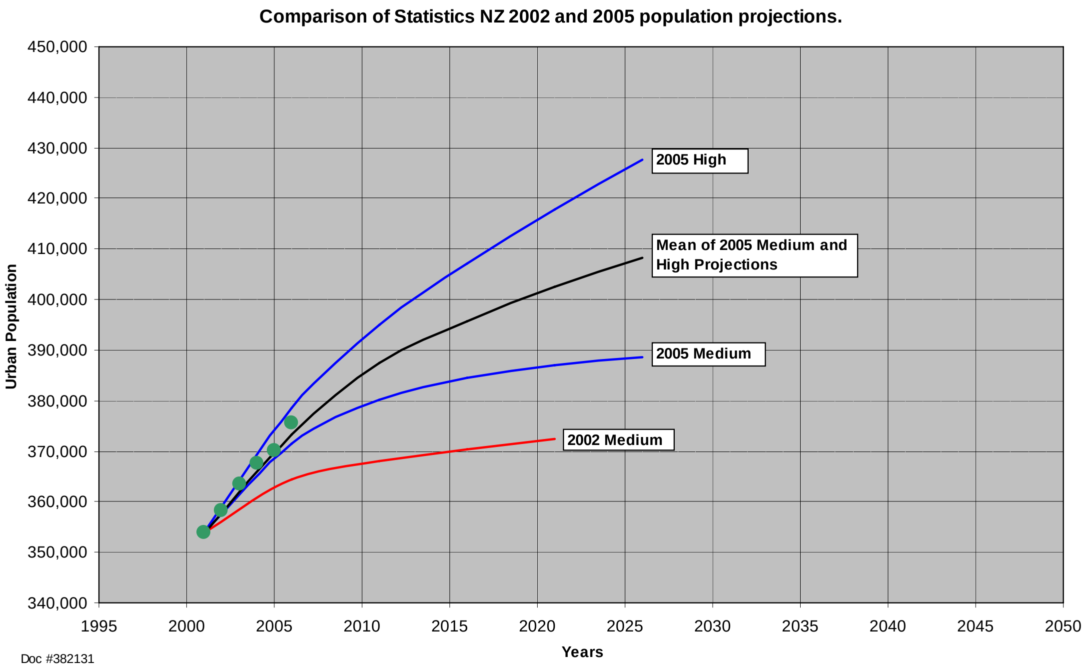
The estimated population for each reporting year and the projected future population are obtained from Statistics New Zealand (population figures are only actual for census years). The annual figures are obtained from "annual estimates of sub-regional urban population" and the 25-year population projections used are the "usually resident urban population", which is very close to the population served by the bulk water supply.

We rely on the Statistics NZ population projections to plan the timing of water asset development. These projections are extrapolated by GWRC staff from 2031 to 2100 for longer-term modelling.

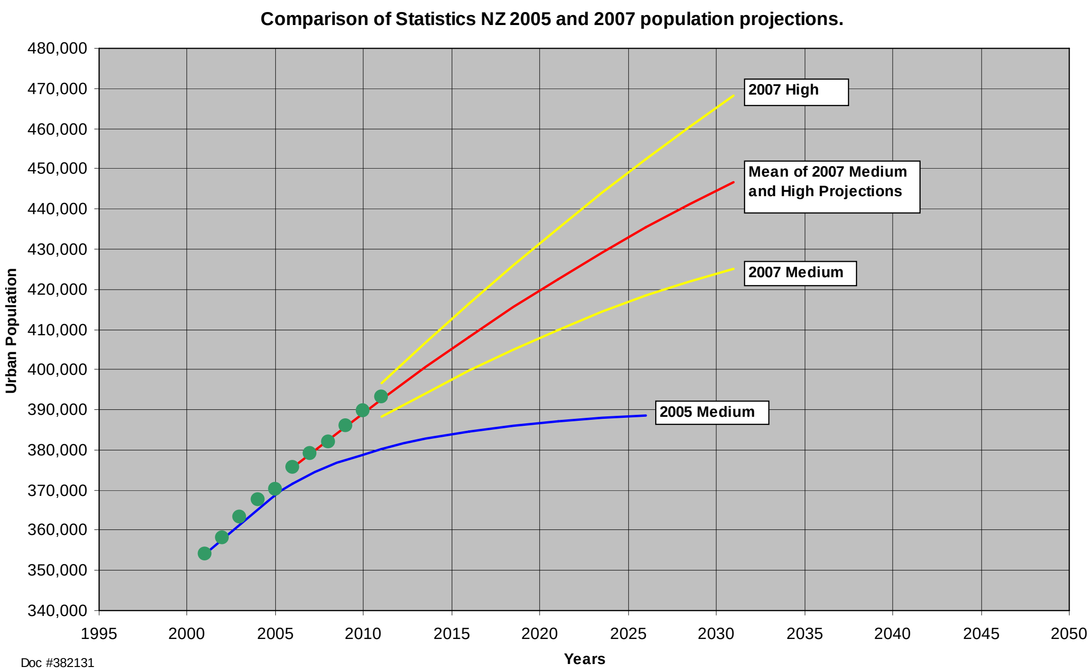
Prior to 2005, Statistics NZ medium population projection figures were used in security of supply modelling. However in 2005 Statistics NZ made a step change in their projections that resulted in a significant increase in population numbers. The effect was to greatly reduce the time before water development would be required to maintain the 2% ASP standard.

The analysis of the new projections concluded that a projection curve midway between the Statistics NZ medium projection and high projection scenarios was more consistent with annual estimated (i.e. actual) population figures and provided a slightly conservative approach. The average (mean) of Statistics NZ medium and high projection scenarios was therefore adopted for planning purposes.

