Water Resource Impact Survey

Kaikoura Earthquake 2016

Flaxbourne Settlers' Association, Marlborough

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1. Introduction

This project aims to identify the changes, and quantify the potential impacts, of the 14 November 2016 Kaikoura Earthquake on the water resources of the Flaxbourne and Waima catchments. The project focuses on changes to both the surface water and groundwater resources, and their interaction, and how these changes have impacted water availability, water use, water-related infrastructure, and hazards.

The wider Flaxbourne community relies heavily on the Flaxbourne and Waima Rivers for a diverse range of agricultural practices and land uses; including irrigation, stock water, and domestic potable water supply. The Flaxbourne-Waima area incorporates 25,000ha of farmland, 2600ha of potentially irrigatable land, and includes 154 rural properties that have been affected directly by the earthquake. Nationally significant infrastructure including roads, railway and township facilities have also been affected. Significant anecdotal evidence is available of the dramatic changes to the landscape and waterways that occurred, including:

- Greater flow in the rivers;
- Changed groundwater levels;
- Changed channel alignments;
- Changes in channel gradient (with implications for erosion, channel stability, sediment transport, flood hazard etc.);
- Changes in the alignment of the thalweg (i.e. dominant channel);
- Changes to groundwater conditions, both in specific bores and at a catchment level;
- Changes to surface water – groundwater conditions;
- Changes to water quality through increased suspended sediment and bedload transport; and
- Changes to the flow regimes of rivers because of landslide-dammed lakes etc.

2. Setting

Anecdotal evidence provided following the Kaikoura Earthquake, suggested that changes to the water resources are different within different zones in each catchment. At a general level, three zones could be identified within the Flaxbourne and Waima catchments:

- The ‘coastal zone’ – where differential uplift at the coast has resulted in significant changes to the channel gradient at the mouths of the various rivers, and throughout the reach immediately upstream of the coast;
- The ‘mid-catchment zone’ – where the results of differential lateral and vertical uplift may affect surface water-groundwater interactions, and the river responds to any disequilibrium caused by changes in the upper and lower catchments; and
- The ‘upper catchment zone’ – where landsliding, and the formation of landslide dammed lakes, may have affected the rainfall-runoff relationships, and the timing and volume of runoff.

Consequently, a catchment-based approach to identifying and quantifying changes to the water resources is required.

Between the Flaxbourne and Waima catchments is the Mirza. This catchment is distinctly different to the two main catchments. It is characterised by small streams, with small catchments, which discharge directly to the coast. Consequently, the Mirza catchment potentially presents a range of additional and different challenges/effects to those which affect the two larger catchments. The Mirza was therefore also included in the study.

The study area therefore includes three catchments; the Flaxbourne, Mirza and Waima. The entire catchments are included, from the coast to the headwaters (Figure 2.1).

