IN THE MATTER of the Resource Management Act 1991

AND

IN THE MATTER of submissions and further submissions by **MERCURY NZ LIMITED** in respect of **PROPOSED PLAN CHANGE 34 FLOOD HAZARD** to the **TAUPO DISTRICT PLAN**

STATEMENT OF EVIDENCE OF DAVID ALFRED PAYNE FOR MERCURY NZ LIMITED

INTRODUCTION

1. My name is David Alfred Payne.

2. I am authorised to present this evidence on behalf of Mercury NZ Limited ('Mercury'), in support of its submission on Plan Change 34 Flood Hazard.

3. I am currently employed at Mercury as the Principal Hydrologist, a position I have held for 10 years. As Principal Hydrologist, I provide hydrological technical expertise to Mercury.

4. Prior to my employment at Mercury, I was employed as Work Group Manager (Natural Resources) at Opus [Consulting Ltd], and before that at the Northland Regional Council as a hydrological technician for 12 years. I have been involved in hydrology either as a hydrology technician or hydrologist for 33 years.

5. I hold a Bachelor of Applied Science and a New Zealand Certificate of Science from the Open Polytechnic of New Zealand. I am a member of the New Zealand Hydrological Society.

6. My evidence will outline:

    - The Waikato Hydro System
    - Lake Taupo storage, inflows and outflows
    - Lake Taupo level regime
    - High flow management
    - Evidence of Dr McConchie, prepared for Taupo District Council

THE WAIKATO HYDRO SYSTEM

7. The Waikato Hydro System ('hydro system') consists of the Taupo Gates and the eight dams and nine power stations on the Waikato River, as shown in Figures 1 and 2.

