TERM OF REFERENCE 3: STATE-WIDE WATER STORAGE MANAGEMENT

*The causes of the floods which were active in Tasmania over the period 4-7 June 2016 including cloud-seeding, **State-wide water storage management** and debris management.*

1 CONTEXT

1.1 Cause of the Floods

(a) It is clear that the flooding that affected northern Tasmania (including the Mersey, Forth, Ouse and South Esk rivers) during the relevant period was directly caused by "*a persistent and very moist north-easterly airstream*" which resulted in "*daily* [rainfall] *totals* [that were] *unprecedented for any month across several locations in the northern half of Tasmania*", in some cases in excess of 200mm.[1]

(b) This paper addresses Hydro Tasmania's water storage management prior to and during the floods.

1.2 Overview

(a) In 2014, Tasmania celebrated 100 years of hydro industrialisation and the role it played in the development of Tasmania. Hydro Tasmania believes that understanding the design and purpose of the hydropower infrastructure that was developed to bring electricity and investment to the state is an important starting point to provide context for our submission. The Tasmanian hydropower system design and operation is highly complex and is generally not well understood in the community. We understand that key stakeholder groups are seeking to better understand the role that hydropower operations may have in controlling or contributing to flood events in Tasmania.

(b) The hydropower infrastructure in Tasmania was designed and installed for the primary purpose of generating hydro-electricity. Flood mitigation was not a primary objective in the design of Hydro Tasmania's dams when the schemes were developed, and any flood mitigation benefit is a by-product of their hydro-generation operation. Some dams in other parts of the world have been intentionally designed for multi-purpose use with the multiple objectives, such

1 Bureau of Meteorology's Special Climate Statement 57, issued on 17 June 2016.

as hydropower generation, water supply and flood mitigation and control (such as Wivenhoe dam in Queensland). As a result of its design, the Tasmania hydropower infrastructure has limited capacity for flood mitigation or control. This point is important for context and is elaborated on during this submission.

1.3 Hydro Tasmania's role and governance

(a) Hydro Tasmania is a "statutory authority" within the meaning of the *Government Business Enterprises Act 1995* (Tas). Its primary governing legislation is the *Hydro-Electric Corporation Act 1995* (Tas)[2].

(b) Hydro Tasmania's principal purpose is to "*efficiently generate, trade and sell electricity in the National Electricity Market*"[3].

(c) Its principal objectives are to perform its functions and exercise its powers to:

(i) be a successful business by operating in accordance with sound commercial practice and as efficiently as possible; and

(ii) achieve a sustainable commercial rate of return that maximises value for the State of Tasmania in accordance with Hydro Tasmania's Ministerial Charter and having regard to the economic and social objectives of the state[4].

(d) Hydro Tasmania has been conferred the access rights to significant water resources for the purposes of hydro generation in Tasmania[5]. This is subject to stringent legislative regulation[6].

(e) Hydro Tasmania's Ministerial Charter also contains several "Strategic Expectations" on Hydro Tasmania, including to:

(i) "prudently manage its water resources consistent with the long run energy capability of its system" and

2 See section 5 for a list of Hydro Tasmania's functions and powers, which are subject to the limitations set out in sections 7 and 8.

3 Section 2.1 of Hydro Tasmania Ministerial Charter (November 2012), issued under the Government Business Enterprises Act 1995 (Tas)

4 Section 2.2 of Hydro Tasmania Ministerial Charter (November 2012)

5 An annual average of 15,364 gigalitres of water flows through its power stations.

6 Hydro Tasmania holds a Special Licence under Part 6, Division 6 of the Water Management Act 1999 (Tas) (WMA) and thus, is a "water entity" within the meaning of that Act. There have a been a large number of "hydro-electric districts" created for the purposes of the WMA. On 9 June 2000 Hydro Tasmania and the Minister entered into the Special Water Licence Agreement pursuant to clause 7(2) of Schedule 4 of the WMA, which has been amended a number of times, the most recent being dated 11 September 2012.

(ii) "act in a socially responsible manner and take all reasonable steps to reduce the risk of adverse effects on the environment that may result from Hydro Tasmania's activities".[7]

(f) Hydro Tasmania takes its obligations with respect to managing the water resources under its care extremely seriously and has in place a robust governance framework to ensure compliance. Its commitment to public safety has primacy and is ingrained in its processes and systems.

1.4 Overview of Hydro Tasmania's Water Assets

Catchments and Storages

(a) The "hydro-electric districts" that Hydro Tasmania administers under the *Water Management Act 1999* (Tas) (**WMA**) includes 45 of Tasmania's major lakes and at least 1200 km of natural creeks and rivers.

(b) These areas are broken down into six major river catchments:

(i) South Esk – Great Lake catchment;

(ii) Mersey-Forth catchment;

(iii) Derwent catchment;

(iv) Gordon catchment;

(v) Anthony Pieman catchment; and

(vi) King catchment.[8]

(c) Hydro Tasmania categorises its primary water storages into three broad sizes (Major, Medium or Minor) based on the typical time required to fill or empty the storage under normal inflow/weather conditions (known as the "the life cycle of the storage"). The following table lists the storages against their appropriate category.

7 Section 2.3 of Hydro Tasmania Ministerial Charter (November 2012)

8 A map of the major storage catchments and power stations in Tasmania is included at Annexure A.

MAJOR (Long Period Cycling)	MEDIUM (Annual Cycling)	MINOR (Run of River)
South Esk–Great Lake Great Lake **Gordon** Lake Pedder Lake Gordon	**Mersey-Forth** Lake Rowallan Lake Mackenzie Lake Gairdner **Derwent** Lake Echo Bronte Lagoon + Bradys lake + Lake Binney + Tungatinah Lagoon **Anthony Pieman** Lake Plimsoll Lake Murchison + Mackintosh **King** Lake Burbury	**South Esk-Great Lake** Lake Trevallyn **Mersey-Forth** Lake Parangana Lake Barrington Lake Paloona **Derwent** Lake Laipootah Wayatinah Lagoon Lake Repulse Cluny Lagoon Lake Meadowbank **Anthony Pieman** Lake Rosebery Lake Pieman

(d) Other storages (such as Lake Augusta which is the size of a medium storage) are not ordinarily included in this list because of either their small capacity or the nature of their water conveyancing, for example if they are not closely linked with a power station.

Water Management Operations Procedures

(a) The operation of the Hydro water storages is governed by a set of Storage Operating Rules (SOR) discussed below. The storages are monitored and controlled 24/7 from the Hobart office for the purposes of dam safety and water management. Each week Hydro Tasmania plans which power stations it will run and when for the week ahead, using complex algorithms and planning software that takes into account factors such as expected rainfall, expected price outcomes, delivery risks and outages, expected usage, capacity of various dams and spill likelihood, and the value of water in different locations, and a range of other factors.

(b) Hydro Tasmania monitors and changes priorities and determines which storages to operate in real time, operating within Storage Operating Rules for each storage, the National Electricity Rules and other governance frameworks, and resolving and responding to issues, and making changes as additional information is made available.

1.5 Explanation of Storage Position

(a) Hydro Tasmania’s core business is as an electricity generator. For this reason we express the water storage position in energy output terms, ie. as GWh equivalent. Internally we also convert inflows and changes in the storage position as yield which we measure in energy output terms (GWh). Storage 'levels' are expressed as a ‘per cent full’ in energy terms. This applies to the system as a whole, but we also refer to the level of particular lakes. The figure is relative to, but is not the same as, the actual level of water in the storage expressed as megalitres for most storage dams. Hydro Tasmania publishes water storage data on its website under ‘energy data’.

Storage Operating Rules

(a) Hydro Tasmania’s Storage Operating Rules describe how water levels and releases from the storages are to be managed. In developing the rules, Hydro Tasmania considers the attributes of the particular lake – physical, climatic, multiple-use, social, environmental and operational requirements. Adjustments to rules are made when conditions surrounding these attributes change significantly. Consultation with relevant stakeholders is undertaken where appropriate to do so.

(b) Due to the prevalence of winter rains and dry summers, Hydro Tasmania’s storage levels will vary considerably over the course of a year. Therefore, Hydro Tasmania’s preferred operating zone varies throughout the year. The preferred operating zone is a range of water levels, referred to as a band, the lower end of which leaves a reserve that can be used to generate electricity when inflows are low, both due to seasonal variations in rainfall and in the case of below average rainfall. Low storage levels result in a greater risk that Hydro Tasmania may not be able to generate electricity as and when required. Maintaining higher storage levels to protect against low inflow events requires significant investment in the form of foregone generation and revenue, which has to be funded by increased debt.

(c) Around two-thirds of Hydro Tasmania’s expected yield in a year occurs in catchments that have minimal storage capability. These storages fill over the course of a full winter/spring season (in some cases many times). Around one-third of yield occurs in catchments from the major storages of Great Lake and Lake Gordon, which rise and fall over years and present no current spill risk.

(d) In managing its storages, Hydro Tasmania must constantly balance the risks arising from:

(i) uncertain inflows against the risk of spilling excess water without power generation and other upstream and downstream considerations including flood potential to ensure optimisation of the resource use and appropriate risk management;

(ii) the current and potential future value of generation; and

(iii) the risk of asset outages (including assets not owned or operated by Hydro Tasmania, such as Basslink and the National Electricity Market (**NEM**) transmission networks) against the cost of alternative generation or supply sources.

(e) Hydro Tasmania's storage optimisation is achieved by integrating water modelling outputs within its total generation portfolio of hydro and gas generation. This is in turn optimised based upon forecasts of Tasmanian electricity demand, wind generation and wholesale electricity market price with imports or exports across Basslink. This process also considers contingencies such as plant and Basslink outages.

(f) In general, as water storages fall, the energy value of stored water increases, which flows through into higher bid prices into the NEM. This in turn triggers decisions on non-hydro generation - Basslink imports and gas generation - to preserve hydro storages.