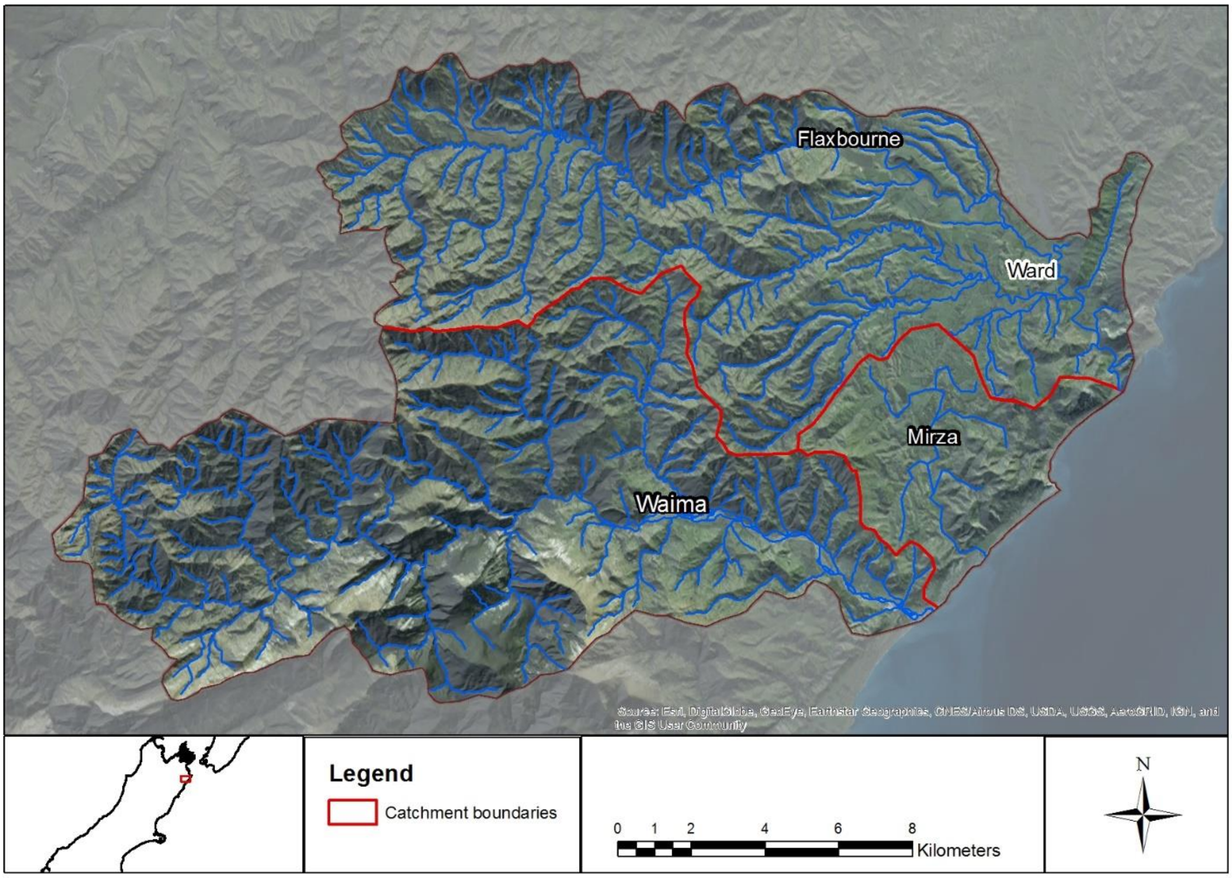

Figure 2.1: Study area for MPI-supported water resource investigation.

3. Survey

With support from the Ministry of Primary Industries, a survey was developed to identify the changes that have occurred to the water resources of the Flaxbourne, Mirza and Waima catchments (Figure 2.1). The survey aimed to gather as much information as possible about any changes to the groundwater and surface-water resources. This information will help to identify, and then hopefully understand, the effects of the earthquake, and its impacts on the community.

To simplify both the collection and analysis of data, and to recognise the dispersed nature of the survey area and potential respondents, an on-line survey was developed.

The survey used an online, interactive mapping tool which operates through a standard web-browser. This allowed people to participate through cell phone, tablet or PC. Basic demographic data was gathered (e.g. age and gender) and subsequently, users marked points of interest on a map, then attached comments and answered a series of context-sensitive 'pop-up' questions. The pop-up questions provided more detail on the item of interest (e.g. on "a place where river water levels have changed", and they clarified the nature, size, scope and significance of this change). Open-ended questions were also asked so that users could, for example, advise any other changes they felt had not already been addressed by the survey (e.g. other changes in the areas, other changes to their property, or potential future changes). Provision was also made so that people could return to their survey at a later point to add more detail. As a result, there was the opportunity for families to complete a collective survey, representing a household or property, or for people to complete an individual survey if this was their preference.

Each survey response was linked to a specific computer, or other ‘smart’ device. This meant that respondents did not have to complete the questionnaire at one time. They could go back, and either change or add to their answers over time. This allowed each respondent, or potentially each family, to build up a 'picture' of the effects of the earthquake on them, and their property. Several members of a family could also complete the survey by using different electronic devices. The survey could also be completed in ‘hard-copy’ for those who did not have access to a suitable electronic device.

The questionnaire was essentially ‘seven pages’, with each page involving the 'dropping' of pins (i.e. location markers) onto a map, adding comments, and then answering a range of questions.

4. Results

4.1. Areal coverage

A total of 68 persons accessed the survey, and identified the ‘location of most significance’ to them; although two located at Cape Campbell were outside of the anticipated survey area (Figure 4.1). As expected, there was a concentration of respondents from near Ward, with others along the Flaxbourne, Mirza and Waima/Ure Rivers. Overall, there was a good spatial coverage from throughout the anticipated survey area.

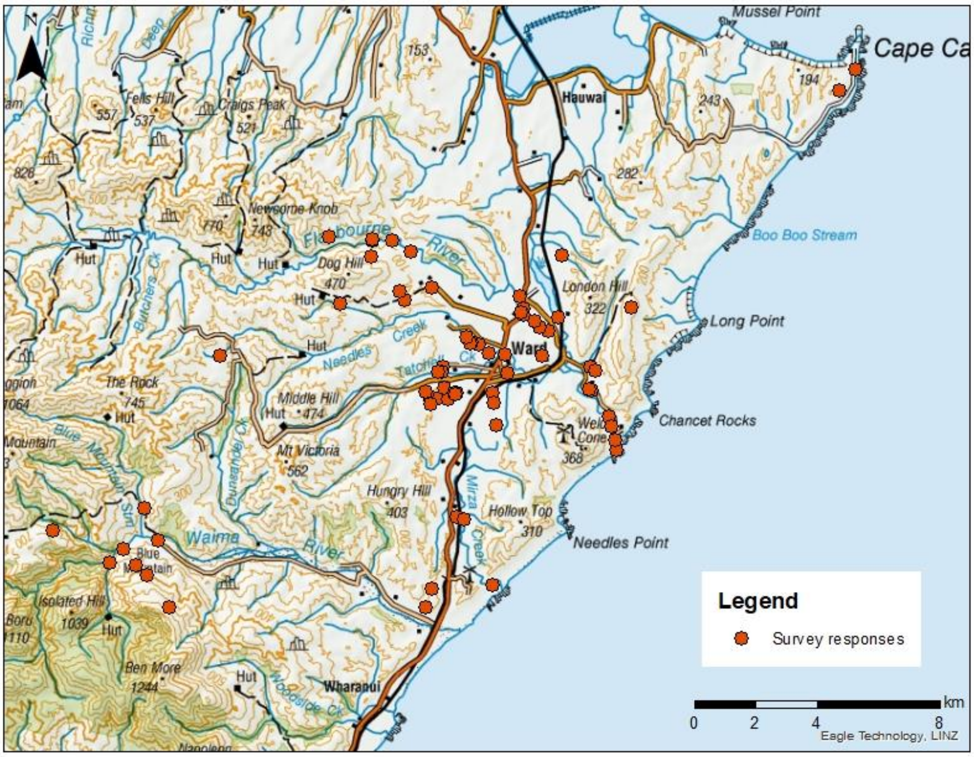

Figure 4.1: Location of respondents to the survey.