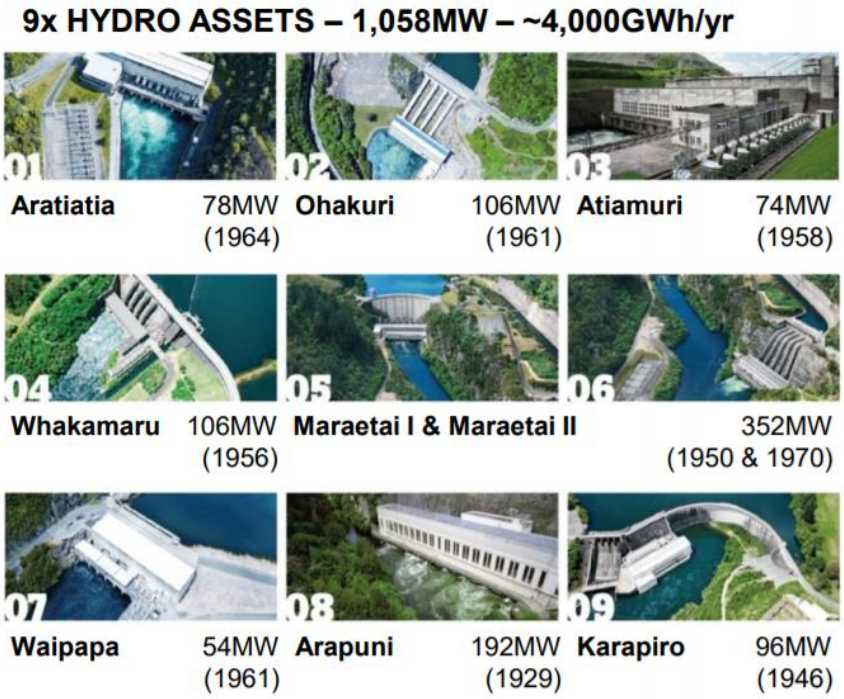

Figure 1: Hydro Generation Assets

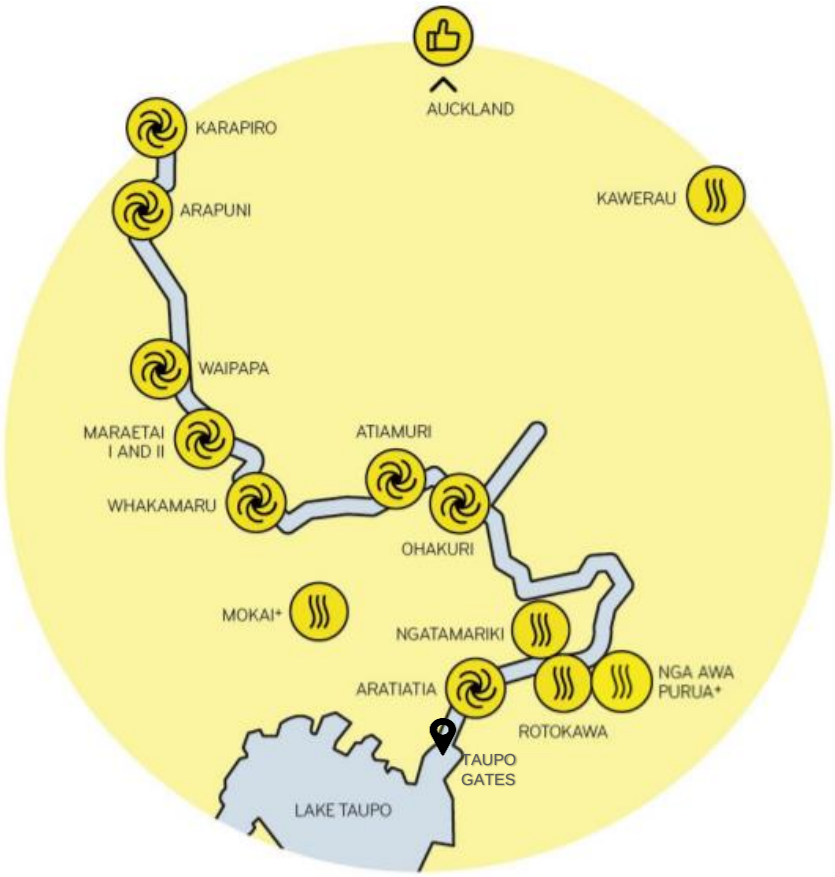

Figure 2: Location of Mercury's Generation Assets (Hydro & Geothermal)

8. The hydro system infrastructure was constructed in stages between 1929 and 1970 and is now embedded in the natural landscape providing a range of ecological, social and economic benefits to the region and the country. The infrastructure has a long-life expectancy and has had significant financial investment put into it to keep it operating safely and to enhance efficiency. That investment is on-going through plant refurbishments.

9. One of the key components of the operation of the hydro system is the existence of the Taupo Gates, commissioned in 1941. At the time of construction, the interconnected North Island electricity generation system otherwise lacked storage capacity making controllable storage very valuable. These reasons for storage are as valid today as when Taupo Gates were installed, and Lake Taupo storage has continued to be used for hydro-electricity generation, as was intended at the time.

10. In constructing the Taupo Gates, a new channel was cut for the river and the gates structure installed. This new channel and gates arrangement has a greater hydraulic capacity than the natural channel. For example, at a lake level of 357.25 metres above sea level (masl)[1] the gates can discharge up to 319 m^3/s, while the natural outlet channel if it existed would discharge 188 m^3/s. This arrangement has resulted in a much greater degree of flexibility for the whole hydro system than would have been possible had the natural outlet for Lake Taupo been retained.

11. There is limited storage capacity in the Waikato River hydro reservoirs below Taupo Gates, which provide only enough storage to manage daily fluctuations. Consequently, the hydro system operates almost as a "run of river" system using water released from Lake Taupo flowing down to Karapiro Dam.

12. The hydro system's use of water through its nine power stations makes a significant contribution to the provision of a secure and environmentally sound supply of electricity to the New Zealand economy and critical major load centres in Auckland, Waikato and the Bay of Plenty.

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[1] 357.25 masl is the Maximum Control Level for Lake Taupo, as set out in Mercury's resource consents for the hydro system. This is discussed further in paragraphs 22 to 28 of this evidence.

LAKE TAUPO STORAGE, INFLOWS AND OUTFLOWS

13. The recording of Taupo Lake Level started on 13 July 1905 and is one of the longest hydrological records in New Zealand.

14. Lake Taupo is inflow dominated, as the seasonal and inter-annual variations in Taupo inflows are controlled mainly by variations in rainfall and evaporation, and to a minor extent by the operation of the Tongariro Power Scheme.[2]

15. Tongariro Power Scheme, consisting of the eastern (1971) and western (1979) diversions, augments the inflows into Lake Taupo. These diversions equate to an annual average inflow of 30 m^3/s, increasing up to approximately 65 m^3/s during flood events. These diversions increase the flow into the Waikato River by approximately 19% at Taupo Gates.

