POST DISASTER OPERATING AND RENEWAL COSTS – AN UNTOLD STORY

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ABSTRACT

Many papers and presentations have been made regarding the damage and post disaster rebuild projects associated with Christchurch City's Infrastructure post the 2010-2011 Canterbury Earthquake Sequence (CES). Little has been told regarding the large impact the CES has had on infrastructure operating budgets and the likely impact on operating and renewal budgets post the completion of the Infrastructure Rebuild by the SCIRT Alliance in December 2016.

This paper describes the additional operational costs incurred by Christchurch City Council following the September 2010 earthquake. The importance of cost tracking and cost engineering in the operations area is illustrated along with the value this provides in developing methodologies for valuing resilience in capital investment models.

The completion of the Infrastructure Rebuild will leave a legacy for Christchurch City to manage into the future. The paper looks at the renewal modeling that has been undertaken to forecast capital and operating cost impacts in Christchurch's current LTP and 30 year Infrastructure Management Plan and how it is planned to manage these challenges into the future.

KEYWORDS

Infrastructure, resilience, cost engineering, Levels of Service, asset renewal planning, operating costs.

1 INTRODUCTION

Christchurch is located on the east coast of the South Island of New Zealand and is the largest city in the South Island with a population of 382,000. The city suffered an extended period of earthquakes, the Canterbury Earthquake Sequence (CES) post September 4 2010. In excess of 12,000 aftershocks were experienced in the City but the majority of infrastructural damage occurred after earthquakes on the 4 September 2010, 22 February 2011 and 13 June 2011. The 22 February 2011 earthquake was by far the most devastating event cutting water to in excess of 30,000 homes and disrupting sanitary services to over 40,000 properties. Some areas of the city sunk by over 500mm after the February 2011 earthquake.

The capital cost of recovery after major natural events, such as the CES, are well published and much has been written about the infrastructure rebuild of Christchurch's infrastructure services (principally wastewater, water, storm water and roading networks). However, the impact of the huge increases in operating expenditure required to return services is rarely reported in any detail. This paper explains how Christchurch City Council went about ensuring it could make reasonable predictions as to the increased infrastructure operating costs associated with the CES. This information was vital to keep all public funding parties, involved in the rebuild of the City aware of the additional pressures these costs placed on the City's budgets. The paper also discusses the impact the inevitable trade-offs in the scope of restoration of infrastructure assets has had on ongoing operational costs for the City.

2 MEASURE TO MANAGE

2.1 ESTABLISHING THE COSTING FRAMEWORK

Post major disasters there are a myriad of requests for costing information. The requests can be for a variety of reasons including:

a. Estimates of damages
b. Insurance assessments and claims
c. Budgetary planning
d. Predictive modeling for funding agencies.
e. Long term planning and annual budget cycles.

In all cases a systematic and structured approach to capturing operating (and capital) costs associated with the response to and recovery from a major disaster is critical. The Christchurch experience also highlighted the value of the ongoing collation of this data with respect to evaluating the cost of services and evaluating long term impacts on the Council's budgets.

It was recognised very early after the September 4 2010 earthquake that the Council would need to accumulate and monitor costs over and above the normal operating costs associated with infrastructure assets. To enable this Council asset owners, working with the City's contractors, established a geo-spatial costing grid that was based on sewer sub-catchments. Sewer sub-catchments were chosen because:

a. They were established geo-spatially and well understood by the 3 waters contractor. Defining boundary definitions in their job systems was therefore relatively simple. This however did cause some minor issues with the roading cost structure as sewer boundaries don't always follow the roading boundaries.

b. Sewer sub-catchments gave a reasonable level of discrimination of area costs which was going to be important to focus capital interventions.

c. From a data manipulation perspective the number of sewer catchments was manageable and could be presented geo-spatially across all infrastructure services.

d. The New Zealand Government defined Residential Red Zone (RRZ – areas of retreat) areas were established as separate catchments as the information needs in these areas were more focused around the ongoing cost of services.

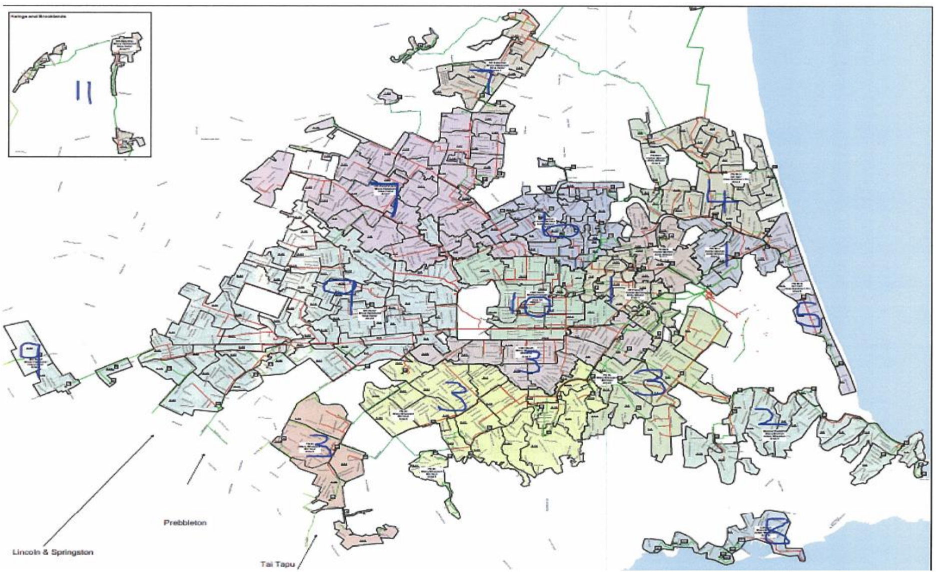

Figure 1 – Christchurch Non-Red Zone Costing Catchments Established Post September 2010

The costing areas established for the RRZ areas are illustrated in Figure 9 later in section 6 of this paper.

Information was collected from Contractors on a monthly basis as part of the monthly claim processes and distributed to SCIRT, Asset Owners and the Council Finance and Insurance team. Council engaged Beca Consultants to prepare consolidated 6 monthly cost reports collating all this information into a report which not only looked at incurred costs but looked to identify opportunities to reduce costs and forecast the impact of the timing of capital works in reducing earthquake (EQ) operational costs.

Beca cost engineers used four methods to review the additional earthquake costs and predict future operating cost scenarios:

a) **Method 1 Historical Assessment** – Reduction in EQ Opex based upon current trends. This method acknowledges that CCC has split their budgets on wastewater, water and storm water into BAU and EQ Opex costs. The EQ Opex costs are codes that are assigned based upon emergency call outs for infrastructure repairs likely to be directly attributable to earthquake damage.

   A review of historical and current costs revealed a trend line highlighting the changes over time. From this results can be extrapolated to provide an assumed trend line into the future.

   This method does rely heavily upon the historical costs trending at levels observed and does not necessarily indicate the effectiveness of renewals and replacement works.

   This rudimentary method was used to provide a comparator to the other methods below.

b) **Method 2 Interpreted Task Method -** This methodology uses the last 12 months of EQ Opex costs and analyses these works to establish the typical works undertaken. These grouped items highlight the proportion of call outs and costs attributable to the different operational tasks such as repairs/cleaning, investigations etc.

   Once these are defined, an assessment of the reduction in the extent of the works is then identified providing a number of scenarios to indicate the likely range of costs that could be experienced over a period of time.

   This method is a better evaluation of actual works undertaken as opposed to financial cost, and does assist in understanding the type and scope of work attributed to extra earthquake opex budgets. The method does provide some sensitivity around the likely reductions/increases in activities going forward.

c) **Method 3 Interpreted Method with proportional assessment of SCIRT renewals (used for wastewater only).** This is an extension of Method 2, where the extents of SCIRT renewals are factored into the on-going likely EQ Opex costs. It uses Opex costs pro-rated by area (as shown above) and then it assumes an inverse linear correlation between reduced opex and the amount of repair completed. For example a catchment with a higher proportion of network renewals completed is likely to have a significantly reduced additional EQ Opex cost moving forward.

