(ALMOST) REBUILDING KAIAPOI

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ABSTRACT

On the 4th September 2010 Canterbury was rocked by a massive 7.1 magnitude earthquake that started a sequence of earthquakes in the region that still continue. Due to the underlying estuarine soils, the coastal town of Kaiapoi, along with two neighbouring settlements, was affected by very severe liquefaction and lateral spread, with approximately one third of the town's water and roading infrastructure made inoperable and over 1,200 homes damaged; many uninhabitable. The Waimakariri District Council provided a leadership role in the rebuild of not only this infrastructure, but also in delivery of the land repair programme, co-ordination and sequencing of the house rebuild and an intensive community support and engagement programme. Although this work was curtailed by the government's decision to purchase the severely affected properties, the experiences and approach taken offers lessons for other disaster recoveries and how the delivery of the public and private parts of the rebuild can be integrated with community support and engagement, and used as tool to assist the community through the recovery.

KEYWORDS

Darfield Earthquake, Waimakariri District Council, Disaster Recovery, Infrastructure Recovery, Kaiapoi

1 INTRODUCTION: WHAT HAPPENED AT 4.36AM 4TH SEPTEMBER 2012

At 4.36am on 4th September 2010, Canterbury was struck by a magnitude 7.1 earthquake. The earthquake was centred close to Darfield, about 40 km west of Christchurch City, at a depth of 10 km. The shaking that lasted for approximately 40 seconds caused significant lateral spread and liquefaction in the district. While thankfully there was no loss of life from the September earthquake, there was widespread damage to homes, businesses, land, and infrastructure, with the worst affected communities in Kaiapoi, Pines Beach, and Kairaki. The Waimakariri District Council serves a population of approximately 50,000 residents, north of Christchurch and these worst affected communities house a population of approximately 13,000 people; over 25% of the district's residents.

This paper describes the Council's response to the earthquakes for the period from 4th September until the announcement of the Red Zone land by the Canterbury Earthquake Recovery Authority (CERA) on 11th August 2011. The Red Zone is land that the Crown has determined is uneconomic to repair, and insured property owners have been made an offer from the Crown to purchase their house and land. Up until that point the Council had been providing leadership not only of the repair of the damaged water and roading infrastructure, but also across the land and home rebuild programmes and social and community support. The paper focuses on the integration of the infrastructure works with these other aspects of the recovery and shows how the engineer fits onto the overall approach taken by the Council.

2 DAMAGE TO THE BUILT ENVIRONMENT

2.1 LAND

The worst affected areas were severely damaged by liquefaction, with settlement of ground levels in the region of 300-400mm in many places, and lateral spread of up to 3.8m near the Kaiapoi River. Figure one shows the change in land level experienced in part of the town and figure two the map of worst affected areas.