16. The available storage within Lake Taupo is controlled by Taupo Gates and is managed within a 1.4 metre operating range prescribed by Mercury's resource consents.[3] Lake Taupo provides 92% of the storage capacity for the hydro system (855 million m^3), with the remaining 8% of storage capacity (71 million m^3) derived from the hydro reservoirs.

17. While the storage within Lake Taupo may seem large, the mean outflow through Taupo Gates of 156.2 m^3/s (January 1980 to June 2018, Mercury Hydrometric Database) equates to 4,926 million m^3 in one year, which is 5.8 times more than available storage. This in turn equates to a turning over of the storage volume of Lake Taupo approximately six times annually.

18. The level of Lake Taupo at any time is a function of the inflows from rainfall and runoff across the Taupo catchment, plus the flows from the Tongariro Power Scheme, evaporation from the lake, and the outflows through Taupo Gates. The level of Lake Taupo increases at times when the inflows exceed outflows, such as during high intensity or prolonged rainfall events, and conversely decreases when the outflows exceed inflows.

19. There is a general pattern in the lake inflow and outflow records across the year. Figure 3 shows the mean monthly inflow and outflow for the period January 1980 to June 2018 (Mercury Hydrometric Database). The time period from 1980 was selected as both

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2 Statement of evidence of Dr Ross Woods for Waikato Regional Council in respect of Variation No. 6 to the Proposed Waikato Regional Plan, 30 July 2010. Paragraph 25.

3 The Lake operating range is discussed further in paragraphs 22 to 28 of this evidence.

diversions from the Tongariro Power Scheme were completed and flowed into Lake Taupo and from this point a stable inflow regime has occurred.

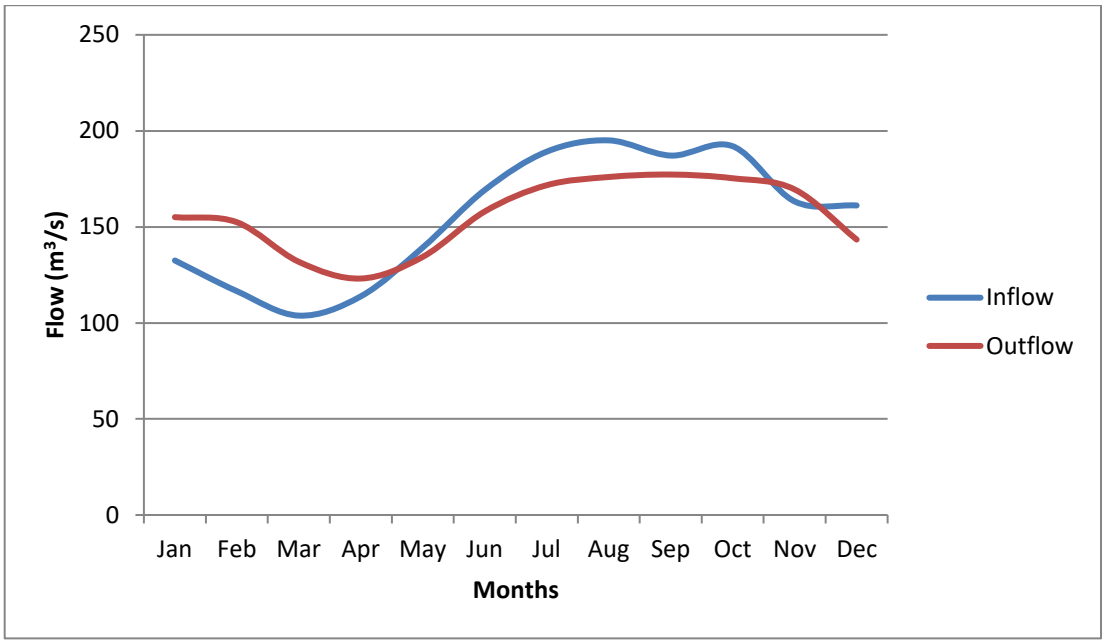

Figure 3: Mean monthly Lake Taupo inflows and outflows (Jan 1980 to Jun 2018).

20. Figure 3 shows that, for the months from January to April, the outflow is typically greater than inflow. The reason for the difference in flow is a combination of generation requirements and the occurrence of dry years where inflow into Lake Taupo and the hydro system is less than the required consented minimum flow at the Karapiro Power Station. In a dry year when inflows are less than the required minimum flow at Karapiro, Lake Taupo storage is used to supplement inflows into the hydro system to maintain the Karapiro minimum flow for the benefit of water users downstream of the Karapiro Dam.