   Areas where networks were completely changed (e.g. vacuum catchments or pressure installations) then opex costs were adjusted for the new technology installed.

d) **Method 4 – Buildup of Opex costs based on changes to assets** – this approach derives Opex costs based on the extent of network changes that have occurred as a consequence of the earthquakes. It looks at the main key metric data available upon which the FY2010 data was used and then increases/modifies these assets based upon the changes to the network. For example CCC now has a greater number of pump stations on the wastewater network requiring more maintenance and on-going power costs. In undertaking this assessment on the Council network the following was considered:

   i. Changes in the numbers of assets in each asset class

ii. Likely emergency work/ cleaning costs associated with impaired assets

iii. The average cost of maintaining pump stations and the likely extra O&M costs associated with impaired networks.

iv. Analysis of the original CCC BAU opex costs based on FY2010 numbers and allocate these across asset classes.

All four methodologies were presented to CCC in preparing estimates of future long run operating costs. Council adopted a hybrid solution from Method s 3and 4 for planning purposes as budgeting for the full impact potential future emergency events was not policy within Council.

3 WHERE THE EXTRA OPEX COSTS COME FROM

3.1 TREATMENT FACILITIES

Whilst the Christchurch Wastewater Treatment Plant (CWTP) was badly damaged post the February 2012 earthquake the plant kept functioning throughout the earthquake sequence. This is in no small way attributable to the skill of the staff and management of the plant. Whilst the plant continued to operate significant additional costs were faced at the plant and these are summarized in the table below.

Cost element description	Post CES costs	Duration of costs (months)
Primary and secondary tank cleaning – removal of sand and liquefaction eject material from the network.	$ 624,000	12
Peroxide injection into oxidation ponds	$ 49,000	6
Polymer addition to aid settling in the clarifiers whilst secondary process compromised.	$ 265,000	3
Imported electricity due to reduction in digester output and cogeneration capability	$ 600,000	6
Digester heat exchanger cleaning and repair	$ 342,000	12
Digester clean-outs to remove grid and eject material – includes final clean out facilitating earthquake repairs.	1,000,000	36
Increased diesel consumption due to reduction in digester gas output	$150,000	3
PST scraper repairs due to overloading of flights from eject material	$ 445,000	12
Total additional EQ operating costs at CWTP excluding additional CCC staff and relocation of staff.	**$ 3,475,000**	

Table 1 – Additional CWTP Earthquake Operating costs post February 22, 2011 Earthquake.

The CWTP annual operating budget in 2011 was approximately $9 million per annum. These additional costs represent a 30% increase on the normal controllable costs associated with CWTP. The majority of these additional operating costs lasted 12 months but the digester cleaning extended over 3 years due to process constraints.

3.2 3-WATER NETWORKS

The disruption to the City's underground networks was extensive post February 22 2011 earthquake. The wastewater network was the most severely damaged of all the infrastructure networks. Additional operating costs in the networks are detailed below.

3.2.1 LABORATORY COSTS

There was a significant demand for additional laboratory testing post each major earthquake. The removal of the chlorination from the water supply in late 2011 also incurred significant testing resources as the withdrawal of the chlorine from the supply had to be very carefully monitored to ensure no E-coli events occurred. The additional laboratory testing required in the 12 months post February 22 2011 accounted for an additional $1.044 million in drinking water compliance testing and a further $44,500 in additional rivers environmental testing.

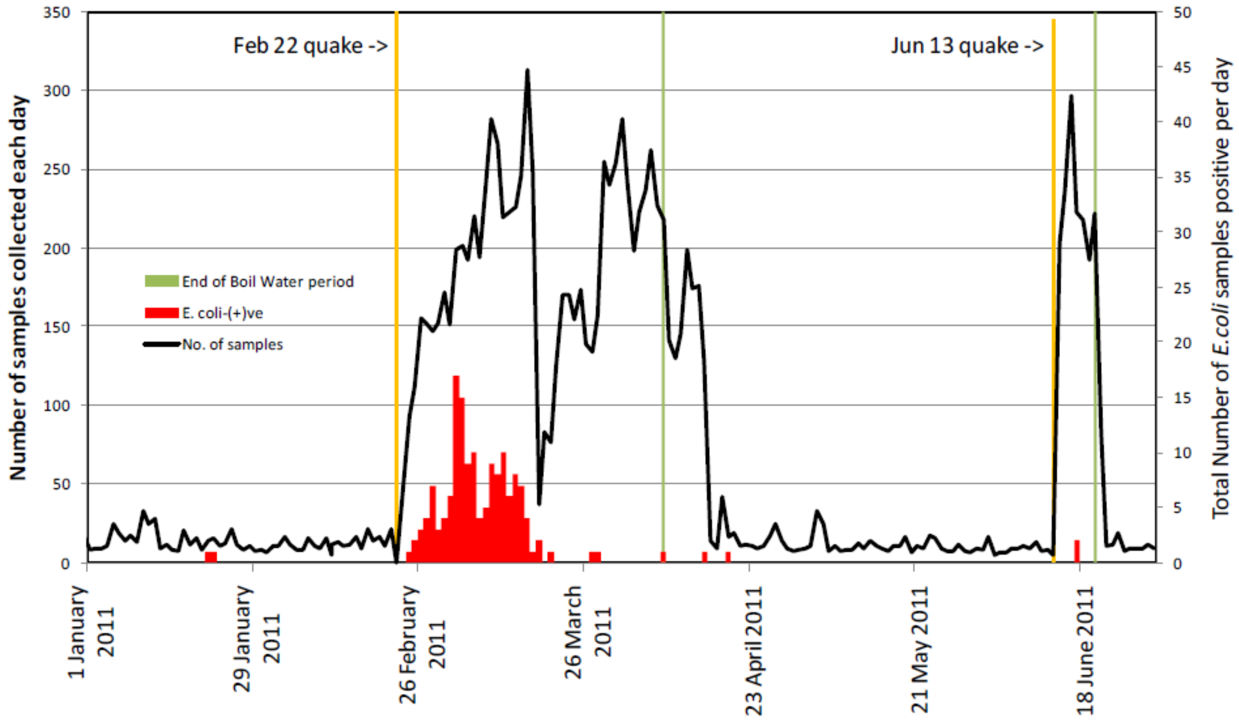

Figure 2 – N^{o} of Drinking Water samples collected during 2011 and corresponding E-Coli transgressions detected.[4]

3.2.2 WATER NETWORK COSTS

The damage to the both the water and wastewater networks post the February required the City to install emergency chlorination on the eastern side of the city to protect the public water supply. This was accomplished by installing 26 dosing rigs at appropriate pumping stations and establishing a chlorine residual in the network.

Water system cost element description	Post CES costs	Duration of costs (months)
Establishment of 26 chlorine dosing stations.	$ 900,000	6
Chlorine chemical supply from Feb 22 2011	$ 725,000	6
Establishment of emergency desalination plant at Brighton beach	$ 1,067,000	12

Inspection and repair of the City's 154 wells post each quake	$ 18,657,000	18

Table 2 – Additional Water Related earthquake Opex Costs

It is worth noting that after each major earthquake the Christchurch well field needed to be re-inspected for damage. This proved a very frustrating and time consuming process and extended the time to complete the repair of the well field as some wells that survived earlier damage required more extensive repairs and in some cases, re-drilling post later aftershocks.

3.2.3 GENERAL NETWORK COSTS

The 3-waters networks incurred a wide range of additional opex costs to those detailed above. Whilst these costs have not been broken out in detail in this paper a summary of these costs is recognised on an annual basis in Table 4.

The table below details the main components of the additional costs.

