Reconnaissance report on landsliding caused by the 19–20 June 2015 rainstorm in the Taranaki-Wanganui-Manawatu region

M.J. Page B.J. Rosser D.B. Townsend
J.M. Carey W. Ries

GNS Science Report 2015/47
September 2015

BIBLIOGRAPHIC REFERENCE

Page, M.J.; Rosser, B.J.; Townsend, D.B.; Carey, J.M.; Ries, W.F. 2015. Reconnaissance report on landsliding caused by the 19–20 June 2015 rainstorm in the Taranaki-Wanganui-Manawatu region. *GNS Science Report* 2015/47. 50 p. + Appendices

M.J. Page, GNS Science, PO Box 30368, Lower Hutt 5040, New Zealand
B.J. Rosser, GNS Science, PO Box 30368, Lower Hutt 5040, New Zealand
D.B. Townsend, GNS Science, PO Box 30368, Lower Hutt 5040, New Zealand
J.M. Carey, GNS Science, PO Box 30368, Lower Hutt 5040, New Zealand
W.F. Ries, GNS Science, PO Box 30368, Lower Hutt 5040, New Zealand

www.gns.cri.nz

ISSN 1177-2425 (Print)
ISSN 2350-3424 (Online)
ISBN 978-0-908349-18-0 (Print)
ISBN 978-0-908349-19-7 (Online)

CONTENTS

FIGURES

TABLES

APPENDICES

APPENDIX FIGURES

ABSTRACT

Heavy rainfall on the 19–20 June 2015 caused landsliding in the Taranaki-Wanganui-Manawatu hill country, over an area of about 8,900 km^2. GNS Science carried out two reconnaissance flights as part of a GeoNet Landslide Response, to gain an initial assessment of the landslide damage using oblique aerial photography. Horizons Regional Council and Taranaki Regional Council have engaged GNS Science to provide a regional perspective of landslide distribution and severity in their regions. This reconnaissance report is based on the photography obtained on those flights, and satellite imagery available at the time. GeoNet, a geohazards monitoring programme operated by GNS Science, funded the reconnaissance flights and access to satellite imagery.

A map of landslide distribution was produced to show approximate landslide extent and severity, using a severity scale of slight (<1% of hill slopes affected), moderate (1–10%) and severe (>10%). Areas of severe landsliding generally corresponded with areas where 48 hour rainfall totals exceeded 150 mm, and occur in the lower and mid reaches of the Whanganui, Whangaehu and Turakina catchments in the Horizons Regional Council area. In the Taranaki Regional Council area, areas of moderate to severe landsliding occur in the lower and mid reaches of the Whenuakura and Waitotara catchments, throughout the Patea catchment, in the hill country between Toko and Whangamomona, and in the upper Waitara catchment. Within these areas the steep dissected terrace-lands between Patea and Turakina were the most severely affected. The June 2015 storm affected much of the same area between Waverley and Woodville as the February 2004 storm, which was the largest on record. While the 2015 landsliding was not as severe across the region, locally some farmers report landsliding was worse than in 2004.

Landsliding was largely confined to areas in pasture, or recently planted or logged forest. Landsliding was infrequent in areas of indigenous forest and scrub, and closed canopy exotic plantation forest. Most landslides were shallow (1–2 m deep), and occurred on steep, north facing slopes between 20 and 35°. There were several large deep-seated landslides triggered by the storm in the Taranaki region. Streambank erosion was locally severe in the mid and lower reaches of the larger rivers.

The outlet channels of two prehistoric landslide-dammed lakes eroded during the storm, leading to a drop in lake level of about 6 m (equivalent to a loss of ~500 000 m^3 of water) in one case, and the complete draining of the lake in the other. These events highlight a need to investigate the potential for other barrier failures and resulting downstream flood hazard, associated with the many landslide-dammed lakes in the Taranaki and Horizons regions. Exposed landslide debris and lake-bed sediment may provide opportunities to identify the ages of these landslides and to compile a storm history for the region.

KEYWORDS

June 2015 storm, Taranaki-Wanganui-Manawatu, rainfall-induced landsliding, landslide distribution, streambank erosion, lake outlet erosion

1.0 INTRODUCTION

1.1 June 2015 Storm Event

The storm on the 19–20 June 2015 caused extensive landsliding in the hill country of Taranaki, Wanganui, Rangitikei and Manawatu districts, with associated flooding and sedimentation affecting many downstream urban and rural communities. Government estimates of the economic impact of the storm have recently been revised up to $275 M. The area affected extended from Waitara/Urenui in the north, to Levin in the south, and to Woodville in the east.

Numerous roads throughout the affected area were damaged, and many closed by landslides and flooding. A state of emergency was declared in Wanganui, Taranaki and Rangitikei. Several townships were isolated by floodwaters, including Waitotara (60 homes evacuated), Whangaehu, and Koitiata near the mouth of the Turakina River. Residents along the river in Wanganui were flooded, with around 400 people evacuated. The Wanganui River reached a record level of 9.1 m at the Town Bridge. Twenty five people were evacuated from Marton following flooding from the Tutaenui Stream. In Taranaki Regional Council area an estimated 100 rural households were initially isolated because of impassable roads, and in some cases were also without electricity, and about 60 local rural roads were blocked by landslides. In some cases repairs are expected to take months. The Government subsequently declared a medium-scale adverse weather event.

Rainfall for the event for the 19–20th June was between 150 and 250 mm in hill country of north Taranaki, and between 100 and 200 mm in the hill country of south Taranaki. In the Wanganui-Manawatu regions, rainfall was highest in the mid to lower reaches of all the main catchments and the upper reaches of the Whanganui catchment. Totals were between 100 and 200 mm, with highest totals in the Whanganui catchment. Totals in the upper reaches of the other main catchments were generally between 50 and 100 mm (Figure 1).

Return periods for the 48-hour rainfall maximums, for much of the hill country affected by landslides were highly variable (Table 1 and Table 2 and Appendix 1). However, in the mid reaches of the Whanganui, Whangaehu, Turakina and Rangitikei Rivers, return periods were generally between 40 and 100 years. In the south Taranaki region affected by landsliding, return periods for the 48 hr rainfall totals were generally between 20 and 50 years (estimated from HIRDS – High Intensity Rainfall Design System, http://hirds.niwa.co.nz). In the central Taranaki area (near Stratford) the return periods were generally between 10 and 35 years, and the rainfall in the area of localised severe landsliding near Uruti had a return period of about 35 years.

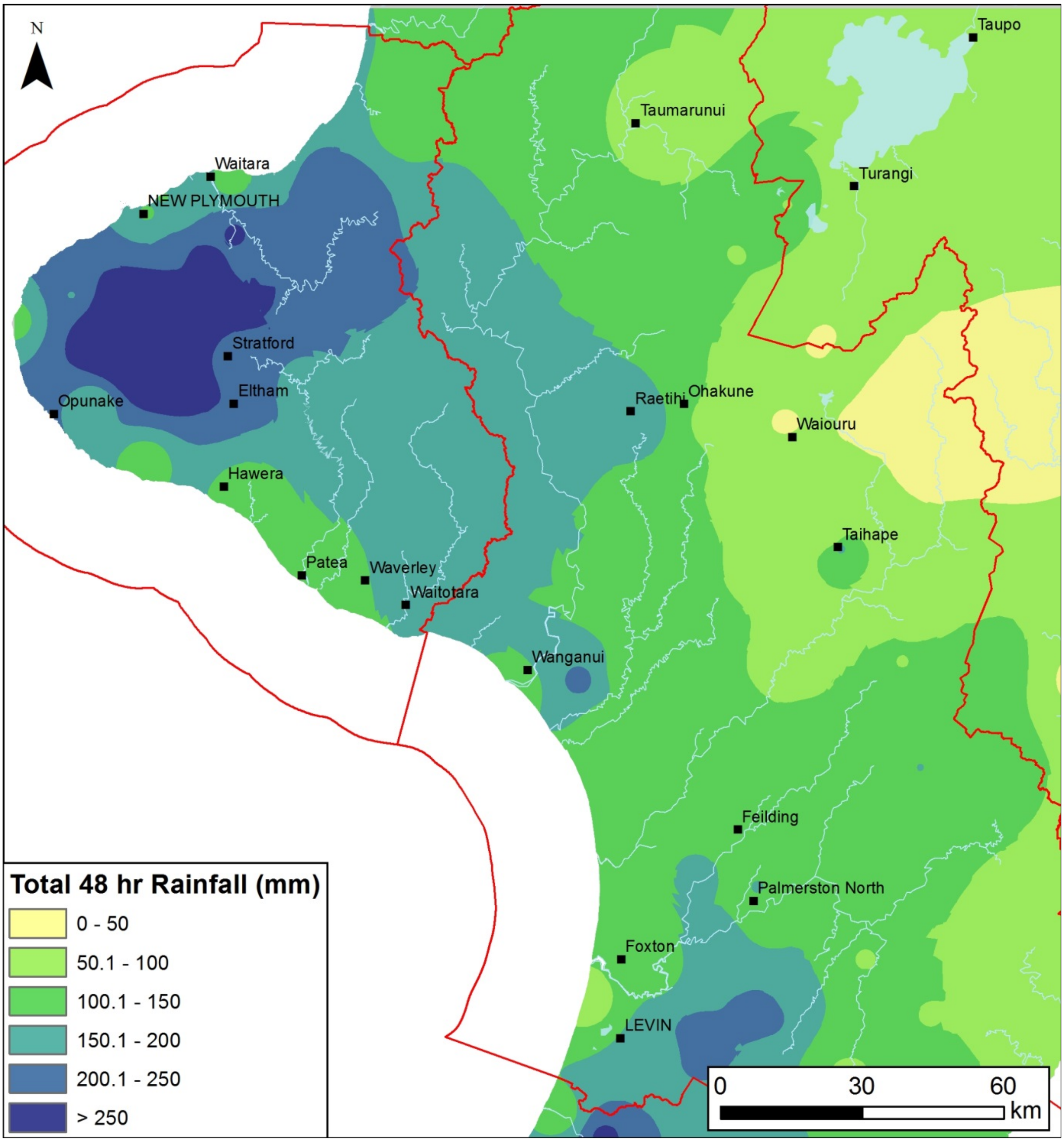


Figure 1 48-hour rainfall totals for the 19–20 June 2015 storm. Data from Taranaki Regional Council and Horizons Regional Council (Red lines show council boundaries).

