Appendix F

Aquatic Ecology Assessment

Hydro Tasmania

Executive summary

Hydro Tasmania is proposing to redevelop the Tarraleah Hydropower Scheme which will include a new power station and associated infrastructure to convey water from Lake King William to the power station including a new pipeline, a tunnel and tunnel portals, surge tower and penstocks. Entura was engaged by Hydro Tasmania to undertake an assessment of the aquatic values of associated waterbodies of the Tarraleah Redevelopment Project (the Project). Associated waterbodies assessed include the River Derwent from Clark Dam to Lake Catagunya, the Nive River from Tarraleah Power Station to Wayatinah Lagoon, Mossy Marsh Pond, No. 1 Pond, No. 2 Pond and unnamed tributary streams within the disturbance footprint of the Project. The aim of the assessment was to provide a description of the aquatic processes and values (flow regime, physical habitats and biological condition) associated with waterbodies for the Project.

Aquatic/flow dependent MNES

- There are two Matters of National Environmental Significance (MNES) associated with these reaches:
- The Tasmanian Wilderness World Heritage Area (TWWHA) – a 23 km reach downstream of Derwent Pumps Weir to upstream of Wayatinah Lagoon.
- *Barbarea australis* (native wintercress) is an annual or short-lived perennial in the Brassicaceae family and is endemic to Tasmania. This species is an opportunistic riparian coloniser, and appears to rely on disturbance, particularly flow disturbance, to turn over bank sediments and create suitable ground for its establishment. There are existing populations in the River Derwent downstream of Wayatinah Lagoon and in the Nive River downstream of Liapootah Dam. No existing populations were found in the River Derwent downstream Clark Dam, however, there are historic records at the bottom of this reach and suitable habitat occurs.

The TWWHA and *Barbarea australis* have the potential to be impacted by changes to the flow regime during operation of the Project.

Flow regime

Changes in flow regime have the potential to impact aquatic habitats and species. The River Derwent between Clark Dam to Wayatinah Lagoon and Wayatinah Lagoon to Lake Catagunya has experienced altered flow regimes since 1938. The headwaters of the River Derwent begin at Lake St Clair, where the flow is regulated by St Clair Dam after which the river flows southeast for 5 km to the hydropower storage of Lake King William, formed by Clark Dam. Water from Lake King William is diverted to the Tarraleah Power Station, where it enters the Nive River upstream of Lake Liapootah. The course of the River Derwent continues downstream of Clark Dam for approximately 31 km southeast past Derwent Pumps Weir to Wayatinah Lagoon where the Nive River then joins the River Derwent. Downstream from Wayatinah Lagoon, the river runs southeast for 6 km to Lake Catagunya. Water from Wayatinah Lagoon is diverted through the Wayatinah Power Station into Lake Catagunya.

The baseflows in the river reaches potentially affected by the Project are derived from tributary inflows and groundwater with no baseflow releases provided by the dams. Tributary inflows are generally minor to all reaches, except for the last 9 km of the River Derwent between Clark Dam and Wayatinah Lagoon where the Counsel River and Beech Creek return a more substantial flow regime. Under baseline operation, dam spills form the largest flow events in the River Derwent and Nive River. Downstream of

Clark Dam, spill events range from a few cumecs to over 200 m^3/s; however, large spills (i.e. spills ~ ≥ 40 m^3/s) do not occur each year. Large spills pass Liapootah Dam into the Nive River, and Wayatinah Dam into the River Derwent, each year.

Hydrological modelling indicates that during operation of the Project:

- The spill regime downstream Clark Dam to the River Derwent would be substantially reduced in frequency and magnitude compared to baseline operation:
  - Without mitigation, a reduced spill regime has the potential to impact TWWHA habitat and species values including habitat for *B. australis* through reduced mobilisation of bed and bank sediments; increasing the rate of encroachment by terrestrial plants leading to accelerated contraction and armouring of the channel; lower quality instream habitats for aquatic species; and, potentially altering riparian vegetation structure. Proposed flow releases to mitigate these impacts are summarised below.
- Spill magnitude would be reduced for the River Derwent downstream Wayatinah Lagoon; however, multiple large spills would still occur each year. The frequency of small spills is predicted to increase under the Project:
  - The reduced magnitude of annual peak flows under the Project is not predicted to have a significant impact on this reach. Hydraulic modelling indicates than the annual peak flows modelled to occur during operation will be sufficient to mobilise the substrate in a similar extent to current operation.
- Spill magnitude would remain similar for the Nive River downstream Liapootah Dam. Spills are predicted to occur more often, but mainly for small spills during winter and early spring:
  - Operation of the Project is not predicted to change habitat suitability for the *B. australis* in this reach.

