

# September 2010 and January 2011 Waikato Floods Review

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September 2009

Document #: 2089835

Approved for release by:  
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Date March 2014

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# REPORT

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Waikato Regional Council

September 2010 and January 2011  
Waikato Floods Review

**Report prepared for:**  
Waikato Regional Council

**Report prepared by:**  
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**Distribution:**  
Waikato Regional Council  
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1 copy

1 copy

**November 2011**

**T&T Ref: 28033**



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## Executive summary

In September 2010 and January 2011 significant rain fell in the Lake Taupo and greater Waikato River catchments. The resulting runoff led to significant water level rises in Lake Taupo and the requirement to manage the resulting flood flows through the Waikato River hydro cascade and into the lower Waikato system. Lake Taupo and the Waikato River were both impacted by the flood events, and consequently the operation of the Tongariro Power Scheme and Waikato Hydro Scheme were important flood management considerations.

Mighty River Power and Waikato Regional Council have each prepared reports on the flood events. In July 2011, Tonkin & Taylor was appointed by Waikato Regional Council to carry out an independent review of the Flood Event Review report prepared by Council. The purpose of the review is to provide an independent opinion of the flood management tools, decisions and outcomes in the September 2010 and January 2011 flood events.

Objectives and responsibilities for flood management are set out in the Agreed Principles of High Flow Management for the Taupo Waikato catchment, a tripartite document prepared by the Waikato Regional Council, Mighty River Power and Genesis Energy. These are reiterated in the Waikato Hydro System High Flow Management Plan, prepared by Mighty River Power, which also includes Waikato Flood Management Rules. The resource consents granted to Mighty River Power also link in to this document.

Flooding through the Taupo Waikato system in September 2010 was the result of sustained rainfall over a period of time, falling on relatively wet catchments. Although rainfall intensities and peak flows were not particularly significant in terms of frequency, the volume of runoff affected storage capacity in the system and led to rising lake and river levels. The January 2011 flooding through the Taupo Waikato system was the result of more significant rainfall, from cyclonic weather systems over the catchments.

The responses to the floods in the system were managed by Mighty River Power and Waikato Regional Council generally in accordance with the guidelines set out in the High Flow Management Plan, and as required by the Mighty River Power consents:

- The management of the two events included for reduction of TPD inflows to Lake Taupo and full opening of the Taupo gates to manage the rise in Lake Taupo levels. These decisions undoubtedly reduced the ultimate peak water level in Lake Taupo.
- In September 2010, flood flows and levels in the central reaches and downstream reaches were apparently higher than simulated under natural conditions. However, the Lawful Decision increasing flows from Karapiro was taken in regard to the saturated catchment conditions and the levels in Lake Taupo.
- In January 2011, the flood management decisions resulted in apparently lower flows and levels in the central and downstream reaches than simulated under natural conditions. Thus all parts of the catchment received flood protection benefit as a result of the operation, thus meeting a key objective of the Agreed Principles.

In practical terms, it is considered that it would be very difficult to ensure that at all times no part of the catchment receives flood protection benefits at the expense of other parts. Decisions must be made to follow Flood Rules and resource consent conditions, and pre-emptive flood management measures are implemented with regard to possible future but unknown meteorological conditions over the catchments.



Overall, the Flood Event Review report provides a clear summary of the conditions leading to the floods and the management of these through Lake Taupo, the Waikato Hydro Scheme, and the central and lower reaches of the river downstream.

# **1 Introduction**

## **1.1 Background**

In September 2010 and January 2011 significant rain fell in the Lake Taupo and greater Waikato River catchments. The resulting runoff led to significant water level rises in Lake Taupo and the requirement to manage the resulting flood flows through the Waikato River hydro cascade and into the lower Waikato system. Lake Taupo and the Waikato River were both impacted by the flood events, and consequently the operation of the Tongariro Power Scheme (TPD) and Waikato Hydro Scheme (WHS) were important flood management considerations.

Mighty River Power and Waikato Regional Council have each prepared reports on the flood events, being:

- September 2010 Flood Audit Report, Mighty River Power, dated 11 November 2010
- January 2011 Flood Audit Report, Mighty River Power, dated 24 February 2011
- Flood event review, September 2010 and January 2011, Waikato Regional Council, dated 1 August 2011.

In July 2011, Tonkin & Taylor (T&T) was appointed by Waikato Regional Council to carry out an independent review of the Flood Event Review report (FERR) prepared by Council.

## **1.2 Purpose**

The purpose of the review is to provide an independent opinion of the flood management tools, decisions and outcomes in the September 2010 and January 2011 flood events, and in particular the consistency of these tools, decisions and outcomes with:

- The resource consents that authorise the operation of the TPD and WHS
- The Agreed Principles for High Flow Management in the Taupo Waikato Catchment
- Best practice regarding the management of hydro-electric operations during flood events
- The reviewers' experience with regard to the management of hydro-electric operations during flood events.

This report presents the outcomes of the T&T review.

## **1.3 Report structure**

This review report is structured as follows:

- Section 2: Flood event management within the Taupo/Waikato region.
- Section 3: Background to the events
- Section 4: September 2010 flood management
- Section 5: January 2011 flood management
- Section 6: Technical information
- Section 7: Summary and Conclusions.

## 2 Flood event management within the Taupo/Waikato region

### 2.1 Introduction

The principles of flood flow management in the Lake Taupo and downstream Waikato hydro system are set out in the Waikato Hydro System High Flow Management Plan (WHS HFMP, Version 8.0), prepared by Mighty River Power in 2008. Fundamental to the WHS HFMP are the Agreed Principles for High Flow Management, which are included in the document. The Agreed Principles were collaboratively prepared by Waikato Regional Council, Mighty River Power and Genesis Energy in 2002.

The WHS HFMP identifies objectives, guidelines for implementation of high flow management, communication plans, and includes the Waikato Flood Management Rules. It is a document requirement of the resource consents 105226, 105227 and 105228, granted to Mighty River Power on the 6th May 2006, which authorise the operation of the WHS. The plan was developed to ensure clarity regarding objectives, roles and responsibilities, and to provide enabling tools which aid in the operation of the hydro schemes (Tongariro and Taupo/Waikato) during high flow events.

The WHS HFMP identifies the respective roles of Mighty River Power and Waikato Regional Council; namely that *in high flow conditions Mighty River Power manages the Waikato Hydro System (WHS) to meet dam safety requirements, and to limit the adverse effects of a flood event that may arise from the existence and operation of the WHS and to also support Waikato Regional Council in their role as Flood Manager.*

On this basis the WHS HFMP clearly defines the roles and responsibilities of each organisation and provides clarity on the different and complementary roles during management of flood events in the Taupo/Waikato system.

The following subsections outline the objectives of the Agreed Principles, the relevant resource consent conditions and *extracts* from the Agreed Principles and WHS HFMP regarding objectives, roles and responsibilities.