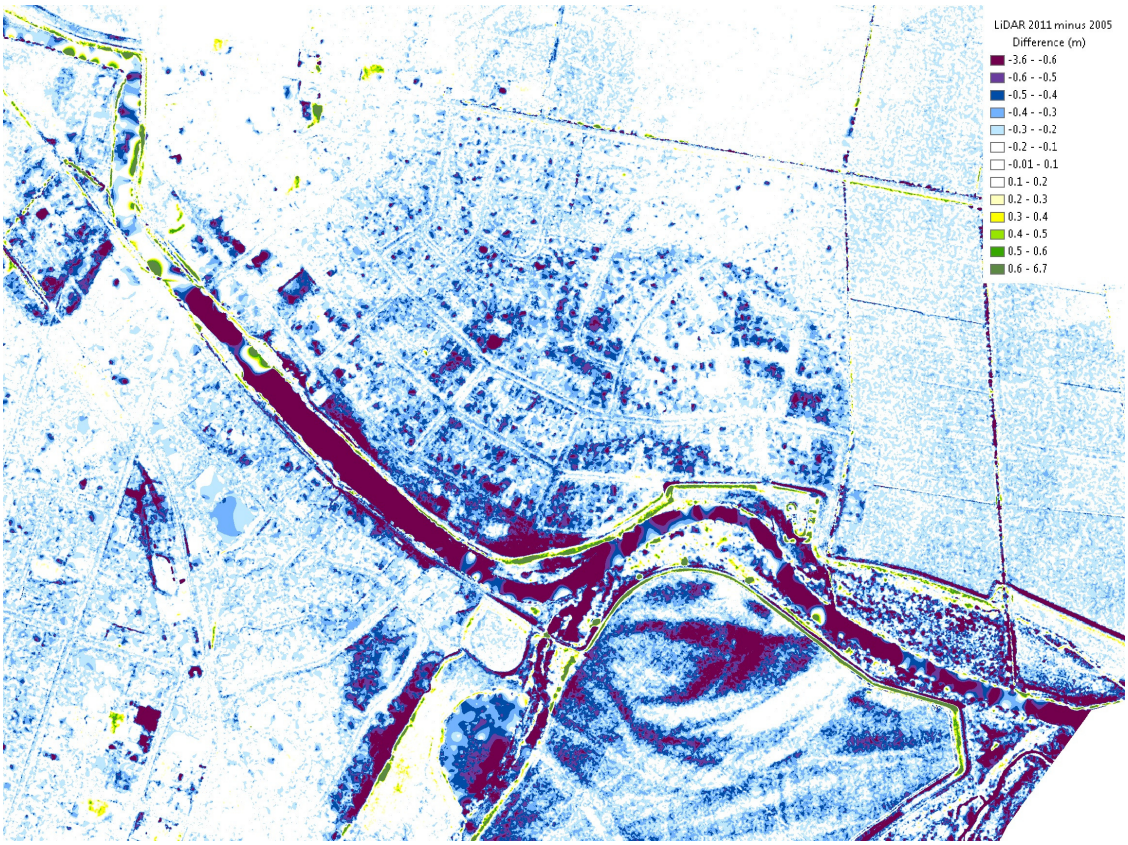


Figure 1: Change in land level in Kaiapoi

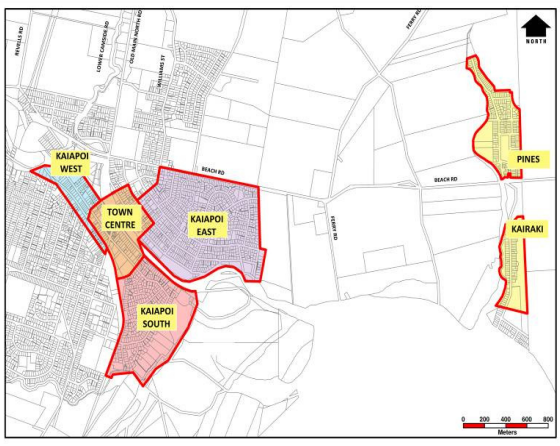


Figure 2: Map of Worst affected areas

A state of 'soil liquefaction' occurs when the effective stress of a soil is reduced to essentially zero, which corresponds to a complete loss of shear strength. This can be caused by a single sudden occurrence of a change in stress, however is better known as a result of earthquake shaking. It is more likely to occur in sandy or non-plastic silty soils, but may in rare cases occur in gravels and clays. Liquefaction then occurs when the vibrations from the earthquake cause the soil particles to lose contact with one another. As a result, the soil temporarily behaves like a liquid, loses the ability to support weight and can flow down even very gentle slopes. See figures 3 and 4 for examples of what can happen.

Figure 3: Aerial view of Kaiapoi immediately after quake showing flooding and silt accumulated on ground

Figure 4: Lateral spread tension cracking on south side of Kaiapoi River adjacent to Bowler Street Stormwater pumping Station

2.2 INFRASTRUCTURE

The damage to infrastructure was substantial and widespread in the communities of Kaiapoi, Pines Beach and Kairaki. The extent of the damage is summarised as follows.

Extent of damage.

- 16 km of Roads
- 16 Bridge approaches and 2 footbridges

- 12 km of watermains
- 3 water supply pump stations
- 18 km of gravity sewer
- 15 sewer pump stations (4 unservicable)
- 13,000 people without water or sewer

Council staff from the Utilities & Roading Department worked with the Council's in-house water maintenance contractor, the Water Unit, and external contractors to firstly identify the extent of damage, prioritise repairs, and then undertake temporary repairs sufficient to reinstate essential services. The remarkable achievements from a water and sewer infrastructure perspective of this team can be summarised as follows:

Day 1: Water on to 70% of affected properties

Day 9: Water on to boundary of all properties

Day 22: Functioning sewer to all occupied houses

Day 32: All wastewater discharges to rivers ceased

2.3 HOMES

Figure six shows an initial estimate of the status of damage of many homes in one part of the Kaiapoi. It was clear from the information that a significant portion of the homes were damaged such that they would require complete replacement. Figure five shows a home severely damaged by lateral spread. It is remarkabale that this home did not collapse.

Figure 5 (right) : House damaged by lateral spread

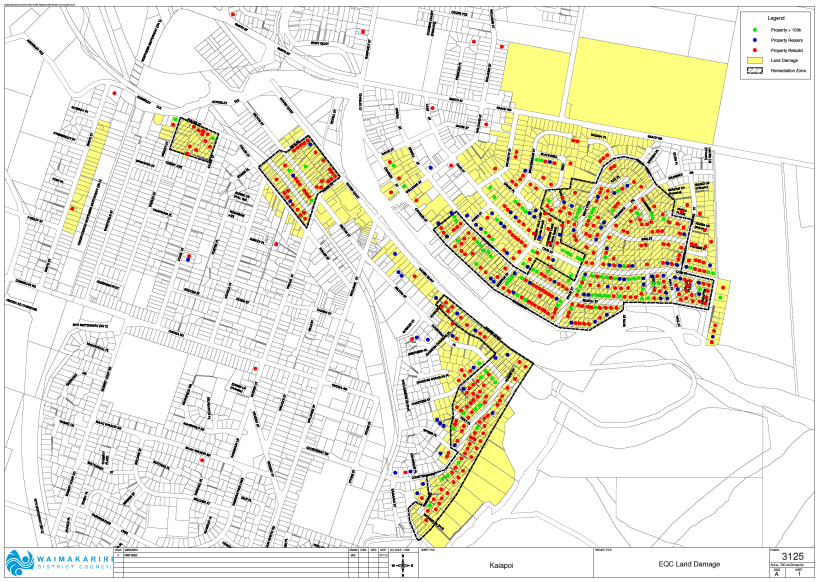


Figure 6 (left): House damage map of Kaiapoi

3 REBUILDING THE TOWN

3.1 HOMES

The repair and rebuild of damaged (insured) homes is the responsibility of the Earthquake Commission (EQC) (below cap of $100,000 per event) and the private insurers (above cap). Each insurer and EQC has contracted with a Project Management Office (PMO) to assist on the assessment of damage of insured properties and manage the physical works on their behalf.

3.2 LAND

For the affected areas that had suffered damage to the land caused by liquefaction and lateral spread, EQC was obliged to return the land to the same state that it was prior to the earthquakes under the land portion of the insurance that it provides.

In addition to these obligations of EQC, the Crown determined that additional work was required alongside the banks of the Kaiapoi River to strengthen the land to mitigate the effects of the life threatening lateral spread. This additional land improvement work was funded by the Crown, with EQC being the Crown's agent for that funding. As the land improvement works were central to the rebuild programme, the Council realised the best outcome for the community would be achieved if they took a lead role in managing and coordinating the works. Consequently, EQC and the Council reached agreement for the Council to manage the delivery of these additional improvement works on behalf of EQC.

These works were to consist of approximately 3kms of 20-30m wide stone column ground improvements works alongside the rivers, and some additional rafting for individual homes that could not be economically protected by the stone column system. See figure 7 below.

