Flood hazard of Dunedin's urban streams

Review of Dunedin City District Plan:
Natural Hazards

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Cover image: Lower reaches of the Water of Leith, May 1923

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1. Introduction

1.1 Overview

As part of its current review of its District Plan, the Dunedin City Council (DCC) is reviewing the way it manages the use of land, so that the effects of natural hazards (including the effects of climate change) can be avoided or adequately mitigated. The Otago Regional Council (ORC) is supporting the DCC by collating and presenting information on natural hazards to help inform this review.

This report defines the characteristics of flood events in Kaikorai Stream, the Water of Leith and Lindsay Creek (Dunedin's 'urban' streams, as shown in Figure 1), and defines the floodplain area that may be affected if floodwater is able to overtop the main channel. The purpose of the report is to provide information and knowledge related to flood hazard, which can be incorporated into planning provisions through the DCC District Plan. This report will also assist with other activities such as the development of local emergency management response plans, building consents, and infrastructure planning, renewal and maintenance.

This report (in bold) identifies areas where flood hazards may affect public safety, buildings and the infrastructure that supports communities. It is part of a series of reports that have been prepared to inform the review of the Dunedin City District Plan:

1. Project overview (ORC, 2014a)
2. Coastal hazards of the Dunedin City District (ORC, 2014b)
3. Flood hazard on the Taieri Plain and Strath Taieri (ORC, 2014c)
4. **Flood hazard of Dunedin's urban streams**
5. The hazard significance of landslides in and around Dunedin City (GNS, 2014a)
6. Assessment of liquefaction hazards in the Dunedin City District (GNS, 2014b)

The description of natural hazards contained in this report should be viewed alongside the information contained in other reports. In particular, the first report listed above provides an overview of this project, while the two GNS reports describe the steeper parts of these catchments that are prone to landslide activity (2014a), and the lower-lying areas that may be subject to liquefaction (2014b). The information in this report should also be considered in conjunction with the information prepared by the DCC on stormwater flooding (DCC, 2011).

1.2 Scope

The geographical scope of this report covers the catchments of the following streams, collectively referred to as 'Dunedin's urban streams':

- the Kaikorai Stream, downstream of Frasers Creek
- the Water of Leith, downstream of Nicols Creek
- Lindsay Creek, downstream of Forrester Park.

The land-use characteristics and population of each of these urban stream catchments is described more fully in each of the flood hazard sections below. The investigation excludes the upper reaches in situations where the main channel is either well incised, heavily modified, has a low population density or is indefinite. It is noted that other watercourses in Dunedin pose a localised flood hazard and are not considered here.

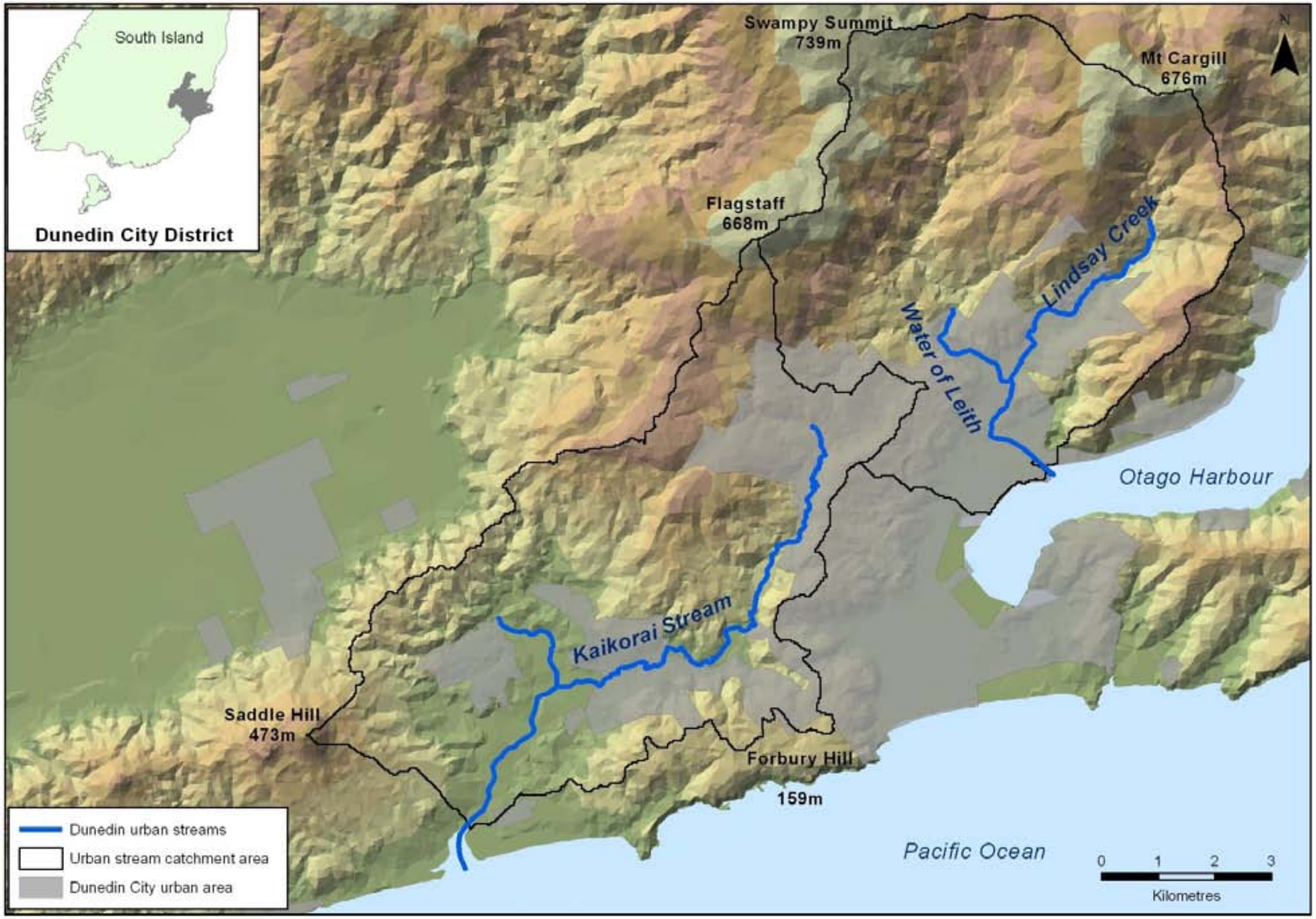

Figure 1 **Topography of the Kaikorai Stream, Water of Leith and Lindsay Creek catchments**

2. Describing the flood hazard of Dunedin's urban streams

The first part of this section describes the general characteristics of flood events in Dunedin's urban streams, while the second part describes the methods used to map areas that may be affected by flood flows.

2.1 Characteristics of flood events

The largest flood events in Dunedin's urban streams typically occur when fronts bringing persistent heavy rainfall pass from east to west over the city. Flood events are caused by rainfall that can either be of short duration and high intensity, low intensity and steady state, medium intensity with a duration of several hours, or a combination of these conditions.

The relatively small and steep catchments of the urban streams can produce significant flooding in just a few hours after the onset of heavy rain, giving little warning. Correspondingly, the duration of peak flows is similarly brief. Flooding can also be compounded by debris blockages of the main channel and by coastal effects (e.g. elevated sea level) at the Kaikorai Stream and Water of Leith mouths.

Damage from previous flood events has included inundation of buildings, houses and roads; scouring of river banks and road embankments; and substantial damage to bridges and fences. Surface flooding and ponding can occur outside the main stream channels and can cause damage to properties and infrastructure that are not located in the immediate vicinity of the channels. The effects of flooding (and other climatic hazards) may be exacerbated in the future by changes in climate, with heavier and/or more frequent extreme rainfalls expected over New Zealand (MfE, 2008).

2.2 Floodplain mapping

The floodplain areas that may be affected by flood flows in Dunedin's urban streams have been identified. A geomorphological approach was used as the basis for identifying land that may be affected by inundation (i.e. landforms that are composed primarily of unconsolidated depositional material derived from sediments that have been transported by fluvial processes). In addition, the land identified as 'floodplain' in this report is that which may be affected if water overtops the main channel, and subsequently flows in a downslope direction across the floodplain. Land that lies well above potential break-out points has been excluded, along with areas that have no direct connection to the wider floodplain (e.g. where road or railway embankments have been constructed).

Physical works have been undertaken over many decades, and to varying standards, to mitigate the effects of high flows and debris (examples are shown in Figure 2 and Figure 3).[1] Physical works have improved channel capacity in some reaches and eliminated or reduced the potential for some of the historically recorded flooding. However, these works are not continuous, and potential still exists for out-of-channel flooding, particularly if the channel becomes blocked with alluvial or landslide debris or the flood event is of an extreme magnitude. Therefore, a residual risk still exists as to flood events that overtop the main

[1] At the time of writing, works to reduce the effects of flooding are still underway in the Water of Leith.

channel and inundate adjacent floodplain areas. It is these areas that have been mapped in this report.

Also within the main channels, there are some reaches that contain bank-protection structures (e.g. concrete lining or gabion baskets). Bank-protection structures in the urban waterways are maintained by their owners, including ORC, DCC and private landowners. Failure of these could result in bank erosion during flood events, contributing debris that may affect channel capacity downstream.

Figure 2 **Debris trap, Malvern Street Park, Water of Leith, April 2006**

Figure 3 **The Water of Leith channel, downstream of Leith Street, at approximately midday on 18 April 2014 (taken close to the peak flow on that day of 71m^3/s – see Figure 9). Works to improve the capacity of this reach commenced in 2011. Photo source: Jeff King**

The area likely to be affected by flooding has not been determined using hydraulic modelling, as the extent of inundation during any event will depend on the location of any overflow and local effects due to the presence of buildings, fences and roads. Instead, the land mapped as 'floodplain' is intended to represent an envelope of areas that may be affected under a range of flood scenarios,[2] rather than an area liable to be fully inundated in any one event. Only flooding from the main channel is included (i.e. the mapped floodplain is not intended to represent areas subject to flooding from stormwater or runoff from adjacent hills). In a significant storm event, discharges from these sources, and from overflow of reticulated public stormwater systems, can contribute substantially to local flooding (Figure 4). Information on the likelihood and effects of stormwater flooding is reported separately by the DCC (2011).

[2] Including variations in the magnitude and timing of inputs from different tributaries, channel blockages and conditions at the mouth

Figure 4 **Stormwater runoff on Stafford Street during a period of intense rainfall, February 2005**

In places, there are 'islands' of high ground within the floodplain, but as these are generally small and only marginally above the potential flood level, they have not been defined. Further, these areas will potentially be isolated in a major flood event and therefore should reasonably be included. Localised topography is shown in a series of more detailed floodplain maps in Appendix 1 – 3. These maps include ground contours, derived from LiDAR, collected in 2009 by the DCC. It is noted that the mapped ground contours will not account for any recent modifications to the floodplain due to earthworks or other construction.

In parts of the floodplain, particularly adjacent to the main channels, the speed and depth of flood flows could damage buildings and other assets, move vehicles and make walking difficult or unsafe for adults, they therefore present a possible risk to life. The likely attributes of flood flows (depth, speed and duration) in these more critical areas are:

- **depth of water:** between 0.1 and approximately 1m, with the deeper water generally being located adjacent to the main channel or in areas of significant ponding, with lower levels on the wider floodplain
- **duration of flooding**: few hours (runoff) to 1 or 2 days (main channel flow), depending on the intensity and duration of the rainfall event
- **water speed:** fast to very fast; with higher water speed and greater turbulence occurring in the upper reaches and within the main channel, and lower water speed and turbulence further downstream and away from the channel.

Elsewhere on the floodplain, the floodwaters will be much shallower and slower, with damage potential reduced accordingly. In some areas, the streets are lower than the adjacent properties and will act as overland flow paths with the main issue for people being access limitations. Further damage can occur when vehicle traffic creates waves that can wash into buildings that would otherwise be above water level.

2.3 Other hazards

Aside from flooding, the Dunedin urban stream catchments are vulnerable to a range of other natural hazards. Climatic hazards, such as drought, wind and snow, affect the area irregularly. Extreme climatic events (such as the snow storm of 1939[3]) can have a significant impact. These hazards have not been addressed as part of this report, and further information is available through the Otago Natural Hazards Database (available through the ORC website www.orc.govt.nz).

The area is also vulnerable to seismic shaking from earthquakes. Dunedin is located close to the Titri and Akatore faults, and other more distant faults could also affect the area. Reports by GNS Science and Opus provide more detail on seismic and landslide hazards in the Dunedin City District (GNS 2014a and 2014b, Opus 2005).

[3] See ODT (2011).

3. Characteristics of flood hazards in the Kaikorai Stream

3.1 Catchment description

The Kaikorai Stream drains the southern and eastern slopes of Flagstaff, Kaikorai Hill and the Balmacewen area (Figure 1). It has a catchment area of 55km^2 that contains the Dunedin suburbs of Halfway Bush, Brockville, Kaikorai, Kenmure, Concord, Green Island, Abbotsford, Waldronville, Fairfield, and parts of Balmacewen, Maori Hill, Roslyn and Mornington. The Kaikorai catchment is used for rural, residential, commercial and industrial activities. The Kaikorai catchment is home to about 24,500 people, with approximately 2,950 permanent residents residing on the floodplain area shown on Figure 6.

Figure 5 Kaikorai Stream flooding, Green Island, looking downstream towards the Main South Road Bridge, March 1994. The location of this photo is shown on Figure 27. Photo source: Otago Daily Times

Past flood-related issues in the Kaikorai catchment have often been caused by mechanisms other than main-channel overflow, including local surface runoff, rainfall-triggered landslip and blockage of the stream mouth.[4] Records of inundation and damage from main-channel overflow have been limited to isolated locations in 1923, 1968, 1991 and 1994 (Figure 5) (ORC, 2001a). Channel works have improved the flood capacity in the Green Island reach, subsequent to those observed events.