Approximately half the respondents, however, provided no further details; and several others provided only limited data relating to specific questions within the survey. Whether these ‘limited responses’ were because the earthquake had not effected these persons, or for some other reason, is unknown.

4.2. River water level change

Whether there has been a perceived change in water level is very subjective; as were most of the responses. Also, to some degree the response and peoples' perception of any change in the water level in rivers, is affected by the actual flows experienced since the earthquake. These responses therefore need to be considered in the context of the flow regime experienced since the earthquake, and not just the effects of the earthquake.

The responses to the question regarding any observed change in the river level of the river, can be summarised as:

- Of the 23 respondents, eight have noticed a change in the water level in rivers and streams in their area (Figure 4.2). Five respondents noticed a decrease in water levels, while three have observed an increase. There does not appear to be a consistent pattern to a person's response. This is likely to be because of the differential uplift and warping of the landscape, rather than a consistent pattern of either upthrow or downthrow;

Figure 4.2: Perceived changes in water level in rivers and streams.

- The change in water level has been reasonably small i.e. for most respondents it has been less than 0.3m (Figure 4.3). The effect of even this minor change in water level could vary depending on the nature of the site, the magnitude of the flows, and how critical water level is to certain activities;

- The impact of any change in water level on 'operations' has so far been small, with only two respondents indicating a greater level of impact. Most respondents expressed concern about the change in river level, and one located near Mirza Creek, noted the change in water level may cause an increased flood hazard. Overall, the risk from the river bed change has been perceived as small; and

- As with the potential impact of any change in water level, any associated costs have also yet to be experienced. These costs are not likely to become apparent until any longer-term impacts on water resources, or infrastructure relating to water resources, are encountered.

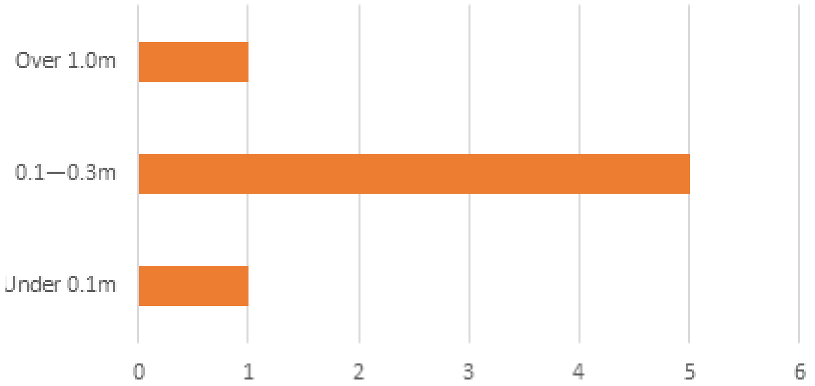

Figure 4.3: Amount of change in water level.

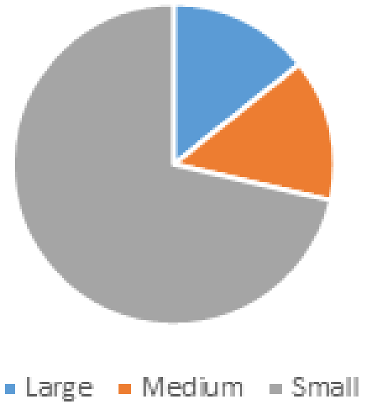

Figure 4.4: Effect of any change in water level on existing operations.

4.3. Water quality

Five of the respondents commented on potential changes to water quality, specifically suspended sediment (Figure 4.5).

