THE CHRISTCHURCH WATER SUPPLY REZONING PROJECT

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ABSTRACT

The Christchurch Water Supply Strategy 2009-2039 set out a number of goals, objectives and targets for the water supply. A number of projects were identified that were aimed at reducing system consumption and leakage in order to defer or potentially avoid the need for an additional major water source for the city that would be required if the predicted city growth occurred without a significant reduction in per capita consumption.

The Canterbury earthquakes highlighted a number of significant issues related to the open nature of the current Christchurch water supply that impeded the response and recovery work and could be improved by re-zoning the system into smaller management zones. Additionally, the network is now somewhat more "vulnerable" as a result of the earth movement and action is required to protect the weakened assets and potentially extend asset life.

In response to the above, Christchurch City Council (CCC) instigated a project with the identified drivers of;

- Defer/avoid the need for an additional source through leakage reduction and demand management
- Improve emergency response capability
- Improve resilience and protect vulnerable assets
- Improve system management and monitoring
- Delivery of optimal supply pressures, and
- Support the Central City Plan and other Policy and Strategy documents

KEYWORDS

Water Supply, System Rezoning, Resilience, Pressure Management, Operational Optimisation

1 INTRODUCTION

The Christchurch Water Supply Strategy 2009-2039 set out a number of goals, objectives and targets for the water supply. A range of projects were identified that were aimed at reducing system consumption and leakage in order to defer or potentially avoid the need for an additional major water source for the city that would be required if the predicted city growth occurred without a significant reduction in per capita consumption.

The Canterbury earthquakes highlighted some significant issues related to the open nature of the current Christchurch water supply that impeded the response and recovery work and could be improved by re-zoning the system into smaller management zones. Additionally, the network is now somewhat more “vulnerable” as a result of the earth movement and action is required to protect the weakened assets and potentially extend asset life.

In the following paper we will describe how the CCC responded to this significant change in circumstances and instigated a project to address these issues by developing a long term plan for the water supply system that would make the system more manageable, more efficient, more resilient and robust and ultimately more sustainable.

2 PROJECT DRIVERS

2.1 PROJECT INCEPTION WORKSHOP

A “Project Inception Workshop” was held which included key members from the CCC Operations and Planning teams, representatives from the Stronger Christchurch Infrastructure Rebuild Team (SCIRT) and the selected Consultant Team from Opus. The principal purpose of the workshop was to establish the objectives and methodology for the Project, to establish an appropriate Project Team and to define roles and responsibilities.

Given the time constraints placed on the CCC and SCIRT team as the recovery and rebuild works continued, the Project Team would essentially be lead by the Consultant Team, with targeted input from the CCC and SCIRT team at strategic times throughout the project. It was agreed that each key task would have an “owner” and the owner would draw on the knowledge of the most appropriate members of the wider team as required. A series of targeted workshops would be used to openly debate and arrive at a consensus on key points such as design criteria and concept design.

Following the Project Inception Workshop a “Road Map” was developed for the Project and the Project Team structure was formalised.

2.1.1 PROJECT OBJECTIVES

The workshop established that the principal objective of the Project was to determine the optimal arrangement of the water supply network zone boundaries, and to design Water Supply Zones (WSZ) to deliver the key outcomes of:

- Defer/avoid the need for an additional source (likely the Waimakariri River) through leakage reduction and demand management
- Improve emergency response capability
- Improve resilience and protect vulnerable assets
- Improve system management and monitoring
- Delivery of optimal supply pressures, and
- Support the objectives and vision outlined in the Central City Plan, the Water Supply Strategy and other key Policy and Strategy documents associated with the rebuild of the City.

A number of additional benefits were also expected to be achieved such as improving energy efficiency, reducing burst rate and the associated disruption and formalising Level of Service (LOS) targets such as pressure and fireflow capability.

Establishing improved monitoring and reporting tools would allow constant review of system performance and potentially lead to the establishment of nightflow target and alarm figures to ensure that bursts and creeping leakage levels are picked up and repaired quickly. This would help CCCs drive to become more proactive in leakage control.

The outcome of the Project was considered to be instrumental for facilitating better management of the system (under normal and emergency operating conditions), effectively allowing CCC to move from a position of “Operating” to “Managing” the system.