[4] A combination of low flows in the Kaikorai Stream and onshore wind and wave action periodically lead to the formation of a large sand bar across the mouth of the estuary. Although the sand bar often dissipates naturally, its presence during storm events may exacerbate flood hazard for low-lying land surrounding the Kaikorai Estuary.

3.2 Kaikorai Stream floodplain mapping

The mapped floodplain extends from Frasers Creek downstream to the Brighton Road bridge (Figure 6). Figure 6 shows that there is potential for widespread inundation in some areas as a result of flood events in the Kaikorai Stream, particularly if the stream experienced significant bed aggradation, debris blockage and/or extreme flood events.

The floodplain extends well beyond the main channel in a number of locations, and these are shown in a series of more detailed maps in Appendix 1.

3.3 Coastal hazards

The lower reaches of the Kaikorai floodplain (below Green Island) could be affected by coastal hazards such as storm surge and tsunami, particularly if the sea level was higher than at present (ORC, 2012).[5] An increase in mean sea level may also have an impact on the depth and extent of inundation from the Kaikorai Stream in the lower reaches during flood events. The interaction of different processes (e.g. coastal storm surge coinciding with high river flows and surface runoff) can also increase the level of hazard for the Kaikorai Estuary (ORC 2014a, ORC 2014b).

[5] MfE (2008) recommend planning authorities consider up to 0.8m of sea-level rise over a 100-year period. However, the most recent expert advice from NIWA (Bell, 2013) recommends revising this figure to 1m to account for projected increases in the rate of sea-level rise beyond 2100.

Figure 6 **Mapped floodplain area for Kaikorai Stream**

4. Water of Leith

4.1 Catchment description

The Water of Leith catchment is located to the north of the Dunedin Central Business District (CBD), and has a catchment area of approximately 42km^2, including parts of Flagstaff, Swampy Spur and Mount Cargill, which rise to approximately 700m above sea level. The permanent population that resides on the Water of Leith floodplain areas is approximately 9,300 (including North East Valley). Much of the floodplain area is also used for commercial and educational purposes and is traversed by important lifeline infrastructure (including state highways, the South Island main trunk line, and electricity and telecommunications links).

Flows start at the Leith Saddle near Sullivans Dam and then travel for 14km southward through the northern part of the city before discharging into the Otago Harbour, south of Logan Park (Figure 1). The main tributaries of the Water of Leith include Lindsay Creek, Morrison's Burn, Nicols Creek, Opoho Creek and Ross Creek. Lindsay Creek, the largest tributary, which joins the Water of Leith in the lower reaches near the Botanical Gardens, is addressed separately in this report. The flood-hazard area for the confluence area is derived both from the Water of Leith and Lindsay Creek.

The upper section of the catchment and its tributaries are characterised by steep slopes and fast flows. The lower reaches are still relatively steep hydraulically, with a fall of 25m between the George Street and Dundas Street bridges. These characteristics result in the Water of Leith having the potential to behave, in times of flood, as a mountain torrent, as evidenced by the large alluvial boulders visible in the channel, even in the lower reaches. The Water of Leith is hydraulically steep, with flood flows moving at up to 3m/s in some reaches (Opus, 2004c). The water surface under flood conditions is likely to be highly turbulent throughout most reaches (Opus, 2004c), with large standing waves being observed in some locations (Figure 7).

Figure 7 Standing wave in the Water of Leith during the April 2006 flood event

During flood events, any increase in rainfall intensity in the upper catchment results in a rapid increase in flow downstream, as runoff quickly reaches the built-up area of Dunedin

(ORC, 1999). An example is shown in Figure 8: Rainfall intensities in the upper catchment started to increase at 6am on the morning of 26 April 2006, followed immediately by an increase in flow downstream at St David Street. By 8:30am, river flow had increased from 63 to 94m^3/sec. A number of properties and other assets were affected during this event (particularly between Dundas and St David streets).

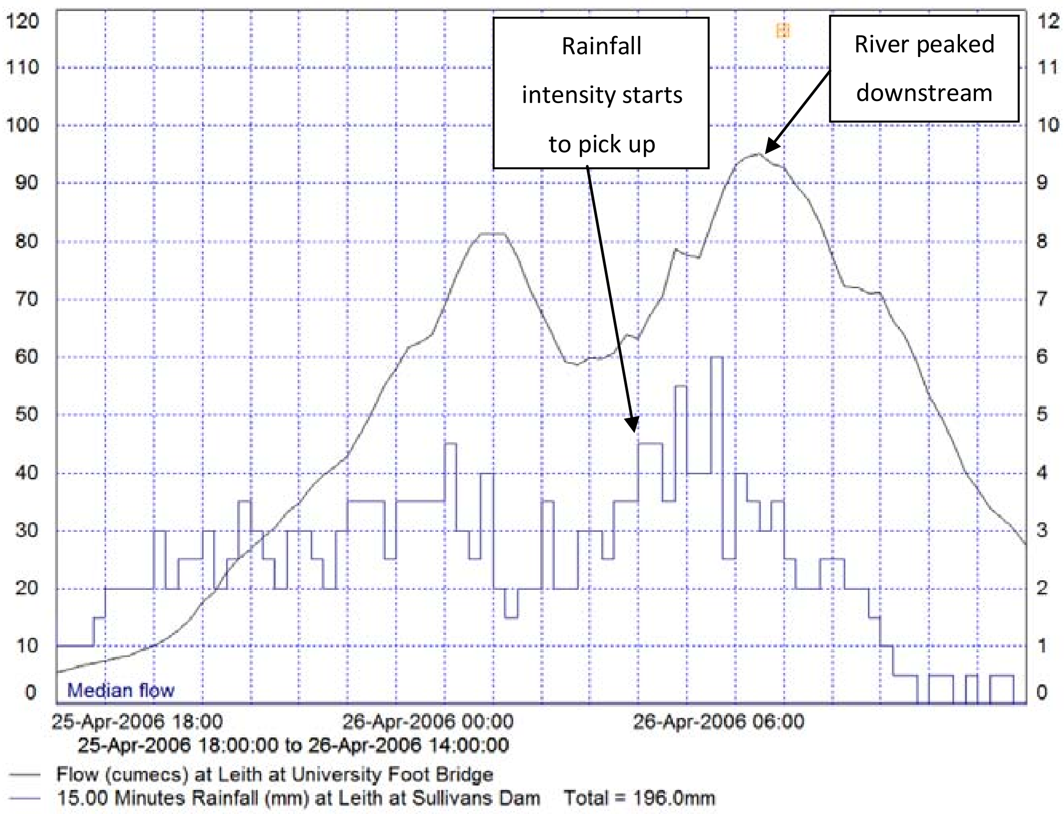

Figure 8 **Upper catchment rainfall (at Sullivans Dam) and river flow (at St David Street) in the Water of Leith catchment during the April 2006 flood event. Each vertical bar represents 1 hour. The left-hand scale shows flow (in m^3/sec), and the right-hand scale shows rainfall intensity (in mm/15minutes).**

4.2 Previous flooding and river control works

Damaging floods in the Leith were a frequent occurrence from the time of first settlement, being recorded in 1868, 1877, 1911, 1923 (Figure 10 and Figure 11) and 1929. The 1929 event was the most severe on record, with floodwaters sweeping away and damaging bridges and other channel structures, affecting numerous houses and flowing along the streets beyond lower Rattray Street. Observed flood extents and anecdotal evidence from previous events show that inundation of 1m or more can occur in some places. During the 1929 event, flood water from the Water of Leith flooded approximately 500 houses in the north end of Dunedin City to a depth of up to 1.2m (MacLean *et al.*, 1931). Since 1929, there have been a number of significant floods in the Water of Leith (the largest in 1991), but none have been comparable to the 1929 event (Figure 9). River-control works have progressively been undertaken within the catchment with a formal flood protection scheme in place. The combination of relatively small flood events and progressive channel improvement and flood protection works has limited the amount of damage caused by flooding since 1929.

At the time of writing, works are underway to reduce the flood hazard of the Water of Leith. As noted above, a residual flood risk will still exist once these works are completed, and the floodplain maps shown below will therefore still be applicable.

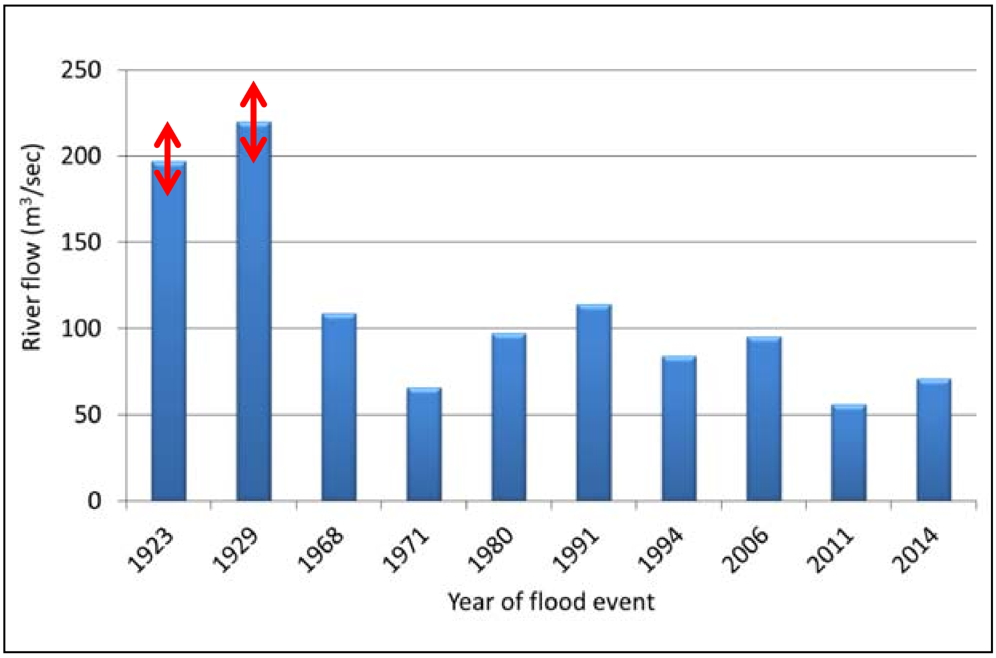

Figure 9 **Top ten flood flows in the Water of Leith at the St David Street footbridge. Continuous flow records commenced in Feb 1963, and the accuracy of the peak flows for the 1923 and 1929 floods is less than for later events.**

Figure 10 **Floodwater from the Water of Leith ponding in Harrow Street (looking south towards the Railway Station), April 1923. The approximate location of this photo is shown in Figure 32.**

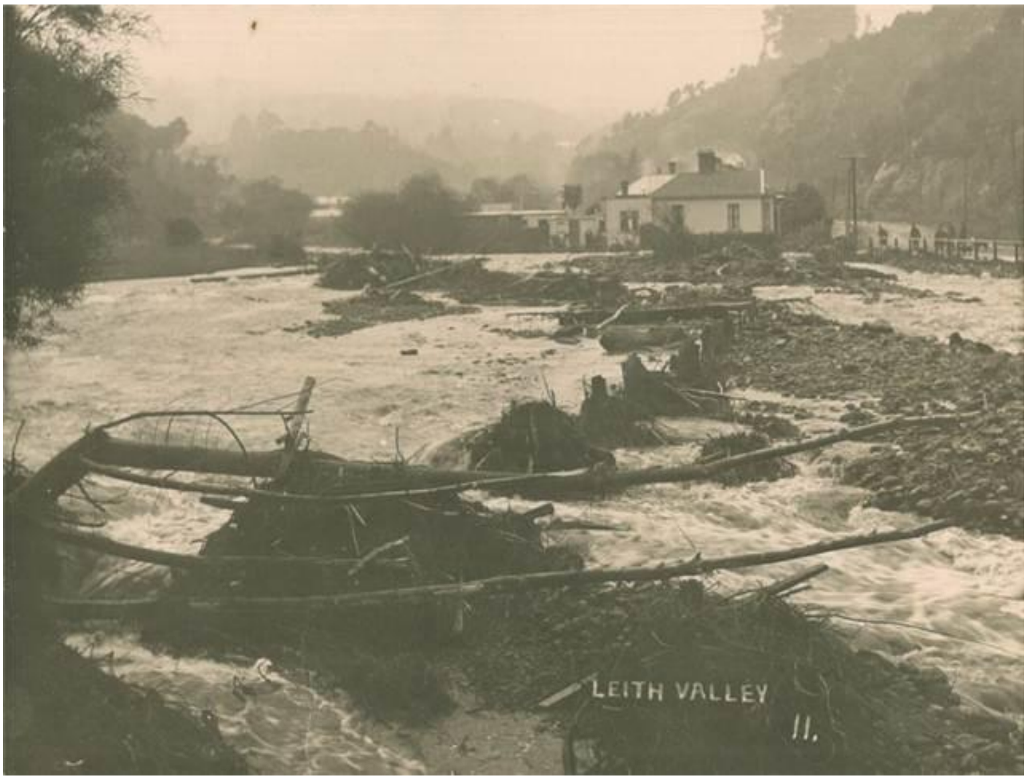

Figure 11 **Water of Leith in flood upstream of the Rockside Road Bridge, April 1923**

4.3 Water of Leith floodplain mapping

The mapped floodplain extends from Nicols Creek, downstream to Otago Harbour (Figure 12). More detailed maps of the upper, mid- and lower reaches of the Water of Leith catchment are shown in Appendix 2.

Above Woodhaugh, the floodplain is bounded by steep slopes, and its margins are well defined by a sharp break in slope. Downstream of Woodhaugh, the floodplain has been mapped to show the expected overland path of any overflows from the main channel, based on the ground contours of the area. Although any flooding would generally be shallow, localised inundation may reach depths of up to approximately 1m, due to impedances to overland flow (e.g. fences, buildings) and land that is particularly low relative to the surrounding area.