Geomorphology

The River Derwent downstream Clark Dam to Wayatinah Lagoon is highly regulated with respect to flow and sediment delivery, but some basic geomorphic functioning of the river continues, especially downstream of the Counsel River, where flow is higher and continuous. Throughout the reach between Clark Dam and Wayatinah Lagoon, channel narrowing is occurring through the encroachment of vegetation. However, there appears to be some processes restricting the rate of encroachment, as exposed banks and bars that are denuded remain, and there is a distinct active channel in the river in many reaches, particularly downstream the Counsel River inflow.

The geomorphic condition of the River Derwent downstream Wayatinah Lagoon is similar to the reaches downstream Clark Dam. The higher energy thalweg (main flow path) displays sediment starvation with the substrate dominated by immobile large boulders. The mobile elements of the substrate are mainly restricted to the elevated bars above the main flow and comprise gravels to small cobbles which collect on the downstream face of boulders. There is a more regular pattern of large spill downstream Wayatinah Dam compared to the reaches downstream Clark Dam and therefore these mobile elements would be moved more frequently. The lower prevalence of encroaching terrestrial vegetation into the channel is another sign of a more active channel.

The Nive River downstream Liapootah Dam has an active channel with an abundance of mobile cobbles, pebbles and gravels. This 9 km reach represents the final and lowest gradient section of the Nive River and thus would have always had an abundant supply of sediment (i.e. sediment drops out of suspension and is less frequently transported from lower gradient reaches). Liapootah Dam typically has large spills each year and much of the sediment present on the bars is mobile. The lower prevalence of encroaching terrestrial vegetation into the channel is another sign of an active channel.

Aquatic habitat

The clear separation in flow volume and sediment supply and mobility in the reaches of the River Derwent up and downstream the Counsel River confluence is reflected in the condition of the aquatic habitats. Riffle and fast run habitats are rare upstream of the Counsel River under baseflow conditions with low energy pools and slow runs dominating the habitat present. AusRivAS river health assessments indicate that these low energy habitats are adversely impacted. The accumulation of thick biofilms are conspicuous indicators of the poor habitat in these lower energy habitats. By contrast, riffle and fast run habitats are common downstream of the Counsel River, even under low baseflow conditions. Slow run/pool habitats are comparatively rare downstream of the Counsel River and where present, accumulations of thick biofilms do not occur as found upstream.

Aquatic habitat in the River Derwent downstream of Wayatinah Lagoon is influenced by the regulated flow regime and sediment starvation. Riffle habitats are rare and this reach is also dominated by low energy, run and pool habitats which appear to be influenced by thick biofilms as described for the River Derwent upstream the Counsel River inflow. However, these must be scoured more frequently due to the more regular pattern of large spills in this reach.

Under baseflow conditions, most of the wetted habitat in the Nive River downstream of Lake Liapootah is confined to a narrow band (5- 8 m wide) in an overwise dry channel. Riffles are rare; however, these appear to maintain flow even during prolonged dry periods which suggests that groundwater contributions supply the channel as there are few tributary inflows. The substrate is dominated by boulder and cobble within the low flow channel, which is also common on the exposed bars in addition to gravels and pebbles. Unlike River Derwent reaches downstream of Clark Dam and Wayatinah Lagoon, the riverbed in this reach of the Nive appears to be far more mobile. Flatter areas of riverbed form most of the wetted habitats in the form of slow runs and pools which do not appear to contain the same thick biofilms as occur in the River Derwent reaches (potentially as large spill usually occurs on an annual basis and much of the riverbed is mobile).

Macroinvertebrate communities and river health bioassessment

Macroinvertebrate river health scores in the survey sites of the River Derwent downstream of the Counsel River inflow were indicative of good river health. This finding was expected and in line with previous assessments of river health sites downstream hydropower dams in Tasmania where significant tributary inflows restore elements of the flow regime (Davies et al 1999, Entura 2016, 2018).

For the River Derwent, the relatively small areas of riffle habitats upstream of the Counsel River inflow and downstream of Wayatinah Lagoon reported good river health scores in spring 2018 and spring 2021 but impaired condition in autumn 2022. The autumn sampling period followed a prolonged dry period which suggests these riffle habitats are less resilient than those downstream of the Counsel River inflow. Edge sampling in 2021/22 assessed the slack water habitats upstream of the Counsel River and downstream of Wayatinah Lagoon as significantly to severely degraded. This result supports the qualitative habitat and geomorphic assessments that the reaches upstream the Counsel River inflow are in poor condition, particularly as slack water areas dominate the aquatic habitat present.