Opex cost generator	Wastewater network	Storm water network	Water network
Stop bank damage	√	√	–
Silt jetting and removal	√	√	–
Increased pump wear	√	√	–
Supply and servicing of portable toilets	√	–	–
Supply and servicing of chemical toilets and collection tanks	√	–	–
Increased pumping costs	√	√	√
Leak detection work	–	–	√
Network pipe repairs	√	√	√
Emergency over pumping	√	√	–
Replacement non return flaps/discharge points	√	√	–
Emergency distribution points	√	–	√
Emergency response costs (rain, snow and aftershocks)	√	√	√
Additional staff supervision	√	√	√

Table 3 Causes of Additional Opex Costs on various 3-Waters Networks.

4 MAGNITUDE OF ADDITIONAL OPERATING COSTS

So how do the operational impacts manifest themselves at a high level?

The table below summarises the magnitude of the Opex costs in each activity on a year by year basis from 2010 to 2014. The totals starting with "EQ" represent the ongoing additional earthquake costs that were incurred additional to the BAU budgets. All numbers are in NZ $ millions.

Activity (NZ $ M)	FY 2010	FY 2011	FY 2012	FY 2013	FY 2014
BAU Opex Water	10.5	8.3	9.8	12.8	12
EQ Opex Water	0	25.2	15.7	4.35	4.2
BAU Opex Wastewater excl treatment	8.3	7.6	8.5	11.4	10.5
EQ Opex Wastewater excl treatment	0	59.3	119.1	36.68	17.5
BAU Opex Storm water	8	7.1	8.9	9.3	9
EQ Opex Storm water	0	11	7.8	3.37	7.2
BAU Opex Roading	33.4	28.9	35.8	38.4	37.1
EQ Opex Roading	0	81.6	46.69	8.1	5.9
Total Infrastructure BAU	60.2	51.9	63.0	71.9	68.6
Total Infrastructure EQ	0	177.1	189.29	52.5	34.8
EQ Additional Opex as % of BAU Opex	0%	341%	300%	73%	51%

Table 4 – Actual CCC additional EQ operating costs for period 2010-2014

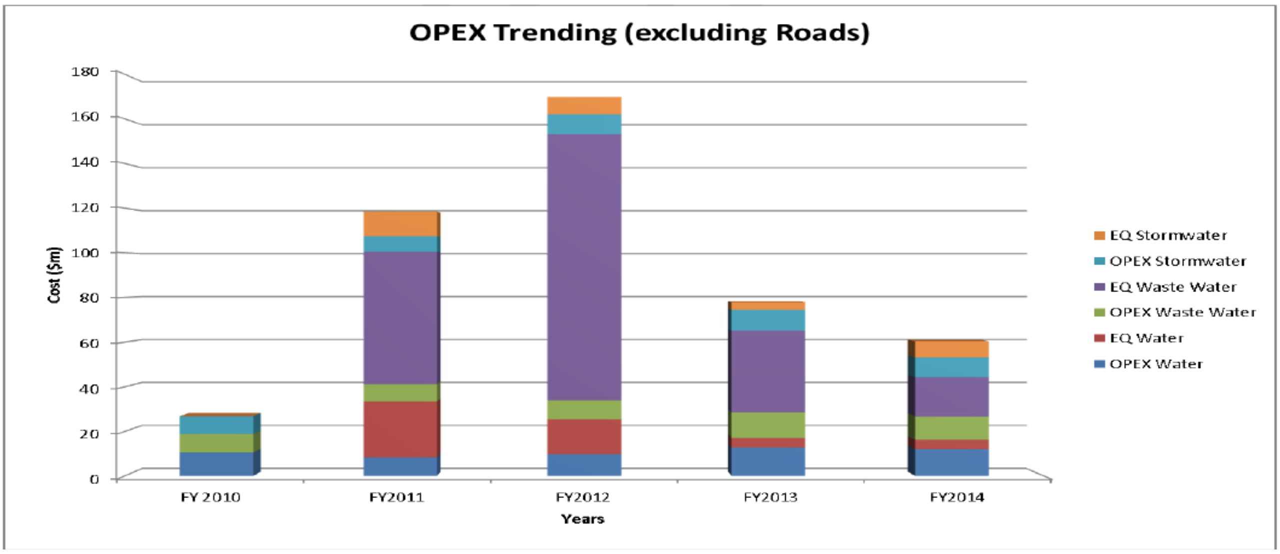

Figure 3 – CCC 3 Waters Infrastructure BAU and EQ Opex Spending 2010-2014.

Whilst the above figures illustrate a marked drop off in additional earthquake operational costs at the end of 2013 additional infrastructure earthquake opex was adding approximately $180/HEU to the rates above BAU levels (approximately $640/HEU pre earthquake). This represents a 28% increase in operating costs for these services over and above any BAU cost fluctuations. It is expected that this additional EQ Opex rate per HEU will continue to drop with the completion of the SCIRT works programme and on-going CCC asset renewal. However it is unlikely that the additional EQ related opex pressures will cease totally within the next 20 years.

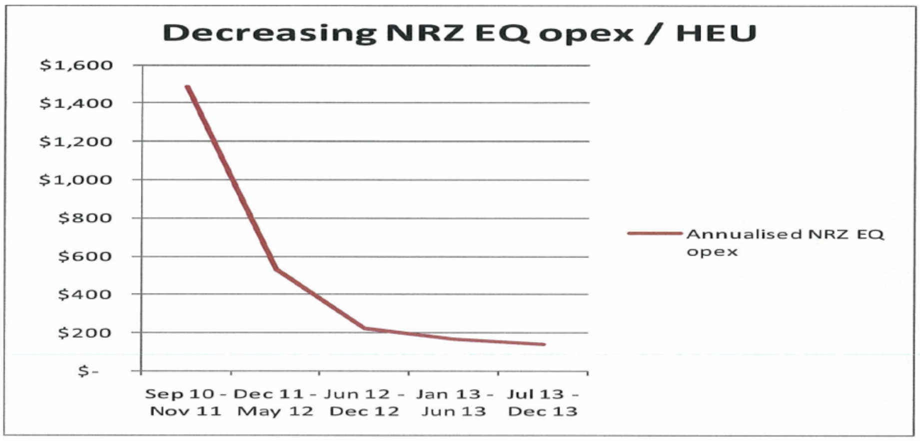

Figure 4 – Reduction of Additional CCC EQ Infrastructure Opex Costs per HEU

In terms of rates impact, in 2014 a NZ $2.8M increase in operating costs translated roughly to a 1% increase in rates for Christchurch City ratepayers.

The NZ Government provided significant support to Christchurch City in financing these additional operating costs but they were funded from the same NZ $2.94 billion bucket of money used to finance the infrastructure rebuild of the city. This meant the longer the earthquake operating costs continued during the Infrastructure Rebuild period the less funding was available to support permanent solutions to reduce the EQ Opex costs. Any delays in the infrastructure rebuild further exacerbate this issue by delaying delivery of capital solutions and prolonging EQ Opex costs.

As part of the infrastructure rebuild, an optimization study was conducted in early 2014. This study had the impact of reducing the volume of work being conducted as part of the infrastructure rebuild due to budget constraints. It also changed the trigger points under which work would be carried out by the SCIRT Alliance. These changes affected the remaining life of assets coming out of the rebuild and the Level of Service they are capable of delivering over their remaining life. The impact of these changes is discussed in section 7.

5 IMPACTS ON LEVEL OF SERVICES

5.1 WATER SERVICES

Potable water levels of service were impacted in several ways after each of the major quakes in the CES.

a) In the initial response to each major earthquake “Boil Water” notices were issued across the City. City wide notices were issued by Community and Public Health (CPH) to simplify communications and provide a consistent message.

b) Many households were without reticulated water and relied on emergency distribution points during the initial days post the major quakes. The restoration of reticulated potable water service, post 22 February 2011 event, is illustrated below.

