SMART SOLUTIONS FOR URBAN MANAGEMENT OF THE 3 WATERS

Steven Roberts, Watersmart Limited

ABSTRACT

This paper looks at the merits of managing the 3 waters on an individual house lot. Research shows this approach can halve potable water use, alleviate stormwater run-off, and reduce the wastewater by 45%. This can lead to existing infrastructure having the capability to support double the amount of housing. Having a decentralized water supply network also improves the community's resilience to disasters.

Kapiti Coast District Council, through the introduction of plan change 75, mandating that any new homes install a raintank and/or a fresh greywater garden irrigation system, has led the development of innovative solutions to balance the water supply and demand equation. Technology has now evolved with the development of passive rain harvesting systems, quiet, efficient immersible pumping systems, discreet underground water tanks, and fresh greywater sub-surface garden irrigation systems.

An example of the results can be seen at the Waterstone subdivision. Here the water consumption has been monitored over the past year, and compared with districtwide averages to demonstrate the savings. The information gained from the experience on the Kapiti Coast has been applied to Christchurch to illustrate potential benefits. This approach is very much aligned with the objectives of National Policy Statement for Freshwater Management 2011.

KEYWORDS

3 waters management, water demand management solutions, greywater irrigation, stormwater attenuation, rain harvesting

1 INTRODUCTION

Growing populations, changes in climate and ageing infrastructure have all provided a strong imperative for regulatory bodies across the world to investigate and adopt alternative water technologies. Here in New Zealand one of the key objectives of the recently released National Policy Statement for Freshwater Management 2011 is "to improve integrated management of fresh water and the use and development of land in whole catchments, including the interactions between fresh water, land, associated ecosystems and the coastal environment."

One district that has already been moving down this path is the Kapiti Coast District. Kapiti has a long history of water supply issues, due to fast population growth combined with a temperate climate and many areas with free draining soil, which creates very high irrigation demand. In 2003, Kapiti Coast District Council adopted its 'Water Matters' - Sustainable Water Use Strategy, which looked at innovative measures to manage the demand and supply of water. Trickle feed supply, outdoor water use entirely fed from raintanks and other combinations have been used to balance supply and demand.

The opportunity to introduce covenants on re-zoned land being developed, has lead to sub-divisions such as Waterstone, which has a trickle fed supply and all outside taps are fed from a raintank and most lots use fresh greywater garden irrigation. Another example, the Ferndale sub-division, has covenants requiring all lots to have fresh greywater garden irrigation and onsite stormwater attenuation tanks, which also store water for toilet flushing and outdoor water use.

Plan change 75 was introduced in February 2008, requiring all new homes to install either a 10,000 litre raintank with trickle fed backup to supply outside taps and toilets, or a fresh greywater garden irrigation system and a smaller 4500 litre raintank supplying toilets and outdoor taps, also with the trickle feed backup. The de-coupling of the potable supply from the irrigation demand will have a significant effect in reducing future peak water use as more new homes are built in the district.

This has led to many new innovations to provide discreet systems that minimize the demand on the potable supply, but also to manage the 3 waters more effectively on individual house lots. Utilisation of fresh greywater for garden irrigation has reduced the hydraulic loading of waste water to be processed, and using rainwater to flush toilets and provide water to outside taps has also reduced the stormwater loading. More recently, the importance of having an uninterrupted water supply (UWS) in the event of a disaster has been a huge benefit of having a water storage system on each individual house lot.

The results of the Water Matters Strategy can be seen in the areas in Kapiti where new building has occurred. At first glance the properties look similar to other areas, with established gardens, and little evidence of the water saving systems that are installed. However these properties are typically only placing half the demand on the infrastructure, and have a backup water supply in the event of emergency as shown from results of the flow monitoring work at Waterstone.

