7. PERFORMANCE OF LIFELINE SYSTEMS DURING 5TH MARCH 2014 FLOODING

The lifelines suffered severe damage after the 2010-2011 Canterbury earthquake sequence. Repair to the lifelines begin immediately following the Darfield earthquake. After the 22nd February 2011 Christchurch earthquake repairs to the water, wastewater and stormwater systems were turned over to the Stronger Christchurch Infrastructure Rebuild Team (SCIRT).

The GEER team followed up on the performance of the lifelines following March 5th flood event.

Water Supply

The City of Christchurch, City Water & Waste Unit (CWW) owns, operates, and maintains the Christchurch water and wastewater (WW) systems. This section described the water system and the next section describes the WW system.

The Christchurch water supply system relies on groundwater wells, pumps and reservoirs located within the city. The CWW Unit Manager, Mark Christison, informed the team that the Christchurch water supply system performed well during the event with no loss of service to customers. At the time of the reconnaissance, the post-earthquake pipe repairs for the water supply system were 64% complete. 33% of pumping stations have been repaired (SCIRT, 2014). As a result of the on-going repairs the system is now largely stable.

Immediately following the 5th March storm, microbial testing of all the wells and reservoirs was carried out and only one well on Colombo Street had *Escherichia coli* (E.coli) present. The well was immediately isolated and further testing is still in progress. CCC's knowledge to date indicates that a sampling problem may have been the cause of the E.coli due to the well head being under flood water at the time of sampling. The investigation is ongoing. Apart from this one well being shut down due to a positive E.coli test, the water supply network performed more than adequately during this flood event.

Wastewater

The WW network is mainly a gravity type design with post-earthquake repairs changing some components of the network to pressure and vacuum systems. There was no loss of service to customers attributed to the flood. SCIRT's post-earthquake rebuild of the wastewater pipe network is 35% complete and the pumping stations are 48% complete (SCIRT, 2014). Repairs still need to be carried out in both the western and eastern portions of the city, but were not adversely affected by rainfall or flooding. There was expected surcharging from various points around the city from sewer manholes which posed a health risk to residents.

The CCC Asset Network & Planning team modelled the predicted surcharging from manholes, under urgency on 6^{th} March, as seen in Figure 7-1. This model prediction was then used in the response as an indicator for where the WW maintenance crews should go to clean up the effects of surcharging WW and inspect/replace manhole covers. This prediction was used in conjunction with WW related geospatially located phone calls placed to CCC in the March 5th event as seen in Figure 7-2, noting that phone call data from a prior flood event in June 2013 was used as a comparison. Specific mention should be made of the Southwest area of Christchurch in Figure 7-1 which the model predicted to have surcharging but which experienced substantially less, most likely due to recent WW project completions.

There was an observed increase in the inflow to the wastewater treatment plant (WWTP) which has a maximum capacity of 7.5 m^3/s. The inflow recorded during the event was just under 7 m^3/s. The average dry weather inflow at the WWTP increased from 1.8 m^3/s to 2.6-2.7 m^3/s following the 2010/2011 earthquake sequence. This is mainly due to water infiltration through damaged pipes into the network. SCIRT, who is responsible for rebuilding these networks, indicates appreciable differences in the inflows into the WWTP will be observed when the entire catchment is repaired/rebuilt in early 2015.