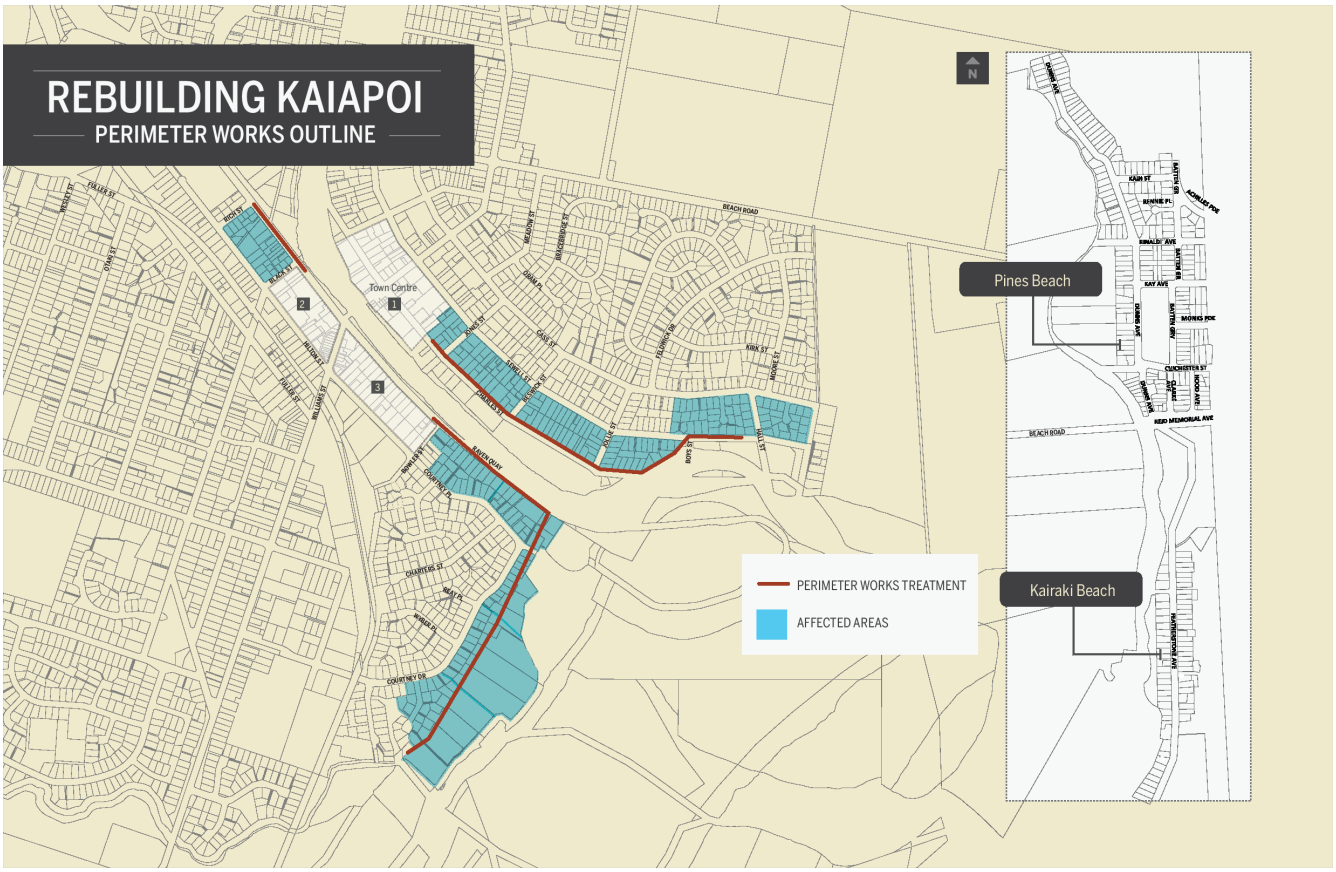


Figure 7: Plan of proposed stone column land improvement works

Much of this land improvement works were to be located on private property, and were essential to allowing property owners (and insurers) to feel confident in the safety of their homes. Public acceptance was gained for these works by the Council. This was achieved through explanation of the benefits of the works to the community through a series of public and private meetings, and then one-on-one engagement with the individual private property owners. Engineers played the central role in this communication.

3.3 INFRASTRUCTURE

The Council realised very early that the rebuild was going to be such a large and complex task that a specific structure within the Council would be required. Just eleven days after the earthquake, the Council appointed an Infrastructure Recovery Manager. His task, working closely with the existing Council staff, was to establish the Infrastructure Recovery Unit (IRU), and this team was responsible for repairing and rebuilding the Council's damaged infrastructure, and later delivery of the land works. Due to the urgency of getting the rebuild going as soon as possible, much of the strategy development was done in parallel with the damage assessment so, in advance of the detailed design of the work, the key strategic activities of this team included:

3.3.1 PAVEMENT LIFE AND DRAINAGE TESTING

The roading team developed a damage assessment process to determine the exact extent of the damage. This established which streets, or parts of streets, needed rebuilding and included a topographical survey of the road reserve and pavement testing. The survey data enabled the kerb and channel flow patterns to be determined and this was supplemented with physical flow testing using fire hydrants.

The pavement testing was undertaken using a Falling Weight Deflectometer (FWD). This method shows the deflections caused by a falling weight and relates this to remaining pavement life. The results showed that many roads still had sufficient remaining life and some required rehabilitation. The form of rehabilitation depended on whether the kerb is to be replaced and hence whether the crown of the road needed lowering.

3.3.2 UTILITIES DAMAGE INVESTIGATION

Damage investigations included:

- Extensive CCTV investigation of wells, wastewater and stormwater piped assets
- Leakage testing
- Manhole inspections
- Structural inspections of chambers and buildings

3.3.3 STREETSCAPE ENGAGEMENT AND DESIGN

The earthquake had caused significant damage to streets in Kaiapoi, Pines Beach and Kairaki. Although this damage was devastating and tragic, it also provided a clear opportunity to build a better public realm for the community and act as a source of hope and provide a reason for looking forward to a future beyond the devastation.

Most of the damaged streets had been developed in the 1970’s or earlier, were wide and lacked character. There was generally no network hierarchy reflected in the existing design of the streets. For example there was no way to know you were entering a cul-de-sac, except if there was a no exit sign; it was not intuitive. These challenges were compounded by the need to progress the project very quickly such that the planning work would not delay the rebuild programme. The only way to achieve this was to run the community engagement process in parallel with the technical damage assessments.

A number of design ideas were developed for each of the various street types and preferences sought on these ideas. The concept of having BBQs within the affected communities, at a convenient time

and with a fun BBQ atmosphere being provided, was central to obtaining open and meaningful feedback on the ideas. The consultation events proved to be an education opportunity for the community. At a higher level it encouraged people to think about their streets as a public space as well as for the movement of traffic, and that the two can be compatible. Most people highlighted excessive speed as a problem in their area and their first request was the installation of speed humps. Through explanation we were able to convince them that the good design of streets can help address this without the need to provide isolated features that usually no one wants outside their house.

The outcome was the development of a range of enhanced streetscape for the residents to look forward to following the rebuild of their community. The process of consultation on the future and the look of their town may have been as important as the final outcome however, as it allowed those residents who were ready, to look forward in hope as they went through the recovery from both the event and the stress of the insurance process.