River health scores in riffle habitat in the Nive River downstream of Liapootah Lagoon vary between impaired and healthy bands with spring surveys reporting poor condition and autumn surveys reporting good condition. This result is likely related to the timing of spills, as large spills often occur in spring but rarely over summer and early autumn. Large spills prior to sampling in spring are likely to temporarily deplete the macroinvertebrate communities and result in low river health scores. Slow water habitats are the main habitats in this reach and the edge habitat scores indicated impaired river health at this site and overall, the river health condition of this reach is assessed as poor.

The sites were re-surveyed in spring 2024 and identified to species. Fifty-three taxa were recorded across the five sites in the River Derwent downstream Clark Dam. There was substantially higher diversity at the two sites downstream the Counsel River inflow compared to the sites upstream which is consistent with the improved river health scores at the downstream sites. Twenty-seven taxa were recorded in the reach of the River Derwent downstream Wayatinah Dam and 17 in the Nive River upstream Wayatinah Lagoon. Across all the monitoring sites, 27 of the taxa are classed as species of conservation significance in Tasmania, mainly because they are endemic to the state, although some are endemic to south-east Australia. None of the species recorded have a restricted distribution in Tasmania.

Fish and other aquatic values

Self-supporting populations of native fish fauna in the associated waterways are either absent or in very low abundance. The presence of dams downstream would prevent the upstream migration of many species; however, the species which may be present, *G. truttaceus* or *G. brevipinnis*, were not recorded. The only native fish recorded was the short-finned eels (*Anguilla australis*) which are only present through occasional stocking of lakes in the Derwent catchment (John Diggle; Director of Inland Fisheries Service personal communication).

The Clarence galaxias (*Galaxias johnstoni*) was identified as potentially present in the Project area through the Protected Matters Search Tool (PMST) based on records within a 5 km buffer of the Project area. This species is listed as endangered under the state Threatened Species Protection Act 1995 and national Environment Protection and Biodiversity Conservation Act 1999. There is no potential for this species to be present in the waterways potentially affected by the Project based on the ecology of the species, its known distribution and vulnerability to introduced fish species.

Introduced brown and rainbow trout (*Salmo trutta* and *Oncorhynchus mykiss*) were the only fish species commonly recorded in all study reaches and are known to outcompete and predate on native species, which may explain the low abundance or absence of *G. truttaceus* or *G. brevipinnis.* The only other fish species recorded was redfin perch (*Perca fluviatilis*) in the lower reaches of the Nive River. Redfin perch, a pest species in Tasmania, is present in several of the upper storages associated with the Nive River, Wayatinah Lagoon and the Derwent storages further downstream. Redfin where not recorded in the lower reaches of the River Derwent downstream of Clark Dam.

Platypus (*Ornithorhynchus anatinus*) scat was recorded from two locations in the River Derwent downstream of Clark Dam to Wayatinah Lagoon (approximately 5 km upstream from Counsel River inflow) during the surveys for *Barbarea australis*. There are historic observations of platypus from Wayatinah Lagoon and No. 2 Pond, and it is likely that this species is common throughout the Project area. Native water rats (*Hydromys chrysogaster*) were not recorded and there are no historic records in the immediate area, although this cryptic species is not commonly seen even when present.

***Barbarea australis* (MNES)**

The riparian plant species *Barbarea australis* is the only MNES species identified to occur in the river reaches potentially affected. There are existing populations in the Nive River upstream and downstream of Lake Liapootah and in the River Derwent downstream of Wayatinah Lagoon. There are two historical records in the River Derwent downstream of Clark Dam from 2000 and 2001, however, this species was not recorded during dedicated surveys of the entire 25 km reach downstream from Derwent Pumps Weir to Wayatinah Lagoon. The records from 2000 and 2001 were in the final reach of the river immediately upstream of Wayatinah Lagoon and comprised only a few plants. Habitat quality is patchy in the entire reach. A reduced peak flow regime, sediment starvation and encroachment of terrestrial plants into the channel limits the areas of mobile sediment where *B. australis* typically occurs.

