MAYORAL FLOOD TASKFORCE

Final Report
Part C - Appendix B: Detailed Area Reports

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Appendix B Detailed Area Reports

B.1 Dudley Creek

B.1.1 Background

Existing studies

The Dudley Creek catchment, which includes what is known as the Flockton Basin, has been extensively studied under the Land Drainage Recovery Programme Dudley Creek project. This study has moved through a six values assessment to an options identification phase and on to a feasibility assessment of two long-term preferred solutions for managing flood risk in the area.

The majority of the houses within the Dudley Creek catchment study area have been surveyed for floor level and ground level, and this information has been electronically recorded in GIS.

Detailed hydraulic modelling of Dudley Creek and its tributaries has been completed to assess pre- and post-earthquake flood risk, which identified widespread increased flood risk. Further modelling was subsequently carried out for flood defence options.

The following reports have been produced for Council:

- Dudley Creek Catchment: Issues and Options Report, Revision F, 13 November 2013
- Post-earthquake Operations of the Upper and Lower Diversion, Revision 0, 30 September 2013
- Effect of Stormwater Flooding in Dudley Creek Catchment on the Wastewater Network, Draft C, 13 August 2013
- Land Drainage Recovery Programme: Assessment of the Effects of Filling Building Platforms, case study report, 12 April 2013

Council has also been working on a Dudley Creek Area Rainfall Response Plan. Investigations and preliminary solutions were identified prior to commencement of the Taskforce.

Flooding history

The Dudley Creek catchment has a history of flooding with documented flood events across the area dating back to the early 1900's. The area was then occasionally flooded up to the 1970's, until the Dudley Creek Diversion was constructed. The diversion significantly reduced flood risk, but since its implementation there has also been a period of fewer severe rainfall events. It is likely to be for these reasons that no flooding of the area has been reported (until the earthquakes) by residents who have lived in the area for 30 years. Since the earthquakes, there have been several floods in the area including August 2102, June 2013, and three times within March and April 2014.

Customer service reports

Numerous Customer Service Reports have been raised across the assessment area. The following is a general summary of the issues raised since the earthquakes:

- Flooding of the street
- Drain blockages
- Requests for sandbags

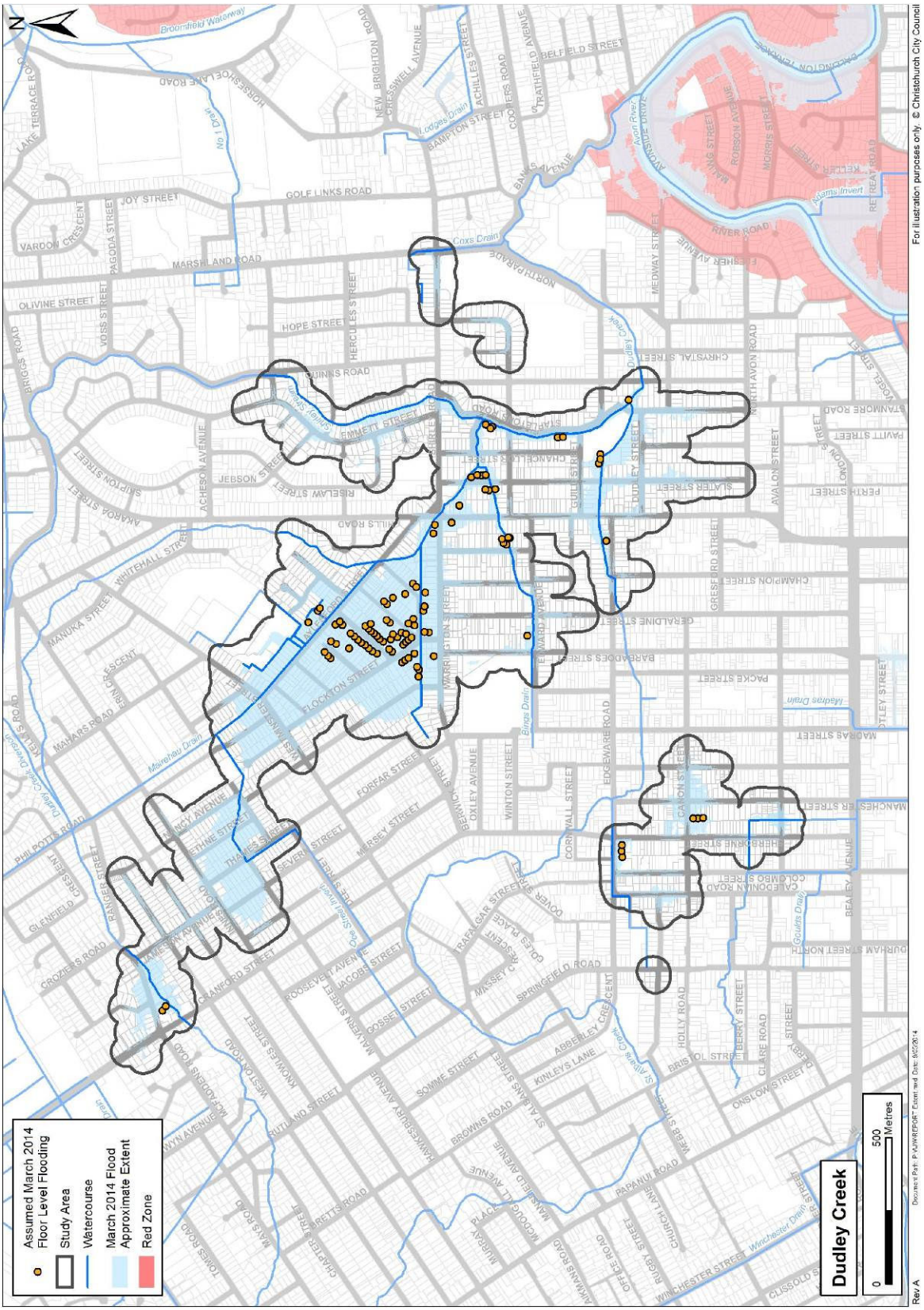

Figure 1 Dudley Creek location plan

B.1.2 Key drainage infrastructure

Dudley Creek and its tributaries are demonstrably under capacity in rainfall events both within the open channels and at culverts. One of the most vulnerable areas within the catchment is the area known as Flockton basin which is bounded by Flockton and Aylesford Streets. As its reference suggests, it has the topography of a basin and during flood events often suffers from significant ponding. Underground infrastructure helps to drain this ponding; however, many of the water levels within the structure rely on hydraulic pressure. The Flockton Invert, located on Harrison Street, is a submerged pipe and water levels equalise with the Dudley Creek. An issue with this is that when equilibrium is achieved, the resultant water level in Flockton area is higher than the ground level. This is due to the height of the Dudley Creek banks at the invert's outlet.

B.1.3 SCIRT projects

SCIRT studies across the assessment area are listed below:

- 11069 St Albans and Mairehau (Roading, Stormwater, Water Supply)
- 11068 St Albans and Mairehau (Wastewater)
- 10811 Richmond and Shirley (Roading, Stormwater, Water Supply)
- 10581 PS7 Catchment Wastewater
- 10915 Shirley NW2 (Stormwater Water Supply & Roading)
- 11044 Edgeware Road

Stormwater works across the Lower Dudley Creek area are proposed under the following projects:

- 11131 Richmond (Roading, Stormwater, Water Supply)
- 11132 Shirley South (Roading, Stormwater, Water Supply):
- 11047 Edgware & Richmond Bridges

The SCIRT catchment study for the Upper Dudley Creek area, including the Flockton area, is currently at concept design stage and the works are yet to be finalised. Preliminary indications are that there will be limited works in the area.

The SCIRT works currently identified in the lower Dudley Creek area through Richmond primarily relate to repairs to existing drainage infrastructure and culverts.

It should be noted that the SCIRT pluvial assessment has been led by the same team completing the fluvial assessment and details of flooding identified have been captured for this assessment.

B.1.4 Existing flood protection infrastructure

Two engineering solutions currently exist:

- Dudley Creek Diversion – The Flockton area has historically had high flood risk. In the 1970s a diversion structure was constructed to divert flood waters from the upper catchment to Horseshoe Lake. This diversion was investigated by Council in 2013 and was found to be operating as designed. Changes in levels were identified but it was not suggested that this would impact operational effectiveness.
- Cranford Basin – Cranford Basin is located in the market gardens between Cranford Street and Philpotts Road. It is used to provide storage during high rainfall events. From here stormwater is pumped via PS219 to the Dudley Diversion, so reduced pumping can further reduce flow and increase storage. Land within the basin is planned for the NZTA Northern Arterial scheme and for the provision of stormwater attenuation.

B.1.5 March 2014 flood extent

Depth

In the March event flooding was in excess of 600mm deep through the centre of Carrick Street, Harrison Street and Slater Street.

Cause

Flooding in the Dudley Creek catchment is a result of under capacity waterways which restrict flows and back up in heavy rainfall. The catchment has suffered from significant settlement and there has been a loss in grade from the upper catchment to its confluence with the Avon. The waterways specifically have suffered from lateral spreading and bed heave further exacerbating the loss of capacity.

The Flockton Basin has specific flooding issues linked to its low lying topography. The area drains to the Flockton Invert to the south, which is a pipe that runs west to east across Harrison Street to Dudley Creek. The pipe remains partially full at all times and when Dudley Creek is in flood it loses functionality and begins to backflow. This is because the drain is hydraulically linked to Dudley Creek and Mairehau Drain and over time water levels in the area equalise with those in the stream. This is accelerated by water spilling out of Mairehau Drain, which compounds the ponding in the area. The depth of the water resulting from this ponding is known to flood many houses above floor level.

Across Dudley Creek and its tributaries, high water levels in the waterways incurred through a loss of capacity has a direct impact on the ability of drainage infrastructure to discharge, leading to widespread pluvial flooding.

General description of damage

During flooding to the Flockton area, many houses were flooded above floor level. For the wider area, many properties experienced flooding across the section or under foundations.

Flood maps highlighted the wide spread house and property damage from the March flooding. Vehicles were also flooded and suffered damage.

Number of affected floors

An estimated 97 properties experienced above floor level flooding in the March event based on validated GIS data and the surveyed flood extent.

Local effects

There was widespread flooding across the catchment during the March 2014 flood, in addition to the properties flooding above floor level there were also hundreds of houses that suffered flooding of the foundations. Numerous other properties suffered on property flooding or lost access to their homes due to carriageway flooding.

Local optional evacuations were required due to the risk of flooding to residents. A local welfare center was also opened; however, this was largely un-utilised.

B.1.6 Other 2014 floods

The catchment has experienced flooding on three occasions in 2014. These include:

- 4 March
- 18 April
- 30 April

B.1.7 Community response and drivers

Social impact

Flooding in the Dudley Creek catchment has caused great stress to the residents and many have moved out of their homes for this reason.

Reports in the media have also cited that some residents are unable to sleep when it rains.

Financial stress is also affecting the community who reported to have been subject to increases in insurance excesses (e.g. excesses of $10,000 for flood damage). Additional financial pressure exists for those which have left their homes and are now paying mortgages, rates and rents at more than one property. Whilst insurance organisations have covered the costs of temporary accommodation in some cases, it is in all cases time bound and for some this has now been exhausted.

Community feedback

Dudley Creek Information Evenings were held in March 2014 to discuss the two long term options presented in the Council report. Feedback from the community was that they welcomed the flood remediation but were concerned by the timeframe for implementation (approximately 2-3 years).

A public focus group was held by Council to discuss the temporary options which are being explored. It became apparent that residents were open to large scale pumping if it relieves flooding. The group was also asked whether they would accept the noise resulting from pumping during flood events, and the group responded favorably to the question.

The public focus group indicated they did not see sand bags as an option, but were open to house tanking. The idea of temporarily raising houses raised concerns over resilience during any future earthquakes.

The Taskforce held a public meeting with the community at Edgeware Bowls Club on 3 June 2014 and the temporary flood mitigation measures identified in this report were presented and discussed. The meeting was well attended by property owners subject to flooding but less so by property owners potentially affected by the solutions.

Meetings to discuss specific components of the Taskforce's proposals with affected property owners have also been held or are planned for the coming weeks. The first meeting was held at the Chancellor Street culvert to discuss its removal on 25 June 2014 following a letter drop. A meeting is planned for the Tay Street Drain Pump Station with Kensington Avenue property owner at Mairehau Library on 2nd July 2014

B.1.8 Field studies

Field visits were undertaken in May and June 2014 to better understand the flooding issues experienced. Properties which were known to be affected were visited by staff who recorded flooding information.

After the June 2013 and March 2014 flood events, the area was also surveyed. This included house surveys, flood level surveys and extent mapping.

As part of the Taskforce, a site walkover was conducted which in conjunction with the existing knowledge of the area was used to identify options for temporary flood mitigation.

Other field studies were completed as part of the Dudley Creek permanent options identification and feasibility studies.

B.1.9 Classification of earthquake effects

Bed heave/hydraulic capacity loss

Bed heave, silt deposition and lateral spreading has occurred extensively along Dudley Creek and its tributaries and a subsequent loss in hydraulic capacity has occurred.

Council have undertaken silt clearance works through the waterways in 2013 and subsequently in 2014 in conjunction with the Taskforce.

Settlement

A large proportion of the catchment has subsided between 200 and 500 mm resulting in a net loss in grade across the reach.

Flood defences

There are flood defences in the Dudley Creek catchment that have been quantifiably affected by the earthquakes. The Upper and Lower Dudley Creek Diversions appear to continue to function as they did prior to the earthquakes.

Infrastructure damage

Damage to culverts and failure of timber retaining structures has been observed across the lower catchment. Structural damage to culverts falls within the scope of SCIRT and remedial works to these and the piped network are proposed in the catchment.

B.1.10 Key photos

Figure 2 Flockton area flooding in March 2014 event

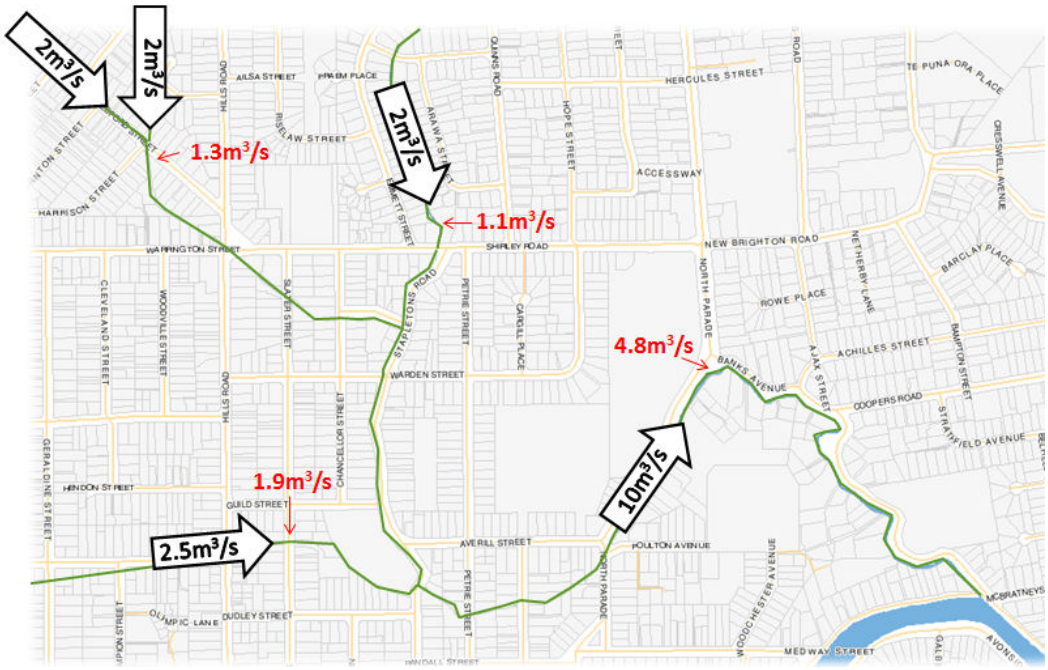

Figure 3 Required flow (arrows) and waterway capacity (red) during a 50 year ARI (Sourced from Dudley Creek information session presentation)

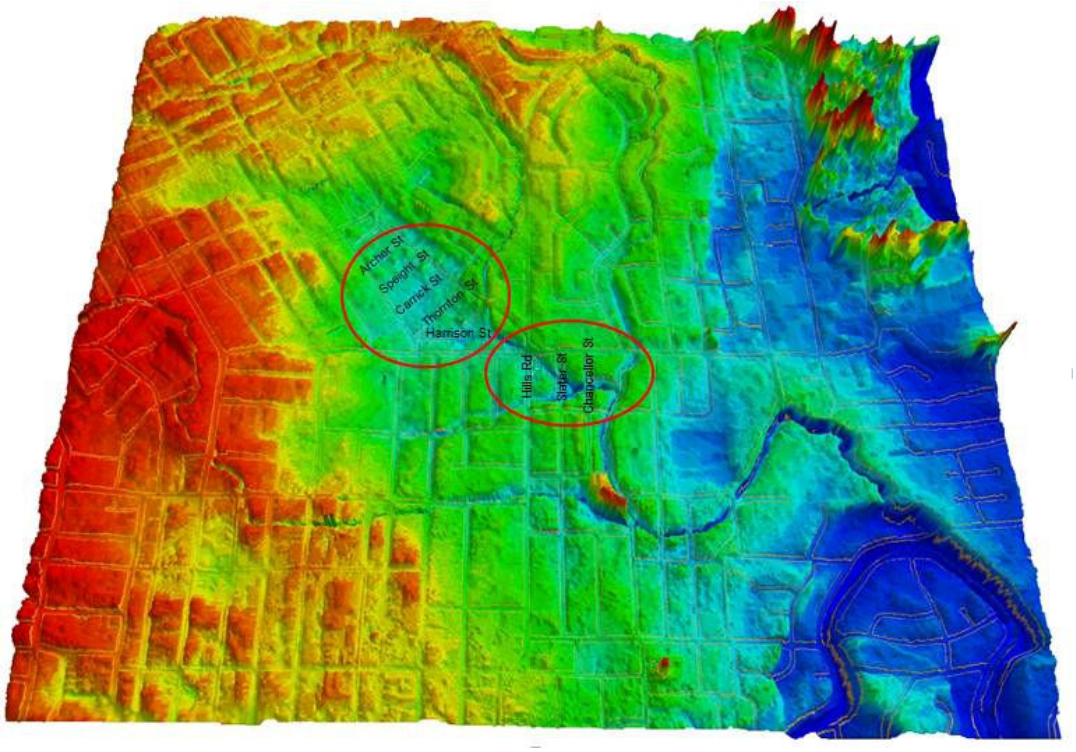

Figure 4 LiDAR image of the Dudley Creek catchment

B.2 Lower Avon: River stopbanks

B.2.1 Background

Stopbanks were first constructed along some lengths of the Avon in the early 20th Century. Following overtopping during major storm events, the stopbanks have been progressively extended and raised.