3 CURRENT SYSTEM LAYOUT AND THE NEED FOR CHANGE

The water supply system in Christchurch City is rather unique. The system is currently divided into a number of relatively large supply zones, each with multiple pump stations sourcing water from the five confined aquifers below the City. There are a number of reservoirs along the hill suburbs to the south of the City that either act as balancing tanks/storage (resulting in higher than necessary pressures across much of the City) or are used to pump water progressively to the higher suburbs.

This system has a number of advantages and disadvantages and the key objective moving forward will be to build on what has worked well, overcome deficiencies and improve the system to be more resilient and flexible in the future, whilst being able to meet the needs of a growing population and many forced relocations.

The current system relies heavily on the intervention of CCCs shift controllers and each has their own individual preferences for operating the current zones. These have been streamlined to a certain extent in recent years through “guidelines” but there is still a certain degree of variability which results in inefficient operation in some cases.

One of the most significant lessons learned from the emergency response phase after the earthquakes was how difficult it was to manage a largely open water supply system with multiple pump stations and multiple pipe and headworks failures. Of particular concern was the length of time it took to return relatively undamaged areas to full service, as they needed to be isolated from severely damaged zones with uncontrolled flow through bursts and pump stations that were damaged and unable to supply water.

Smaller zones are more manageable and easier to test and return to full service in a phased manner. This can perhaps be best demonstrated by looking at the number and layout of the Orion Electricity Zones covering the City. Orion was able to return zones to full service in a more controlled, phased and efficient manner than was possible for the water supply.

During the response phase, the water operations team actually “closed in areas” effectively creating smaller zones, but leaving valves on strategic mains open. This meant than in subsequent significant and damaging events, only relatively few valves needed to be closed to isolate an area and return it to service isolated from more damaged zones. With the proposed rezoning, effectively the reverse would apply. Generally zones would be closed in and running independently, but if necessary it would be relatively easy to open a number of strategic valves to allow supply in from an adjoining zone.

With the proposed rezoning CCC will have better access to live data in the form of zone flows and key system pressures. It will be possible to make quicker and more informed decisions on a zone by zone basis regarding the status of the zones and to more readily return service in a phased and controlled manner.

4 LEVEL OF SERVICE

One of the key objectives of the Project was to define the current and future expected Level of Service (LOS) that CCC would be able to commit to. It is important to understand the value of LOS, to be clear on the consequence of setting unrealistic or unnecessarily high target values, and to demonstrate value for money and affordability. Understanding the consequences of maintaining/improving LOS and the consequences of failing to achieve the standards agreed to and the public perception of this is also important.

The Project Team realised that the earthquakes had significantly changed people's attitude and to a certain extent their perception of what is truly important and what is not. The public were aware and understood that the significant series of events had materially damaged not only their own properties but the core infrastructure that services them. This Project was seen as a one-off opportunity to revisit LOS in the aftermath of the earthquakes and the sense of "the new normal". For example, it was thought that the public would accept lower water pressure if it could be communicated that this would reduce leakage from the damaged network and help extend the asset life of the "weakened" water supply network, provided that the supply was still adequate and reasonable and it didn't detract too far from the service ultimately expected by the customer.

Reducing pressure related demand (such as garden irrigation) and leakage from the system, and consequently reducing energy consumption, could also be communicated as being consistent with the community's position in the "share an idea" campaign of wishing to make Christchurch a "greener" city for the future.

The LOS standards considered during the Project were:

- Minimum and maximum pressure
- Minimum and maximum velocity
- Fireflow availability
- Reliability and security of supply
- Water loss
- Operational efficiency
- Water quality
- Minimum flow and static pressure at the customer meter, and
- Customer satisfaction

The types of factors considered include; current performance, future predicted performance (whether the rezoning is undertaken or not), domestic/commercial/special needs customers – customer/community expectations and legal obligations, and opportunities and constraints. It was considered important to better understand the current system performance so that a fair and balanced assessment could be made regarding the effect of the rezoning and whether this has reduced or improved the overall LOS to the customer.

5 DESIGN CRITERIA

In addition to developing zones that would deliver the desired LOS performance as detailed above, the team established a series of design guidelines/criteria that would be used to help establish and test the concept design.