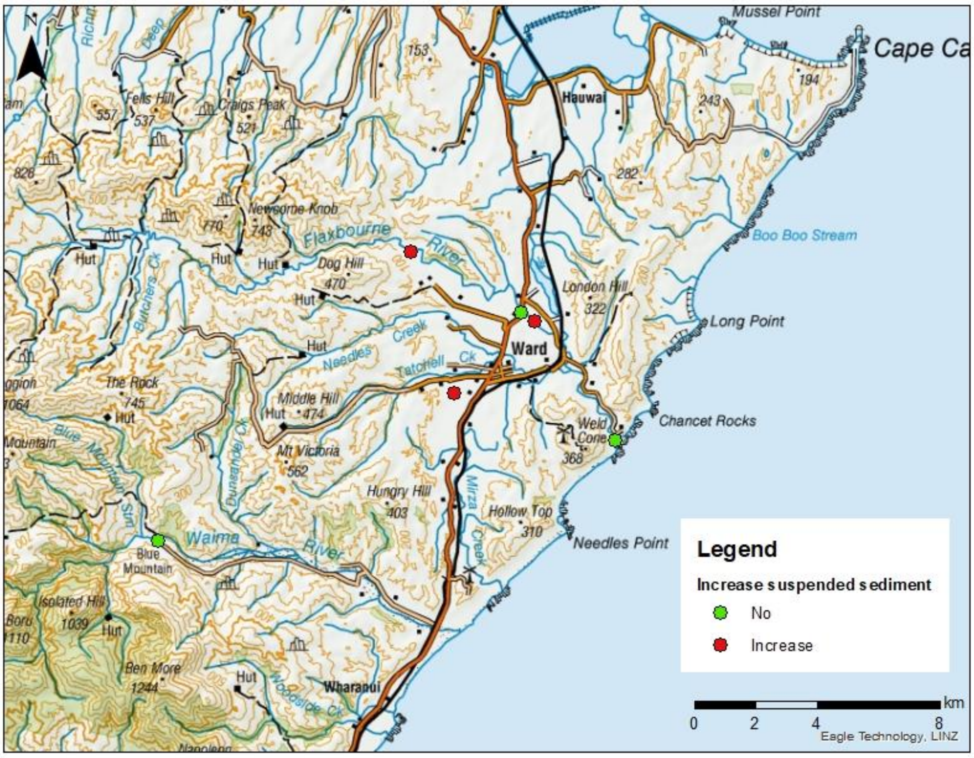

Figure 4.5: Perceived changes in water quality i.e. suspended sediment, in rivers and streams.

The responses to the question regarding any observed change water quality, can be summarised as:

- The pattern of increases and decreases in suspended sediment is again random. For example, two locations on the Flaxbourne River, next to each other, have observed contrary behaviour; with one remarking on an increase in suspended sediment and the other a decrease;

- Using the 'starter locations' to identify which river is most likely to be the subject of a particular comment, it is possible to identify differences between the various catchments. For example, while an increase in suspended sediment has been observed in Tatchell Creek, no increase has been observed in the Waima/Ure (Figure 4.6). This may partly be a result of the naturally higher suspended sediment within the Waima/Ure River. While most respondents are from the Flaxbourne catchment, they are split evenly between those who have observed and increase, and those who have not (Figure 4.6);

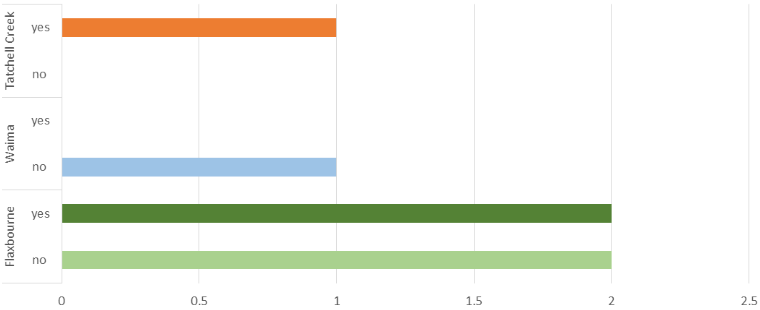

Figure 4.6: Changes in suspended sediment within the rivers and streams.

- Where an increase in suspended sediment has been observed, it would appear to have become a persistent problem (Figure 4.7). In most situations, increased suspended sediment is still apparent. In only one case did increased suspended sediment last for less than a week; and

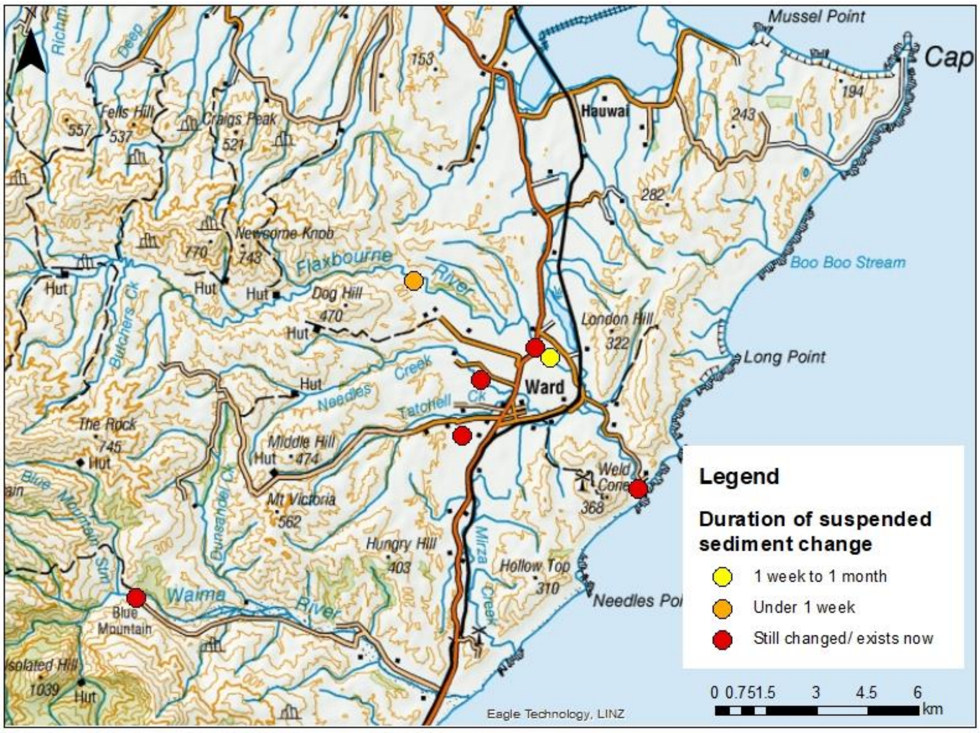

Figure 4.7: Duration of increased suspended sediment.