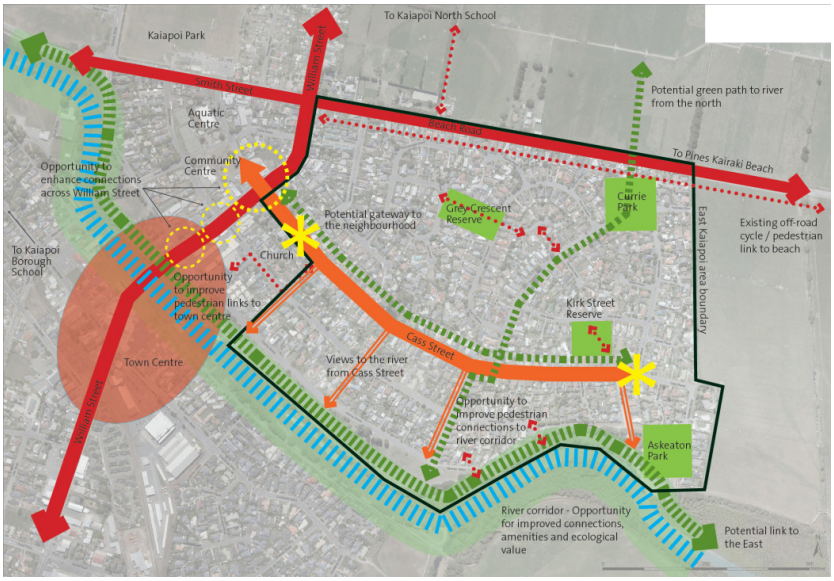


Figure 8: A context plan for design of East Kaiapoi streetscape

3.3.4 WASTEWATER STRATEGY

With up to 70% of the wastewater network requiring replacement in each of the affected areas, and the strong likelihood that any wastewater system rebuilt would be subjected to an earthquake again during its lifetime, Council considered that an examination of alterative approaches to wastewater servicing was essential. Appendix B shows the extent of damage to the network in East Kaiapoi.

To meet the urgency necessary to get the town back on its feet as quickly as possible, much of the investigation and strategy development processes were done in parallel, whereas they would be typically done in series in 'normal' times. Thus CCTV survey and complementary damage assessments were down at the same time as works commenced on development of the wastewater strategy. A detailed costing (based on the tendered unit rates) system was established, along with a multi-criteria analysis approach to assessing the non-price attributes of the four systems considered: Deep gravity, Shallow gravity (multiple pumping stations), Low Pressure Wastewater and Vacuum sewerage. The key considerations were the balance between cost, the different levels of service of each system, the different degrees of resilience. This paper will not detail these considerations however they were intensive

3.3.5 WATER SUPPLY STRATEGY

There is no simple damage assessment process for the water supply system as there is for the wastewater. Once the initial repairs were undertaken, and aside from a few minor bursts in the weeks

following, the emergency repairs proved very stable, and leak detection testing did not find any issues with the network beyond normal use rates. However, with the significant number of bursts repaired, it was clear that the life of the network had been significantly reduced.

Again, we will not seek to explain the approach developed for developing the replacement and leave that to another paper, however the approach focused on (i) damage and repair records during the response, (ii) vulnerability assessment by material type and (iii) using damage to other assets (ie roads, homes, land and wastewater) as a proxy to understanding the likely effect on the life of the water supply reticulation.

Appendix B shows a plan of the replacement strategy for East Kaiapoi.

3.3.6 STORMWATER STRATEGY

With the significant land movement, it was clear that the flood risk profile for the affected areas was likely to have changed. The Council undertook extensive hydraulic modeling using LiDAR (Light Detection and Ranging: an aerial method which creates a digital elevation model) data to understand the change in flood risk to properties and develop mitigation strategies, along with CCTV damage assessments for the reticulation.

At a more local level, there were a large number of properties that were, or appeared to have sunk below the level of the road, and were now at risk of ponding during rain events. At an early stage, a full topographical survey of the roads and manholes was undertaken. In addition, spot levels were taken in the corners of each section, plus the floor level of the house. Coupled with LiDAR, inspection of properties, and a survey of residents coming to public meetings to gather observations, these properties were identified, and options developed for each one to resolve the issue. See figure 9 below for an example.

Figure 9: Localised ponding map

3.3.7 TENDERING UNIT RATE 'FRAMEWORK' CONTRACTS FOR ALL INFRASTRUCTURE WORKS

The affected areas were divided up into geographical work packages and contacts awarded for (i) wastewater and (ii) water supply, roading and stormwater. Tenders were sought for unit rates against a broad range of items and then evaluated using approximate quantities for each package using the price quality method. This was done in order to secure a committed resource for the rebuild in advance and establish prices that will be maintained throughout the rebuild period.

4 THE COUNCIL'S APPROACH TO THE REBUILD

4.1 PHILOSOPHY

The Council understood early on that the rebuild is not the recovery; rather it is one of the tools to achieve the recovery. This was epitomised by the Council's Chief Executive when at a staff briefing he said "*we will not be measured by the kilometres of pipe and road that we replace, but by how our people come through this*". As such, the rebuild may be characterised by the philosophy of 'people first, engineering second'.

It was never more apparent that the purpose of our infrastructure and our engineering practice is to serve and protect the people that live and work in our community. The Council established a clear focus for the Infrastructure Recovery Unit and Asset Management team as being an essential component of the Council's work with the community to assist them through the recovery. Beyond simply an infrastructure provider, the Council saw its role as the community leader and embraced that responsibility.

The approach that WDC adopted was derived from a wide range of discussions between the many people and organisations involved, and developed over the initial months of the recovery as the understanding of the issues and opportunities of the recovery process emerged and has been through the process of trial and error inherent in such an unusual environment. The model is based on a close integration between the social support services, the engineering works and the insurance companies, and acknowledges at its core that the engineering is there to serve the community, and that long term recovery is achieved only through attention to both the social and physical aspects of the community. It is formed of a set of tools that are derived to meet an overarching set of principals.