The principal purpose of establishing smaller WSZ is to create zones of a convenient size for improving day to day management, operational efficiency and emergency management. They will be used for undertaking future strategic planning work at a manageable scale. The WSZ will also be the "base units" for system performance and LOS reporting purposes.

On the “flatter areas” of the City, it was suggested that WSZ will typically include a number of source pump stations (typically 3-4), but this may not be the case for the topographically challenging hill suburbs.

It is envisaged that the larger or “Primary” WSZ will comprise on average 5,000 - 10,000 properties but it was considered that this was only a guide and ultimately population was not a key design criteria. The Primary WSZ effectively replace the current zones which were designed more along the lines of political boundaries that existed prior to local authority amalgamation in 1989. The WSZ would ultimately have additional pressure control in the form of variable speed drives at pump stations and/or strategically placed pressure reducing valves (PRVs).

It was recognised that some additional pumping capacity may be required in some areas to account for damaged/de-commissioned headworks (such as in Red Zones) or to compensate for where peak demand in excess of pumping capability had previously been met from reservoir storage that was previously available for large parts of the City supply due to the open nature of the network.

A good valve management policy will be required, and this is something that has been the subject of discussion before in CCC as “uncontrolled” valve operation is a constant issue for CCC and indeed many other Councils across New Zealand. With the rezoning in place there will be a need to carefully police valve operation and to keep the zones “tight”.

The Project Team made the following recommendations for WSZ design criteria for the rezoning which take into account current LOS targets and performance indicators for CCC. Whilst these are the optimum criteria for most zones, it was acknowledged that they may need to be adjusted (relaxed or made more stringent) for complex areas such as those dominated by large industrial users or topographically challenging zones:

- Zone boundaries to take advantage of geographic features where convenient/appropriate e.g. rivers, key roads/motorways or railway lines, by topographic factors or to define areas of similar user types.

- Back-up power generation is needed in each area to maintain “adequate” supply – this could be at a reduced LOS? The aim is for 50% of normal supply capability in the zone to have back-up power.

- Consider adding a new source in an area if peak demand warrants this and can’t be met from existing sources. This may be the case particularly during the summer evening peak demand where this may previously have been supplemented by supply from reservoirs.

- Optimise the number of points of supply (sources) preferably 2-4. It was agreed that the ideal number is 4 but that more or less were acceptable. It was agreed that each zone should be able to operate with one pump station out under normal peak week demand conditions.

- Each WSZ to be able to meet average winters day demand using diesel generators to take advantage of the current power tariff structure.

- Security of Supply – agree acceptable solutions with operations staff at the detailed design stage. Automated solutions will most likely only be used in critical zones with consideration given to hospitals, nursing homes and other sensitive locations. Need to avoid areas with significant traffic management issues for any key valves.

- Zone to be designed to minimise the number of boundary valves if possible.

- Real time management – need to adopt a suitable monitoring and management system to ensure all WSZ key flows and pressures are constantly recorded and monitored regularly for detailed analysis and that suitable alarm values are set to trigger action to respond quickly to bursts or system failures.

- Minimise the number of dead ends and consider if additional steps such as providing a means of flushing is required where these exist.

- WSZ design should not compromise fire flow or provision of adequate supply in the event of a mains break.

- Optimum pressure range 35-50m at the consumer, acknowledging that some properties will inevitably remain above or below this band.

- Minimum design pressure of 25m at any point of supply at critical point at peak day demand.

- Minimum flow requirement of 25l/min at the customer meter

- Minimise daily pressure range as far as practical - ideally less than 20m

- Latest technology flow meters: appropriately selected and sized for each zone to provide sufficient accuracy across the expected flow range and particularly minimum night flows.

- Maximum pipe velocity not to exceed 1.5m/s under normal operating conditions

- Maximum pipe headloss 10m/km under normal operating conditions – preferably <5m/km

- Permanent pressure monitoring at source pump stations and other suitable locations in the network – acknowledging pressure monitors are being established at Wastewater PSTs and may be suitable for critical or average zone monitoring points.

- Liaison needed with the WQ team to determine the effect of rezoning on the WQ testing procedures and in particular check where an above ground sample tap is needed on a zone by zone basis.

- An optional extra is to provide a facility to check the integrity of boundary valves but a boundary valve management plan is required

- Need to ensure adequate reservoir turnover under different demand conditions with the new WSZ design, as reservoir supply areas may change significantly.