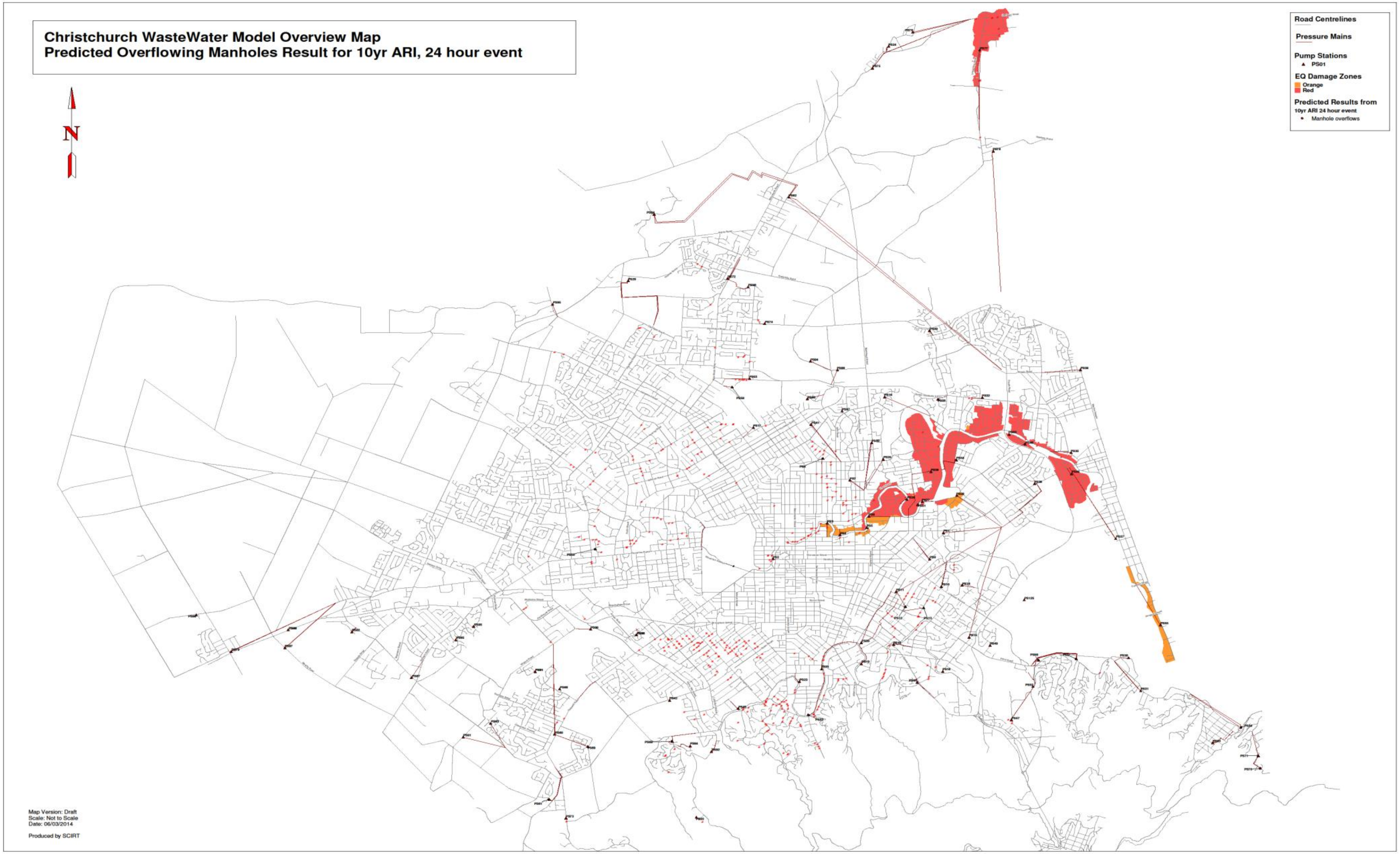

Figure 7-1 Prediction modelling of a 1 in 10 year rain event effects on the wastewater system in Christchurch, used as a guide only for the 5th March event, source R. Meek (personal communication, 7th April 2014).

