Tools for Estimating the Effects of Climate Change on Flood Flow

Many of New Zealand's towns and cities are affected by flooding from rivers, lakes, overland flow, the sea and in some cases, a combination of all of these. Projected changes in rainfall, temperature and sea level are likely to exacerbate these flood risks for many sectors, systems and groups. In order to manage and minimise the risks associated with flooding, tools for estimating the effects of climate change on flood flow have been developed to assist local authorities and environmental managers with decision making.

What causes flooding in New Zealand?

The most common weather-related cause of river flooding in New Zealand is heavy rainfall. This can greatly increase water levels in rivers and lakes and cause water to overflow into surrounding areas. Flood magnitude depends on many factors. These include the land form and sub-surface features, the vegetation and soil characteristics of the catchment, the wetness of the catchment before the storm, evaporation, and the intensity and duration of rainfall.

How will climate change affect flooding in New Zealand?

Projected changes in average annual rainfall across New Zealand generally indicate increases in the west (up to 5% by 2040 and 10% by 2090) and decreases in the east and north (exceeding 5% in places by 2090) (Figure 1). Heavier and/or more frequent extreme rainfalls are also expected, especially in places where mean annual rainfall is predicted to increase. As extreme rainfall is the most common trigger for flooding in New Zealand, predicting the frequency and intensity of such precipitation plays an important part in assessing the effects of climate change on flood flow. Flood magnitude is also affected by indirect means. For example, any change to the balance of sediment transported within a river, storminess, sea levels or even the cycles of natural variability in the climate can have an affect on river processes and flooding. When assessing future flood risk all of these factors need to be considered in order to see how they interact for a given area

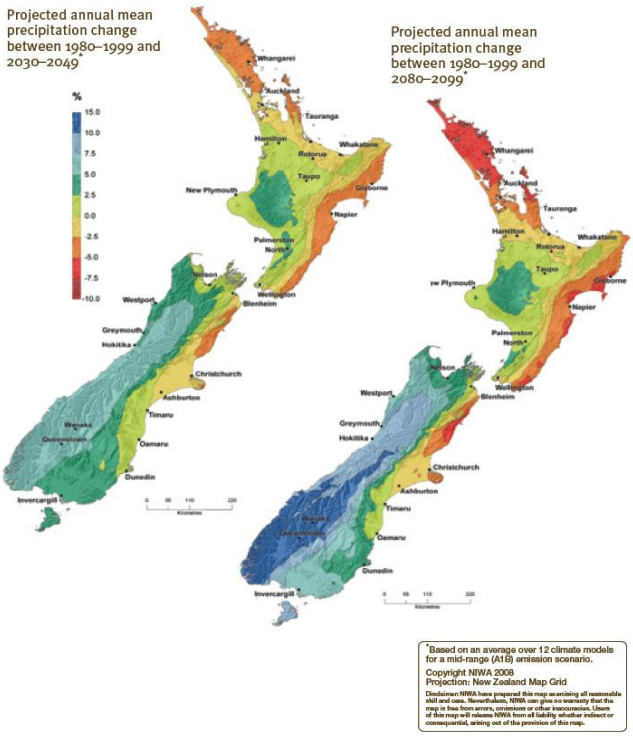

Figure 1: Projected mid-range changes in annual mean rainfall (in %) relative to 1990

Choosing a method to estimate the impact of climate change on flooding

A range of methods are available to estimate the impact of climate change on flooding. The methods described here fall into two main categories: basic screening tools and advanced methods (Figure 2). Screening methods are simpler and can be used to show if there is a potential risk posed by climate change. Advanced methods provide a more detailed assessment of potential risks and are used where screening suggests there could be an impact.