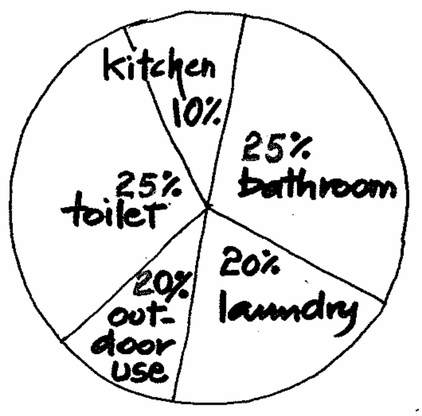
2 MANAGING THE 3 WATERS ON INDIVIDUAL LOTS

Although there is a lot of published data on the benefits of installing rainharvesting systems, storage of rainwater on site, and irrigation using fresh greywater, the reality is that without regulation, very few people in New Zealand take the opportunity to include these systems in the design of new homes (Lawton et al., 2008).
The Kapiti Coast District Council, through its plan change, has created a centre for the development of practical solutions that effectively manage the 3 waters on individual house lots. The merits of this are examined below.

2.1 DOMESTIC WATER USE

Although there is some variation across New Zealand in terms of typical household water use, often the bathroom and laundry figures equate to 45% (as shown in Figure 1, taken from Waitakere City Council sustainable home guidelines).

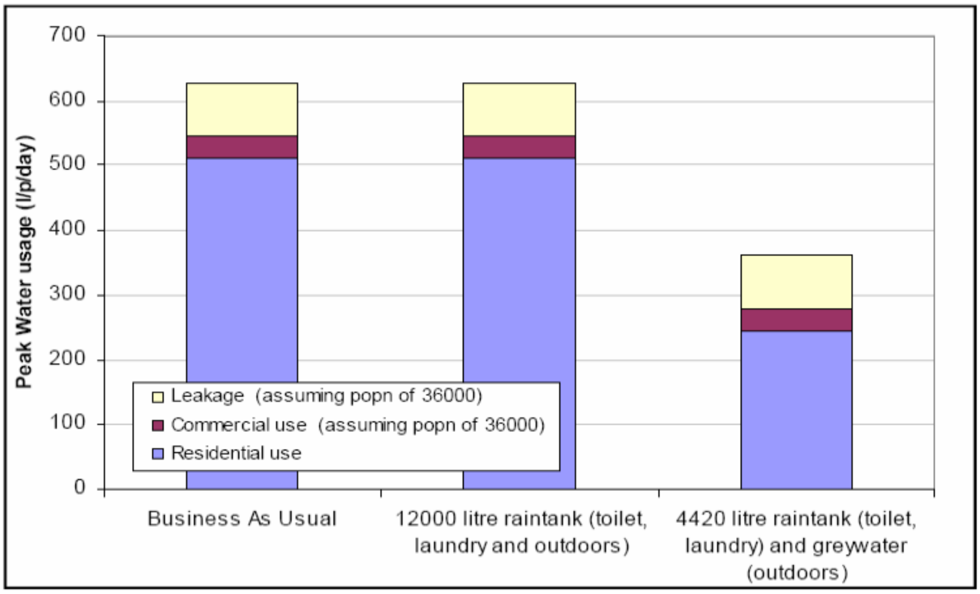
Figure 1: Typical household water use (source Waitakere City Council sustainable home guidelines)



Analysis of this would suggest that the bath, shower and laundry water easily satisfies the amount of water required for irrigation purposes outside. Reusing this water would reduce the overall water usage by up to 20%. If all of the bathroom and laundry water was reused for garden irrigation water, the reduction in the wastewater would be 45%. By collecting rainwater, and re-using this to flush toilets, provide laundry water, and to supply any outdoor use, the potable water is reduced by 65%.

However it is important to look at peak water requirements when analyzing these figures. If the raintank is empty (during the middle of summer for example), and this is the time when peak irrigation demand occurs, then there will be no reduction in the potable supply network requirement. The combination of a fresh greywater garden irrigation system and a small raintank gives the best result. Studies done by SKM for KCDC (Martell, et al. 2008) illustrate this point graphically (refer to Figure 2) – the installation of a 12,000 litre raintank alone had no effect on peak water use, however the use of fresh greywater garden irrigation combined with a 4,500 litre raintank reduced the peak demand by 37% (this modeling assumes there is an unrestricted back-up town water supply to the tank, which opens when the tank level is below 1000 litres).

