

# Queenstown Tackle Waterloss From All Angles!

- Leak Detection
- Flow Modulated Pressure Reduction
- Night Flow Monitoring



## 1 Introduction

Queenstown Lakes District Council (QLDC) engaged MWH to develop and manage a waterloss programme focussing on leakage reduction through a variety of different measures. The four main objectives of the programme were to:

1. Develop a programme of active leak detection and repair works in the areas of highest leakage in Queenstown
2. Attain an overall reduction in leakage levels of 25% from April 2008 to April 2009.
3. Utilise the most effective water demand reduction measures for the Queenstown area.
4. Raise public awareness of water demand issues and encourage conservation.

## 2 Methodology

The demand reduction measures utilised in the programme are briefly outlined in Table 2-1 below and are largely focussed on leakage reduction.

**Table 2-1 : Demand Reduction Measures**

<b>Demand Reduction Measure</b>	<b>Description</b>	<b>Pressure Zone this work was carried out in</b>
Accuflow Testing	Innovative new technology measuring flow through isolation valves on the reticulation. This highlights areas of potential high leakage for detailed follow up work	Fernhill and Kelvin Heights
Acoustic Logging	Targeted active leakage reduction measure using purchased Gutermann acoustic loggers. Carried out in an area sensitive to mains isolation (CBD).	Wakatipu
Leak detection Pinpointing	Follow up work from Accuflow testing and acoustic logging using purchased ground microphone and correlator. This was followed up with timely repair work.	Fernhill, Wakatipu and Kelvin Heights
Flow modulated PRV	Pressure reducing valve that accommodates diurnal changes in flow and fire flow requirements. Reduces current leakage, prolongs pipe life and reduces pipe burst frequency. Installed in April 2009.	Larchwood

Demand Reduction Measure	Description	Pressure Zone this work was carried out in
Commercial Metering	A pilot metering study of a range of commercial properties to understand current commercial demand in Queenstown and identify potential for demand reduction. Meters installed in February 2009.	Wakatipu
Sustainability Workshop	Workshop for local businesses to identify current practices, raise awareness of water demand management and provide commercial operators with a toolkit for water conservation ideas and implementation. Held in May 2009.	All of Queenstown
Night flow Monitoring	Testing carried out at the end of the years work in April 2009 to estimate the current level of leakage for Queenstown. This testing will provide a comparison with the level of leakage measured in April 2008 and verify the success of the demand reduction work carried out.	All of Queenstown

## 3 Results

### 3.1 Accuflow testing

Accuflow testing was carried out in Fernhill, Kelvin Heights and Frankton pressure zones. These were chosen as they had the highest level of leakage along with Wakatipu pressure zone. Accuflow testing is a new technology that provides quantitative flow measurements without the need for expensive meter installations. It measures flow 'listening' to isolation valves as they are closed with the Accuflow valve key. Accuflow testing was chosen over traditional step testing as it offers accurate flow measurement without the necessity of installing expensive flow meters and with less supply interruption. QLDC were the first Council in New Zealand to use this method of flow measurement, however it has been used successfully in the UK for a number of years. In total 32 tests were carried out. The results show higher flows than legitimate night consumption in 21 areas tested. These results were used to determine which areas to follow up with further leak detection work. In each of the targeted areas at least one significant leak was found, although some of these proved to be private leaks. Only approximately 40% of the Fernhill pressure zone was Accuflow tested as Lakes Engineering developed an intensive approach to one discrete area with the pressure zone as their methodology. In Kelvin Heights and Frankton area a more holistic approach was developed by MWH to test the entire area. The latter methodology proved to be more suited to Accuflow testing as it is low impact and able to cover large areas quickly and provide valid results.

### 3.2 Acoustic Logging

QLDC purchased a set of 20 Gutermann Zonescan correlating loggers for United Water to use for the acoustic logging work. This was carried out in the Wakatipu pressure zone incorporating the Queenstown CBD as it is a less intrusive method of leak detection compared to Accuflow testing. Figure 3-1 shows United Water installing one of these loggers onto a hydrant.