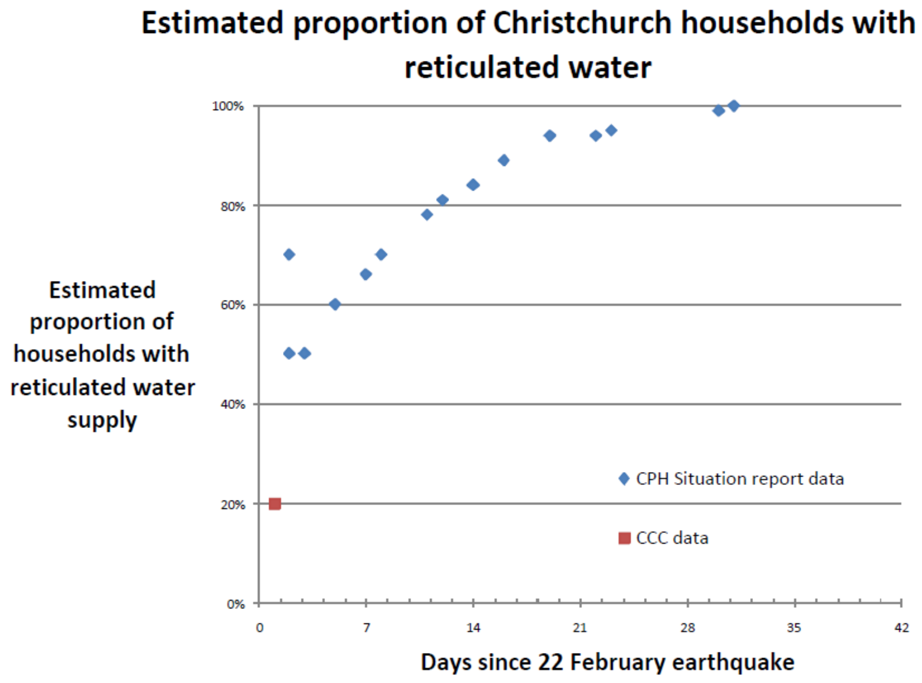

Figure 5 – Time to Restore Reticulated Potable Water to Christchurch Households Post February 22 2011.[4]

c) Once reticulation was available the eastern side of the City was chlorinated through dosing stations installed at each water pump station in the affected areas.

The time frame for the restoration of various components of Levels of Service post 22 February 2011 is illustrated in the Figure 6.

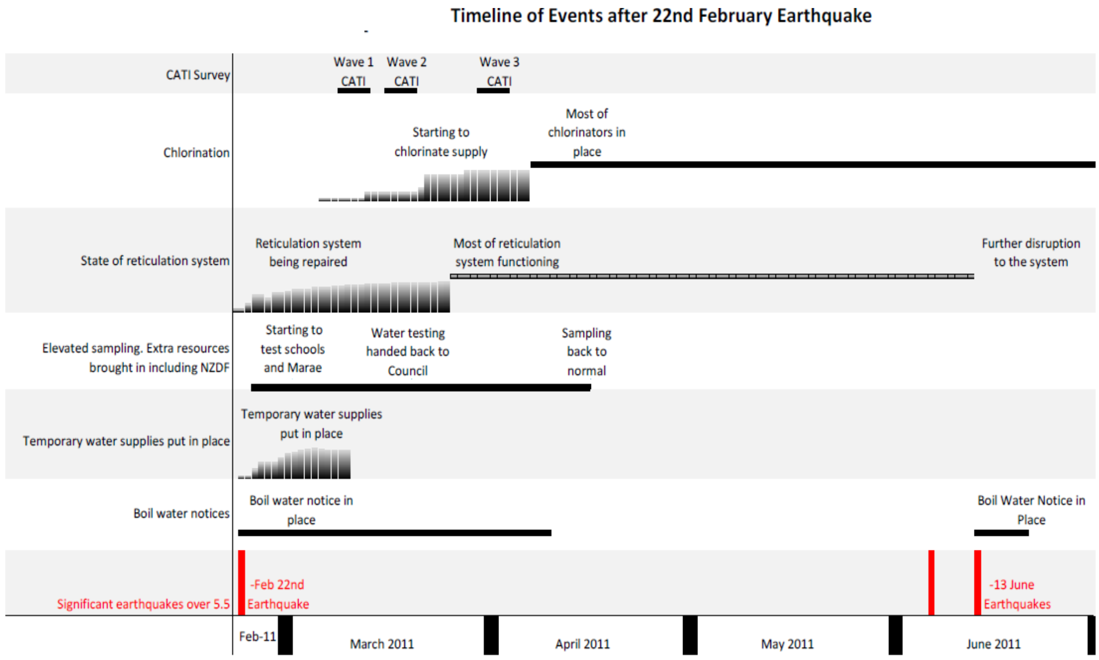

Figure 6 – Restoration of Water LOS Post February 22 Earthquake[4]

d) Burst rates and leakage in the restored network were much higher than pre the CES. These parameters improved through the infrastructure rebuild but as shown in Figure 7, remain significantly higher than pre-CES break rates.

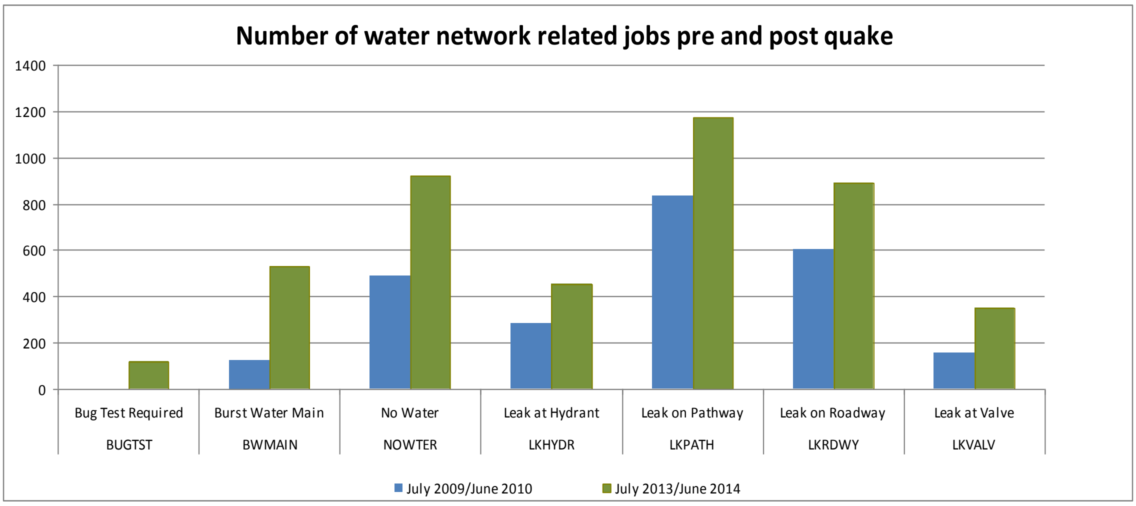

Figure 7 – Analysis of CCC Water Reactive Jobs FY09-10 (Pre-CES) compared with FY 13-14 (3 years Post Feb 2012).

5.2 WASTEWATER SERVICES

The largest disruption to wastewater service came post 22 February 2011. In excess of 40,000 homes were without reticulated wastewater services. Similarly to water the wastewater level of services moved through several steps prior to full restoration of service. In the case of wastewater services the final restoration of service in same cases involved a different technology delivering the service.