Table 1 Average recurrence intervals (ARI) and 48-hr rainfalls for selected rainfall monitoring sites in the Taranaki Regional Council area.

Rainfall monitoring sites	48 hr rainfall (mm)	ARI (yrs)
North Egmont at Visitor's Centre	456	7
Dawson Falls	531.5	15
Kahui Hut	366	8
Mangorei at Reservoir	175.5	7
Hillsborough	187.5	7.5
Mangati at SH3	150	7.5
Waiwhakaiho at Egmont Village	238.5	8
Manganui at Everett Park	260	25
Inglewood at Oxidation Ponds	273.5	15
Patea at Stratford	209.5	15
Mangaehu at Bridge	178	35
Kotare at O'Sullivans	113	1.5
Uriti at Kaka Rd	244.5	35
Pohokura Saddle	231	15
Taungatara at Eltham Rd	154.5	10
Tawhiti at Duffy's	109.5	10
Patea at Bore 3	111.2	7
Omaru at Charlies	161.5	3
Omahine at Moana Trig	172.5	20
Waitotara at Rimunui Station	174	50
Waitotara at Ngutuwera	153.5	40

Table 2 Average recurrence intervals and 48-hr rainfalls for selected rainfall monitoring sites in the Horizons Regional Council area.

Rainfall monitoring site	48 hr rainfall (mm)	ARI (yrs)
Air Quality at Taihape	160.9	100+
Kahuterawa at Scotts Road	177.4	100+
Makino at Cheltenham	134.9	30
Makino at Halcombe Road	138.9	60
Makohine at Zohs Road	42.4	<1.5
Makuri at Bee 4 Trig	99.9	<1.5
Manawatu at Moutoa	125.2	55
Mangaetoroa at Scarrows	181.5	50
Mangaone at Milson Line	117	25
Mangatainoka at Hillwood Hukanui	206	40
Mangawhero at Aberfeldy	137.2	100
Mangawhero at Bangonie	141.4	40
Mangawhero at Raupiu Road	141.9	90
Matarawa at Matarawa Valley	110.9	10
Ngahere Park Climate Station	132.4	15
Ohura at Waitewhena Airstrip	117.5	1.5
Pakihikura at Pakihikura Airstrip	87.5	7.5
Pohangina at Makawakawa Divide	148.3	2
Porewa Catchment at Tututotara	143	75
Ruatiti at Ruatiti Station	187	7.5
Tapuae at Waituna West	109.8	15
Tiraumea at Alfredton	96.3	7.5
Turakina at Otairi	123.2	80
Tutaenui at Ribby Farm	149	80
Whangaehu at Kauangaroa	131.2	50
Whangamomona at Bridge to Somewhere	200	25
Whangamomona at Marco Road	213.2	15
Whanganui at Pipiriki	193.8	45
Whanganui at Te Rewa	150.6	25

1.2 SCOPE OF THE REPORT

Horizons Regional Council (Horizons) and Taranaki Regional Councils recognised that, following this event, there was a need to collect and analyse data on the nature and extent of the resulting landslides and other erosion processes, before this information was lost (e.g. due to revegetation). This information can then be used to support the regional councils and other end-users who may require this data for damage assessment purposes, and planning recovery and mitigation measures for future events.

Horizons Regional Council and Taranaki Regional Council engaged GNS Science to provide a reconnaissance-scale report to obtain a regional perspective of landslide distribution and severity in their regions. The report was to be based on reconnaissance flights and available satellite imagery. The reconnaissance flights and access to satellite imagery was funded by GeoNet.

The purpose of this reconnaissance was to identify the areas of moderate and severe landsliding, where detailed assessments could be undertaken to gather quantitative landslide and streambank erosion data. Such detailed assessments would involve analysis of aerial photography, field work and high-resolution satellite imagery. These data could then be used to inform Horizon's Sustainable Land Use Initiative (SLUI), and to improve SedNet NZ, a GIS model that routes sediment delivered from hill slopes and channel-bank failure processes through stream and river networks.

2.0 RECONNAISSANCE FLIGHTS

Two reconnaissance flights were undertaken as part of a GeoNet Landslide Response to the 19–20 June 2015 storm. The purpose of the flights was to gain an initial assessment of the extent and severity of landslide damage and to document the nature of the landsliding through oblique aerial photography. Following initial unsuitable weather conditions and aircraft availability issues, the first flight occurred on 13 July. This flight was undertaken by Mike Page and Dougal Townsend (GNS Science) in an Air Charter Manawatu Cessna 172 from Taonui Aerodrome near Feilding. The flight path was along the main river systems from the Whanganui catchment in the west, to the Pohangina River in the east, and then through the Manawatu Gorge as far east as the Puketoi Range (Figure 2). A total of 970 oblique photographs were taken. The second flight by Brenda Rosser and Dougal Townsend (GNS Science), took place on 23 July, again from Taonui Aerodrome. A total of 1190 photographs were taken. The flight path was along the upper Whanganui River as far as Tahora, west to Uruti in north Taranaki, and along the main river systems of the eastern Taranaki hill country south to the Waitotara River (Figure 2). The flight paths of these two flights only covered part of the very large area of landsliding. All place names referred to in this report are shown on a map in Appendix 2.

2.1 AERIAL PHOTOGRAPHS

The oblique aerial photos (n=2160) have been geo-located by synchronising their time of capture with a hand-held GPS track log. These photos have been supplied to Horizons and Taranaki Regional Councils (at half original resolution) as part of this report. Given the largely descriptive nature of the reconnaissance report, a large number of photos have been included to illustrate the observations that were made. Geological information included in photo figure captions is taken from QMap 1:250 000 Geological Map 7 (Townsend et al. 2008), Map 8 (Lee et al. 2011), and Map 11 (Lee and Begg 2002). Appendix 3 shows the location of each aerial photograph, classified according to landslide severity.

In addition to the oblique aerial photos taken on the GeoNet reconnaissance flights, Beef and Lamb NZ commissioned a series of vertical aerial photographs in the area between the Turakina Valley and Hunterville. Vertical aerial photography of a number of production forests between Wanganui and Hunterville have also been taken for Forest Companies. These data sources have not been used in the compilation of this report.

2.2 SATELLITE IMAGERY

The initial intention was to supplement information on the spatial extent and general severity of landsliding observed on the two reconnaissance flights, with information from satellite imagery taken after the storm. However, the weather conditions which had delayed the aerial reconnaissance meant that cloud-free images were not available. A number of medium resolution Digital Globe QuickView images with different post-storm dates were used to provide the “best” coverage available. However, the resolution was marginal at best, for identifying landslides. The imagery was best where landsliding was severe or in areas of woody vegetation. It was of very limited value in areas of pasture where landsliding was only slight or moderate. Because of the low sun-angle at this time of year, shadow effects are significant, and this further limited landslide identification, especially on south-facing slopes.