Due to the general southward slope of this part of the floodplain, overland flows may reach as far as Queens Gardens (Figure 32) before exiting to the Otago Harbour between Fryatt and Birch streets. This is consistent with the tentative conclusion of MWH (1999). The land continues to slope to the south from this point. It is therefore possible that the overflow from the Water of Leith that was not contained within the Queens Gardens' area could continue to drain towards the Oval, and beyond. Due to the very flat relief of this area, and the potential effects of buildings, roads and the stormwater system, the floodplain has not been defined beyond Jetty Street. Land that lies at the same level, or downslope of the floodplain at this point, is shown in Appendix 5.

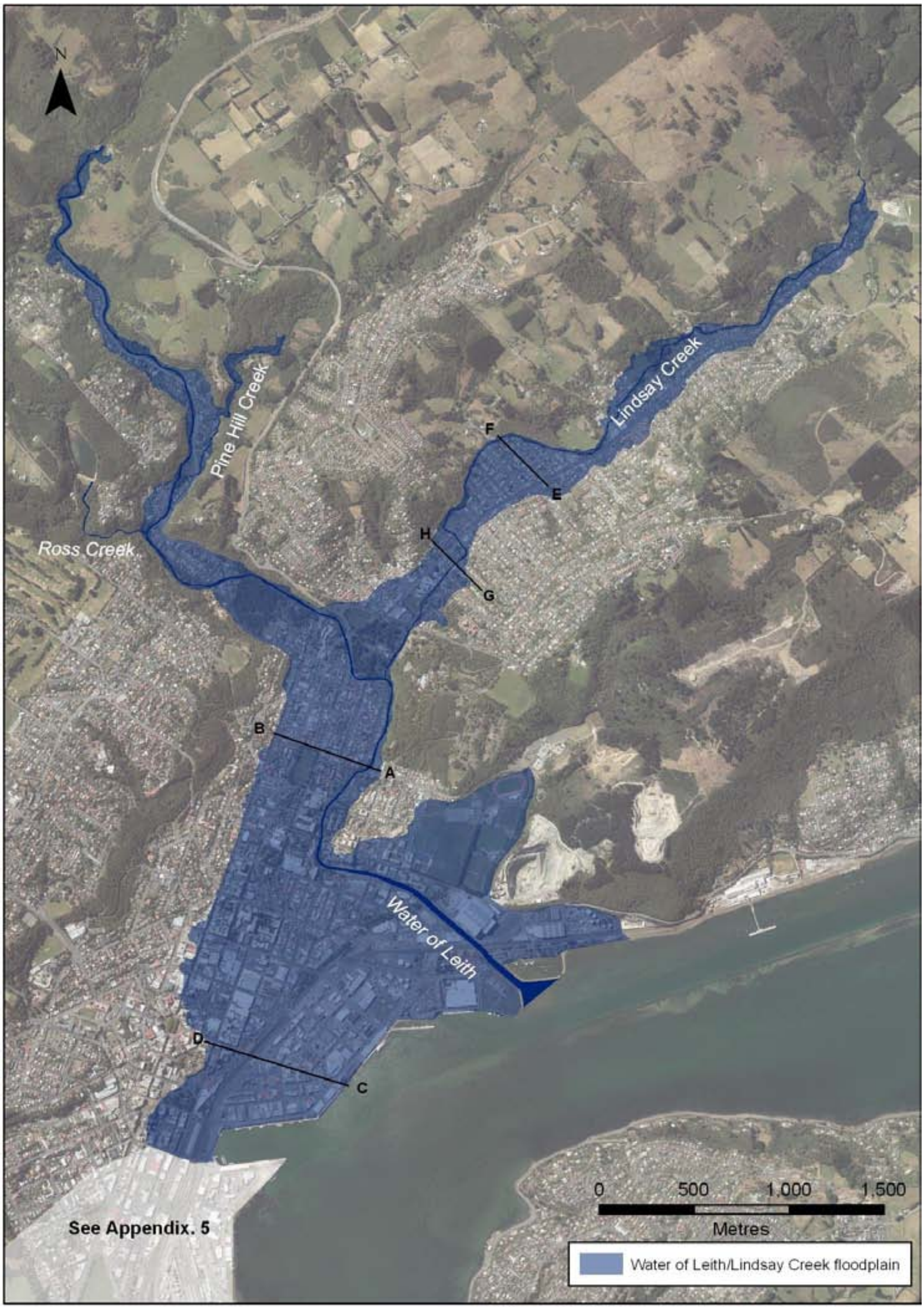

Figure 12 **Water of Leith and Lindsay Creek mapped floodplain area. The locations of the cross sections shown in Figure 13, Figure 14, Figure 19 and Figure 20 are also shown. The topography of the area to the south of Jetty Street (shaded white) is shown in Appendix 5.**

The approximate area inundated during previous events (including the 1929 flood, Figure 9) is shown in Appendix 4. The main parts of the Water of Leith floodplain that were not included in this earlier flood hazard map, but have been identified as 'floodplain' in this report, include:

- land between the one-way system (Great King and Cumberland streets) and George Street in North Dunedin. As noted above, this part of the floodplain includes the area that could be affected by overland flow, originating from overtopping of the channel further upstream (i.e. in the vicinity of the George Street bridge/Woodhaugh Gardens). Figure 13 shows cross section A-B through this part of the floodplain, along Dundas Street.

- land to the east of the Forsyth Barr Stadium, as far as the raised bund that separates the BP oil terminal from Palmers Engineering. This land is at the same, or a lower, elevation than the existing flood hazard area which extends into Parry Street.

- reclaimed land between the South Island main trunk line and Otago Harbour (Anzac Avenue to Fryatt Street). This land has been included as it lies at a similar or lower elevation than the previously mapped area (Figure 14). Although the effects of overland flow may be mitigated by the presence of raised road and railway embankments, this area has a very subtle topography, and it has therefore been included within the mapped floodplain area for the purposes of this report. Parts of this area may also be increasingly affected by extreme sea-level events, due to sea-level rise (ORC, 2014b), and it has been affected by surface runoff during previous heavy rainfall events.

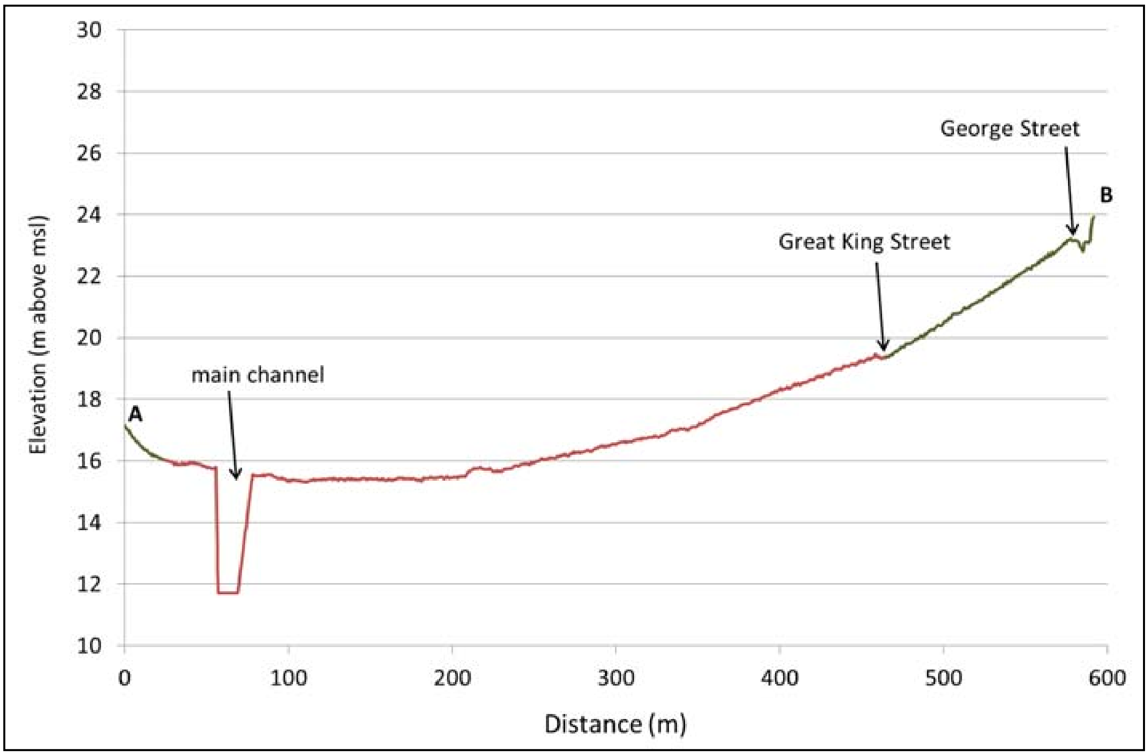

Figure 13 **Cross section A-B (along Dundas Street) showing the extent of the previously mapped flood area (red line) and the floodplain area mapped for this report (green line)**

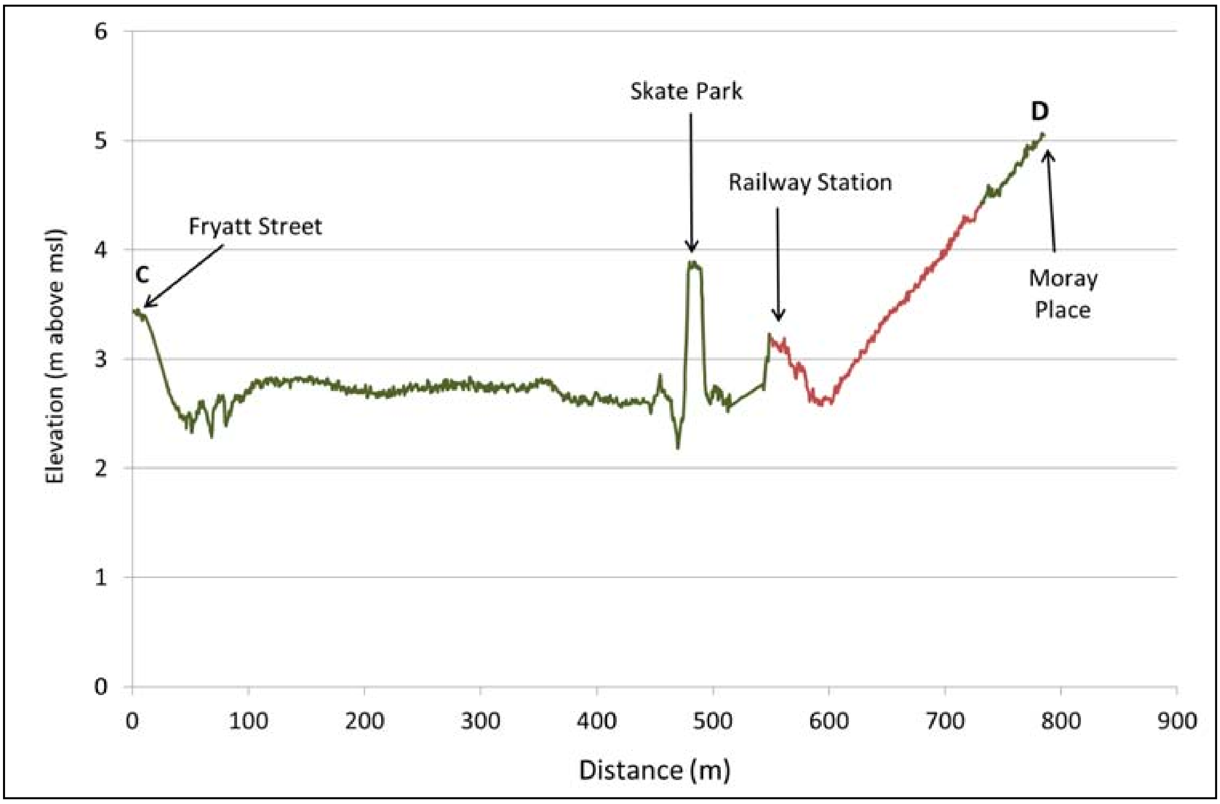

Figure 14 **Cross section C-D (along Mason and Stuart streets) showing the extent of the previously mapped flood area (red line) and the floodplain area mapped for this report (green line)**

5. Lindsay Creek

5.1 Catchment description

Lindsay Creek rises on the flanks of Mount Cargill and runs southwest, draining North East Valley and joining the Water of Leith at the Botanic Garden. The catchment area is about $12km^2$, and the length of the main channel is about 7km (Figure 1).

In the upper catchment, the streambed is steep, and the stream has the characteristics of a mountain torrent. Under high flows, it can erode its banks and carry large volumes of debris and detritus. In the lower catchment, the slope of the streambed decreases through the urbanised area of North East Valley. All along the catchment, short tributaries (also with short, steep catchments) contribute to the flow in Lindsay Creek. The western slopes are mainly bush covered, with farmland and some urban development on the lower slopes, while the sunnier, eastern slopes are more densely populated. The valley-floor floodplain is intensely developed, with urban land use occurring immediately next to the creek (Figure 15). Several hundred residential properties have some degree of exposure to flood hazard, along with three schools, Ross Home and the Otago Community Hospice, roads (including North Road, which is the main access to North East Valley) and a number of commercial properties.

Figure 15 House located immediately next to the main channel of Lindsay Creek

Figure 16 **View from Blacks Road across the North East Valley floodplain, during an event in 1912 (above), and approximately the same view today (below)**

The potential for flood damage from Lindsay Creek is exacerbated by bank instability, with associated erosion, bed aggradation and/or debris blockage possible in places. Dormant and creeping landsliding above some points of the channel could be activated in an extreme storm and partially or fully block the channel, causing substantial out-of-channel overflow. A number of landslide features on the steep true-right (northern) bank of Lindsay Creek were identified by Coffey Geotechnics (2010), and the toe (or base) of these landslides encroach into the main channel of Lindsay Creek (Figure 21). Stormwater overflows are also believed to have contributed significantly to previous surface flooding.