The key stages involved:

a. Household self-sufficiency – latrines were dug in many backyards. Portable toilets deployed to affected areas as fast as they could be delivered to Christchurch. Red wheelie bins were utilised to dispose of wastewater solids until chemical toilets were distributed. A limited number of mobile shower blocks were also deployed on the eastern side of the City.

b. 32,000 chemical toilets, 500 street collection tanks and associated treatment chemicals were distributed to households in areas of the city where the gravity network was not available. This occurred between early March and late April 2011.

c. Areas were progressively taken off chemical toilets and allowed back onto the damaged reticulation system as critical repairs were completed that allowed flows to resume to the Council's wastewater treatment plant. This process had to be repeated after the June 13 2011 earthquake due to the ingress of liquefaction into the damaged network.

d. Overflows to waterways were reduced from 90,000 m3/day on February 23 2011 to zero by early November 2011. The restoration of low volumes of dry weather overflows allowed recreation activities to resume on beaches and waterways in the summer of 2011/12. However, as shown in Tables 5 and 6 the frequency of dry weather overflows and sewage spills on Private Property is still considerably higher than it was in 2009. This is due to the damaged state of the network.

e. The full restoration of service will be completed with SCIRT completing the Infrastructure Rebuild in early 2017. Pressure sewer and vacuum systems have been installed in various areas of the City were risk of future liquefaction were high.

The graphs below indicate some of the key changes in levels of service post the CES compare with pre CES performance.

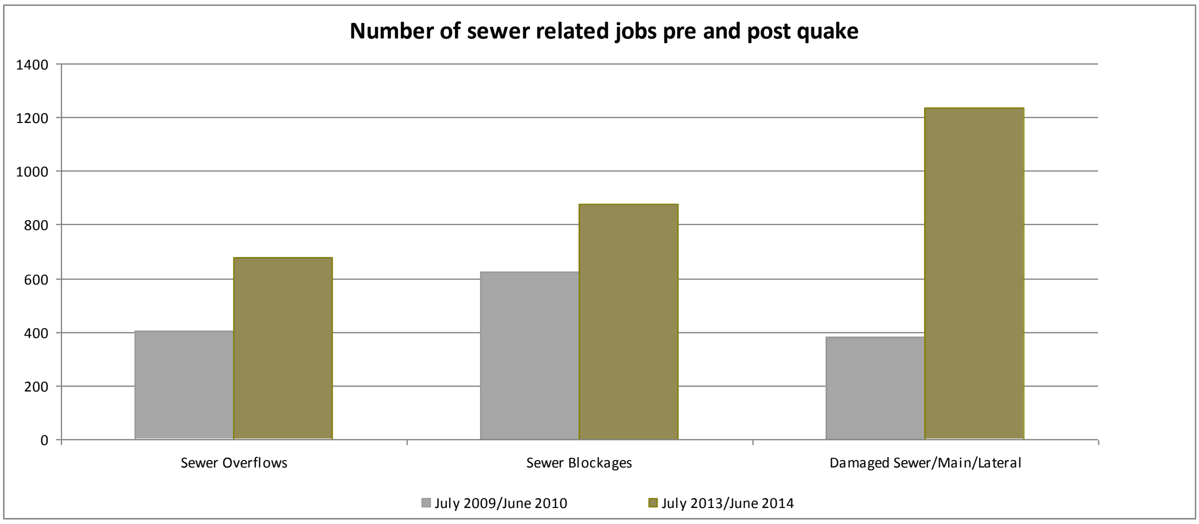

Figure 8 – Analysis of CCC Wastewater Reactive Jobs FY09-10 (Pre-CES) compared with FY 13-14 (3 years Post Feb 2012).

Service Description	FY 09-10	FY13/14
Wastewater cleanups on private property	0	143

Table 5 – Comparison of CCC Private Property Sewage Clean-ups Pre-CES and Post Feb 2012).

Number of overflows				Financial	Overflow volume (m3)			
Dry	Wet	2011 EQ	Total	Year	Dry	Wet	2011 EQ	Total
3	12	0	15	**2009**	57	3,100	0	3,158
9	27	262	298	**2010**	223	21,710	5,981,661	6,003,594
41	12	60	113	**2011**	80,546	28,367	1,789,240	1,898,153
29	30	0	59	**2012**	7,058	104,537	0	111,595
48	54	0	102	**2013**	122,989	234,577	0	357,567

Table 6 – Comparison of Dry and Wet Weather Overflows FY09-10 (Pre-CES) compared with FY 13-14 (3 years Post Feb 2012).

5.3 LAND DRAINAGE/STORMWATER SERVICES

The periodic use of storm water and land drainage assets can mask the hidden cost and loss of service associated with these assets post a natural disaster. Storm water capacity restoration was relatively slow compared to other services. However, since the flooding events of 2013 Christchurch City Council has expensed considerable sums in analyzing and addressing solutions to the flooding issues in areas of the City caused by the subsidence of land post the CES,

Changes in Levels of Service manifested themselves in the storm water network in the following ways:

a. Increased ponding on roads and flooding of property entranceways in low intensity rainfall events.

b. Leakage through Avon River stop banks under high tidal conditions. This caused flooding of local roadways and increased incident management costs.

c. Increase in the number of properties vulnerable to flooding post CES. This was measured in three ways:

   i. Those were flood waters entered the home,

   ii. Those where flood waters were under the house floor level but not in the house, and

   iii. Properties that had ponding or flood water on their sections (nuisance flooding).

Restoration of pre-earthquake service levels is difficult in the land drainage area. Considerable modeling effort is required to ascertain scope of works to restore service. Remedial measures often involve extensive capital works some of which impinge on private property. All these factors combine to slow delivery of permanent solutions and lead to the Council incurring additional operating costs for an extended period. This is the situation Christchurch City has had to manage.

6 OPEX COST IN RETREAT AREAS (RRZ)

The CES created areas within the Christchurch urban boundaries that were classified as Red Zones by the NZ Government. RRZs were created for two key reasons:

- The land was subject to extensive lateral spreading and/or liquefaction and deemed not to be suitable for reconstruction works; or
- On some of the Hill Suburbs the risk to life from rock fall or cliff collapse was considered too great to allow sites to remain occupied and/or for homes to be repaired or built on.

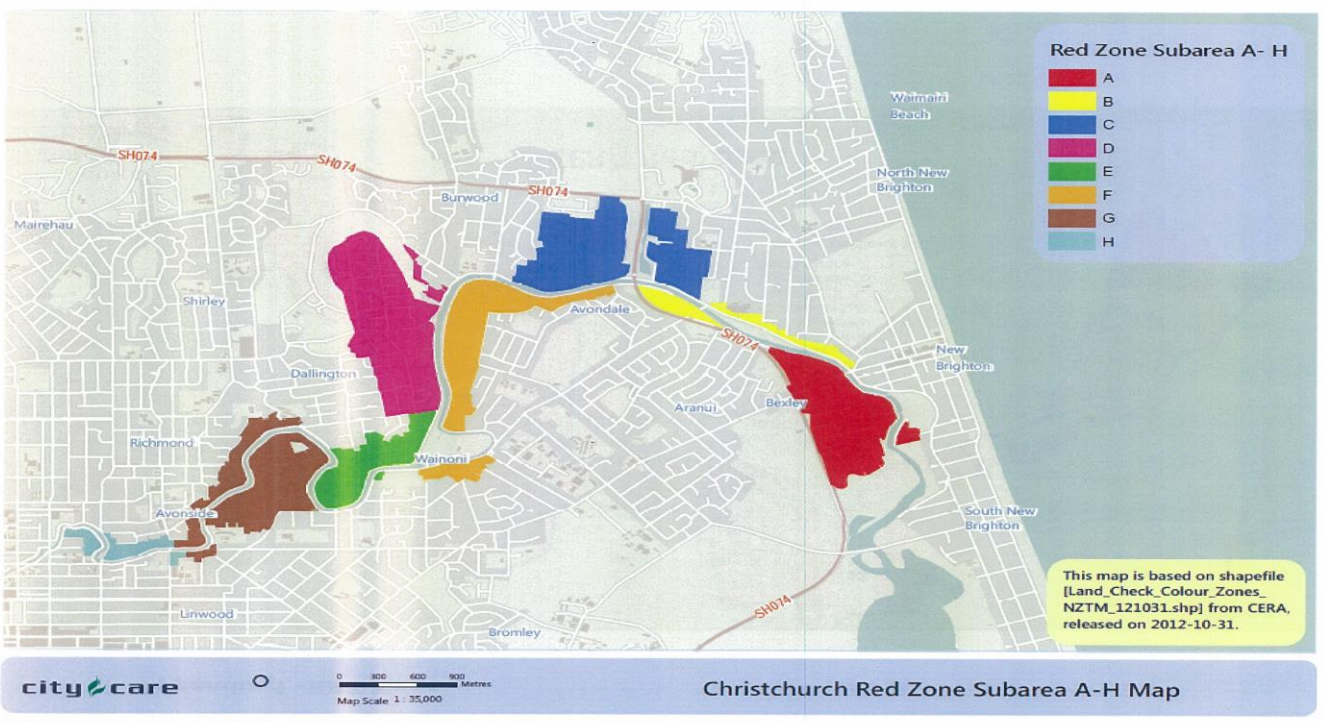

Figure 9 – Red Zone Areas Established by Central Government in Christchurch City – excludes hill suburbs and Brookland.