The earthquakes resulted in significant slumping along the banks of the Avon as a result of liquefaction and lateral spreading and the major subsequent earthquakes have caused further damage and settlement. The stopbanks were subsequently reconstructed along the river's edge as a temporary measure. The stopbanks continue to suffer from bank slumping and fill consolidation which results in areas of the stopbanks being lower than the river flood level.

New alignments for the permanent stopbanks are currently being considered.

Location

The stopbanks are present along the entire length of the Lower Avon.

Existing studies

The following existing studies have been identified:

- An Emergency Management Plan was created in 2012 following identification of the priority areas for stopbank monitoring in the event of high tides, high rainfall and aftershocks.
- The full stopbank length was inspected in March 2014 prior to Cyclone Lusi and low-lying sections were topped up as required.
- Council has requested Davie Lovell Smith to undertake a new survey of the stopbanks and the field work component of this has been completed.

Flooding history

During major storm events the river has over topped the stopbanks resulting in a progressive extension and raising of the stopbanks. A notable significant historic flood event occurred following a snow storm in 1992. The river also over topped its banks during the March 14 storm events in some locations, e.g. New Brighton Road at Pump Station 205.

B.2.2 Key drainage infrastructure

The stopbanks incorporate stormwater outfalls, some of which have some backflow prevention installed some of which are in need of repair.

B.2.3 SCIRT projects

Stopbanks are not within SCIRT scope.

B.2.4 Existing flood protection infrastructure

The Avon stopbanks are the primary flood protection for the Lower Avon area. In order to prevent backflow and flooding each stormwater outfall through the stopbanks is fitted with a flap valve for backflow prevention.

B.2.5 March 2014 flood extent

During March the Avon River flood levels peaked above ground level, so land drainage within the stopbanks was inhibited, which resulted in flooding on the inside of the stopbanks. Flooding was also caused by back flow through the drainage network where flaps valve were not functional.

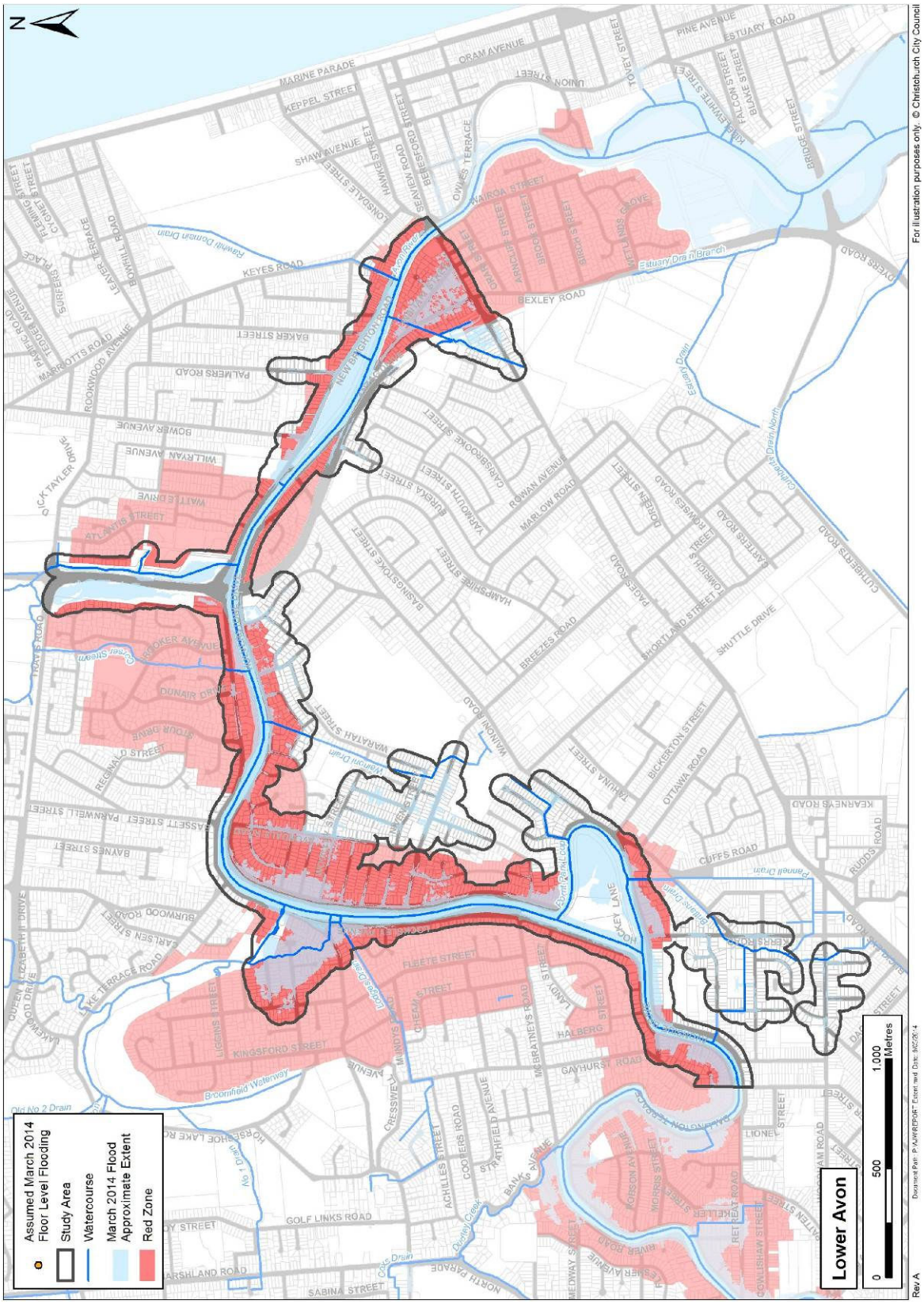

Figure 5 Lower Avon River location plan

Cause

The flooding was caused by a lack of channel and stormwater network capacity, the overtopping of banks and the poor condition of the flap valves causing tidal and river backflows into the stormwater network.

Local effects

The affected properties can be grouped into two key locations associated with stopbanks and backflow:

- Avondale, generally between Avondale & Wainoni Rd
- Dallington

Additional areas of flooding not associated with stopbanks include:

- Brittans Drain, around Kerrs Road
- Knights Drain, around Pages Rd ANZAC Drive
- Pamela Street Drain

B.2.6 Community response and drivers

The stopbanks are essential to prevent tidal flooding. However they also cause other adverse effects such as ponding within the protected area. Improved maintenance and operational activities are required to minimise this flooding.

B.2.7 Field studies

The Emergency Response Plan identified the following as critical areas:

- Kibblewhite Street
- Evans Avenue
- Owles Terrace
- New Brighton Road
- Locksley Avenue
- Dallington Terrace
- River Road
- Avonside Drive
- Hulverstone Drive

A full survey of the stopbanks has been completed by Davie Lovell Smith on behalf of Council.

An investigation completed in March 2014 identified that topping up of the stopbanks is required in some locations, particularly Hulverstone Drive and the Owles Terrace boat ramp. It was also identified that multiple flapgates in the lower Avon are either missing or blocked open.

B.2.8 Earthquake effects

The effects of the 2011 Canterbury earthquake sequence on the area are described in this section and have been derived from information provided by the Canterbury Geotechnical Database (CGD), SCIRT Geodatabase (SGD), CERA and field observations.

Land level changes

The CGD vertical and horizontal ground movement database indicates land changes between -0.1 m to -0.5 m have been observed along the Avon with some localised movement of -0.5 m to -1.0 m.

Lateral spread

Moderate to severe lateral spread has occurred along the length of the Avon and within the Residential Red Zone.

The Avon River banks suffered significant slumping as part of liquefaction and lateral spreading. Temporary stopbanks were reconstructed along the river's edge. Each major earthquake event caused further damage and settlement to the stopbanks. These stopbanks continue to suffer from bank slumping and fill consolidation. This results in areas of the stopbanks being lower than the river flood level.

Liquefaction

CERA has classified land across Christchurch due to the significant effects of liquefaction and lateral spreading. Moderate to significant liquefaction occurred along the Lower Avon during the earthquake series. Therefore, much of the area in the Lower Avon was classed as Residential Red Zone (RRZ). The remainder was classed in three Green Zone technical categories (TCs), which describe how the land is expected to perform in future earthquakes. Within the Lower Avon area outside the RRZ the land is classified as TC2 and TC3 indicating minor to moderate and moderate to significant land damage from liquefaction is possible in future significant earthquakes, respectively.

Ground cracking

The CGD ground cracking database indicates cracks of 10 to 50 mm along the length of the Avon with some 50mm to 200 mm cracks identified with some in excess of 200mm in the Red Zone.

Waterway observed changes

Bed heave will have occurred within the Lower Avon reach.

Infrastructure damage

The local drainage network will have suffered a reduction in capacity during peak river levels.

The emergency response placement of the stopbanks has inadvertently covered some manholes and sumps causing local drainage issues. Ongoing maintenance difficulties are being experienced.

Bed heave / hydraulic capacity loss

The local drainage network will have suffered a reduction in capacity during peak river levels due to ground settlement.

B.2.9 Key photos

Flooding at the stopbanks is illustrated in Figure 6; a further photo in Figure 7 provides an example of a low point in the stopbanks is at the Owles Tce boat ramp.

Figure 6 Lower Avon flooding behind stopbanks

Figure 7 Lower Avon stopbanks at Owles Terrace

B.2.10 Constraints

The stopbanks cannot be removed until an alternative alignment for the permanent stopbanks has been determined.

B.2.11 Opportunities

The relocation of the stopbanks away from the river bank will reduce the risk of ground settlement and lateral spread.

B.2.12 Emergency response plan

An Emergency Response Plan has been developed and used since 2012 during periods of high tides and/or rainfall. Emergency response is also triggered in the event of significant aftershocks. It is recommended that this plan is continued and updated as required, for example to account for the abandonment of Residential Red Zone land.

B.3 Lower Avon: Avondale area

B.3.1. Background

The Avondale area suffered area-wide ground settlement as a result of the Canterbury Earthquake sequence and as a result, the ground level is now typically RL10.5 – RL11m. This change in level has resulted in a reduced hydraulic head for the operation of the local stormwater network, thus reducing the network's efficiency. Some parts of the area are now below annual high tide level and the river flood level for major events.

The area is protected by the Avon River stopbanks and back flow prevention devices on the stormwater network outfalls.

Location

The Avondale area is located between Breezes Road in the south, the Avon River in the north and west, and Hulverstone Drive and Waratah Street to the east.

Existing studies

- Investigation of the operation of Pump Station 220 by SCIRT
- Survey of the river stopbanks

Flooding history

One significant historical storm event was the 1992 snow storm when the river overtopped the stopbanks along Hulverstone Drive. During the March 2014 storm event the river also overtopped the stopbanks in some locations, e.g. New Brighton Rd at Pump Station 205.

B.3.2. Customer service reports

Customer service reports indicate that seven properties have experienced flooding up to the building foundations and two properties suffered garage flooding. While no house floors were flooded during the March 2014 event, feedback from local residents confirms that houses were at risk. The properties are clustered in two groups.

B.3.3. Key drainage infrastructure

The area is served by stormwater network piping which discharges directly to the river. The main pipeline is Wainoni Drain which discharges at Hulverstone Drive. This pipeline includes Pump Station 220 which pumps stormwater into the river during peak tides and flood events.

There are numerous stormwater outfalls (ranging in size from 225 to 825 mm) which also discharge to the river.

B.3.4. SCIRT projects

The following SCIRT projects are applicable to the area:

- 11086 Avondale Rd rebuild in Residential Red Zone.
- 10802 Pump Station 54 Stage 1 roading renewal (includes stormwater network repairs).
- 11071 NE4-Aranui North, repairs to roading and stormwater assets.

SCIRT has completed an investigation of the operation of Pump Station 220 which found the following:

- The existing outlet is damaged and held open allowing back flow of water from the river.
- The outlet scour protection is gone.

- The pump size is considered adequate.
- The other local flap gates have been removed or are damaged allowing back flow into the network.

B.3.5. Existing flood protection infrastructure

The wider area is protected by the Avon stopbanks and the council stormwater network which discharges through the stopbanks. Some of the piped outfalls have flap valve back flow prevention and it has been identified that some are in need of repair.

B.3.6. March 2014 flood extent

Depth

Areas within the Residential Red Zone experienced above-floor level flooding and the Residential Green Zone areas experienced property and garage flooding.

Cause

Flooding along the urban side of the stopbanks was caused by both fluvial and pluvial sources. The Avon River back flowed through the flap gates inundating the streets and surface water flooded behind stopbanks because it was unable to drain to the river. A resident stated that, “the water flows back up Prestwick Street at high tide, then onto Avondale Rd”. These comments seem to suggest the local flap gates may not be sealing correctly as the flooding occurs during ‘all’ high tides. The Avondale Rd properties have also been flooded three times since the earthquakes.

The main outfall for the area, Pump Station 220, is reported to have a damaged flap gate, possibly allowing back flow into the stormwater network.

The high river flood level reduced the capacity of the stormwater network. No stopbank overtopping was reported at this location.

General description of damage

The GIS mapping indicated that continuous flooding was experienced inside the stopbank from Porrit Park to the Avondale Rd bridge along Avonside Drive and on the adjacent Red Zone properties. Between Avondale Rd and Wainoni Rd Street flooding was noted with property surface flooding.

Number of affected floors

House floor level flooding has not been identified, however four garages were flooded. It can be concluded that as the garages were flooded to a depth of 100mm, water would have also have been present under the floor of the houses. Some degree of flooding has been observed at 20-30 properties across seven streets and further flooding occurred in the Residential Red Zone.

Local effects

The affected properties were clustered along Avondale and Breezes Road.

B.3.7. Other 2014 floods

It was reported by one resident that their property had been flooded three times since the Canterbury earthquake sequence.

B.3.8. Community response and drivers

Social impact

A report specific to this area has not been received however street flooding would cause access difficulties for the wider community. The flooded properties, especially those who have had repeated garage flooding would experience increased levels of anxiety, possible loss of property and increased insurance costs.

Community feedback

The community has reported flooding as previously recorded.

B.3.9. Field studies

Site inspections were undertaken on 3rd to 4th May 2014 to inspect the area to identify area and individual property flooding.

B.3.10. Earthquake effects

These effects are described in section B.2.8 above.

B.3.11. Key photos

The photograph in Figure 8 is indicative of flood levels in Avondale.

Figure 8 Lower Avon Avondale example of flooding up to house foundations and in garage

B.3.12. Constraints

The following constraints have been identified:

- The stopbanks cannot be removed until an alternative alignment for the permanent stopbanks has been determined.
- Access to maintain the existing flap gate is difficult due to high tides and soft soils within the river channel.

B.3.13. Opportunities

Shallow stormwater holding basins could be formed in the Residential Red Zone away from the residential Green Zone properties. Runoff could be directed to these basins. During major events, stormwater could be pumped direct from these basins into the river.

B.4 Lower Avon: Residential Red Zone

Note that while the Residential Red Zone is reported on here it was excluded from consideration of any short-term flood defence measures as it is the subject of longer term discussions on land use.

B.4.1. Background

The Residential Red Zone (RRZ) area suffered area wide ground settlement as a result of the Canterbury Earthquake sequence. As a result the ground level is now typically RL10.0 – RL11 m and the hydraulic head necessary for the local stormwater network has been reduced, thus reducing the stormwater network's efficiency. Some parts of the RRZ area are now below annual high tide level and the river flood level for moderate to major storm events. Hence, the area is protected by the Avon River stopbanks and back flow protection devices on the stormwater network outfalls.

The March 2014 flood maps indicate that six areas within the RRZ experienced property and house flooding, these areas are;

- Avonside Drive and Retreat Road river loop, including land adjacent to the Dudley Creek confluence with the Avon.
- Dallington Terrace and Locksley Ave / Gayhurst Road river loop.
- Avonside Drive and Porrit Park river loop.
- Avonside Dr and Hulverstone Drive in Avondale.
- New Brighton Road at the Horseshoe Lake outfall.
- Knights Drain Outfall, Pages Road and ANZAC Drive.

Location

The RRZ is situated along the River Avon predominantly in Avonside and includes the areas outlined above.

B.4.2. Customer service reports

As the area is classified as RRZ there are no customer service reports available for recent flooding events.

B.4.3. Key drainage infrastructure

There are numerous piped and open drain outfalls to the river, including discharges from Pump Stations 205, 204 and 220.

B.4.4. SCIRT projects

SCIRT are currently undertaking a large number of projects that interact with the RRZ, however due to the size of the area covered and number of projects involved they have not been listed.

B.4.5. Existing flood protection infrastructure

The RRZ is located along the banks of the Avon River. The river stopbanks and the local council stormwater network provide flood protection and drainage. The piped outfalls have flap gate back flow prevention.

B.4.6. March 2014 flood extent

Depth

Property level flooding was not investigated for this study because this study area is classified as RRZ.

Type

Flooding along the urban side of the stopbanks was caused by both the river flood waters back flowing through the flap valves and rainfall within the catchment, i.e. behind the stopbanks, being unable to drain out due to high river levels.

Cause

Bank overtopping has occurred as a result of stopbank slumping and settlement and the flooding in these areas has been worsened by post-quake maintenance practices of blocking off some piped stormwater outfalls. In some areas this has been undertaken as the location of the recovery stopbank over manholes prevents access for maintenance of the flap gates. In other areas this has been carried out to prevent backflow from the river but has resulted in surface ponding.