- Where an increase in suspended sediment has been observed, this is thought to be a result of either landslide activity, or channel erosion. Despite the apparent increase in suspended sediment, it would appear that this has not affected most properties adversely. Only one property says that they have been adversely affected; this would appear to be a vineyard.

4.4. Channel/Bank characteristics

Several respondents commented on how the various rivers, or reaches of rivers, have changed since the earthquake (Figure 4.8). One respondent has noticed a significant build-up of sediment within the Waima/Ure River which has resulted in aggradation of the bed, and consequently a shallower channel. This has been attributed to erosion in the upstream tributaries, which experienced many, often very large, landslides during the earthquake.

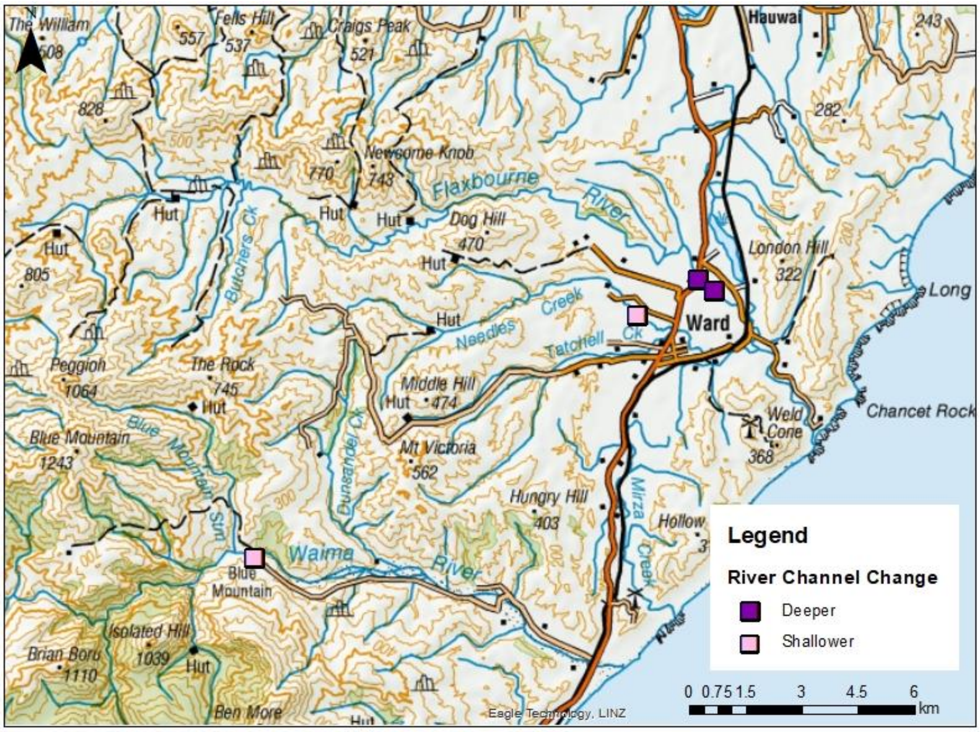

Figure 4.8: Channel changes observed since the earthquake.

- All the changes observed with respect to the characteristics of river and stream channels have so far been permanent i.e. the effects are still apparent. It is also likely that some of the effects have been progressive over time i.e. aggradation or degradation of the bed is continuing;
- Uplift of the mouth of the Flaxbourne River has resulted in the channel deepening by approximately 2m. This has led directly to the draining of the previous estuary and wetland adjacent to Ward Beach; and
- Although only a small number of respondents commented on observed changes to the channel form of the various rivers and streams, these effects have had a significant effect on farming operations (Figure 4.9). Half of the respondents believe that the changes have had a large effect, while the remainder believe that the effects have had a moderate impact on their operations.

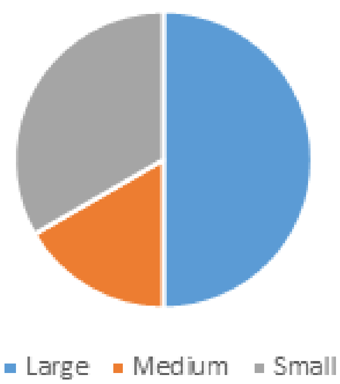

Figure 4.9: Effect of channel changes on farming operations.

4.5. Groundwater

Several respondents (i.e. 7) commented on the effect of the earthquake on the local groundwater resource. In most instances, the groundwater level has increased i.e. groundwater is now closer to the ground surface than it was before the earthquake (Figure 4.10).