6 PERFORMANCE BENCHMARKING

Detailed hydraulic models were used to establish the performance of the current system against the agreed LOS and Design Criteria. The system performance was to be reviewed before and after the rezoning, initially using the calibrated models from prior to the earthquakes, then the models were updated with the latest information and checked with and without the proposed zones. Eventually, monitoring at critical points in each of the WSZ will be used to confirm the actual system performance and guide the staged pressure management programme.

It was considered important to understand where the system performs well and where it is currently deficient. This would provide a balanced assessment of the impact of the rezoning work and will also inform future LOS decisions.

A fire flow requirement/availability plan was developed and used to judge the performance of the current and subsequently the proposed system against the latest requirements as detailed in New Zealand Fire Service Code of Practice SNZ:PAS 4509. The models were used to assess the performance before and after rezoning to ensure that the system performance did not deteriorate significantly as a result of the rezoning. It was acknowledged that some localised upgrades may be necessary and this is acceptable if the overall benefits outweigh the additional cost involved.

The system generally performs well, with few properties experiencing pressures below the target LOS minimum pressure (25m). However a large number of properties are currently experiencing pressures in excess of 80m, and a key objective of the rezoning project was to reduce this number significantly.

Finally future planning models could be used to assess the deficiencies in the WSZ moving forward as growth and relocation occurred and in particular the need for additional wells and surface pump stations.

7 CONCEPT PLAN DEVELOPMENT AND TESTING

The Consultant Team developed a “Preliminary Concept Design” and this was then reviewed in detail at a Concept Design Workshop, which included the entire core project team. This was considered important so that the design could be assessed from the differing perspectives of the planning, operations and asset management teams.

The preliminary design was modified to a point where consensus was achieved between the attendees. This was actually less of a problem than had initially been expected, given the differing views expressed at the initial Project Inception Workshop. On reflection, perhaps this was actually more a measure of the growing sense of a combined team trying to achieve a shared goal and a realisation that the project could deliver a workable solution that would be able to gain widespread acceptance and the necessary traction to succeed.

The initial zone boundaries were established and the next key objective was to demonstrate a workable supply and demand balance within each zone and to make any necessary changes before proceeding to detailed operational testing of the zones using the models. Each WSZ was analysed in detail, running at the current pressure and then the potential for pressure management was established.

The supply/demand balancing exercise resulted in a number of adjustments to the zone boundaries, but the design essentially remained faithful to the concept design agreed at the workshop.

The outcome of this work is that it is proposed to divide the City into 14 Primary Zones (with their own sources of water) with a number of Secondary Zones (essentially the existing Hill Zones) which are fed from the Primary Zones without their own independent sources. Where practical, natural features such as rivers/streams and significant roads and railway lines have been used to help define the zone boundaries. A plan showing the proposed WSZ is presented as Appendix 1.

Each Primary Zone will have multiple sources to balance supply and demand, and back-up generators provided to maintain supply in the event of a power failure and to retain the current capability to reduce electricity demand during peak tariff periods controlled by “ripples”.

The WSZ were given names that reflected their geographical location/primary source location, ensuring that none of the previously used names were used. It was considered important to present “a clean slate” and it was also considered important to avoid any of the names that had become synonymous with the most damaged zones such as “Bexley” or “Eastern Suburbs”, so that this re-emphasised positivity and a “fresh start for all”.

The proposed WSZ were set up in the models and tested at peak and low demand conditions to establish any weaknesses in the system and pump station or system upgrades required. Minor changes to the WSZ boundaries were made as necessary, but no significant changes were required.

The hydraulic modelling and system performance analysis highlighted a number of weaknesses in the current “trunk main” system. These weaknesses are currently “masked” by the open nature of the current network, and the high system pressure means that high head losses during peak demands generally do not result in low pressure LOS failures. However, when the zones are closed in and the general system pressure is dropped, these weaknesses would result in LOS failures if they are not addressed.

A number of pipework upgrades were therefore identified as being essential and it was important to consider these in the context of the current renewals programme and perhaps more importantly with the SCIRT programme of work. In this way the best opportunity could be taken to tie in with the “one-pass” approach adopted by SCIRT, under which water, wastewater and stormwater upgrades would be undertaken simultaneously or closely in sequence before the road was repaired/re-surfaced.