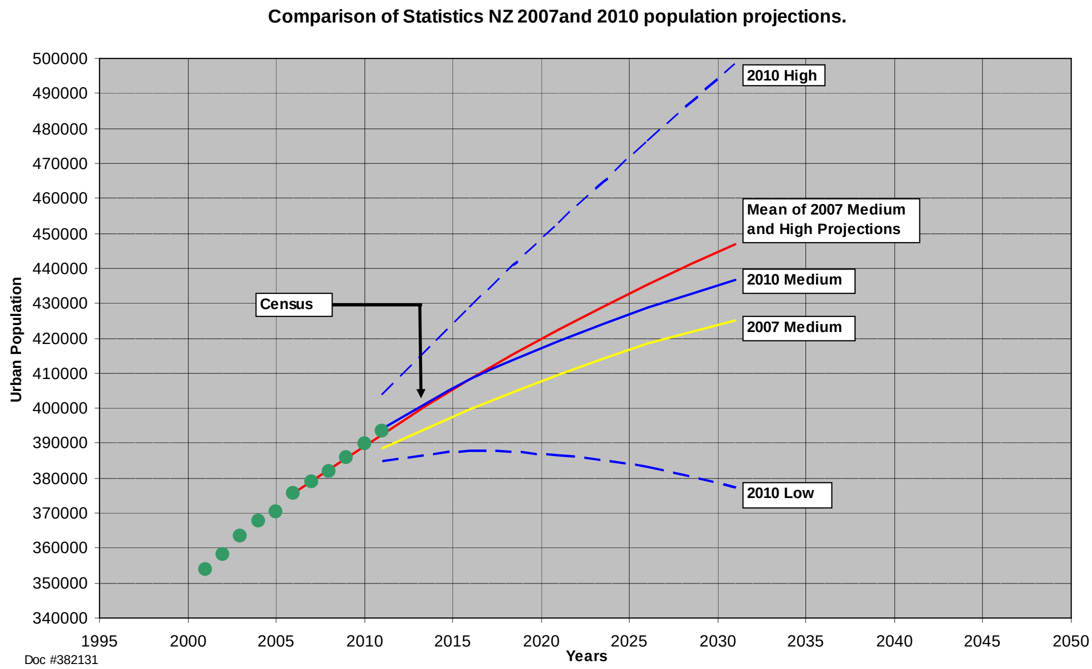
The step change by Statistics NZ and GWRC's adopted projection curve are both shown in the following graph.



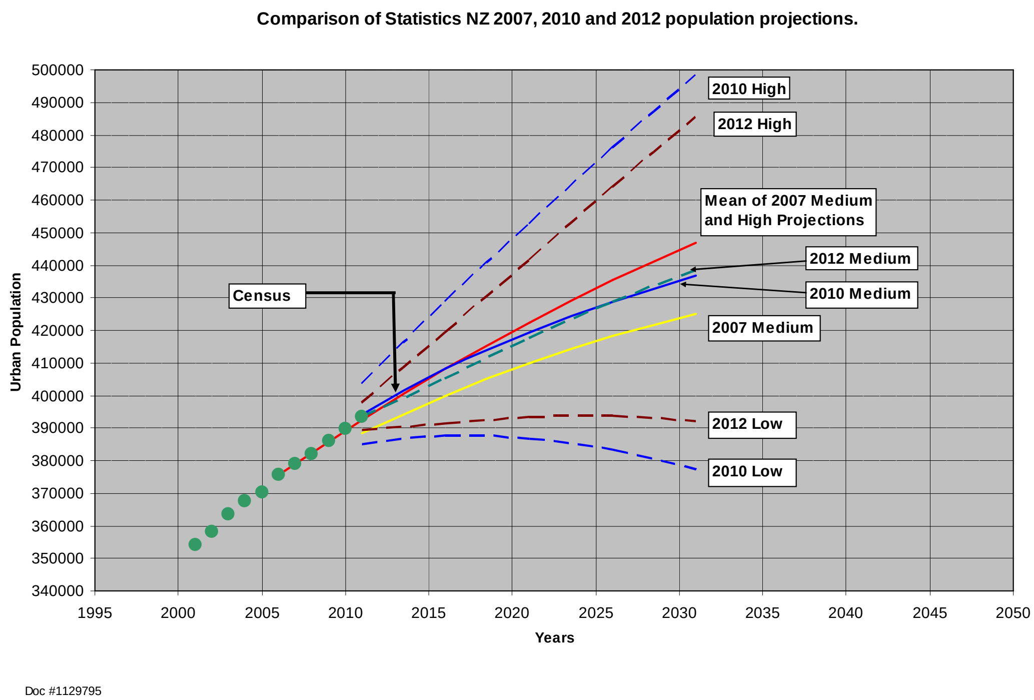
Another significant step change in population projection was made by Statistics NZ in 2007. As in 2005, the average of the Statistics NZ medium and high projection scenarios was therefore adopted for planning purposes. The graph below shows the impact of the 2007 adjustment.



In 2010, Statistics NZ again modified their population projections, increasing the medium projection curve practically in line with the curve GWRC had adopted. As a result GWRC is once again using the Statistics NZ medium population projection curve for the forecast population. The following graph illustrates this point.



In early October, Statistics NZ made a further, unexpected update to their projections of population growth. The latest projections are plotted in the figure below, alongside the 2010 projections. It can be seen that there is only a small adjustment to the medium projection but the high projection has dropped significantly and the low projection has risen. It would seem that Statistics NZ has become more confident about some of the factors causing uncertainty in their projections. These latest figures do not alter our analysis.