5.2 Previous flooding

Records and observations indicate that flooding from Lindsay Creek has been a regular occurrence. A number of floods in Lindsay Creek have caused damage to properties through bank erosion and from floodwater overtopping the river banks. Severe flooding and consequent damage was reported in 1868, 1877, 1912 (Figure 16), 1923, 1929, 1968, 1971 and 1991 (ORC, 2001b). The largest flood event in the last decade was in April 2006 (Figure 18). The ten largest flood events since continuous monitoring commenced in 1979 are shown in Figure 17.

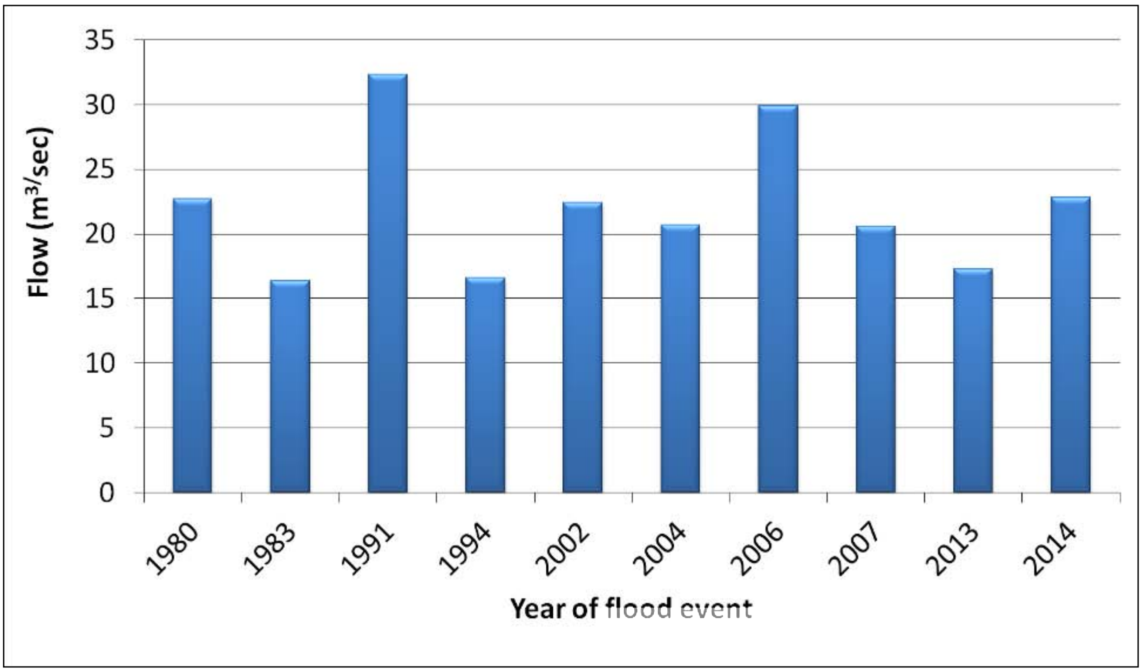

Figure 17 **Top ten flood flows in Lindsay Creek at the North Road Bridge. Continuous flow records commenced in October 1979.**

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Figure 18 **Lindsay Creek at Palmers quarry bridge, April 2006 (looking upstream). This photo was not taken at the peak of the flood.**

5.3 Lindsay Creek floodplain mapping

The Lindsay Creek floodplain extends from Forrester Park downstream to the confluence with the Water of Leith (Figure 12). More detailed maps of the upper, mid- and lower reach of the Water of Leith catchment are shown in Appendix 3.

The mapped floodplain area covers the valley floor and is reasonably consistent with historically observed flood extents and previously mapped flood-hazard areas (Appendix 4). The main parts of the Lindsay Creek floodplain that were not included in earlier flood-hazard maps, but have been identified as 'floodplain', in this report include:

- the valley floor upstream of Normanby (Bonnington Street) to Forrester Park. This part of the floodplain had not previously been mapped.
- land to the east of North Road, particularly between James Street and Normanby. Although the previous flood-hazard area was truncated at North Road, there is a strip of land to the east that lies at, or below, the level of the previous flood-hazard area (Figure 19).
- parts of the true-right floodplain downstream of Buccleugh Street (including Sacred Heart School). This land also lies at a similar elevation to the rest of previous flood-hazard area (Figure 20).

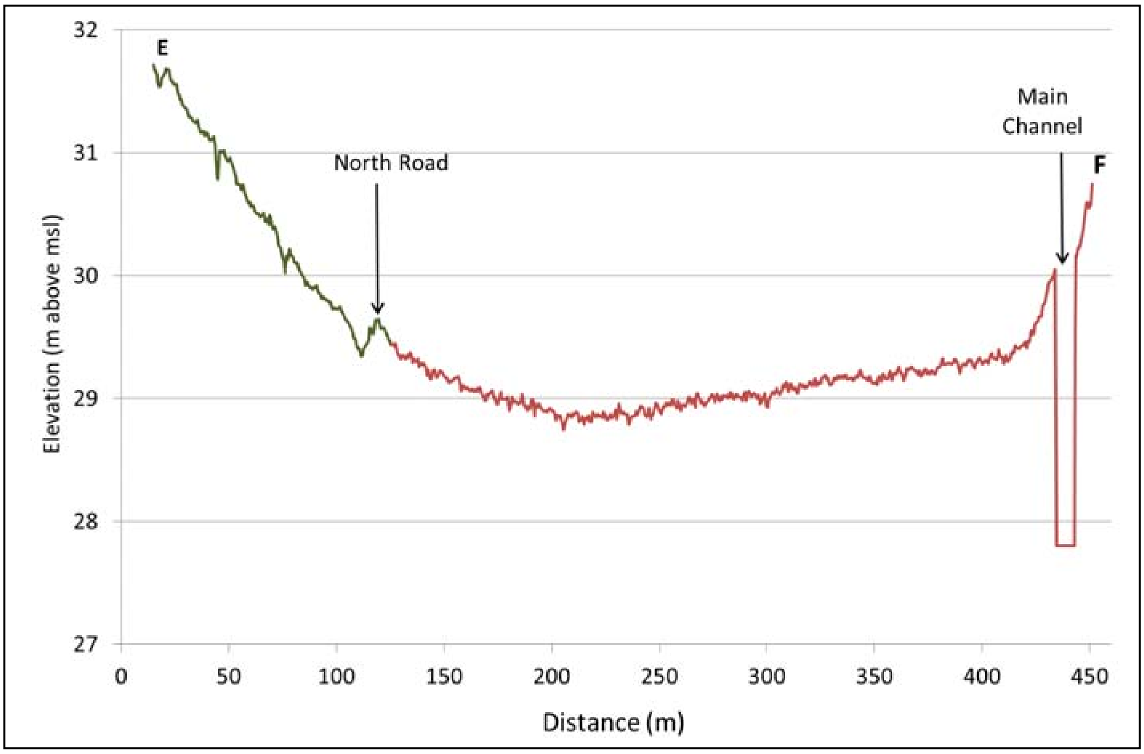

Figure 19 **Cross section E-F (North East Valley School to Selwyn Street) showing the extent of the previous flood-hazard area (red line) and the floodplain area mapped for this report (green line)**

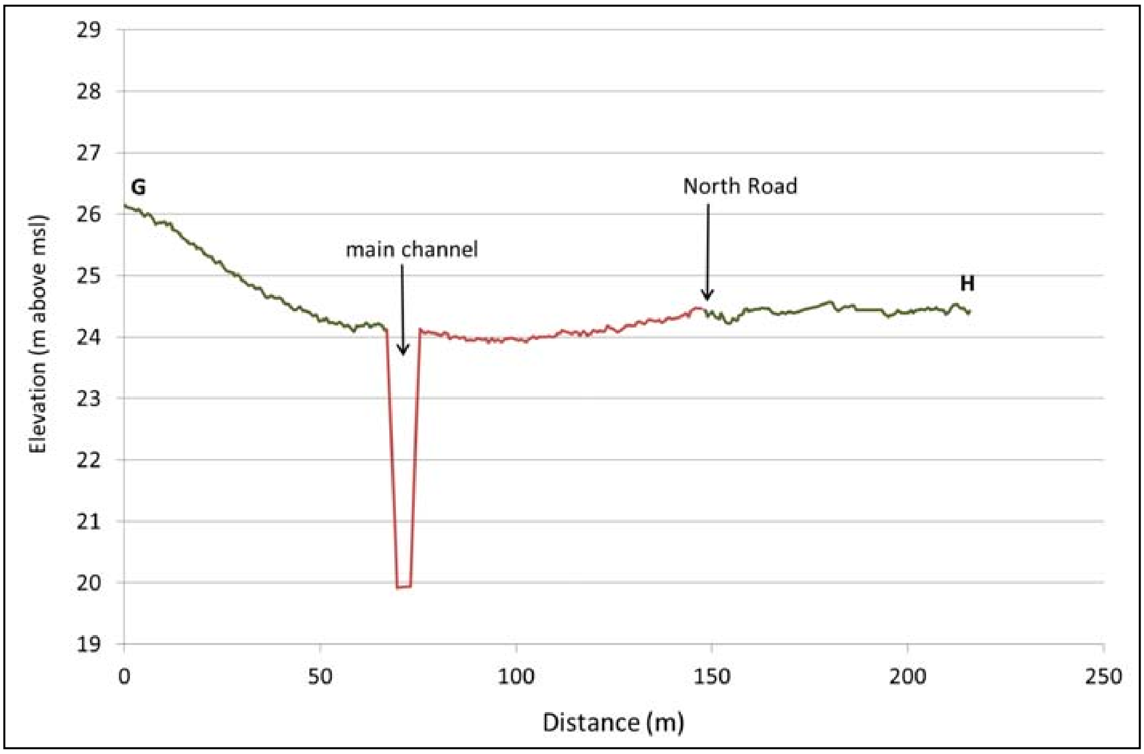

Figure 20 **Cross section G-H (Chambers Street to Buccleugh Street) showing the extent of the previous flood-hazard area (red line) and the floodplain area mapped for this report (green line)**

Figure 21 Geological summary map of Lindsay Creek between Watts Road and North Road bridge, as prepared by Coffey (2010)

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Appendix 1. Kaikorai Stream floodplain maps

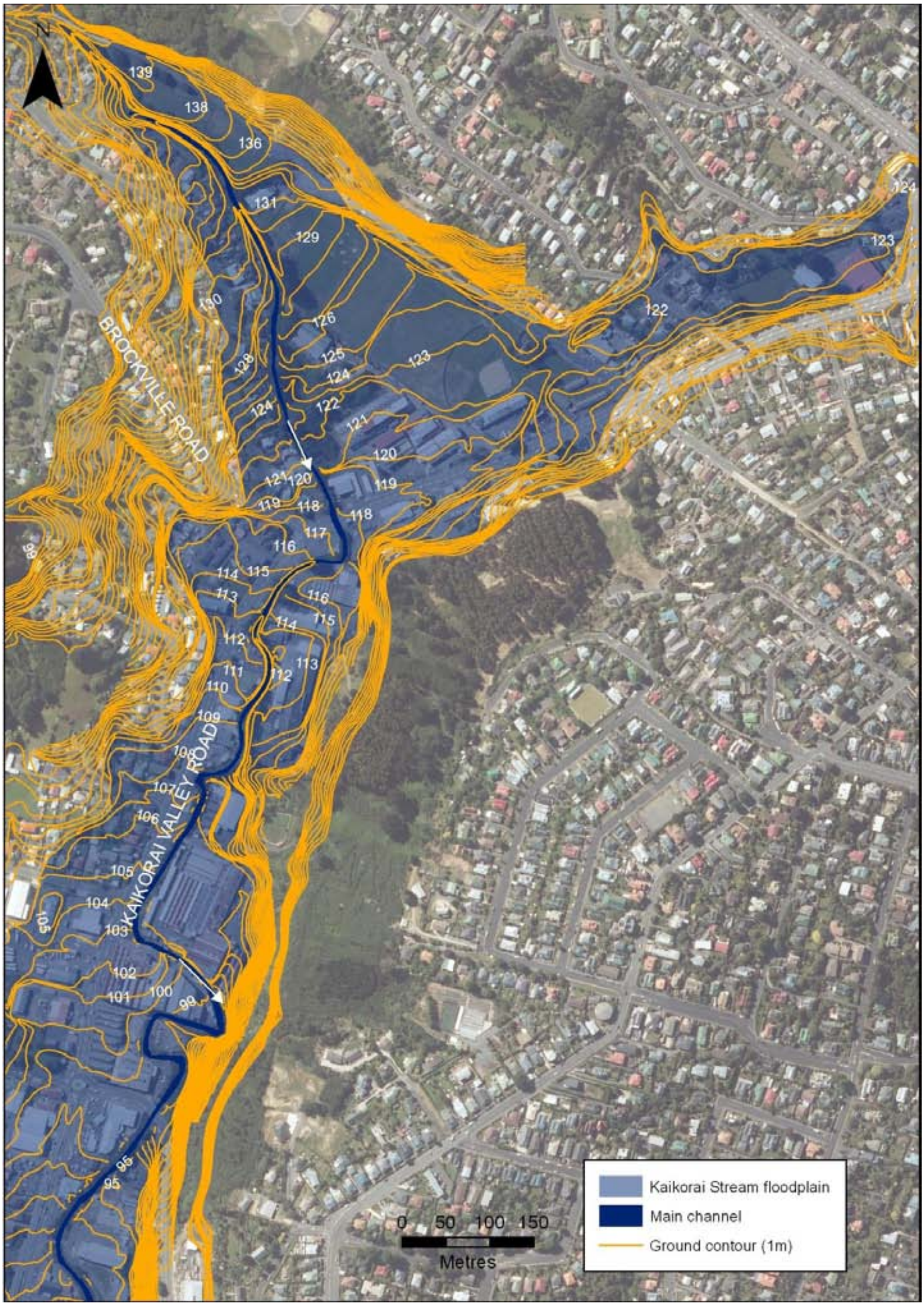

Figure 22 **Kaikorai Stream floodplain area: Frasers Creek confluence to Stone Street**