## 2.2 Agreed Principles for High Flow Management

### 2.2.1 General

The Agreed Principles is tri-partite agreement that *sets out the principles for a co-ordinated approach to high flow management in the Taupo Waikato catchment.* The Agreed Principles were developed collaboratively by Waikato Regional Council, Mighty River Power and Genesis, and the agreement between the parties signed in November 2002. The Agreed Principles include consideration of:

- Objectives
- Responsibilities
- Management objectives
- Taupo-Waikato High Flow Management Plan

The Agreed Principles have been incorporated in later documents, including the WHS HFMP and the resources consents granted to Mighty River Power.

## 2.2.2 Objectives

The stated objectives of the Agreed Principles of High Flow Management for the Taupo Waikato Catchment are as follows:

- To effectively manage floods in the catchment using a pre-determined set of flood management rules, developed in accordance with the provisions of the above agreement
- To ensure that the management of floods is carried out in a balanced approach so that no part of the catchment receives flood protection benefits at the expense of other parts of the catchment as a result of this operation
- To limit the extent of flooding of any property to the extent that it is no worse than would have occurred under “natural” conditions, unless the effects of any management decisions are deemed to be minor and within the bounds of “normal” operations.
- To audit periodically the responses of the Environment Waikato (sic), Mighty River Power and Genesis Power (sic) during floods and to amend them as necessary to ensure that future flood management is effective, efficient and consistent with the provisions of the above agreement.

## 2.2.3 Taupo-Waikato High Flow Management Plan

To meet the above objectives, the Agreed Principles include for the Taupo-Waikato High Flow Management Plan to assist Waikato Regional Council, Mighty River Power and Genesis in managing high flows. This is outlined in Section 5 of the Agreed Principles, which also includes clarification of the Waikato River Power Development Flood Management Rules.

The flood rules dictate a phased response to the management of high flows in the Taupo-Waikato catchment. Phases I and II (which require a co-operative approach to flood management between parties) are voluntary and relate largely to the management of flood flows up to the order of a 100 year average recurrence interval (ARI) event. Mandatory Phases III to V relate to events with frequency significantly greater than 100 years, and which pose a significant threat to the safety of structures in the WHS.

The Taupo-Waikato High Flow Management Plan as defined is also to include provision for audit and review, as well as consultation between the parties, and between Waikato Regional Council and stakeholders (e.g. district councils, key agencies, flood prone landowners).

The Waikato Hydro System High Flow Management Plan prepared by Mighty River Power addresses many of the requirements of Section 5 of the Agreed Principles. However, it is noted that it focuses on the management of Lake Taupo and the hydro reservoirs during a high flow event.

In order for effective management of information to be achieved, the Waikato Regional Council maintains the capability of establishing a Flood Response Centre to assist with collation of information, the planning of response actions and the coordination of organisational liaison during a flood event.

## 2.3 Resource consent conditions

The WHS HFMP is a requirement of the resource consents 105226, 105227 and 105228 granted to Mighty River Power in 2006/9. These consents include conditions 2.4 to 2.6 (Taupo Gates) and 5.1 to 5.11 (Waikato River) which authorise the operation of the WHS.

Specific conditions of resource consent 105228 relating to the September 2010 and January 2011 flood events are:

- **Condition 2.4:** The Taupo gates may not be used to manage the level of Lake Taupo above 357.25 masl primarily for the purpose of generating electricity. If at any time the lake rises above this level, then the Taupo gates shall be operated in such a way so as to return the level of the lake to 357.25 masl as soon as is practicable.
- **Condition 2.5:** The consent holder shall operate the Taupo gates according to a management regime designed to achieve the following objectives for the level of lake Taupo:
  - A less than 20 % annual exceedance probability of 357.25 masl (i.e. an average 1 in 5 year recurrence interval).
  - A less than 5 % annual exceedance probability of 357.39 masl (i.e. an average 1 in 20 year recurrence interval).
  - A less than 1 % annual exceedance probability of 357.5 masl (i.e. an average 1 in 100 year recurrence interval).
- **Condition 5.5:** Within four weeks of the end of any event during which the Waikato hydro system was operated under the provisions of the high flow management plan, the consent holder shall forward a report to the Waikato Regional Council describing:
  - The operation of the Waikato hydro system prior to, during and after that event
  - Performance relative to the objectives of the High Flow Management Plan
- **Condition 5.9:** At all times when the discharge from Karapiro exceeds 500 m<sup>3</sup>/s and/or the flow at Ngaruawahia exceeds 850 m<sup>3</sup>/s the consent holder shall, unless lawfully directed by the Waikato Regional Council for flood management or other emergency reasons, operate the Karapiro hydro reservoir so that flows in the Waikato River downstream of Karapiro are similar to or less than those that would have occurred without the hydro operations in place.

## 2.4 WHS HFMP Objectives

The objectives of the WHS HFMP Plan are:

- To ensure that roles and responsibilities are clear and understood between Mighty River Power and Environment Waikato (sic)
- To ensure that information on catchment and river inflows during High Flow conditions is transparent to Environment Waikato (sic)
- To ensure that communications roles and responsibilities are clear between Mighty River Power and external parties (Environment Waikato (sic), Genesis Energy, Taupo District Council, Waikato District Council and Franklin District Council) and during High Flow conditions.
- To describe the management of the Taupo Gates and the Waikato hydro system prior to and during high flow events.
- To describe how Lake Taupo will be managed to meet the requirements of conditions 2.4 and 2.5 of the consents, as above.
- To describe how Lake Karapiro will be managed to meet the requirements of conditions 5.9 of the consent, as above.

- To improve decision-making involvement and community understanding of the roles of Environment Waikato (sic) and Mighty River Power in flood management of the Taupo-Waikato catchment.
- High Flow Management for the Taupo Waikato Hydro System is based on a series of five steps or phases. The phases are entered into depending on the severity of the climatic event and the resultant inflows to the Waikato Hydro System.
- Phases I and II are voluntary and focus on the provision of information in order to allow for informed decision making prior to and during an event.
- Phases III, IV and V are mandatory and involve predetermined actions and responses. The primary focus of these three phases is dam safety.

## **2.5 Roles and responsibilities**

### **2.5.1 Waikato Regional Council (previously as Environment Waikato)**

Environment Waikato (sic) has the statutory responsibility for flood management in the catchment. Under this agreement Environment Waikato (sic) is specifically responsible for:

- Coordinating real time flood management information and response, and disseminating this information to appropriate parties (including Mighty River Power and Genesis)
- Undertaking an audit of the flood management decisions and operations following each flood that triggers the operation of the flood rules, and for disseminating this information to the public via an appropriate forum
- Provide information as defined in Schedule 1 of the Agreed Principles.

### **2.5.2 Mighty River Power**

Mighty River Power is responsible for the lawful operation of the WHS. During floods, Mighty River Power's specific responsibilities under this agreement are to:

- Fulfil resource consent requirements and achieve the management objectives as defined for Lake Taupo, Waikato hydro reservoirs, Karapiro outflows
- Provide information as defined in Schedule 2 of the Agreed Principles
- Provide information as required by Environment Waikato (sic) to undertake flood audits.