(g) Through the interaction of these factors and optimisation, Hydro Tasmania meets its Government Business Enterprise (**GBE**) obligation to maximise the value of the business for Tasmania.

1.6 Safety as a Priority

(a) Hydro Tasmania's commitment to public safety has primacy and is ingrained in its processes and systems.

(b) Public safety is the number one consideration in the management of its catchments and operation of our power stations. All Hydro Tasmania employees (including those who manage flows and water levels) must take all practicable steps, regardless of generation implications, system security and any other considerations, to protect human life.

(c) Processes for managing flows during floods are described in the Storage Operating Rules. These processes are regularly reviewed and updated.

(d) Hydro Tasmania is committed to continuous learning and improvement. In this respect, it undertook a review following the 2011 Queensland floods and has incorporated the learnings from the Queensland experience into its planning tools and operational processes.

(e) A desktop flood simulation exercise was performed in conjunction with BoM in May 2011 to test processes, protocols, decisions and notifications. This showed that the protocols were simple and robust and well executed, and identified areas for improvement which were implemented.

1.7 Background Facts to June 2016 Floods

Water Management late 2015 / early 2016

(a) The period of October 2015 through April 2016 was amongst the driest 8 month periods on record in Tasmania. When combined with the extended forced outage of Basslink that commenced on 20 December 2015 (and concluded on 13 June 2016), this resulted in hydro storage levels reaching a record low of 12.5 per cent in late April 2016.

(b) As a consequence, Hydro Tasmania's primary focus was on ensuring continuation of supply to the Tasmanian electricity system[9].

(c) Storage levels improved in May 2016, which was the wettest May on record in

9 The primary response to the energy supply situation came through the Energy Supply Plan.

terms of inflows into Hydro Tasmania's storages. During the month the storage position increased by over 10% with many of the smaller lakes either spilling for a period or approaching their full supply level (**FSL**). Notwithstanding these inflows, on 30 May, the week prior to the floods, the storages were still only at 23 per cent. As Basslink was still out of service a conservative approach was being taken to water (energy) management.

Forecast Rainfall

(a) The operations team uses forecasts from the Bureau of Meteorology (**BOM**) and other forecasting models and information to plan operations. A wide range of forecasts exist but accuracy dramatically declines for forecasts beyond 3 to 4 days. The reliability of forecast rainfall information means that it is only possible to forecast with limited accuracy three to four days ahead where and when heavy rainfall will occur.

(b) It is noted that although rainfall may be predicted, if the location varies, the actions that Hydro Tasmania may take in anticipation can vary significantly. Therefore, it is careful to ensure that it makes decisions only once information is sufficiently certain, in order to comply with its obligations and achieve its objectives.

(c) In the days leading up to the unprecedented rainfall on 5 and 6 June 2016, there was uncertainty about how much rain was going to fall and where it was likely to fall. For example:

   (i) On 2 and 3 June 2016 the forecasts were for potentially heavy rain in the North East of Tasmania (rather than the North West and central Tasmania) or that it would miss Tasmania altogether.

   (ii) By later on 3 June and into 4 June, the forecasts provided more certainty as to the location of the rainfall, but there was still uncertainty as to the expected volume.

(d) The following table sets out the flood warnings issued by BOM that were applicable for Hydro Tasmania's catchments between 3 June 2016 and 8 June 2016. The table lists the first time each level of warning was issued for each river.

Table 1: Status of flood warnings issued in early June

BoM warning	Time/date first issued	River	Hydro catchment
Flood Watch	11.58am 3 June 2016	All northern and eastern river basins	Tasmania
Moderate	3.17pm 4 June 2016	Mersey River	Mersey-Forth
Minor	3.27pm 4 June 2016	North Esk	South Esk
Moderate	3.50pm 4 June 2016	South Esk River	South Esk
Minor	3.52pm 4 June 2016	Meander River	South Esk
Minor	4.19pm 4 June 2016	Macquarie River	South Esk
Minor	4.20pm 4 June 2016	Forth River	Mersey-Forth
Moderate (upgraded)	12.44pm 5 June 2016	North Esk	South Esk
Flood Watch (broadened)	4.15pm 5 June 2016	All Tasmanian river basins	Tasmania
Major (upgraded)	4.16pm 5 June 2016	Mersey River	Mersey-Forth
Moderate (upgraded)	5.14pm 5 June 2016	Forth River	Mersey-Forth
Major (upgraded)	9.58pm 5 June 2016	Meander River	South Esk
Minor	10.36pm 5 June 2016	Derwent (inc Ouse)	Derwent
Major (upgraded)	6.25am 6 June 2016	North Esk	South Esk
Major (upgraded)	7.21am 6 June 2016	South Esk	South Esk
Moderate (upgraded)	8.05am 6 June 2016	Macquarie River	South Esk
Major (upgraded)	8.37am 6 June 2016	Forth River	Mersey-Forth
Major (upgraded)	12.10pm 6 June 2016	Derwent (inc Ouse)	Derwent
Major (upgraded)	5.14pm 6 June 2016	Macquarie River	South Esk
Moderate (downgraded)	6.22pm 6 June 2016	Forth River	Mersey-Forth
Moderate (downgraded)	3.03am 7 June 2016	North Esk	South Esk
Moderate (downgraded)	6.46am 7 June 2016	Derwent (inc Ouse)	Derwent
Moderate (downgraded)	7.07am 7 June 2016	Mersey River	Mersey-Forth
Minor (downgraded)	7.42am 7 June 2016	Forth River	Mersey-Forth
Moderate (downgraded)	9.54am 7 June 2016	Macquarie River	South Esk
Major (upgraded)	10.39am 7 June 2016	Macquarie River	South Esk
Moderate - Derwent Minor – Ouse (downgraded)	1.07pm 7 June 2016	Derwent (inc Ouse)	Derwent
Minor (downgraded)	8.13pm 7 June 2016	Mersey River	Mersey-Forth
Minor (downgraded)	9.00pm 7 June 2016	North Esk	South Esk
Minor (downgraded)	11.29pm 7 June 2016	Derwent (inc Ouse)	Derwent

2 DESIGN AND CONSTRUCTION OF DAMS

2.1 Background information

(a) The following table lists the dams that are potentially relevant to the terms of reference, together with background information on when they were built and the enabling legislation under which they were constructed.

Dam	Year of commissioning	Enabling Legislation[10]
Mersey-Forth		
Lake Rowallan	1968	*Hydro-Electric Commission (Mersey-Forth Power Development) Act 1963* (Tas)
Lake Barrington	1969	As above
Lake Parangana	1969	As above
Lake Cethana	1971	As above
Lake Gairdner	1971	As above
Lake Paloona	1972	As above
Lake Mackenzie	1973	As above
Relevant to the Ouse		
Penstock Lagoon	1916	*Complex Ores Act 1908* (Tas)
Shannon Lagoon	1927	As above
Lake Augusta	1953	As above
Relevant to the South Esk		
Lake Trevallyn	1955	*Loan (Hydro-electric Commission) Act 1947* (Tas)
Great Lake / Poatina Power station	1966-1977	*Hydro Electric Commission (Lower Derwent Power Development and Miena Dam) Act 1966* (Tas)
Poatina Re-regulation pond	2005	*Water Management Act 1999* (Tas) (dam permit)

(b) The primary purpose of Hydro Tasmania's schemes is for hydro power

10 The *Electricity Supply Industry Restructuring (Savings and Transitional Provisions) Act 1995* repealed the various construction Acts noted below which enabled the various power schemes to be built ('enabling legislation'). This did not affect the ability of Hydro Tasmania to operate and maintain the various schemes.

generation and the objective of flood control and mitigation was not included as a design objective when the schemes were developed. The design therefore limits the ability to influence flood outcomes in the operation of the system. Some of the storages also supply water for irrigation, town water supply and domestic use, aquaculture, recreational use, stock use, and environmental entitlements.

(c) Hydro Tasmania is committed to sustainable use of this shared resource, and maintaining a balance between electricity generation and those other needs.

2.2 Design of Hydro Tasmania storages

(a) In general terms, Hydro Tasmania's dams are not designed for flood mitigation (that is, they are not designed with a specific purpose in mind to prevent or reduce the severity of floods). Once they are full, any further water that flows into the storage (from any source) must flow out, either through the attached power station (where applicable) or by way of "spill".

(b) This is an important distinction from some other dams in Australia and elsewhere, such as Wivenhoe Dam in Queensland (involved in the Queensland floods in 2011), which was designed and installed with a dual purpose: water supply *and* flood mitigation, by pre-releasing water, and temporarily storing flood inflows to release gradually.

(c) Certain dams in Victoria which were involved in floods there in 2010-2011 also have flood mitigation as one of their design purposes. The relevant Victorian legislation lists a number of design and operational objectives including "flood mitigation, where possible" (ie without compromising reliability of supply and dam safety).

(d) All dams have a natural effect to attenuate floods; that is the peak outflow cannot exceed the peak inflow unless there is an operational release (eg gates or other form of outlet) to do so.

(e) Where a dam has an uncontrolled spillway (ie the discharge is purely a function of the lake water level) there is very little operational control over the flood discharge. The main contributing factor is then the lake level at the start of a flood inflow event.

(f) Hydro Tasmania does have some dams that incorporate operable spillway gates that govern the passing of operational flows and spillages through or between storages, that are considered dam safety critical plant. These often allow dynamic management of lake levels, with flexibility to store inflows up to full supply level and maximize generation from stored water. The majority of these gates represent the sole outlet for flood waters for their dams. None of these were involved in the June 2016 floods.[11]

(g) The storages upstream of the areas affected by the June 2016 floods in the Mersey, Forth, Ouse and Trevallyn rivers have fixed crest (ungated) structures, which do not have operable spillways.[12] This means that it is not possible to hold back or release flood waters by opening gates in the dam. Water will generally exit the dams into the river system downstream in three ways:

(i) Through a power station associated with the particular dam;

(ii) Via uncontrolled spilling over the dam's spillway; or

(iii) Via valves in the dam structure for the purpose of limited but controlled releases (where these exist).