The first step in estimating the effects of climate change on river flood flows is to calculate the change in rainfall. A general approach is to convert projections into a time-series of rainfall and then to the amount of water flowing in a river. Historical data and ongoing data collection are vital components of future flood flow estimates and are used to calibrate and test models of river flow. Past extreme events may also be used as indicators of future trends. Inundation will be affected by a combination of changes in rainfall, river flow and sea level. Coastal and low-lying riverine communities are particularly vulnerable to increased inundation. There is a range of methods to estimate how changes in flood flows may affect inundation levels. Each method converts flood flow data into an estimate of flood height, flow speed and spread across the land.

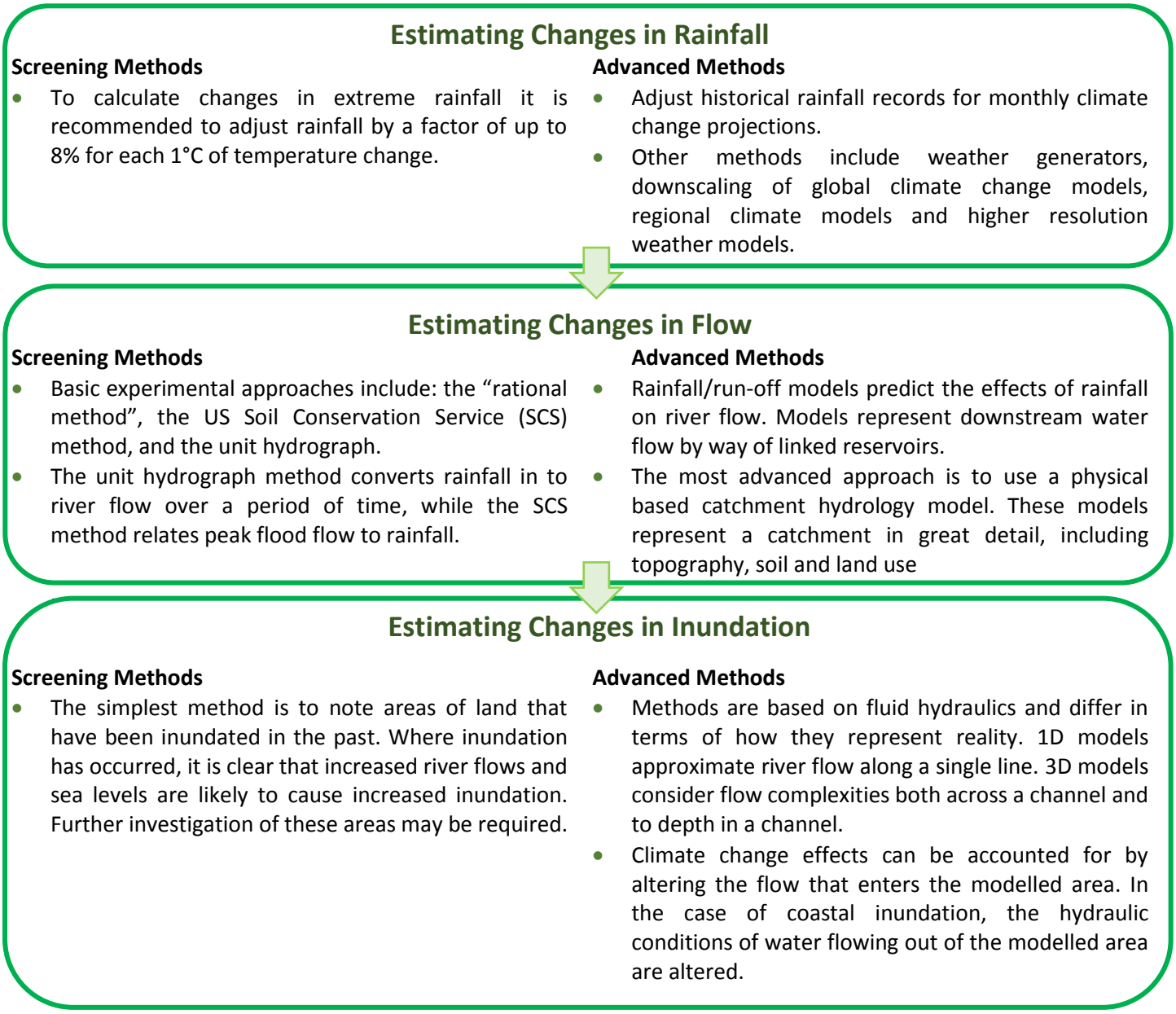

Figure 2: Methods for estimating the impact of climate change on flood flow

Case Study: Leith Lindsay flood protection scheme, North Dunedin

The Leith Stream, and its tributary Lindsay Creek, pose a flood hazard in the reaches flowing through the urban area of North Dunedin. In 2005 the Otago Regional Council conducted a study to assess the possible changes in flood risk due to increases in rainfall intensity associated with climate change and to assess the performance of the proposed flood mitigation scheme. The approach is described in further detail below.

Step 1: Calculate the increase in storm rainfall. The study used expected annual mean temperature changes by 2080 (from 0.4 to 3.1°C), as recommended for the Otago region in the 2004 edition of *Preparing for Climate Change*, to increase rainfall intensities. These changes suggested that the rainfall intensities for a 12-hour duration, 1 in 100-year event, could increase by between 3 and 21%.

Step 2: Convert rainfall to flow rate. The study used the upper limit percentage increase in storm rainfall (21%) with a calibrated rainfall losses/run-off model to determine flood flows for the Leith Lindsay catchment. The study found that the 1 in 100-year flood peak for the Leith Stream (above the tidal limits) could increase, on average, from the present day value of 171 m3/s to 200 m3/s (a 17% increase in flow).

Step 3: Inundation modelling. The design flood estimates determined in Step 2 were then used with models to assess the performance of the proposed flood mitigation scheme.