Mossy Marsh and No. 2 ponds

Mossy Marsh Pond and No. 2 Pond are artificial storages. Mossy Marsh Pond has patches of productive aquatic macrophyte beds which support a relatively diverse and abundant macroinvertebrate community. No. 2 Pond has a more barren shoreline, although a few patches of macrophyte beds occur which also support a relatively diverse and abundant macroinvertebrate community. The fish populations of both ponds are low in abundance and consists mostly of introduced trout, although low numbers of native short-finned eels are present through occasional stocking. Mossy Marsh Pond and No. 2 Pond both provide suitable habitat for platypus (*Ornithorhynchus anatinus*) and, potentially, water rats (*Hydromys chrysogaster*).

Flow mitigation

The proposed measure to mitigate the impact of a reduced spill/high flow regime to the River Derwent downstream Clark Dam is to have planned spill events of sufficient magnitude and frequency to maintain geomorphic processes, habitat and species values in the TWWHA, including habitat suitability for *B. australis*. The proposed mitigation measures are one annual high flow release and three annual lower fresh releases:

- High flow releases. To compensate for the modelled reduction in overall spill frequency, the proposed high flow release will be an alternating annual release of 60 m^3/s in one year and up to 100 m^3/s in the following year. The releases would result in an increase in the frequency of ≥ 60 m^3/s events; ensure at least one event ≥ 60 m^3/s occurs each year, which does not occur currently under baseline operation; result in similar or higher mean annual maximum flow than occurs under baseline operation; and avoid years where the peak flows are very low (~≤ 20 m^3/s).
- Lower flow releases (freshes): It is proposed to provide a fresh magnitude flow range from 5 to 10 m^3/s (one at the end of summer, one in the first month of winter, and one in December). Provision of smaller freshes will assist in flushing algae and biofilms from instream habitats, provide high flow cues for instream species, increase nutrient exchange between the banks and low flow channel, and recharge water supply to banks and riparian zone.

Construction impacts

Potential water quality impacts from the construction sites and construction activities include increased turbidity, changes in pH, elevated concentrations of metals, hydrocarbon contamination and nitrate and ammonium in 6 unnamed streams. These potential impacts would be greatest in the direct vicinity of the disturbance area but may also impact the downstream receiving waterways which include the River Derwent, Nive River, Mossy Marsh, No. 2 and No. 1 ponds, Lake Liapootah and Wayatinah Lagoon.

With implementation of the Water Quality Management Plan (WQMP) there are expected to be minimal impacts to the water quality of the streams entering the River Derwent or the Nive River including minimal increases in nitrate levels. Therefore, there are not expected to be any impacts to species of conservation significance, or general aquatic values, in the River Derwent, Wayatinah Lagoon, Nive River and Lake Liapootah resulting from poor water quality from the construction areas.

Acknowledgement of Country

The authors of this report pay our respects to the rich, long and ongoing history of the Traditional Owners and Custodians of the lands and waterways that we study. We acknowledge that the mountains, lakes and rivers that capture and channel water for hydropower are rich in Aboriginal history, culture, and tradition. We acknowledge ongoing Aboriginal connection to culture and custodianship of the lands and waters of places we share. We pay our respects to Elders past and present, and we extend that respect to all Aboriginal and Torres Strait Islander peoples today.

Contents

Appendices

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Glossary of terms

A00: Base case future modelling scenario that reflects the current configuration of the Tarraleah Hydropower Scheme with additional flexibility to target higher price periods, which is how it is expected the power station would be operated in future (referred to in the report as the *BAU*).

A00Hist: Base case future modelling scenario that reflects the current configuration of the Tarraleah Hydropower Scheme operated in a similar manner to historical operation (referred to in the report as *baseline operation*).

Associated waterbodies: rivers and storages that hydrological modelling indicates may be impacted by the Tarraleah Redevelopment Project, namely River Derwent from Clark Dam to Lake Catagunya, the Nive River from Tarraleah Power Station to Wayatinah Lagoon, Lake King William, Lake Liapootah, Wayatinah Lagoon, Mossy Marsh Pond, No. 1 Pond and No. 2 Pond.

Baseflow: Flows in a waterway that occurs between runoff events which generally provides a continuous flow through the channel (historic/current operation modelling scenario).

BAU: Business as usual

Cumec: a measure of flow in cubic metres per second (m^3/s)

D50: median particle diameter or median particle size.

Disturbance footprint: any land that may be physically disturbed by the construction of the Project. The disturbance footprint excludes land that may be used for the Project but which will not be physically disturbed e.g. ongoing use of existing elements of the Tarraleah Hydropower Scheme, such as sections of No. 2 Canal.

DPIP model: Dynamic Real-time Inflow Prediction model.

DS: downstream

F60: Future modelling scenario that reflects operation of the Tarraleah Redevelopment Project with 61 m^3/s pressurised conveyance from Lake King William to a new power station with two machines (referred to in the report as *operation of the Project*).