3 NO DAM INFRASTRUCTURE FAILURES DURING FLOODS

3.1 Dam Safety Procedures

(a) Hydro Tasmania's Dam Safety Procedures framework is a comprehensive suite of policies, incorporating a high level policy, a long term strategic and risk management standard, and a number of operational documents setting out procedures to follow in the lead up to and during dam safety events or emergencies. This framework relates to the safety and integrity of the dams themselves, rather than downstream impacts.

(b) Hydro Tasmania's dam safety is consistent with best practice in Australia. Dam Safety Performance Review Group meetings occur six monthly, with the

11 The dams with spillway gates known as 'primary protection assets' (and the schemes they are a part of) are as follows: Clarke (Upper Derwent), Crotty (King), Lake Echo (Upper Derwent), Lake St Clair (Upper Derwent), Liapootah (Lower Derwent), Meadowbank (Lower Derwent), Miena (Great Lake), and Serpentine (Gordon).

12 Except Poatina re-regulation pond. See section 4.6 South Esk below.

most recent one having occurred on 31 May 2016. This involves an independent expert reviewing the program and providing recommendations, giving an opportunity for continual improvement. This review system has been widely regarded as an industry leading governance forum.

3.2 Actual Events

(a) The floods in June 2016 were significant and many dams exceeded their previous high levels, and the levels which are considered by Hydro Tasmania that there is a 1 in 20 year chance of exceeding.

(b) Despite these extreme events, there were no dam failures (that is, to the safety and integrity of the dams).

4 OPERATION OF DAMS

4.1 Operation of Hydro Tasmania's assets prior to the June 2016 floods

(a) When Hydro Tasmania's dams are almost full or spilling, Hydro Tasmania seeks to generate electricity from them as strongly as possible to avoid or minimise uncontrolled spill. Hydro Tasmania had already been operating storages to reduce levels in the systems that were almost full or spilling following the significant inflows in May 2016.

(b) In areas where heavy rainfall is predicted Hydro Tasmania's practice is to draw down storages to capture as much inflow as possible by operating the associated power station prior to the rainfall occurring. . This is known as creating airspace in the dams to make room for anticipated rainfall to be collected. The desire to capture as much inflow as possible is balanced with the increased risk of having drawn too much out of the dams should the actual inflows be less than expected. The target levels for balancing this risk take account the individual schemes, rest of the hydro portfolio, availability of other supply sources (wind, gas and interconnection), time of year and confidence in forecasts.

(c) In accordance with this practice, once it became apparent that many of Hydro Tasmania's storages could anticipate significant inflows, Hydro Tasmania actively drew down a number of storages in the relevant areas prior to the floods, by operating the associated power stations. This had the effect of creating "air space" in the dams, which reduced the total volume of water that spilled as a consequence of the rainfall and delayed the onset of the floods, as the rainfall and run-off must first fill up the dam before it spills (this is also known as an attenuation effect).

(d) Although this assisted in attenuating the flood flows, the impact that this can have is limited by the size of the dams and the amount of rainfall.

4.2 Operation of Hydro Tasmania's assets during the floods

Overview

(a) As mentioned above, all storages considered in this review which were upstream of flooding in the Mersey, Forth, Ouse and Trevallyn, are fixed crest (ungated) structures, which do not have operable spillways. This means that it is not possible to hold back or release flood waters by opening gates in the dam. Water will generally exit the dams into the river system downstream in three ways:

(i) Through a power station associated with the particular dam;

(ii) Via uncontrolled spilling over the dam's spillway; or

(iii) Via valves in the dam structure for the purpose of limited but controlled releases.

(b) When a large volume of rainfall occurs, the dams fill up faster from rainfall than the rate at which the power stations can release the water. Consequently, the excess water flows over the dam's spillway instead of through the power station (called "spill").

(c) This is particularly so for minor or "run of river" storages.[13] Many of the storages that spilled during the June 2016 floods were small storages, which fill and spill quickly.

(d) The rainfall that occurred in early June 2016 significantly exceeded the

13 'Run of river' storages are operated by diverting river flow through the power stations before returning the water back to the river downstream. As such, unlike conventional hydro-power schemes, their dams are generally small storages.

capacity of many of these dams, causing them to spill.

(e) If a Hydro Tasmania dam is spilling, Hydro Tasmania generally continues to operate the associated power station to generate power from that storage, since at least it gets the economic benefit from the water (as opposed to the zero economic benefit from water that "spills").

(f) The operation of a power station once a dam is spilling generally does not affect the volume of water flowing downstream, as the water simply flows through the power station rather than over the spillway. An exception is the Lemonthyme Power Station (Lake Parangana) referred to below, where the volume of water flowing down the Mersey River was reduced, as this water was diverted to the Forth River.

4.3 Operations in the Derwent river system (impacting the River Ouse)

Ouse - Overview

(a) The River Ouse is located in the Derwent Catchment. The Derwent cascade of power stations is a run-of-river system and is quite complex as the lakes have small storage capacities. Water from almost the entire Derwent catchment is utilised for hydro-electricity generating system. The freshwater portion of the Derwent catchment covers an area of approximately 7,400 km2 in south-east and central Tasmania. The area encompasses the catchments of the River Derwent and several tributary rivers including the Ouse, Nive and Dee.

(b) The River Ouse starts at an elevation of 1,210m in the central plains. It then drops over its 131km length, flowing generally in a north-south direction, through Julian Lakes (at 1,206m), Lake Augusta (at 1,152m) and the township of Ouse (at 150m) before it joins the River Derwent.

(c) In normal circumstances, some of the head waters of the River Ouse are diverted across to Great Lake (via Liawenee Canal) and the middle reaches are diverted across to Lake Echo (via Montpeelyata Canal). The maximum capacity of the canals is as follows:

(i) Liawenee Canal – 23.3m^3/sec (cumecs); and

(ii) Montpeelyata Canal – 14.16 cumecs.

(d) The creeks and rivers with the largest catchment areas which flow into the River Ouse are the Shannon River, Kenmere Creek, Blackburn Creek, James River, Boggy Marsh Rivulet, Ripple Creek and Simpsons Creek.

(e) Hydro Tasmania has the following storages which can contribute to water flow into the River Ouse:

(i) Lake Augusta;

(ii) Little Pine Lagoon;

(iii) Shannon Lagoon (from Great Lake); and

(iv) Penstock Lagoon

(f) Lake Augusta and Shannon Lagoon are located physically within the Ouse catchment, and in normal circumstances contribute water to Great Lake which discharges via Poatina Power Station into the South Esk catchment (via the Liawenee Canal). During flood events however, water can spill from Lake Augusta and Shannon Lagoon into the River Ouse and Shannon Rivers respectively in the Derwent catchment.

(g) In addition, the River Ouse travels a further 70km downstream of Montpeelyata Canal, through an additional 830km^2 of catchment before reaching the river monitoring station at Ashton Creek (approximately 15 kilometres north of Ouse township).

(h) A map and schematic of the Derwent Power Scheme is attached at Annexure C.

Ouse - Operation of Hydro Tasmania's assets prior to the floods

(a) The water level in Lake Augusta was actively drawn down in the 2 to 3 days before the heavy rainfall via:

(i) operation of Liawenee canal to transfer water away from the River Ouse and into Great Lake; and

(ii) operation of Montpeelyata canal to transfer water away from the River Ouse and into Lake Echo.

(b) The lake level in Shannon Lagoon was also actively drawn down prior to the floods.

(c) At 9am on 5 June 2016, the levels of Lake Augusta, Lake Shannon and Penstock Lagoon were:[14]

Lake	Lake level	Full level	NMOL[15]
Lake Augusta	1149.61	1150.62	1141.63
Shannon Lagoon	1017.57	1017.66	1016.97
Penstock Lagoon	919.78	919.86	919.30

Ouse - Operation of Hydro Tasmania's assets during the floods

(a) From a hydro-generation perspective Lake Augusta is generally considered to be part of the Great Lake catchment, as its water is transferred into Great Lake during usual operations. In extreme rainfall events, when Lake Augusta reaches capacity and spills, Hydro Tasmania uses the canals to the greatest extent possible to transfer water into Great Lake or Lake Echo, however where the amount of water exceeds the capacity of these canals, the excess water flows down the River Ouse. In early June 2016, a significant amount of rainfall fell into Lake Augusta's catchment causing the lake to reach capacity and spill in this manner.