The capacity of the stormwater network has been reduced due to land settlement.

General description of damage

GIS mapping of the March flood extent indicated that 396 properties experienced some flooding in the Lower Avon area. The majority of these are in the RRZ.

Number of affected floors

128 houses were estimated to be flooded above floor level within the RRZ area during the March event. A number of properties also reported flooding up to the house foundations.

Local effects

The affected properties can be grouped into six areas as noted in the Background section above.

B.4.7. Other 2014 floods

Some areas within the RRZ have been noted as flooding at least three times since 2011.

B.4.8. Community response and drivers

The land has been placed in the RRZ and is unoccupied. Community feedback has not been investigated for this report.

B.4.9. Field studies

As the area is RRZ it has not been investigated for this report.

B.4.10. Earthquake effects

These effects are described in section B.2.8 above.

B.4.11. Opportunities

The large area of the RRZ may provide opportunities for the construction of flood protection measures as part of other studies or works. However, these works will not be part of the Taskforce activity which is only considering protection of houses.

B.4.12. Key photos

Figure 9 Lower Avon RRZ – flooding within stopbank

B.5 Lower Avon: Brittans Drain area

B.5.1. Background

Brittans Drain serves a residential area south of the Avon River Porritt Park loop. The wider area is protected by stopbanks on the southern bank of the Avon River, although the Avon itself does not typically threaten Green Zone houses. Properties immediately adjacent to the Avon River have been red zoned by CERA.

Several complaints in recent years have been lodged to address maintenance issues causing localised flooding. The March 2014 event caused section flooding on multiple properties as well as flooding at or near foundation level for properties directly adjacent to Brittans Drain.

Location

Brittans Drain is located between Pages Road and the River Avon and includes Wainoni Road south of Porritt Park.

Existing studies

Brittans Drain was modelled by SCIRT as part of a catchment investigation. This identified some capacity issues given the large catchment area feeding the drain. In particular, modelling indicated surface ponding potential around the commercial properties of Eastgate Mall at the head of the catchment.

The drain outfall at Porritt Park was also investigated by SCIRT. This identified a lack of a flap gate at the outfall.

Flooding history

Residents in Avonside Drive report that Brittans Drain regularly floods; however, this area is now part of the Residential Red Zone. The Green Zone experiences localised flooding which is typically confined to the road carriageway.

B.5.2. Customer service reports

Multiple customer service reports have been lodged both pre- and post-earthquake for the area. These relate to maintenance issues such as blocked sumps or constrictions in Brittans Drain. Reports have increased since the earthquakes with the infrastructure rebuild contributing to sump blockages.

B.5.3. Key drainage infrastructure

The area is served by Armstrongs and Brittans Drain which feed into the Porritt Park loop of the Avon River. Brittans Drain is an open drain which flows along the back of residential properties before entering a 900 mm brick barrel along Wainoni Road. It transitions into 1200 mm concrete pipe after being joined by Pannell Drain. The catchment drainage network is complex and included six manholes where flow can occur in multiple directions.

B.5.4. SCIRT projects

SCIRT project 10876 modelled the Brittans Drain stormwater network and project 10809 investigated the outfall on the Avon loop. Piped repairs and renewals are recommended within the catchment.

Roading repairs have been made in isolated areas, and project 10876 recommends further repairs with significant carriageway work for two sections of road. This has yet to be undertaken.

B.5.5. Existing flood protection infrastructure

Stopbanks on the south side of the Avon River protect the area from large scale fluvial (river) flooding.

B.5.6. March 2014 flood extent

Depth

The worst affected house in March experienced flooding to a depth of 50 mm up the foundations. Brittans Drain was reported as 2 m deep at Kerrs and Wainoni Roads intersection.

Type

Several properties experienced pluvial (rainfall) flooding of their driveways and front yards with water overtopping the kerb and channel. More significant fluvial flooding was experienced by properties backing on to Brittans Drain.

Cause

Green Zone properties on the corner of Kerrs Road and Dunarnan Street experienced flooding from Brittans Drain. These properties in particular were flooded due to a large tree creating a significant constriction in the drain at this location.

Other nuisance flooding was a result of the March event exceeding the capacity of local kerb and channel. This may have been worsened by the earthquake as localised changes to the grade are apparent. This flooding is not however a risk to floor levels and is therefore a lower priority.

General description of damage

No damage to property, garages or houses has been identified in the Residential Green Zone. Impacts were limited to inundation of properties.

Number of affected floors

No properties experienced floor level flooding in March 2014. Two properties adjacent to Brittans Dain experienced foundation level flooding.

Local effects

The worst affected properties were clustered around the intersection of Dunarnan Street and Kerrs Road. This coincides with the Brittans Drain constriction created by a large tree.

B.5.7. Other 2014 floods

The residential area is not known to have experienced any other significant flooding in 2014.Avonside Drive along the river in this area is frequently inundated however this does not threaten Green Zone properties or their direct access.

B.5.8. Community response and drivers

March flooding in this area is believed to be at a nuisance level. No roads in the area have been closed due to flooding. However disruption to property access is a potential issue for the two properties which have experienced inundation across their section to their foundation. Water is not believed to have extended beneath foundations for any Green Zone houses in the area.

B.5.9. Field studies

The area was inspected in the days following the March 2014 flood event. Flood extents were derived by identifying and surveying remaining debris marks. Residents gave additional information such as the frequency and depth of flooding. This information was used to produce the flood extent maps.

B.5.10. Earthquake effects

The effects of the 2011 Canterbury earthquake sequence on the area are described in this section and have been derived from information provided by the Canterbury Geotechnical Database (CGD), SCIRT Geo Database (SGD), CERA and field observations.

Land level changes

The CGD vertical and horizontal ground movement database indicates land changes between -0.1 m to -0.5 m have been observed along the Avon with some localised movement of -0.5 m to -1.0 m.

Residential land in the Brittans Drain area has settled by approximately 300 mm due to the earthquakes. This settlement is greater along areas immediately adjacent to Brittans Drain and in the Residential Red Zone with settlement in these locations of up to 1 m. The fall of the land however is relatively unchanged.

Lateral spread, liquefaction, ground cracking and infrastructure damage

These effects are generally described in section B.2.8 above.

The local drainage network will have suffered a reduction in capacity during peak river levels due to ground settlement. SCIRT modelling investigations suggest that any post-earthquake reduction in service is predominantly due to damage to piped infrastructure rather than land settlement. Concept design of the stormwater system recommends repair of 8% of the pipes in the catchment and renewal of 32%.

Damage has also been identified to roads in the area with significant deformation and kerb and channel damage identified for Dunarnan Street and parts of Woodham Road. Isolated damage has also been observed for Kerrs Road and other minor roads in the area

B.5.11. Key photos

Figure 10 Debris mark showing water level on foundation of Kerrs Road property after March 5th event

Figure 11 Brittans Drain sump two days after March 5th event

Figure 12 Large constriction in Brittans Drain (since removed)

B.5.12. Constraints

Brittans Drain flows between residential properties with fences backing onto the drain. This restricts options to significantly alter the drain profile.

B.5.13. Opportunities

There are opportunities to provide a ‘quick fix’ for the most severe flooding by immediate removal of constrictions in Brittans Drain.

B.6 Lower Avon: Knights Drain area

B.6.1 Background

The ANAZC Drive area suffered area widespread ground settlement as a result of the Canterbury earthquake sequence. As a result of the ground level dropping (now typically RL 9.5 m – RL 10.5 m) and the hydraulic head for the operation of the local stormwater network has been reduced, and thus the network's efficiency has been reduced. Some parts of the area are now below annual high tide level and the river flood level for major events.

The area is protected by the Avon River stopbanks. A storm water pump station (PS204) on Knights Drain provides the necessary lift to provide drainage for this low lying area.

Location

The study area is located between Pages Road and Anzac Drive.

Existing studies

- SCIRT investigation of the operation of the pump station (PS204).
- Davie Lovell Smith survey of the river stopbanks.

Flooding history

One significant historical storm event was the 1992 snow storm when the river over topped the stopbanks along Hulverstone Drive. During the March 2014 storm event the river also overtopped the stopbanks in some locations, e.g. New Brighton Road at Pump Station 205.

B.6.2 Customer service reports

Reports indicate that seven properties have experienced flooding up to the building foundations and four properties have had garage flooding in this area. While no house floors were reported as flooded during the March 2014 event, the level of the ground would indicate that some flooding under the floor of houses would also have occurred.

B.6.3 Key drainage infrastructure

The area is served by stormwater network piping which discharges to Knights Drain and then Pump Station 204 which pumps directly to the river. Other numerous local pipelines also discharge to the river.

B.6.4 SCIRT projects

SCIRT has undertaken an investigation into the operation of Pump Station 204. A low flow bypass existed on the pump station pre-quake. However this has been removed and the pump station now pumps all of the storm water discharged from the local area.

B.6.5 Existing flood protection infrastructure

The wider area is protected by the Avon stopbanks and the council stormwater network which discharges through the stopbanks. The piped outfalls have flap valves to reduce back flow from the river.

B.6.6 March 2014 flood extent

Type

Flooding along the urban side of the stopbanks was caused by a combination of the river flood flows back flowing through the flap values, inundation of the streets, and rainfall within the residential area being unable to drain out due to high river levels.

Cause

The flooding was primarily caused by the low lying nature of the ground and the relatively high flood level of the Avon River during the 14 March event. Also, Knights Drain is poorly graded with a high point in the midpoint of the drain, meaning flows will have had difficulty draining away.

No stopbank overtopping was reported at this location. However, the recorded river flood levels of RL 11 to 11.14 m in this area are above the level of identified low points in the stopbanks. It is likely that some overtopping of the stop bank did occur, but was not reported.

General description of damage

GIS mapping indicated that sheet flooding was experienced inside the stop bank for the area bounded by the river, ANZAC Drive and Pages Road. Flooding on the east of Pages Road also occurred.

Number of affected floors

No house floors were reported as flooded in this event; however, four garages were flooded. In addition 20 to 30 properties across seven streets experienced some degree of flooding. The wide spread surface flooding would have resulted in ponded water under the house floors.

These numbers exclude the Residential Red Zone.

Local effects

The affected properties were clustered along Pages Road and between Knights Drain and Pages Road. Up to 30 properties were affected by the surface flooding.

B.6.7 Other 2014 floods

No information about previous flooding is known, and flooding was only reported during the March 14 event. However, the land is very low lying and at Pages Road the carriageway level is being raised, leaving some properties below the road level. This will increase their vulnerability to future flooding.

B.6.8 Community response and drivers

No specific report was received for this area. However, street flooding would cause access difficulties for the wider community. The flooded properties, especially those who have had repeated garage flooding, would experience increased levels of anxiety, possible loss of property value and increased insurance costs.

B.6.9 Field studies

The area was visited in May 2014 to inform this study.

B.6.10 Earthquake Effects

These effects are described in section B.2.8 above.

B.6.11 Key photos

Figure 13 Ponding remaining around property three days after the March event

B.6.12 Constraints

The stopbanks cannot be removed until an alternative alignment for the permanent stopbanks has been determined. Access to the existing flap valves for maintenance is difficult due to high tide levels and soft soils within the river channel.

B.6.13 Opportunities

Knights Drain between ANZAC Drive and Pump Station 204 is piped. This pipeline could be day-lighted potentially increasing its capacity. In addition shallow stormwater holding basins could be formed in the Residential Red Zone away from the Green Zone properties. Runoff could be directed to these basins away from the Green Zone properties.

B.7 Heathcote Valley

B.7.1 Background

Existing studies

- Council's Heathcote Valley Report

Flooding history

During significant rainfall events flooding has occurred around the lower lying properties of Pawaho Place and Stedley Place from two sources:

1. When water flowing along Bridal Path timbered drain adjacent to the properties breaches the timbering and back flows along the outfall pipes serving the area.

2. When there have been blockages in the upstream network at critical inlet structures sites water has spilt over and flowed along the roading network to Martindales Road and into Pawaho Place.

B.7.2 Customer service reports

There have been the following customer service reports:

- Flooding on Martindales Road
- Blocked drains
- Severe silt deposits in Pawaho Place up to 0.5m depth
- Silt on Martindales Road
- Road close requests due to flooding

B.7.3 Key drainage infrastructure

The key drainage networks in the Heathcote area are the Bridle Path Waterway, Heathcote Valley Drain and Matuku Waterway. These systems are a combination of piped and open channel sections. There is a piped system in Martindales Road conveying water from Tunnel Road.

Currently the Bridle Path Waterway route follows the west side of the railway embankment then passes under the embankment via a 1200 mm brick barrel approximately 300 m downstream of Martindales Road to connect with the Truscotts Stream Branch timbered drain that discharges to the Heathcote River.

Note: A contract to divert the flow from the west side of the embankment drain to the east side drain is currently being let.

The water from Heathcote Valley Drain now receives additional water from the Matuku Waterway that was constructed as part of the Morgan's Valley subdivision development. The current outfall is a combination of sections of 750 mm and 900 mm pipes and open channel system that runs from Bridle Path Road to Martindales Road to an outfall at Truscotts Road. This network was likely sized for the flows from the original farmland draining to Heathcote Valley Drain and does not have the capacity for the additional flows from the Matuku Waterway.

The current outfall is a temporary arrangement. To provide the long term outfall with the capacity to receive storm flows, land was purchased to extend the Matuku Waterway approximately 400 m north adjacent to a proposed carriageway through a proposed subdivision. Much of this is now Red Zoned land.

The lower section of Matuku Waterway section was constructed along with the subdivision at Cooks Lane. An outlet structure and a section of 1600 mm pipe was laid out into Bridle Path Road for the

future extension of approximately 65 m to connect with the extended waterway from the Morgan's Valley waterway development.

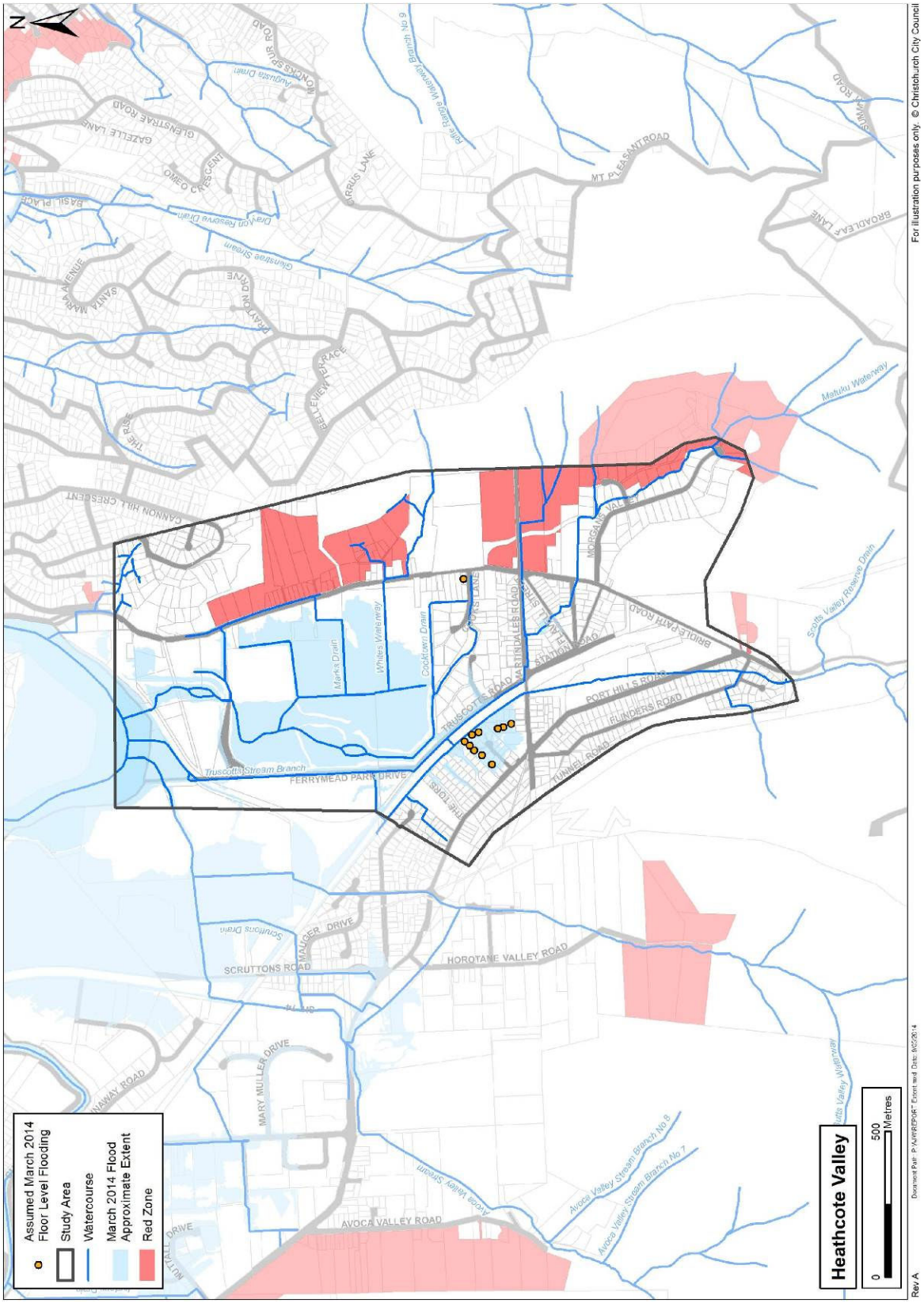

Figure 14 Heathcote Valley location plan

B.7.4 SCIRT projects

The preliminary design for the Port Hills Area 3 project number 11065 proposes renewals to pipes in Marsden Road, Martindales Road and Port Hills Road. Repairs are to be carried out on part of the network discharging from Tunnel Road. None of this repair work directly affects the pipe network in the area of flooding.

B.7.5 Existing flood protection infrastructure

There are currently tide gates and stopbanks in this area.

B.7.6 March 2014 flood extent

Depth and depth

Up to 500mm of pluvial (rainfall) flooding occurred.