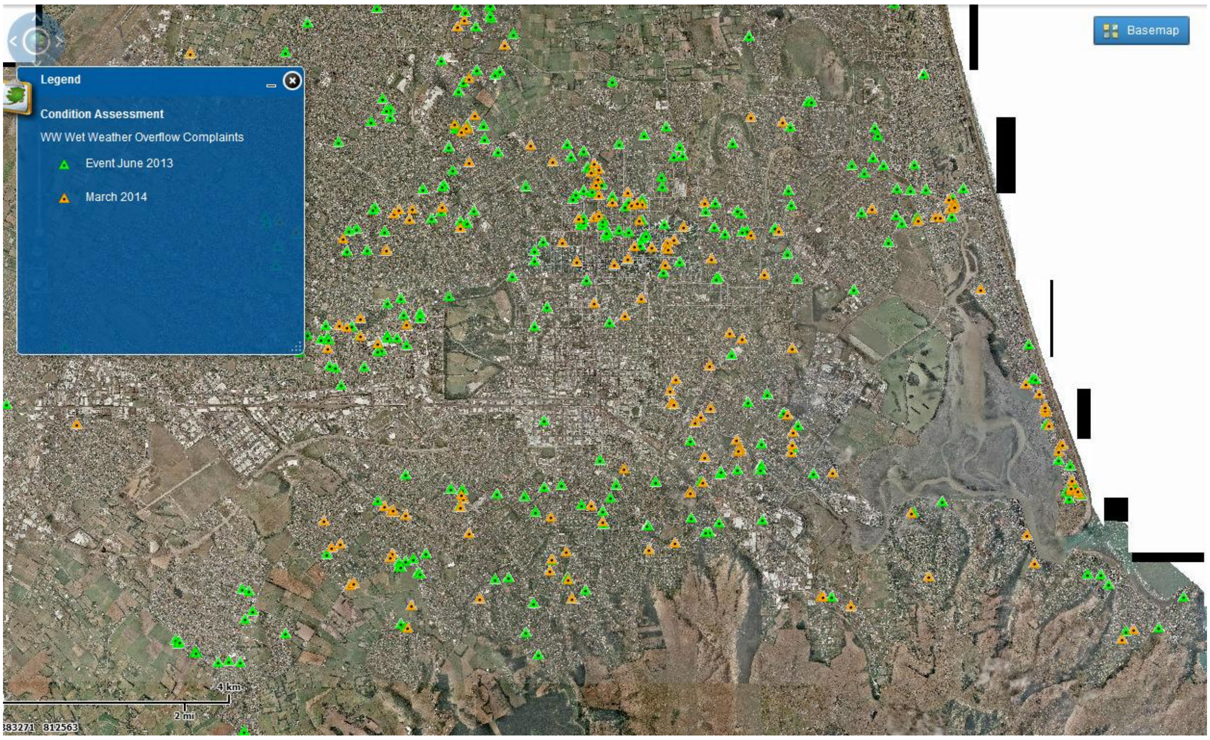

Figure 7-2 Location of WW related received calls taken by the CCC call centre during the event with calls from a previous large rainfall event in June 2013, R. Meek (personal communication, 7th April 2014).

A large terminal pump station located in Pages Rd that is responsible for directing 35% of the city's WW to the WWTP suffered extensive damage in the earthquake sequence as seen in Figure 7-3. The pumping station moves wastewater via two 1.2 m diameter pipes to the WWTP, but currently is only pumping through one new Glass Reinforced Plastic (GRP) 1.2 m diameter pipe. The conveyance capacity in this part of the network has been reduced by 50%. The WWTP had available capacity that was unable to be utilised during the flooding which caused overflows to be activated into the Avon and Heathcote river systems and the estuary in line with normal business process.

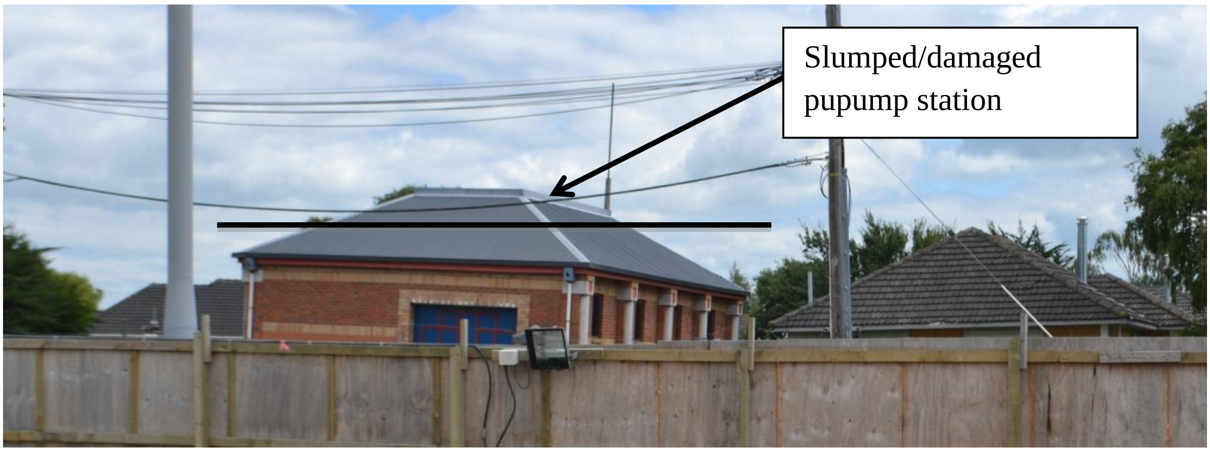

Figure 7-3 Currently damaged Pages Road gravity pump station (-43.513658°, 172.709793°). View from new gravity pump station construction site opposite. Photo courtesy of Dave Holland.