Generally the second series of Red Zoned properties (Hill suburb areas) did not require the same elevated level of expenditure as the areas on the flats. This difference was principally due to:

- Difficulty in getting wastewater away from isolated houses in a collection area with broken pipes and very little grade. In some cases reverse grades. The wastewater service for many red zone properties involved pumping from isolated pipes in the network or temporary tanks installed on individual properties.

- The flat RRZ areas were subject to ongoing inundation of silt and debris due to high water levels in these areas. This was not an issue for RRZ properties on the Hills.

- Additional water testing and temporary lines were required in the Red Zones to protect the water supply. The turn-over of potable water in the RRZ areas was closely monitored to avoid stagnation and over-heating in the summer months which could have led to contamination issues.

- Rain events caused significant issues in the RRZ's and adjacent low lying areas as land in many of these locations had sunk by 500 mm or more. Leakage through stop banks and close monitoring of "King" tide and heavy rainfall events was necessary to protect public health. Wet weather events that pre 2010 would have caused little or no concern were now costing the Council in excess of $1M in response costs per event.

The colour coding of zones in Figure 9 was established to allow the Council to closely monitor the ongoing cost of supporting the Red Zones whilst the Canterbury Earthquake Recovery Authority (CERA) worked through the purchasing of the properties from the property owners. The government offer to private property owners was not compulsory and there were certain types of property that were not initially eligible for the Government buy-out offer (uninsured properties, bare land, not for profit organisations and community facilities).

Whilst this paper does not explore the background or effectiveness of the Government's buy-out strategy of residential properties the impact of the policy was that there was no final occupancy date (because the sale-purchase process was not a compulsory one) that could be enforced. This meant that no date was established to terminate services in the affected areas (in fact utilities were not permitted under existing legislation to cut off services to those choosing to stay). This left the Council in the unenviable position of having to continue to provide a "Level of Service" to the residents who wished to stay.

As the number of residents reduced in the RRZs the relative EQ opex cost to service each remaining property increased significantly as highlighted in Figure 10. By January 2014 some occupied properties in the Avon River RRZ were costing close to an additional $90,000 per annum to maintain infrastructure services. To put this cost in context the average cost of 3-waters infrastructure services per household prior to September 2010 was approximately $640/HEU.

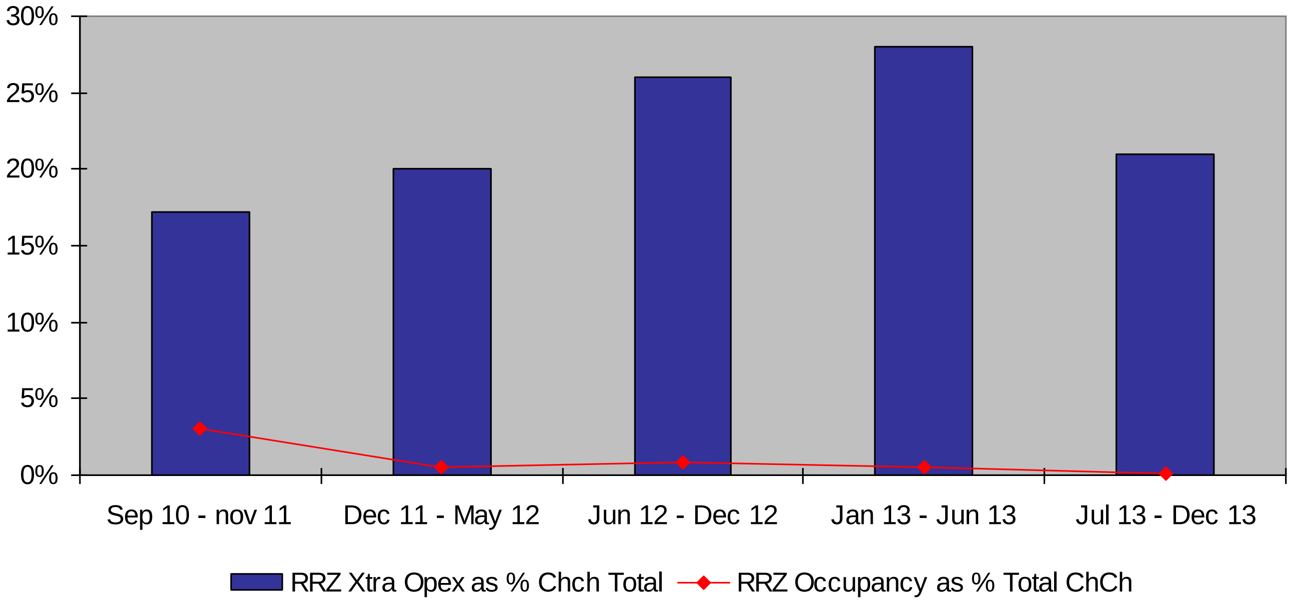

Figure 10 – Christchurch Residential Red Zone Extra Opex and HEU's as a % of total Christchurch City Council Infrastructure Opex and HEU's.

Figure 10 illustrates that by December 2013 the remaining occupied RRZ properties (approx. 0.1% of the total HEUs in Christchurch City) were accounting for over 20% of the extra EQ Opex costs.

7 ASSET RENEWAL IMPLICATIONS

Like most similar natural disasters around the world there is rarely sufficient capital to fully restore services to their pre-disaster condition. The infrastructure rebuild budget was established at NZ $2.94 billion and to ensure the most critical components of the infrastructure services were restored within the rebuild period (target completion December 2016) an optimization study was undertaken between the funders, asset owners and SCIRT.

One of the important outcomes of this study was a revision of design intervention levels. This change in design standards meant a lot of impaired assets will not be repaired under the infrastructure rebuild programme. Christchurch City Council and NZTA have the responsibility to manage these assets post the rebuild.

Whilst the impact of EQ Opex costs has decreased significantly as a percentage of the SCIRT capital spend (see Table 7 and Figure 11) during the infrastructure rebuild, concerns over legacy issues with 3 waters and roading assets prompted the Council to undertake a detailed asset renewal profiling exercise with SCIRT assistance.