Figure 2: Reduction in peak water use with a raintank vs fresh greywater garden irrigation (source SKM/Kapiti Coast District Council)



This also shows that, whilst average water use figures indicate that outdoor irrigation is only 20%, actual peak figures may be far higher than this. It is estimated that up to 40% of Kapiti's potable water is poured on gardens in the summertime.

By de-coupling the outdoor water use from the potable supply (by using a trickle fed tank on the new house lot for example, with a restriction of 600 litres/day), the peak demand is controlled at a much lower level, yet also provides homeowners with a means to manage irrigation on their own house lot.

Connecting this tank to the stormwater collection from the house, and utilizing a rain harvesting components such as first flush diverters, calmed inlets, vacuum overflows and floating intakes in the collection system will result in the homeowner also having an uninterrupted water supply (UWS) in the event of an emergency.

Designing in buffer storage at the top of the same tank to attenuate high rainfall events, will mean that not only is the stormwater used in the toilets and outdoor taps not entering the stormwater system, house lots can be designed to be stormwater neutral, without significant increase in cost.

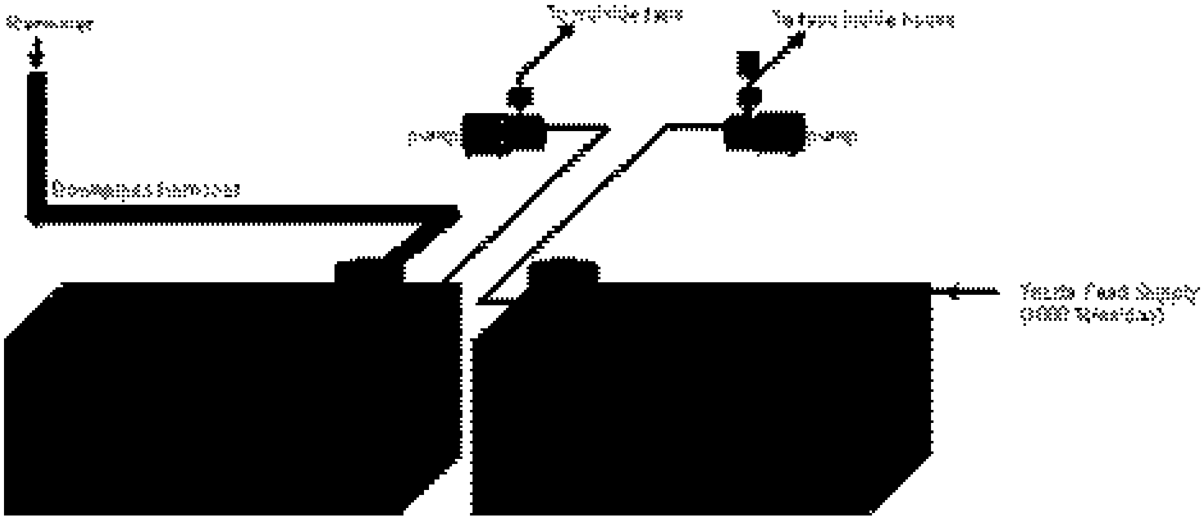
2.2 EVOLUTION OF THE SOLUTION

Although there is a current trend encouraging eco building, people do not want to be inconvenienced in their daily lives as a result of choosing this option. So having great water pressure for showers, and having lush green lawns and gardens, are not to be compromised. People are also prepared to pay slightly more for 'out of sight and mind' solutions. This has lead to much innovation and development as suppliers and building companies look to meet market demands in a cost effective manner. Pricing for including these systems in new homes has reduced from over ten thousand dollars to under half this figure. Examples are given below, showing how the solutions have evolved to provide efficient solutions at reasonable prices, now equating to about 2% of the building cost.

2.2.1 TANKAGE

The importance to the consumer of 'out of sight, out of mind' solutions is highlighted in the Waterstone subdivision, where, despite a plastic raintank being the cheapest means of storing the required minimum volume, all of the properties have used underground molded concrete tanks, as shown in Figure 3.