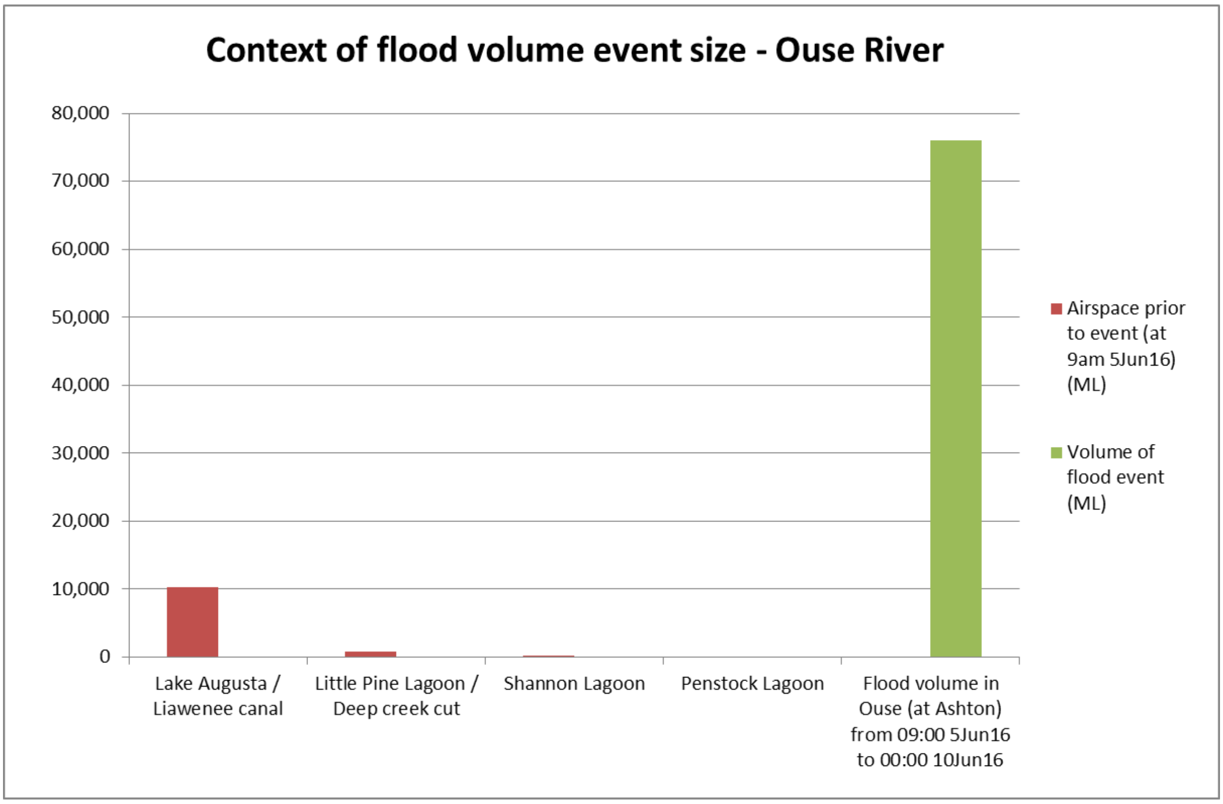
(b) No additional water was transferred into the River Ouse via active operations during the floods once Lake Augusta was spilling. Water was not released from Great Lake into Shannon Lagoon, and water was not released from Little Pine Lagoon via Deep Creek Cut into the River Ouse. Little Pine Lagoon filled and it's water spilled into Little Pine River and flowed through to the Nive River and did not enter the River Ouse.

14 All measurements are in metres above sea level.

15 A storage's Normal Minimum Operating Level (NMOL) is determined by the lowest level at which the civil infrastructure design allows the power station to operate. There are additional operational limits that may also exist to ensure compliance with a number of other obligations including environmental, recreational, licenses, irrigation environmental, recreational and community considerations and requirements.

(c) There was also rainfall in other areas of the catchment, and the small storages of Shannon Lagoon and Penstock Lagoon also filled and spilled, with a negligible spill flowing from those storages through to the River Ouse.[16] Local pick up from rainfall throughout the rest of the catchment would also have contributed to water in the River Ouse.

(d) The following chart provides some context of the volume of water in comparison to the airspace in the relevant storages prior to the flood event.[17]



(e) In the River Ouse a volume of 75,952 ML flowed (measured at Ashton) during the period 09:00 on 5 June 2016 to 00:00 on 10 June 2016.[18] In comparison and contrast, the Lake Augusta airspace prior to the flood event was 10,280 ML.

(f) Prior to the construction of the dams at Miena the water flows from Great Lake would have flowed down the Shannon River into the River Ouse. During the June flood no water was released from Great Lake into the River Ouse

16 See the peak spill figures in table E in the annexure.

17 Peak data of flood volume was estimated using surveys due to an instrument failure during the event.

18 Peak data of flood volume was estimated using surveys due to an instrument failure during the event.

catchment.

Ouse – Conclusion

(a) Hydro Tasmania's actions in the period leading up to and during the June 2016 floods did not increase the volume of water that would otherwise have flowed down the River Ouse, and in fact their operations *reduced* the volume of water. Water was transferred *away* from the River Ouse to Great Lake (via Liawenee canal) and to Lake Echo (via Montpeelyata canal) and neither of those large storages spilled during the floods.

4.4 Operations in the Mersey River System

Mersey - Overview

(a) The Mersey River starts below Mount Rogoona (at an elevation of 948m)[19] and flows in a northerly direction through Rowallan Lake (at 488m) and Lake Parangana (at 381m), and flows past Liena, Kimberley and Latrobe townships on its way to Bass Strait at Devonport.

(b) A number of creeks and rivers flow into the Mersey River, including the Arm and Fisher rivers. The Fisher River flows through Lake Mackenzie before it joins the Mersey River.

(c) The Mersey River forms part of the Mersey-Forth system. The Mersey-Forth catchment is in the north-west of Tasmania. It uses water from four main rivers – Fisher, Mersey, Wilmot and Forth. Lakes high in the Western Tiers feed the rivers below and in turn the power stations.

(d) The Mersey-Forth hydro scheme is a run-of-river system. The Mersey Forth catchment has a combined area of 2,800 $km^{2.}$. The following table sets out the storages and associated power stations in the Mersey-Forth catchment:

19 All heights are described as metres above sea level

Storage 	Storage Volume GL	Full Storage Level FSL (m)	Normal Minimum Operating Level NMOL (m)	Associated power station	Average annual Capacity MW	 Generation GWh/annum
Lake Rowallan	120.64	487.68	466.65	Rowallan	10.5	39
Lake Mackenzie	18.98	1120.75	1,111.00	Fisher	43.2	227
Lake Parangana	2.60	381.00	378.56	Parangana (mini-hydro)		3
Lake Parangana				Lemonthyme	51	271
Lake Gairdner	7.39	472.44	460.71	Wilmot	30.6	130
Lake Cethana	19.99	220.98	216.41	Cethana	85	390
Lake Barrington	33.95	121.92	116.59	Devils Gate	60	278
Lake Paloona	6.76	53.40	49.07	Paloona	28	125
Total[2]	**210.30**				**308**	**1,463**

(e) The Mersey River flows through Lake Rowallan (and the Rowallan power station), and Lake Parangana (and the Parangana mini hydro), whilst the Fisher River flows through Lake Mackenzie (and the Fisher Power Station), before it flows into Lake Parangana.

(f) A map and schematic of the Mersey-Forth catchment is included at Annexure B.

Mersey - Operation of Hydro Tasmania's assets prior to the floods

(a) The power stations in the Mersey associated with Lake Rowallan (Rowallan Power Station), Mackenzie (Fisher Power Station) and Parangana (Lemonthyme Power Station) were operated prior to the June floods to draw down storages in anticipation of rainfall.

(b) At 9am on 5 June 2016, the levels of Lake Rowallan, Lake Mackenzie and Lake Parangana were:[20]

Lake	**Lake level**	**Full level**	**NMOL**
Lake Rowallan	486.78	487.68	466.65
Lake Mackenzie	1119.94	1120.75	1111.00
Lake Parangana	380.65	381.00	378.56

20 All measurements are in metres.

Mersey - Operation of Hydro Tasmania's assets during the floods

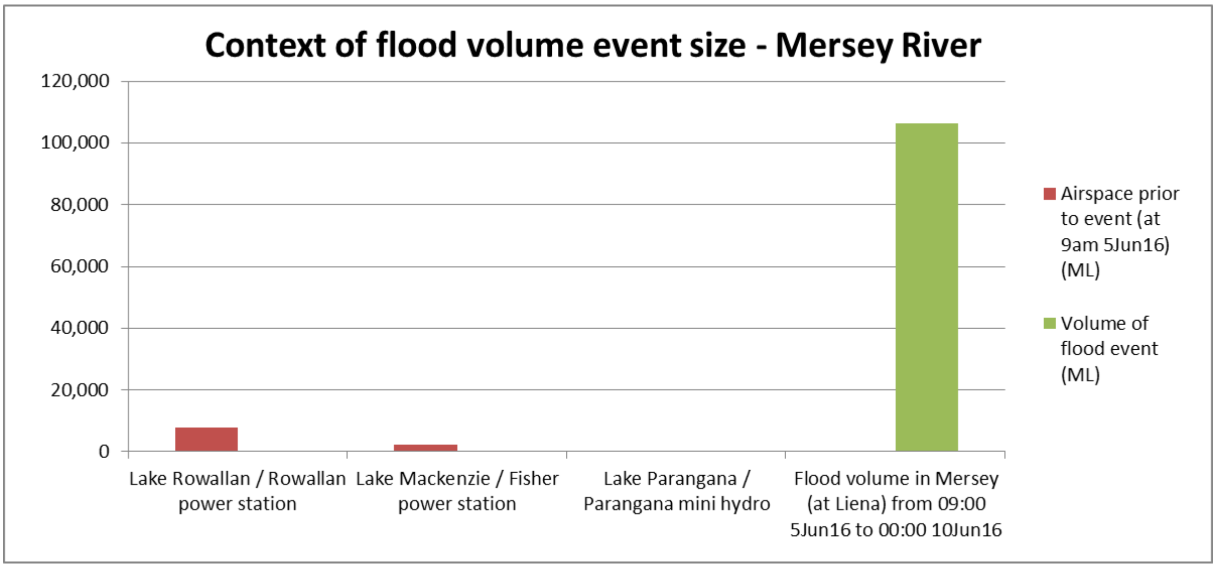
(a) During the June 2016 floods, northern Tasmania received unprecedented rainfall, and all seven lakes in the Mersey-Forth catchment spilled, as the volume of inflows significantly exceeded the capacity of the lakes.

(b) The table in Annexure E sets out the details of when each lake spilled and ceased spilling, the duration on spill, and the peak flow over the spillway.