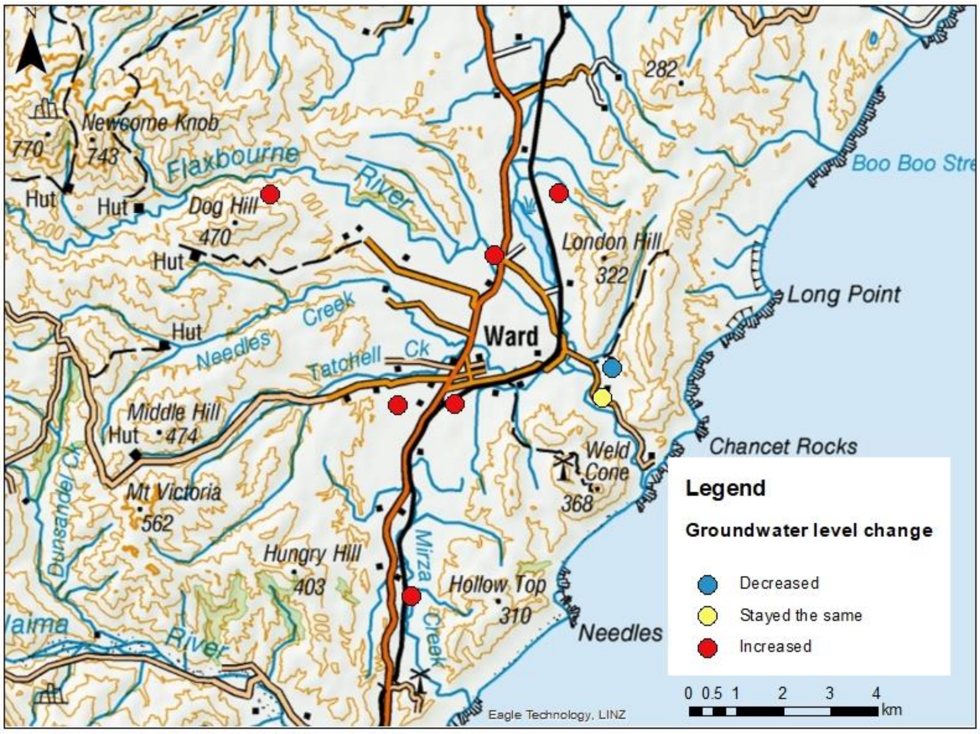

Figure 4.10: Response of the groundwater to the earthquake.

Other comments relating to the groundwater system included:

- The only area where it appears that the groundwater level has dropped is in the lower Flaxbourne River, towards Ward Beach. This data, however, appears anomalous as the same respondent reported an increase in groundwater level of over 1m;
- The magnitude of change in groundwater seems to increase towards the coast. The groundwater level rose from 0.1-0.3m, about 7km upstream on the Flaxbourne River. About 3.5km upstream on Mirza Creek, the rise was from 0.3-1.0m, while towards the mouth of the Flaxbourne River the groundwater level increased over 1m (Figure 4.11);
- Overall, it appears that the changes observed in the local groundwater system have been persistent, at least of the period between the earthquake and the survey (Figure 4.12). Most the changes, irrespective of whether it was an increase or decrease, are still present;
- A change in groundwater level has resulted in 40% of respondents experiencing disruption to both their domestic and farm water supplies; and
- Other issues relating to groundwater-related infrastructure were mostly negative, including the emergence of new springs. It would appear, however, that the impact of these changes on the respondents' operations was minimal.

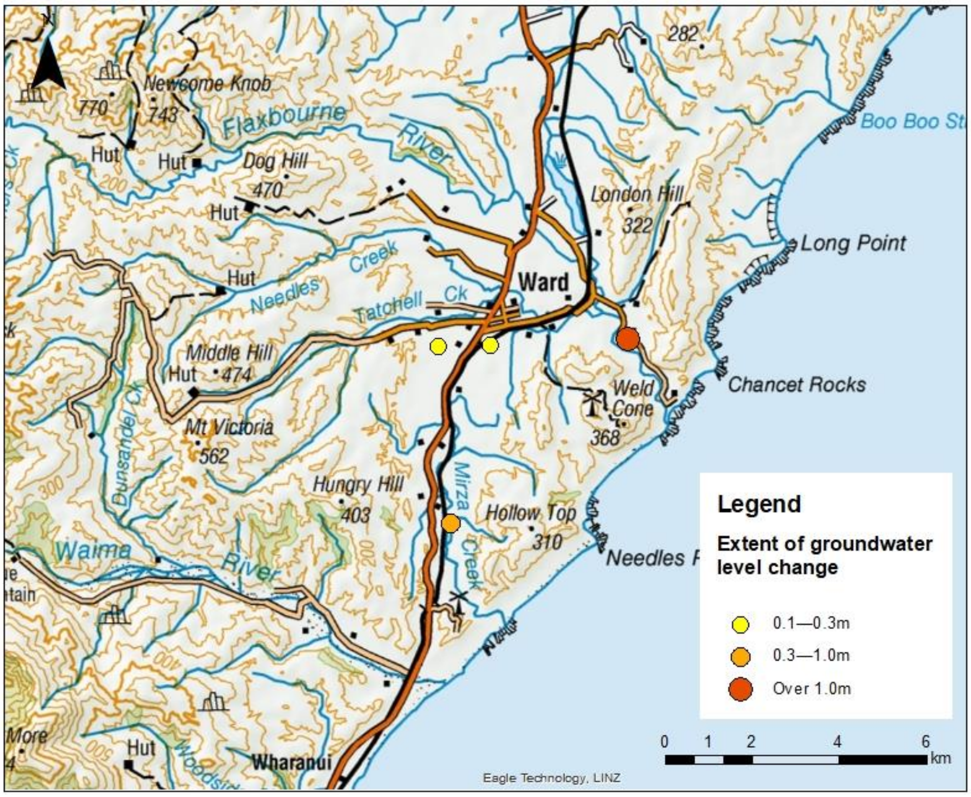

Figure 4.11: Degree of change in groundwater levels.