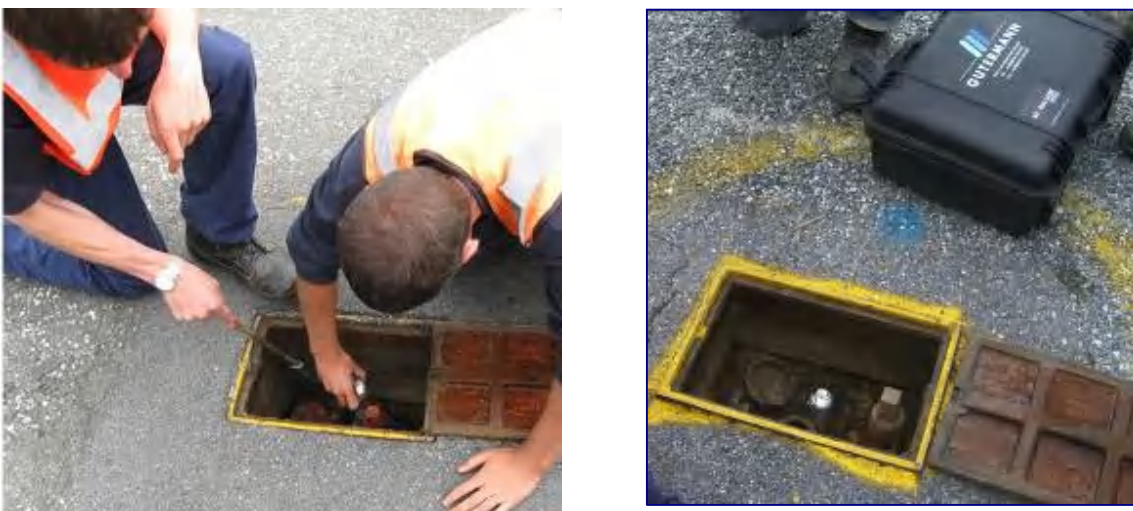


Figure 3-1 : Installing an acoustic logger in Queenstown

The Gutermann acoustic loggers work by being temporarily placed onto main fittings such as hydrants and valves. They are programmed to record noises on the main over a set period (i.e. 1am to 5am) when leakage is the highest percentage of total demand. The loggers are then downloaded either remotely or by manual collection. This downloaded data then indicates the possibility of leaks within approximately 80 metres of the logger. Other useful features of these loggers are the ability to remotely correlate between loggers to provide an area where the leak is suspected and the ability to actually listen to the leak noises recorded. The results of the acoustic logging provided leak locations within a couple of metres to follow up with the leak pinpointing work. This work resulted in 21 leaks being found in the Wakatipu pressure zone.

### 3.3 Leak Detection Pinpointing and Repair



QLDC purchased a Gutermann Aquascope 3 ground microphone and listening stick and Gutermann Aquascan 610 analogue correlator for United Water to use. Training was provided by Gutermann on the effective use of all the equipment. The areas identified by acoustic logging in the Wakatipu area and by the Accuflow testing in Fernhill pressure zone were followed up by United Water. A total of 21 leaks were inputted into the United Water Maximo system for repair, with twelve of these being repaired prior to the night flow testing. After the Accuflow testing a further 21 leaks were located, with seven of these being on private connections, in total twelve were repaired prior to the night flow testing.

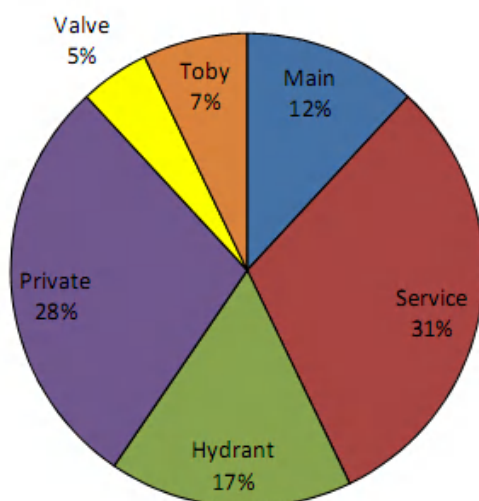


Figure 3-2 : Leak Detected by Type

3-3. The small reduction in the leakage level in Fernhill is due to only approximately 40% of the area being covered by leakage reduction work.