### **2.5.3 Genesis Energy (previously as Genesis Power)**

Genesis Power (sic) is responsible for the lawful operation of the Tongariro Power Development (TPD). During floods, Genesis Power's (sic) specific responsibilities under this agreement are to:

- Fulfil resource consent requirements and achieve the management objectives namely ceasing to divert TPD foreign water into Lake Taupo if the maximum control level for Lake Taupo (357.25 masl) has been reached
- Provide information as defined in Schedule 3 of the Agreed Principles
- Provide information as required by Environment Waikato (sic) to undertake flood audits.

### 3 Background to the events

La Niña conditions were developing and took effect during the late 2010 winter months, and have prevailed through to mid winter 2011. La Niña conditions usually are accompanied by *“more north–easterly winds, which tend to bring moist, rainy conditions to the north–east of the North Island, and reduced rainfall to the south and south–west of the South Island”*.

According to NIWA (refer Appendix A, NIWA 2008), the chance of above normal rainfall in a La Niña phase for the central North Island is:

- 70 % to 80 % during Spring
- 70 % to 80 % for the eastern parts of Taupo, and 40 % to 60 % for the rest of the region during summer.

#### 3.1 September 2010

##### 3.1.1 Seasonal Conditions

Rainfall in the months prior to September 2010 event was variable, with a very dry July (rainfall totals in the Waikato region were approximately half of the average for the month), while in August and September some parts of the catchment (Taupo, upper Waikato and upper Waipa) received almost double the average rainfall for the month.

##### 3.1.2 Event Rainfall

There were four distinct rainfall events identified in September, with steady rainfall between. Analysis of maximum 24, 48 and 72 hour rainfall depths show that the recorded totals for these durations were less than the mean annual event. However, it is noted the catchment was moderately wet at the start of September due to the antecedent rainfall in August, contributing to higher runoff as rain continued to fall on the catchment.

##### 3.1.3 Runoff

Runoff from the rainfall events was variable across the Waikato Region, as summarised in the following table.

**Table 3.1: September 2010 Runoff Frequency**

Location	Frequency
Lake Taupo levels	5 year to 20 year
Waipa flows	Mean Annual to 5 year
Hamilton flows	10 year to 20 year
Ngaruawahia flows	5 year to 10 year
Rangiriri flows	Mean Annual to 5 year

Runoff volume, and not just peak discharge from the catchment, contributes to flooding extent given the finite storage capacity along the river system. Although runoff volume thresholds are harder to define in term of frequency and flooding effects, it is noted that the threshold of entering into Phase III of the WHS HFMP is based on the volume of estimated runoff within the WHS catchment.

## **3.2 January 2011**

### **3.2.1 Seasonal Conditions**

Rainfall in the months prior to January 2011 event was approximately 50 % monthly average in October and November 2010 and near average during December and January. However, with La Niña seasonal conditions, the chances were raised of tropical cyclones affecting New Zealand.

### **3.2.2 Event Rainfall**

There were three distinct storm events identified within the January event, two of which were cyclones – Zelia and Wilma. Analysis of maximum 24, 48 and 72 hour rainfall shows that rainfall totals were in the order of 2 year to 5 year ARI event in the Waipa catchment, and 5 year to 10 year ARI events in the Taupo and Lower Waikato catchments.

However, information provided by Waikato Regional Council and included in the Flood Event Review report, shows that for shorter durations during Cyclone Wilma, the average recurrence intervals of recorded rainfall in some parts of the catchment were 50 years to 100 years.

### **3.2.3 Runoff**

Due to the drier catchment conditions the runoff volume was less than that in the September 2010 event, with exceptions being the flow at Hamilton (10 year to 20 year ARI event) and the level at Lake Taupo (5 year to 20 year ARI event). Note runoff average recurrence intervals are taken from the supplied reports, and no further analysis carried out to check independently that they are accurate.



## 4 September 2010 flood management

### 4.1 Introduction

As a part of the response to the forecast severe weather warnings, and in order to facilitate communication and coordinate the response to this event, the Flood Response Centre was established by Waikato Regional Council, and information was shared and communicated via this facility. This section of the report reviews the tools used during the September 2010 event, as well as decisions, objectives and outcomes of the event and discusses their consistency with the requirements of the High Flow Management Plan.

### 4.2 Tools

Tools and information used by Mighty River Power prior to and during the flood event included:

- Levels and flows at the start and during the event
- Risk management - Lake Taupo level prediction (based on historical data)
- Catchment wetness, antecedent precipitation index calculations
- Limit of Discretionary Release (LDR) predictive Lake Taupo management tool
- Residual storage volume index and WHS available storage volume
- Proactive use of storage in the WHS.

Tools used by Waikato Regional Council to facilitate flood event management included:

- River and lake level forecasting
- Catchment wetness calculations
- Flood briefing and advisories
- Weather forecasting
- Response coordination
- Response escalation and de-escalation.

The tools used by both Mighty River Power and Waikato Regional Council are considered consistent with tools mentioned in the Flood Rules and Schedules 1 and 2 of the Agreed Principles (cf. Section 2.5 above).

These in combination with the establishment of the FRC helped facilitate the response and management of the event.

### 4.3 Decisions

Table 4.1 below outlines decisions made during the September flood event and their compliance with resource consent conditions and the WHS HFMP.

**Table 4.1: September 2010 Flood Management Decisions**

Date	Action	Relevant section of resource consent or WHS HFMP
9 September	Phase I of WHS HFMP initiated. Taupo lake level 357.088 masl. Taupo outflow 280 m <sup>3</sup> /s (fully open gate) due to persistent rain falling on catchment and rising lake level.	WHS HFMP: Lake Taupo level greater than 357 masl

10 September	Karapiro flow increased to 490 m <sup>3</sup> /s.	WHS HFMP: Pre-emptive measures: Draw down of reservoirs to create storage.
12 September	Mighty River Power requests Lawful Direction to discharge up to a maximum of 500 m <sup>3</sup> /s from Karapiro.	Condition 5.9 of consent 105228
12 September	Waikato Regional Council Lawfully Directs Mighty River Power to discharge up to 500 m <sup>3</sup> /s from Karapiro. Based on initial Lawful Direction, an instruction to if required increase flows from Karapiro to a maximum of 550 m <sup>3</sup> /s was given.	Condition 5.9 of consent 105228
13 September	Phase II of the WHS HFMP initiated.	WHS HFMP: Ngaruawahia flow greater than 850 m <sup>3</sup> /s
14 September	Request to Waikato Regional Council to increase Karapiro to a maximum of 600 m <sup>3</sup> /s. Waikato Regional Council agrees but flows not to exceed 600 m <sup>3</sup> /s from Karapiro.	Condition 5.9 of consent 105228
15 September	Waikato Regional Council requests Genesis to turn out foreign TPD flows. Genesis complies and turnout is initiated.	WHS HFMP: ceasing to divert TPD foreign water into Lake Taupo if the maximum control level for lake Taupo has been reached
15 September	Karapiro outflow 580 m <sup>3</sup> /s.	
16 to 26 September	Karapiro outflow fluctuated between 450 m <sup>3</sup> /s and 600 m <sup>3</sup> /s.	
6 October	Reinstatement of TPD foreign water inflows into Taupo.	De-escalation plan
6 October	Exit out of Phase II, entry into Phase I.	De-escalation plan
14 October	Exit out of Phase I, normal operation.	De-escalation plan
11 November	Mighty River Power 2010 Flood Audit Report.	Condition 5.5 of consent 105228

It is considered that the decisions made are generally in line with the rules and objectives of the WHS HFMP and consent conditions. However, the following management issues were identified:

- Entry into Phase I

Phase I was entered on the 9 September 2010. Perhaps it could have been entered into earlier given the Lake Taupo level passed through the 357 masl maybe as early as 7 September. However, in this context, it is noted that Phase I is a warning phase and its use is optional (cf. Flood Management Rules, WHS HFMP). The WHS HFMP notes that omission of Phase I "*will not endanger the safety of the power stations, but its use will, in other than the very biggest floods, reduce the chances of excessive discharges from Karapiro, e.g. discharge in excess of 620 cumecs which might make flood treatment downstream difficult in modest floods*".