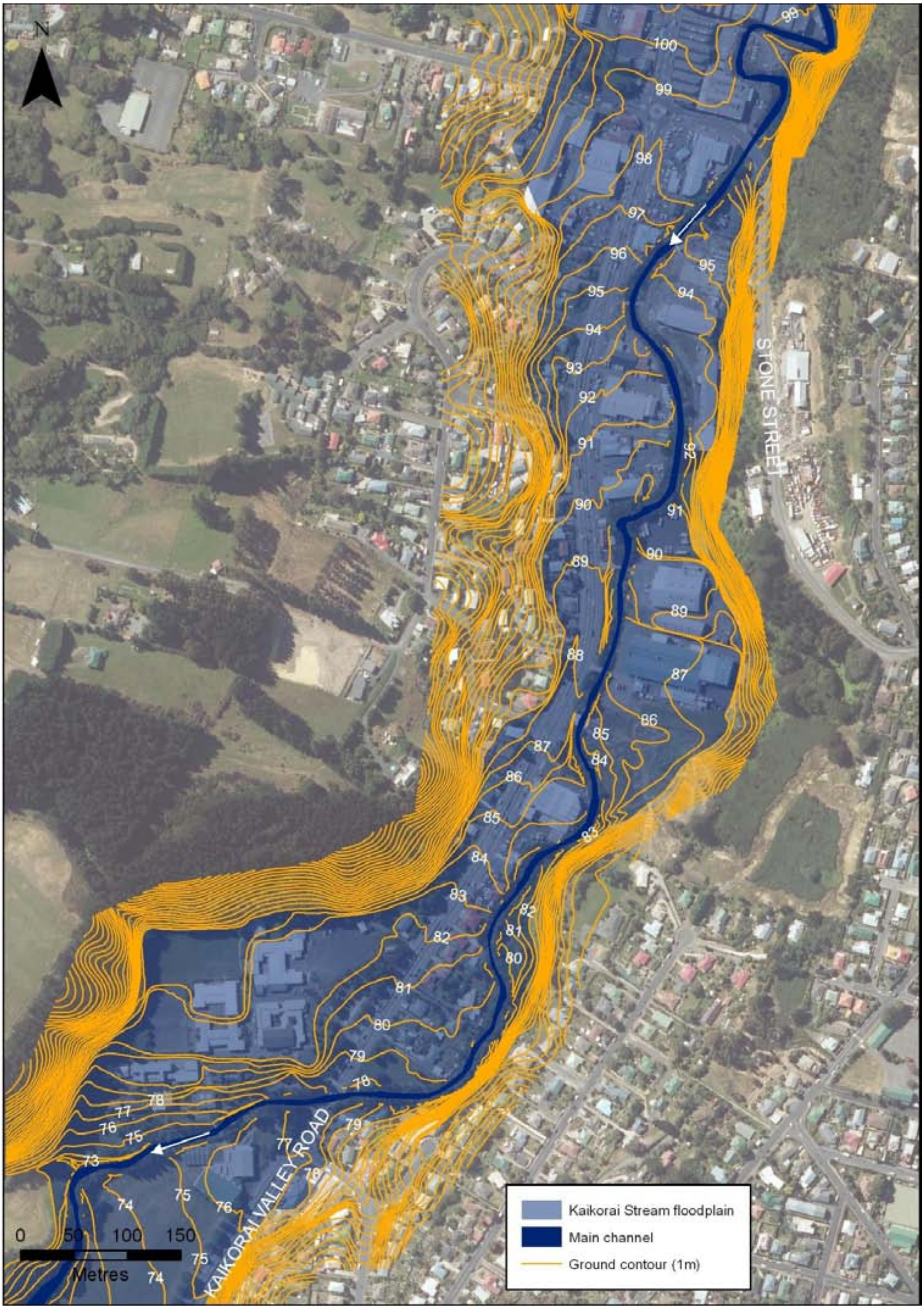

Figure 23 **Kaikorai Stream floodplain area: Stone Street to Kaikorai College**

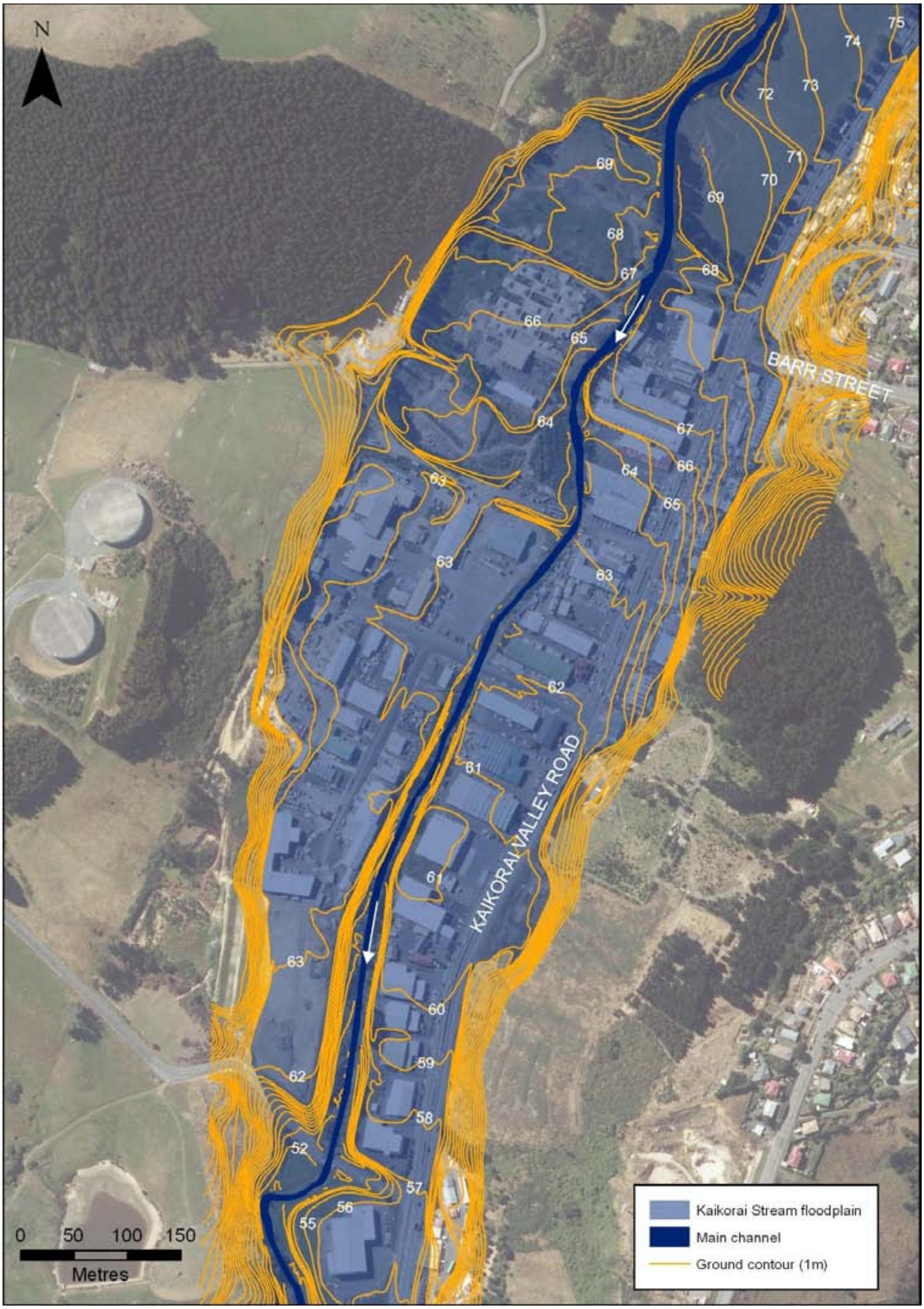

Figure 24 **Kaikorai Stream floodplain area: Kaikorai College to Townleys Road**

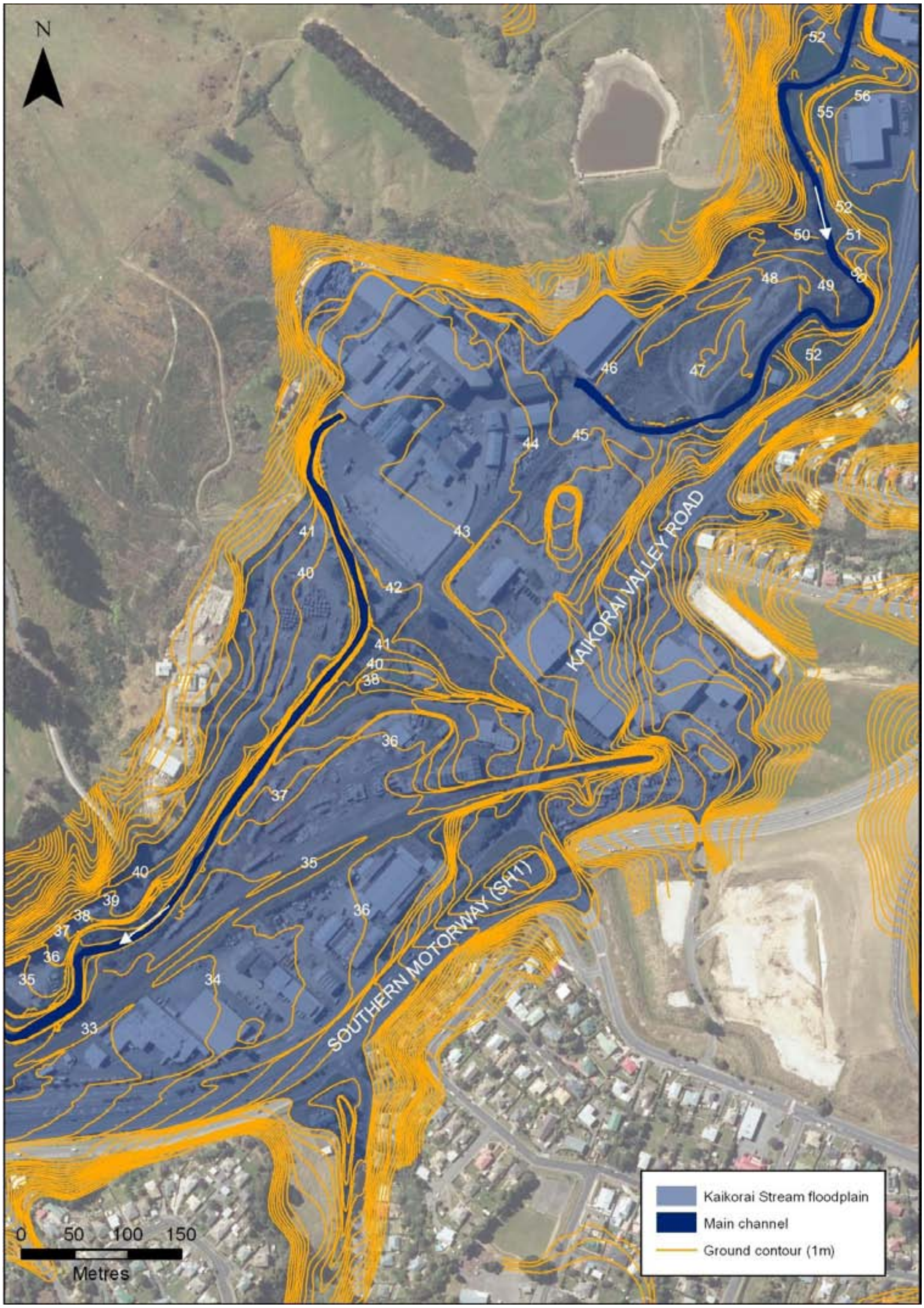

Figure 25 **Kaikorai Stream floodplain area: Townleys Road to the Southern Motorway**