Figure 3: Waterstone tankage configuration



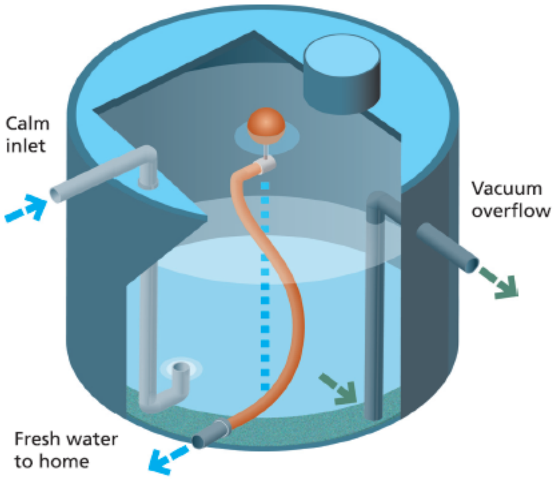
The discreet nature of the tankage is the reason for this, as illustrated by photograph 1.

Photograph 1: Discreet raintanks

2.2.2 RAIN HARVESTING

The ongoing issues with tank cleaning, staining of toilets and generally poor quality rainwater can be avoided by incorporating first flush diverters, leafslides, calmed inlet systems and vacuum overflows into the rain collection system when it is installed. Unfortunately when the budget for building a new home is reduced, these systems can be left out of the design to keep the cost down. However, as is described in the rain harvesting work done by Massey University (Golay, 2011), the improvement in water quality is dramatic. If the water is to be used in the event of an emergency there is even more reason to ensure that these components included at the time of installation. Figure 4 shows how simply these components can be incorporated:

Figure 4: Rain Harvesting Components



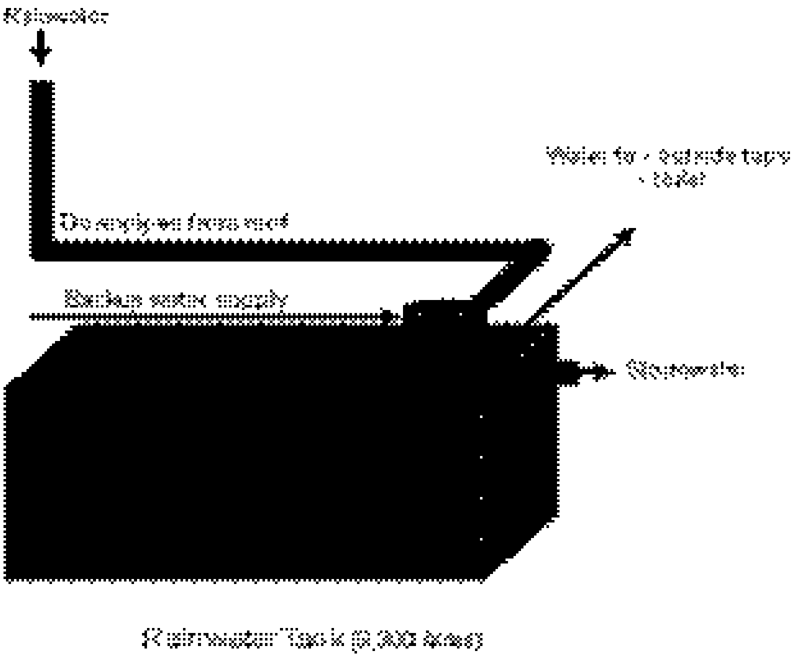
Despite marketing literature often showing first flush units on the side of walls, again the out of sight installations are proving more popular – as shown in Photograph 2 below.

Photograph 2: Buried first flush diverter vs wall mounted unit

2.2.3 PUMPING TECHNOLGY

The location of the pumps required to provide water pressure quickly evolved. Initially pumps were located in garages, however due to noise these moved to outdoor sheds/covered boxes. Issues with priming of pumps when they were drawing water from underground tank also became apparent. These issues were all solved with the introduction of ‘hush’ pumps – submersible pumps located inside the water tank itself, as shown in Figure 5.