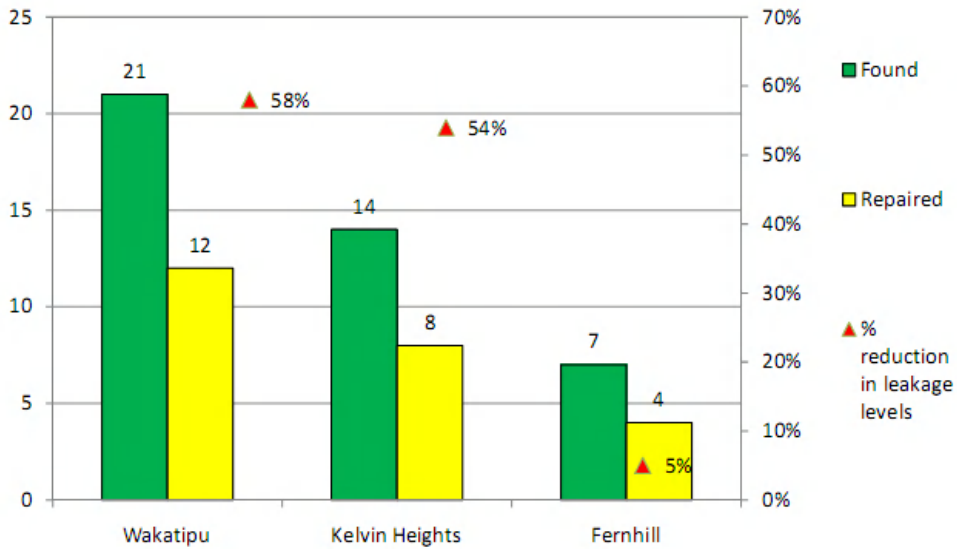


Figure 3-3 : Numbers of leaks found and repaired by Pressure Zone

### 3.4 Flow Modulated Pressure Reducing Valve (PRV)

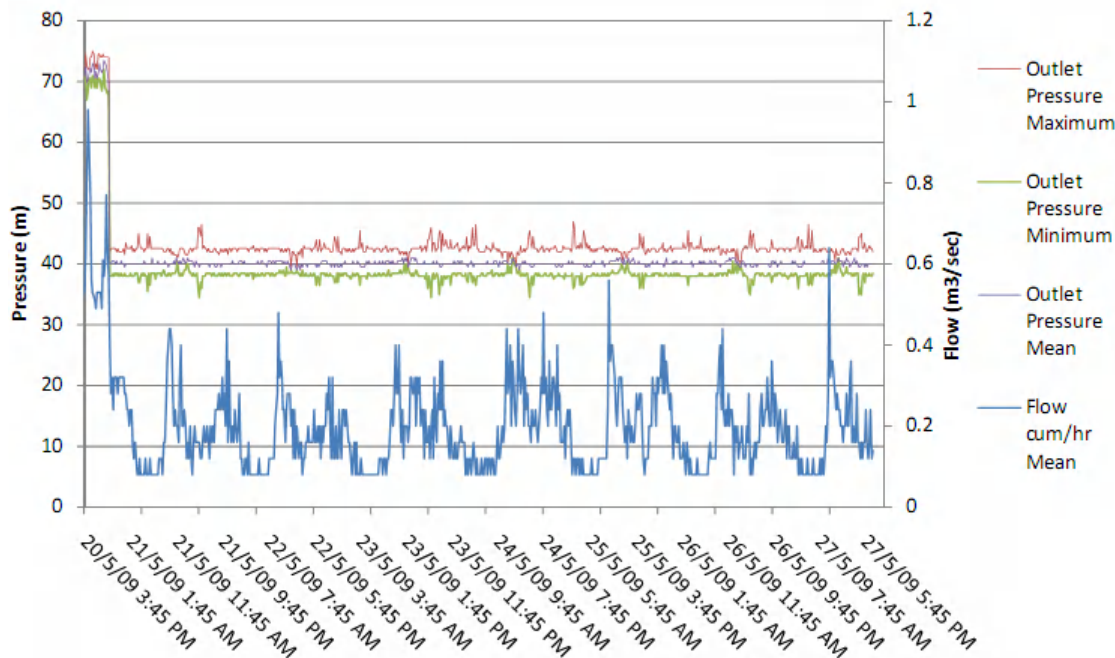
A flow modulated Bermad 720.100mm PRV with Modulo control unit and Meistream 100mm Class B inline meter was purchased by QLDC and installed at the intersection of Windsor Place and Edinburgh Drive on a water main that feeds a total of 110 residential properties in the Larchwood pressure zone. This area was chosen following hydraulic model work by Tonkin and Taylor, pressure logging and numerous site checks as it provided a discrete area with high night flows requiring a significant pressure reduction.