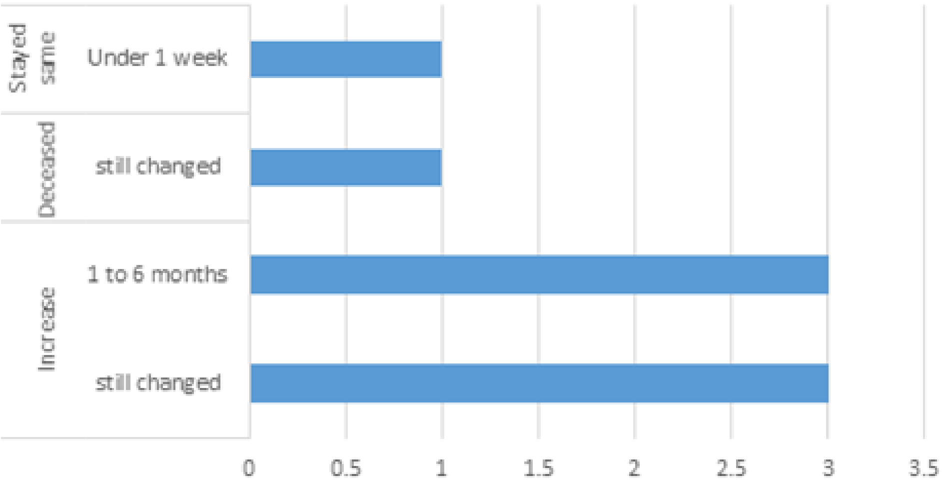

Figure 4.12: Relative persistence of the changes observed in groundwater levels.

4.6. Landslides

The final questions in the survey related to the impact of earthquake-triggered landslides. The responses are summarised below:

- Most of the landslides were located on steeper topography, and generally at higher elevations;
- The material displaced by the landslides was a mixture of soil and rock, and the landslides appear to have occurred in clusters (Figure 4.13). Whether this was a function of the way the question was answered, or the actual location of the landslides, is difficult to determine. However, the Flaxbourne valley would appear to have been affected particularly badly. One respondent experienced over 100 landslips (Figure 4.13);

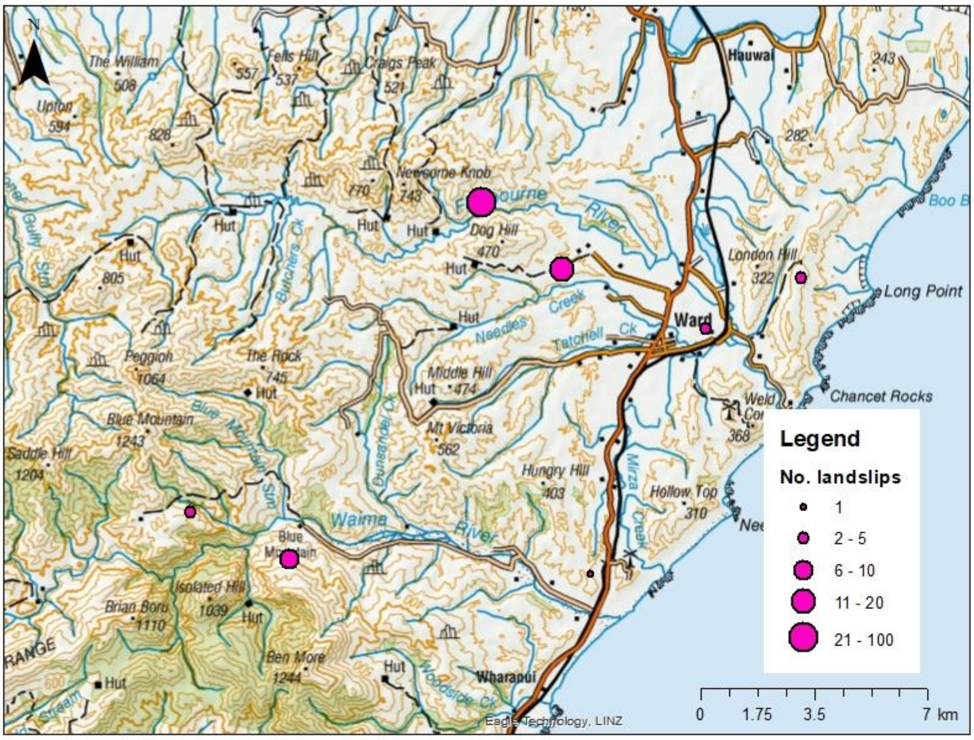

Figure 4.13: Location of earthquake-triggered landslides.

- The amount of land affected by landslides is directly related to the number of landslides experienced on a property i.e. those with the most landslides, also experienced the greatest loss of productive land. Two of the respondents lost between 2-5ha of productive land, and another two lost more than 5ha (Figure 4.14);