Figure 5: Hush pumps in tanks



Photograph 3: Hush pump example showing pump in tank

2.2.4 FRESH GREYWATER GARDEN IRRIGATION

When comparing the two options to comply with the KCDC plan change 75, often the available space determined which option was implemented. The fresh greywater garden irrigation systems typically replace the gully dish in the home and therefore take up very little space, as shown in the photograph below. On the left a greywater diversion device is installed, on the right a representation is given on the space that a 3,200 litre tank wo uld take up. Often this is not practical; hence the fresh greywater garden irrigation system is preferred.

Photograph 3: Comparison of space taken up by a greywater diversion device vs a raintank

Despite being high users of water in the summertime, beautiful lawns are still desired by many living on the Kapiti Coast. This has lead to the development of sub-surface irrigation systems that utilize the bath, shower and laundry water to automatically water lawn areas in controlled amounts. Photograph 4 shows the wetting pattern and different lawn varieties being trialed. Photograph 5 illustrates the fresh greywater irrigated lawn compared to the control lawn. All of these solutions have evolved as a result of the demand driven by the KCDC plan change.

Photograph 4: Wetting pattern with subsurface lawn trial

Photograph 5: Fresh greywater irrigated tall fescue variety (on left) vs control lawn (photos taken 7 Dec 2010)

2.3 THE END RESULT

The Waterstone subdivision in Kapiti (see photograph 6) was evaluated for water usage for the period from March 22nd 2010 to March 8th 2011.

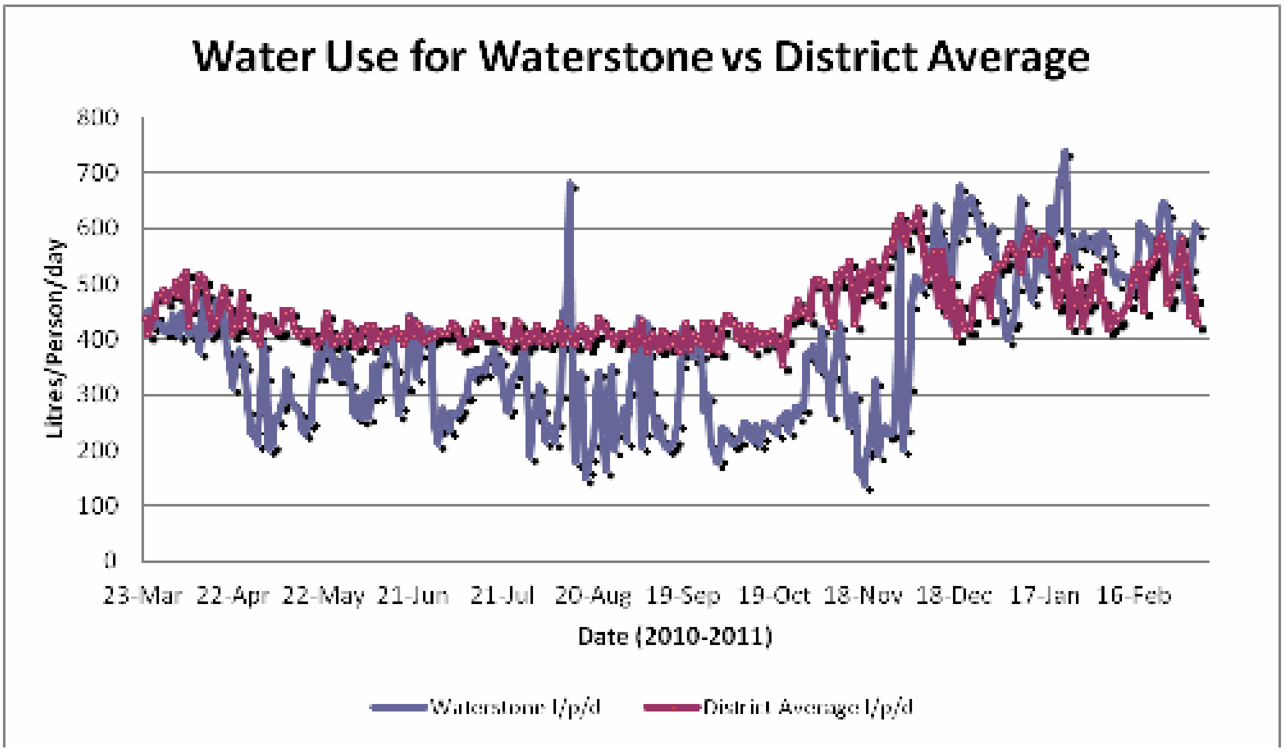
Photograph 6: Waterstone subdivision in Kapiti