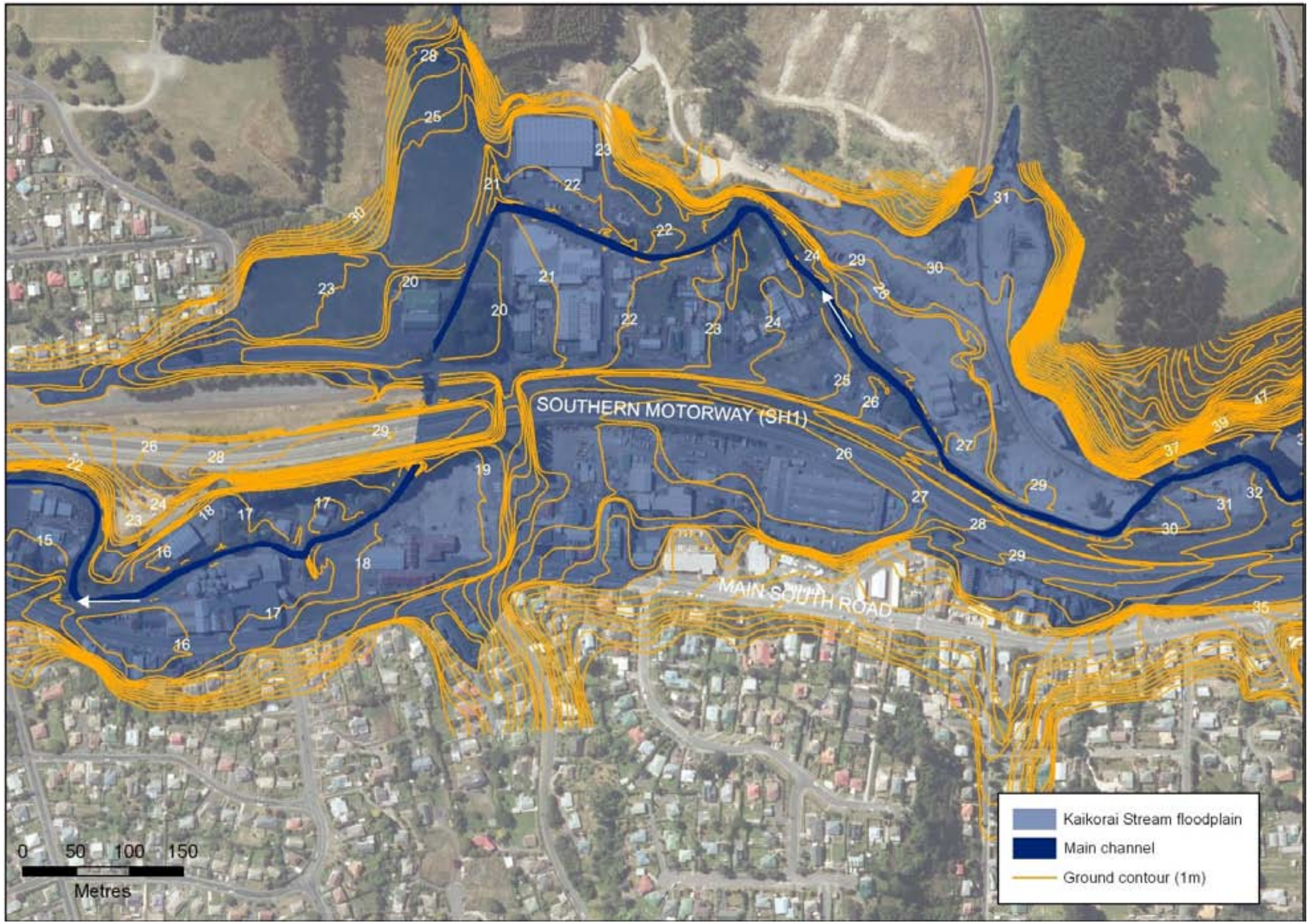

Figure 26 **Kaikorai Stream floodplain area: Southern Motorway to Green Island**

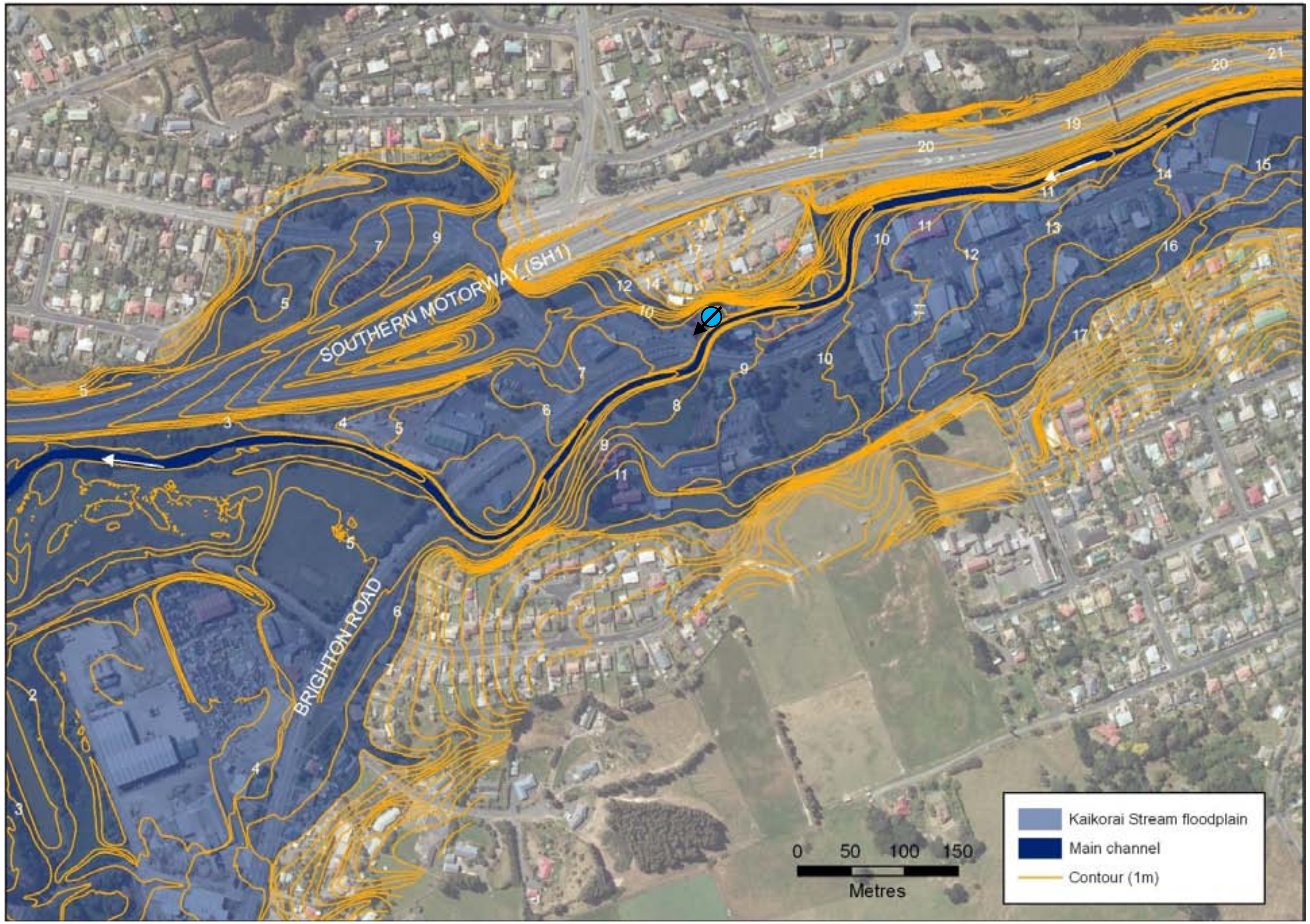

Figure 27 **Kaikorai Stream floodplain area: Green Island to Brighton Road. The approximate direction and location of the photo shown in Figure 5 is also shown.**

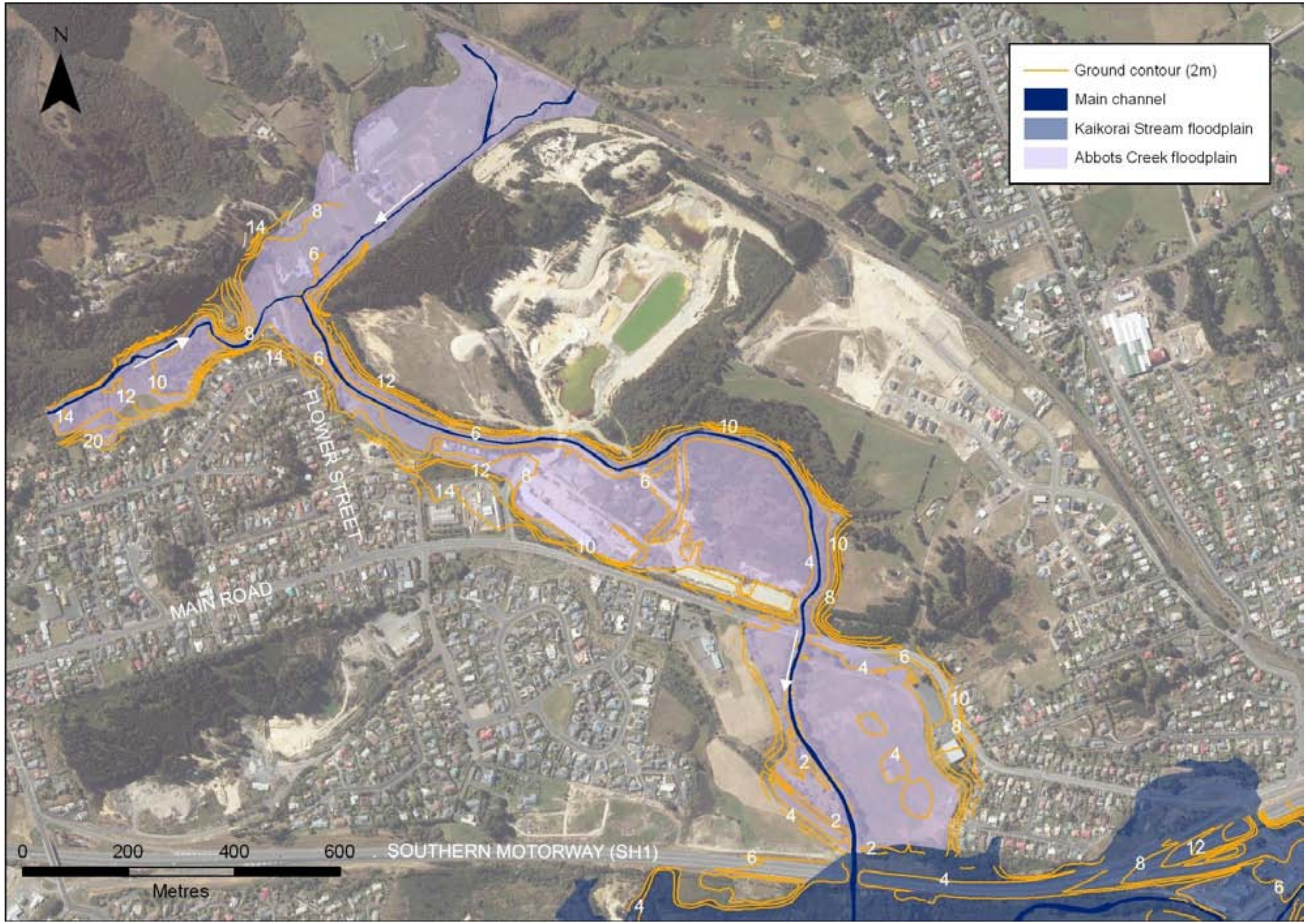

Figure 28 **Abbots Creek and Kaikorai Stream floodplain area: adjacent to Sunnyvale and SH1**

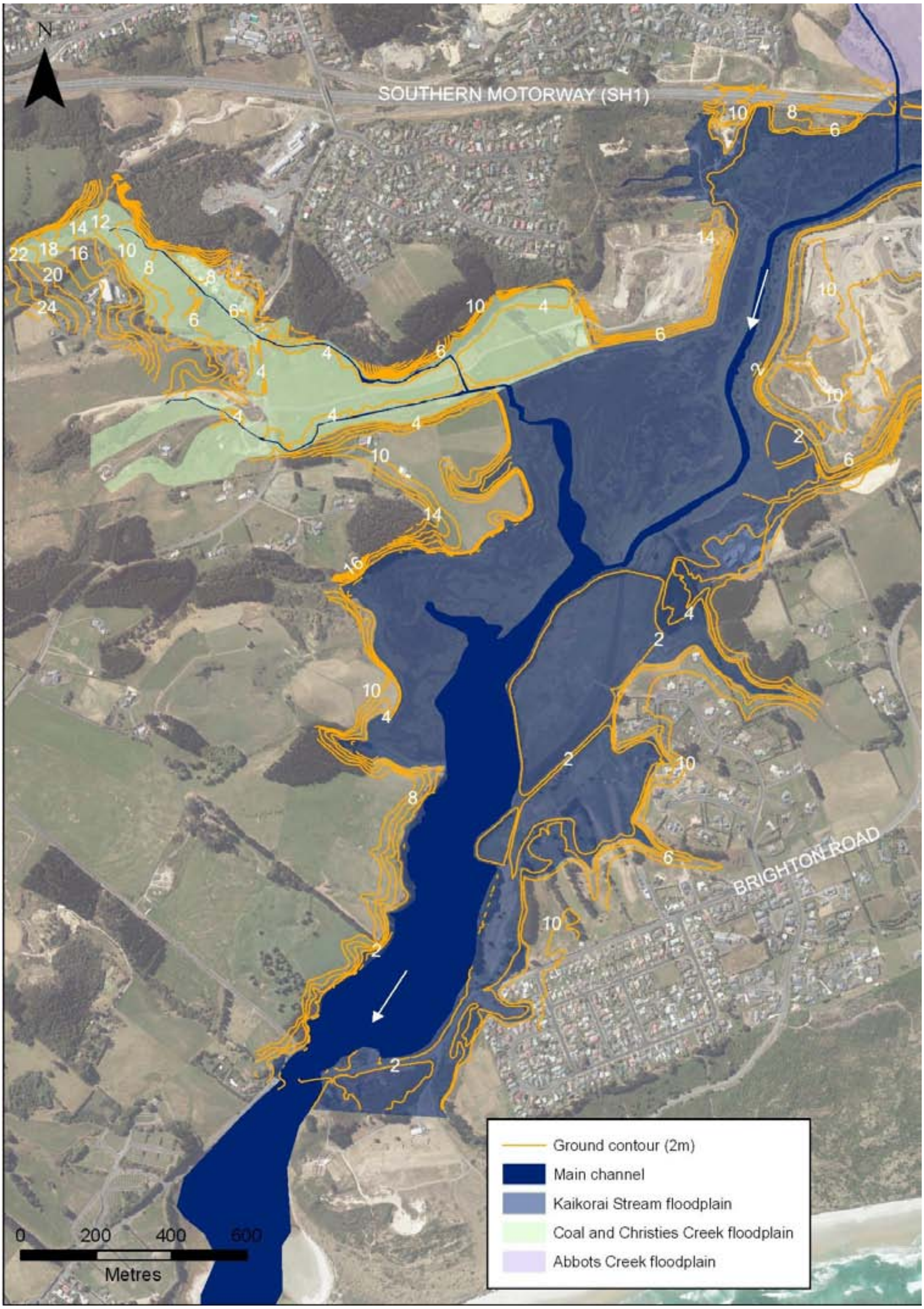

Figure 29 **Kaikorai Stream, and Coal Creek and Christies Creek floodplain area: Sunnyvale to the Brighton Road bridge.**