1.3 Sustainable Yield Model (SYM)

GWRC's Sustainable Yield Model (SYM) is a sophisticated NIWA-designed modelling software that uses Monte Carlo analysis to calculate the % ASP achieved by the bulk water network for a specific population and consumer demand. Consumer demand is modelled using climatic factors such as temperature, rainfall, soil moisture and sunshine hours, and water availability is modelled based on historical climate records over more than 100 years, river flow data, aquifer levels and water storage levels.

A major component of the SYM is the synthesised demand function. The demand function can be calibrated to match a chosen average demand and capped to limit maximum demand. For the purposes of calibration the annual average daily water consumption is averaged for the five previous years to smooth out the effect of abnormal conditions in any year. The current average demand over the period 2006 to 2011 is 387 litres per head per day.

The SYM uses the estimated population at the end of each reporting year to calculate the % ASP achieved in that year. Results from the SYM are also applied to the forecast population projection to identify when the 2% ASP standard would be exceeded. In addition, "what-if" analysis can be carried out for different levels of consumption, population and % ASP and incorporating future water source developments.

There have been various changes and upgrades to the model and demand module that have changed the population that can be sustained by the bulk water system and therefore the year when the 2% ASP standard would be exceeded (see table below). A climate change module has also been added to allow longer term modelling to incorporate expected future changes to weather, river flows and aquifer level.

In 2010 the model was upgraded to disaggregate the population and water consumption by city and zones within each city (a total of 8 zones). The demand model for each zone is calibrated against the five-yearly average demand for that zone, and the overall model calibrated against the overall average demand.

Any impact from changing water consumption patterns as a result of demographic or behavioural changes is managed by the regular updating (normally annually) of the five-yearly average demand for each city zone.

Modelling date	Average demand L/hd/day	Basis for average demand	Sustainable population	Year population reached
2002	450	Long term average demand	377,000	2007
2007	427	Average demand 1990 to 2009	364,000 (reflects change in SYM supply model	2003
2010	404	Average demand 2004 to 2009	390,000	2010
2011 *	387	Average demand 2006 to 2011	405,000	2015

* 2011 is the current model; however the population increases to 414,000 when the lakes upgrade is included. The population is predicted to reach 414,000 in 2019 so effectively a new supply is needed by the summer of 2019/20 if consumption does not change and there is not to be a breach of the security standard.

Note: The volume supplied in 2011/12 was the lowest on record for over 20 years. However, this was affected by a significant increase in water conservation advertising conducted because of the upgrade work to the Stuart Macaskill lakes, and poor summer weather conditions. To avoid potentially over-optimistic results, the model will not include the 2012 data until there is confidence this is not simply due to a limited period of abnormal weather or demand conditions.

1.4 Kaitoke Weir – short term reduction in residual flow

The 2008 report *Wellington Metropolitan Water Supply Development* listed as the main short term water supply option - seeking a change to the resource consent for the water take at Kaitoke weir, to reduce the residual flow over the weir from 600 litres/second to 400 litres/second. Modelling at the time showed the change would provide an average of 18 million litres of additional water per day for no capital cost and maintain the security of supply at or below 2% ASP through to 2018. Wide ranging environmental studies indicated there would be minimal effect on the environment.

The original intention was to apply for a consent change for a period of 12 years, which would have allowed sufficient time to consent and develop a new major water source. However unease about the proposal among sectors of the general public and some Territorial Authority councillors led to a decision to reduce the term applied for to 3 years as a contingency measure against water shortage during the Stuart Macaskill Lakes upgrade project, currently 50 % complete and scheduled to be completed before the 2013/14 summer.

1.5 Stuart Macaskill Lakes upgrade

A second short term option in the 2008 water supply development report was to increase the usable capacity of both Stuart Macaskill Lakes by 13% by raising the water level of both lakes around 1.3 metres. Modelling completed in 2008 showed this increase in volume would yield an additional 440 million litres of stored water and meet the summer peak water demands of an additional 10,000 population (equivalent to six years of population growth). Recent modelling shows that the increased volume of stored water is expected to maintain the 2% security of supply standard to a population of 414,000 that is projected to occur in 2019/20.

The detailed feasibility study into raising the lakes' embankments, using modern dynamic modelling and recent seismic information from GNS Science, revealed weaknesses in parts of the embankments of both lakes that was not compliant with recommendations in dam safety guidelines. The recommended solution was to strengthen parts of the external embankments and internally line these embankments with a special polyethylene liner concurrent with raising the level of the embankments. This work is underway and the first lake (Lake 2) has been completed. All work should be completed by December 2013.

1.6 Upper Hutt aquifer

In 2005 initial desktop studies of the possible use of the Upper Aquifer for public water supply began. Following this study, a second stage of more detailed investigations was undertaken, involving the drilling of two exploratory bores and two monitoring bores. Pumping tests were conducted and the results used to calibrate a mathematical model of the aquifer.

Scenario modelling using this aquifer model in conjunction with the SYM, was conducted to establish the effects of abstraction from the aquifer for public water supply. Two scenarios were modelled:

- Abstracting 15.5 MLD for 90 days
- Abstracting 23.3 MLD for 90 days

In both cases modelling indicated that:

- After 30 days 50% of the water came directly from the Hutt River
- After 60 days 80% of the water came directly from the Hutt River
- After 90 days 85% of the water came directly from the Hutt River

These results clearly indicate the close connection of the Hutt River and the Upper Hutt aquifer. While limited storage is available in the aquifer, any significant use very quickly draws on water from the Hutt River, potentially depleting its flow. Given the quite widespread concern about water quality in the Hutt River and the worry that further depletion could exacerbate this problem, it was judged that the development was not appropriate. Consequently the project has not been progressed further at this time.

1.7 Dam sites

Statistics NZ step change in population projections in 2005 indicated the need to identify new long-term water source options much earlier than previously expected. The SYM model showed that the 2% ASP standard would be breached in 2006.