4.2 KEY PRINCIPALS OF WDC APPROACH

- Wellbeing of the Community is the principal focus (People first, engineering second)
- Leadership and communication led by Council
- Locally responsive to resident's feedback
- Integrated programme of land remediation, infrastructure repair and house repair/rebuild
- Physical works co-ordinated with social support services

5 KEY TOOLS WITHIN THE WDC APPROACH

5.1 HUMAN SCALE

The severely affected areas within the district comprised of approximately 1,200 properties, with the Kaiapoi town centre also significantly affected. Therefore there are approximately 3,000 people in the most affected areas, and in the vicinity of 15km of roads, sewers, water supply pipelines and associated stormwater infrastructure damaged.

While this is a considerable area, it has been found that the key issues and activities are able to be comprehended by each key individual involved. A larger area would likely prevent such an understanding be able to be achieved and so limit the organisations ability to respond to the

community needs. As such, it was possible to apply a more bottom-up approach to the management of the affected areas, rather than more hierarchical top-down approach.

5.2 CLOSE INTEGRATION WITH COUNCIL'S MANAGEMENT AND GOVERNANCE STRUCTURE

Simultaneously with the appointment of the Infrastructure Recovery Manager, a Social Recovery Manager was appointed and, along with the Recovery Manager, formed the nucleus of an extensive social support and engagement network. This network included pastoral care, social workers, community support co-ordinators, community development, business recovery and several other Crown and not-for profit agencies. The link between the engineering and the social support was an essential component how the Council engaged with the community.

The Earthquake Recovery structure is presented in Appendix A. Note that the structure presented emphasises the engineering roles within the structure given its relevance to this entry. The recovery part of the project was branded 'New Foundations'. A website was set up to allow speedy access to information. Kaiapoi and Pines Beach-Kairaki were split into manageable scale recovery areas as shown in Figure 2 above and were used on the New Foundations website (www.newfoundations.org.nz) as way of getting location specific information to residents.

The Council believed it was important for the Council's management and governance structures to be closely involved with the recovery programme. This includes three full time senior managers devoted to the recovery and weekly senior management briefings and fortnight meetings of the newly formed Earthquake Recovery Committee. This is a sub-community of Council and effectively acts as a Steering Group for the recovery process.

5.3 COMMUNITY INVOLVEMENT WITH ENGINEERING

To provide that leadership, first the team needed to understand what the community needed. The Council initiated a series of forums, meetings and consultation sessions. These were both with individuals, resident and community groups as well as large scale exercises to connect with affected residents. Initially the majority of these were listening events, where staff and other agencies could hear and understand the issues that were important. This is where the engineering team begun to understand and develop the philosophy outlined above, as we heard from the community their first and fundamental question: "When will my house get fixed?" From this, Council's community involvement by the engineering team included:

- *The Kaiapoi Earthquake Hub*: A one stop shop for all earthquake enquiries, with engineers available to meet with callers as required. (see later)
- *Newsletters, notice boards and website*: Monthly newsletter and website updating on progress, events, profiling the team, current activities, construction activity and news.
- *Myth of the month*: An important part of the newsletter that provided the opportunity to correct the many misunderstandings that circulated through the community, particularly regarding the land and house insurance.
- *Streetscape Consultation*: Intensive streetscape design and consultation process (described earlier).
- *Residents Associations*: Weekly meetings with the leaders of the residents associations.
- *Support co-ordination and pastoral care*: Working closely with the social support teams.
- *Public meetings*: Extensive rounds of public meetings (up to 400 each night for 2,500 people each round) which allowed detailed explanations of the works that will occur, the proposal for the rebuild of infrastructure, land works and explanation of the programme and the rationale for the sequence and timing of works.

5.4 THE KAIAPOI EARTHQUAKE HUB

The nature of the recovery meant that there were a large number of parties involved with the recovery. The Hub provided the opportunity for as many parties as possible to be co-located together. This allowed formal and informal contact between the delivery agents, support workers, Council staff

and infrastructure designers. It also provided a focus for the community to see the activity, providing confidence and reassurance to them. This consisted of a re-purposing of the community centre and the installation of a large number of portable buildings into a small village to accommodate this wide variety of organisations involved in the recovery. The value of this facility cannot be understated.

5.5 COLLABORATION OF PRIVATE INSURERS, EQC, COUNCIL AND SOCIAL SUPPORT SERVICES.

Acknowledging the central importance of their role in the rebuild, working with these organisations became an important component of the Council's overall engagement process and the critical relationship between flood risk, serving and the home rebuild was able to be worked through with each of the delivery agents. This was achieved by a variety of means:

- Establishment of the Kaiapoi Earthquake Hub: Co-locating many of the delivery agents in one place to maximise interaction, including the social and community support services, infrastructure, land remediation and PMO's.
- Weekly Hub Coordination meeting: attending by Infrastructure, Land Remediation, PMO's, EQC, Police, Support co-ordinators and others, chaired by the Council's Infrastructure Recovery Manager
- Monthly strategic meetings: attended by Insurers, PMOs, Council, Crown and others
- On-going one on one interaction with each delivery agent.

6 CO-ORDINATION OF THE REBUILD

With 1200 homes to repair or rebuild in the worst affected areas, $40M of infrastructure to reinstate, and up to $60M of land improvement works to be undertaken, the complex interdependencies meant that it was essential that this project was well co-ordinated.

As leader, the Council took the initiative and developed a detailed programme of works, integrating all these activities into a sequenced construction programme. This programme set out when works would be undertaken, and crucially, established timeframes for when homeowners could expect their home to be repaired or replaced. In doing this, the Council took on significant reputational risk and other potential liabilities, however took the view that the needs of the community outweighed these risks.

The factors influencing the programme were numerous and complex. These included the need to sequence multiple infrastructure renewals, demolition, land improvements, and house rebuilding, while still being mindful of a functioning community adjacent to and surrounding the works. It is this programme of works that the residents were most interested in, and was essential to allow them to plan their lives and hence begin the process of recovery: Without that timetable they would have been unable to recover.

The programme had many uncertainties, however the Council believed that by putting the programme together, being open and honest about the uncertainties, and providing that co-ordination role, they were best serving the most fundamental need of their community during the recovery. Further, it helped the insurers to plan, resource and control their workload, ensure that the works were the most efficient and cost effective, provided more accurate forecasts of temporary housing needs, and minimised the health and safety issues inherent in living and working in a construction site for many years.

While a detailed Gantt chart was prepared covering all aspects of the rebuild, this was clearly inappropriate for communication with the public, and so a simple programme showing when homes woul start to be fixed was developed: This is presented below as figure 10.