In September 2010 an earlier entry into Phase I may have enabled management of Karapiro discharges to be lower than the 600 m<sup>3</sup>/s which resulted. However, this may not have been significant given the duration of the event, the saturated catchment and

decisions taken with regard to possibility of further rainfall and the need to manage the system for this risk.

- Karapiro outflow

Rainfall accumulation graphs (Figure 8 of Flood Event Review report) show that Storm Event 2 occurred on the 12 September. It was preceded by severe weather outlooks, watches and warnings from 3 September onwards, and entry into Phase I on 9 September. However, it is noted that there was no clear and specific Severe Weather Warning for Event 2. The flow at Karapiro, which was under normal generation operation prior to the 12 September, was increased on the 15 September and remained above 450 m<sup>3</sup>/s until 26 September.

## 4.4 Objectives and Outcomes

**Table 4.2: Agreed Principles Objectives and Outcomes: September 2010**

Objective	Outcome
To effectively manage floods in the catchments using pre-determined flood management rules, developed in accordance with the provisions of the agreement	The systems and logic applied by Mighty River Power and Waikato Regional Council when making decisions on flood management during the events are generally in line with the WHS HFMP and resource consent 105228. Information was exchanged openly and effectively which aided in the effective management of the September 2010 flood event.
To ensure that the management of floods is carried out in a balanced approach so that no part of the catchment receives flood protection benefits at the expense of other parts of the catchment.	Although flood flows downstream of Karapiro Dam were greater than might have been in natural conditions, flooding was contained in the flood protection system and flood management was carried out in a balanced approach given the possibility of further rainfall in the catchment and conditions of Lake Taupo.
To limit the extent of flooding of any property to the extent that it is no worse than would have occurred under "natural" conditions, unless the effects of any management decisions are deemed to be minor and within the bounds of "normal" operation	<u>Lake Taupo</u> : during the event effects were less than that which would have naturally occurred (due to larger gate opening) <u>Downstream</u> : more than what would have naturally occurred, however: <ul style="list-style-type: none"> <li>• Within the stopbanks</li> <li>• Pre-emptive releases given wet catchment conditions and Lake Taupo management objectives</li> </ul>
To audit periodically the responses of Waikato Regional Council and Mighty River Power and Genesis Power during floods, and to amend them as necessary to ensure that future flood management is effective, efficient and consistent with the provisions of this agreement	Flood Audit Report provided by Mighty River Power, 11 November 2010. Flood Event Review Report by Waikato Regional Council, August 2011 (incorporating also January 2011 event).

**Table 4.3: Lake Taupo Management Objectives and Outcomes: September 2010**

<b>Lake Taupo Management Objectives</b>	
<b>The gates will be used to manage the level of Lake Taupo with the following management objectives:</b>	
<b>Objectives</b>	<b>Outcomes</b>
<p>A less than 20 % annual exceedance probability (AEP) of 357.25 masl (i.e. an average of 1 in 5 year recurrence interval)</p> <p>A less than 5 % AEP of 357.38 masl (i.e. an average of 1 in 20 year recurrence interval)</p> <p>A less than 1 % AEP of 357.50 masl (i.e. an average of 1 in 100 year recurrence interval)</p>	<p>Analysis undertaken by Mighty River Power shows that the peak lake level reached in this flood had a frequency of 9 % AEP (11 year ARI).</p>

**Table 4.4: Lake Karapiro Outflow Objectives and Outcomes: September 2010**

<b>Karapiro Outflow</b>	
<b>Under flood conditions Karapiro peak outflow shall be similar to or less than that which would otherwise occur without the hydro operations in pace with the aim of meeting the following objectives:</b>	
<b>Objectives</b>	<b>Outcomes</b>
Dam safety requirements	Dam safety was not compromised by decisions made during the course of the flood (release of more than that which would have occurred naturally in order to maintain storage, or freeboard)
The Flood Rules	Decisions made during the period of the high flow were per Flood Rules in the WHS HFMP
<p>The following flood management objectives for Karapiro :</p> <p>A less than 10 % AEP of a daily average flow from Karapiro of 500 m<sup>3</sup>/s (i.e. an average of 1 in 10 year recurrence interval)</p> <p>A less than 1 % AEP of a daily average flow from Karapiro of 650 m<sup>3</sup>/s (i.e. an average of 1 in 100 year recurrence interval)</p>	<p>Karapiro peak flow 600 m<sup>3</sup>/s, no frequency analysis provided. And noting that the peak daily average flow was somewhere between 500 m<sup>3</sup>/s and 600 m<sup>3</sup>/s.</p>
<p>The following flood management objectives for Ngaruawahia:</p> <p>A less than 33 % AEP of a daily average flow from Ngaruawahia of 850 m<sup>3</sup>/s (i.e. an average 1 in 3 year recurrence interval)</p> <p>A less than 2 % AEP of a daily average flow from Ngaruawahia of 1,250 m<sup>3</sup>/s (i.e. an average 1 in 50 year recurrence interval)</p> <p>A less than 1 % AEP of a daily average flow from Ngaruawahia of 1,500 m<sup>3</sup>/s (i.e. an average 1 in 100 year recurrence interval)</p>	<p>Ngaruawahia peak flow 940 m<sup>3</sup>/s, no frequency analysis provided. And noting that the peak daily average flow less than this but greater than 900 m<sup>3</sup>/s.</p>
As otherwise lawfully directed by Waikato Regional Council for flood management or other emergency reasons	This condition took effect as Waikato Regional Council lawfully directed Mighty River Power to release up to but no more than 600 m <sup>3</sup> /s, to enable Lake Taupo objectives to be met and also objectives further downstream.

## 5 January 2011 flood management

### 5.1 Introduction

As in September 2010, the Flood Response Centre was established.

This section of the report reviews the tools used during the January 2011 event, and the outcomes of the event.

### 5.2 Tools

As for the September 2010 event, tools and information used by Mighty River Power prior to and during the flood event included:

- Levels and flows at the start and during the event
- Risk Management - Lake Taupo level prediction
- Catchment wetness, antecedent precipitation index calculations
- LDR predictive management tool
- Residual storage volume index and WHS available storage volume
- Proactive use of storage in the WHS.