21. From April rain in the catchment usually starts to fall and inflows increase. Figure 3 shows that lake inflows typically exceed outflows from May to October, resulting in storage in Lake Taupo being increased.

LAKE TAUPO LAKE LEVEL REGIME

22. The operating range for Lake Taupo is 1.4 metres between 355.85 masl (the Minimum Control Level) to 357.25 masl (the Maximum Control Level), as prescribed in Mercury's resource consents.

23. Figure 4 shows annual lake level from 2006 (when Mercury's resource consents were granted) to the end of 2017 (only complete years are graphed). The figure shows the variability of the lake level due to climatic variations. The data includes dry, average and wet years and a combination of dry and wet years.

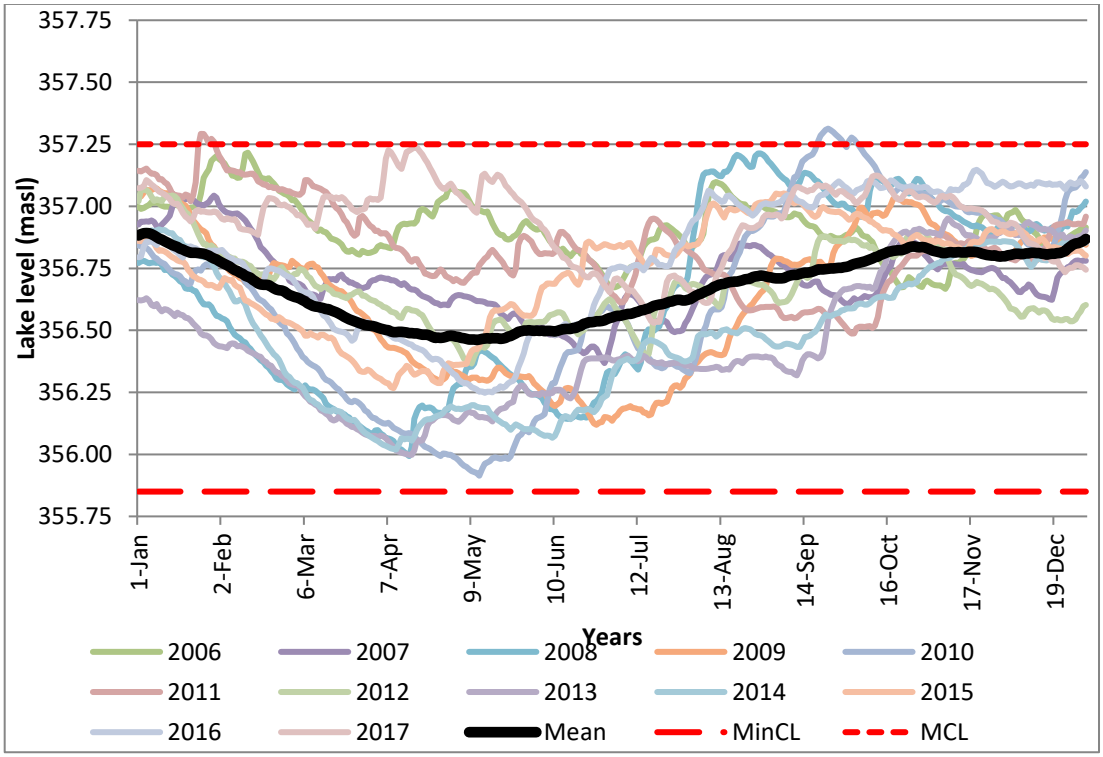

Figure 4: Annual Lake Taupo level 2006 to 2017.

24. To demonstrate this variability, Figure 5 shows that during the 2010 year the lake level nearly dropped below the Minimum Control Level in May during drought conditions, which was followed by above average rainfall and a flood in September resulting in the Maximum Control Level being surpassed. Despite this variability, analysis shows 2010 to be an average year in terms of annual mean lake level, highlighting how small the operating range is for Lake Taupo.