Figure 3-4 – Flow modulated PRV on Windsor drive

Figure 3-4 shows the PRV after the Modulo controller unit has been fitted. A normal PRV just reduces pressure in an area to a set downstream pressure. A flow modulated PRV works by monitoring the flow into an area and adjusting the pressure accordingly to pre-set levels. This means at times of low flow, typically during the night, the pressure level drops to a set minimum to ensure lower flow through existing leaks. During times of high demand, typically during the day or in the occurrence of a fire, the pressure reducing valve will open to meet demand. The meter that was installed adjacent to the PRV measures the total flow

into the area. Readings were taken before any pressure reduction occurred and with the flow modulation unit installed. This clearly shows a reduction in pressure of approximately 30 metres. Figure 3-5 shows the dramatic reduction in flow and pressure that occurred when the flow modulated PRV was commissioned on the afternoon of 20<sup>th</sup> May. Due to delays in installation the Modulo control unit was not installed in time for the final night flow testing. This means the PRV was working as a normal pressure reducing valve, but the gains made overnight were not realised in the testing. Further savings of up to 20% would be expected from the shutting down of the PRV during low flow conditions.



**Figure 3-5 : Pressure and flow during commissioning of Flow Modulated PRV**

### 3.5 Commercial Metering

A total of seventeen commercial water meters were read for the commercial metering programme over a 2 month period, twelve of these were installed as part of this programme. There was a variety of commercial user types which were split into three categories; hotels, restaurants / bars and light commercial. Figure 3-6 shows a typical commercial water meter installed on Camp Street.



**Figure 3-6 : Commercial water meter installed on Camp Street**

Table 3-1 below shows the results of the average flows from all of these readings by commercial user type. These readings were based on readings taken between 6th March 2009 and 1st May 2009. The time of year the readings were taken is the end of the summer main season into one of the shoulder seasons, so results would likely be higher over an annual average. There were a total of three large hotels, nine light commercial properties and five restaurant / bars that made up the data sets.

**Table 3-1 : Commercial Meter reading average daily flow results.**

	Light Commercial	Restaurant/Bar	Large Hotel
Daily Flow (m <sup>3</sup> /day)	2	11	91
Daily Flow (L/hr)	90	460	3780
Night Flow (L/hr)	30	140	1140

These flows were higher than anticipated for the light commercial and restaurant/bar categories compared to the figures previously assumed. Most noticeable was the restaurant/bar category with an average daily usage of 11m<sup>3</sup>/day. The hotels actually had a lower night flow than recorded last April in Queenstown. These results were used to calculate the legitimate night consumption for the night flow testing. To calculate the night consumption from daily metered data without having hourly data figures, an assumption has to be made. The figure of 30% of the average daily flow in L/hr is an estimate for night flow based on industry best practice from Benchmarking of Water Losses in NZ 2008. This method was also used in last year's calculation of hotel night time demand. Hourly meter readings would have given better night flow data, however eight separate hotels were initially approached to have meters and data loggers fitted to record hourly flows, but all of them refused to have meters fitted. The workshops that helped identify businesses that wanted meters fitting were held in May 2009, and the businesses that had meters fitted needed to be identified prior to this, in October 2008.

### 3.6 Sustainability Workshop

In conjunction with the MFE-funded Queenstown Sustainable Business Programme (QSBP) represented by local Sustainable Tourism Advisor Sharon Schindler, the Council ran a workshop on Water Demand Management on 21 May 2009. The workshop objective was "To build relationships with local businesses to guide QLDC and assist customers to achieve efficient and sustainable water use." The workshop was attended by five industry people representing eight local businesses including Skyline Gondola, Nomad Safaris, Kingsgate, Copt Horne, Millennium, QTN Rafting and Kiwi Discovery. Four other businesses involved in the programme have also indicated an interest in improving their water management. The workshop included a discussion session where a number of questions were posed. Among the workshop participants, there is a high level of interest in Council assistance with the installation of water meters to allow measurement of the effectiveness of conservation initiatives and to provide data that will improve knowledge of water use. The initial positive response from these businesses presents an opportunity for Council to trial and obtain feedback on future water demand management initiatives. There is also the potential to work further with this group as part of Council's overall sustainability programme.