8 COST BENEFIT APPRAISAL

8.1 DEVELOPING A BUSINESS CASE

CCC needs to understand the financial return (or payback period) for implementation of the re-zoning design. The Project Team were instructed that they need to demonstrate a reasonable “payback” period, perhaps within a 10 year period. A payback period of more than 20 years was unlikely to be acceptable. The Project Team needed to detail how the payback could be calculated and demonstrated/refined as the works proceed.

In effect, the Project Team had to demonstrate that there is a plan for measuring success. A detailed cost benefit appraisal was carried out and is described below.

8.2 BENEFITS

8.2.1 MORE EFFICIENT OPERATION

The new WSZ will be smaller and more “manageable” on a day to day basis than the current system. This will facilitate better monitoring of performance and optimisation of the system controls to facilitate a reduction in total energy consumption whilst maintaining a more consistent, regulated and ultimately reduced system pressure.

With new correctly sized pumps and variable speed controllers being installed at a number of the pump stations over time, it will be possible to closely control system pressure and operate the pumps near to maximum efficiency through a wide range of demand scenarios. Together with the expected reduction in water pumped through reduced leakage and pressure related demand, it is anticipated that the overall power usage will drop by around 10-20%. Given that the current annual cost of electricity for the Christchurch water supply is approximately $2.6M, this will perhaps provide the single most significant benefit in terms of overall cost savings.

8.2.2 EMERGENCY OPERATION

The smaller zones will also be significantly more manageable than the existing system in the event of further significant seismic activity or another emergency. The zones will be more closely monitored and controlled, and clear emergency operating procedures will be established and detailed in the zone operating manual. The procedures will detail operation of back-up power supplies, operation of back-up feeds in from adjoining zones and any instructions on the need to limit demand by enforcing compulsory restrictions.

In addition, more system pressure monitoring points are being established, such as at wastewater pump stations that are linked to telemetry, and these will help the operators to better understand and control the zones as they are gradually re-established following an outage.

8.2.3 PRESSURE RELATED DEMAND AND LEAKAGE

The relationship between pressure related demand such as irrigation, leakage and system pressure is generally well understood. Under normal circumstances it would be relatively straightforward to approximately predict the savings in overall usage that could be expected from introducing a pressure management scheme once the average drop in system pressure has been established.

However, the effect of the earthquakes meant that leakage rates more than doubled in some areas. The leak detection and repair teams were tasked with reducing the leakage to pre-earthquake levels through targeted repairs and replacements. Whilst there was reasonable data detailing the system performance before the earthquakes, the rapidly changing situation with the repair/replacement programme together with the effect of the ongoing aftershocks on a more vulnerable system make it impossible to estimate with any certainty or ultimately to quantify the benefits that are directly as a result of the rezoning work.

It is estimated from use of the hydraulic models and specialist water loss management software that the resultant drop in overall system leakage as a result of the rezoning and pressure management work would be in the order of 20% when compared against the pre-earthquake average levels.

8.2.4 REDUCED BURST RATE

Similarly, the relationship between burst rate and pressure has also been the subject of recent study, with the Water Services Association of Australia (WSAA) leading the way with research in this area over the last few years.

Thirteen years of records prior to the earthquakes were assessed, demonstrating that the annual number of pipe bursts in the Christchurch system and indeed the monthly variation, were fairly consistent. Again the immediate effect of the earthquakes was a large number of mains and service pipe bursts. This has been followed by a period of extensive “patching” followed by the SCIRT driven rebuild work. It is not therefore possible to predict or quantify the drop in burst rate as a direct result of the pressure management and rezoning, but it is estimated that the drop compared to the previous total could be in the order of 20-40%, which given that there are approximately 5,000 bursts per year across mains and service connections represents a potential annual saving of around $200k.