Appendix 2. Water of Leith floodplain maps

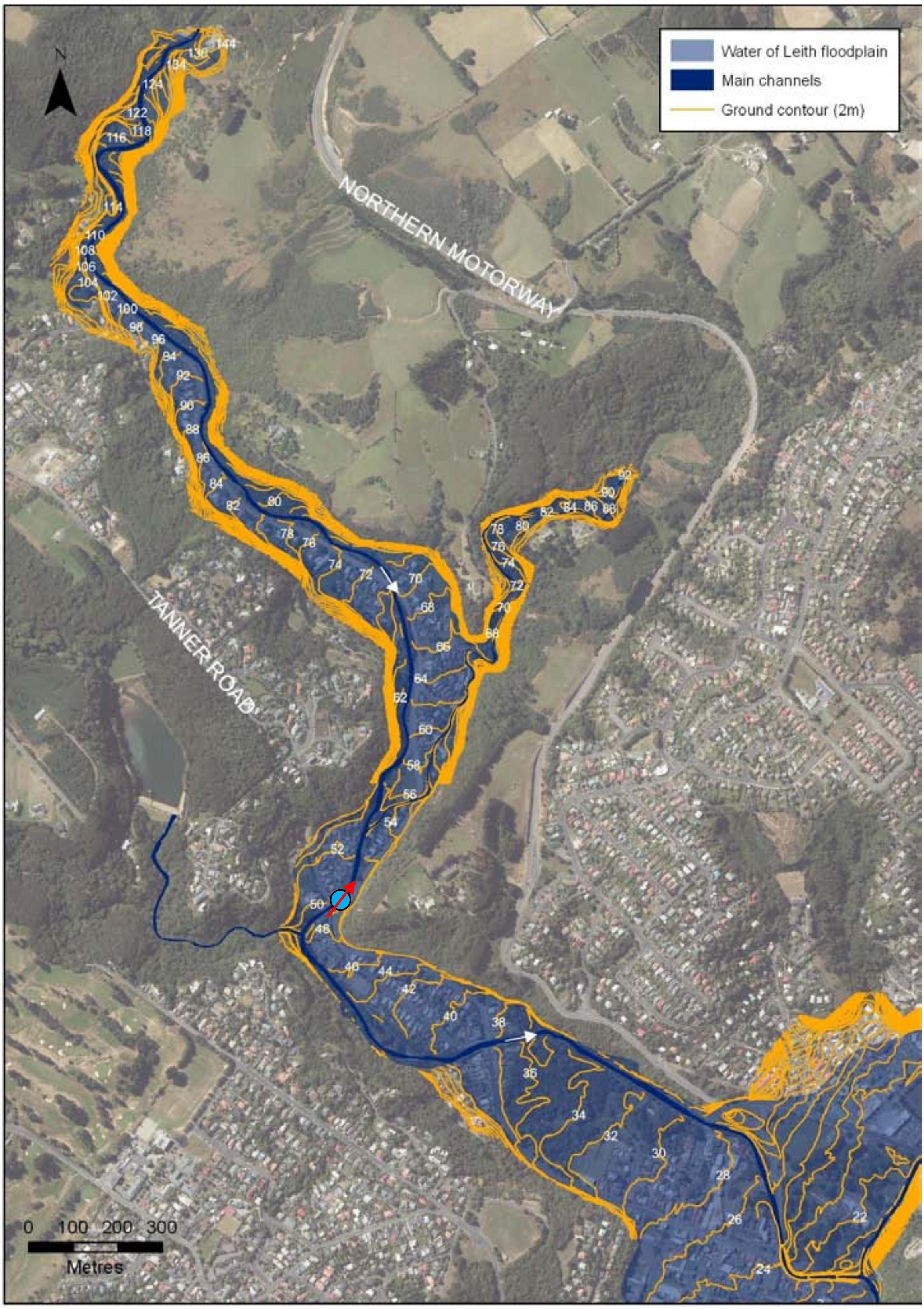

Figure 30 **Mapped floodplain areas in the upper Water of Leith catchment. The approximate direction and location of the photo in Figure 11 is also shown.**

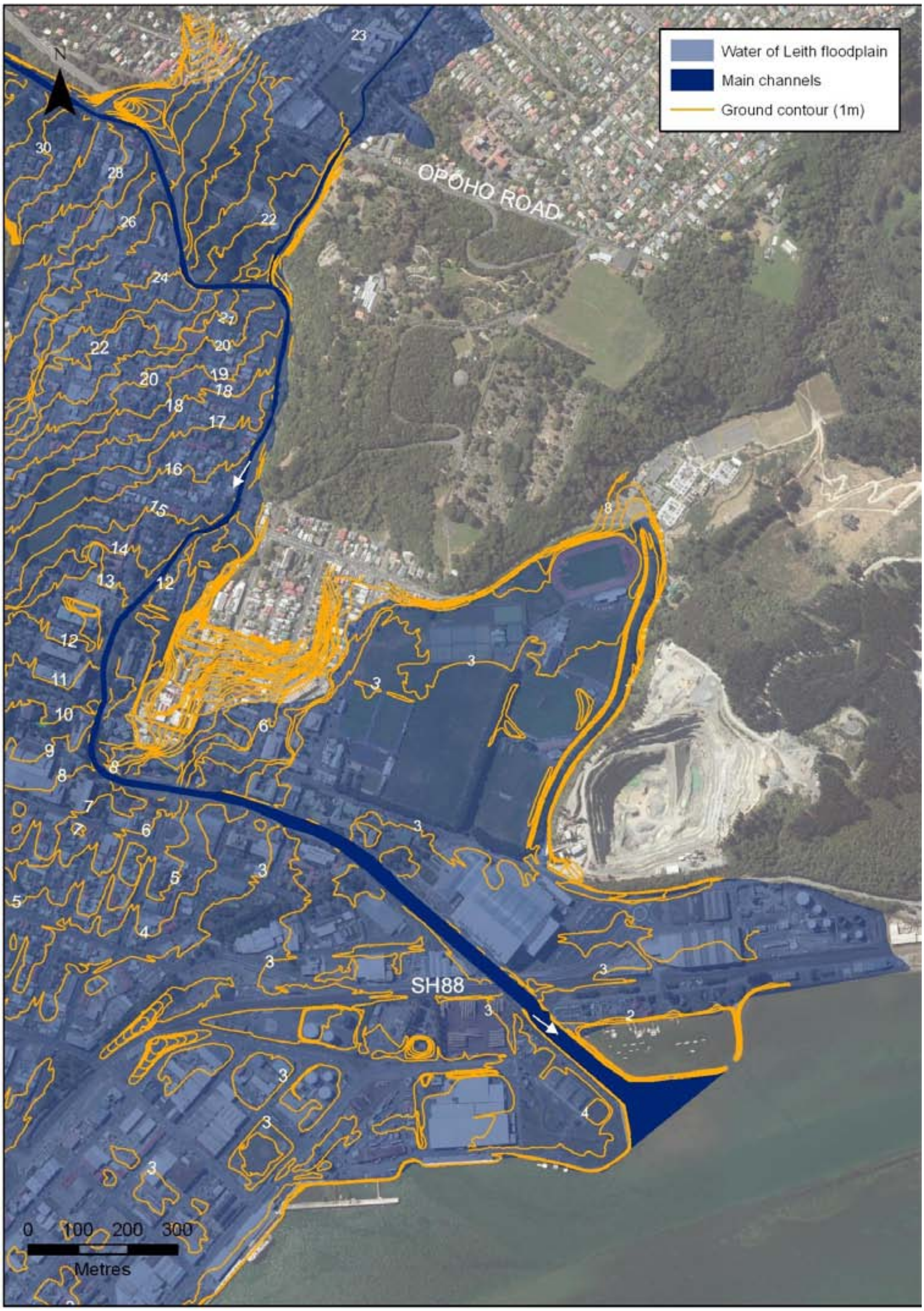

Figure 31 Mapped floodplain area in the mid Water of Leith catchment

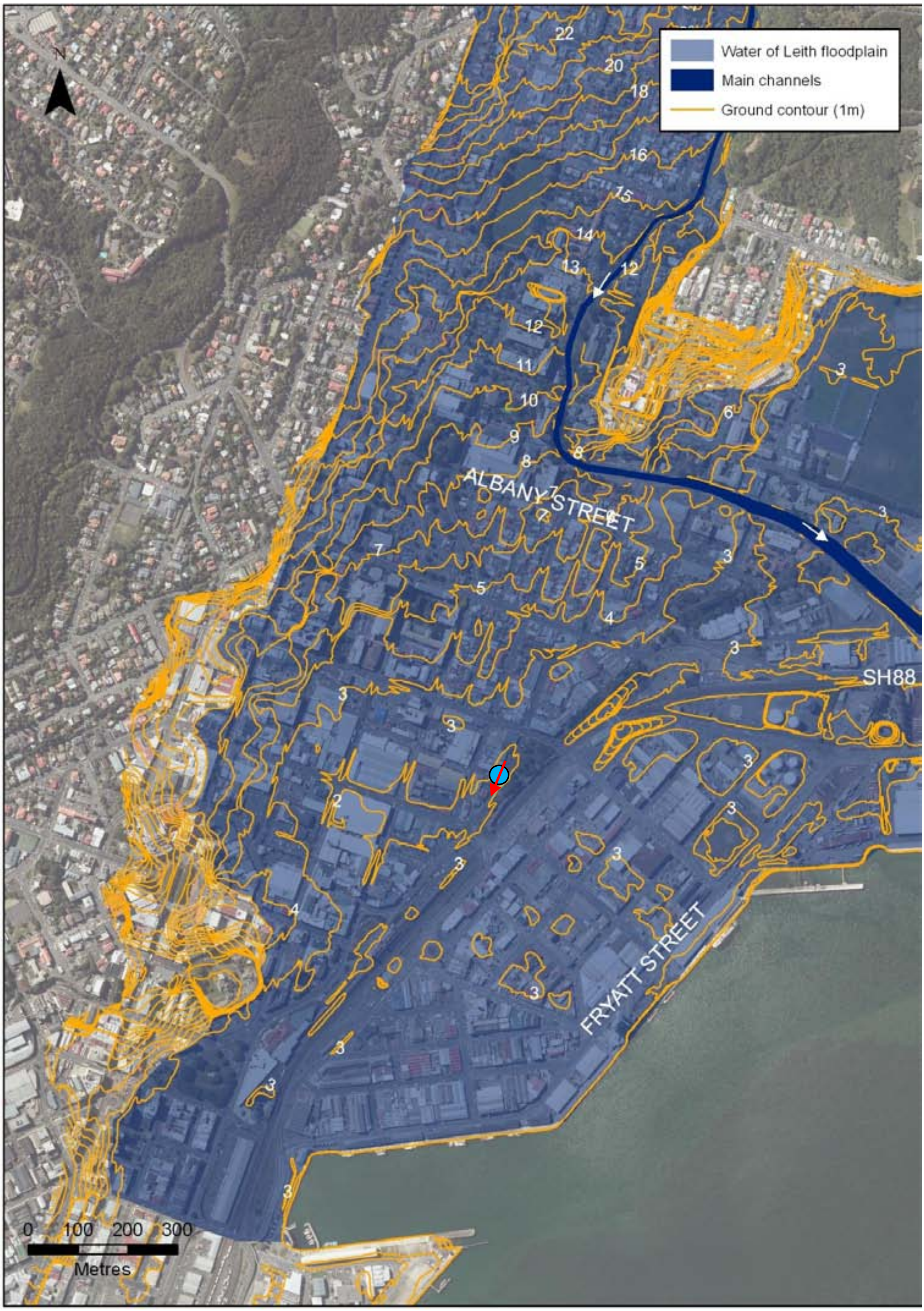

Figure 32 **Water of Leith - CBD reach floodplain area. The approximate direction and location of the photo in Figure 10 is also shown. The topography of the area to the south of Jetty Street is shown in Appendix 5.**