Cause

There were multiple sources of flooding for the 5 March event:

1. Approximately 60 m^3 of material was deposited into the inlet structure of the 1200 mm pipe at the south upper end of the former Malt works site. This piped section is part of the Bridle Path Waterway system. This resulting blockage caused the water to bypass over the sides of the inlet structure and flow across the site and out on to Martindales Road where it proceeded west towards the low point of Martindales Road and then down Pawaho Place on the north side. The properties at the end of Pawaho Place are on some of the lowest land in this area.

2. The inlet grill to the Bridle Path Waterway culvert on Port Hills Road blocked and sent water over flowing along Port Hills Road to Martindales Road and into Pawaho Place.

3. The inlet grill that receives the flow from Heathcote Valley Drain on Bridle Path Road blocked and water overflowed along the east side of Bridle Path Road towards Cooks Lane. Some also flowed across Bridle Path Road and down Marsden Road, Station Road and then into Martindales and lastly Pawaho Place. Some water flowed across some properties on the north side of Marsden Road at the Bridle Path Road end.

4. Overflow from Heathcote Valley Drain that headed north along east side of Bridle Path Road crossed to the west side at the intersection of Cooks Lane and flowed past the existing triple sump down the driveway and across a Bridle Path Road property.

General description of damage

Damage occurred to carpets, wall linings and possessions and there was significant deposition of silt over private properties and carriageways.

Number of affected floors

- 10 properties reported flooding above floor level
- Two properties reported flooding above garage level
- 43 properties reported flooding up to foundations

Local effects

The clusters of houses in Pawaho Place, Stedley Place, Hamlet Lane and Deavoll Place were all subject to flooding.

B.7.7 Other 2014 floods

18 April 2014

The rain event on 18 April resulted in approximately 30 m^3 of material from the true left side of the inlet to the Bridle Path Waterway culvert being scoured out and entering the culvert and consequently

being deposited into the inlet structure of the 1200 mm pipe at the upper end of the former Malt works site.

As in the March event, this resulting blockage caused the water to bypass over the sides of the inlet structure and flow across the site, out on to Martindales Road and then down Pawaho Place.

The inlet grill at the time of the rain event was not able to be cleared and water continued to overflow. The contractor who is carrying out the site development cut a channel from the inlet structure to a section of broken 1200 mm pipe to allow the water back into the piped section of the system. This resulted in a reduction of flow across the site towards Martindales Road. A small cut off channel was made at the north end of the site to divert the remaining water flowing across the site back into the open section of the Bridle Path Waterway just upstream of Martindales Road.

Silt and water from the Tunnel Road piped network flowed out of existing sumps connected to the 675 mm pipe along Martindales Road. This system should discharge into the timbered drain on the west side of the railway embankment. This additional silt laden water bubbled out of the sumps and flowed down Pawaho Place contributing to the flooding around and through a couple of the lower houses.

29 April 2014

Three inlets / grills were cleaned prior to the rain event of the 29 April: the inlet grill to the piped section of Bridle Path Waterway at the south end of the former Malt Works site; the inlet to this system on Port Hills Road; and the inlet grill that receives the flow from Heathcote Valley Drain on Bridle Path Road.

The developer of the former Malt works site was instructed to excavate another cut off channel at the north end to divert flows from the site to the open section of waterway.

During the rain event stormwater from the 675 mm pipe system from Tunnel Road again exited from the sumps as a result of outlet being partially blocked and from silt within the pipe itself. A pump and sand bags were used to contain and then disperse the water to the west timbered drain at the railway embankment.

Water also exited Truscotts Stream into Trustcotts Road where the boards from dropped. The depth of water increased until it was able to cross the carriageway further along Deavoll Place and enter the swale system on the north side and drain to the Matuku Waterway branch adjacent to Truscotts Road.

B.7.8 Community response and drivers

A meeting was held on the 20 March 2014 with Council and community representatives to visit specific sites along the stormwater network and to discuss what was observed during the 5 March event.

B.7.9 Field studies

Areas visited were:

- Cooks Lane entrance at Bridle Path Road.
- Heathcote Valley Drain inlet structure at Bridle Path Road opposite Marsden Road.
- Heathvale Place
- Port Hills Road inlet structure of Bridle Path Drain.
- Inlet structure to DN1200 piped section of Bridle Path Waterway at the South end of the former Malt works site.
- Stedley Place
- Pawaho Place
- Martindales Road.

- Truscotts Road.

Modelling of upper Bridle Path Waterway is currently being carried out to determine storm flows and existing network capacity.

B.7.10 Earthquake effects

The effects of the 2011 Canterbury earthquake sequence on the area are described in this section and have been derived from information provided by the Canterbury Geotechnical Database (CGD), SCIRT Geo database (SGD), CERA and field observations.

Land level changes

The only area of significant land change is along Truscotts Stream Branch timbered drain which has been shown to settle by 0.8 m to 0.9 m. The lower board level enabled the water to breach the timbering at this low point adjacent to Deavoll Place and flow across Truscotts Road and into Deavoll Place with the flood levels threatening houses in this area.

Lateral spread

No lateral spread has been mapping in the Heathcote Valley.

Liquefaction

CERA has therefore indicated the area is situated within the Green Zone. Land in the CERA Green Zone has been divided into three technical categories (TC). These categories describe how the land is expected to perform in future earthquakes. The area is TC2 indicating minor to moderate risk from liquefaction and non residential land. In addition area to the south is classified under the Port Hills and Banks Peninsular area.

Ground cracking

The CGD ground cracking database indicates minor cracking at the eastern extend of Martindales Road and in the northern extent of Avoca Valley.

Waterway observed changes

The invert of the timbered drain along Truscotts Road has heaved. It was originally 1-1.2 m from the top board to the invert but it is now approximately 0.6 m over approximately 400 m of the drain, and to a lesser amount further downstream.

Infrastructure damage

Sinking of Truscotts Stream Branch was observed.

B.7.11 Key photos

Figure 15 Truscotts Road showing subsidence of timbered drain

Figure 16 Truscotts road north of Deavoll Place

Figure 19 Truscotts Road outlet of 1200 mm brick barrel after trimming sections of berm

Figure 17 Truscotts Road north of Deavoll Place

Figure 20 Truscotts Road berm cut down to allow flow into Matuku Waterway

Figure 18 Truscotts Road at outlet of 1200 mm brick barrel

Figure 21 Heathcote Valley – 1200 mm brick barrel

Figure 22 Bridle Path drain west of rail embankment property side timbering to the raised

Figure 23 drain inlet structure at 78 Bridle Path Road

Figure 24 Bridle Path valley waterway - inlet at Port Hills Road

Figure 25 Bridle Path valley waterway - Inlet structure at south end of former malt works site

B.8 Upper Heathcote

B.8.1 Background

Location

The Upper Heathcote study area looks at flooding on both sides of the Heathcote River from Halswell Road to Cashmere View Street.

Existing studies

Council's 50 year Average Return Interval (ARI) flood maps predict flooding across approximately 12 sections.

Flooding history

Residents report a history of flooding that pre-dates the earthquakes. However there is a perceived increase in frequency following the earthquakes, with flooding across sections and into Weir Court on approximately six occasions.

Land damage mapping

EQC land damage maps do not extend east to this area. Comparison of July 2003 LiDAR with July 2011 LiDAR shows very little land damage in this area. The subsidence observed is generally less than 100 mm.

B.8.2 Customer service reports

Customer service reports are consistent with the observations noted in the flooding history section above (B.8.1).

B.8.3 Key drainage infrastructure

Weir Place drainage network consists of two single sumps that outfall to the Heathcote River via a 300 mm internal diameter pipe fitted with an inline check valve.

Greenpark Street drainage consists of two 225 mm and one 300 mm internal diameter outfalls.

B.8.4 SCIRT projects

The existing 225 mm internal diameter pipe was replaced with a 300 mm pipe outfall under a SCIRT work package on the Heathcote River.

B.8.5 Existing flood protection infrastructure

There is no existing flood protection infrastructure in this area.

B.8.6 March 2014 flood extent

Depth

In the March event the depth of flooding increases as the sections slope towards the river. The depth near the river would have been in excess of 1 m and up to 500 mm around some houses and over the carriageway.

Cause

Flooding was a combination of fluvial and pluvial. The river overtopped the banks and flowed overland through some properties on Weir Place into the road and also in and around adjoining properties. In total 28 properties along Greenpark Street had water within the section either from water overflowing or backflowing from the river or the street catchment.

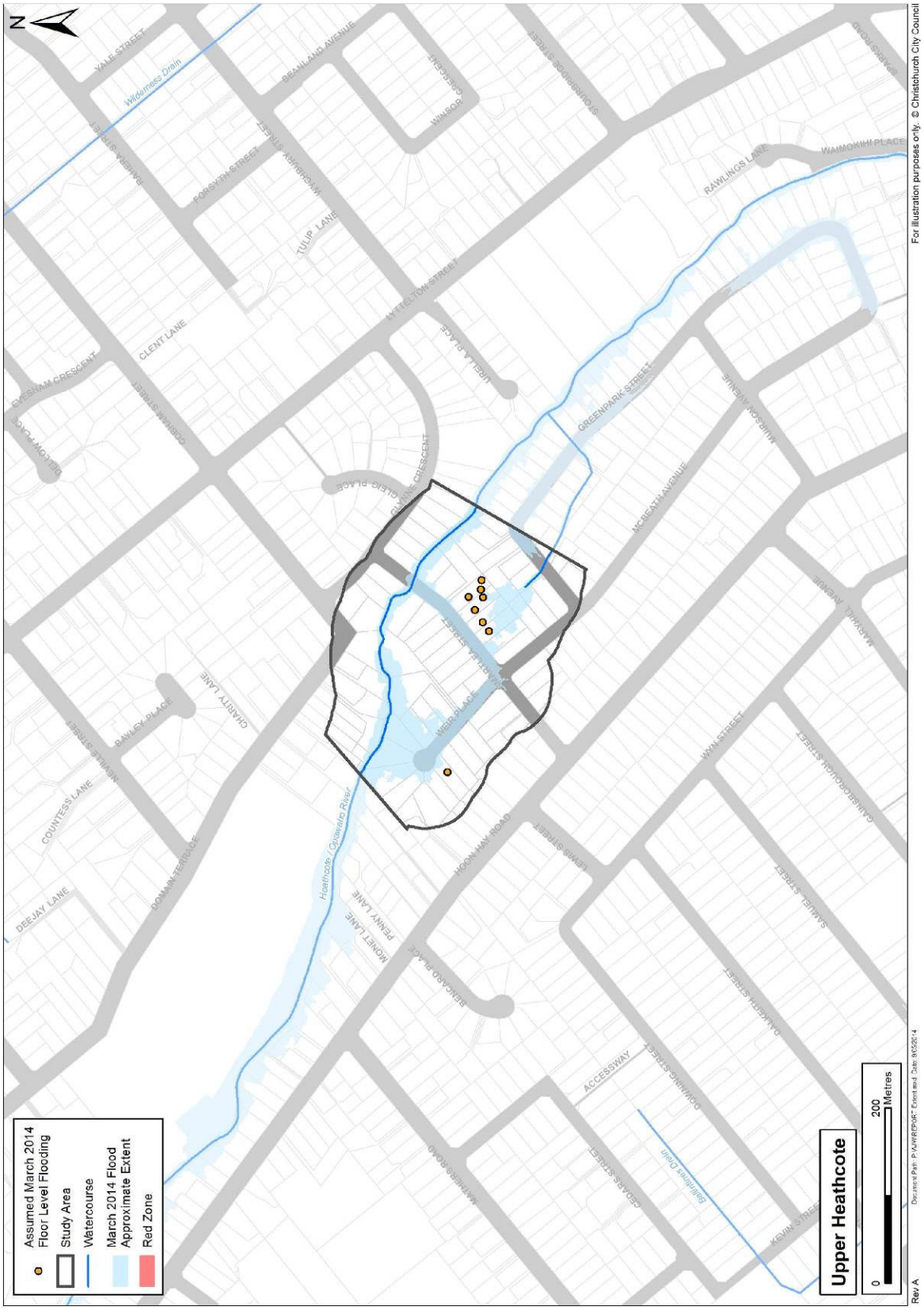

Figure 26 Upper Heathcote location plan

General description of damage

Flooding caused damage to houses, garages and gardens. Several houses were surrounded by floodwaters making access/escape dangerous or impossible. Weir Place was completely covered in floodwater and not safely passable.

Number of affected floors

Two properties were known to have flooded above floor level and two or three other properties came close to being inundated.

Local effects

The primary area of impact was a cluster of three houses adjacent to the river and one Weir Place property, along with one garage in Smartlea Street. A further nine garages were reported to have had garages flooded above floor level.

B.8.7 Other 2014 floods

During the other 2014 flood events the Heathcote River has risen onto sections and carriageway, limiting access to Weir Place but has not severely limiting property access along Greenpark Street.

B.8.8 Community response and drivers

Social impact

The community has been impacted by property damage, temporary access difficulties and ongoing concerns about the potential impact of future flood events.

Community feedback

Individual residents were consulted in the week following March 5 and again during Taskforce investigations were conducted to determine the extent and nature of flooding in this area.

B.8.9 Field studies

Individual residents were consulted following the March flooding event and site visits and further investigations were undertaken during the Taskforce work.

B.8.10 Earthquake effects

The effects of the 2011 Canterbury earthquake sequence on the area are described in this section and have been derived from information provided by the Canterbury Geotechnical Database (CGD), SCIRT Geo database (SGD), CERA and field observations.

Land level changes

The CGD vertical and horizontal ground movement database indicates the area has generally settled 0.1 m to 0.3 m during earthquake events.

Lateral spread

Site observations and conversations with property owners indicate that some areas have experienced lateral spread. It was also commented by residents that the river bed is now lower.

Liquefaction

Minor to moderate liquefaction occurred. CERA has therefore indicated the area is situated within the Green Zone. Land in the CERA Green Zone has been divided into three technical categories (TC). These categories describe how the land is expected to perform in future earthquakes. The area has both TC2 and TC3 land which indicating minor to moderate and moderate to significant land damage from liquefaction is possible in future significant earthquakes, respectively.

Ground cracking

The CGD ground cracking database indicates that there was no obvious ground cracking.

Waterway observed changes

Localised bed heave is likely to have occurred. Comments for residents suggest in some areas the bed of the river is now lower.

Infrastructure damage

No infrastructure damage was observed.

B.9 Lower Heathcote: Riverside properties

B.9.1 Background

Location plan

The Lower Heathcote catchment has been defined as the catchment area contributing to the length of river between Colombo Street and Radley Street.

Existing studies

- Heathcote River Catchment Investigation Stage 2, Christchurch Drainage Board, 1985
- Heathcote River Floodplain Management Strategy, CCC, ECAN, 1998
- Storm Report – 11-13 October 2000, Ken Couling, CCC, 2000
- Mid Heathcote River Masterplan, T.B. Oliver, 2009
- Additional Council studies on the Woolston Cut and Heathcote modelling by Council, NIWA and ECAN

Flooding history

The Heathcote River Flood Plain Management Strategy (1998) highlights the historic flooding of the Heathcote River. This records flooding of 73 houses above floor level on at least four different occasions (1968, 1975, 1977 and 1980) prior to 1998. The most affected areas were noted as Waimea Terrace, Richardson Terrace, Aynsley Terrace, Clarendon Terrace, Riverlaw Terrace and Eastern Terrace.

Physical works previously undertaken include:

Widening and deepening of the river channel and dragline operations (from 1920s); Construction of the Woolston Cut (1986) to provide a more efficient flow of water and the installation Woolston Tidal Barrage (1994); Construction of the Wigram East Retention Basin; Raising of 19 house from 1983 to 1998.

Although flooding had previously been experienced in the catchment, a number of residents in the area indicated that there had been no previous property flooding on their properties prior to the earthquakes. This potentially indicates a change in vulnerability or increase in the risk of flooding of the area due to the earthquake sequence. It is fairly common for riverside properties in this catchment to experience shallow flooding or have restricted access during large rainstorms.

There have been three severe rain events from March 2014 to April 2014 which have resulted in the recent floor level flooding in the area, along with widespread road, property and ancillary buildings flooding.

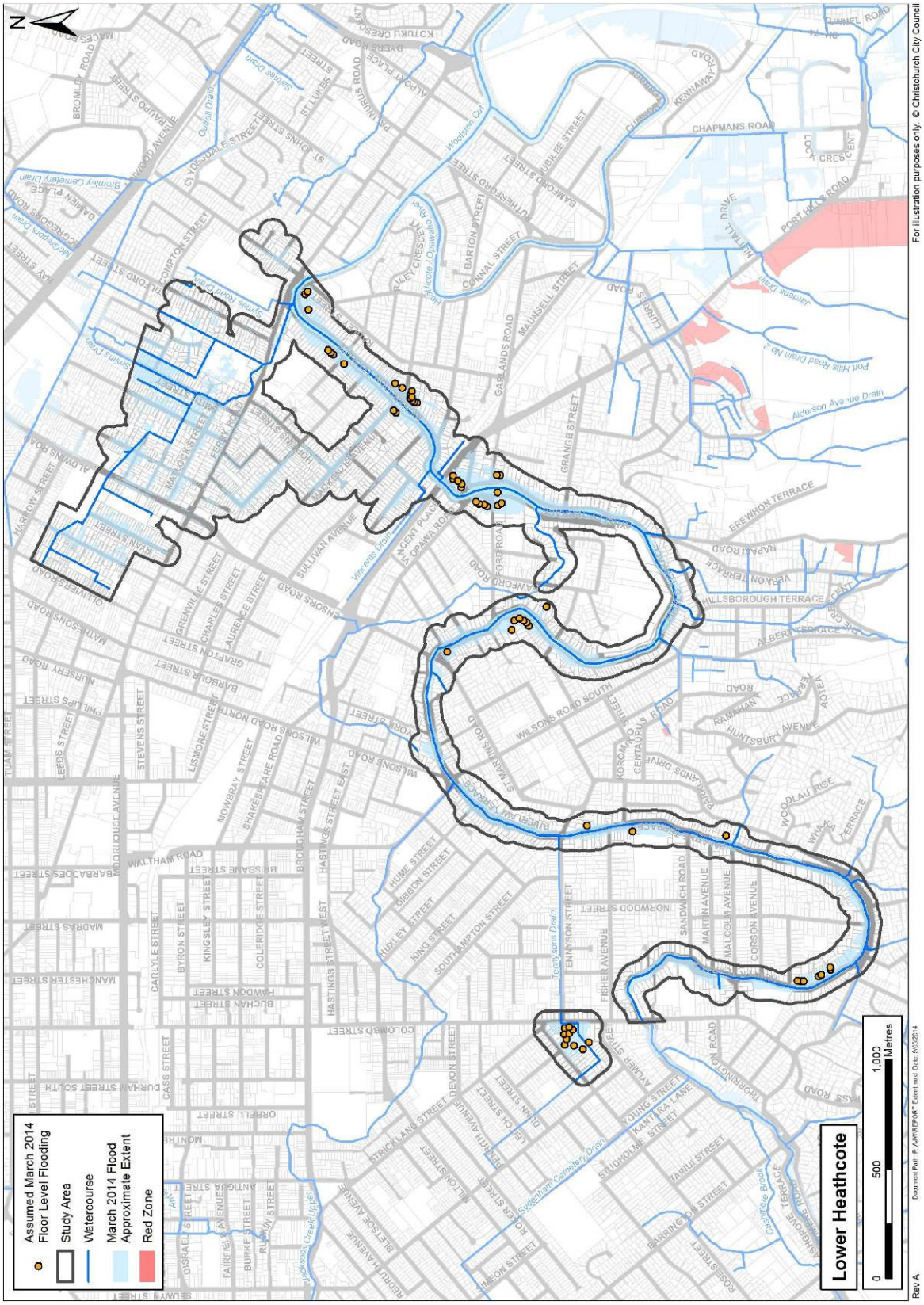

Figure 27 Lower Heathcote riverside properties location plan

Land damage mapping

LiDAR mapping from CERA Project Orbit indicates that there has been both land uplift and settlement over the Lower Heathcote Area.