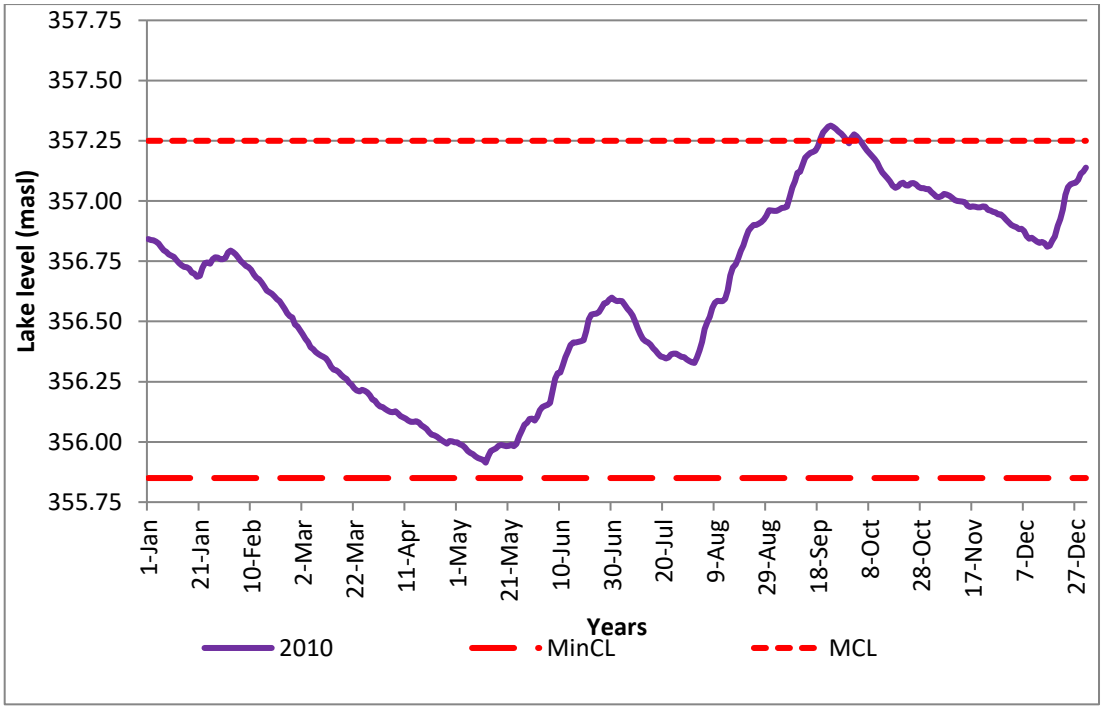

Figure 5: Lake Taupo level record for 2010.

25. Figure 6 shows the lake level recessions that have occurred for four dry years; 2008, 2010, 2013 and 2014. For three of those dry years the drought broke around mid-April but for the 2010 event the dry period extended into May and the drought did not break until mid-May. If the May event had lasted another ten days the lake level would have dropped below the Minimum Control Level.