Establishing the programme required the collaboration and support of all the delivery agents and required detailed engagement with each of the insurers and PMO's, EQC as well as internal Council staff. The release of the rebuild programme effectively delivered the answer to the question that was foremost in homeowners' minds – when will my house be repaired or rebuilt? It needed to be managed very carefully to ensure homeowners were presented the information in a careful and

sensitive manner and, most importantly, the Council's rational for the programme needed to be sufficiently robust to withstand the scrutiny of insurers, project managers, and crucially, homeowners, who had hoped their homes would be rebuilt at the beginning rather than the end of the overall programme.

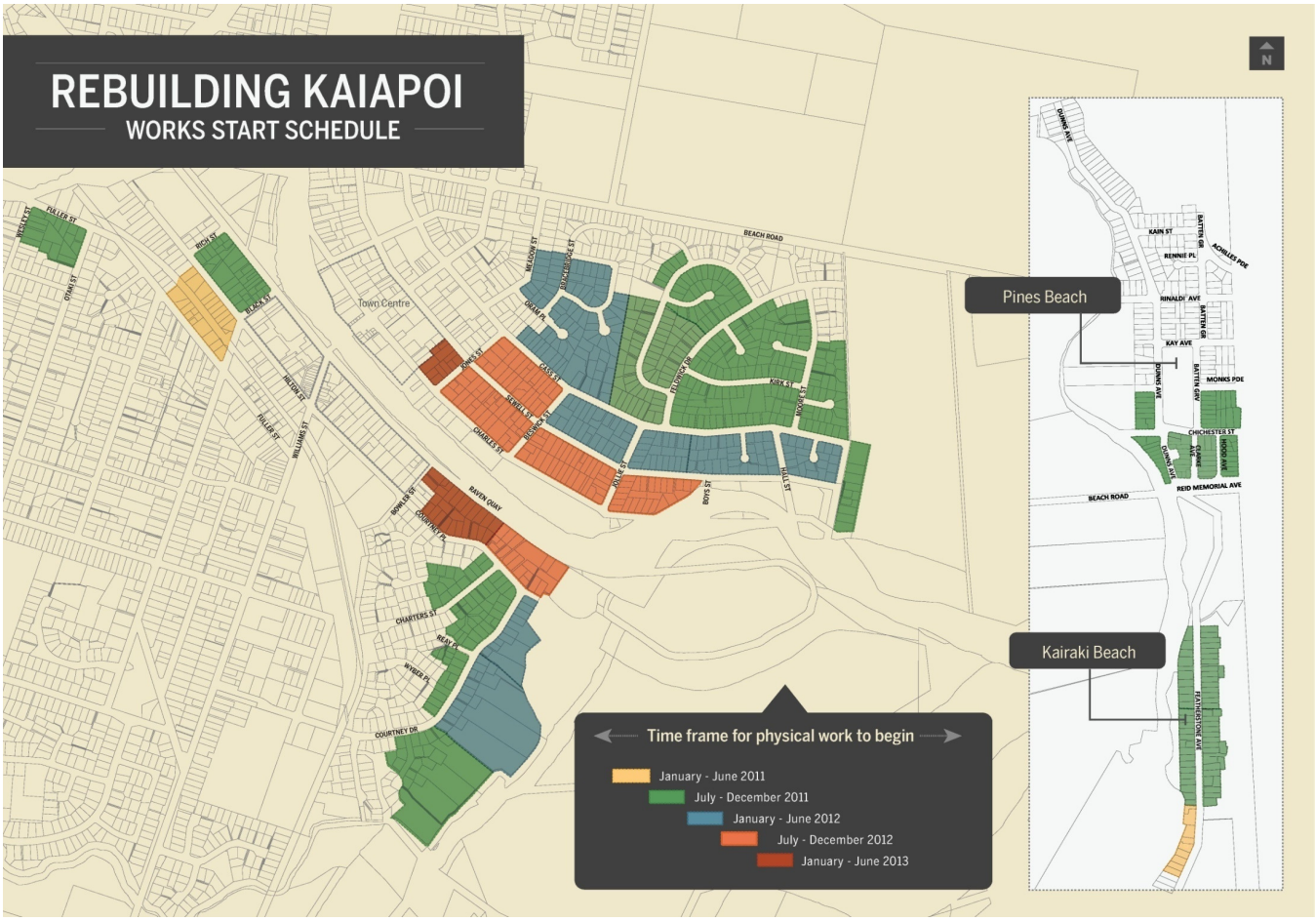


Figure 10: Rebuild programme for Kaiapoi

7 SUMMARY AND CONCLUDING REMARKS

We have learnt a number of lessons from our experiment in working through this process which we would like to offer for those who may one day be in the same position:

- The best preparation for a disaster by an infrastructure provider is to have accurate GIS records of assets. This cannot be understated.
- The immediate response is challenging but conceptually simple; the long term process of rebuilding and recovery is more complex and difficult.
- The essential services of water and wastewater are the most critical components during the immediate response, but become secondary once a basic level of service has been established.
- Keep things human scale: recovery is a human thing
- Collaborate, and if possible co-locate, with the many different organisations responsible for the rebuild and recovery
- The rebuild is not the recovery - it is a tool to achieve the recovery - so integrate the physical works with the social support, and enable residents to understand what is happening, have input and use this information to plan their own recovery.
- Now is the time for organisations, engineers and individuals to step up and take leadership. This may mean taking on additional risk but that is what your community demands.