Appendix 3. Lindsay Creek floodplain maps

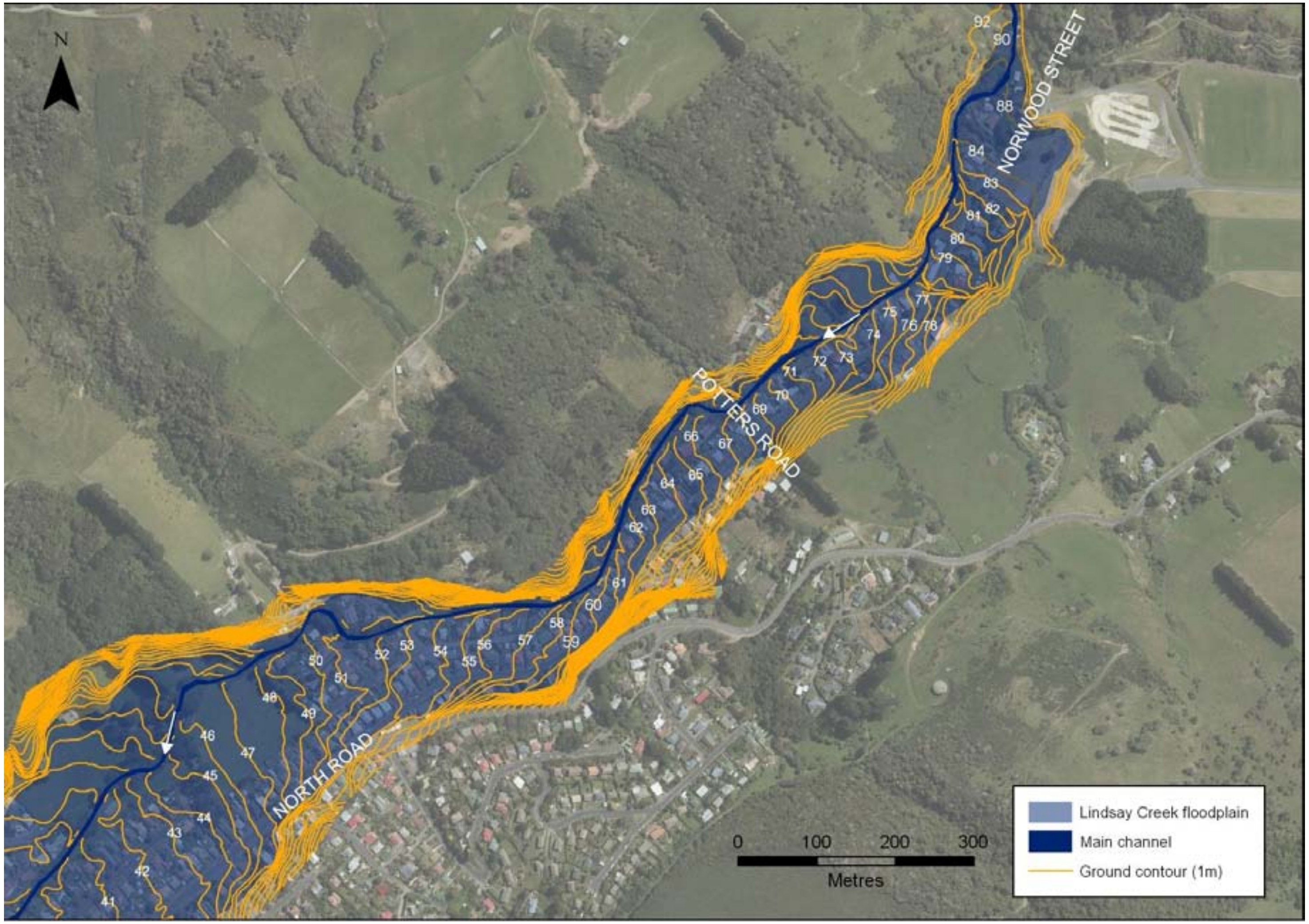

Figure 33 **Lindsay Creek floodplain area – upper reach**

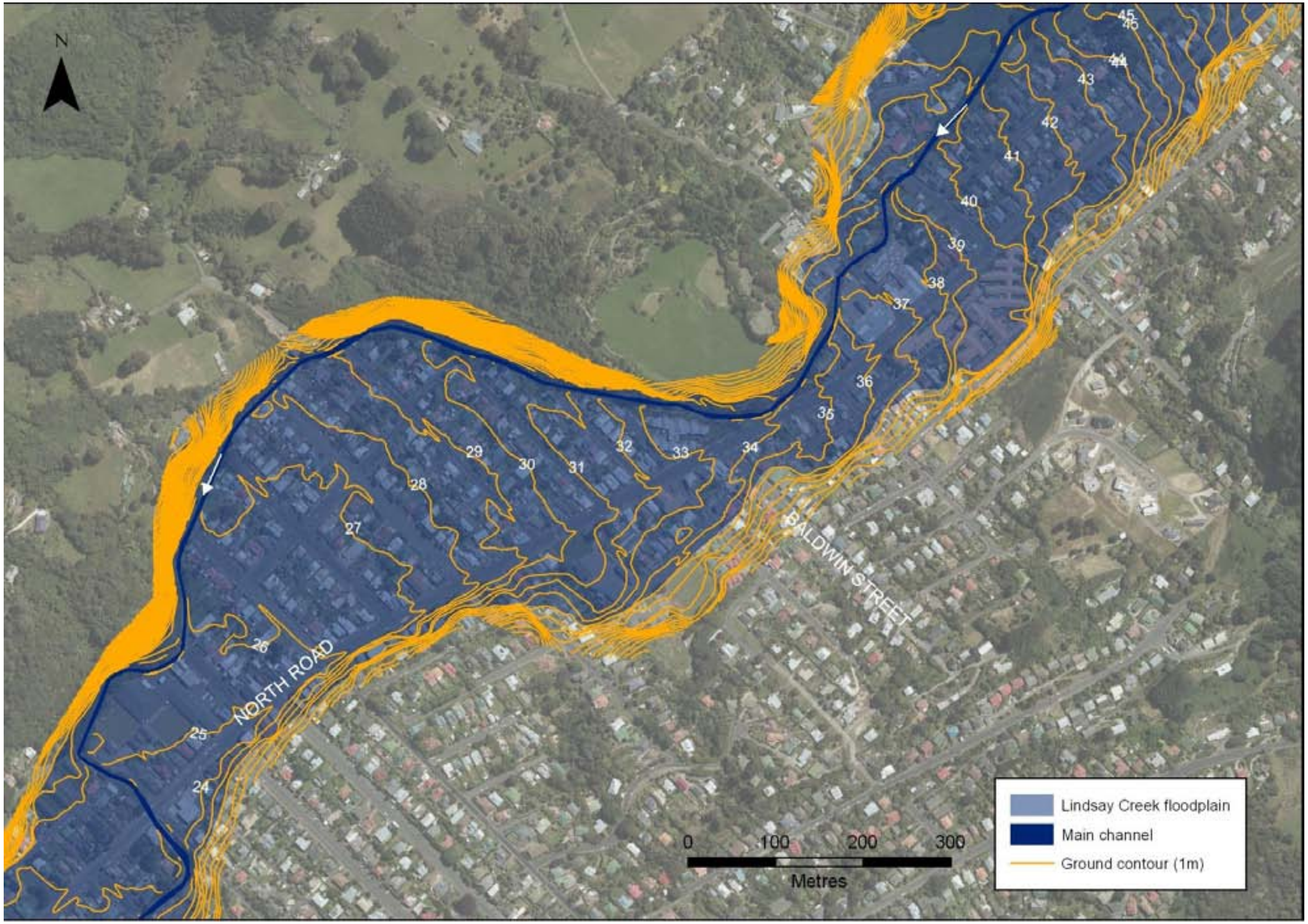

Figure 34 **Lindsay Creek floodplain area – middle reach**

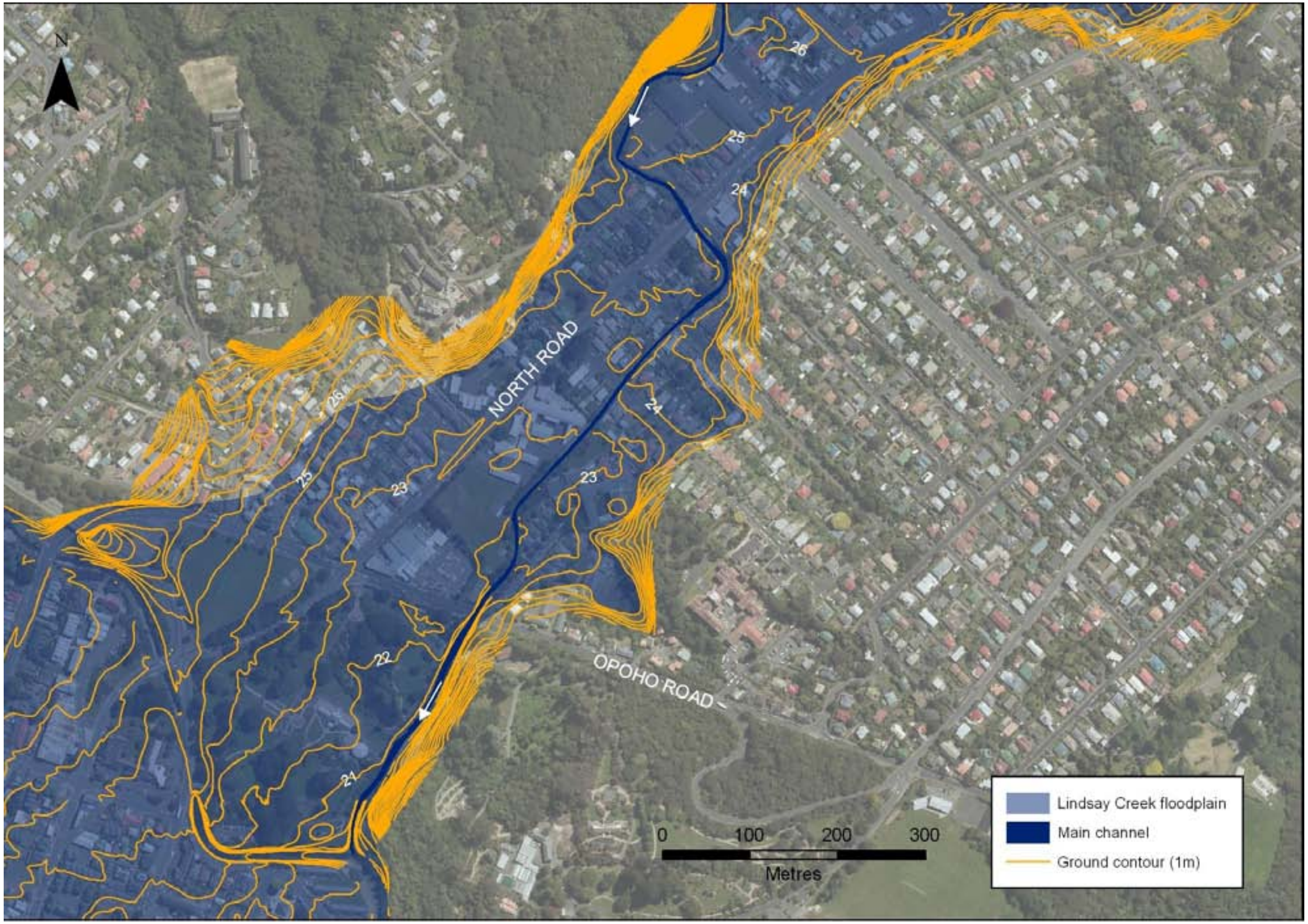

Figure 35 **Lindsay Creek floodplain area – lower reach**

Appendix 4. Previous flood-hazard maps

Figure 36 **Previously mapped flood-hazard area in the Water of Leith and Lindsay Creek catchments.**

Appendix 5. Topography of the area south of Jetty Street

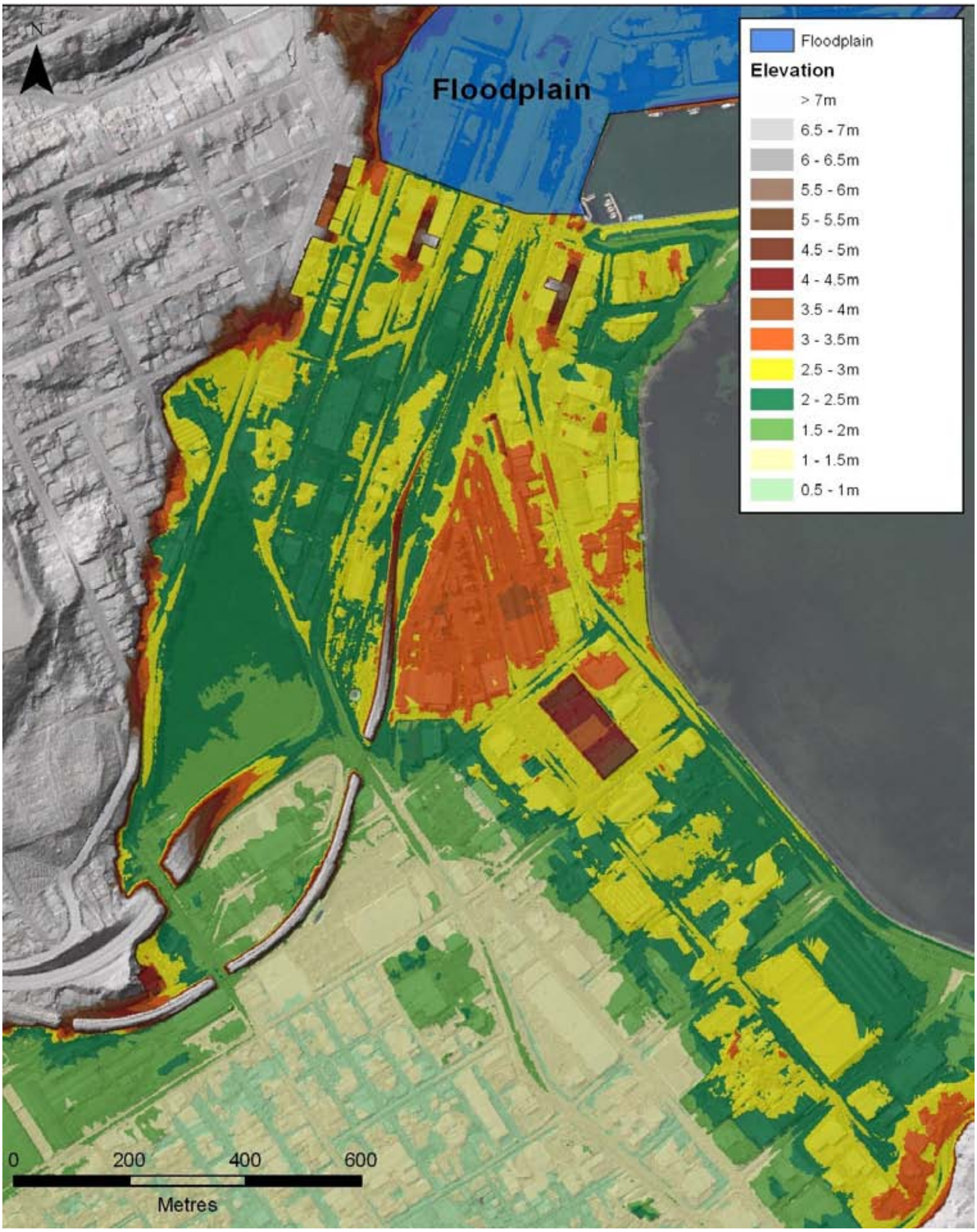

Figure 37 **Topography of the area between Jetty Street and the South City area**

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