The lower section of the Heathcote River is tidally influenced and is reported to have risen by up to 400 mm, while the upstream portion of the river has settled by 100-300 mm. This has resulted in a flatter hydraulic grade reducing the hydraulic capacity of the River and leading to increased bed levels. The river is beginning to re-establish lower inverts in the downstream section.

River tidebanks in the region of Radley to Garlands are lower in places than the 10.9 m level constructed in 1986. In isolated areas, e.g. in vicinity of railway, there is an area that is now at 10.4 m. This area was historically lower than 10.9 m because of difficulties installing a river barrier in the confined space but unlikely as low as 10.4 m.

Recent rock movement, slope cracking and slumping in the Port Hills has resulted in additional silt loading on the river and consequentially increased bed levels. The area also had extensive liquefaction and pipe damage (wastewater and stormwater) which has resulted in additional silt and sand loading.

Residential properties on the banks of the Heathcote River have suffered some lateral spreading and settling within the property boundary, this settlement increases the susceptibility to flooding.

B.9.2 Customer service reports

Flood reports from the 3 March 2014 event indicate a range of concerns in the catchment.

Priority concerns indicate that siltation and detritus in the sumps are a constant issue. Requests to clean the sumps prior to rain events are a common occurrence. Residents highlight access to properties as a major concern. Residents have requested sandbags to protect property. Concerns over wastewater overflows have also been raised due to the flooding.

B.9.3 Key drainage infrastructure

The Lower Heathcote Catchment consists of approximately 100 km^2 of urban and semi urban drainage. The River is the terminal outfall for major streams and drains in the South of the city. The river is tidal within much of the urban catchment. Since the construction of the Woolston Cut and the tidal control (RL10.9m) stopbanks the Heathcote River tidal and flood flows are mostly contained within the river banks.

The local stormwater drainage network within the areas adjacent to the river consists of both road drainage and large catchment drainage such as Tennysons Drain. SCIRT assessment of the drainage infrastructure indicated that there was some damage to outfall pipes. This damage is currently being assessed and some of the outfalls are highlighted for repair.

Drainage outfalls diameters range from 150 mm to above 2100 mm. Some outfalls in the lower reaches have flapgates to prevent river and tidal backflow (many stormwater outlets between Radley and Opawa have a double flapgate system). These flapgates are in need of maintenance and residents indicate that backflow is the primary cause of flooding in some areas of the downstream section of the River, indicating that the valves are not operating as designed.

B.9.4 SCIRT projects

Due to the size of the Lower Heathcote catchment area there are numerous SCIRT project areas covering the catchment. Condition assessment reports indicate more damage to the stormwater network closer to the river and on older drainage systems. Some wastewater repairs have been undertaken. However stormwater drainage repairs are still in construction or planned within the next three years. These are mostly repairs and relays of existing pipe capacities.

B.9.5 Existing flood protection infrastructure

Lower Heathcote properties were historically protected by local sumps and gravity piping to the Heathcote River with double flapgates installed in some areas to prevent river and tidal backflow. The Woolston Cut was installed to help the drainage capacity of the river in the downstream reaches. There are no large scale stopbanks installed on the Heathcote River, only some lower 'tidal' banks protecting Richardson and Clarendon Terrace during more frequent high tides. Survey undertaken between Garlands Road and Radley Street in May 2014 indicates that there has been some localised reduction in tide bank heights; the design level for this bank (in 1986) was set at 10.9 mRL, however the survey indicates that approximately 20% of the banks have lower levels than designed, with some areas now having a level as low as 10.4 m RL.

B.9.6 March 2014 flood extent

Depth

Flooding depths varied along the length of the river; depths were anecdotally recorded from 300 - 1000 mm on properties. The flood depth on the road corridor was too deep for vehicle passage and resulted in isolation of residents.

Type

River flooding, with some due to local rainfall intensity (Mackenzie Street). Tidal influence contributes to increased flooding. Some localised stormwater flooding due to inability of stormwater to enter the river.

Cause

The Heathcote River has sustained earthquake damage with lateral spreading, siltation and bed heave reducing the capacity of the river system. This has contributed to an increase in property level flooding within the catchment. Overtopping of the river occurs at RL10.9 m (at 10.8m manhole lids cause lower flooding points) with overtopping of the tidal banks especially where land settlement has occurred. Some properties may have settled due to earthquakes and could be prone to more frequent flooding.

Residents reported that flooding was initially coming from the street sumps indicating that the flap gates are no longer operating correctly. Visual inspection of the flap gates indicates that they no longer close fully and allow river backflow into the drainage system.

Flooding occurred in the Talbot/Judge Street area. There are no reported above floor flooding occurrences in this area. However the flooding extents highlight that this area is likely to have had on property flooding with some access issues for elderly residents. The flooding in this area has not been assessed further due to the absence of above floor flooding data.

General description of damage

Flooding above floor level has resulted in damage to houses and contents. On property damage includes flooding of cars and garages. Restricted access to property increases the feeling of vulnerability among residents.

Number of affected floors

The total identified number of above floor level flooding properties during this event for the Lower Heathcote Catchment Study is 19. LiDAR contour maps predict that unrecorded flooding exists in other streets in these areas.

Local effects

River flooding was seen along the lower reaches of the Heathcote River and the streets adjacent to the river banks. Localised rainfall intensity flooding was seen in the intersection of Colombo and Somerfield Streets.

B.9.7 Other 2014 floods

The streets adjacent to the Heathcote River have flooded three times in 2014 to 30 April. The Colombo/Somerfield Streets area has flooded only once in March 2014.

B.9.8 Community response and drivers

Social impact

River flooding has a severe social impact with the restriction of access to and from houses on the riverbanks. Residents highlighted the main concern was emergency access, and food and water access.

Public health issues arose where wastewater has been seen coming out of gully traps and manholes. This was highlighted in the Claredon Terrace area where residents' comments perceived this is more prevalent post SCIRT wastewater repairs. It should be noted that most floodwaters have some contaminants.

Community feedback

Residents indicated access to and from properties as a main concern. Flooding and velocity of river flows concerned some residents. Residents highlighted lack of maintenance and visibility of Council contractors during and post flooding events as a key issue. Access to food and water when property access was limited was a concern.

A Beckenham neighbourhood group is collecting flood data to present to the local community board. To date, this highlights frequent on-property flooding in the Waimea Terrace area.

B.9.9 Field studies

Investigations were conducted following the March 2014 event and again to inform this May report.

B.9.10 Earthquake effects

The effects of the 2011 Canterbury earthquake sequence on the area are described in this section and have been derived from information provided by the Canterbury Geotechnical Database (CGD), SCIRT Geo database (SGD), CERA and field observations.

Land level changes

Between Barrington Street and Opawa Road land changes post earthquake show a change on average drop of 0.1 to-0.2 m in ground level. Some localised areas have experienced drops of 0.4 m and 0.5 m.

From Opawa Road to the estuary land levels have generally rose by 0.2 to 0.3 m.

The area at the end of Tennyson Street and the rear of Somerfield Street has experience settlement of 0.2 to 0.30m. In addition local information indicates a spring appeared in a garage on Somerfield Street.

SCIRT GIS maps indicate that some properties along the banks of the Heathcote have slumped and therefore are more susceptible to flooding in peak events. There are also isolated areas of differential settlement in the Tennyson area.

Lateral spread

Moderate to major lateral spread has been exhibited in around Hanson Park, Clarendon Terrace and downstream of Radley Street to Woolston Cut. An area downstream of Woolston Cut on the northern bank to the estuary has also suffered lateral spread.

Liquefaction

Liquefaction occurred at locations of the Lower Heathcote area which has contributed to significant volumes of material entering the Heathcote River.

This area has been included within the CERA residential Green Zone. Land in the CERA Green Zone has been divided into three technical categories (TC). These categories describe how the land is expected to perform in future earthquakes. Within the Lower Heathcote land has been classified as TC2 and TC3 indicating minor to moderate and moderate to significant land damage from liquefaction is possible in future significant earthquakes, respectively. This will increase possible risk to future siltation with the Heathcote River.

Ground cracking

The CGD ground cracking database indicates minor cracking around the Lower Heathcote.

Waterway observed changes

Settlement has resulted in reduced hydraulic capacity of drainage network around the Tennyson Street flooding area. The lower reaches of the Heathcote suffered raised bed level in the region of 400 mm and therefore has reduced the hydraulic gradient of the river resulting in a loss of capacity.

Bed heave and increase sediment deposition has occurred between Aynsley Terrace and the Heathcote Tow Path. It has been estimated this change in sediment is 130,000 m^3 of deposited silt post earthquake. Localised stop bank damage was observed at Clarendon Terrace.

There are some informal 'tidebanks' on the Lower Heathcote which may have settled between 100-300mm. The initial tidebanks were designed to generally contain a 50 year event of 10.8 -10.9 m. Settlement may mean that tidebanks are now lower than design. A May 14 survey between Radley and Garlands identifies about 20% of the tide banks are up to ~200mm below 10.90m. SCIRT works and other contractors have caused isolated low points in the tidebanks due to construction activities. Flapgates may have rotated at the outlets and no longer close. Woolston Cut has risen up to 400 mm and therefore has reduced its hydraulic capacity.

Infrastructure damage

SCIRT damage assessment maps indicate that there was considerable damage to pipes adjacent to the river. This includes damage to outfalls and flap gates. SCIRT works to be undertaken include repair of some damaged stormwater pipes in the area. Residents highlighted issues with sumps blocked with silt and other detritus post-earthquake on a regular basis.

B.9.11 Key photos

Figure 28 Lower Heathcote riverside properties - floor level flooding at Clarendon Terrace

Figure 29 Flooding on Riverlaw Terrace

Figure 30 Extensive floor level flooding on Riverlaw Terrace

B.10 Lower Heathcote: Bells Creek catchment

B.10.1 Background

The Bells Creek sub catchment of the Heathcote River may have suffered differential land movement and localised ground settlement (through liquefaction) as a result of the Canterbury Earthquake sequence. This may have reduced grades across the sub-catchments drainage network increasing flood risk.

Location

This area is located to the north east of the Heathcote River and is bound by Randolph Street to the east, Ferry Road to the south, Bordesley Street to the west and Harrow street to the north.

Existing studies

A project is soon to be initiated as part of the Land Drainage Recovery Programme.

Flooding history

Feedback from Council staff is that the Bells Creek has not been a problem area in the past, though flood modelling has highlighted the area is at risk. This may be due to its low lying nature relative to the surrounding land, being similar is level as the banks of the Heathcote (at least post-quake).

Land damage mapping

EQC have determined this catchment is subject to increased vulnerability. Pre and post change in catchment level indicates settlement may have been differential resulting in a reduction in catchment slope.

B.10.2 Customer service reports

No properties were reported being flooded above floor level, with 21 reported as having flooding to their foundation and 113 with flooding on their sections. Property inspections during 4/5 May 2014 uncovered one resident who reported above floor level flooding on three occurrences. In addition the resident identified an additional property that may have experienced above floor level flooding, although no evidence of floor level flooding was found. This is an area of low confidence around habitable floor flooding and frequency.

B.10.3 Key drainage infrastructure

The area is drained via a mix of shallow drains and pipework, all of which discharges to the Bells Creek, which in turn flows into the Lower Heathcote River.

B.10.4 SCIRT projects

In this area there are SCIRT Projects 10945, 11160 and 11158 covering stormwater, wastewater, water and roading, as well as works underway at PS11 (Bass Street).

B.10.5 Existing flood protection infrastructure

The area relies on the existing Council drainage infrastructure for flood protection.

B.10.6 March 2014 flood extent

Depth

No properties reported being flooded above floor level during the March event, with 21 reported as having flooding to their foundation and 113 with flooding on their sections. A resident of Smith Street identified two properties which may have experienced above floor level flooding. The area experienced widespread ponding; photographs taken during flooding shows depths above kerb and across footpaths and into adjacent sections indicating flood depths of 100 – 300 mm depth.

This is an area of low confidence around habitable floor flooding and frequency.

Type

Intensity and rainfall depth flooding is due to limited drainage, so higher depth events result in larger flood volumes and greater depths.

Cause

The primary cause of flooding in Wildberry Street, Bordesly Street and Ryan Street was street sumps blocked with sediment. Randolph Street is in a low area along the Bells Creek and the sump there was blocked on inspection.

Flooding in Smith Street appears to have been caused by inadequate drain capacity (Tamai No.2 Drain and Staffa Invert) due to sediment build-up. Water from the drain also floods out into the rear of the gardens. The upper drain is reported as being heavily silted whilst the lower section is not. This may indicate that the drain has limited grade.

The one property of Smith Street that reported repeated habitable floor flooding appears to be flooding due to a surcharging grate that is flush with the floor level of their property. The drainage infrastructure in the property is unclear. It is likely to be private drainage and the internal flooding is due to the property floor levels being flush with the drain grate. If a flow path was provided the issue would probably be resolved.

General description of damage

Flooding in Ryan Street, Bordesley Street and Wildberry Street appears to have been limited to ponding of flood waters in the road corridor and sections but without entering foundations or exceeding habitable floor levels.

Randolph Street was similar in nature, but did reach the foundations of one residential property and may have flooded it internally. This property is at a low point.

Smith Street appears to have been the worst affected area, with one resident reporting being flooded internally three times. Inspection of adjacent properties did not suggest they had been flooded internally; adjacent properties may have had flooding to foundations. A photograph of flooding at this location confirmed at least one other property had below floor level flooding. The one property that reported internal flooding is suspected as being due to a private drainage issue combined with no flow path away from the building and no building freeboard.

Number of affected floors

One household reported flooding above their floor level, 21 properties are estimated to have had flooded to their foundations whilst an estimated 113 properties had their sections flooded.

Local effects

All the flooding appears to be due to localised issues that may be resolved through maintenance of blocked sumps and clearing of silt from drains. The single property with multiple flood events above floor level appears to be a result of a private drain, no flow path and no building freeboard.

B.10.7 Other 2014 floods

One resident on Smith Street reporting having been flooded three times since the earthquakes, but it is unclear if they all occurred in 2014.

B.10.8 Community response and drivers

Social impact appears to be limited to reduced access (ponding in the road corridor) and section flooding. Only one possibly two properties are known to have flooded above their floor level, whilst a number (estimated 21 properties) may have had water under their floor level. Only one property is known to have flooded several times.

B.10.9 Field studies

Field visits were conducted on 3 and 4 May 2014.

B.10.10 Earthquake effects

The effects of the 2011 Canterbury earthquake sequence on the area are described in this section and have been derived from information provided by the Canterbury Geotechnical Database (CGD), SCIRT Geo database (SGD), CERA and field observations.

Land level changes

Between Barrington Street and Opawa Road land changes post-earthquake show a drop on average of 0.1 to 0.2 m in ground level. Some localised areas have experienced drops of 0.4 m and 0.5 m. From Opawa Road to the estuary land levels have generally risen by 0.2 to 0.3 m.

Lateral spread

Moderate to major lateral spread has been exhibited in around Hanson Park, Clarendon Terrace and downstream of Radley Street to Woolston Cut. An area downstream of Woolston Cut on the northern bank to the estuary has also suffered lateral spread.

Liquefaction

Liquefaction occurred at locations of the Lower Heathcote area which has contributed to significant volumes of material entering the Heathcote River.

CERA has therefore indicated the area is within the Green Zone. Land in the CERA Green Zone has been divided into three technical categories (TC). These categories describe how the land is expected to perform in future earthquakes. Within the Lower Heathcote land has been classified as TC2 and TC3 indicating minor to moderate and moderate to significant land damage from liquefaction is possible in future significant earthquakes, respectively. This will increase possible risk to future siltation with the Heathcote River.

Ground cracking

The CGD ground cracking database indicates minor cracking around the Lower Heathcote.

Infrastructure damage

SCIRT condition assessment maps indicate non critical damage to the drainage network in the area.