(c) While the dams at Lakes Rowallan, Mackenzie and Paragana were spilling, the Fisher Power Station (Lake Mackenzie), Rowallan Power Station (Lake Rowallan) and Lemonthyme Power Station (Lake Parangana) generally continued to operate when not unavailable (due to local plant issues associated with the floods). The operation of these power stations once the lakes were spilling did not impact the flow down the Mersey as the water used would otherwise have spilled over the top of the dam's spillway in an uncontrolled manner.

(d) The operation of the Lemonthyme power station reduced the water flowing down the Mersey River as the water was diverted into the Forth River via a tunnel.

(e) The following chart shows the small size of the airspace in the relevant storages prior to the flood event in comparison with the volume of water experienced during these floods.



(f) In the Mersey River a volume of 106,439 ML flowed (at Liena) during the period 09:00 on 5 June 2016 to 00:00 on 10 June 2016. [21]

(g) Due to the high inflows in the preceding month of May 2016, the available air space in Lake Rowallan was only 7,900 ML. It was drawn down, in accordance with SOR, in the five to six days prior to the floods.

Mersey - Conclusion

(a) There are three dams upstream of Latrobe, each of which reached its capacity and spilled during the June 2016 floods. None of these dams have operable spillways which could be used to manage releases.

(b) Once the dams were full, the water that flowed in, flowed out either over the spillways and/or through the associated power stations. Operation of these power stations during the floods did not create any additional water flow towards the town of Latrobe.

(c) The operation of Lemonthyme power station reduced water flow towards Latrobe as it diverted water to the Forth River.

4.5 Operations in the Forth River system

Forth - Overview

(a) The Forth River forms part of the Mersey-Forth catchment. Like the Mersey River, it rises on the central plateau and flow northwards to the coast near Devonport. The majority of the Forth catchment is upstream of Paloona Dam, with the remainder being downstream of hydro generation infrastructure. A number of creeks and rivers flow into the Forth River, including the Wilmot River.

(b) The Forth hydro scheme is a “run of river” system, made up of small storages which fill and spill quickly. The following table sets out the storages and associated power stations in the Mersey-Forth catchment:

21 Post event gauging indicates that the rating curve at Mersey at Liena was underestimating by approximately 25%, meaning the flood volume would actually be higher than this figure, and higher than indicated on the graph.

Storage	Storage Volume GL	Full Storage Level FSL (m)	Normal Minimum Operating Level NMOL (m)	Associated power station	Average annual Capacity MW	Average annual Generation GWh/annum
Lake Rowallan	120.64	487.68	466.65	Rowallan	10.5	39
Lake Mackenzie	18.98	1120.75	1,111.00	Fisher	43.2	227
Lake Parangana	2.60	381.00	378.56	Parangana (mini-hydro)		3
Lake Parangana				Lemonthyme	51	271
Lake Gairdner	7.39	472.44	460.71	Wilmot	30.6	130
Lake Cethana	19.99	220.98	216.41	Cethana	85	390
Lake Barrington	33.95	121.92	116.59	Devils Gate	60	278
Lake Paloona	6.76	53.40	49.07	Paloona	28	125
Total[2]	**210.30**				**308**	**1,463**

(c) The Forth River flows through Lake Cethana (and Cethana Power Station), Lake Barrington (and Devils Gate Power Station), Lake Paloona (and Paloona Power Station) and then continues downstream. The River Iris and River Lea flow into Lake Gairdner then through to Wilmot River or alternatively through Wilmot Power Station into Lake Cethana. Water from Lake Parangana in the Mersey is transferred into Lake Cethana via the Lemonthyme tunnel and Power station.

(d) The map and Schematic of the Mersey-Forth catchment are included in Annexure B.

Forth - Operation of Hydro Tasmania's assets prior to the floods

(a) The power stations in the Forth were operated prior to the June floods to draw down storages in anticipation of rainfall.

(b) At 9am on 5 June 2016, the levels of the lakes were:[22]

Lake	Lake level	Full level	NMOL
Lake Paloona	52.56	53.34	49.07
Lake Barrington	121.17	121.92	116.59
Lake Cethana	217.23	220.98	216.41
Lake Gairdner	468.06	472.44	460.71

Forth - Operation of Hydro Tasmania's assets during the floods

22 All measurements are in metres above sea level.

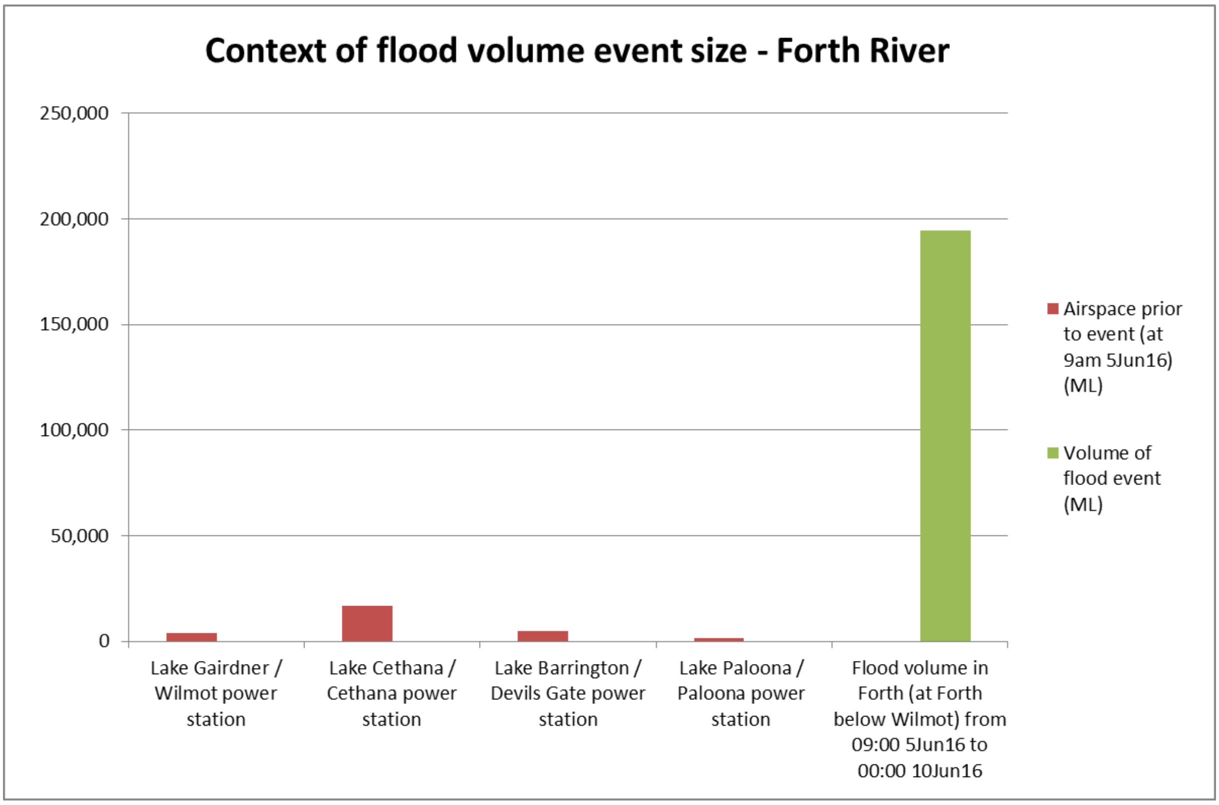
(a) During the June 2016 floods northern Tasmania received unprecedented rainfall, and all seven lakes in the Mersey-Forth catchment spilled, as the volume of rainfall that fell significantly exceeded the capacity of the lakes.

(b) While the dams were spilling, the Wilmot, Cethana, Devils Gate and Paloona power stations continued to operate. The operation of these power stations once the lakes were spilling did not increase flood flow down the Forth River as the water used would otherwise have spilled over the top of the dam's spillway in an uncontrolled manner.

(c) The Lemonthyme Power Station at Lake Parangana also continued to operate once Lake Parangana was spilling. It diverted water from the Mersey to the Forth (thereby reducing flood flows in the Mersey but increasing flood flows in the Forth). The water was transferred in order to make best use of it for energy generation, in circumstances where both catchments were flooding and it was not possible to anticipate which valley would have more significant floods. The maximum flow of water via Lemonthyme tunnel was $44m^3/s$ (cubic metres per second), which is small in the scheme of the floods (this can be compared to the peak flow of $800m^3/s$ which flowed over the spillway at Lake Paloona, the final dam in the Forth River).

(d) The operation of the Wilmot Power Station at Lake Gairdner transferred water from the Wilmot River into the Forth River. However, in any event, spill from Lake Gairdner flows into the Wilmot River which then joins the Forth River downstream of Lake Paloona (upstream of the town of Forth). Hence operation of the Wilmot power station did not impact the volume of water that flowed towards the town of Forth.

(e) The following chart provides some context of the airspace in the respective storages in the Forth in comparison to the volume of water in these floods.



(f) In the Forth River a volume of 194,580 Mega Litres (ML) flowed (at Forth below Wilmot) during the period 09:00 on 5 June 2016 to 00:00 on 10 June 2016. In comparison and contrast, the storage on the Forth River with the greatest airspace prior to the flood event was Cethana with an airspace of 16,630 ML.

Forth – Conclusion

(a) Hydro Tasmania's actions in the period leading up to and during the June 2016 floods marginally increased the volume of water that flowed down the Forth River, as water was transferred from the Mersey to the Forth via Lemonthyme Tunnel. However, this water would have otherwise added to flooding in the Mersey.

(b) Hydro Tasmania's actions did not otherwise increase the volume of water in the Forth River, and did provide some mitigation through the attenuation effect due to drawing down storages prior to flooding. None of these dams have operable spillways which could be used to release flood waters.

4.6 South Esk

South Esk - Overview

(a) The greater South Esk River catchment is the largest water catchment area in Tasmania, making up almost 15% of Tasmania's land mass, covering an area of almost 9,000 km2. Its major rivers are the South Esk, Macquarie, and Meander Rivers. The North Esk and South Esk Rivers both flow into the head of the River Tamar within 1 kilometre of each other.