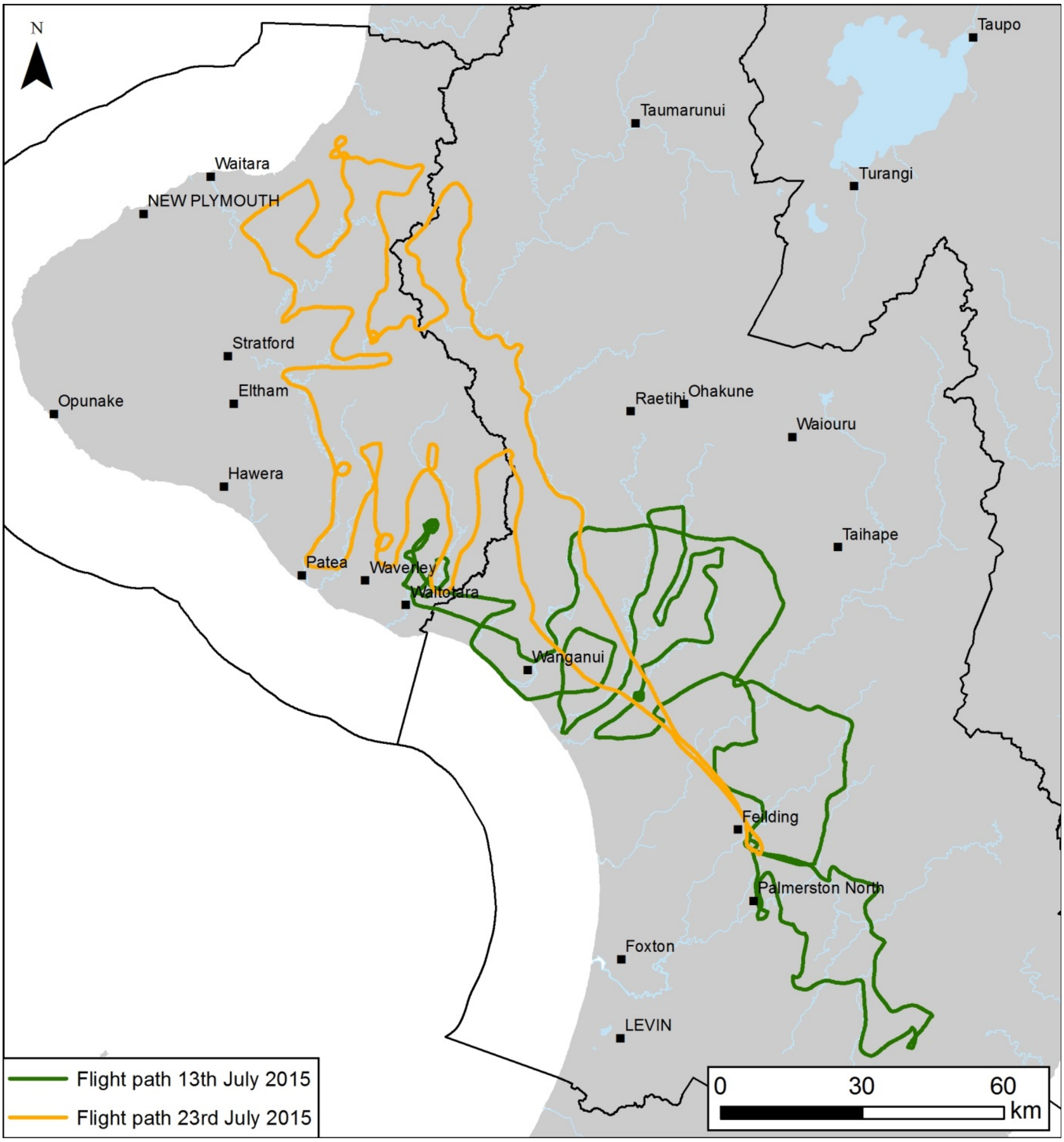


Figure 2 Flight paths for the two reconnaissance flights undertaken by GNS Science staff on 13 July and 23 July 2015.

3.0 LANDSLIDE SEVERITY AND DISTRIBUTION MAPS

Landslide severity was classified into three classes: slight (<1% of hill slopes affected) (Figure 3 and Figure 4), moderate (1–10%) (Figure 5–Figure 8), or severe (>10%) (Figure 9 and Figure 10). Because of the limited value of the satellite imagery, the map showing approximate landslide extent and severity (Figure 11) was largely based on the reconnaissance flights, with spatial extrapolation using storm rainfall and terrain characteristics. Landsliding classified as slight occurred across ~4600 km^2 of hill country, moderate landsliding across 3600 km^2, and severe across 700 km^2. Figure 12 shows the landslide extent and severity in the February 2004 storm, which was the most severe storm on record in the region (Hancox and Wright 2005a). A comparison of the extent of landsliding in the 2015 and 2004 storms is presented in Section 4.0. The severity scales for the 2015 and the 2004 maps are different. The 2004 assessment has four severity classes with narrow % landsliding ranges (<5%), while the 2015 assessment has only three severity classes with broader landslide % ranges (10%). The 2004 severity assessment was based on a combination of oblique and vertical aerial photos, satellite imagery and ground checking, The 2015 severity assessment was only based on the oblique aerial photos, with very limited information added from the satellite imagery, and this only provided sufficient information for the broader classification.

Given the often localised nature of intense rainfall, resulting localised areas of severe landsliding can be expected to occur within areas where landsliding is classified as moderate (Figure 13 and Figure 14). An example is the hill country east of Stratford (see Appendix 3). Nevertheless the maps, together with media reports, damage reports from a variety of agencies, and Horizons Regional Council information, are sufficient to identify the major areas of moderate and severe landsliding, where detailed assessments to gather quantitative landslide data could be undertaken. Such detailed assessments would involve analysis of aerial photography, field work and high-resolution satellite imagery.

Figure 3 Slight landsliding on mudstone/siltstone between Papanui Junction and Kakatahi, Whangaehu catchment. *(GNS Photo: D02_1181)*

Figure 4 Looking west near Poukiore, Turakina catchment. Slight landsliding in foreground on sandstone/ siltstone, and moderate landsliding in background. *(GNS Photo: D02_1158)*

Figure 5 Moderate landsliding on Shakespeare Group (Quaternary) marine sediments, 6 km east of Halcombe (north-facing slopes). *(GNS Photo: D02_1840)*

Figure 6 Moderate landsliding in Kiwitea Stream area, in Okehu Group Quaternary sandstone. *(GNS Photo: D02_1132)*

Figure 7 Moderate landsliding in foreground, in Quaternary sandstone. Upper Beehive Creek, Pohangina catchment. *(GNS Photo: D02_1119)*

Figure 8 Moderate landsliding on Quaternary sediments, Rangitikei Valley, 4 km northwest of Waituna West. *(GNS Photo: D02_1800)*

Figure 9 Severe landsliding, Makirikiri Valley. *(GNS Photo: D02_1510)*

Figure 10 Severe landsliding, Kai-Iwi catchment, Brunswick Rd in distance. Maxwell and Nukumaru Group sandstone/siltstone. (*GNS Photo: D02_1458)*

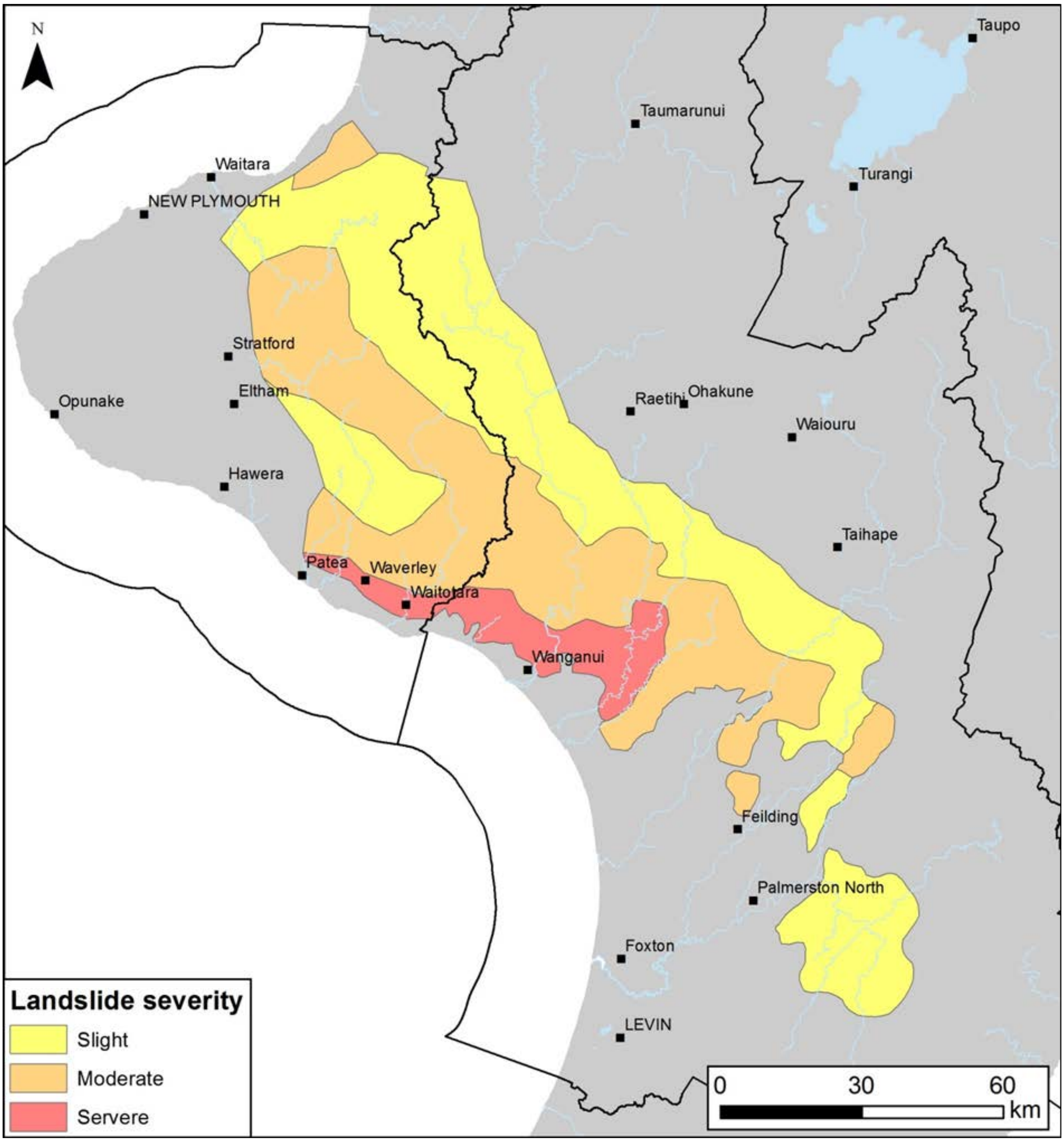


Figure 11 Map showing distribution of landslide severity in the June 2015 storm. Slight – <1% of hill slopes affected, Moderate – 1–10% of hill slopes affected, Severe – >10% of hill slopes affected.