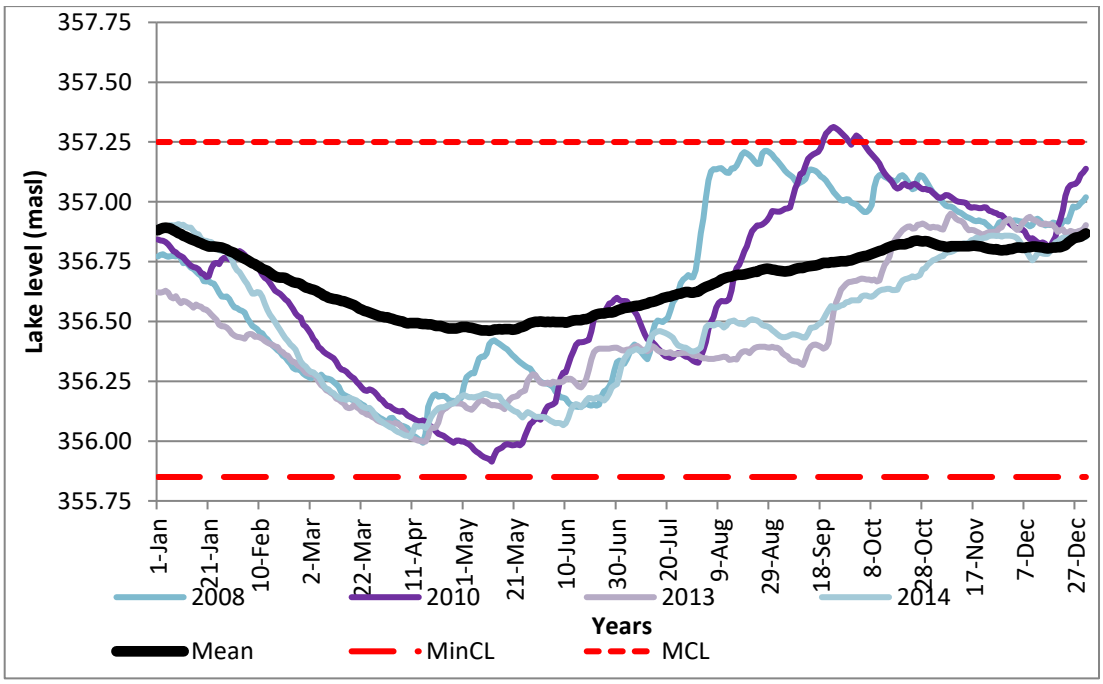

Figure 6: Annual Lake Taupo level 2006 to 2017.

26. If the lake level drops below the Minimum Control Level (implying drought conditions persist), then the discharge below Karapiro Dam must equal the inflows coming into Lake Taupo and the hydro system catchments. If this had occurred in May 2010, the Karapiro discharge flow would have reduced from the normal minimum of 140 m^3/s to approximately 100 m^3/s, which may have caused water supply problems for abstractors and other water users below Karapiro.

27. The long hydrological record for Lake Taupo shows that inflows and outflows to the lake over time are equal (allowing for some loss for evaporation). This situation arises as a result of the relatively small storage capacity in Lake Taupo that can be utilised by the hydro system. This results in a need to manage the Lake Taupo storage in a conservative manner to avoid the extremes of the range.

28. Prudent and practical operation of Lake Taupo storage requires that the lake is held somewhere in the mid-range between the Maximum and Minimum Control Levels, as represented by the mean lake level in Figures 4 and 6. The times when the lake goes to either the top or bottom ends of the storage range are those that occur as a result of continued dry or wet weather periods that are longer or more intense than expected.

29. The impacts of flood events were recognised during the consenting process by the Commissioners which resulted in resource consent condition 2.5.

30. Condition 2.5 acknowledges that flood events will occur and cause the lake level to exceed the Maximum Control Level. The condition reads:

> *The consent holder shall operate the Taupo Gates 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 357.50 masl (i.e. an average 1 in 100 year recurrence interval).*

31. To comply with condition 2.5 of Mercury's resource consents, a predictive tool was constructed in conjunction with Auckland University, Department of Statistics and the School of Operations Research and Industrial Engineering, Cornell University, New York.

32. Mercury in conjunction with the Department of Statistics at Auckland University has conducted a statistical analysis of Lake Taupo historic inflows to assess the probability of high flow events at Lake Taupo.

33. A lake Level is calculated for each day of the year for which an exceedance limit is reached (but not exceeded) based on historic inflow sequences and maximum release from Lake Taupo. Simplistically, if the lake is at the calculated daily level and a 1 in 100 year event flows into the lake then a 100-year level of 357.5 masl should occur.

34. This tool (known as the Limited Discretionary Release method) is reviewed bi-annually or sooner if significant floods (i.e. 1 in 20 year) occur within that period.

HIGH FLOW MANAGEMENT

35. The operation and maintenance of the hydro system is authorised by resource consents granted in April 2006. The conditions attached to the resource consents authorise the operational levels of Lake Taupo and the Waikato River reservoirs. Under the resource consents, 'high flow conditions' are deemed to exist when any of the following occur:

    - Lake Taupo level exceeds 357.25 masl (Maximum Control Level)
    - Waikato River flow is greater than 1000 m^3/s at Ngaruawahia
    - Catchment and/or river inflows cause or seem likely to cause any of the hydro reservoirs or Lake Taupo to rise above maximum control levels as described in the resource consents.

36. Included in the conditions was a requirement for a High Flow Management Plan (HFMP) that describes how Mercury will operate the hydro system during high flow conditions. The HFMP describes the management of Lake Taupo and the hydro reservoirs during a high flow event and the period until normal flows are re-established within the hydro system.

37. The HFMP demonstrates how the hydro system will be operated (in order of priority) to:

- Meet dam safety requirements (i.e. to ensure the integrity of the dam structures is not compromised).

- Limit the adverse effects of a flood event that may arise from the exercise and operation of the hydro system or any other cause, including effects on Lake Taupo, the hydro reservoirs and the Waikato River downstream of Karapiro.

- Assist the Waikato Regional Council in its role as flood manager.