Due to the extensive coverage of the flood water some sewers were adversely affected while others were not. Gravity sewers in the worst flooded areas were surcharged through the manholes. The WWTP oxidation pond contents are discharged in to the ocean, three kilometres offshore, via the ocean outfall pump station and pipe which was running at design capacity of 5.5 m^3/s during the event. The oxidation ponds, downstream of the WWTP, still had capacity for this event and were able to accommodate the 1.5 m^3/s differential between the WWTP outflow and flow through the outfall. Overall, the wastewater system performed as expected, with minor surcharging, given the extent and severity of the flood water coverage with service to customers expected to improve as entire catchments have upgrades and repairs completed.

Christchurch Stormwater

An interview with Mr. Tom Parsons and Mr. Graham Harrington from Christchurch City Council (CCC) was conducted for information on the performance of the stormwater system on 5 March flood event.

The Christchurch stormwater network is planned and operated by CCC. It is mainly a gravity system which involves conveyance of surface runoff through sumps, pipes, open channels and rivers to the discharge outlet at the Avon Heathcote Estuary. The city is divided into five river catchments: the Avon, Heathcote, Styx, Otukaikino and Halswell.

Much of the stormwater pipe network capacity is designed for a 5 year recurrence interval event. Flood water exceeding this level is conveyed through the secondary flow paths which include the roads, waterways and swales. The pipes suffered earthquake-induced damages such as breakages, cracks, liquefaction blockages from sand infiltration, collapses, and loss of gradient (SCIRT, n.d.). The capacity of the open channels and waterways have been reduced to some degree due to lateral spreading (up to 6 m in one cross-section of the Avon River), subsidence of stopbanks, and changes in river beds and gradient, which are addressed in Chapters 3 and 5.

The stormwater team at CCC receives meteorological information from MetService. The 3-day and hourly rainfall forecast and rain radar information are analysed to determine the magnitude of the expected storm in terms of return period. At 5 pm on 4 March, the storm was expected to be a 5 year event. In advance of the storm, standard flood management activities were employed. All gratings and critical inlets were checked prior to and during the event, to the greatest extent possible. Additional measures were also undertaken during the event, but given the short advance notice of the storm, there was no time for event specific flood preparation. The normal mitigation strategies that were employed would have made very little change to the flooding observed, except for some localized conditions such as the Lyttelton overflow described in Chapter 6, as the intensity and duration of the storm far exceeded the overall network capacity.

The magnitude of the 5 March event was significantly greater than what the stormwater pipes and the open flow networks were designed for. Therefore, city-wide flooding was experienced, especially in the low-lying areas and floodplains. In particular, as shown in Figure 7-4 the very low-lying flood-prone Dudley Creek catchment suffered the greatest. The water level survey data obtained on 5 March has been used to determine the number of houses that may have flooded.

The flow through the Avon River is believed to have been restricted by earthquake repair works. Scaffolding under the Colombo Street Bridge impeded flows and may have increased flooding in the central city. No other instances have been reported of bridges blocked by debris. The effect of restriction of rivers on the extent of the flood will be analysed in the future using data collected for the flood debris along the Avon. Also, the city's river models will be tested and calibrated using actual precipitation data from many rain gauges and the observed extent of the flood.

Despite the high intensity of the storm, the stormwater system did not suffer any significant damage. The flat topography of Christchurch means that the overland flow velocity is low, thus the damage that the flood water can do to the stormwater network is minor. Scour from high energy waters from small but steep catchments in the Port Hills is possible, and some instances of damage were reported as exemplified in Chapter 6.

Figure 7-4 Dudley Creek overflowing on to Stapletons Road (-43.509433°, 172.655949°) and footbridge in Richmond, Christchurch. Photo courtesy of Su Young Ko.