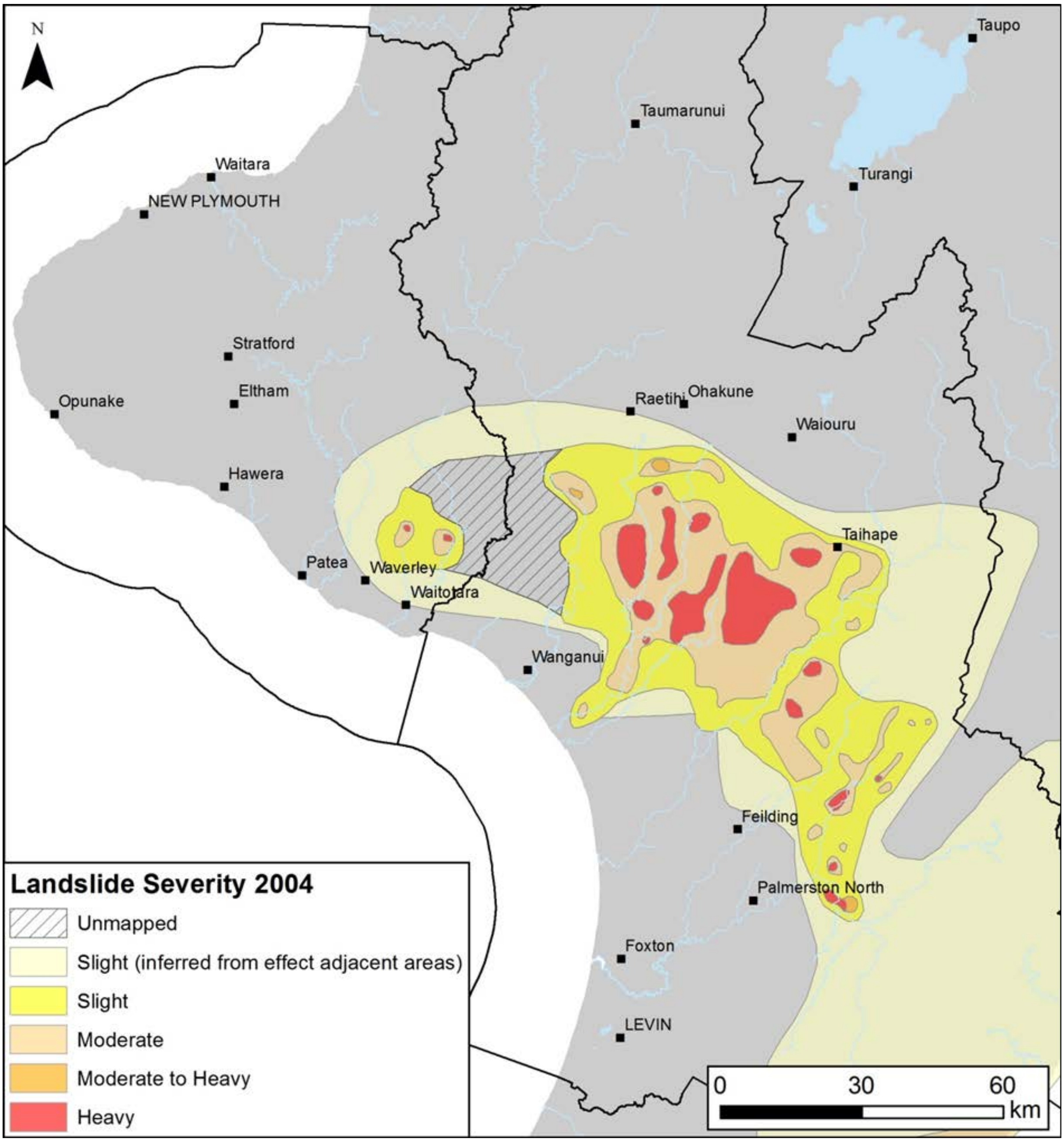


Figure 12 Map showing distribution of landslide severity in the February 2004 storm (from Hancox and Wright 2005a). Slight – <1% landsliding per km^2, Moderate – 1–2.5% landsliding per km^2, Moderate to heavy – 2.5–5% landsliding per km^2, Heavy – 5–10% (some areas 10–35%) landsliding per km^2.

Figure 13 Severe landsliding (centre of photo) within area where landsliding has been classified as moderate. Turakina Valley near Lakes Ngaruru and Namunamu. *(GNS Photo: D02_1708)*

Figure 14 Small area of severe landsliding on Kai-Iwi Group (Quaternary) sediments, Turakina Valley near Makuhou Rd. *(GNS Photo: D02_1734)*

3.1 OBSERVATIONS ON LANDSLIDING AND STREAMBANK EROSION IN HORIZONS REGIONAL COUNCIL AREA

1. Landsliding was generally confined to areas where 48-hour rainfall totals were >100 mm (Figure 1). This approximated an Average Recurrence Interval of between 20–100 years (from HIRDS).
2. Landsliding was largely confined to areas in pasture (Figure 15 and Figure 16), or recently planted or logged forest (Figure 17). Landsliding was less common in scrub (Figure 18, Figure 19, Figure 20), and infrequent in areas of indigenous forest and closed-canopy exotic plantation forest (Figure 21 and Figure 22).

Figure 15 Moderate landsliding on Kai-Iwi Group sandstone/siltstone with loess cover deposits, Makuhou Rd, near Marton Reservoirs. *(GNS Photo: D02_1764)*

Figure 16 Moderate landsliding on Pliocene sandstone, Whangaehu Valley, near Mangamahu. *(GNS Photo: D02_1649)*

Figure 17 Severe landsliding in areas of new plantings on Maxwell Group sandstone, Matariki Forest, Whangaehu Valley. *(GNS Photo: D02_1596)*

Figure 18 Moderate landsliding in scrub underlain by Pliocene sandstone, 5 km north of Parikino, on western side of the Whanganui River. *(GNS Photo: D02_1211)*

Figure 19 Moderate landsliding in scrub on Whenuakura Group sandstone, near Ridge Rd north of Ngutuwera, Waitotara catchment. *(GNS Photo: D02_1370)*

Figure 20 Moderate landsliding on scrub, Whangaehu Valley, 3.5 km north of Mangamahu. Note lack of landslides in exotic forest (background). *(GNS Photo: D02_1659)*

Figure 21 Indigenous forest and scrub on Whenuakura Group sandstone, near Mangawhio, Weraweraonga catchment. Note there are very few landslides. *(GNS Photo: D02_1382)*

Figure 22 Localised severe landsliding at Otairi, Turakina Valley. Note lack of landslides in exotic forest. *(GNS Photo: D02_1697)*

3. Given the above controls on landsliding, the areas affected were the mid to lower reaches of the rivers between Wanganui and Feilding. These are the Whanganui, Whangaehu, Turakina and Rangitikei Rivers and their tributaries.

4. The most severely affected areas were the steep dissected terrace lands between Maxwell and Halcombe (Figure 23, Figure 24, Figure 25), and also areas of Tertiary hill country in the mid reaches of the catchments between Hunterville and Wanganui (Figure 22 and Figure 26). The northernmost (inland) extent of landsliding was from Mangaweka, west to Papanui Junction, Oreore and Pipiriki.

Figure 23 Severe landsliding in Kai-Iwi Group (eQk) early Quaternary sandstone/siltstone terrace scarps. Note brown colour of landslides near ridge line, indicating presence of weathered tephra/tephric loess cover deposits. Head of Makirikiri Valley, lower Whanganui catchment. *(GNS Photo: D02_1504)*

Figure 24 Severe landsliding on scarps of Kai-Iwi Group marine terraces, Makirikiri Valley. *(GNS Photo: D02_1505)*

Figure 25 Severe landsliding in head of Matarawa Stream, north of Fordell. Note location of landslide initiation at terrace-scarp boundary. *(GNS Photo: D02_1496)*

Figure 26 Moderate landsliding with area of severe landsliding in centre. Pliocene sandstone, Parikino, Whanganui River. Note presence of old debris fans (in pasture) at foot of slope. *(GNS Photo: D02_1218)*

5. The majority of landslide failures can be classified as soil slides and soil flows.
6. Landslides were typically small to medium size (<100–1000 m^3), shallow (1–2 m deep) and occurred in regolith or cover beds (tephra and loess).
7. Most landslides occurred on steep slopes (~20–35°).
8. The most severe landsliding was on north facing slopes (Figure 27 and Figure 28). This observation was based on the reconnaissance flights.
9. In areas of severe landsliding both landslide scars and debris tails often coalesced with those of adjacent landslides (Figure 29 and Figure 30).

Figure 27 Severe landsliding on north facing scarp of Kai-Iwi marine terrace. Outskirts of Whanganui East in right background. Note coalescing of adjacent landslide scars and debris tails. *(GNS Photo: D02_1247)*

Figure 28 Severe landsliding on north facing terrace scarps, Okehu catchment, between Kai Iwi and Maxwell. Late Pliocene to early Quaternary sandstone/siltstone. *(GNS Photo: D02_1282)*

Figure 29 Severe landsliding at Mangamahu, on Pliocene sandstone. Coalescing of landslide debris tails has increased run-out distance. *(GNS Photo: D02_1653)*

Figure 30 Rangatira Rd east of Hunterville. Note gullying along debris tail path, and resulting deposition of bedrock material on lower slopes, and ponding of sediment-laden water beside road. *(GNS Photo: D02_1145)*

10. None of the many pre-existing, deep-seated large landslides that were seen were reactivated by the rainstorm, and it appears that no new ones were formed.
11. There appeared to be extensive streambank erosion along most rivers (Figure 31). Flood sediment has been deposited on the banks of these rivers during the falling stage of the flood, making it difficult at times to identify where bank erosion has occurred (Figure 32). A comparison of pre- and post-event satellite imagery should help to resolve this.