(b) Hydro Tasmania's storages that feed its hydro power stations in the South-Esk Great Lake hydro catchment are as follows:

Storage	Storage Volume	Full Storage Level	Normal Minimum Operating Level	Associated power station	Average annual	
	GL	FSL (m)	NMOL (m)		Capacity MW	Generation GWhr/pa
Lake Augusta	21.32	1,150.62	1,141.63			
Great Lake**	3063	1,039.37	1,018.03	Poatina	350	1051
Arthurs Lake	448.79	952.82	943.05	Tods Corner	1.7	6
Woods Lake*	43.67	737.77	733.96			
Lake Trevallyn	8.52	126.49	117.96	Trevallyn	100	418
Total	**3,585.31**				**452**	**1,475**

*Woods Lake is primarily used as storage for Hydro Tasmania to meet irrigation water supply obligations along the Lake River

**Great Lake is physically located in the Derwent hydro-electric district, however the water is used in the South Esk hydro-electric district.

(c) With respect to the rivers that suffered flooding during the June 2016 Floods:

(i) The South Esk River enters Lake Trevallyn / Trevallyn Dam from which the water can either pass via the power station or Cataract Gorge into the River Tamar. The Lake River starts at Arthurs Lake and passes via Woods Lake into the Macquarie River, which joins the South Esk River. Neither of Arthurs Lake or Woods Lake spilled during the flood event, and did not contribute any water to the flood flows.

(ii) Poatina Power Station (which takes its water from the Great Lake) discharges into Brumby's Creek, which flows into the Macquarie River.

(iii) The Meander River starts below Bastion Bluff and runs for 112km before merging with the South Esk River immediately above Lake

Trevallyn. Hydro Tasmania does not have any dams on the Meander River.

(iv) Hydro Tasmania does not have any dams or relevant infrastructure on the North Esk River. The North Esk River also experienced severe flooding during the June floods, contributing to water flow in the Tamar.

(d) As can be seen from above, water from the Macquarie River, Meander River, Upper Lake, Lake Rivers and Brumby's Creek (via the Macquarie River) and South Esk River all ultimately flow through to Trevallyn Lake and Trevallyn Dam. Lake Trevallyn has very little storage.

(e) As previously discussed in section 4.3(f), although Great Lake is located in the natural Derwent catchment area, it supplies water to Poatina Power Station in the South Esk. Great Lake captured rainfall during the floods and its level rose but it did not spill, and did not contribute any water to flood flows.

(f) A map and schematic showing the Great Lake / Trevallyn Power Scheme is included at Annexure D.

South Esk - Operation of Hydro Tasmania's assets prior to the floods

(a) Trevallyn Power Station was operated prior to the June floods to draw down Lake Trevallyn in anticipation of high inflows.

(b) Poatina Power Station was not operated in the days prior to the June 2016 floods as there was sufficient generation capacity available at other spilling storages to meet the Tasmanian electricity demand.

(c) At 9am on 5 June 2016, the levels of Lake Trevallyn, Poatina Re-regulation Pond, Great Lake and Woods Lake were:[23]

Lake	Lake level	Full level	NMOL
Lake Trevallyn	118.75	126.49	117.96
Poatina Re-Regulation Pond	156.53	157.50	155.00

23 All measurements are in metres.

Great Lake[24]	1022.48	1039.37	1018.03
Woods Lake[25]	735.94	737.77	733.96

South Esk - Operation of Hydro Tasmania's assets during the floods

(a) During the June 2016 floods, there was a sudden and significant increase in flows in the South Esk river and its tributaries as a result of high rainfall.

(b) Consistent with the Storage Operating Rules Poatina Power Station did not operate during the June 2016 floods in order to prevent adding to flood flows.

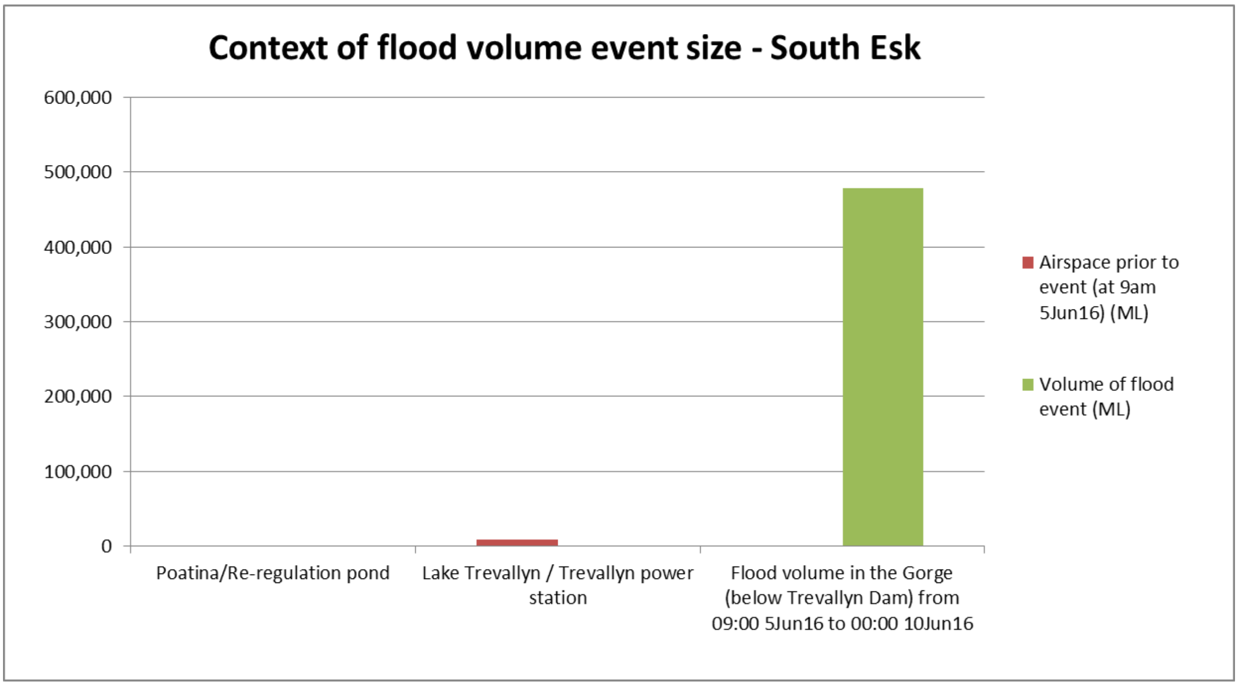
(c) A small water volume was gradually discharged from the Poatina Regulation Pond, in order to prevent a larger sudden automatic discharge which would have otherwise been required to protect the dam. This water was run off from the area next to the canal and was not from the power station.

(d) The water level at Lake Trevallyn quickly increased on 6 June 2016 due to significant rainfall in the South Esk catchment during the course of the floods, leading to Lake Trevallyn spilling on 6 June 2016. The power station continued to operate during the floods, however this did not impact on the volume of water as that water simply ran through the power station rather than over the spillway.

(e) The following chart shows the small size of the airspace in the respective storages prior to the flood event in comparison with the volume of water experienced during these floods.

24 Did not spill or release water

25 Did not spill or release water



(f) In the Cataract Gorge (below Trevallyn Dam) a volume of 478,684 ML flowed (into the River Tamar) during the period 09:00 on 5 June 2016 to 00:00 on 10 June 2016. Upstream, the Trevallyn Dam had an airspace of 8,010 ML and it was drawn down as far as reasonably possible in the days prior to the flood event.

South Esk – Conclusion

(a) Hydro Tasmania's actions in the period leading up to and during the June 2016 floods did not increase the volume of water that would otherwise have flowed through to Trevallyn Dam and Launceston, apart from releasing a negligible amount of water from Poatina Re-Regulation pond in order to prevent a larger sudden automated release.

(b) The operation of Trevallyn Power Station prior to the floods had the effect of drawing down Lake Trevallyn, which had the effect of only slightly reducing the flood.