B.10.11 Key photos

Figure 31 Photo of private grate that surcharges and enters nearby doorway due to lack of flow path away from building and freeboard above the adjacent paving

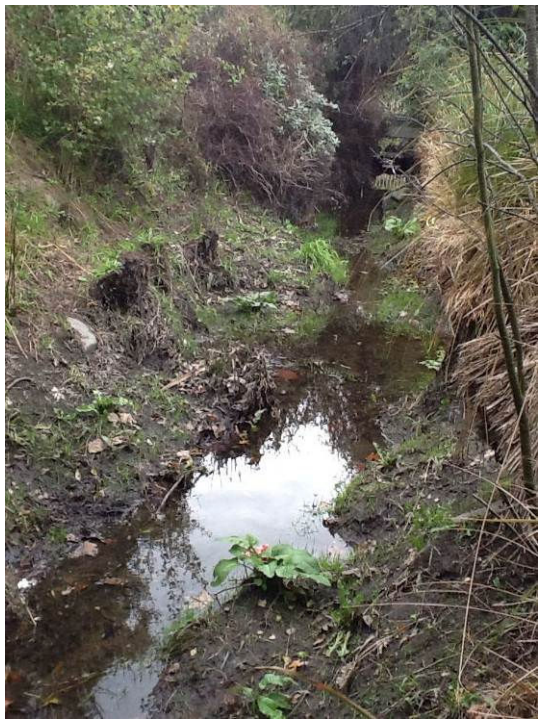

Figure 32 Upper Bells Creek: scope to increase channel capacity

Figure 33 Silt in invert of drain at Okeover Street

Figure 34 Blocked sump at PS11, possibly due to recent construction activity

B.11 Lower Heathcote: Tennyson Area

B.11.1 Background

The Tennyson area is located to the north of the Heathcote River. The area is bound by Colombo Street to the east, Somerfield Street in the north, Selwyn Street to the west and Aylmer street to the south.

The sub catchment bounded by Colombo Street and Somerfield Street may have suffered localised ground settlement as a result of the Canterbury earthquake sequence. As a result, there is a visually obvious low point to the rear of a Somerfield Street property which falls towards the Heathcote River. This appears to have been the significant factor in above floor level flooding of up to 16 properties.

Flooding history

There is no known record of flooding in this area.

Customer service reports

Up to 16 properties were described as experiencing above floor level flooding with additional properties experiencing garage flooding. The properties are clustered within the bounded area.

Key drainage infrastructure

The area is served by Tennyson Drain which flows between Somerfield Street and Aylmer Street. It enters a 900 mm brick barrel stormwater trunk main which flows through to Colombo Street and down Tennyson Street to discharge to the Heathcote River. The inlet to the 900 mm brick barrel may have blocked in the March 2014 event, contributing to the flooding. The 900mm brick barrel is known to have capacity issues pre-earthquake, although it did not result in floor level flooding. The impact of

the limited capacity appears to have been made worse by the Canterbury earthquake sequence and land level change.

B.11.2 SCIRT projects

The following SCIRT projects were undertaken prior to the flooding and covered the associated areas, although no work was proposed on the drainage in the area.

- SCIRT 10949 Spreydon / Somerfield roading, stormwater and water
- SCIRT 10958 Beckenham/Waltham/Opawa Rd stormwater and water

B.11.3 Existing flood protection infrastructure

The area relies on the existing Council drainage infrastructure for flood protection.

B.11.4 March 2014 flood extent

Depth

Up to 16 properties experienced above floor level flooding from surface water. LiDAR shows localised settlement of 200-300 mm which coincides with indications from resident of areas which experienced up to 500 mm deeper flooding than the rest of the catchment.

Cause

The flooding in this area was attributed to four main causes:

- Localised settlement of the properties near Somerfield Street.
- Capacity of existing Council drainage infrastructure (Tennysons Drain and the 900 mm brick barrel).
- Blockages of sumps and the point where Tennysons Drain enters the 900 mm brick barrel.
- Surface flooding from Somerfield Street and Colombo Street.

General description of damage

There was considerable flooding at some properties in the vicinity of a Colombo Street residence that experienced above floor level flooding of up to 100 mm and additional properties which experienced flooding above 100 mm.

There were also numerous properties that experienced garage and car flooding.

Number of affected floors

The floors of 16 houses have been reported as flooded and an additional eight garages were reported as flooded. It is suspected that further properties experienced on-property or garage flooding.

Local effects

Road flooding at the intersections of Colombo Street and Tennyson Street, Selwyn Street and Somerfield Street, Aylmers Street and properties bounded within the Somerfield and Colombo Streets.

B.11.5 Other 2014 floods

A resident of Somerfield Street indicated his garden has flooded to considerable depth twice since the March flood.

B.11.6 Community response and drivers

No specific report has been received. Considerable social impact of above floor level flooding and residential property flooding is expected.

B.11.7 Field studies

Field inspections were undertaken on 3 and 4 May 2014 to inform this report.

B.11.8 Earthquake effects

The effects of the 2011 Canterbury earthquake sequence on the area are described in this section and have been derived from information provided by the Canterbury Geotechnical Database (CGD), SCIRT Geo Database (SGD), CERA and field observations.

Land level changes

The area at the end of Tennyson Street and the rear of Somerfield Street has experience settlement of 0.2 to 0.3 m. In addition local information indicates a spring appeared in a garage on Somerfield Street.

Liquefaction

CERA has designated the area within the Green Zone. Land in the CERA Green Zone has been divided into three technical categories (TC). These categories describe how the land is expected to perform in future earthquakes. Within the Lower Heathcote land has been classified as TC2 and TC3 indicating minor to moderate and moderate to significant land damage from liquefaction is possible in future significant earthquakes, respectively. This will increase possible risk to future siltation with the Heathcote River.

Ground cracking

The CGD ground cracking database indicates minor cracking around the Lower Heathcote.

Hydraulic capacity loss

Settlement has resulted in reduced hydraulic capacity of the drainage network around the Tennyson Street flooding area.

Infrastructure damage

SCIRT projects indicate non-critical damage to the drainage network in the area.

B.12 Southshore

B.12.1 Background

The Southshore study area includes all areas on the Southshore Spit south of the Pages Road Bridge. The primary flood risk in the area is tidal along the inner edge of the estuary.

On Ebbtide Street, numerous flap valves are either blocked, obscured or broken. Localised nuisance flooding at intersections has been observed as well as at low points on the carriageway, especially towards the southern end of Rocking Horse Road.

A major concern in this area is the rapid erosion of the walkway on top of the old retaining wall. Emergency works will be required to prevent possible sea breaching along this section and putting the road at risk.

Flood history

Modelling by SCIRT demonstrates that South New Brighton and Southshore (south of Estuary Road) is vulnerable to flooding by tidal inundation. Throughout Rocking Horse Road, flooding depths of up to 0.4 m are shown to be possible during the scenario modelled - a five year storm and one year tide. Some private property floor levels were obtained during the SCIRT Southshore Project No. 11109. In a five year return period scenario there is some risk but not a certainty that private property floor levels would be at risk of flooding.

The depth and extent of flooding in a 50 year storm with a five year tide is somewhat worse than the five year storm scenario. The amount of on-road and on-property storage available buffers flood levels significantly. The 50 year storm model demonstrates depth of flooding to 0.5 m and significantly more properties are at risk of flooding. Those most susceptible to flooding are adjacent to Rocking Horse Road and Estuary Road. Some properties along the estuary edge are vulnerable to tidal flooding, and even a five year high tide with strong south-westerly winds could breach the informal shoreline bund that exists.

To alleviate the flooding risk with a high level of certainty additional flood protection measures such as a stopbank and, potentially, pump stations are required. Such solutions were outside of SCIRT's scope and while some have been identified they have not been pursued by SCIRT. Further modelling is planned by Council to determine the value of a shore-front stop bank.

It should be noted that modelling of pre and post-earthquake stormwater showed that flooding levels after the earthquakes were within 100 mm that of the pre earthquake condition. Given that accuracies in the input data and model have a tolerance of 100 mm, SCIRT moved forward on the basis that there has been no change to the level of service across the catchment.

Customer service reports

Council records identify customer service requests regarding flooding relating to overflows over Bridge Street as well as poorly functioning flap valves exacerbating flooding issues. There are also historic flooding issues around the intersection of Owles Terrace and Beresford Street. Some of these known problems are being addressed as part of SCIRT projects.

B.12.2 SCIRT projects

SCIRT has undertaken several stormwater roading related projects throughout this study area and the recommendations can be found within the concept and detailed design reports. It should be noted a number of these projects have been or are nearing completion and early indications are that areas are no longer causing service related issues.

SCIRT projects within the study area:

- 11109 Southshore South of Beatty Street
- 11021 New Brighton - Owles Terrace

- 11070 Blake Street SW
- 10840 PS37-Catchment Study
- 10874 PS36 -Catchment Study
- 10429 Estuary Road

Additional investigation works can be found in catchment studies 11110 and 11111.

SCIRT are currently planning or undertaking three stormwater pump stations and associated reticulation, as well as repairing or relaying a large proportion of existing reticulation.

Approximately 40% of the stormwater reticulation network requires repair or renewal, to address earthquake damage impacting the level of service within the catchment. This comprises 1200 m of pipe for relay and 650 m for repair. A further 40% requires no action and the remaining 20% suffered minor damage; repairing this damage will not impact the level of service within the catchment, and hence SCIRT will not complete these repairs.

B.12.3 March 2014 flood extent

Depth

Four properties were identified as flooding above floor level and numerous properties were inundated and damage sustained to garage contents.

Type and cause of flooding

The predominant flooding issues on Southshore are caused by tide flowing inwards through damaged storm water outlets, made worse by a number of additional factors. These include:

- Earthquake damage to existing storm water infrastructure and carriageways disrupting flow paths to storm water outlets
- Localised property damage (subsidence) giving rise to localised ponding
- Flap valves stuck open or sealed shut. The consequence of this is there is no effective outlet for street drainage, or where flap gates are open high tides 'hold back' street run off until the tide recedes and sufficient head is generated to allow discharge
- Numerous street gully grates are blocked or restricted by vegetation. Cabbage tree leaves are especially good at restricting flows at these outlet points

General description of damage

Flooding of house floors, numerous properties were inundated and damage was sustained to garage contents. Access in and out of certain properties was a cause for concern for some residents. These were generally alleviated once tidal waters in the Avon River and Estuary began to ebb.

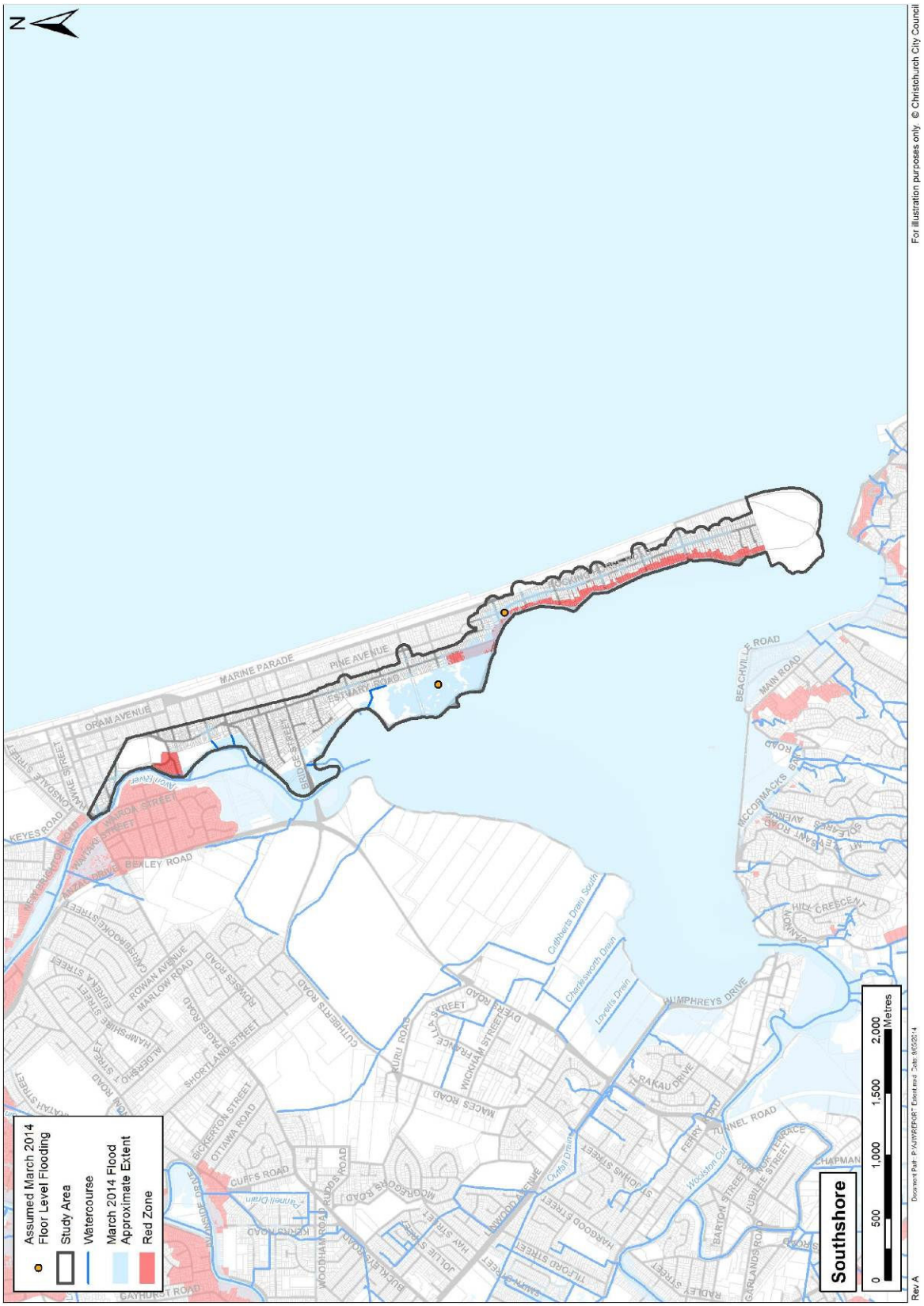

Figure 35 Southshore location plan

B.12.4 Community flood response and drivers

Social impact

Discussions with the community illustrated that there were concerns with the tide levels, but a general understanding that once the SCIRT works are completed these would be resolved.

Community feedback

There are wider community concerns in Southshore about sea level rise and the measures Council are considering to address this.

Concerns were also raised by the Southshore Residents Association about the condition of the Ebbtide St stop bank and also the loss of protection from tidal flooding caused by clearance of RRZ properties and damage to existing private seawalls that had protected those properties. Much of the flooding around these areas in the March event was related to seawater ingress around or through vulnerable sections of existing protective measures.

Other issues raised by residents at public meetings and through survey feedback included:

- Tidal flooding through damaged or poorly maintained flap gates, review of how this maintenance is managed
- Localised flooding on properties as a result of land settlement and loss of ability to drain to the road or other outfall
- Section 72 Hazard Notices for flooding being placed on titles as a result of the building consent process for earthquake rebuilds

B.12.5 Field studies

Site surveys were undertaken as part of the Taskforce. This included checking all the flapgates into the estuary, both existing and recently constructed, and speaking to contractors working on existing SCIRT contracts on Kibblewhite Street to gain updates of their anticipated completion dates.

Where encountered local residents were surveyed, including residents who had raised concerns and had localised property flooding.

A subsequent site visit with SCIRT contractors was undertaken to all vulnerable locations throughout the study area to determine temporary work solutions and action plans in the event of another severe weather/ tide event.

Further field work was undertaken in June 2014 to assess additional properties identified as having flooding issues and to scope repair works required on the Ebbtide St stop bank.

A walkover of the Southshore Residential Red Zone (RRZ) was also undertaken with representatives from CERA to assess the increased vulnerability to tidal flooding being potentially created by clearance of Red Zone properties and damage to existing private seawalls. This included identifying possible remedial actions to address issues in the short term until a more permanent defence solution can be investigated.

B.12.6 Earthquake effects

The effects of the 2011 Canterbury earthquake sequence on the area are described in this section and have been derived from information provided by the Canterbury Geotechnical Database (CGD), SCIRT Geo database (SGD), CERA and field observations.

Land level changes

Significant land changes have occurred post-earthquake. The eastern edge of Southshore has been shown to have risen by 0.4 to 1.0m. To the west of this and in the central section of Southshore a drop of 0.1 to 0.5 m has occurred. Drops of 1.0 to 1.5 m have occurred at the south-western area of the spit and in the area south of Bridge Street and around Owles Terrace.

Lateral spread

Moderate to major lateral spread has been exhibited on the western side of Southshore.

Liquefaction

Minor to moderate liquefaction was observed at Southshore. CERA has indicated the area is situated within Red and Green Zones. Land in the CERA Green Zone has been divided into three technical categories (TC). These categories describe how the land is expected to perform in future earthquakes.

Southshore comprises of Residential Red Zone (RRZ) on the western extent and a combination of TC2 and TC3 properties. This means the RRZ land is deemed unsuitable for residential land use and TC2 and TC3 areas indicate minor to moderate and moderate to significant land damage from liquefaction is possible in future significant earthquakes, respectively.

Ground cracking

The CGD ground cracking database indicates cracking of 1 to 50 mm cracks on the western side of Southshore.

Infrastructure Damage

There is outfall damage at a number of locations south of Owles Terrace. The construction of the temporary stopbanks and subsequent earthquakes has further damaged the connecting pipes and outfalls. Minor damage has occurred to pipes around Kibblewhite Street where the stopbanks have been raised resulting in poor flood management protection of this area. All the major outfalls sustained damage on the western side of Southshore.

B.13 Sumner: Sumner Village

B.13.1 Background

Location

The Sumner study covers two areas. One area extends from Augusta Drain to the eastern end of Moncks Bay and back to the base of the hills. The other area covers Sumner Village, from the intersection of Marriner Street and Nayland Street to the end of the Esplanade.

Existing studies

- SCIRT Project Concept and Detailed design #11055
- SCIRT Scope and Standards Paper 323
- Walter, John. 2009 "*Sumner Flood Relief Pipe; Sediment and Odour Issue Assessment*" Capital Programme Group, Christchurch City Council
- Couling, Ken. 2000 *"Storm Report 11-13 October"* City Solutions, Christchurch City Council

Flooding history

Marriner Street and Esplanade have a history of flooding and were affected significantly in the October 2000 flood event. Sections on Clark Street and Arnold Street also have a history of flooding as a result of the low lying typography of this area and proximity to the Sumner Main Drain (SMD). Sections on Paisley Street near the Sumner Stream/SMD also have a history of flooding.