An initial study of on-river and off-river storage solutions identified three sites (all in GWRC-owned water catchments) for an on-river storage dam capable of yielding sufficient water for a population of at least 450,000. The three sites were Skull Gully (in the Wainuiomata catchment), Ladle Bend (on the Pakuratahi River), and Whakatikei River (in the Akatarawa Forest).

Following extensive investigation and information gathering on each site, workshops were held to evaluate the three sites using multi-criteria analysis techniques. Separate multi-criteria workshops were held with GW Councillors, water supply customer representatives and GW senior staff. The clear preference of each workshop, by a significant margin, was for a dam on the Whakatikei River (including necessary network upgrades) at an estimated cost of **$142M** (2008 figures).

1.8 Kaitoke storage lake

As a result of a general concern (both nationally and regionally) about the environmental impacts of on-river storage dams, sites suitable for off-river storage were prospected in 2010. A shallow basin on farmland owned by AgResearch Ltd, immediately north of the Kaitoke Hill, and forming part of the catchment of the Kaitoke Stream, appeared suitable for off-river storage. A desktop study was carried out. The study showed that up to 5,000 million litres of water could be stored in this basin following the construction of embankments both upstream and downstream, and diversion of the Kaitoke Stream through a tunnel.

A Memorandum of Understanding was signed with AgResearch Ltd providing an option to purchase the land subject to its suitability for a water storage lake and the Council wishing to purchase by February 2012 (subsequently extended to December 2012).

Initial investigations for the Kaitoke storage lake (Lake 3) on this land have been completed and there is a very high probability the land is suitable for a dam. One remaining unknown is whether an inferred splinter fault actually exists. Even if it does, the consulting engineers are confident a dam can still be built safely on the site.

Construction of Lake 3 would increase the supply population to 450,000 (2010 modelling) provided some improvements to the distribution capacity are implemented over time. This population is expected to be reached about 2040. The estimated cost of Lake 3 is **$90M** (2011 dollars).

At present the site is open farmland with some shelter belts. It is one of the few relatively flat farmland sites available near the existing water supply infrastructure. The main advantage of this scheme over the Whakatikei site is that it has low environmental impacts. Initial cost will also be lower, but to gain the full benefit of the facility beyond 2040 the capacity of the Te Marua WTP will need to be increased at a cost of approximately $30M (not included in the cost above).

2. Demand

2.1 Population trends

Statistics NZ's estimated population for metropolitan Wellington has been growing at just over 1% per annum since the last census in 2006. Statistics NZ's current population projection to 2031 shows growth continuing but at a slightly declining rate, dropping to less than 0.5% by 2031.

However since the 2006 population census there has been a global and local recession, the government sector has been restructuring with substantial job losses in Wellington, some commercial operations have moved away from Wellington, there has been population movement within New Zealand as a result of the Christchurch earthquakes and there has been a high level of migration overseas.

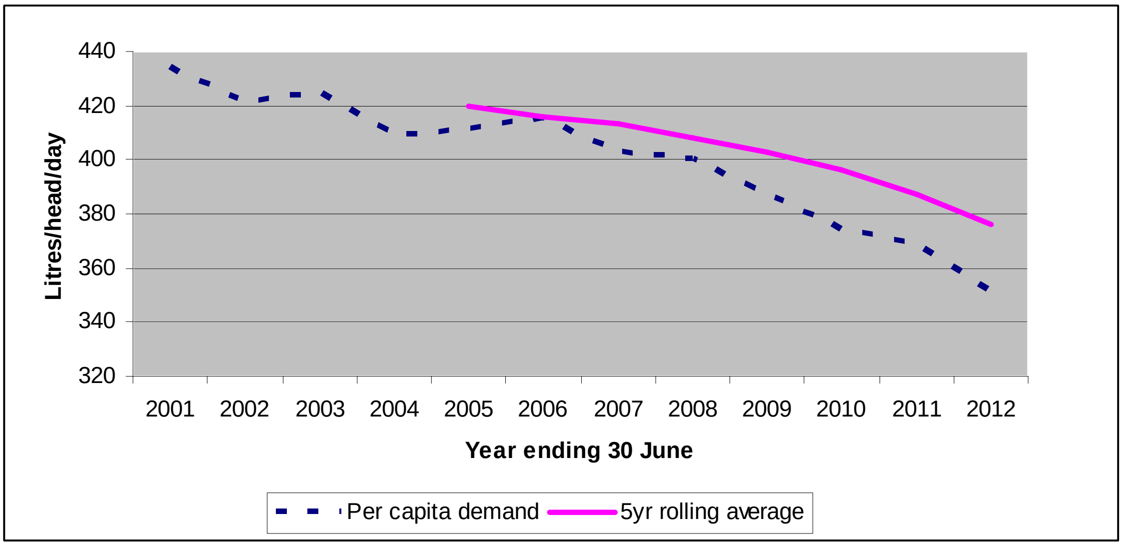
As a consequence there is some uncertainty over the accuracy of the current population estimate. The next census, in March 2013 (deferred from 2011 because of the Christchurch earthquakes) will provide a more certain baseline but may result in further change to Statistics NZ's population projections. This information is expected to be available in 2014.

2.2 Water use trends

Since 2000/01 water use per head of population has trended downward as shown in the table and graph below.

Year ending 30 June	Per capita demand Litres/head/day	Five year rolling average Litres/head/day
2001	434	
2002	421	
2003	425	
2004	409	
2005	411	420
2006	415	416
2007	403	413
2008	400	408
2009	387	403
2010	374	396
2011	369	387*
2012	351**	376

* Figure currently used as the basis for demand modelling.
** Influenced by an intensive conservation campaign associated with the Stuart Macaskill Lakes upgrade



2.3 Contributing factors

While no specific research into the factors behind the reduction in per capita water use has been conducted, the following factors are believed to be contributing (Reference *Wellington Metropolitan Bulk Water Supply – Climate Corrected Demands* MWH – August 2010).