Similarly, tools used by Waikato Regional Council to facilitate flood event management included:

- River and lake level forecasting
- Catchment wetness calculations
- Flood briefing and advisories
- Weather forecasts
- Response coordination
- Response escalation and de-escalation.

The tools used by both Mighty River Power and Waikato Regional Council are considered adequate, and are in-line with tools mentioned in the Flood Rules and Schedules 1 and 2 of the Agreed Principles.

### 5.3 Decisions

Table 5.1 below outlines decisions made during the January flood event and their compliance with either resource consent conditions or the flood rules.

**Table 5.1: January 2011 Flood Management Decisions**

Date	Action	Relevant section of resource consent or WHS HFMP
22 January	Phase I of the WHS HFMP initiated. Taupo Lake level 357.051 masl, Taupo outflow 280 m <sup>3</sup> /s (fully open gate).	WHS HFMP: Lake Taupo level higher than 357 masl
22 January	Karapiro flow increased to 450 m <sup>3</sup> /s.	Flood rules – Pre-emptive measures: Draw down of reservoirs to create storage
23 January	Genesis turn out foreign TPD flows.	Flood Rules: ceasing to divert TPD foreign water into Lake Taupo if

		the maximum control level for Lake Taupo has been reached
23 January	Request to increase Karapiro discharge.	Condition 5.9 of consent 105228 Flood rules – Pre-emptive measures: Draw down of reservoirs to create storage
23 January	Lawful direction by Waikato Regional Council to Mighty River Power to discharge no more than 600 m <sup>3</sup> /s.	Condition 5.9 of consent 105228
23 January	Karapiro outflow increased to 550 m <sup>3</sup> /s.	Condition 5.9 of consent 105228
23 January	Phase II of WHS HFMP initiated.	WHS HFMP: Lake Taupo level likely to exceed 357.25 masl
23 January	Karapiro outflow increased to 600 m <sup>3</sup> /s.	Condition 5.9 of consent 105228
24 January	Advise entry into Phase II to Genesis Energy and local affected councils.	Communication plan
01 February	Reinstatement of TPD foreign water inflow into Taupo.	De-escalation plan
01 February	Exit out of Phase II and WHS HFMP, no entry into Phase I required.	De-escalation plan
01 February	Advise Exit of Phase II and WHS HFMP to Genesis and local authorities.	Communication plan
24 February	Mighty River Power Audit Report.	Condition 5.5 of 105228

It is considered that the decisions made are generally in line with the rules and objectives of the WHS HFMP and consent conditions. The following management issue was identified:

- Entry into Phase I

Phase I was entered into on 22 January 2011. Given that the Lake Taupo level had been above the Phase I threshold since late December and that Weather Watches started on the 14 January, and Severe Weather Warning started on the 17 January, entry to Phase I might have been initiated sooner. However, again noting in this context that the entry into Phase I is optional under the Flood Management Rules of the WHS HFMP. Given the ultimate outcome with all parts of the catchment receiving flood benefits from the operation of Lake Taupo and the WHS, the entry point to Phase I was not significant.

## 5.4 Objectives and Outcomes

**Table 5.2: WHS HFMP Objectives and Outcomes: January 2011**

Objective	Outcome
To effectively manage floods in the catchments using pre-determined flood management rules, developed in accordance with the provisions of the agreement.	As with the September event, the systems and logic applied by Mighty River Power and Waikato Regional Council when making decisions on flood management during the events, are generally in line with the WHS HFMP and resource consent 105228. Information was exchanged openly and effectively which aided in the effective management of the

	January 2011 flood event.
To ensure that the management of floods is carried out in a balanced approach so that no part of the catchment receives flood protection benefits at the expense of other parts of the catchment.	Flood management was carried out in a balanced approach as all parts of the catchment received flood benefits from the operation of Lake Taupo and the WHS.
To limit the extent of flooding of any property to the extent that it is no worse than would have occurred under "natural" conditions, unless the effects of any management decisions are deemed to be minor and within the bounds of "normal" operation.	<u>Upstream (Lake Taupo)</u> : during the event effects were less than that which would have naturally occurred (due to larger gate opening) <u>Downstream</u> : it is apparent that natural runoff volume was similar to that experienced with the WHS in place. However, the effects were minimised as the Waikato hydro reservoirs were used to absorb a simulated natural peak of approximately 870 m <sup>3</sup> /s within the dam system, compared with a peak observed outflow at Karapiro of 608 m <sup>3</sup> /s. Therefore this objective was achieved.
To audit periodically the responses of Waikato Regional Council and Mighty River Power and Genesis Power during floods, and to amend them as necessary to ensure that future flood management is effective, efficient and consistent with the provisions of this agreement.	Flood Audit Report provided by Mighty River Power, 24 February 2011. Flood Event Review Report by Waikato Regional Council, August 2011.

**Table 5.3: Lake Taupo Management Objectives and Outcomes: January 2011**

<b>Lake Taupo Management Objectives</b>	
<b>The gates will be used to manage the level of Lake Taupo with the following management objectives:</b>	
<b>Objectives</b>	<b>Outcomes</b>
A less than 20 % AEP of 357.25 masl A less than 5 % AEP of 357.38 masl A less than 1 % AEP of 357.50 masl	Analysis of the five day lake level undertaken by Mighty River Power shows AEP to be 19 %, i.e. approximately five year ARI.

**Table 5.4: Lake Karapiro Outflow Objectives and Outcomes: January 2011**

<b>Karapiro Outflow</b>	
<b>Under flood conditions Karapiro peak outflow shall be similar to or less than that which would otherwise occur without the hydro operations in pace with the aim of meeting the following objectives</b>	
<b>Objectives</b>	<b>Outcomes</b>
Dam safety requirements	As with the September event, dam safety was not compromised.
The flood rules	Decisions made during the period of the high flow were generally per flood rules in the WHS HFMP.
The following flood management objectives for Karapiro: A less than 10 % AEP of a daily average flow	Karapiro peak flow 600 m <sup>3</sup> /s, no frequency analysis provided (also peak flow, not daily average).

<p>from Karapiro of 500 m<sup>3</sup>/s  A less than 1 % AEP of a daily average flow from Karapiro of 650 m<sup>3</sup>/s</p>	
<p>The following flood management objectives for Ngaruawahia:</p> <p>A less than 33 % AEP of a daily average flow from Ngaruawahia of 850 m<sup>3</sup>/s</p> <p>A less than 2 % AEP of a daily average flow from Ngaruawahia of 1,250 m<sup>3</sup>/s</p> <p>A less than 1 % AEP of a daily average flow from Ngaruawahia of 1,500 m<sup>3</sup>/s</p>	<p>Ngaruawahia peak flow 879 m<sup>3</sup>/s, no frequency analysis provided (also peak flow, not daily average).</p>
<p>As otherwise lawfully directed by Waikato Regional Council for flood management or other emergency reasons.</p>	<p>This condition took effect as Waikato Regional Council lawfully directed Mighty River Power to release up to but no more than 600 m<sup>3</sup>/s.</p>



## 6 Technical Information

### 6.1 General

Information presented in the reports was taken at face value and no further investigation was done regarding the sources or basis of the information presented, nor analysis for frequency and significance of events.