ANNEXURE A

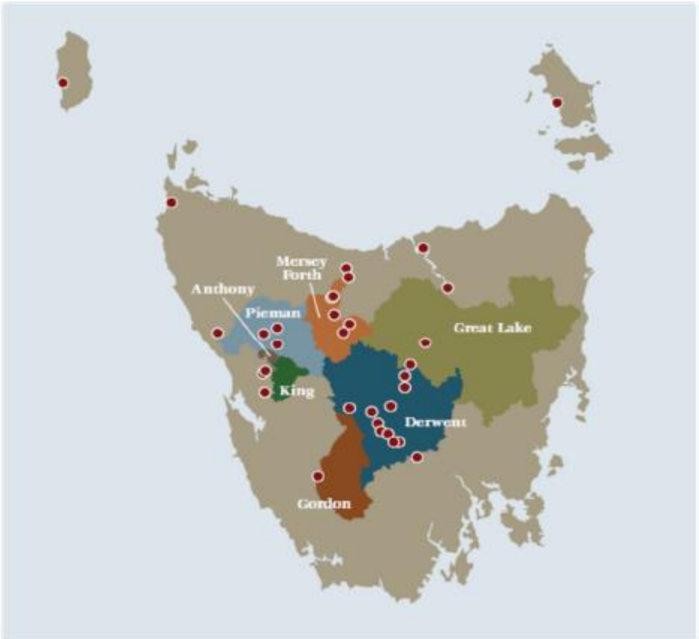
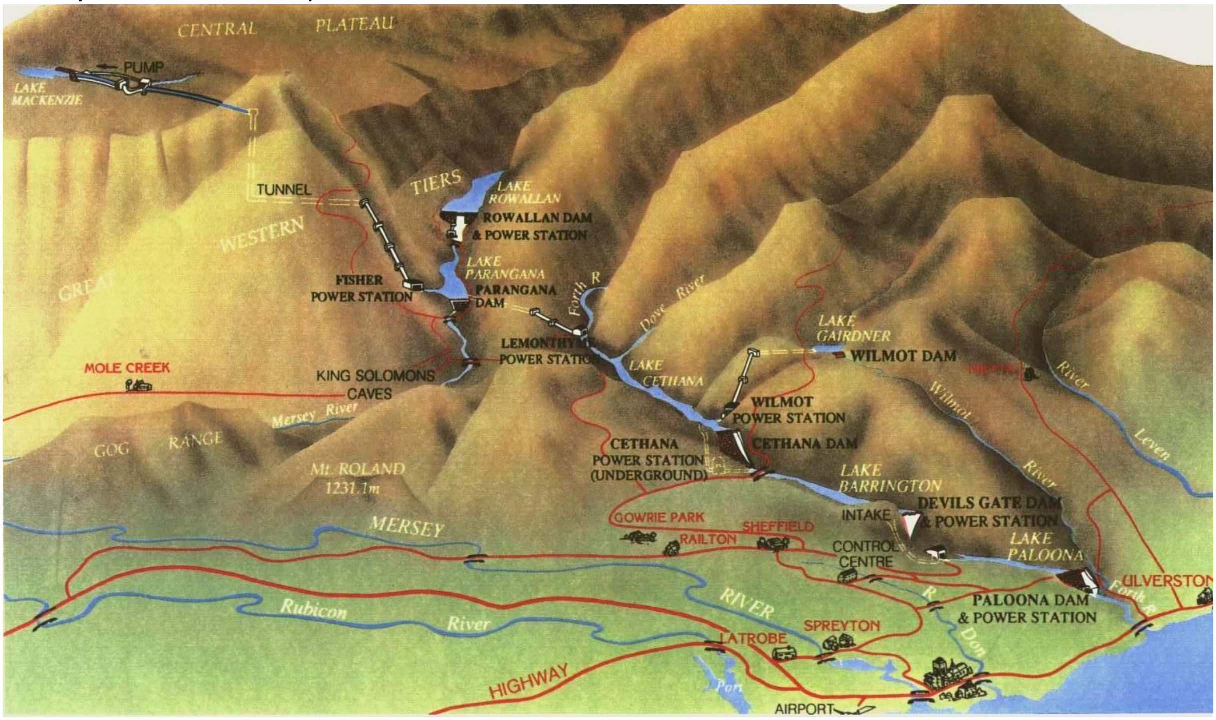


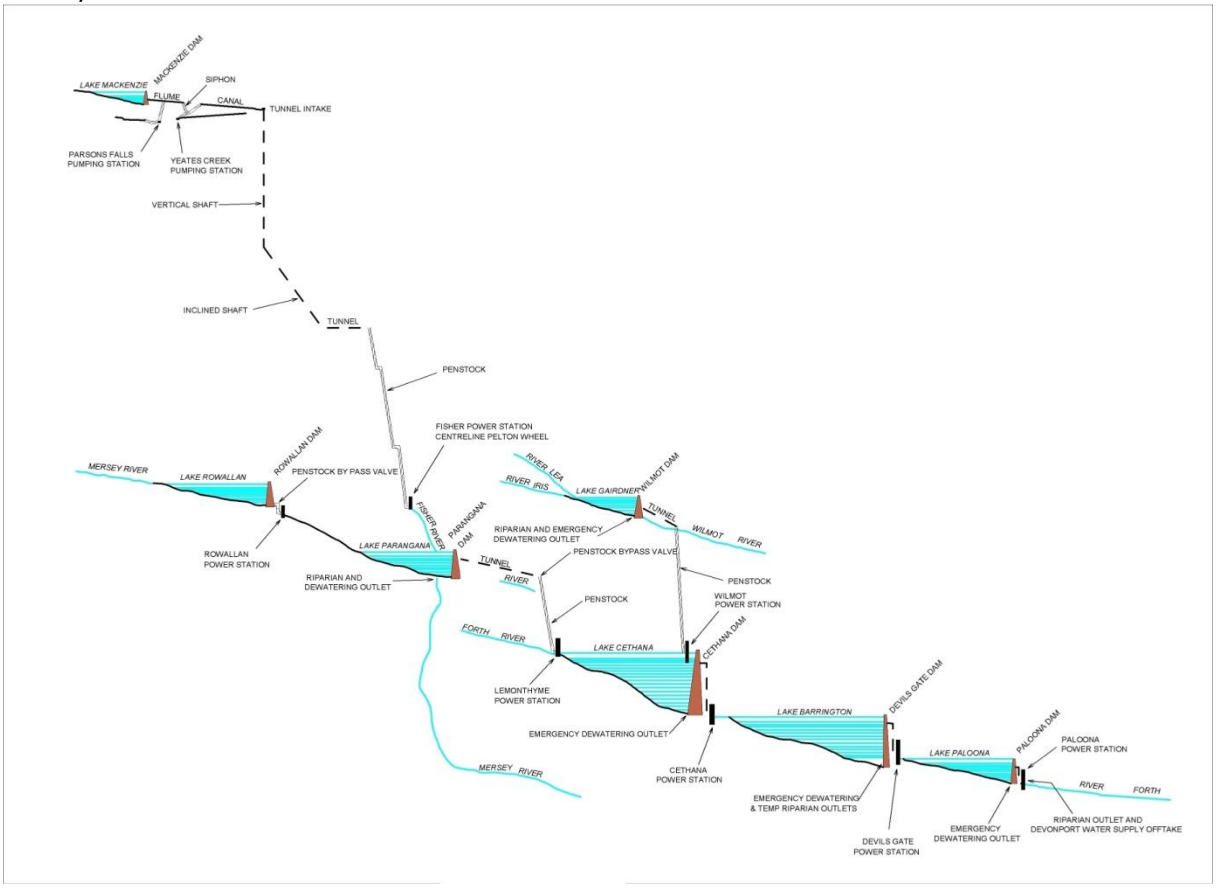
Figure 1: Major Storage Catchments and Power Stations in Tasmania