Causal factor	Expected to continue?
Active leak detection programme	Yes - at current level of activity
Quicker response to notified leaks	Yes - at current level of activity
Infrastructure renewals	Yes – change expected to continue
More apartments and infill housing	Yes
Improved water efficiency in household appliances	Yes - follows international trend
Greater awareness of conservation issues	Yes – with ongoing advertising and promotion
Climate	Uncertain - hotter drier summers could increase water use.

The table above demonstrates that the current reduction in water use could be expected to be maintained. While it cannot be assumed that the downward slope of the trend will continue, it seems unlikely that the trend will reverse.

Water consumption could be reduced further through the use of more intensive demand management practices, such as domestic water meters. However there is a high capital cost to their installation, estimated at approximately $80 million, and ongoing operating costs.

2.4 Impact of decreasing demand

The upgraded SYM model in 2007 predicted a reduced sustainable population of 364,000 at 2% ASP. The population at the time was 373,400, which meant the 2% ASP target had been breached.

Since that time the decrease in average annual demand has resulted in a decreased 5-year rolling average demand, and an increased sustainable population. The current sustainable population at 2% ASP is 405,000, which is expected to be reached in 2015. The decrease in demand has restored the 2% ASP and together with the Stuart Macaskill Lakes upgrade has extended the period before the development of an additional water source will be required through to 2019.

3. Availability of Water

Apart from natural variation in climatic condition, which is taken into account by SYM modelling, the main factor governing the availability of raw water is the conditions set in the various consents held by GWRC to abstract water. While the major consents last until 2033/35 (and the expiry date can't be changed) any significant change to the Regional Fresh Water Plan (RFWP) could lead to a change in the consent conditions.

The RFWP is currently being reviewed as part of an all encompassing review of Natural Resources Plans in the region. GWRC is proposing a collaborative, catchment based approach to limit setting for water resources, through zone or "whaitua" committees, which will involve stakeholder representatives. There is therefore some uncertainty about the outcome of the RFWP review and whether or not changes to GWRC abstraction consent conditions could eventuate. GWRC will of course promote the importance of public water supply to the Hutt River Whaitua Committee and seek support for the most cost-effective development options as required by new Local Government Act provisions.

The result of the RFWP review will influence the timing of the development options described below. If less water was to be allocated, development would have to be accelerated. On the other hand if the allocation to public water supply was increased, some deferral of future source development would be possible.

4. Development options

A number of possible development schemes are outlined in this section. Each provides an increase in the population that can be supplied by GWRC's water supply infrastructure. The benefits of the various development schemes are discussed further in the Economic analysis in section 5.

4.1 Current provisions in the LTP

Funding provision of $10M has been made in the Council 2012-22 LTP over the period 2017-2020 to indicate the level of funding that might be required to provide some additional water supply capacity by 2020. However, unless additional water is allocated to public supply following the Regional Plan

Review, it is likely that new storage capacity will be required at a considerably higher cost.

4.2 Third storage lake at Kaitoke

A proposal for a third storage lake at Kaitoke is described in section 1.8 of this attachment. The AgResearch land that can accommodate this lake and the Pakuratahi lakes described in section 4.3 is shown on the map on the following page.

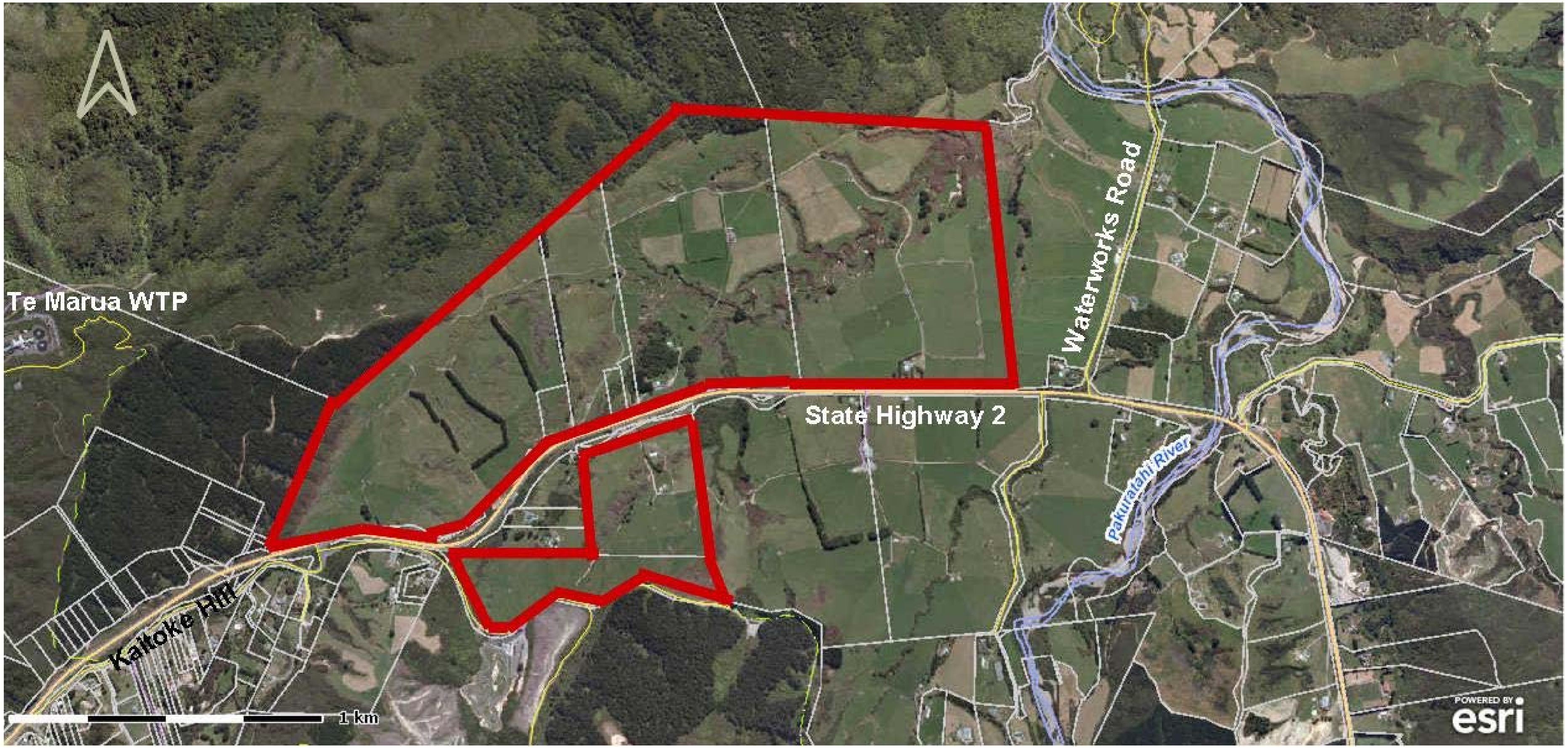
4.3 Additional raw water storage at Pakuratahi