38. The HFMP details:

- Objectives of the plan
- Flood management responsibilities
- Phases of high flow management
- Lake Taupo risk management tools
- An overview of the Mercury Flood Rules
- Communication protocols
- Reporting requirements.

39. The objectives of the Plan are:

- To ensure that roles and responsibilities are clear and understood between Mercury and Waikato Regional Council.

- To manage tributary inflows into the hydro system catchments during times of high flow.

- To ensure that communications, roles and responsibilities are clear between Waikato Regional Council as the statutory flood manager, Mercury and external parties (Genesis Energy, Taupo District Council, Hamilton City Council, Waipa District Council, Waikato District Council) during high flow conditions.

- To ensure that information on catchment and river inflows during high flow conditions is transparent to Waikato Regional Council.

- To ensure that Mercury complies with all resource consent conditions for the hydro system.

40. Waikato Regional Council has the statutory responsibility for flood management in the catchment. Specifically, Waikato Regional Council is responsible for:

- Co-ordinating real time flood management information and response and disseminating this information to appropriate parties (including Mercury and Genesis Energy).
- Disseminating information to the wider public.
- Administering the Waikato Civil Defence Emergency Management Group

41. Mercury is responsible for the lawful operation of the hydro system and during high flow conditions specific responsibilities are to:

- Fulfil resource consent requirements and achieve the management objectives of the HFMP.
- Provide real time information to Waikato Regional Council to assist them in their role as flood manager.
- Provide information as required by Waikato Regional Council to undertake flood audits.
- Communicate information to Territorial Authorities.

42. Genesis Energy is responsible for the lawful operation of the Tongariro Power Scheme and during high flow conditions specific responsibilities are to:

- Fulfil resource consent requirements.
- Provide real time information to Waikato Regional Council to assist them in their role as flood manager.
- Provide information as required by Waikato Regional Council to undertake flood audits.

43. Territorial Authorities are responsible for:

- Disseminating information to their local communities.
- Local Civil Defence responses.

44. High flow management for the hydro system is based on decision making with the Waikato Regional Council, in conjunction with Mercury and Genesis Energy, and involves a series of

steps or phases. Transition between the phases depends on the severity of the climatic event and the resultant inflows into Lake Taupo and/or the hydro system.

45. There are three Phases of high flow management.

46. **Phase 1** is an early warning discretionary stage. It allows the reservoirs to be drawn down in advance of a catchment storm predicted by weather forecasts. Negotiations with Waikato Regional Council for draw down of reservoirs and the creation of flood storage may be entered into when a weather forecast of catchment heavy rain is received or significant rainfall is recorded.

47. There are three triggers for consideration for entering Phase 1 (pre-high flow warning)

- Waikato River at Ngaruawahia exceeds 650 m^3/s OR
- Lake Taupo reaches 357.00 masl OR
- One or more Flood Table Discharge Levels are likely to be exceeded AND
- High flows are anticipated.

48. The Flood Table Discharge Level (FTDL) is a mandatory flow rate that must be discharged passed a dam structure when the operating range of the hydro reservoir is exceeded during high flow conditions. As the severity of the flood increases, and the level of water in the hydro reservoir increases, so too does the mandatory flow rate. More than one FTDL may also be triggered (see Phase 3 below). The purpose of the FTDL is to ensure dam integrity is maintained during high flow events.

49. **Phase 2** is entered when high flow conditions exist and when the rain that has been forecast starts falling. Phase 2 provides for actions to be taken during flood events to limit the effects of flooding. Triggers for consideration for entering Phase 2 are:

- Waikato River flow at Ngaruawahia exceeds 1000 m^3/s OR
- Lake Taupo reaches 357.25 masl OR
- One FTDL exceeded AND
- High inflows are occurring.

50. **Phase 3** is entered when three or more Power Station FTDL's are exceeded. This Phase involves implementation of the Mercury Flood Rules and table discharges at the affected

stations and lower discharges at other stations and Taupo Gates to create storage in the lower reservoirs. If three or more FTDL's are exceeded, flows through Taupo Gates must be reduced to 50 m^3/s.

51. The Flood Rules[4] were created to ensure dam integrity in the event of a severe flood. Under Phase 3 conditions, Mercury must operate the hydro system in accordance to mandatory prescribed discharges established in the Flood Rules. These mandatory rules determine outflows for each structure in the hydro system based on existing water levels at each dam. Mercury must ensure the structural integrity of the dam structures and ensure that the design capacity of the reservoirs is not exceeded.