### 6.2 Average Recurrence Interval

The frequency of levels observed in Lake Taupo during the events has been presented in the Mighty River Flood Audit reports and the Waikato Regional Council FERR in terms of multi-day average levels (cf. thirteen and seventeen day levels for September 2010, and five day level for January 2011). It is not clear that the frequencies for the management levels as noted in the WHS HFMP are based on the same durations: this should be clarified.

It is noted that the WHS HFMP and Mighty River Power resource consent conditions require a certain frequency of event occurrence defined as follows:

- For Lake Taupo levels:
  - A less than 20 % AEP of 357.25 masl
  - A less than 5 % AEP of 357.38 masl
  - A less than 1 % AEP of 357.50 masl
- for Karapiro:
  - A less than 10 % AEP of a daily average flow from Karapiro of 500 m<sup>3</sup>/s
  - A less than 1 % AEP of a daily average flow from Karapiro of 650 m<sup>3</sup>/s
- The following flood management objectives for Ngaruawahia:
  - A less than 33 % AEP of a daily average flow from Ngaruawahia of 850 m<sup>3</sup>/s
  - A less than 2 % AEP of a daily average flow from Ngaruawahia of 1,250 m<sup>3</sup>/s
  - A less than 1 % AEP of a daily average flow from Ngaruawahia of 1,500 m<sup>3</sup>/s

On the basis of the information provided by Waikato Regional Council and Mighty River Power the frequency of the events in September 2010 and January 2011 is summarised in Tables 6.1 and 6.2 below.

**Table 6.1: September 2010 event frequency**

Lake Taupo peak inflow (mean daily)	630 m <sup>3</sup> /s	
Lake Taupo level	357.325 masl	11 year ARI
Karapiro outflow	597 m <sup>3</sup> /s	More frequent than 10 year ARI
Ngaruawahia peak flow	940 m <sup>3</sup> /s	Five year to 10 year ARI

**Table 6.2: January 2011 event frequency**

<b>Lake Taupo inflows (mean daily)</b>	1,030 m <sup>3</sup> /s	
<b>Lake Taupo level</b>	357.303 masl	ARI just greater than five years
<b>Karapiro outflow</b>	608 m <sup>3</sup> /s	Less frequent than 10 year ARI
<b>Ngaruawahia peak flow</b>	879 m <sup>3</sup> /s	Approximate three year ARI

There is not necessarily a directly proportional relationship between rainfall frequency and runoff frequency, though clearly high flow conditions require significant rainfall. However, it is not always possible to determine the frequency of an event during its passage.

In a controlled environment such as the Taupo-Waikato system, the frequency of events will to a significant extent be determined by operational and management decisions. The frequency of levels and flows will be determined by analysis of the observed values over a period of time, and compared to the analysis of the historical record. The confirmation of meeting resource conditions and WHS HFMP objectives will be determined in this manner in retrospect, rather than on an event by event basis during the passage of the flood.

It is noted also that the flood frequency statistics may change to some extent with additional records, and based on events in the catchment and operational decisions made regarding management of floods through the system.

It is noted that the ARI flows for Karapiro and Ngaruawahia stations presented in the Flood Event Review report (cf. Figure 40) are not consistent with those in the consent conditions and the WHS HFMP (cf. Section 4.4 of Agreed Principles). This may relate to actual peak flows (in the Flood Event Review report) as compared to daily average flows (in the WHS HFMP). In this respect the Mighty River Power Flood Audit Reports also present flood level frequency data for different durations (17 day and 5 day durations for the September 2010 and January 2011 events respectively). The inconsistency between durations makes comparison difficult across events.

### **6.3 Simulated natural conditions**

The schedules to the Agreed Principles provide for sharing of information between Waikato Regional Council, Mighty River Power and Genesis Energy. This includes for assessment of simulated versus actual Lake Taupo levels to be provided by Mighty River Power. These data are required in order to assess outcome in relation to objectives of the WHS HFMP.

Simulated natural flows (e.g. Lake Taupo level, Karapiro Dam discharge) for the September 2010 and January 2011 events were provided to Waikato Regional Council by Mighty River Power.

It is understood from discussions with Waikato Regional Council that with regard to the Lake Taupo levels the natural series is generated with initial conditions defined from the managed lake levels. The natural series may thus not accurately represent conditions in Lake Taupo that would have occurred without the Taupo gates in place.

With regard to the September 2010 event the Karapiro Dam simulated natural discharge shown in FERR Figure 50, appears to indicate a lesser volume of water compared with the recorded discharge during the duration plotted. It is not possible to comment in detail on this, or other simulated natural data without further background to the modelling, and the detailed modelling results.

## **6.4 Previous events**

Waikato Regional Council presents data (in terms of levels and flows) from previous events (Section 4.5 FERR). These provide useful comparison for the events experienced in September 2010 and January 2011, and enable assessment within the historic context.

## **7 Flood management best practice**

The Associated Programme on Flood Management, a joint initiative of the World Meteorological Organisation and the Global Water Partnership has developed a Flood Management Tools Series. Technical Document No 6, Formulating a Basin Flood Management Plan (March 2007) includes the following elements:

- Basin flood management vision and policy
- The planning process
- Survey and analysis
- Flood risk assessment
- Setting target for basin flood management plan
- Identification and selection of options to reduce risks
- Implementation plan and monitoring.

The WHS HFMP generally includes all these elements.

It is noted that the WHS includes dams and reservoirs undoubtedly designed primarily for hydro-electric generation. However, these now fulfil a greater multi-objective role in management of the river and levels in Lake Taupo.

## **8 Summary and Conclusions**

### **8.1 Summary**

#### **8.1.1 General**

Objectives and responsibilities for flood management are set out in the Agreed Principles of High Flow Management for the Taupo Waikato catchment, a tripartite document prepared by the Waikato Regional Council, Mighty River Power and Genesis Energy. These are re-iterated in the Waikato Hydro System High Flow Management Plan, prepared by Mighty River Power, which also includes Waikato Flood Management Rules. The resource consents granted to Mighty River Power also link in to this document.

Waikato Regional Council has the statutory responsibility for flood management in the catchment, and is specifically responsible for coordinating real time flood management information and response, and disseminating this information to appropriate parties. Mighty River Power is responsible for the lawful operation of the WHS. During floods, Mighty River Power's specific responsibilities are to fulfil resource consent requirements and achieve the management objectives as defined for Lake Taupo, Waikato hydro reservoirs, and Karapiro outflows.

#### **8.1.2 September 2010 event**

Flooding through the Taupo Waikato system in September 2010 was the result of sustained rainfall over a period of time, falling on relatively wet catchments. Although rainfall intensities and peak flows were not particularly significant in terms of frequency, the volume of runoff affected storage capacity in the system and led to rising lake and river levels.