Land damage mapping

On the Canterbury Land Information map released by CERA, the majority of the project area in Sumner is categorised as Technical Category 2 (TC2) in which "minor to moderate land damage from liquefaction in future large earthquakes" is possible. Only minor liquefaction was observed along Nayland Street immediately after the February and June 2011 earthquake events.

A small number of properties within the Sumner area have been Red Zoned due to associated risks with the surrounding cliffs in Sumnervale Drive, Ocean View Terrace, Heberden Avenue, Scarborough Hill, Searidge Lane and Wakefield Avenue.

Land maps illustrating the difference between 2003 and June 2011 LiDAR data indicates that the flat land of Sumner has lifted near the Port Hills and dropped slightly nearer to the coast.

B.13.2 Customer service reports

A number of service reports have been lodged to Council through the Council Call Centre both before and after the March 2014 flood event. The majority of reports relating to the March event were associated with maintenance issues. These issues included blocked sumps and drains, insufficient capacity of the Sumner Stream along Paisley Street and the SMD located along the rear sections of Head Street as well as the existing beach outfalls being blocked, especially the Sumner Flood Relief Pipe (SFRP) and the Burgess Street outfalls at beach level. Also noted by residents was the increase in suspended silt in the flood waters in the March flood event compared to previous floods. One report referred specifically to significant silt deposits collecting at a Finnsarby Place property where flooding occurred to house foundation level.

During site inspections local Sumner residents suggested that the majority of surface flooding which occurs along Marriner Street and the Esplanade can be attributed to operation and maintenance issues associated with the stormwater outfalls at Cave Rock and Burgess Street. During the March flooding event the Cave Rock outfall was operational however the Burgess Street DN650 outfalls were potentially blocked which resulted in surcharging of the stormwater network upstream in Marriner Street. During previous flood events the Cave Rock outfall has been completely restricted by sand deposits which were removed in 2011 through an excavator in order to prevent further flooding on Marriner Street (Figure 37).

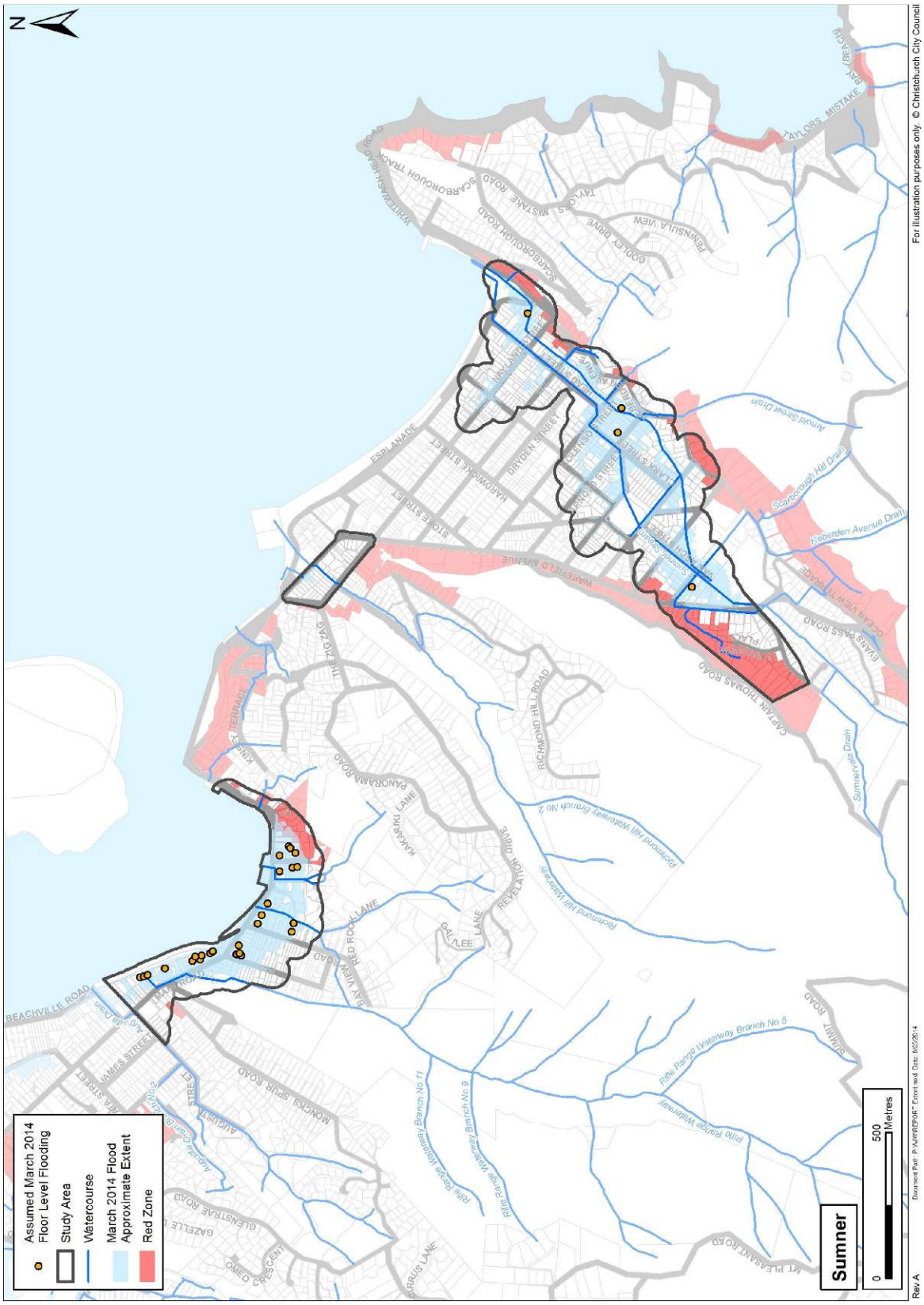

Figure 36 Sumner Location Plan

Local residents on Paisley Street noted that very little maintenance had been completed on the Sumner Stream and SMD adjacent to Paisley Street and Wakefield Street. Residents also noted the overall depth of these open channels have gradually reduced due to accumulation of sediment.

Residents witnessed silty stormwater flowing across Wakefield Street into Paisley Street from under the shipping containers which border the Residential Red Zone on Wakefield Street. Also noted was that the majority of the flooding in Paisley Street was associated with the section of the Sumner Stream at the intersection of Paisley and Van Asch Streets.

The residents at a Wakefield Street property observed that the stormwater in the sump outside their property was not draining away during heavy rain periods even though the water level in the SMD was lower.

Residents at a Finnsarby Place property noted the stormwater runoff from the Residential Red Zone (RRZ) on Sumnervale Drive contained a high concentration of suspended silt which then accumulated further downstream at Finnsarby Place and Sumnervale Drive in the sumps, kerb and channels.

B.13.3 Key drainage infrastructure

Sumner Main Drain (SMD)

This is a combination of open drains with timber sides and concrete sides/base, RCRR pipe and box culverts under roads. Recently a new box culvert has been added outside a property at Heberden Avenue.

SMD runs through numerous private properties (refer to Figure 38). During the March flooding event high levels in the SMD contributed to flooding in adjacent properties in Arnold Street, Nayland Street, Wakefield Street and Paisley Street.

Sumner Flood Relief Pipe (SFRP)

This 2100 mm RCRR pipe located through reserves and roads, discharging at the outfall located near Scarborough Park adjacent the SMD outfall. It was constructed to reduce the load on the SMD.

Ocean Outfalls:

- DN300, Nayland Street
- DN1200, Esplanade overflow for Richmond Hill Road drain and discharges to a swale at the corner of Marriner Street and Esplanade. This is secondary system to minimize flooding when the capacity of the Cave Rock / Burgess Street system is exceeded.
- DN1350, Cave Rock, Esplanade. Flooding occurs on Marriner Street and Esplanade when the flap gate is restricted by sand and debris accumulation at the outfall and within the pipe (Refer to Photo 3 and 4).
- 2 x DN675 Burgess Street/Esplanade. A flap gate on the end of the Burgess Street DN900 pipe is located within a manhole structure immediately upstream of the twin outlet. This structure has been known to fill with sand, blocking the DN900. The DN675 outlets did not have backflow prevention during the March event but flap gates have been recently installed. Flooding occurs when the stormwater network surcharges back towards Marriner and Nayland Streets when the outfalls are not operating correctly or are restricted with sand (Refer to Photo 5 and 6).
- DN225, Marriner Street/ Esplanade
- DN300 Stoke Street/Esplanade
- DN750 Hardwick Street
- DN2100 SFRP Scarborough Park. Rocks/debris is often mobilized during nor-easterly storms and jam the flap gate. Residents noted that the local fire service previously attempted unsuccessfully to open flap gate manually.

- SMD outfall and tide gate installed in 2004

B.13.4 SCIRT projects

- SCIRT project #11055 Stormwater, Roading and Water infrastructure (Planned 11 August construction start, City Care)
- SCIRT project #11054 Wastewater (Planned 4 August construction start, City Care)

B.13.5 Existing flood protection infrastructure

As a result of the October 2000 Sumner flooding stormwater drainage improvements were completed on the Richmond Hill Road waterway. These included the Nayland Street culvert and high level weir which provides additional capacity by diverting flow away from the pipeline through Richmond Hill walkway into the Burgess Street system. During the March flood the Cave Rock outfall was operational and flooding in this area was not as significant as previous events. However information from residents suggests the Burgess Street pipeline was surcharged during an event in April which resulted in some flooding in Marriner Street.

Tidal flood protection for the stormwater network in Sumner is limited to flap gates on approximately four of the ocean outfalls.

B.13.6 March 2014 flood extent

Cause

The main cause of flooding in the March event was the depth of the rainfall event coinciding with the very high tide.

Operational issues encountered during flooding included:

- Main ocean outfalls at Cave Rock, Burgess Street and the SFRP not operating correctly due to debris/sand blockage
- Reduced capacity of open drains due to silt build-up contributing to overflows from Sumner Stream and SMD around Van Asch and Paisley Streets
- Surface flooding at existing low points on Clark Street, Arnold Street and Colenso Street possibly worsened silt build-up in SMD
- Surcharging of SFRP possibly due to restriction of the flap gate and/or build-up of silt and marine deposits

General description of damage

Above floor level flooding and flooding up to foundations was observed during the March flooding event in approximately 32-42 sections located in areas which are either adjacent or in close proximity to the SMD. The Taskforce gathered information from field surveys, public meetings and survey responses from residents, and determined that during March there were approximately:

- 7 houses flooded above floor levels
- 42 houses flooded up to foundation level

Surface flooding was also noted by residents in Marriner Street, Wiggins Street and the Esplanade. Large quantities of silt and sediment were reported at Finnsarby Place downstream of the Red Zone.

Local effects

The majority of the sections flooded in the March event were located in the Clark Street/Arnold Street/Colenso Street area. This area is low lying with a history of flooding and is within the modelled flood extents (refer to Figure 43).

Wiggins Street also has a history of surface flooding which affects road access around the school. Marriner Street has a history of flooding which affects the retail sector of Sumner and major access route through to Sumner from Main Road.

B.13.7 Other floods

One property on Wakefield Street has been flooded four times up to foundation level in 2014 and two times in 2013. Three other nearby properties have also had flooding up to foundation level or under floor on more than one occasion since 2010.

B.13.8 Community response and drivers

Social impact

Households with floor level flooding experienced considerable impact. The wider community was impacted by residential property flooding and restricted access to amenities including Sumner School, the retail sector and the main access into Sumner through Marriner Street.

Community feedback

During site inspections many residents noted that diligent operation and maintenance of the Cave Rock and Burgess Street outfalls is essential in flood prevention of Marriner Street and Nayland Street. Many residents actively maintain local kerb and channels by clearing silt and debris to prevent localized flooding such as Finnsarby Place.

A community meeting was held on 5 May where residents were able to confirm the extent of the March flood event and houses which were affected.

B.13.9 Field studies

Site visits were completed during May and June.

Sand sediment was observed to be covering most of the Cave Rock outfall and SFRP outfall appears jammed partially open with rocks.

Large amounts of sediment were observed in invert of Sumer Stream and SMD along Wakefield and Paisley Streets and through to Arnold St. Water was ponding in the Wakefield Ave culvert crossing and in Sumner Stream.

Large amounts of silty sediment deposits were observed in the Red Zone on Finnsarby Place and in sumps and kerb and channels. Some deposits also from Red Zone were located downstream on Wakefield Avenue.

Subsequent to Phase 1, additional flood affected properties were identified on Wakefield Ave where runoff was coming through the Red Zone properties at the end of Finnsarby Place.

B.13.10 Earthquake effects

The effects of the 2011 Canterbury earthquake sequence on the area are described in this section and have been derived from information provided by the Canterbury Geotechnical Database (CGD), SCIRT Geo database (SGD), CERA and field observations.

Land level changes

The CGD vertical and horizontal ground movement database shows the difference between 2003 and June 2011 LiDAR data. This indicates that the flat land of Sumner has lifted near the Port Hills and dropped nearer to the coast.

Liquefaction

Only minor liquefaction was observed along Nayland Street immediately after the February and June 2011 earthquake events.

Land in the CERA Green Zone has been divided into three technical categories (TC). These categories describe how the land is expected to perform in future earthquakes. CERA has therefore indicated the area is in the majority is categorised as TC2 indicating minor to moderate land damage from liquefaction is possible in future significant earthquakes.

Infrastructure damage

Localised earthquake damage to pipe infrastructure to be completed under SCIRT project #11055. Damage also occurred to SMD however the drain has been propped and this has not affected the capacity.

Bed heave/hydraulic capacity loss

The invert of the Colenso Street SMD culvert has cracked and heaved along its length. The SMD bed has also heaved slightly in some locations.

Sediment deposits in Sumner Stream /SMD along Wakefield Avenue and Paisley Street are a possibly from unstable slopes within Red Zone and surrounding slopes in the rural zone.

B.13.11 Key photos

Figure 37 Cave Rock sand removal

Figure 38 Sumner Main Drain with private access bridge

Figure 39 Cave Rock outfall with sand restrictions

Figure 40 Cave Rock outfall during March event (flap gate partially open)

Figure 41 Burgess Street outfalls with sand build-up

Figure 42 Burgess Street outfall with new flap gates

Figure 43 March flooding up to foundations

B.14 Sumner: Moncks Bay

B.14.1 Background

Location

The Sumner –Monks Bay area comprises Beachville Street to the end of Moncks Bay at Cliffs Road.

Existing studies

- SCIRT Project Concept Design #10924 Ferrymead to Sumner Catchment Study
- SCIRT Project Detailed Design #11107 Redcliffs McCormacks Bay
- SCIRT Project Detailed Design #11108 Redcliffs McCormacks Bay
- SCIRT Project Detailed Design #10667 Moncks Bay Seas Walls

Flooding history

Cliff Street has a history of flooding due to area being the lower than surrounding streets. The properties that are adjacent to the Rifle Range Drain also have a history of section flooding in addition to the sections that are adjacent Barnett Park and the Rifle Range Drain overflow.

Main Road has a history of flooding as the Rifle Range Drain secondary flow path spills over the road, however only a few houses opposite Barnett Park and the Moa Community Kid Learning Centre reported flooding above floor level in the March flooding event. One property on Main Road recently has reported multiple above and below floor level flooding.

B.14.2 Customer service reports

A number of service reports have been lodged to Council through the Council Call Centre both before and after the March 2014 flood event. The majority of reports relating to the March event were associated with flooding from the Rifle Range Drain which runs through private properties on Bay View Road.

Localised flooding was also reported in properties opposite Barnett Park which was caused by the secondary flow path from the Rifle Range Drain discharging across Main Road. The Rifle Range Drain was also reported to be close to bursting its banks near the sub-station at the top of Bay View Road. A large sink hole also appeared after the March flooding event where the joints of a 1350 mm pipe have separated due to lateral spread approximately 8 m from the ocean outfall (refer). Repair for this fault is scheduled to be completed under SCIRT project #11107.

The majority of historic and post-earthquake flooding complaints are related to maintenance of blocked sumps.

B.14.3 Key drainage infrastructure

Rifle Range Drain and overflow:

This is a combination of open drain through Barnett Park, open drain with timber sides, concrete base with timber sides, RCRR pipe and box culverts under roads. A weir is located inside Barnett Park where high level flows are diverted through to an overflow drain and open grated inlet outside the Moa Community Kids Early Learning Centre on Main Road. This inlet is linked to the DN1200 stormwater pipe on Main Road which discharges at the Rifle Range Drain outfall located at the rear a property on Main Road.

Bay View Waterway:

This is a timber lined drain which intersects the Rifle Range Drain inside private property on Bay View Road.

Ocean Outfalls:

- DN1350 Main Road, repair and inline check valve to the completed under SCIRT project #11107
- DN225 Main Road through sea wall
- DN300 Main Road through sea wall
- DN450 Main Road through sea wall
- 4x DN225 Main Road through sea wall
- DN1800 Main Road through sea wall (Rifle Range drain outfall)
- DN750 Main Road through sea wall
- DN525 Main Road through sea wall
- DN375 Main Road through sea wall
- DN1300 Beachville Road
- DN375 Beachville Road
- 2x DN225 Beachville Road

Approximately 70% of the ocean outfalls in Moncks Bay have flap gates. Under SCIRT project #11107 an inline check valve has been included in the stormwater design along with the removal of the existing concrete structure at the Rifle Range Drain outfall (refer to).

One of the DN300 outfalls opposite Main Road will be removed and the upstream pipe connected to the adjacent DN375 outfall as part of SCIRT project #11108.

Two DN225 outfalls will be removed and a short section of an existing DN375 will be relayed through the ocean wall as part of SCIRT project #11107. The smaller diameter pipes along Beachville Road are higher and will have Tideflex/WaStop installed in the pit upstream of the outfall however no flap gates or back flow prevention valves will be installed in the DN1300 as part of this project.