Road Network

As a part of the traffic management plan, Christchurch City Council's Land Drainage and Roading teams closed off some roads in Mairehau/Richmond area in the evening of 4 March. The list of road closures grew longer by the morning of 5 March as increased surface flooding was observed from persistent rainfall and high spring tide. The flooded streets were mainly in the eastern suburbs: New Brighton, Avonside, Wainoni, Bromley, Linwood, Central City (Figure 7-5), Edgeware (Figure 7-6), Richmond (Figure 7-7), St Albans, Shirley, Mairehau and Opawa. Some streets in the Port Hills were also closed off due to concerns of slope instability. After the retreat of flood waters, storm debris and new potholes on the roads presented traffic hazards to travellers (Christchurch City Council, 2014).

Figure 7-5 Avon River overflow causing surface flooding on Fitzgerald Avenue (-43.524078°, 172.650935°), Central City, Christchurch. This road demonstrates a post-earthquake reconstruction design error. The road should have been built at a higher elevation to avoid flooding. Photo courtesy of Su Young Ko.

Figure 7-6 Road closure due to temporary traffic management – Geraldine Street (-43.515579°, 172.647506°), Edgeware, Christchurch. Photo courtesy of Su Young Ko.

Figure 7-7 Warning sign for flooded streets – Warden Street (-43.510297°, 172.655095°), Richmond, Christchurch. Photo courtesy of Su Young Ko.

Telecommunications Network

Information on the flood impacts to the telecommunication network was obtained from an interview with Mr Rob Ruiter from Chorus. Chorus is the largest telecommunications utility company in New Zealand.

Chorus provides high capacity internet and communication services to Christchurch. There are three types of network cables: the older paper and lead copper cables, modern plastic copper cables and fibre optic cables. Most of the high capacity cables are either in 20 mm, 50 mm or 100 mm ducts in the ground which provides extra level of resilience and easy access to faulty portions of the network. The telecommunication network has been designed to be inundated. The 5 March flood caused problems for cables that probably had some damage from the earthquakes, but were not manifested as faults. Some paper and lead copper cables were damaged from earthquake induced land movement. These cables were laid from the 1920s and the old and brittle lead sheathing cracked at the neck of the joints under the tensile forces experienced by the land movement. Flooding and the high groundwater table (as a result of rainfall) have caused water to enter into the cables through the cracks and resulted in faulting.

Figure 7-8 shows where the major cable fault locations occurred in Bexley, New Brighton and Beckenham as a result of the flooding. Access to some of the sites was not possible because large portions of these suburbs were inundated to depths of 1.5 m.

Approximately 600 customers lost service for about 3 to 4 days until the flood water receded and the access was gained for repair.

There was no damage to plastic copper cables and the fibre optic lines as a result of the flood event. Plastic copper cables are greased with plastic sheathing which repels water. The fibre cables are intrinsically water resistant.

The failure of the electricity connection to Banks Peninsula (operated by Orion) for 2 to 3 days meant that an alternative power source had to be provided to the Little River exchange (Figure 7-8). High flood waters blocked the streets; however, a large transporter was engaged to deliver the generator to the site and the service was regained. Both Akaroa and Mt Pearce exchanges ran on their own generators during the power outage. Visits were made to outlying radio stations and cabinets to replace the batteries or to apply portable generators.

Figure 7-8 Map showing the locations of major telecommunication cable faults in Christchurch and Banks Peninsula (Google, 2014).

Waste Disposal

The GEER team contacted Canterbury Waste Services (CWS) which owns and operates the Kate Valley Landfill and the transit stations for waste disposal services within the Canterbury region (2014). CWS did not see an increase in tonnage delivered to the landfill as a result of the March flood event. CWS did note that additional business was generated for waste hauling companies providing skips and containers to affected households. Upon request of Christchurch City Council CWS provided additional kerbside mobile garbage bins to the affected neighbourhoods.

Gas Distribution System

Contact Energy (Rock Gas) who operates the natural gas pipeline system in Christchurch and is owned by Contact Energy was contacted by the GEER team (2014). The pipeline gas network and feeder plants suffered no damage as a result of the flooding and the systems performed well. Rock Gas has upgraded internal communications equipment as result of the performance of their public band UHF radios during the post-earthquake shutdowns. Rock Gas intends to operate now using the Team Talk which is a lifeline communications provider, which is already in use by Rockgas's LPG cylinder distribution network of trucks and will be utilized by other parts of the company in the near future.

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