ANNEXURE B

Mersey-Forth Scheme map

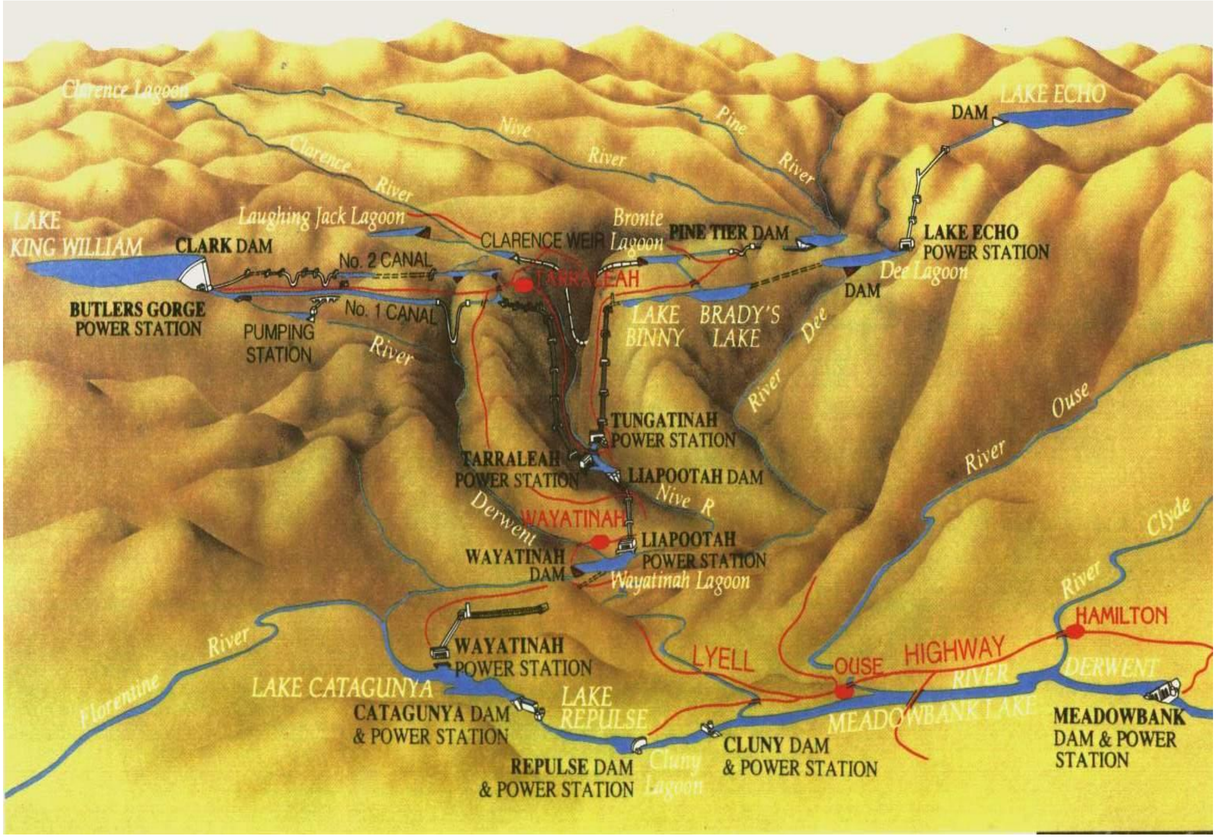


Mersey Forth Scheme schematic

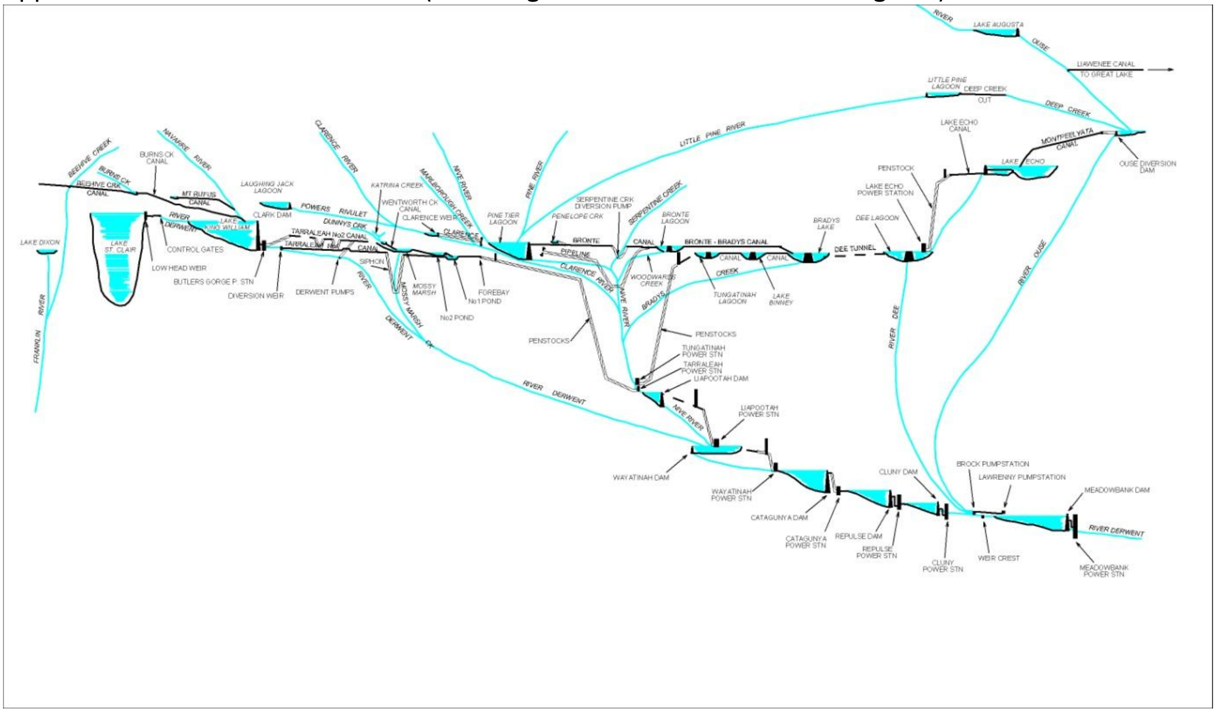


ANNEXURE C

Upper and Lower Derwent Scheme (including the River Ouse) map

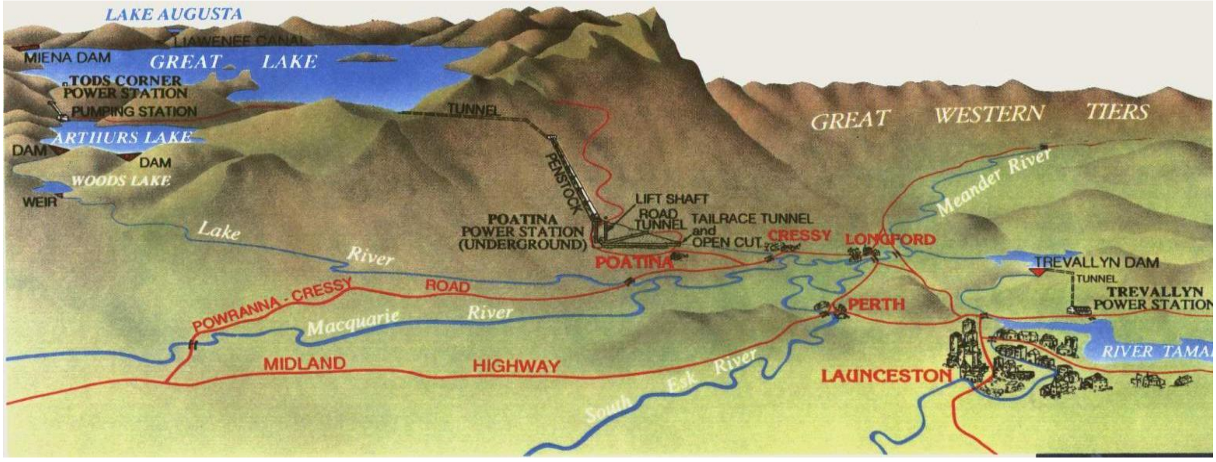


Upper and Lower Derwent Scheme (including the River Ouse and Lake Augusta) schematic

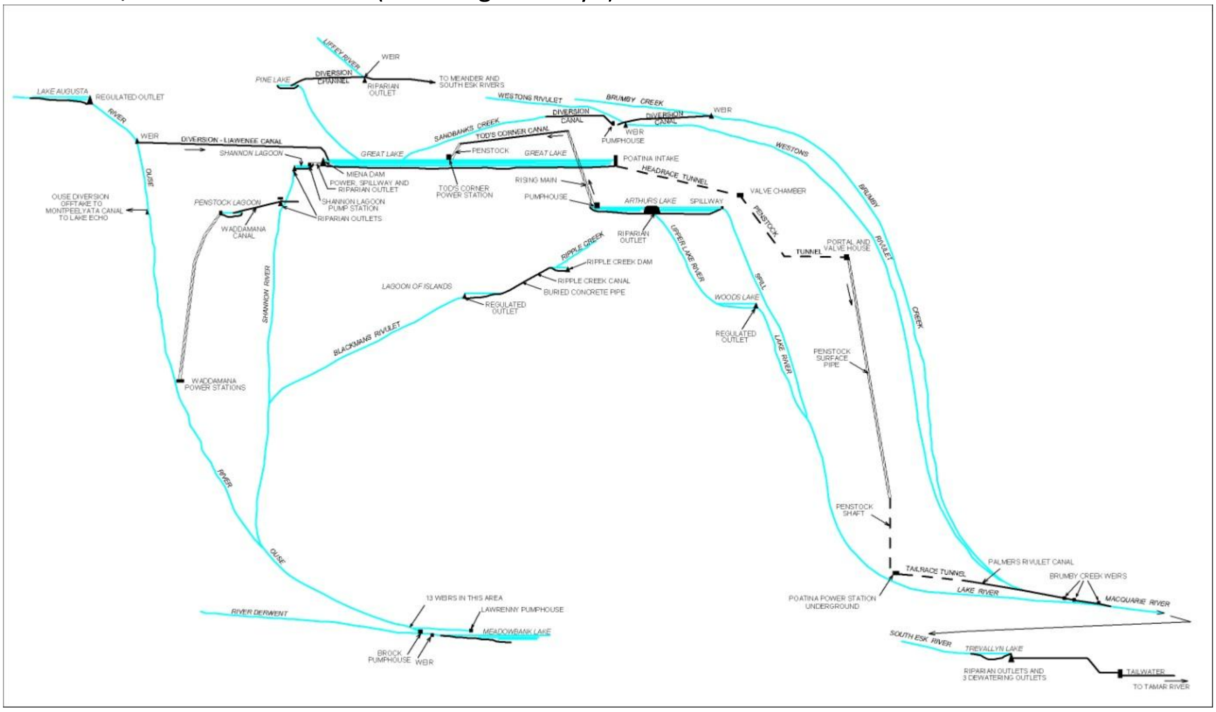


ANNEXURE D

South Esk / Great Lake Scheme (including Trevallyn) map



South Esk / Great Lake Scheme (including Trevallyn) schematic



ANNEXURE E

Storage	Date/Time on Spill	Date/Time off spill	Duration on spill (hours)	Peak Flow (cumecs)[26]	Comment
Affecting the Mersey					
Lake Rowallan	6/06/2016 0:10	17/06/2016 18:10	282	128	
Lake Mackenzie	5/06/2016 13:35	13/06/2016 15:30	194	286.6	
Lake Parangana	5/06/2016 9:25	19/06/2016 15:00	342	912.1	Note returned to spill shortly after this ~ 1 day later, and spilled with a few brief dips below FSL until 29/08/2016
Affecting the Forth					
Lake Gairdner	5/06/2016 12:40	13/06/2016 20:35	200	430.2	
Lake Cethana	5/06/2016 17:15	15/06/2016 18:00	241	770.1	
Lake Barrington	5/06/2016 19:20	21/06/2016 22:05	387	807.7	
Lake Paloona	6/06/2016 0:30	22/06/2016 11:55	395	800.8	Note returned to spill shortly after this ~ 1 day later, and has been largely spilling since with a few brief (up to 2 days) dips below FSL
Affecting the Ouse					
Lake Augusta	5/06/2016 16:45	14/06/2016 12:30	212	487.6	
Little Pine Lagoon (relevant because of Deep creek cut)	6/06/2016 0:45	20/06/2016 13:45	349	70.78	Little Pine Lagoon spills into the Little Pine River and then reaches the Nive River, so does not enter the River Ouse
Monpeelyata Weir	5/06/2016 13:00	11/06/2016 12:00	143	559.6	
Shannon Lagoon	5/06/2016 23:00	19/06/2016 22:30	335	8.11	
Penstock Lagoon	6/06/2016 5:00	2/07/2016 12:15	631	0.78	
Great Lake	Did not spill				
Affecting the South Esk					
Woods Lake	Did not spill				

26 The peak flow is the water flow over the spillway of the dam, measured in cubic metres per second ('cumecs')

Storage	Date/Time on Spill	Date/Time off spill	Duration on spill (hours)	Peak Flow (cumecs)[26]	Comment
Great Lake	Did not spill				
Poatina Re-regulation pond	5/06/2016 19:40	7/06/2016 10:40	39	46.43[27]	Time of release above 2 cumecs. Also released up to ~4 cumecs on the 4/6/16
Lake Trevallyn	6/06/2016 13:45	17/06/2016 9:50	260	2376	

27 The peak flow value for Poatina re-regulation pond is discharge rather than spill.