Figure 31 Example of streambank erosion and sediment deposition in the Waitotara Valley, just north of Rangitatau. Note fresh bank failures (exposed brown sediment) at right, and incision (gullying) of channelized flow into streambank. *(GNS Photo: D02_1318)*

Figure 32 Streambank erosion in the Waitotara Valley, just north of Puao. Note drape of fresh grey silt deposited on banks. *(GNS Photo: D02_1333)*

12. There appeared to be less streambank erosion along reaches of streams and rivers planted with willows.
13. Woody debris was largely absent from the sediment deposited on the floodplains of the major rivers. However, woody debris was observed on the beaches immediately south of the Whanganui River, and around the supports of a number of bridges.
14. Landsliding extended for several kilometres north and south of the Manawatu Gorge, and several kilometres into the hills east of Woodville (Figure 33), and several kilometres south of Pahiatua. Landsliding in this area was only slight, except for a small area of moderate landsliding near the Saddle Rd (Figure 34).

Figure 33 Slight landsliding east of Woodville. *(GNS Photo: D02_1888)*

Figure 34 Moderate landsliding on mudstone near Saddle Rd, north of Manawatu Gorge. *(GNS Photo: D02_1872)*

15. There are a number of large landslides in the Manawatu Gorge that periodically reactivate, at times blocking the highway for several weeks to several months. Almost all are failures associated with road cuttings. Following failures in 2004 and 2011, the largest of these landslides was cleared of surficial material, the slope benched, and drainage pipes installed in the rock face. During the June 2015 storm an area of the cleared head scarp of the landslide failed, and the resulting debris accumulated on three of the benches below (Figure 35).

Figure 35 Head scarp failure of pre-existing landslide in Manawatu Gorge. The landslide had been benched and drainage installed following major failures in 2004 and 2011. *(GNS Photo: D02_1859)*

16. The Anzac Park cliffs are located on an outside bend of the Manawatu River, opposite the Manawatu Golf Club in Palmerston North. There has been a recent increase in the rate of cliff retreat, including some rock fall during the 2014 Eketahuna earthquake (Rosser et al. 2014). Comparison of photos taken after the Eketahuna earthquake and the 2015 storm indicate further retreat during the 2015 storm (Figure 36).

Figure 36 Cliff failure along the Manawatu River at Anzac Park, Palmerston North. *(GNS Photo: D02_2080)*

17. Inevitably there have been reports in the media comparing the June 2015 storm with the February 2004 storm which is regarded as the most severe to have affected the Wanganui-Manawatu area in the last 100–150 year. Given that such storms characteristically contain cells of very high intensity rainfall, some farmers have reported that landsliding in 2015 was worse than in 2004 on their properties. However, overall landslide damage in 2015 is not considered as severe across the region as it was in 2004.

3.2 OBSERVATIONS ON LANDSLIDING AND STREAMBANK EROSION IN TARANAKI REGIONAL COUNCIL AREA

1. Landsliding was generally confined to areas where 48-hour totals were >150 mm (150–300 mm). This approximated an Average Recurrence Interval of between 10 and 50 years.
2. The highest 48-hour rainfall occurred near the Whangamomona saddle (200–220 mm) and the upper Whanganui River (>160 mm). This area is largely covered in indigenous forest and scrub or plantation forest.
3. Landsliding was largely confined to areas in pasture, or recently planted or logged forest. Landsliding also occurred in areas of indigenous forest and scrub, and closed canopy exotic plantation forest, although it was less common than in areas of pasture (Figure 37 and Figure 38)

Figure 37 Landslides on mature indigenous forest covered slopes in the Puniwhakau Stream catchment, a tributary to the Mangaehu Stream, Matemateaonga Range near Tututawa. Whangamomona Group sandstone. *(GNS Photo: D02_2767)*

Figure 38 Moderate landsliding on scrub covered slopes on Whangamomona Group sandstone on the Matemateaonga Range near Makahu. *(GNS Photo: D02_2788)*

4. The main areas affected by landsliding in the Taranaki Region were in the mid reaches of the Mimi River near Uruti, inland from Stratford in the upper reaches of the Patea and Waitara Rivers near Strathmore, and in the lower reaches of the rivers from Patea to Waitotara. These rivers included the Patea, Whenuakura and Waitotara Rivers, and their tributaries.
5. The most severe landsliding occurred near Strathmore, from Purangi in the north, Pohokura to the east, Te Popo to the west, and Matemateaonga in the south. This corresponded with 48-hour rainfall totals of 200–250 mm, largely in areas of pasture or regenerating scrub (on steep slopes) (Figure 39–Figure 43). Although this area was classified overall as moderate landslide severity, there were localised areas of severe landsliding (e.g. Figure 43).

Figure 39 Moderate landsliding near Makahu. Kiore Formation sandstone, Whangamomona Group. *(GNS Photo: D02_2486)*

Figure 40 Moderate landsliding on Miocene age Whangamomona Group Sandstone in the Mohakau Stream catchment near Huiroa (inland from Stratford). *(GNS Photo: D02_2721)*

Figure 41 Moderate landsliding on Miocene age Whangamomona Group Sandstone in the Mangaotuku Stream catchment, near Strathmore. *(GNS Photo: D02_2741)*

Figure 42 Moderate landsliding in the Mangaehu Stream catchment on Miocene age Whangamomona Group Sandstone. *(GNS Photo: D02_2758)*

Figure 43 Localised severe landsliding on Miocene age Whangamomona Group Sandstone in the Mangaehu Stream catchment near Tututawa. *(GNS Photo: D02_2796)*

6. A localised zone of moderate to severe landsliding occurred near Uruti, north of Waitara (Figure 44). The storm rainfall in this area was about 230 m, which corresponded to a 48-hour average recurrence interval of about 35 years (estimated from HIRDS).

Figure 44 Localised severe landsliding near Uruti, on Miocene age Mt Messenger Formation sandstone, Whangamomona Group. *(GNS Photo D02_2579)*

7. In the lower reaches of the Patea, Whenuakura and Waitotara Rivers, landsliding was particularly severe on terrace edges or steep hillsides adjacent to river channels (Figure 45).

Figure 45 Landsliding on steep hillsides adjacent to the Pokeka Stream, tributary of the Waitotara River. The landslides are formed on Whangamomona Group sandstone. *(GNS Photo D02_3095)*

8. In the Waitotara Valley there appears to have been areas where willows have been removed from streambanks between 2007 and 2012. In these areas there was significant streambank erosion in the June 2015 storm.
9. Despite the significant sedimentation, very little woody debris was deposited on the floodplain and alluvial terraces of the major rivers.
10. The majority of landslide failures can be classified as soil slides and soil flows.
11. Landslides were typically small to medium size (<100–1000 m^3), shallow (1–2 m deep) and occurred in regolith or cover beds (tephra and loess).
12. None of the many pre-existing, deep-seated large landslides that were seen were reactivated by the rainstorm. Ten newly developed deep seated, moderate to large landslides (>1,000 m^3) were seen in the Taranaki region. These were mostly in pasture or scrub-covered hill country inland from Stratford. Debris from two of these landslides had blocked streams, and small lakes had formed (Figure 46–Figure 48).

Figure 46 Large, deep-seated landslide near Whangamomona, in Whangamomona Group, siltstone. *(GNS Photo: D02_2516)*

Figure 47 Deep-seated landslide near Pohokura saddle, Waitara River, on Miocene age Whangamomona Group sandstone (Kiore Formation). Note the small lake formed upstream of the landslide debris. (*GNS Photo: D02_2620*)

Figure 48 Moderate deep-seated landslide near Huiroa (inland from Stratford) that blocked the channel of the stream below. The landside is in Miocene age Whangamomona Group Sandstone. (*GNS Photo: D02_2713*)

13. Most landslides occurred on steep slopes (~20–35°).
14. The most severe landsliding was on north-facing slopes.
15. As in the Manawatu region, in areas of severe landsliding, both landslide scars and debris tails often coalesced with those of adjacent landslides.
16. There appeared to be extensive streambank erosion of the alluvial terraces along most rivers (Figure 49–Figure 51).

Figure 49 Severe streambank erosion along the Mangaehu Stream, tributary to the Patea River. *(GNS Photo: D02_2802).*

Figure 50 Severe streambank erosion along the lower reaches Whenuakura River, near Patea. *(GNS Photo: D02_2920)*

Figure 51 Severe streambank erosion along the lower reaches Whenuakura River, near Patea. *(GNS Photo: D02_2930)*

17. There was less streambank erosion along reaches of streams and rivers planted with willows.
18. Lake Rotorangi on the Patea River was highly discoloured by sediment (Figure 52). Adjacent to the Patea Dam there is an ancient deep-seated landslide, on which there are pre-existing cracks that indicate landslide movement (Figure 53). It was not possible to determine if there had been any movement caused by the June 2015 rainstorm event. TransPower has installed equipment to monitor movement of the landslide, and analysis of these data could determine whether the rainstorm has had any effect on movement of the landslide.