Figure 6 shows the water main feeding the 102 properties currently connected and the location of the TSC Ultrasonic Water Flow meter (model TOS MWA – 10) used to capture the flow information. Readings were taken at 3 minute intervals throughout the period.

Figure 6: Waterstone subdivision water reticulation network

The results are presented in Figure 7.

Figure 7: Waterstone subdivision water supply monitoring results



Kapiti's peak water use in 2010 was 634 litres/person/day, and averaged 452 l/p/d. In Waterstone, there is an average of 3 people/home (Dean, 2010) and by virtue of the trickle feed supply being limited to 1000 litres/dwelling on some homes, and others having a restricted supply to the outside taps, this should correspond to a peak water use of approximately 330 litres/person/day. There were some exceptions, namely:

- when fire hydrants were tested;
- when the restrictors were removed from the water supply toby during the time when a new home was being constructed;
- from 1 December 2010 it is likely that there was a calibration issue, with the meter reading high, as a test later showed the meter continued to record 2 l/s flowrate with the supply valve closed.

These exceptions clearly showed up with increased flowrates during the day, as shown in the above graph. The average usage for Waterstone residents was 378 l/p/d, however removing the above exceptions from the dataset, the average usage becomes 307 l/p/d (or 32% less for the entire year), with a peak usage of 339 l/p/d (47% less than the district average).

Although the figures show an average daily value, due to the trickle feed supply this figure also correlates very closely with the peak water flowrate for any 3 minute interval. For the entire subdivision, the peak water flow (outside of the above exceptions) was 1.2 l/s for 102 dwellings. So not only is the daily average peak value a lot lower, the instantaneous flowrate is significantly reduced, placing far less demand on the supply infrastructure.

Hence, having a restricted supply to raintanks, so that homeowners are able to manage their irrigation requirements themselves may be a great compromise, to maintain levels of service whilst minimizing peak demand.

2.4 ASSISTING THE CHRISTCHURCH REBUILD

As was shown graphically in the media (see photograph 7 below), water supply and waste treatment were major issues following the Christchurch earthquakes.

Photograph 7: Media images following the Christchurch earthquake in February 2011

The benefit of having a water tank on individual house lots would have assisted the community greatly.

Even prior to the earthquake, the potential issues with meeting the future demand were being identified. Much of this demand was due to garden irrigation. Two thirds of the total water use during peak hours comprised of domestic garden water use as shown in Table 1. In 2008, the Council's operations manager for water and wastewater mentioned in a media story: "It comes down to a question of does the council want to put down more wells at about $1 million a shot to provide garden watering for one day a year or do we start to think about how we are using our water".

Table 1: Christchurch peak hour of water use figures

Christchurch Total water usage during PEAK HOUR in summer	
Domestic garden use	66%
Commercial/Industrial external use and public irrigation	16%
Domestic internal use	13%
Commercial/Industrial internal use	5%