EQ Opex $ Million	FY 2012 Actual	FY 2013 Actual	FY 2014 Forecast	FY 2014 Budget	FY 2015 Budget	FY 2016 Budget	FY 2017 Budget
Road Network	$54.9	$9.0	$6.1	$5.9	$5.5	$1.5	$1.5
Waterways and Land Drainage	$7.8	$3.4	$2.4	$7.2	$7.2	$7.2	$7.2
Wastewater Collection	$119.1	$36.7	$16.2	$17.5	$12.5	$7.5	$3.5
Water Supply	$15.7	$4.4	$4.4	$4.2	$3.0	$1.8	$1.0
TOTAL OPEX	**$197.5**	**$53.4**	**$29.0**	**$34.8**	**$28.2**	**$18.0**	**$13.2**
SCIRT Capex	**$249.0**	**$455.5**	**$560.1**	**$486.0**	**$472.2**	**$257.2**	**$257.2**
EQ Opex / SCIRT capex %	**79%**	**12%**	**5%**	**7%**	**6%**	**7%**	**5%**

Table 6 – Summary of CCC Infrastructure Capex and EQ Opex Spend 2012 to 2017

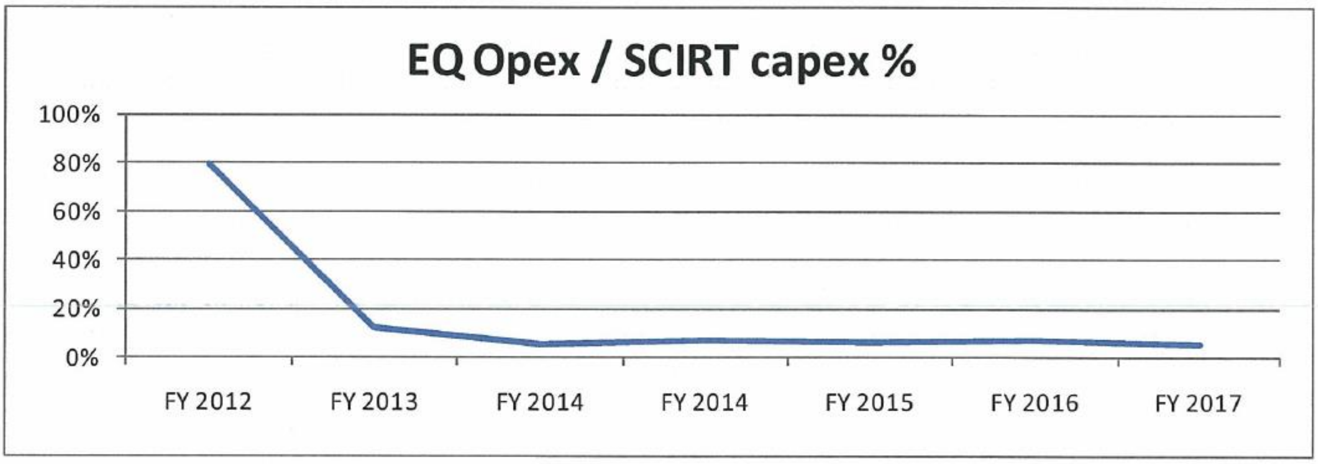

Figure 11 – Graph illustrating Reduction in EQ opex as a % of Infrastructure Capital Spend.

The outcome of the infrastructure asset remaining life study is highlighted in the following graphs for wastewater assets.

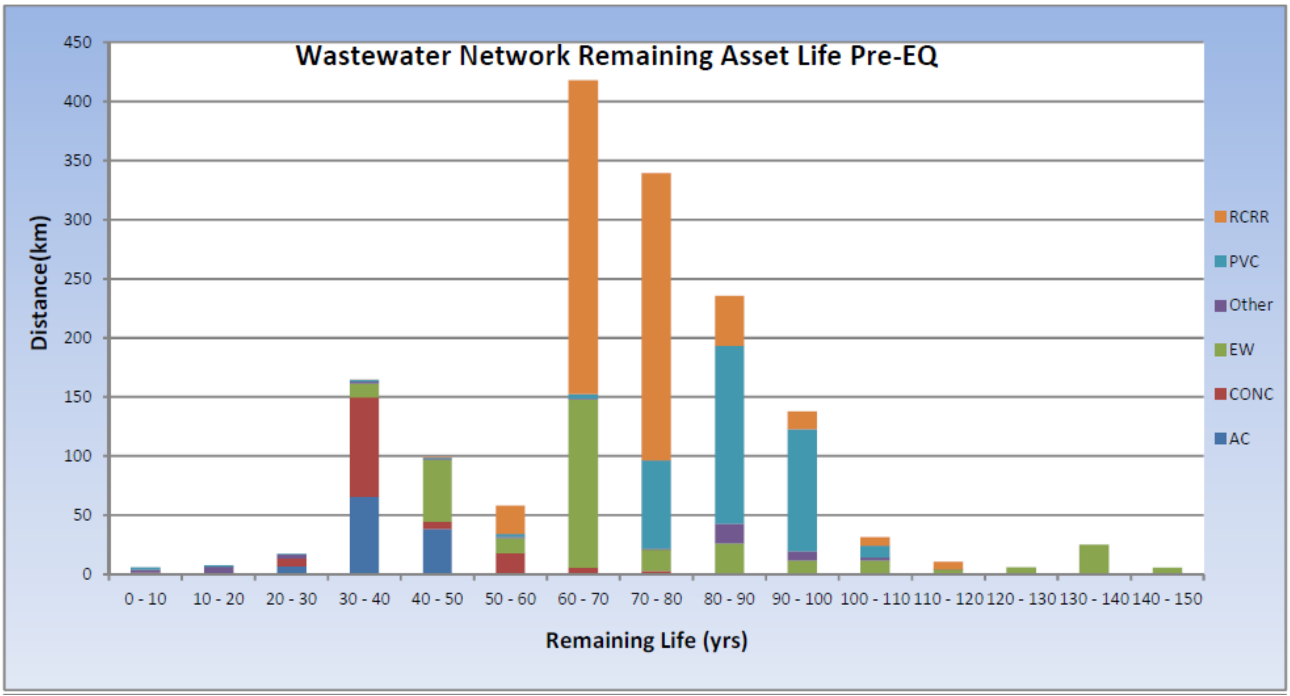

Figure 12- CCC Wastewater Network estimated remaining Life Pre September 2010

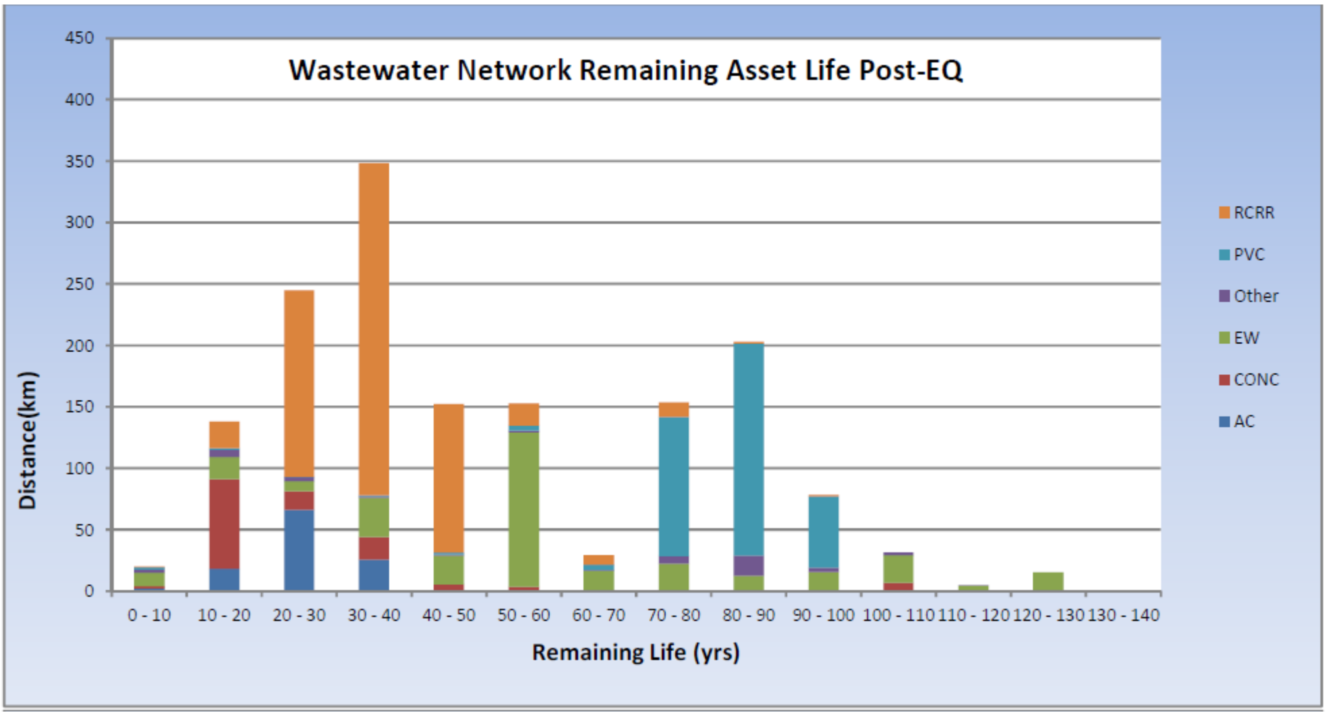

Figure 13 - CCC Wastewater Network estimated remaining Life Post February 2011 Earthquake