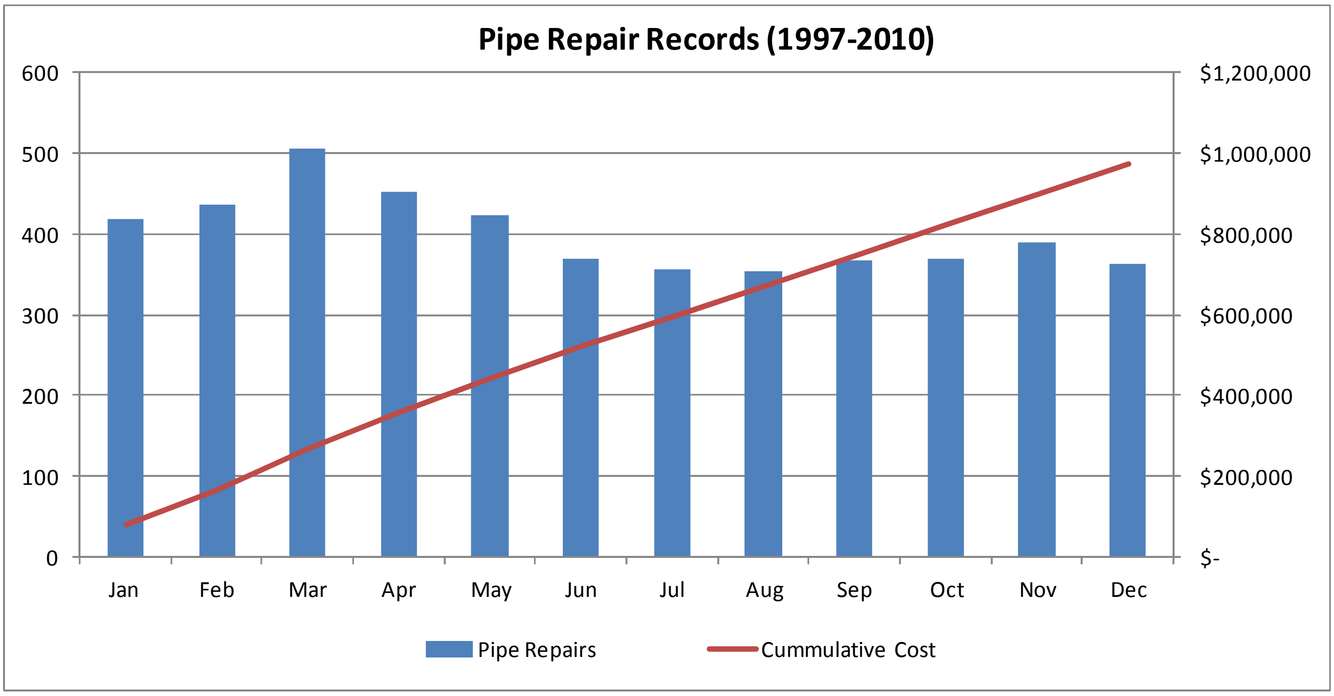

Figure 1: Pipe repairs 1997-2010 and cumulative costs

8.2.5 EXTENDED ASSET LIFE

It has long been understood that reducing system pressure and minimising the experienced range in pressure results in an extended asset life, deferring the need for renewals. The effect varies from material to material and with a number of small diameter “brittle” pipes being replaced with more flexible materials, the balance of material in the system is changing. The remaining pipes may be more vulnerable as a result of the earthquakes and continuing aftershocks and ground movement, but only time will tell the true extent of this.

It is not possible to predict with any certainty the overall benefit of the rezoning project in terms of extended asset life, but given the above factors, generally reducing the system pressure and in particular significantly reducing the peak/excessive pressure and the pressure range experienced by the pipe assets can only be beneficial to the system.

8.2.6 DEFER CAPITAL EXPENDITURE – A MAJOR NEW SOURCE

The Christchurch Water Supply Strategy 2009-2039 identified a range of projects that were aimed at reducing total system demand in order to defer or potentially avoid the need for an additional major water source for the City that would be required if the predicted city growth occurred without a significant reduction in per capita consumption. The cost of the new source is expected to be in excess of $150M when connecting pipework and reticulation upgrades are included. The projects included a proposal to investigate the possibility of reducing system pressure across the system to reduce pressure related demand and system leakage. Effectively the rezoning project has fulfilled this role to a large extent.

The effect of the earthquakes on the long term population growth in Christchurch is the subject of much debate and uncertainty. The migration from the city after the earthquakes will be balanced to a certain extent in the short-term by the temporary workforce required to re-build the city. However, whether the long-term growth of the city will be in line with previous predictions or not is hard to judge and only time will tell.