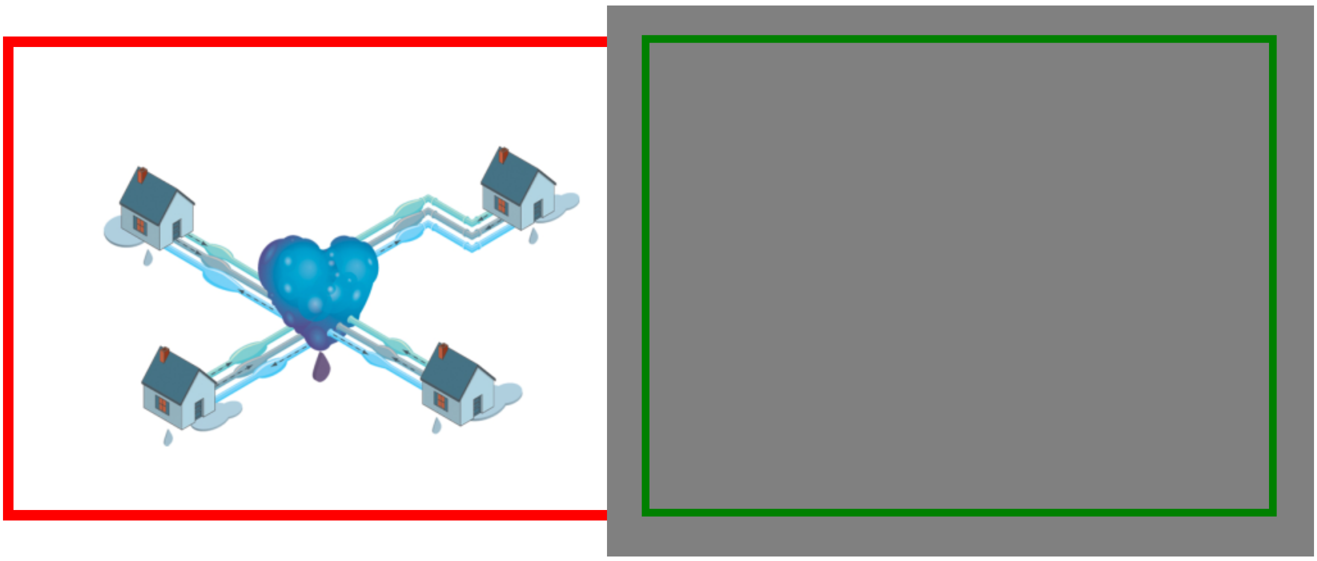
Figure 8 gives a conceptual image of how a fresh greywater garden irrigation system and stormwater attenuation tank, which also provides water to the home for toilet flushing and outdoor water use, complete with trickle feed top up (at low level) if required could be accommodated in a section. This shows the provision of a 22,500 litre underground tank, however as demonstrated in the Waterstone subdivision, 2 of 6,000 litre underground tanks, and a fresh greywater garden irrigation system were easily incorporated in the design on 350 m^2 sections.

Figure 8: Example of a 3 waters solution

Having a fresh greywater garden irrigation system could potentially reduce the peak hour of water use significantly, whilst also reducing the loading on the wastewater flow. The combination of this technology with a rain harvesting tank to give an uninterrupted water supply, with stormwater attenuation built in, minimizes the demand on the 3 waters required by this individual house lot. For 30,000 new homes, this equates to water savings of 10 million litres per day (based on 32% savings and an average of 3 persons/household).

The 3 waters are essentially the 'heart' of the community. Figure 9 illustrates how better management of the 3 waters on individual sites could allow double the housing to be built for the same infrastructure.

Figure 9: Schematic showing the potential benefit for infrastructure



3 CONCLUSIONS

Kapiti Coast District Council has been at the forefront of many new water demand management initiatives. This has led suppliers to develop a number of innovative solutions to manage the 3 waters on individual lots. These innovations have meant consumers do not compromise their level of service, or lifestyle and available space in their new homes, yet place significantly less demand on the infrastructure requirement for the 3 waters.

Management of the 3 waters on site can:

- Reduce potable water demand by up to 60%
- Reduce waste water flow by up to 45%
- Provide lots with the ability to be stormwater neutral
- Provide an uninterrupted water supply (UWS) through a distributed network of water storage for greater community resilience in the event of a disaster

Results from the Waterstone subdivision in Kapiti show that this is possible with discreet installations of the required systems. A similar approach could have substantial benefits for the City of Christchurch.

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