Recent desk top studies have identified a second possible development on the AgResearch land at Kaitoke. Two storage lakes could be built near the eastern boundary of this land (i.e. near the Pakuratahi River).

Storage lakes at Pakuratahi could be filled with water taken from the Hutt River at the Kaitoke Weir. By building a pumping station alongside the Strainer building and installing a pipeline south along Waterworks Road, this pipeline could then be used to supply water to the lakes and return it under gravity back to the Kaitoke/Te Marua pipeline during periods of low river flow. In other words, the Pakuratahi lakes would represent a duplication of the Stuart Macaskill Lakes and operate in a similar manner to the proposed third lake at Kaitoke.

A single lake storing 1,800 ML would increase the supply population to 437,000, expected to be reached about 2031, and would cost about **$30M**. A second lake, containing 1,200 ML, would extend the supplied population to 441,000 (expected to be reached in 2034) and would cost a further **$26M**. The disproportionately high cost of this lake is due in part to the need to relocate a major high-voltage transmission line and in part to the inefficient shape of the lake, which is constrained by the Kaitoke Stream to the south and the Wellington Fault to the north. Until more modelling is undertaken there is some uncertainty about why the second lake increases the supply population by only 4,000 people. There may be a capacity restraint in the raw water pipeline, the Te Marua WTP or the distribution network. This issue will be resolved as part of the proposed feasibility studies.

Map showing location of AgResearch land at Kaitoke



Boundary of the AgResearch land

4.4 Whakatikei dam – further information

4.4.1 Further studies undertaken

Early in 2012 MWH Consultants were commissioned to undertake optimisation studies of the Whakatikei Dam site. These studies had four objectives:

1. To examine various options for siting the dam with a view to reducing its visual impact.
2. Examining the feasibility and cost of impounding an increased volume of water with a view to establishing an optimal size for the dam.
3. Establishing the impact of the dam on existing recreational activities and identifying future recreational opportunities.
4. Establishing the feasibility and cost of constructing the dam in stages to reflect population growth.

4.4.2 Siting of dam

Two alternative sites, approximately 100m and 260m upstream of the previously identified site respectively, were examined for suitability from the point of view of topography and geology. Both were found to be similar to the original site and suitable for dam construction. A simple multi-criteria analysis considering capital cost, constructability, social impacts, environmental impacts and geology was conducted by project staff. As a result of this exercise the site furthest upstream was selected as the preferred site because it had reduced visual impact and enhanced recreational opportunities, especially regarding opportunities for the public to swim in the deep pools immediately downstream of the dam site. However if serious consideration is given to building a dam, more investigation work will be needed before finally selecting which of the three sites is best.

4.4.3 Increased storage volume

MWH were briefed to examine storage volumes adequate to increase supply from the previously planned population of 450,000 to a populations of 500,000 and 550,000, assuming no change in current per capita demand and allowing for climate change. These populations are expected to be reached about 2070 and 2100 respectively, at current population trends. The estimated costs are summarised below.

Population supplied	Dam and associated costs
450,000	$145M
500,000	$157M
550,000	$185M
550,000 (staged)	$198M (stage 1 $157M, stage 2 $41M)

It can be seen from the table above that the incremental cost of providing for a bigger population is relatively small. And while the total cost of a staged development is higher than building a larger dam first off, there are financial advantages in delaying the additional capital expenditure. A simple NPV analysis suggests a saving of $10M to $20M, depending on the discount rate chosen for the analysis.

Building a higher dam and increasing the storage volume has the effect of inundating a larger area of land upstream. This would result in an environmental impact on a larger area of regenerating native vegetation, including greater impact on an area of tawa forest growing on the river terraces and regarded as an outstanding natural feature.

4.5 Network pumping capacity

A key requirement of increased water supply to meet a growing population, and particularly peak summer demand, involves the development of additional pumping capacity in the water supply network.

Water supply from the Te Marua water treatment plant is currently limited by the quantity of water the Te Marua pumps can pump over Haywards Hill. A new pumping station at Silverstream and upgrading of the Haywards pumping station is required to boost the water supply above the present limit of 95 million litres/day. In addition to boosting the water supply for peak demand, upgrade of Haywards pumping station would also improve backup supply when other treatment plants are off-line.