Conclusion: The Otago Regional Council found the flood magnitude for a given standard of protection is expected to increase, but also that there was some uncertainty about the magnitude of the increase. The results showed the proposed scheme would perform safely under the extreme and long-range climate change scenarios developed using the 2004 edition of *Preparing for Climate Change*.

Addendum: The 2008 edition of *Preparing for Climate Change* revised the expected temperature change for Otago by 2090 to 2.0°C average and a range of 0.8 to 4.6°C. Based on these latest projections, the rainfall intensities for a 12-hour duration, 1 in 100-year event, would be expected to increase by between 6 and 37% - a higher estimate than considered in this case study. This shows the importance of using the latest climate change information available and re-evaluating the impact of climate change from time to time as new information comes to light.

Photo courtesy of Otago Regional Council

Further Information

The full technical report, *Tools for Estimating the Effects of Climate Change on Flood Flow: A Guidance Manual for Local Government in New Zealand*, can be downloaded from http://www.mfe.govt.nz/publications/climate/climate-change-effects-on-flood-flow/.

An additional summary document - *Preparing for future flooding: A guide for local government in New Zealand* also shows how you can consider the consequences of future flood risk in a risk management framework and highlights options and principles for managing future flood risk. This can be downloaded at http://www.mfe.govt.nz/publications/climate/preparing-for-future-flooding-guide-for-local-govt/

In addition to these manuals, a range of complementary guidance is available on climate change and hazard management from the Ministry for the Environment, including:

• *Climate Change Effects and Impacts Assessment: A Guidance Manual for Local Government in New Zealand* (2nd edition, May 2008)

• *Coastal Hazards and Climate Change: A Guidance Manual for Local Government in New Zealand* (2nd edition, July 2008).

The NIWA website provides a useful toolbox for estimating the effects of climate change on heavy rainfall, flood flow and inundation http://www.niwa.co.nz/climate/urban-impacts-toolbox/toolbox-trays/second-tray-assess-the-likely-hazard/bin-21-flooding

Extensive flooding at Foxton