Figure 52 Lake Rotorangi on the Patea River, upstream of the Patea Dam, discoloured by sediment. *(GNS Photo: D02_2845).*

Figure 53 The Patea Dam, and an ancient deep seated landslide to the centre right. Note pre-existing signs of movement on the landslide (cracks). However, it was not possible to determine whether the rainstorm had caused movement of the landslide. (*GNS Photo: D02_2856*)

3.3 STREAMBANK EROSION

Streambank erosion was common along the floodplains of all the major rivers. The Waitotara Valley appeared to be particularly severely affected (Figure 31 and Figure 32). In some instances bank erosion was obvious by the fresh crenulated outline of the banks, the sub-vertical angle of the banks and the brown colour of the exposed material. In many instances however, fresh grey silt has been deposited on the banks during the falling stage of the flood, and at times this drape of sediment made it difficult to identify fresh bank erosion.

In some instances, where channelised overland flow across the floodplain had entered the river, the channel had gullied back into the floodplain sediment (Figure 31).

4.0 COMPARISON WITH THE FEBRUARY 2004 MANAWATU-WANGANUI STORM

The 19–20 June 2015 storm was the largest to occur in the region since the February 2004 storm and floods. While on a regional scale the landsliding and flooding in 2015 was not as severe as in 2004, in some areas farmers have reported that the 2015 event was worse. This is to be expected as cells of high-intensity rain commonly occur within the broader rainfall pattern of such storms. Following the 2004 storm, two GNS Science Reports were published. The first report provides an initial assessment of the overall extent and location of landsliding, and illustrates the nature and types of landslides (Hancox and Wright 2005a). The second report contains a detailed analysis of factors that controlled the distribution of landslides, sediment delivery to streams, and landslide damage (Hancox and Wright 2005b). There are some broad similarities in the distribution of landsliding in 2015 and 2004 (Figure 11 and Figure 12). The main differences are that the 2015 event extended north from the Waitotara catchment to affect the eastern Taranaki hill country as far north as Waitara/Urenui, and in the south extended only as far as Woodville and Levin. In 2004 slight to moderate landsliding also occurred in the Wairarapa and Wellington regions. In the 2015 storm the most severe landsliding in the Horizons Regional Council area was nearer the coast, and occurred on the dissected terrace-lands and extended up to 40-45 km inland on Tertiary hill country between Waitotara and Feilding. In 2004 the same catchments were affected, but the most severe landsliding was further inland, in an area between 30 and 70 km from the coast. Overall landsliding occurred over an area of 8,900 km^2 in 2015, compared with 16,000 km^2 in 2004.

In the Wanganui-Manawatu districts where landsliding was significant, 2-day totals were between 100 and 200 mm in the 2015 storm, whereas in the 2004 storm the 3-day rainfall was between 140 and 200 mm. For the 2015 storm, return periods for the 48-hour rainfall maximum for much of the hill country affected by landslides, were between 10 and 50 years. However, in the mid reaches of the Whanganui, Whangaehu, Turakina and Rangitikei Rivers, return periods were between 40 and 100 years. In the 2004 storm, the return period for the 72-hour rainfall totals was about 100–150 years (Horizons Regional Council 2004).

5.0 LAKE MANGAWHIO

Lake Mangawhio is a small (8.3 ha) lake, ~17 km north of Waitotara township, at the head of a tributary of the Weraweraonga Stream which drains into the Waitotara River (Figure 54). During the storm the outlet of Lake Mangawhio eroded, leading to a drop in lake level of ~6m, a widening of the outlet channel of ~40 m and a deepening of ~20m. This was accompanied by a “blow out” of a culvert, which drains water from the lake (pers. comm. D. Potts, landowner) (Figure 55 and Figure 56). The lake is one of many landslide-dammed lakes in the southern Taranaki hill country. Although its age is unknown, the lake may date from around 1300 yr BP (Crozier and Pillans 1991, Crozier et al. 1995). The lake was viewed during the reconnaissance flight and eleven oblique photographs were taken of the lake and its surrounds. It appears that the estimated drop in lake level and the outlet dimensions are substantially correct. This would suggest a loss of ~500,000 m^3 of lake water. This is significant, and the landowner is concerned about further erosion and loss of lake water. Sediment from erosion of the outlet covered a 3–km length of valley floor downstream of the landslide debris that originally formed the lake, as far as the junction with the next valley (Figure 57). It is unknown how much further downstream the sediment extends, or how far any impact from the loss of lake water extended. The lake is administered by DoC, and the access road is a county road maintained by South Taranaki District Council (STDC). In 2004 or 2006 STDC upgraded the road following a storm, and replaced the bridge crossing the outlet stream from the lake with a culvert.

Examination of a Google Earth image from March 2001 shows a small road/track that crosses the base of the landslide debris, just above the outlet stream. At this time, the outlet channel was stable (although a very small subsidence can be seen below the road 200m south of the lake). A Google Earth image in May 2007 shows the substantial upgrade of the road, and significant erosion of the channel below where the road crosses the outlet (~120 m below outlet). Sediment can be seen covering the valley floor downstream for a length of 1.5 km.

The outlet of a 2.1 ha lake in a small catchment between the Kaikanui and Hetore Streams on the Whenuakura River also eroded during the storm, leading to complete drainage of the lake (Figure 58). In this case Google Earth images show an access track existed across the outlet since at least April 2001 (Figure 59). The small size of the catchment together with the relatively wide valley floor at the head of the lake indicate an abundant supply of sediment, and suggest that the sediments exposed in the lake bed may contain a storm history record.

Figure 54 Lake Mangawhio, a prehistoric landslide-dammed lake on a tributary of the Weraweraonga Stream**,** Waitotara catchment. Incision of the outlet channel can be seen (centre). *(GNS Photo: D02_1422)*

Figure 55 Outlet channel of Lake Mangawhio showing incision that occurred during June 2015 storm. Note location of the county road, and the point where it crossed the outlet channel. *(GNS Photo: D02_1420)*

Figure 56 Outlet of Lake Mangawhio, showing drop in lake level and exposed lake margin. *(GNS Photo: D02_1393)*

Figure 57 Sediment covering the valley floor downstream of Lake Mangawhio. *(GNS Photo: D02_1388)*

Figure 58 Small, unnamed lake near Karahaki, Whenuakura catchment. The lake drained following incision of the outlet channel in the June 2015 storm. Note incision of outlet channel, farm track across outlet and gullying within the lake-bed sediments. *(GNS Photo: D02_2946)*

Figure 59 Google Earth image (September 2013) showing lake, outlet and access track prior to failure.

These are the only observed instances of pre-existing landslide-dammed lakes being affected by erosion of the landslide debris that led to their formation, and there are numerous such lakes in the south-eastern Taranaki hill country. Further, none were affected by the 2004 storm. In the case of Lake Mangawhio, it may be that the upgrade of the road and establishment of the culvert were instrumental in the erosion of the outlet channel and drop in lake level during the June 2015 storm. Similarly, for the small lake in the Whenuakura catchment, it would appear that culverting of the outlet under the access track around the lake may have been instrumental in the erosion of the outlet channel and subsequent draining of the lake.

Once access is restored to these sites, GNS Science recommends that field visits be made to investigate the circumstances leading to the drop in lake levels, the consequences of a rapid release of water on flood levels downstream, assess the future stability of the channels, and potentially collect organic material from the exposed landslide debris and lake sediments for radio-carbon dating.

6.0 CONCLUSIONS

The June 2015 storm significantly affected areas of hill country in Horizons and Taranaki Regional Council regions. There was widespread flooding, landsliding and erosion of varying severity across the regions. Sediment-generating processes operating along major water courses were significantly affected. This reconnaissance report provides an initial regional perspective on the spatial extent and severity of landsliding in both the Horizons and Taranaki Regional Council regions. Whilst the number of landslides caused by this event has not been identified, the reconnaissance indicates that the event is of national significance. There is now an opportunity to collect detailed data for key sites, to quantify sediment contributions from landslides and streambank erosion during such regional storms. Such data would support and inform Horizons' Sustainable Land Use Initiative, and improve SedNet NZ, which Horizons uses to model sediment generation and distribution. Collection of these data would be of national benefit as SedNet NZ is used by a number of councils.

7.0 ACKNOWLEDGEMENTS

We thank Sally Dellow and Mauri McSaveney (GNS Science) for their thorough and insightful comments in reviewing this report.

8.0 REFERENCES

Crozier, M.J.; Pillans, B.J. 1991. Geomorphic events and landform response in south-eastern Taranaki, New Zealand. *Catena 18:* 471-487.

Crozier, M.J.; Deimel, M.S.; Simon, J.S. 1995. Investigations of earthquake triggering for deep-seated landslides, Taranaki, New Zealand. *Quaternary International 25:* 65-73.

Hancox, G.T.; Wright, K. 2005a. Landslides caused by the February 2004 rainstorms and floods in southern North Island, New Zealand. *GNS Science Report 2005/10. 33p.*

Hancox, G.T.; Wright, K. 2005b. Analysis of landsliding caused by the 15-17 February 2004 rainstorm in the Wanganui-Manawatu hill country, southern North Island, New Zealand. *GNS Science Report 2005/11. 64p.*

Horizons Regional Council, 2004. Storm: Civil Emergency – Storm and Flood Report. *Horizons Regional Council Report Number 2004/EXT/591, September 2004.*

Lee, J.M.; Begg, J.G. (compilers) 2002. Geology of the Wairarapa area. Institute of Geological and Nuclear Sciences 1:250 000 geological map 11. 1 sheet + 66 p. Lower Hutt, New Zealand. Institute of Geological and Nuclear Sciences Limited.