Two new pumping stations have also been identified to ensure peak supply can continue to be provided to the Wellington CBD as demand increases over time. At some point in the future new pumping stations will be necessary at Takapu Road and Maldive Street. When these two pumping stations will be required is uncertain and depends on population growth and water consumption. The total cost of upgrading existing pumping stations and building new ones is likely to range from $20M to $25M.

4.6 Review of Waiwhetu aquifer

The Waiwhetu aquifer supplies about 40% of the water required by the four cities. It has always been operated in a conservative way to ensure that there is no risk of saline intrusion. Additional monitoring wells were installed over recent years.

However, as knowledge increases about aquifers generally and mathematical models replicating them, there is greater certainty about how the aquifer will respond to operational demands and about the risk of saline intrusion.

Studies are underway by a specialist consultant to update and upgrade the mathematical model of the Waiwhetu Aquifer. While this update is aimed primarily at providing short term information to assist in source management during drought conditions, the consultant believes that the new model might indicate that an increase in the sustainable yield of the aquifer is possible. At this early stage it is not possible to quantify what this increase might be (if any), or whether it would constitute sufficient evidence to support an application to increase the consented take from the Waiwhetu Aquifer or to reduce the minimum level which must be maintained in the aquifer at the Petone foreshore. This minimum level keeps the aquifer under pressure and prevents salt water intrusion. Any changes contemplated would only occur following a thorough evaluation of all the issues, agreement with Environment Management staff, public consultation and a formal consenting process.

5. Economic analysis of the options

The benefits of deferring capital expenditure can be demonstrated by a Net Present Value or NPV analysis. In such an analysis future expenditure is discounted at a rate which represents the opportunities available for alternative use of the money. Just what this discount rate should be is often debated, but a rate equal to the cost of funds less inflation is commonly used. Future costs are not adjusted for inflation.

The simple NPV analysis undertaken assumes that the provisions in the current Regional Freshwater Plan will remain unchanged. Any changes to these provisions may alter the timing of the developments. .

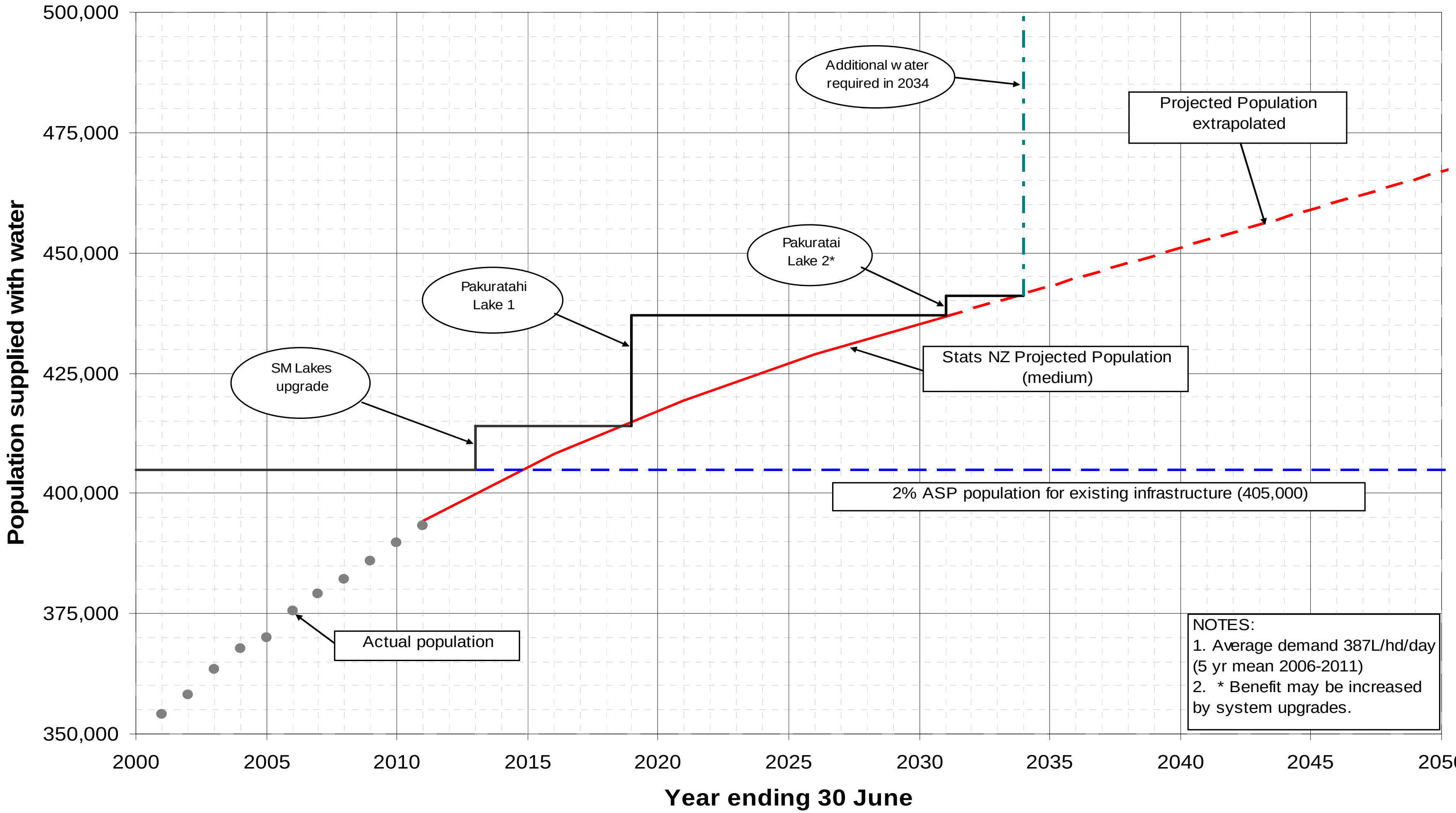
For comparison, an analysis has been carried out assuming that each of the Pakuratahi Lakes 1 and 2, Kaitoke Lake 3 and the Whakatikei Dam (two-stage) options were the first option to be constructed by 2019/20. Diagrams showing the timing and benefits in terms of the supply population for these three options are shown on the following three pages.