### 3.7 Night Flow Monitoring

Night flow monitoring tests were carried out for Queenstown at the end of April 2009. Table 3-2 below shows the actual level of minimum night flow into each pressure zone. This is not taking into consideration any legitimate night consumption, therefore shows the actual gains and losses in the total quantity of water flowing into each pressure zone. The figures in red represent a decrease in flow (saving in water).

**Table 3-2 : Comparison of minimum night flows**

Pressure Zone	2009 Total min night flow into pressure zone (L/s)	2008 Total min night flow into pressure zone (L/s)	Change between 2008 and 2009 (L/s)	Change between 2008 and 2009 (%)
Fernhill	14.5	15.1	-0.6	-4%
Kelvin Heights	20.7	30.2	-9.5	-32%
Wakatipu	49.2	50.6	-1.4	-3%
Larchwood	1.8	2.3	-0.6	-25%
Commonage	23.7	17.8	5.9	33%
Ben Lomond	1.3	0.2	1.1	565%
Goldfields	0.8	0.6	0.3	46%
Queenstown	110.7	107.7	3.0	3%

A portion of the night flow will be due to legitimate night time consumption which includes both actual demand (e.g. toilet flushing) and property leakage. Legitimate consumption can be estimated by property type and Table 3-3 below shows the legitimate night consumption levels used for the 2009 testing. The 2009 figures differ from the legitimate night consumption figures used in the 2008 night flow monitoring as the actual water

meter data has been used to determine commercial demand instead of industry standards used in 2008. This gives a more robust figure as it is based on actual meter readings. Residential demand has been left as industry standard values as there is minimal residential metering and these were not included in the meter reading programme. Night consumption was defined as between 02:00 and 04:00, as this is typically the time period of lowest consumption in Queenstown and was also the time that the 2008 tests were carried out, so this ensured the data was comparable.

**Table 3-3 : Legitimate Night Consumption estimates and data source**

		<b>Estimates (L/property /hour)</b>	<b>Data Source</b>
<b>Residential</b>	Night Consumption	2	Industry standard from NZWWA Benchmarking of Water Losses in NZ 2008
	Leakage	1.5	Industry standard from NZWWA Benchmarking of Water Losses in NZ 2008 of 0.3L / residential connection /hour/ metre of customer service pipe. Assumed length of 5 metre service pipes.
<b>Light Commercial</b>	Night Consumption	27.5	30% of average daily flow from light commercial properties, includes leakage.
<b>Bars / Restaurants</b>	Night Consumption	137	30% of average daily flow from restaurant / bars – used only for Wakatipu pressure zone. Includes leakage.
<b>Hotels</b>	Night Consumption	459	30% of average daily flow from hotel meter readings, includes leakage.

Table 3-4 below shows the estimated 2009 leakage levels in each of the Queenstown pressure zones by daily total amount and by number of connections. These are then compared to the 2008 leakage levels. The figures in red represent a percentage reduction in leakage level. These leakage levels are calculated by taking the minimum night flows (shown in Table 3-2), subtracting the legitimate night consumption (shown in Table 3-3) and converting this into a daily flow by multiplying by a night day pressure conversion factor (based on pressure logging results carried out during testing).