Lee, J.M.; Bland, K.J.; Townsend, D.B.; Kamp, P.J.J. (compilers) 2011. Geology of the Hawke's Bay area. Institute of Geological and Nuclear Sciences 1:250 000 geological map 8. 1 sheet + 93 p. Lower Hutt, New Zealand. GNS Science.

Rosser, B.J.; Townsend, D.B.; McSaveney, E.; Reis, W. 2014. Landslides and ground damage associated with the M6.2 Eketahuna earthquake, 20 January 2014. *GNS Science Report 2014/51. 34p.*

Townsend, D.B.; Vonk, A.; Kamp, P.J.J. (compilers) 2008. Geology of the Taranaki area. Institute of Geological and Nuclear Sciences 1:250 000 geological map 7. 1 sheet + 77 p. Lower Hutt, New Zealand. GNS Science.

APPENDICES

This page is intentionally left blank.

A1.0 APPENDIX 1 – RAINFALL MONITORING SITES

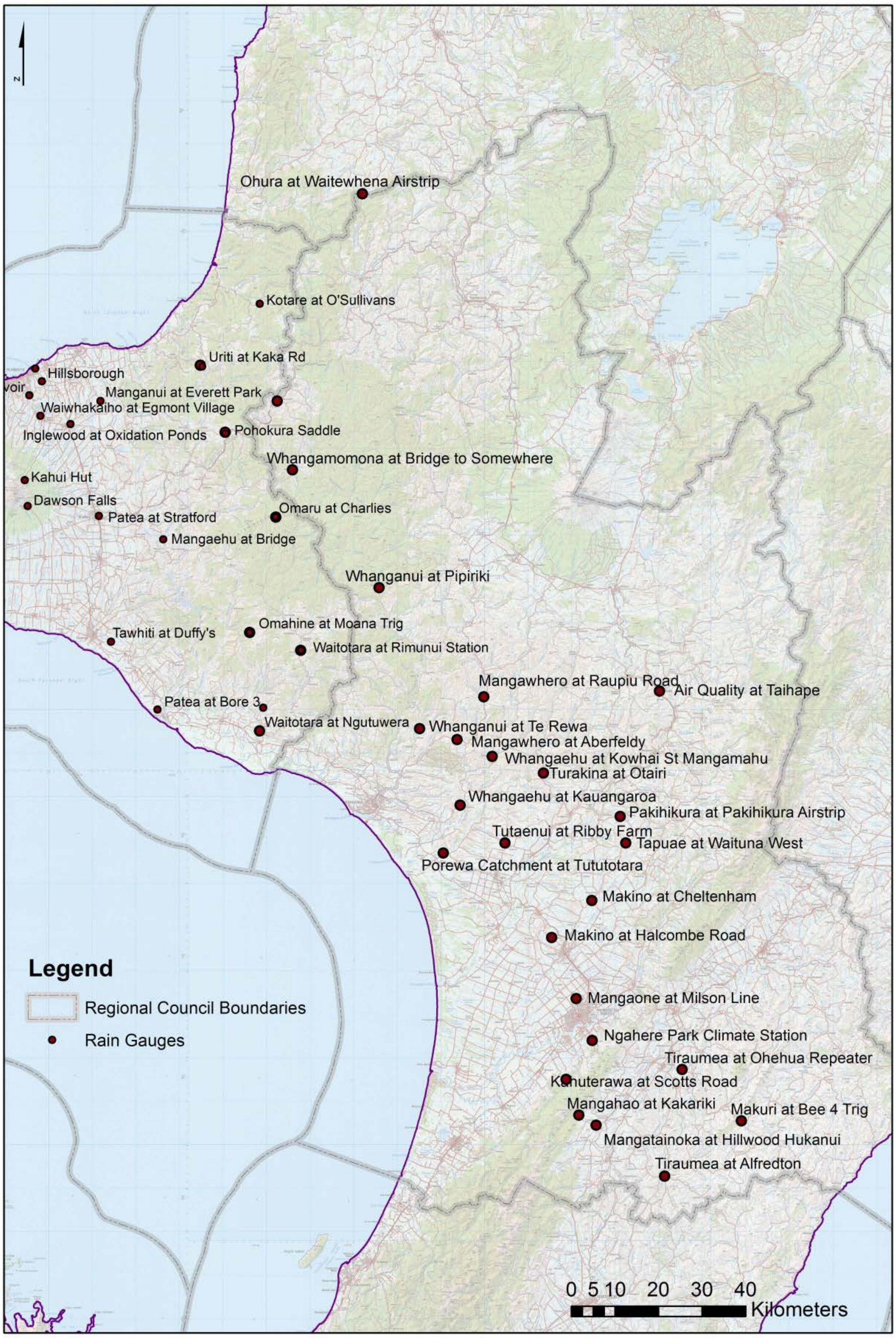
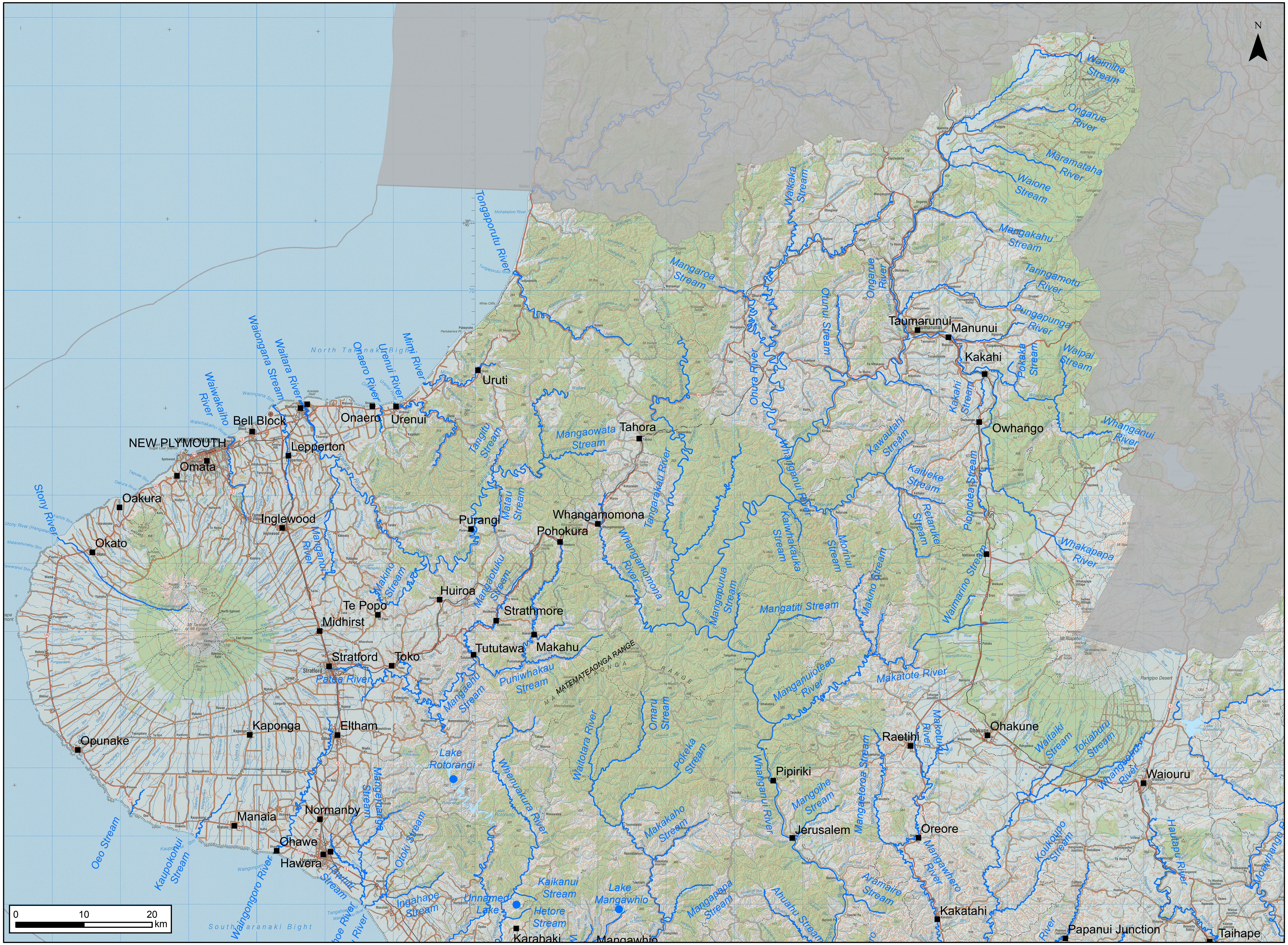


Figure A1.1 Location of rainfall monitoring sites from Table 1 and Table 2.

A2.0 APPENDIX 2 – PLACE NAMES

Figure A2.1 Location of place names used in the text.