The overall reduction in water usage predicted as a result of the rezoning work and pressure management would be equivalent to a delay of up to 10 years in the need to develop a further source for the city, if compared to the previously developed graph of growth and water usage. This potential deferral is certainly significant.

8.3 COSTS

At the time of writing this paper, the costs for detailed design and implementation of the rezoning were being calculated. Early estimates have suggested that the repayment period for investing in the rezoning will be less than 10 years.

Many of the pump stations that will need to be modified to facilitate the new system pressure and flows are in excess of 50 years old. It is envisaged that a significant proportion of the upgrades could justifiably be implemented and funded as “business as usual”. New pumps specifically designed to meet the expected flow range together with variable speed drives, are expected to repay the investment within a couple of years through more efficient operation.

The detailed design costs will to a large extent be dependent on whether CCC are able to resource the work internally or whether they will need to engage a consultant team. It is unlikely that the costs would be excessive as much of the Concept Design work has been quite comprehensive.

The cost of establishing the zones (excluding the headworks upgrades described above) will be largely dependent on the detailed design. The rezoning will inevitably result in a number of dead ends, and it will be necessary to either loop rider mains to the larger mains in the street or to include additional valves and hydrants for flushing. The number of dead ends would be minimised and the most appropriate solutions determined during the detailed review and “fine tuning” of the zone boundaries. It is anticipated that this could cost in excess of $0.5M in total, but that this could be reduced by co-ordinating with routine maintenance, planned upgrades and the SCIRT re-build works as far as practicable.

There will be a number of PRVs that will be required on a temporary basis to facilitate staged upgrades at pump stations, and permanently in the network to provide localised pressure reduction or emergency feeds into zones. It is hoped to minimise the cost by selecting a single supplier and standardising the details as far as possible.

It is proposed to purchase a proven monitoring and performance reporting system and this is expected to cost in the region of $25-50k to purchase and configure. It is assumed that the ongoing costs would be <$10k per year.

There will be a number of additional boundary valves and PRVs in the rezoned network that will require ongoing maintenance. Additionally, there may be an increased need for mains flushing due to the increased number of dead ends. The additional resources required for these will need to be established and monitored over time. On the flip side, it is expected that the number of pipe bursts will be reduced by 20-40%, greatly reducing maintenance costs.

8.4 BUSINESS CASE

The business case to implement the water supply rezoning plan needs to take into account not only the expected payback period, but also the non cost related benefits such as the improved emergency response. As detailed above, the costs vrs benefit appraisal is currently being finalised following the successful development and hydraulic model testing of a Concept Plan.

With early indications suggesting that the project could demonstrate a repayment period of less than 10 years together with achieving the wide range of desired outcomes, it is highly likely that the business case for the Christchurch Water Supply Rezoning will be accepted by Council and the project progressed to the detailed design stage followed by staged implementation.

The long term benefit of deferring or potentially avoiding the need for an additional major source of water for the City should not be forgotten. This was after all the original driver for the investigation into the potential for pressure management suggested in the Christchurch Water Supply Strategy 2009-2039.

9 IMPLEMENTATION

Initially it was expected that 2-3 pilot zones would be selected and developed through detailed design, implementation and pressure management. These would be used to test the process and demonstrate that the anticipated benefits could be achieved.

However, as the project progressed it became evident that it is feasible to establish the zones and run them for a period without pressure management for a period to gather baseline data and then stage in the pressure management in a prioritised and affordable manner.

The staged implementation will enable CCC to make the best possible use of scheduled/business as usual funded upgrades to pump stations and system pipework.

Using PRVs on a temporary basis on the delivery pipework at selected pump stations is perhaps counter-intuitive, but this enables a staged implementation of the full pumping station upgrades and will be effective in immediately reducing system pressure and consequently leakage and pressure related demand.

Table 1 below shows a preliminary implementation programme.