**Table 3-4 : 2009 Leakage Levels by Pressure Zone**

<b>Pressure Zone</b>	<b>No. of Connections</b>	<b>2009 Total amount of Leakage (m<sup>3</sup>/day)</b>	<b>2008 Total amount of Leakage (m<sup>3</sup>/day)</b>	<b>2009 Leakage levels (L/ connection/ day)</b>	<b>2008 Leakage levels (L/ connection/ day)</b>	<b>Difference between 2008 and 2009 levels (%)</b>
<b>Fernhill</b>	744	1,110	1,180	1,490	1580	-6%
<b>Kelvin Heights</b>	151	1,010	2,170	380	810	-53%
<b>Wakatipu</b>	2,550	1,360	3,270	530	1280	-59%
<b>Larchwood</b>	234	110	160	450	680	-34%
<b>Commonage</b>	570	2,050	1,520	3,600	2670	35%
<b>Ben Lomond</b>	2,689	90	2	620	15	3952%
<b>Goldfields</b>	66	50	30	790	440	80%
<b>Queenstown</b>	<b>7,004</b>	<b>5,600</b>	<b>7,470</b>	<b>800</b>	<b>1070</b>	<b>-25%</b>

The leakage levels can both increase and decrease depending on the work carried out in each pressure zone. A water network deteriorates over time causing higher leakage levels. The rate of network deterioration depends on many factors such as pipe material, age of pipes, surrounding bedding materials, pressure, flows etc. Leakage levels have decreased due to leak reduction work and repairs carried out in each pressure zone. All of the four pressure zones where demand reduction work has been carried out as part of this programme has resulted in a reduction in the level of leakage.

The graph below shows an overview of the leakage levels by pressure zone in both 2008 and 2009, with a percentage change highlighted. There was an overall 25% reduction in the level of leakage for the whole of Queenstown over the year. The four pressure zones where demand reduction measures were applied (Fernhill, Kelvin Heights, Wakatipu and Larchwood) all showed a decrease in the leakage levels, whereas the three remaining pressure zones all experienced a rise in leakage levels due to the natural rate of rise of leakage.