8 ACKNOWLEDGEMENTS

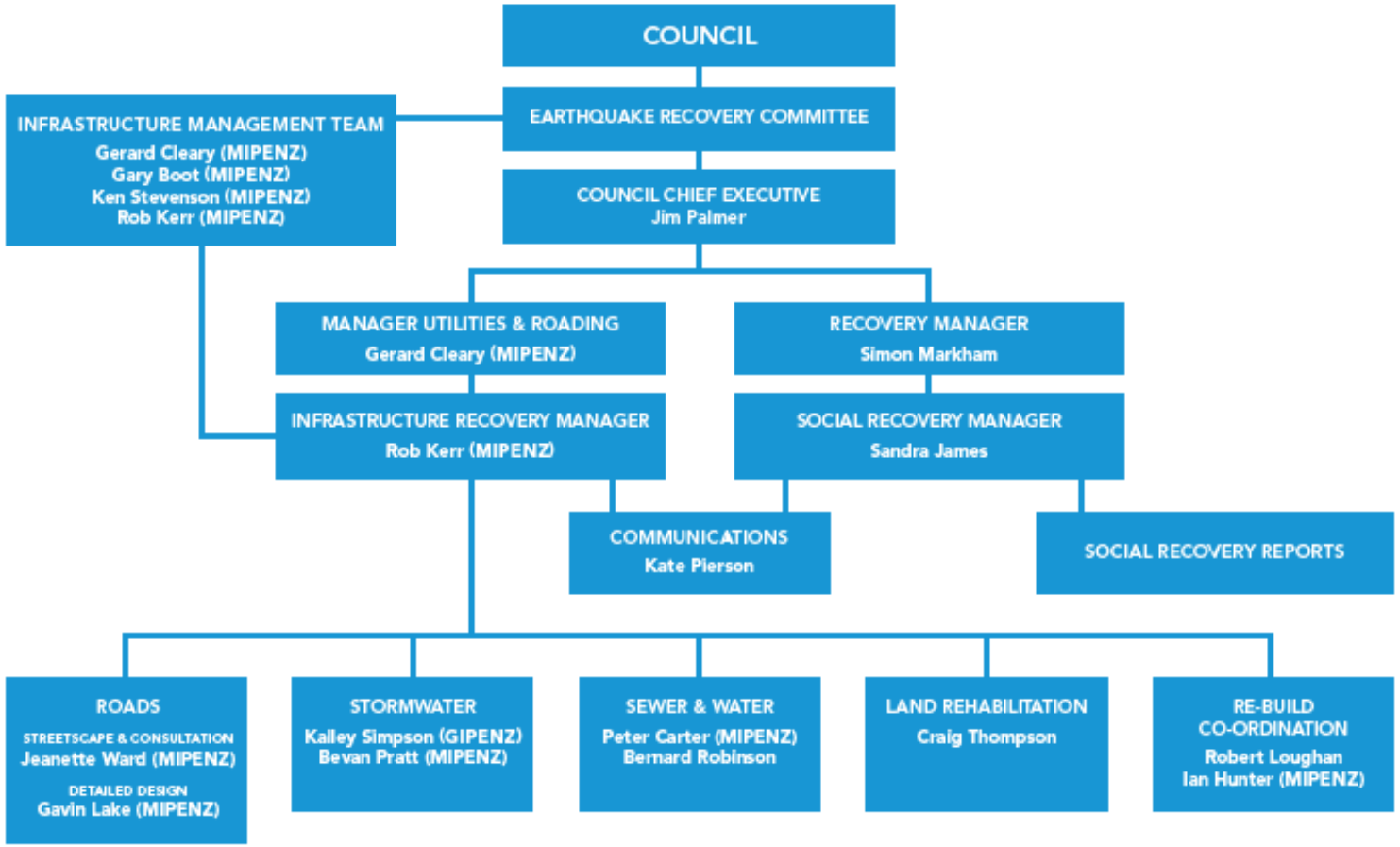
The writers would like to acknowledge the staff at the Waimakariri District Council including the Infrastructure Recovery Unit, Utilities and Roading Unit, Sandra James, Simon Markham, and the multitude of insurers, project managements, EQC staff, social agencies and others who worked collaboratively with great goodwill to achieve what was almost achieved.

Most of all, we wish to acknowledge the residents of Kaiapoi, Pines Beach and Kairaki for their great fortitude, support and persistence in the face of what was an unimaginable catastrophe in their lives.