Stage 1	Establish Zone Boundaries	Apr-June 2013
Stage 2	Run at current pressure and establish baseline performance data and basic operating rules	June 2013-May 2014
Stage 3	Implement Priority 1 pump station upgrades & pressure management schemes and incrementally reduce pressure	June 2014-May 2015
Stage 4	Implement Priority 2 pump station upgrades & pressure management schemes and incrementally reduce pressure	June 2015-May 2020
Stage 5	Ongoing pump station upgrades & pressure management and system optimisation	2020-2050

Table 1: Preliminary Implementation Programme

10 MEASURING SUCCESS

During the detailed design phase, a number of available monitoring and reporting software packages will be investigated and the most appropriate solution purchased and configured. Adopting a proven system will enable CCC to continue to closely monitor the performance of the zones and ultimately to demonstrate the success of the rezoning project.

Establishing the zones and leaving them running at close to existing pressure for a 6-12 month period will enable calculation of a baseline against which the success of the pressure management can be judged. The baseline results would also be reviewed against the pre-earthquake data to establish whether the rezoning alone has resulted in more efficient operation through more “balanced” and manageable zones.

The pressure will be reduced in steps over time, allowing for a period of “consolidation” after each decrease, which will help the operators to overcome any unexpected issues, optimise operation and to allow the improvements to be measured and assessed against the expected outcomes. Reducing pressure in stages will also help reduce the perceived impact on customers, reducing the number of expected enquiries/complaints that CCC would otherwise expect to receive if the pressure was dropped significantly in one go.

Flow and power consumption will be closely monitored and monthly burst rates observed to establish the benefits achieved. In particular the nightline will be closely monitored which will help establish the reduction in leakage.

Another measurement of success, though perhaps less obvious, would be if the changes result in no or a limited increase in customer queries or complaints regarding system pressure or water quality. A clear communications plan will be developed by CCC prior to the implementation phase, which will explain the reasons behind the changes and the overall benefits that these will bring.

The costs of establishing and maintaining the zones will also be carefully monitored and assessed against the predicted costs. The cost of upgrading pump stations is highly dependent on the existing pipework configuration and the need to upgrade switch gear, power supply etc. and that will be confirmed during the detailed design stage.

Reducing the extremely high summer evening peak demands across the City would also be considered a successful outcome for the project. The extreme peaks resulting from garden watering and other outdoor uses should be significantly reduced and evident as the system pressure is incrementally reduced, resulting in considerably less wastage.

11 CONCLUSIONS

In order to progress the actions identified in the Christchurch Water Supply Strategy 2009-2039 and to effectively respond to significant issues related to the open nature of the current Christchurch water supply that were highlighted by the Canterbury earthquakes, CCC instigated a project to develop a long term plan for the water supply system that would make the system more manageable, more efficient, more resilient and robust and ultimately more sustainable.

The first stage of the Project is now nearing completion. This was development of a Concept Design and presenting a business case to demonstrate that the rezoning of the water supply was both technically possible and economically viable. A Concept Design has been established that promises to deliver all of the main objectives and drivers developed by the Project Team. The Concept Design has been tested using detailed hydraulic models and a staged implementation plan has been proposed.

At the time of writing this paper, the costs of implementation were being estimated and the potential benefits quantified. Early indications are that the rezoning will result in a significant reduction in total water pumped, possibly in excess of 3000 ML/year, and a reduction in energy consumption of 10-20%. It is expected that the burst rate will be reduced by 20-40% and that leakage will be reduced by in the order of 20%.

The total reduction in demand anticipated as a result of the rezoning is the equivalent of a delay of up to 10 years in the need to establish a new source for the City if there is a return over time to the growth rates that were anticipated before the earthquakes.

Early indications are that the rezoning would have a payback period of less than 10 years and would deliver a more manageable, more efficient, more resilient and robust network.

Whilst the project is not yet complete and CCC has yet to confirm that the rezoning will proceed to the detailed design and implementation stages, the project has already resulted in a number of benefits to CCC, including;

- A sense of a shared focus amongst the various teams responsible for water supply at CCC and a better understanding of the drivers for each group
- An improved knowledge of current system performance and in particular fire fighting capability and identification of critical points in the system
- Better understanding of source and surface pump capability and “zones of influence” for each pumping station under different demand conditions
- Improvements to the hydraulic models and better understanding of demand patterns and seasonal variation
- A better understanding of the current and future potential roles for the main reservoirs
- An opportunity to review level of service objectives and set realistic and meaningful performance targets for the future.

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APPENDIX 1 PROPOSED WATER SUPPLY ZONE LAYOUT