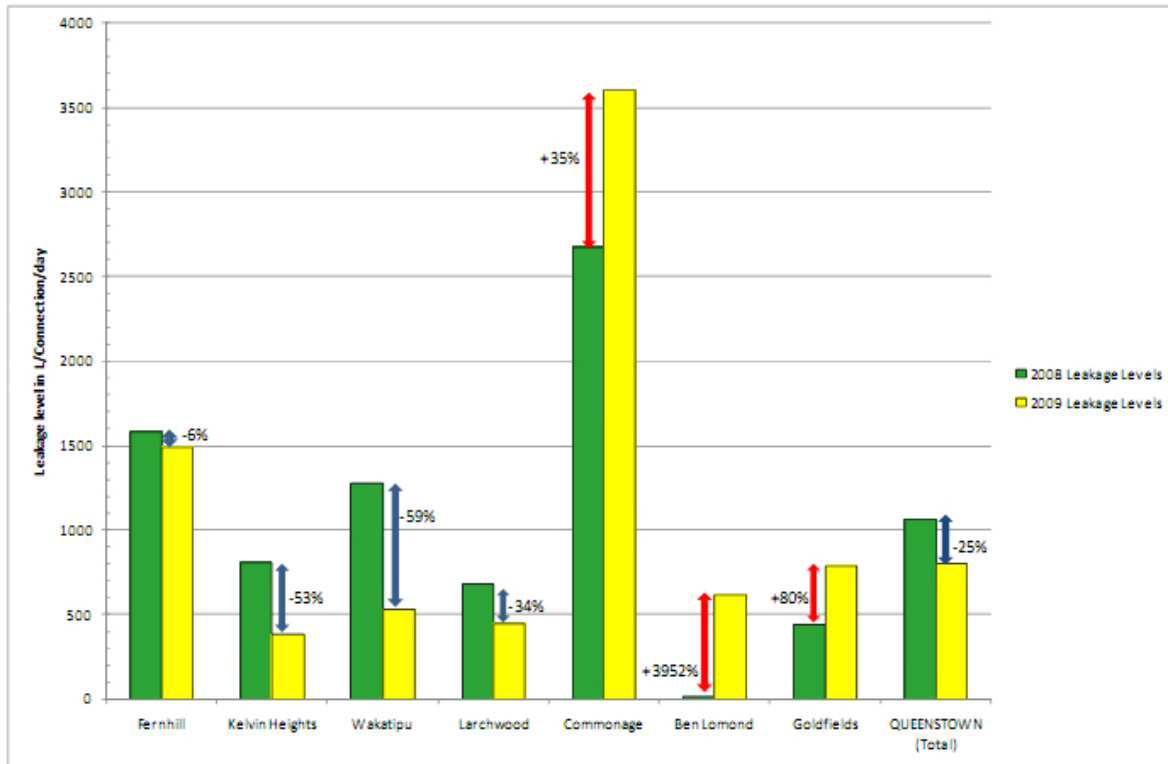


Figure 3-8 : Changes in Leakage Levels between 2008 and 2009

### 3.10 Demand Reduction Method Comparisons

**Accuflow Testing** The Accuflow testing carried out in Kelvin Heights and Fernhill pressure zones proved to be a very effective method of highlighting sections of high leakage in large areas. The ability to quantify leakage levels at a local level enables focussed leak pinpointing without the requirement of meter installations.

**Acoustic Logging** The QLDC purchased acoustic loggers proved effective in finding leaks on the non-metallic mains of Queenstown. A defined area and systematic programme of acoustic logging needs to be developed to get the best results. The interpretation of the data from the loggers is also key to their successful use.

**Leak Detection Pinpointing and Repairs** There was a 100% success rate with the leak detection work carried out in Queenstown in terms of finding and fixing leaks. This is an outstanding success rate especially on non metallic mains for no 'dry holes' to be reported in the repair work carried out despite none of the leaks being visible from the surface. This proves the staff and equipment both work well on the Queenstown water reticulation network.

**Flow Modulated Pressure Reducing Valve** The installation of a PRV is a longer term investment on maintaining the network by reducing pressures on a permanent basis. There are a number of other sites in the Queenstown network that have pressures consistently exceeding the QLDC maximum pressure limit of 900kPa that would be ideal for pressure management. The installation of a flow modulated PRV offers further savings in demand during periods of low flow.

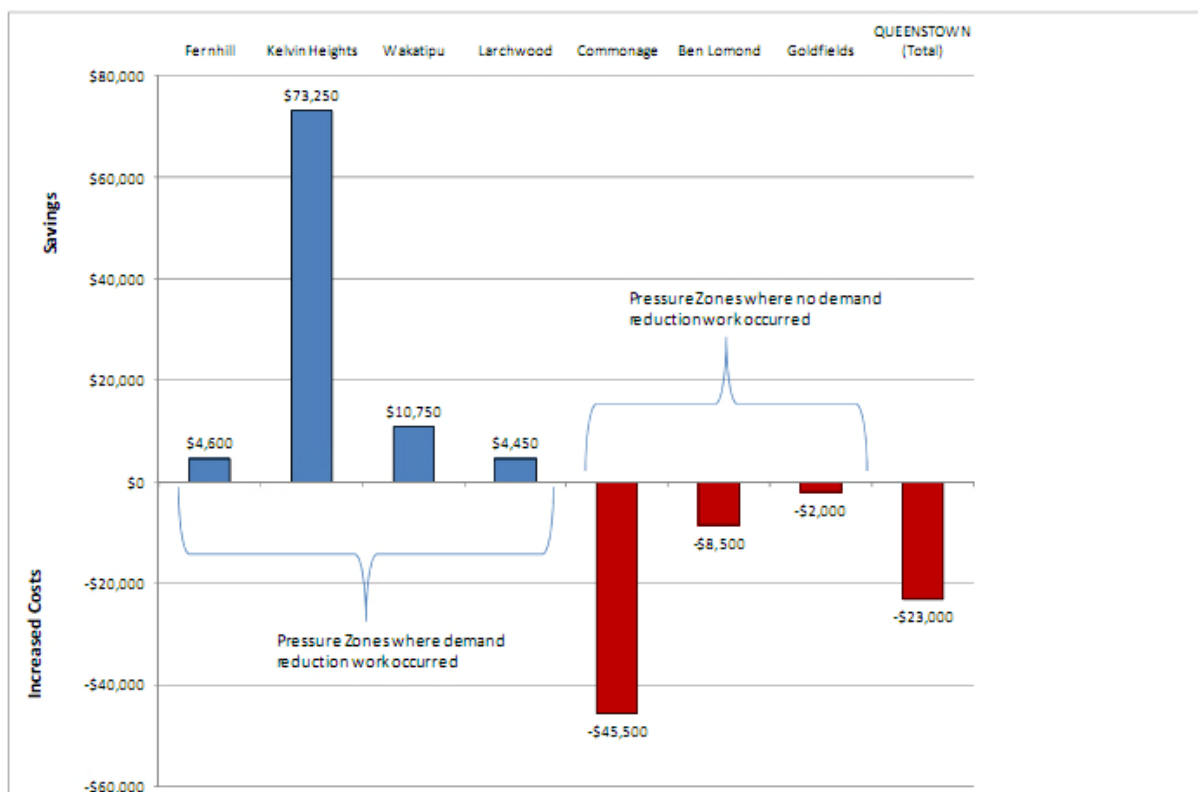
**Commercial Metering** The data set of seventeen commercial meters needs to be expanded significantly to give more accurate information on commercial demands in Queenstown. A number of these should also be data logged to determine actual legitimate night demands, meaning far fewer assumptions have to be made for night flow monitoring. The commercial property meter data shows that the commercial water demands in Queenstown are significantly higher than industry standard levels in NZ, based on the Benchmarking of Water Losses 2008. The repair work was only undertaken in the last two weeks of the programme. It is clear a significantly greater reduction in leakage levels could have been attained with further repairs carried out.