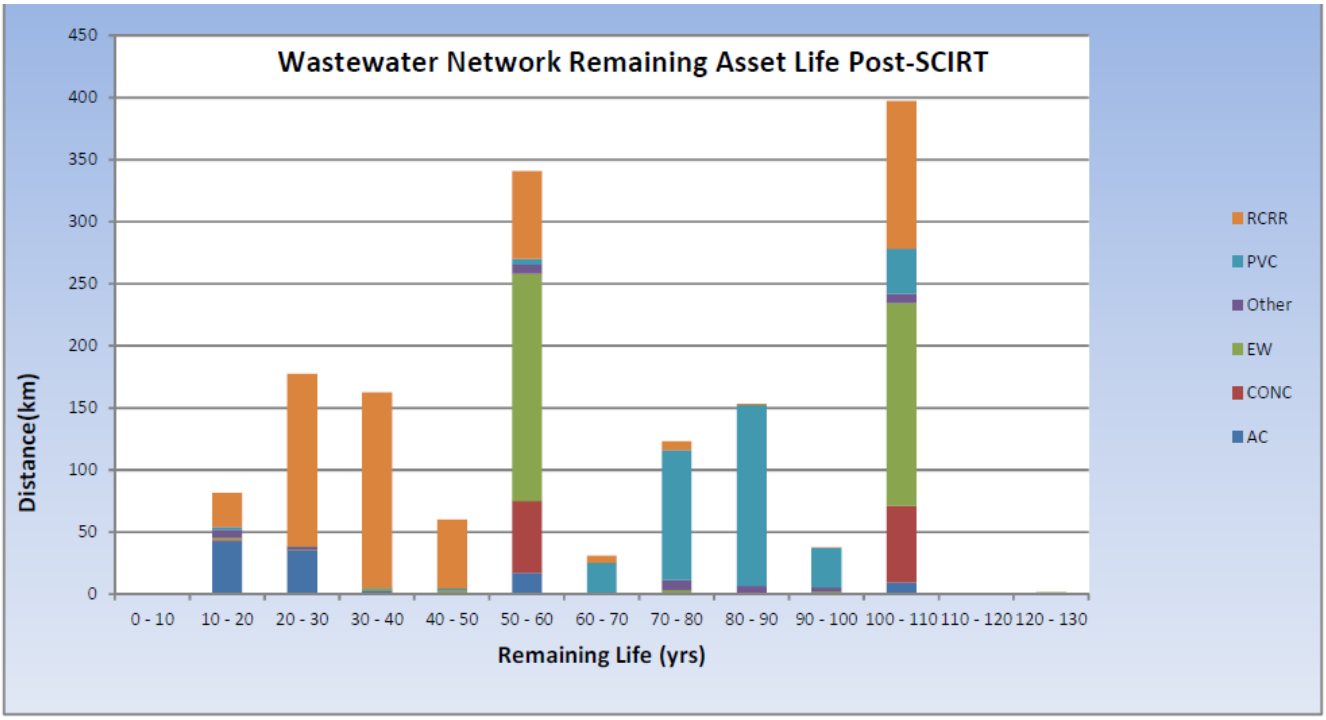

*Figure 14 - CCC Wastewater Network estimated remaining Life Post Infrastructure Rebuild December 2016**

Figure 14 above does not include the impact of revisions to the design standards as part of the Infrastructure rebuild optimization project. The impact of these changes effectively reduced the remaining life of impaired assets from the curves presented in Figure x above.

A calculation of the change in remaining asset life across the wastewater network is shown in Table 8.

	Pre-EQ	Post-EQ	Post-SCIRT	Change (Pre-EQ to Post-EQ)	Change (Pre-EQ to Post-SCIRT)
Indicative asset age adjusted value	$1.98B	$1.32B	$1.82B	$0.66B	$0.15B
Back calculation of a change in remaining asset life	-	-	-	22yrs	5yrs

Table 8 – Calculation of Loss in Value (and Remaining Life) in the CCC Wastewater Network Assets Pre September 2010 to Post Infrastructure Rebuild.

Christchurch City Council has taken the data from the above analysis and used it to reforecast asset renewal under its 30 year Infrastructure Plan.

8 CONCLUSIONS

The CES has highlighted that post disaster operating costs for water services can be a significant burden to the recovery of a City post major disasters. Preparing tools that allow accurate cost tracking and reporting in advance of such events will allow quicker and accurate forecasting of the financial impact of such events.

Whilst no two disasters are the same there are some salient lessons from the CES to take forward in planning for major disasters:

a. The magnitude of extra operating costs can be several times the level of pre-event operating costs and last for many years.

b. Completion of an official infrastructure rebuild period is not necessarily going to restore pre event Levels of Service for the same level of operating expenditure. Christchurch City Council is facing several decades of accelerated renewal programmes to reduce operating costs back to a level similar to pre the CES. These extra earthquake related Opex costs are incurred at the same time ratepayers are facing a multitude of other economic pressures (housing costs, insurance issues, change costs bought about by the disaster etc.).

c. Operating expenses have a much greater and immediate effect on rating levels than capital expenditure. Extra disaster operating costs make it harder for TLA’s to fund the operating and capital demands to facilitate the repaid recovery of a City’s infrastructure. Rapid reduction in extra operating costs by early identification of key infrastructure service enablers is a key to reducing this burden.

d. The direction of capital spending has a direct impact on the ongoing demand for additional operational expenditure. Development of investment models that look at resilience as an input to developing business cases should enable the right balance to be achieved by targeting renewal and improvement expenditure in areas that will benefit most after a disaster.

e. Deployment of advanced asset management and cost engineering tools in the business as usual environment allow for a higher level of preparedness, better prioritisation of renewal spending pre and post disasters and accurate accounting of costs by the Asset Owner. Accurate and focused cost engineering greatly assists discussions with insurers and Government funders regarding the cost of response and recovery of services post natural disasters.

f. Retreat areas can impose significant ongoing Opex costs on asset owners post disasters due to the need to continue services to a reducing number of residents in these areas. Non-compulsory property buy-out options, such as those used in Christchurch, do not assist the reduction of additional opex costs in a rapid manner.

g. It is recommended as part of disaster preparedness that Asset Owners consider the cost of purchase vs. hiring emergency response tools (generators, emergency fencing, portable toilets, sucker trucks etc.) as the hire costs for these assets working on a 24/7 basis quickly mounts and it is likely the initial purchase in major events will be considerably cheaper than commercial hire arrangements. The likely duration of the event obviously needs to be considered prior to an investment decision but this can be easily modeled.

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- Citycare staff for provision of maintenance cost information associated with response and recovery costs associated with 3 waters assets.
- Downer and Fulton Hogan staff for roading cost information.

- Community and Public Health staff in Christchurch for analysis of data associated with water services.

REFERENCES

1. Beca Residential Red Zone and Non Red Zone Earthquake Opex Report – six month update to December 2013 dated February 2014.

2. Annual Report on Drinking–Water Quality 2010-2011 Appendix 3 Christchurch Earthquake Report by Community and Public Health.

3. Initial Evaluation of Christchurch City Council Future 3 Waters Opex Costs dated 1 July 2014

4. SCIRT Technical Memo on Remaining 3 waters Asset Life dated November 2013