APPENDIX A

COUNCIL'S REBUILD ORGANISATIONAL STRUCTURE

Earthquake Recovery Structure

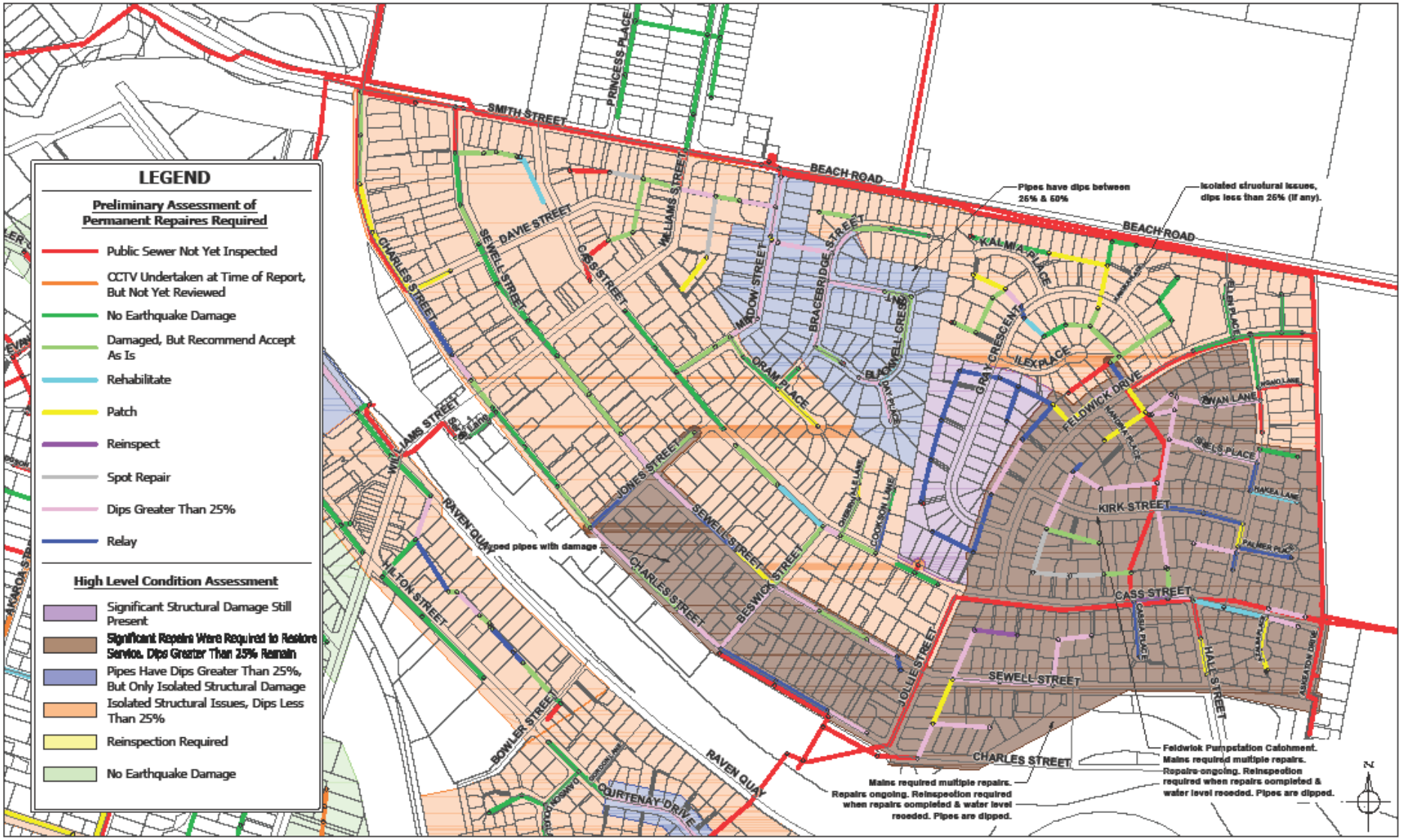


WAIMAKARIRI DISTRICT COUNCIL

NEW FOUNDATIONS

APPENDIX B

WASTEWATER DAMAGE MAP



Rev.	Reason	By	Checked	Approved	Date
D	Further Assessments Completed				13/08/18
C	Further Assessments Completed. Notes Amended				8/11/18
1	Initial Drawing				7/11/18

	By	Checked	Date
Designed/Prepared:			
Checked:			
Checked:			
Approved:			
Approved By: Planning & Projects Group Manager			

North Kaiapoi
Condition of Sewer Mains Following Repairs to Restore Service

ProjectMax

WAIMAKARIRI DISTRICT COUNCIL

Scale	Contract No.	
N.T.S.	Drawing No. 3K.1	Rev. C
Location: Kaiapoi	Sheet 1 of 1	Sheets

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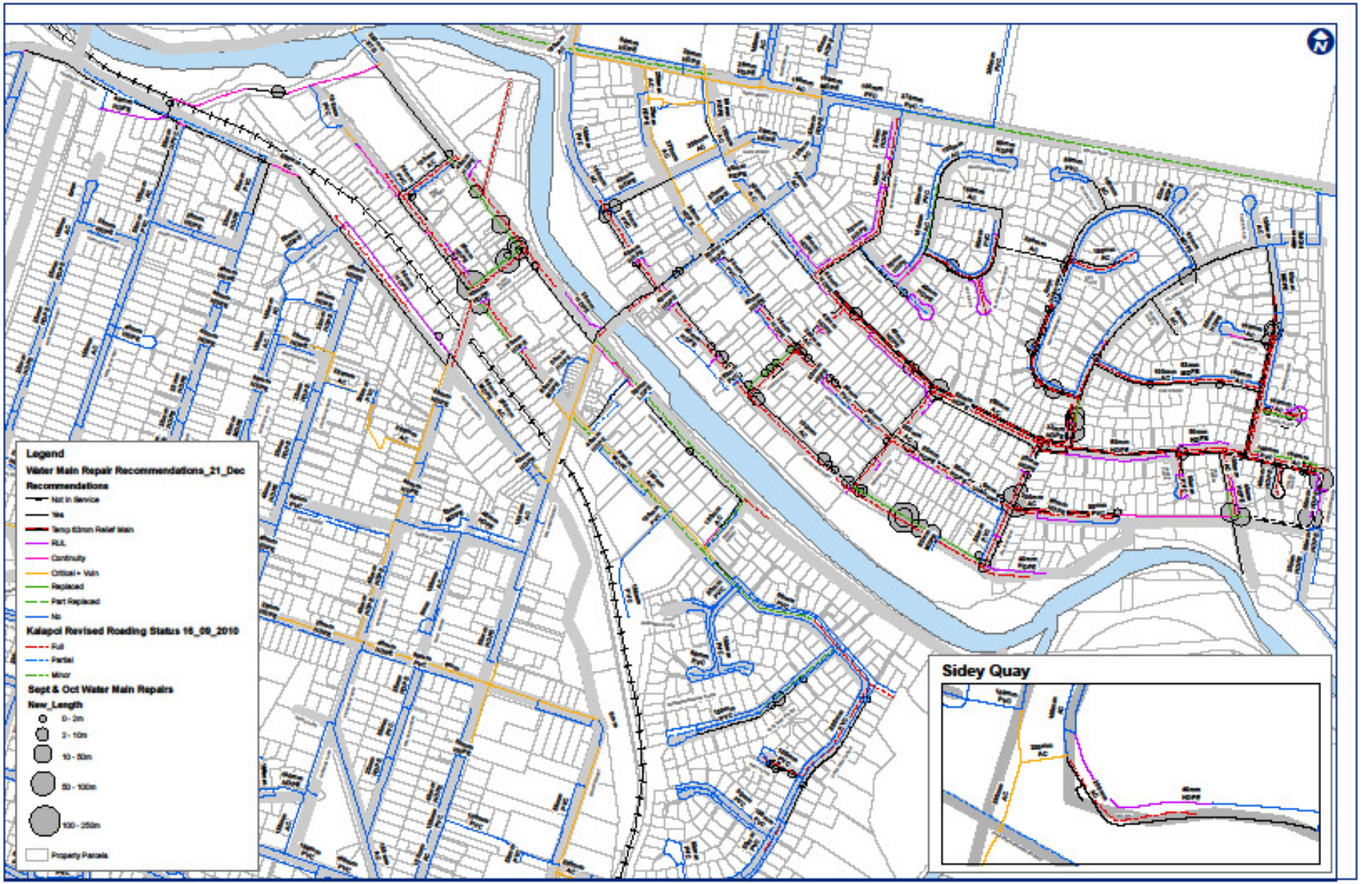
APPENDIX C

WATER SUPPLY REPLACEMENT AND DAMAGE MAP



Rev	By	App	Description	Date

Revised	21 December 2010		
Approved	Martyn Wonnacott	Date	21 Dec 2010
Designed	MA	Checked	XXX
Drawn	Joanne Golden	Checked	XXX
File Name	WDC_Mains_Renewals_Kalapoi		

AECOM

WAIMAKARIRI DISTRICT COUNCIL

Water Main Renewal Recommendations
Kalapoi

Scale: 1:8,862 (A4 size) 0 80 160 320 Meters

Status: Draft | Drawing No: Figure 1 | Rev: B