B.14.4 SCIRT projects

- SCIRT Project #11107 Redcliffs McCormacks Bay (Planned 11 August 2014 construction start, Fulton Hogan. Construction date may vary due to proposed Coastal Pathway)
- SCIRT Project Detailed design #11108 Redcliffs McCormacks Bay (Planned 9 June 2014 construction start, Fulton Hogan)
- SCIRT Project Detailed design #10667 Moncks Bay Seas Walls (currently on hold due to mass movement area)

B.14.5 Existing flood protection infrastructure

- Flap gates are present on approximately 70% of outfalls in Moncks Bay to help protect against tidal flooding.
- Weir and overflow drain located in Barnett Park to reduce load on Rifle Range Drain which drains into an open grated inlet structure in front of the pre-school (refer to).

B.14.6 March 2014 flood extent

Cause

Land in Moncks Bay was inundated due to fluvial and tidal flooding. This has various contributing causes:

Tidal flooding in conjunction with rainfall events

- General surface flooding during rainfall events which co-inside with high tide. As the road level is approximately at the high tide level, stormwater collects at low points in Cliff Street and Main Road and is unable to discharge through the ocean outfalls. Some ocean outfalls have no backflow prevention against tidal flooding

Secondary flow path and existing low lying topography

- Secondary flow from the Rifle Range Drain Overflow through Barnett Park, Moa Community Kids Early Learning Centre through to Main Road.
- Secondary flow from Main Road has no direct route to the estuary therefore contributes to flooding in Main Road, Wakatu Avenue, Bayview Road and Cliff Street
- Accumulation of surface flooding in Cliff Street due to the existing low point in the area

Siltation

- Potential reduced capacity in the stormwater pipes upstream of the Rifle Range Drain outfall and Beachville Road outfall due to sediment and marine deposits. CCTV investigations for condition assessments identified a number large diameter pipes in the Moncks Bay area were 30-50% full of marine silt.

General description of damage

Above floor level flooding and flooding up to foundations was observed during the March flooding event in properties located in low lying areas in Bayview Road, Cliff Street, Wakatu Avenue and properties opposite Barnett Park.

The Moa Community Kids Early Learning Centre also reported flooding above floor level and contamination from wastewater overflows. Pump Station 31 adjacent to the pre-school is also located in the Rifle Range Drain overflow secondary flow path and was flooded in the March event (Refer to Photo 4).

Affected properties included:

- Approximately 61 up to foundation level (not confirmed by residents)
- Approximately six above floor level (not confirmed by residents)
- One vacant section was also flooded

Local effects

The majority of sections that flooded in the March event were either adjacent or in close proximity to the Rifle Range Drain, the Rifle Range Drain overflow secondary flow path or within the low points in Cliff Street, Bay View Road and Wakatu Avenue where stormwater discharge to the ocean outfalls was restricted by incoming tidal flooding (Refer to Figure 47).

B.14.7 Other 2014 floods

Residents from Main Road properties have confirmed flooding has occurred previously on Main Road opposite Barnett Park. One property has reported multiple occurrences above and underfloor flooding.

B.14.8 Community response and drivers

Social impact

No specific social impact report has been received .There can be expected considerable social impact from above floor level flooding and residential property flooding. Surface flooding on Main Road can potentially restrict access to properties in Moncks Bay and other areas including Clifton, Sumner and Scarborough.

Community feedback

During site inspections a resident on Main Road confirmed that Main Road was flooded opposite Barnett Park and several properties opposite and downstream of the park in the March event. The manager from the Moa Community Kids Early Learning Centre confirmed that the March event was the only time flooding has occurred above foundation level.

Reports and flooding complaints from residents suggest that when the Rifle Range Drain reaches high levels it often floods into the rear of sections on Bay View Road (refer to Figure 46 and Figure 47).

B.14.9 Field studies

Site visits were completed during May and June.

The high flood level was visible along the Rifle Range Drain where vegetation had been flattened and debris was visible in the weir. The secondary overflows through the Moa Community Kids Early Learning Centre property was identifiable by silt deposits in the car park and access to the playground was still restricted. Immediately after the March event Chem-dry cleaners were onsite to decontaminate both the building and playground.

Silt deposits were also observed at along Bay View Road. The resident at a Bayview Road property confirmed that the garage and the property had been flooded in the March event by overflows from Rifle Range Drain located at the rear of her property.

B.14.10 Earthquake effects

The effects of the 2011 Canterbury earthquake sequence on the area are described in this section and have been derived from information provided by the Canterbury Geotechnical Database (CGD), SCIRT Geo database (SGD), CERA and field observations.

Land level changes

The CGD vertical and horizontal ground movement database shows the difference between 2003 and June 2011 LiDAR data. This indicates that the flat land of Sumner has lifted near the Port Hills and dropped nearer to the coast. Some areas of Moncks Bay have uplifted by 0.5 m.

Liquefaction

Only minor liquefaction was observed along Nayland Street immediately after the February and June 2011 earthquake events.

Land in the CERA Green Zone has been divided into three technical categories (TC). These categories describe how the land is expected to perform in future earthquakes. CERA has therefore indicated the area from Barnett Park along Main Road is categorised as TC2 in which “minor to moderate land damage from liquefaction in future large earthquakes” is possible. The area from

Wakatu Avenue to Celia Street on the ocean side is categorised as TC3 where “moderate to significant land damage from liquefaction in future large earthquakes” is possible.

Infrastructure damage

Localised earthquake damage to pipe infrastructure occurred and is to be repaired under SCIRT projects #11108 and #11107. SCIRT project #11107 includes road reshaping in front of the properties identified as the most vulnerable from flooding by the Rifle Range Drain secondary flow path on Main Road. A pulled joint at the Rifle Range Drain outfall will also be repaired as part of this project.

B.14.11 Key photos

Figure 44 Moa Community Kids Early Learning Centre day after March 2014 flooding event

Figure 45 Surface flooding Bayview Road March 2014

Figure 46 Rifle Range Drain in Barnett Park. High flood level indicated by flattened vegetation and gravel deposits

Figure 47: Top of Bayview Road with silt deposits day after March 2014 flooding event

B.15 Little River

B.15.1 Background

Location plan

The Little River study area looks at the little river township along Christchurch Akaroa Road from Morrisons Road to Fleet Street. This extent is shown in Figure 48.

Existing studies

Flood extent mapping following the 5 March 2014 event by Council March 2014 has been used to inform this study.

Flooding history

The Little River area has a long history of flooding.

No evidence was found showing any difference between flooding pre and post-earthquakes. There is little visible land damage and no evidence of land rising or falling in the catchment.

Land stability issues in the upper catchment that have caused slips and waterway blockages may be earthquake related but these could also be attributable to the recent high intensity rainfalls.

The recent series of flooding seems to be related to the high rainfall intensity during recent events rather than earthquake effects.

B.15.2 Customer Service Reports (CSR)

A review of CSRs showed very few reports of residential flooding above the floor level. The records showed one property including a house and sleep-out that had been flooded and a second property where a sleep-out had flooded.

There are a number of CSRs for commercial properties in the area.

B.15.3 Key drainage infrastructure

Generally flooding in the Little River area is due to flowing rather than ponding water. The area consists of a steep upper catchment that funnels into a flatter lower valley where the township is situated. From here water drains via the Okana River system through Te Roto Wairewa / Lake Forsyth to the sea. The outlet of the lake is artificially opened by Council to manage the lake level.

There is a small amount of drainage infrastructure around the main township area and in other areas related to conveying water under the roads.

The top end of Barclays Rd including the southern end of the Heritage Park is a relatively low area that is drained via a pipe that runs from open channel drains on the north side of 10 Barclays Rd to an open channel on the east side of the Christchurch Akaroa Highway. The area is often flooded as a result of high water level at the pipe outlet restricting flow out of the basin area. On occasion water has been reported to be flowing back up through the pipe.

This pipe is also scheduled for replacement and will be upsized following capacity concerns however the area will still be flooded until the water level at the outlet can be reduced.

This is a pipe / culvert located on east side of main road past 4230 to 4240 Christchurch Akaroa Rd (includes Library / Service Centre). This pipe carries water between the open channels above and below it on the side of the main road.

A larger pipe may ease some of the flooding around the area of the shops by reducing the amount of water flowing over the road.

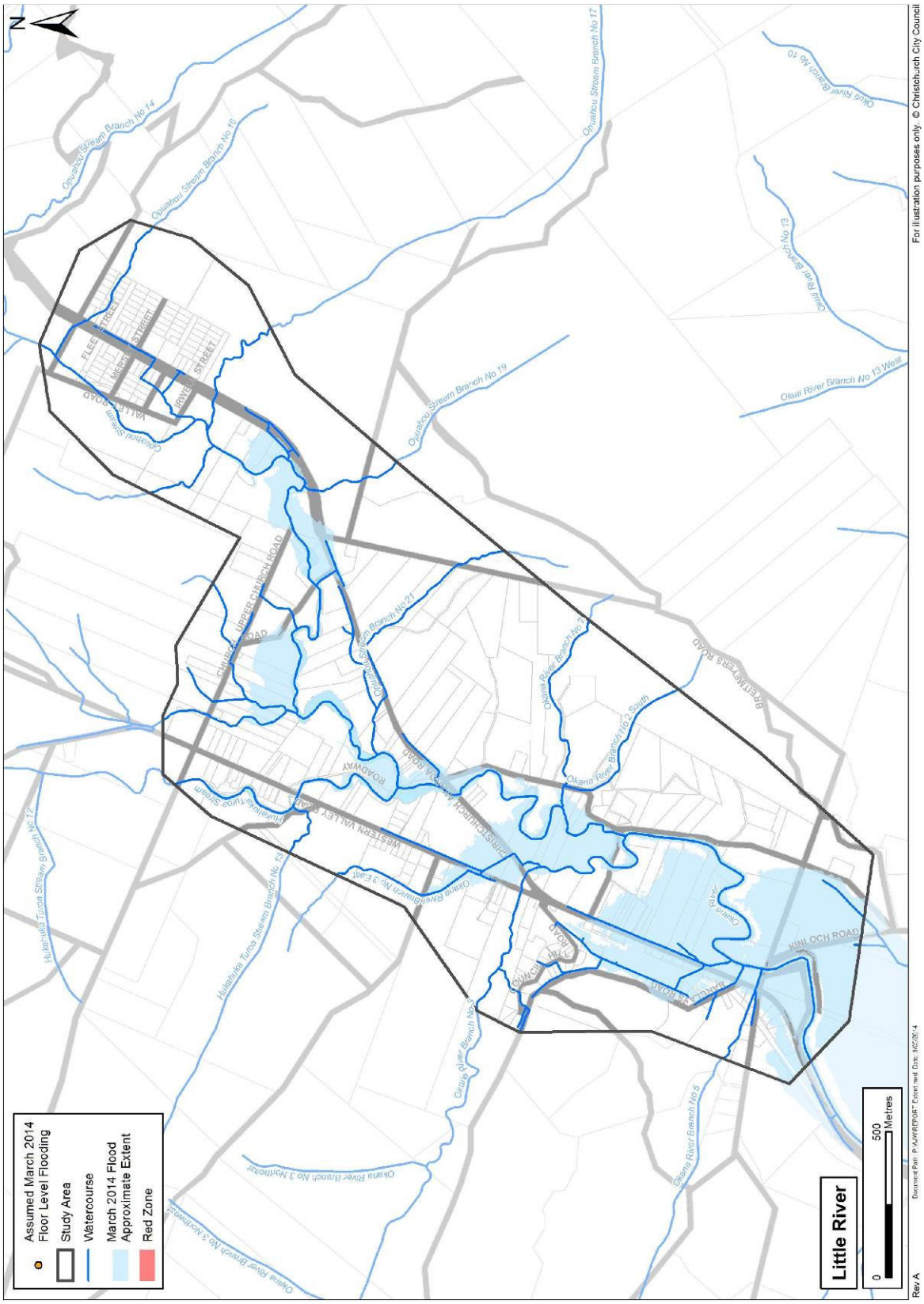

Figure 48 Little River study area extents

Wairewa Pa Road Bridge (Kinloch Road end)

In large events the bridge does not pass the entire flow. Overflows bypass on either side of the bridge causing flooding on the Highway, private property and local roads (Wairewa Pa Rd and Kinloch Rd). Local observations have been made of a 'wave' or back surge of water travelling back upstream and through the overland flow into the township once the water level reaches the beams under the bridge.

B.15.4 SCIRT projects

There are no SCIRT projects in this area.

B.15.5 Existing flood protection infrastructure

Currently the lake outlet is artificially opened. Lake openings are initiated by the Christchurch City Council for flood prevention reasons. The operation of this outlet has not been affected by earthquake damage.

In some areas the remains of what look like bunds along river banks are visible. However, it is unclear whether these are merely spoil piles or bunds placed purposefully to mitigate flooding issues.

B.15.6 March 2014 flood extent

Depth and type

Flooding is predominantly as a result of fluvial flowing water rather than ponding, depth therefore varies based on topography and flow paths, but has been anecdotally identified to be as deep as 0.5-1 m in places.

Cause

Flooding in Little River has a number of causes. Field investigation has identified that the predominant cause of flooding is likely to be inadequate channel capacity and the constraining impact of the Wairewa Pa Road Bridge.

The minimal maintenance within the Okana River corridor and its tributaries has led to the establishment of extensive vegetation, particularly willow trees, along and within the river corridors. This effect is catchment wide.

Flooding of the Little River township is most likely caused by water overflowing from the Okana River Branch No3 (Police Stream) which is severely choked. On the downstream side of the main road conveyance is heavily constrained by vegetation. Once flood water spills into the township the local drainage infrastructure becomes submerged and unable to function causing more widespread ponding from other sources e.g. at Barclays Rd / Heritage Park area.

The Wairewa Pa Road Bridge (Kinloch Road end) appears to form a significant restriction to channel flow and also forms a bund impeding flow away from the township. However, secondary flow paths do form and are essential to allow flow to escape the township area.

The Opuahou Stream and its tributaries in Cooptown are potentially under capacity and the banks have overtopped in places directing water into properties. However, further investigation of this is required for increased certainty.

General description of damage

Property flooding in the area was reasonably widespread, but typically limited to below floor levels. Houses in Little River have been constructed to varying standards but many have been constructed with high floor levels. This has resulted in significantly less damage than would otherwise have been expected. One house has been designated as a rebuild following flood damage and there are others that have now been vacated to allow for repairs works to be completed. A number of garages and other ancillary buildings that have been constructed with a lower floor level were flooded. The risk of flood waters being contaminated by sewage is far less than urban areas.

Number of affected floors

- Six residential buildings
- Four commercial buildings

Local effects

All houses identified as having been flooded (with the exception of a sleep out in Barclays Rd) are located in the lower Cooptown / Church Rd area.

Flooding of the road and township has the effect of isolating the community and disconnecting other areas of Banks Peninsula such as Akaroa.

B.15.7 Other 2014 floods

There have been three flood events that have resulted in on property flooding in 2014:

- 4 March
- 18 April (Good Friday)
- 30 April

Anecdotally there have been seven on property flood events since the earthquakes.

B.15.8 Community response and drivers

Social impact

While flooding in the Little River area only enters a few houses above floor level (six identified) it does have a large impact on the community. A large number of properties have been inundated multiple times including close to floor level under houses and also entering into garages and ancillary buildings.

A number of commercial buildings have been flooded impacting on the owner and the associated businesses.

Road closures on the Christchurch Akaroa Highway impact the community in a number of ways including isolation of Peninsula. Preventing travel and limiting tourist activity affects both individuals and businesses.

Deep flowing water on the main road, often at night, creates a hazard to the local community and visitors.

Community feedback

There have been very few complaints logged with the Council regarding residential flooding. In order to address the uncertainty, the investigations have involved discussions with property owners in the area to identify vulnerable homes.

Key community members were contacted and their local knowledge used to identify which buildings to visit and also to recommend other people to contact. While in the field conversations with the residents also help to gather more information and identify further sites to investigate.

B.15.9 Field studies

During the field studies known problem areas along the rivers and streams from upper Cooptown down to the lake outlet were visited.

Prior to and during our visit enquires were made with members of the community, business owners, members of the Community Board, and Council staff to identify known and suspected flood prone houses. These were all visited and inspected.

B.15.10 Earthquake effects

The effects of the 2011 Canterbury earthquake sequence on the area are described in this section and have been derived from information provided by the Canterbury Geotechnical Database (CGD), SCIRT Geo database (SGD), CERA and field observations.

Land level changes

Land stability issues in the upper catchment that have caused slips and waterway blockages may be earthquake related but these could also be attributable to the recent high intensity rainfalls.

No settlement has been identified in this area.

Lateral spread, liquefaction and infrastructure damage

Lateral spread and liquefaction has not been identified in Little River. There is no known damage to infrastructure.

Waterway observed changes

The earthquakes are possibly linked to slips and increased sediment run off from catchment leading to deposition in the rivers and lake. There is no evidence of bed heave, lateral spreading or other direct land damage impacts. No known earthquake damage to flood defences.

B.15.11 Key photos

Figure 49 Little River – An indication of the level of vegetation in Okana River Branch 3

Figure 50 Little River – Wairewa Pa Road Bridge; a key constraint on the network

B.15.12 Constraints

In the past, under the Wairewa Borough Council, river maintenance was funded (at least partly) by national funding from the government. This funding ended around the time the Banks Peninsula District Council was founded and a ratings district was proposed. Following community meetings and consultation in 1993 a resolution was passed by community vote that rather than a rating being introduced land owners would look after the maintenance of the waterways. This approach was not successful as while some properties were well maintained others were neglected. Later, circa 2008 the Regional Council sought to introduce a ratings district and the vote was not passed.

Currently the maintenance of waterways, including the control of trees and removal of debris is the responsibility of the property owner. Management and maintenance of crown land around waterways is unclear and will require further work to identify who this responsibility lies with.

As many of the waterways are located on private land, any works that could lead to increased flooding or land requirements will require land owner agreement. This is particularly important for any works required for the construction of flood flow channels across the flood plain downstream of the Wairewa Pa Road Bridge.

Vegetation clearance and in channel works would lead to increased flows downstream, the downstream affects would need to be assessed. Further removal of trees could also lead to increased bank erosion and stability issues; this is a key consideration when assessing what works are required.

Plans for vegetation clearance will need to balance the benefits of removing channel constrictions with the increased risk of erosion, loss of streamside habitat and loss of stream shading.