N
NEW PLYMOUTH
Bell Block
Omata
Oakura
Okato
Lepperton
Inglewood
Onaero
Urenui
Uruti
Tahora
Purangi
Whangamomona
Pohokura
Huiroa
Te Popo
Midhirst
Strathmore
Makahu
Tututawa
Stratford
Toko
Kaponga
Eltham
Opunake
Manaia
Normanby
Ohawe
Hawera
Pipiriki
Jerusalem
Raetihi
Ohakune
Oreore
Waiouru
Kakatahi
Papanui Junction
Taihape
Karahaki
Mangawhio
Taumarunui
Manunui
Kakahi
Owhango
MATEMATEAONGA RANGE
North Taranaki Bight
South Taranaki Bight
Stony River
Waiwakaiho River
Waiongana Stream
Waitara River
Onaero River
Urenui River
Mimi River
Tongaporutu River
Mangaroa Stream
Waitaka Stream
Ohura River
Otunui Stream
Ongarue River
Waimiha Stream
Ongarue River
Maramataha River
Waione Stream
Mangakahu Stream
Taringamotu River
Pungapunga River
Waipai Stream
Pokaka Stream
Kakahi Stream
Whanganui River
Kawautahi Stream
Kaitieke Stream
Retaruke Stream
Piopiotea Stream
Whakapapa River
Waimarino Stream
Makotote River
Mangaowata Stream
Tangitu Stream
Waitaanga Stream
Tangarakau River
Whangamomona River
Kaiwhakauka Stream
Mangapurua Stream
Mangatiti Stream
Makino Stream
Manganuioteao River
Makino Stream
Mangaehu Stream
Patea River
Manganui River
Mangaotuku Stream
Puniwhakau Stream
Mangaehu Stream
Waitotara River
Omaru Stream
Pokeka Stream
Whenuakura River
Lake Rotorangi
Mangaroa Stream
Otoki Stream
Makakaho Stream
Mangoihe Stream
Mangaetoroa Stream
Mangawhero River
Makotuku River
Waitaiki Stream
Tokiahuru Stream
Whangaehu River
Hautapu River
Moawhango River
Oeo Stream
Kaupokonui Stream
Waingongoro River
Tawhiti Stream
Ingahape Stream
Unnamed Lake
Kaikanui Stream
Hetore Stream
Lake Mangawhio
Mangapapa Stream
Aramaire Stream
Kauhipo Stream
0
10
20
km

N
Patea
Waverley
Karahaki
Mangawhio
Puao
Ngutuwera
Waitotara
Maxwell
Kai iwi
Brunswick Road
Ridge Road
Parikino
Kakatahi
Papanui Junction
Taihape
Mangaweka
Mangamahu
Otairi
Poukiore
Matariki Forest
Makirikiri Valley
Wanganui
Fordell
Hunterville
Rangatira Road
Makuhou Road
Whangaehu
Ratana
Turakina
Koitiata
Marton
Marton Reserviors
Kimbolton
Norsewood
Halcombe
Bulls
Sanson
Feilding
Rongotea
Bunnythorpe
Saddle Road
Manawatu Gorge
Woodville
Dannevirke
Tangimoana
Himatangi Beach
Palmerston North
Longburn
Anzac Park Cliffs
Linton
Foxton Beach
Foxton
Tokomaru
Mangamutu
Pahiatua
Waitarere
Shannon
Hokio Beach
LEVIN
Pongaroa
Eketahuna
Waikawa Beach
Lake Mangawhio
Unnamed Lake
Lake Namunamu
Lake Ngaruru
Kaikanui Stream
Hetore Stream
Werawera Stream
Mangapapa Stream
Ahuanu Stream
Aramaire Stream
Kauarapaoa Stream
Karemu Stream
Urukongaro Stream
Turakina River
Makohine Stream
Patea River
Whenuakura River
Waitotara River
Okehu Stream
Kai Iwi Stream
Whanganui River
Kaitoke Stream
Whangaehu River
Turakina River
Matarawa Stream
Mangamahu Stream
Mangapapa River
Omanga Stream
Porewa Stream
Rangitikei River
Mangawharariki River
Mangamako Stream
Kawhatau River
Pourangaki River
Whakaurekou River
Waiokotore Stream
Mangatera River
Maropea River
Makiekie Creek
Pohangina River
Makawakawa Stream
Manawatu River
Mangatera Stream
Mangapuaka Stream
Tamaki River
Waituna Stream
Kiwitea Stream
Oroua River
Beehive Creek
Makirikiri Stream
Tutaenui Stream
Mangaone West Stream
Makowhai Stream
Rangitikei River
Mangaone Stream
Pohangina River
Manawatu River
Mangapuaka Stream
Mangahao River
Makuri Stream
Kahuterawa Stream
Mangatainoka River
Tiraumea Stream
Owahanga River
Akitio River
Wainui River
Mangamaire Stream
Ohau River
PUKETOI RANGE
RUAHINE RANGE
TARARUA RANGE
Cape Turnagain
0
10
20
km

A3.0 APPENDIX 3 – PHOTO LOCATIONS

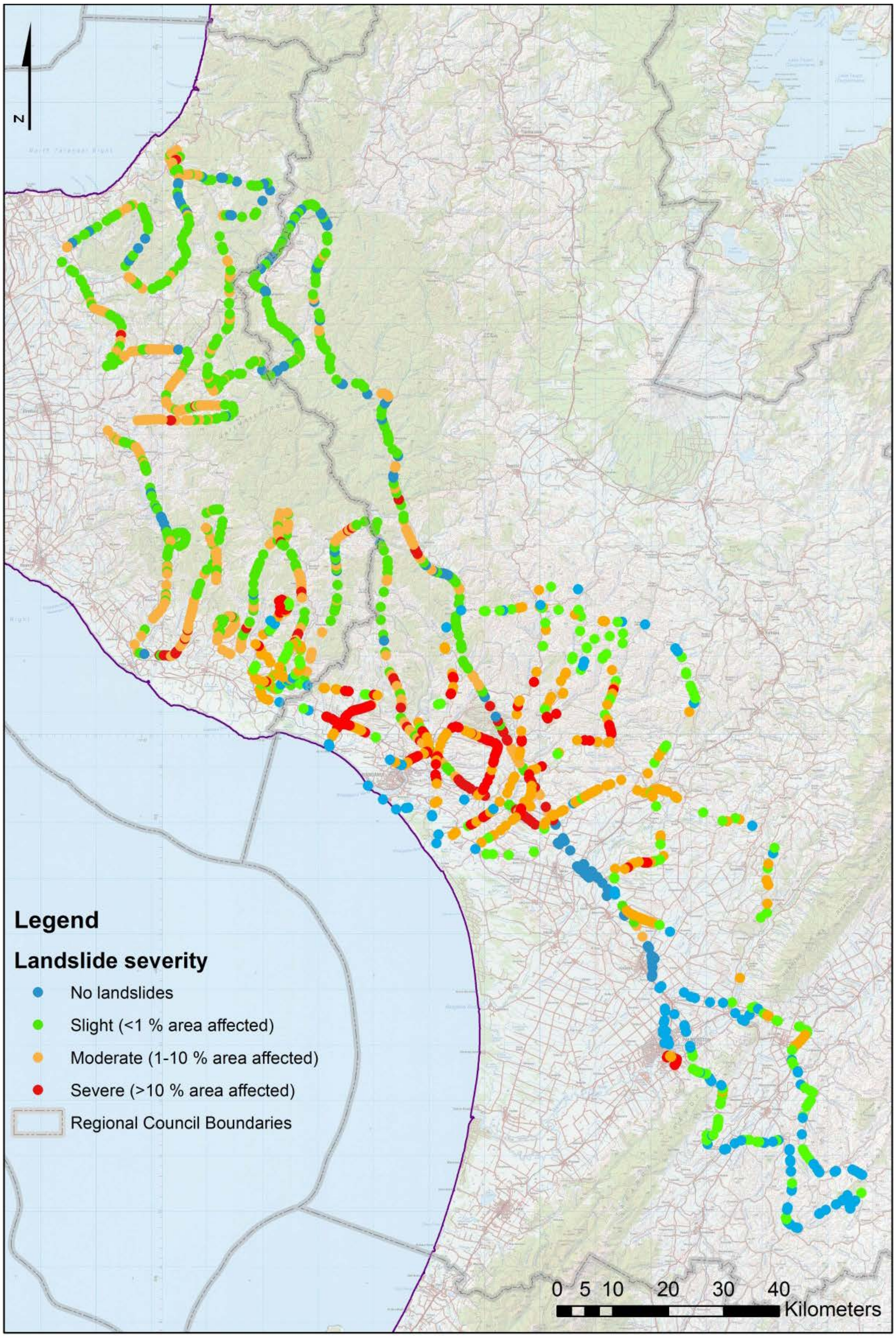


Figure A3.1 Photo locations from the reconnaissance flights classified according to landslide severity.

www.gns.cri.nz

Principal Location

1 Fairway Drive
Avalon
PO Box 30368
Lower Hutt
New Zealand
T +64-4-570 1444
F +64-4-570 4600

Other Locations

Dunedin Research Centre
764 Cumberland Street
Private Bag 1930
Dunedin
New Zealand
T +64-3-477 4050
F +64-3-477 5232

Wairakei Research Centre
114 Karetoto Road
Wairakei
Private Bag 2000, Taupo
New Zealand
T +64-7-374 8211
F +64-7-374 8199

National Isotope Centre
30 Gracefield Road
PO Box 31312
Lower Hutt
New Zealand
T +64-4-570 1444
F +64-4-570 4657