The table below sets out the capital cost, the NPV and the NPV per head of additional population supplied for the three options described above. The numbers in the table have been calculated using a discount rate of 4%. Other discount rates have been used in a sensitivity analysis but do not markedly change the outcome.

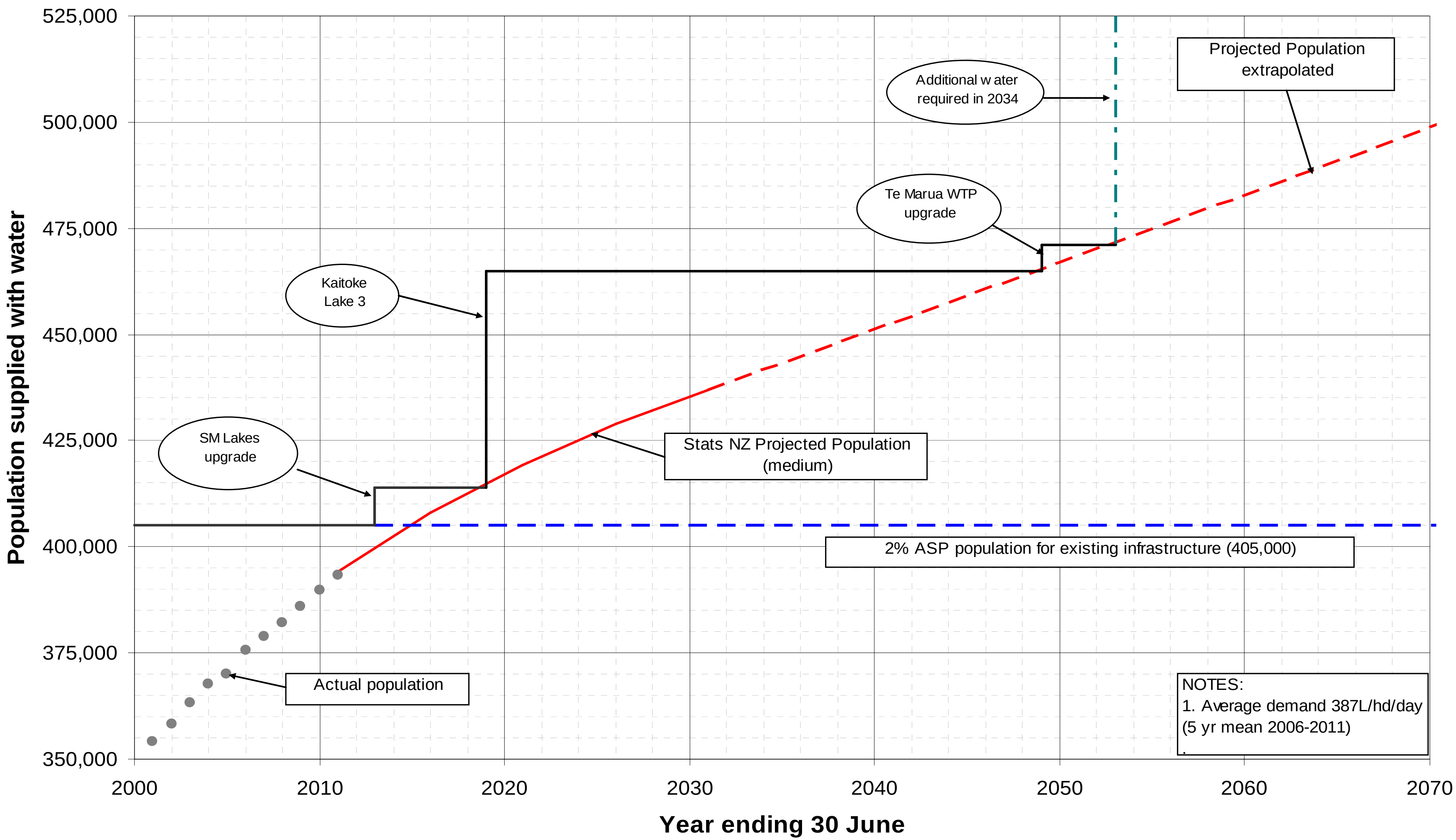
Option	Capital cost $M	NPV $M	NPV per head of additional population.
Pakuratahi Lake 1	$30M	$23.8M	$882
Pakuratahi Lakes 1 & 2	$56M	$36.4M	$1,347
Kaitoke Lake 3	$120M	$79.2M	$1,391
Whakatikei two stages	$198M	$138.1M	$1,016

Pakuratahi Lake 1 has the lowest cost per head of additional population served by a significant margin. The second Pakuratahi Lake appears to have much lower benefits, but further work on analysing these is to be undertaken (see section 4.3) Constructing Kaitoke Lake 3 as a stand-alone option has the highest cost per head of additional population, and because the Whakatikei Dam is able to supply such a large population (550,000), it is surprisingly cost-effective.

Water Supply Development – Storage Lakes 1 and 2 at Pakuratahi



Water Supply Development – Third lake at Kaitoke



Water Supply – Whakatikei dam