The flood response in the system was managed by Mighty River Power and Waikato Regional Council generally in accordance with the guidelines set out in the High Flow Management Plan, and as required by the Mighty River Power consents.

Although flood flows downstream of Karapiro Dam were greater than might have been in natural conditions, flooding was contained in the flood protection system and flood management was carried out in a balanced approach given the possibility of further rainfall in the catchment and conditions of Lake Taupo.

#### **8.1.3 January 2011 event**

The January 2011 flooding through the Taupo Waikato system was the result of more significant rainfall, from cyclonic weather systems over the catchments.

The flood response in the system was managed by Mighty River Power and Waikato Regional Council generally in accordance with the guidelines set out in the High Flow Management Plan, and as required by the Mighty River Power consents.

Flood management was carried out in a balanced approach, and all parts of the catchment received flood benefits from the operation of Lake Taupo and the WHS.

#### **8.1.4 Outcomes**

The management of the two events included for reduction of TPD inflows to Lake Taupo and full opening of the Taupo gates to manage the rise in Lake Taupo levels. These decisions undoubtedly reduced the ultimate peak water level in Lake Taupo.

In September 2010, flood flows and levels in the central reaches and downstream reaches were apparently higher than simulated under natural conditions (cf. FERR, section 6.2.2). However, the

Lawful Decision for this was taken in regard to the saturated catchment conditions and the levels in Lake Taupo.

In January 2011, the flood management decisions resulted in apparently lower flows and thus levels in the central and downstream reaches than simulated under natural conditions (cf. FERR, section 6.2.3). Thus all parts of the catchment received flood protection benefit as a result of the operation, thus meeting one of the objectives of the Agreed Principles.

In practical terms, it is considered that it would be very difficult to ensure that at all times no part of the catchment receives flood protection benefits at the expense of other parts. Decisions must be made to follow Flood Rules and resource consent conditions, and pre-emptive flood management measures are implemented with regard to possible future but unknown meteorological conditions over the catchments.

In a managed environment such as the Taupo-Waikato system, the frequency of events will be affected by operational and management decisions. Ultimately the frequency of levels and flows for particular events will be determined by comparison and analysis of the observed values over a period of time. The confirmation of meeting resource conditions and WHS HFMP objectives must thus be determined in this manner retrospectively, rather than on an event by event basis during the passage of an event.

## 8.2 Conclusions

Rainfall in the catchments caused significant runoff and sustained high flows through Lake Taupo and the WHS in September 2010 and January 2011. Contributing to the former event were wet catchment conditions, caused by relatively high rainfall in the months preceding.

In each event a Flood Response Centre as established by the Waikato Regional Council to manage the flood effects through Lake Taupo and the Waikato River system downstream.

The management of the floods was generally in accordance with the requirements of the Mighty River Power consents held for its operations in the catchment, the High Flow Management Plan for the WHS, and the Agreed Principles, and Flood Management Rules therein contained.

Mighty River Power and the Waikato Regional Council have prepared flood audit reports and a flood review report respectively as required by the High Flow Management Plan.

In reviewing the Waikato Regional Council Flood Event Review report, the following points are noted:

- Information regarding simulated natural flows in the catchment is reliant on data provided by Mighty River Power. It is not possible to comment in detail on this, or other simulated natural data without access to the detailed modelling results.
- There is some confusion about presentation of event frequency in the different documents, with various references to peak and/or average flows. Consistency of approach would reduce this.
- The frequency of levels and flows in the catchment will be determined by analysis of the observed values of the historical record, which will change with additional data. The confirmation of meeting resource conditions and WHS HFMP objectives will be determined in this manner in retrospect over the period of the record, rather than on an event by event basis during the passage of the flood.
- In practical terms, it is very difficult to ensure that at all times no part of the catchment receives flood protection benefits at the expense of other parts. Decisions must be made to follow Flood Rules and resource consent conditions, and pre-emptive flood management measures may be implemented with regard to possible future conditions in the catchments which may not eventuate.

Overall, the Flood Event Review report provides clear summary of the conditions leading to the floods and the management of these through Lake Taupo, the WHS, and the central and lower reaches of the river downstream.

## 9 Applicability

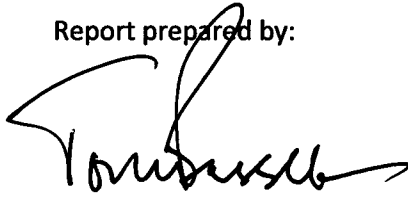
This report has been prepared for the benefit of the Waikato Regional Council with respect to the particular brief given to us and it may not be relied upon in other contexts or for any other purpose without our prior review and agreement.

Tonkin & Taylor Ltd

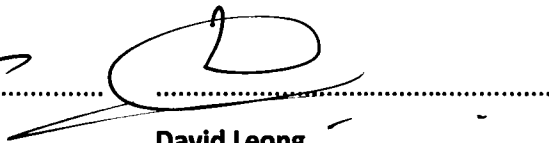
Environmental and Engineering Consultants

Report prepared by:

Authorised for Tonkin & Taylor Ltd by:



**Tom Bassett**  
PROJECT MANAGER



**David Leong**  
PROJECT DIRECTOR

Tom Bassett

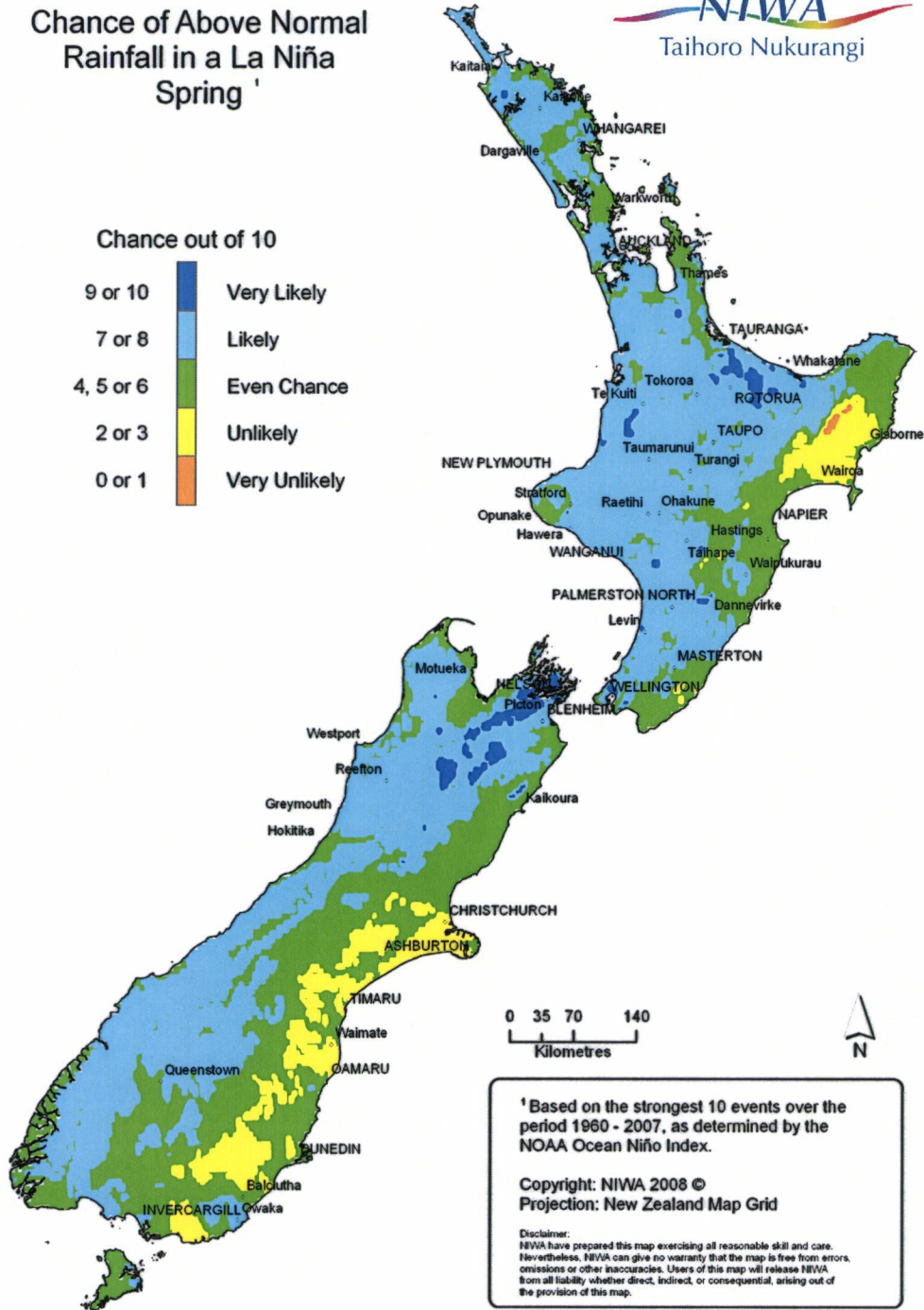
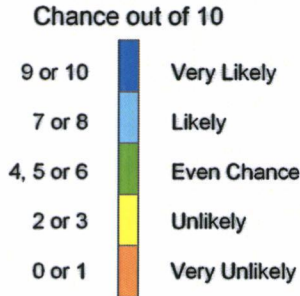
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## **Appendix A: NIWA La Niña Forecasts**

- **NIWA website: <http://www.niwa.co.nz/education-and-training/schools/students/enln>**

# Chance of Above Normal Rainfall in a La Niña Spring <sup>1</sup>

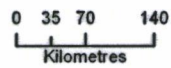
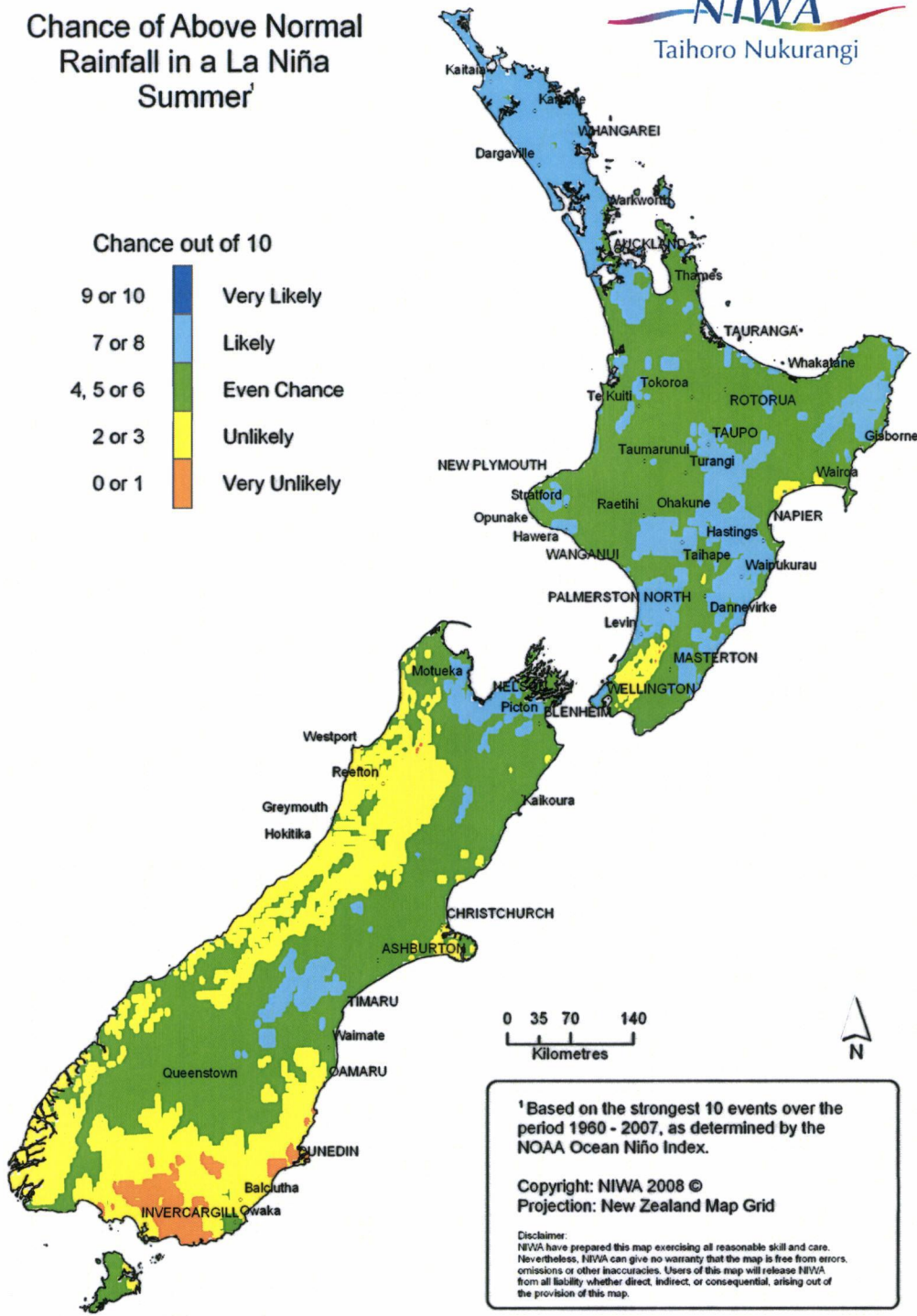
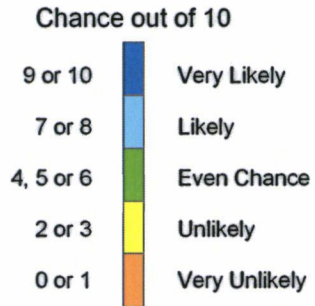


<sup>1</sup> Based on the strongest 10 events over the period 1960 - 2007, as determined by the NOAA Ocean Niño Index.

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# Chance of Above Normal Rainfall in a La Niña Summer<sup>1</sup>



<sup>1</sup> Based on the strongest 10 events over the period 1960 - 2007, as determined by the NOAA Ocean Niño Index.

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