52. The Flood Rules were formally introduced in 1975, and the latest update to the rules was 2011. The rules were developed following the large 1958 flood and the completion of the eight power stations on the Waikato River. Another factor in the development of the rules was the addition of Tongariro Power Scheme diversion flows. The Tongariro Power Scheme is now operated and controlled by Genesis Energy and completely independent from the operation of Mercury's hydro system.

53. In Phase 3 when Taupo outflow is restricted to 50 m^3/s it is likely that the Lake Taupo level will rise significantly, but a Phase 3 has not occurred since the Flood Rules were formalised in 1975. However for illustrative purposes, the 2011 flood event was operated under Phase 2 of the HFMP, with the Taupo Gates discharging approximately 300 m^3/s before, during and after the storm event. This flood event recorded the second highest inflow of 1,022m^3/s since records began in 1905, and Lake Taupo level rose approximately 200mm in one day.

54. Active communication with specific external agencies during a high flow event is vital to ensuring that the operation of the hydro system is integrated into Waikato Regional Council's flood management actions. The HFMP includes an external communication plan that details the information that organisations outside of Mercury will be provided with in the lead up to and during catchment wide high flow events, and the information and any directions that Mercury expects to receive from these organisations. External agencies include Waikato Regional Council, Genesis Energy and the territorial authorities between Lake Taupo and Port Waikato.

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4 The Flood Rules are a controlled document within Mercury. The Flood Rules are periodically updated by Mercury independent of the HFMP process.

55. The communication relationship between Mercury and Waikato Regional Council changes as a high flow event increases in severity.

- Advisory - Mercury liaises with Waikato Regional Council, given early indications of a potential high flow event.
- Discussion - between Mercury and Waikato Regional Council. This can occur in Phase 2 before the prescriptive components of the Flood Rules are in effect.
- Direction – of Mercury by Waikato Regional Council. Waikato Regional Council has powers under the Soil Conservation and Rivers Control Act, the Civil Defence Act and the Resource Management Act to issue directions for the purpose of preventing flooding and/or erosion while ensuring dam safety is not compromised.

EVIDENCE OF DR MCCONCHIE PREPARED FOR TAUPO DISTRICT COUNCIL

56. In this section I discuss the hydrological evidence of Dr Jack McConchie (dated 27 September 2018), including areas of agreement or disagreement.

57. Mercury's submission sought an amendment to the definition of 'Annual Exceedance Probability' to make it clearer but also to ensure that it remained appropriate to apply to river flood flows and to lake flood levels. I support the evidence of Dr Jack McConchie (paragraph 236, parts a and b) in relation to an amended definition for 'Annual Exceedance Probability' and for a new definition 'Design Flood'. The 'Design Flood' definition is particularly useful to clarify the difference between river flood flows and lake flood levels.

58. The effect of lake wave activity and set up on the landward extent of inundation has been deliberately excluded from the flood hazard maps and the policy framework of Plan Change 34. The evidence of Dr Jack McConchie records that (paragraph 74) "*The risk from a combination of high lake levels and large waves was excluded from consideration because of the lack of empirical data to calibrate the results of the wave modelling; beyond a qualitative level.*"

59. Mercury believes Council need to collect wave data to support numerical modelling to address wave activity and set up effects on the foreshore and backshore environments around Lake Taupo, and that this will be undertaken to inform a natural hazards chapter for the District Plan review in the future. However, awareness of wave activity on Lake

Taupo by the community and an understanding of its potential risks remains to be a relevant issue for this plan change.

60. It is noted that wind induced waves may be associated with storm events that bring high inflows into Lake Taupo, but may also occur independent of high inflow events. Either way, wave activity can affect property by causing inundation as well as lake shore erosion. Property owners are unlikely to distinguish between inundation caused by a high lake level or through the action of waves (which may or may not be caused by the same storm event). Therefore, property owners may experience inundation effects due to high water level and waves (and possibly erosion, subject to the proximity of the property to the lake shore) that is greater than the inundation effect caused solely by high static water level.

61. Mercury's submission sought the inclusion of interim measures in Plan Change 34 until more information becomes available for the District Plan review to acknowledge that lake wave activity is part of the process that causes inundation (and lake shore erosion). The specific provisions sought on wave activity is addressed in the planning evidence of Mr Reuben Hansen on behalf of Mercury.

David Payne

8 October 2018