**Sustainability Workshop** The workshop was positive in that it started to form a relationship between local business and Council to develop further water demand management and sustainability initiatives. There needs to be continued work to maintain and grow this relationship by trialling and gaining feedback on further sustainability work.

**Night Flow Monitoring** In a network with minimal bulk metering and no district metered areas, night flow monitoring is the most cost effective method of obtaining levels of leakage. Leakage levels are necessary to understand the overall efficiency of a network and can assist in understanding the most efficient renewals and capital expenditure programmes.

## 4 Conclusions

The graph below shows the costs related to raw water production based on daily flows from the minimum night flow calculations. These costs are represented as the annual difference in water production costs based on the calculation of one cubic metre of water costing \$0.24. This shows the significant savings that can be made from leakage reduction, and this is not taking into account any maintenance, labour or equipment costs. As an example the total cost of the work carried out in Kelvin Heights pressure zone was just over \$55,000, whereas a saving in raw water costs alone of over \$73,000 has been attained, **giving an immediate payback with a saving of over \$17,000.**



Progress in achieving the four main project objectives is as follows:

- Develop a programme of active leak detection and repair works in the areas of highest leakage in Queenstown** Active leak detection was undertaken in three of the seven pressure zones in Queenstown, with pressure management being installed in a different pressure zone. The repair work was not carried out in sufficient time and quantity to enable major savings in all the pressure zones. A secondary benefit of this programme has been the development of a process for scheduling repair work to be carried out from leaks detected by United Water. As active leak detection had not been carried out previously in Queenstown there was no method of getting the repairs on to United Water’s system to enable the repairs to take place. A simple process of United Water staff entering the data directly onto the Maximo system was agreed to enable the scheduling of repair work in a timely manner.

• **Attain an overall reduction in leakage levels of 25% from April 2008 to April 2009.** The total reduction in the level of leakage between April 2008 and 2009 is 25.1%. This was not solely accomplished by a reduction in demand through leakage repairs. The 2009 Queenstown leakage level of 800 L/connection/day is a more robust figure than the 2008 level as it is based on actual meter readings of commercial demand instead of assumed levels. The four individual pressure zones of Wakatipu, Kelvin Heights, Larchwood and Fernhill had individual decreases of 59%, 53%, 34% and 6% respectively which provided the overall reduction of 25% for Queenstown.

• **Utilise the most effective water demand reduction measures for the Queenstown area.**

The most effective demand reduction method for Queenstown is to use a programme that determines the most effective method depending on the type of area and results required. It is difficult to compare all the methods of demand reduction, as they all have different benefits. The significant reduction made in Kelvin Heights pressure zone shows that Accuflow testing and follow up work is effective for covering large areas. Similarly a total of 21 leaks detected in the Wakatipu pressure zone by using acoustic logging and follow up work was a less intrusive method of demand reduction for the CBD area of Queenstown. The flow modulated PRV does not immediately look as cost effective in Table 4-1 however this is due to the small area of the trial. The lower pressures mean less main breaks and permanently lower demand levels, so this would have greater payback over a longer period of time.