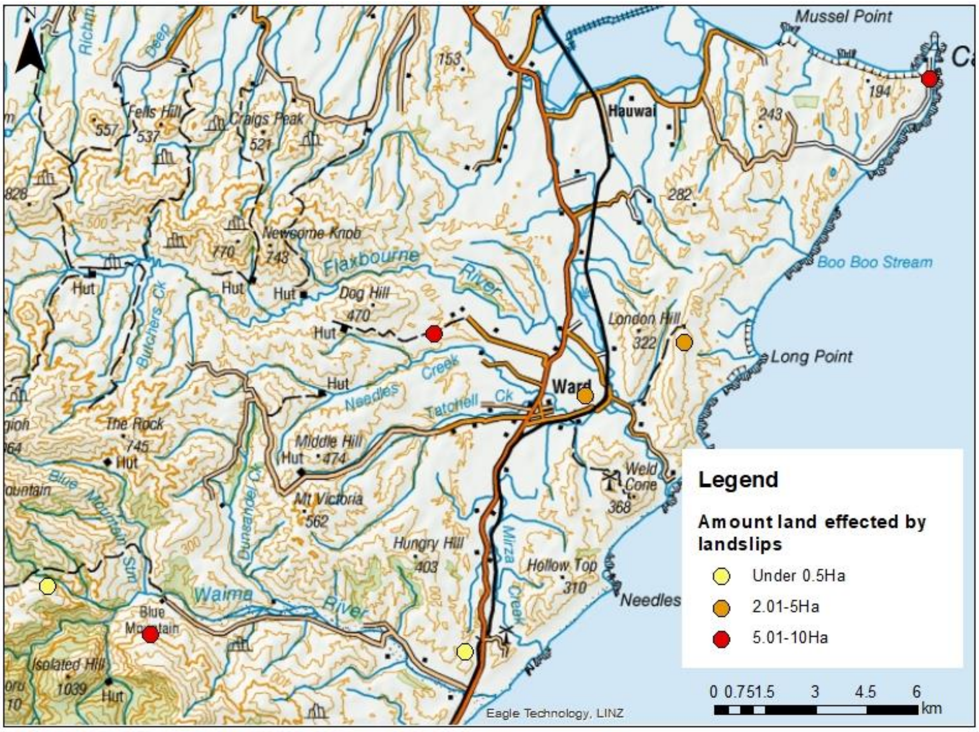

Figure 4.14: Area of lost production from earthquake-triggered landslides.

- The slip debris is now being discharged into the rivers during large rainfall and flow events. This is causing elevated suspended sediment, and reduced water quality; and

- Three landslides caused dams; one on Needles Creek, and two in the upper Waima/Ure River (Figure 4.15). The subsequent dam formed in Needles Creek was estimated to be <50m², while those in the Waima River were estimated to be from 51-100m².

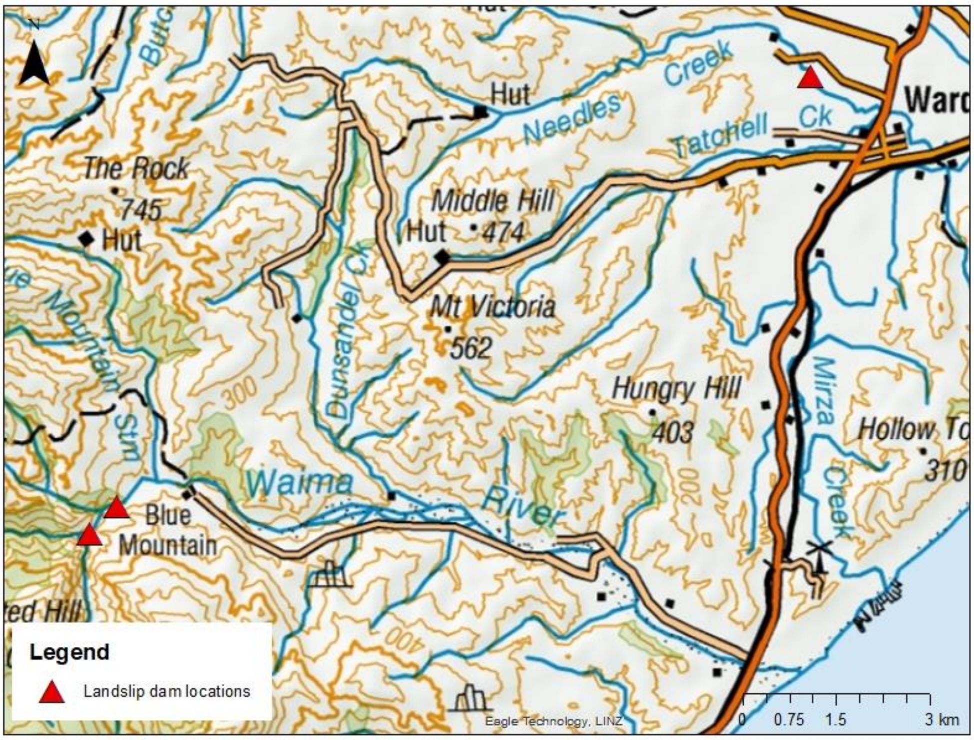

Figure 4.15: Location of landslides which dammed rivers and streams.

5. Recommendations

A review of the responses to the survey leads to the following recommendations:

- Although 68 people accessed the survey, the detail of the responses was highly variable. While some respondents provided a considerable amount of information, others did not. It would be worth exploring whether it is possible to increase the level of detail provided by more of the respondents;
- Information relating to the effect of the Kaikoura Earthquake on water resources from other sources should be reviewed to provide a comprehensive review of all existing information;
- Available hydrometric data, including rainfall, river flow (and level) and groundwater should be reviewed so that the dynamics of the hydrological system since the earthquake can be placed in a longer-term context;
- Changes in the local topography caused by the earthquake should be quantified using the new LiDAR and survey information, and survey data prior to the earthquake. These data should be reviewed in the context of:
    - Changes in channel form, character and process;
    - Changes in groundwater conditions.

This information could be used to provide an explanation of the changes to the water resources in the Flaxbourne-Mirza-Waima catchments. It could also be used to identify potential future trends and changes in the water resources. This will allow proactive adaptions and management to mitigate the potential adverse effects in the future.

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