Flow-duration Curve: A cumulative frequency curve that shows the percentage of time that specified discharges are equalled or exceeded.

Freshes: used to denote small and short duration higher flow events. These are flows that exceed the median flow and last for at least several days, often as a result of intensive and sometimes localised, rainfall.

High flow: Flow events between Q20 and Q5 flow

Hydstra: Hydrological modelling and time series data management platform.

MNES: Matter of National Environmental Significance as listed under the *Environment Protection and Biodiversity Act 1999* (Cth)

Maximum flow: The maximum flow of a stream over the period assessed.

Peak flows: Flow events greater that Q5

PLEXOS : Optimisation software used for power market modelling.

Qn Flow: flow which is only exceeded for n% of the time.

Reach: Longitudinal zone of a river that has similar geomorphological and hydrological characteristics.

TUFLOW-HPC modelling software. TUFLOW is a 1D and 2D modelling software for simulating floods, tides and urban stormwater network hydraulics. TUFLOW HPC, with its powerful Sub-Grid Sampling feature, produces accurate results for flow along narrow channels at any orientation of the structured mesh.

1. Introduction

Entura was engaged by Hydro Tasmania to conduct a detailed freshwater values assessment for the Tarraleah Redevelopment Project. This assessment includes:

- Desktop and field studies to document aquatic species and habitat values.
- Hydrological and hydraulic modelling to describe current and proposed flow regimes and their impact on instream and riparian habitats.
- Impact analysis of construction and operation on habitat and biological values.
- Mitigation and monitoring measures to address potential impacts.

The Project area (including the disturbance footprint) comprises the pipeline alignment, tunnel portals and spoil emplacement areas, surge facility, pump station, power station and 14-15 km of transmission line alignment; while associated waterbodies includes rivers and storages that hydrological modelling indicates may be impacted by the Tarraleah Redevelopment Project, namely River Derwent from Clark Dam to Lake Catagunya, the Nive River from Tarraleah Power Station to Wayatinah Lagoon, Lake King William, Lake Liapootah, Wayatinah Lagoon, Mossy Marsh Pond, No. 1 Pond and No. 2 Pond (Figure 1.1). Lake King William, Mossy Marsh Pond, No. 1 Pond, No. 2 Pond, Lake Liapootah and Wayatinah Lagoon are all artificial water bodies.

The potential impacts of construction of the upgrade works on Lake William have been assessed separately. Potential operational impacts on Lake King William are not included in this referral as there are no records of MNES in this storage and no potential for MNES based on known distributions.

The main potential impact on aquatic values is through changed spill regimes during operation on the reaches of the River Derwent downstream Clark and Wayatinah dams and on the Nive River downstream Liapootah Dam. The assessment focuses on these impacts and proposes measures to mitigate them. Direct construction impacts are limited to small tributary streams although the rivers (River Derwent and Nive River) and storages (Wayatinah Lagoon and Lake Liapootah could also be impacted by poor water quality from these streams.

Storages below Wayatinah Lagoon were not assessed as the greatest hydrological changes are in the rivers and lakes upstream of Wayatinah Lagoon. There are existing operating water level ranges for each lake and these levels will not change through operation of the Project. A schematic of the entire Derwent hydropower scheme is provided in Figure 1.2.

1.1 Catchment overview

The Derwent Catchment covers an area of approximately 8,800 km^2 in south-east and central Tasmania. The River Derwent is the second longest river in Tasmania, originating at Lake St Clair and flowing south-east over approximately 187 km to New Norfolk where it enters the Derwent Estuary. The River Derwent and a number of its main tributaries have been dammed by, or diverted to, 21 storages for the generation of hydro-electricity. The headwaters of the River Derwent begin at Lake St Clair, where the flow is regulated by St Clair Dam after which the river flows southeast for 5 km to the hydropower storage of Lake King William, formed by Clark Dam. Water from Lake King William is diverted to the Tarraleah Power Station, where it enters the Nive River upstream of Lake Liapootah Figure 1.2). The course of the River Derwent continues downstream of Clark Dam for approximately 31 km southeast past Derwent Pumps Weir to Wayatinah Lagoon where the Nive River then joins the River Derwent. Downstream from Wayatinah Lagoon, the river runs southeast for 6 km to Lake Catagunya. Water from

Wayatinah Lagoon is diverted through the Wayatinah Power Station into Lake Catagunya (Figure 1.2). The river channel through both these bypassed reaches is within a steep, narrow valley and there are no wetland or floodplain habitats present.

The flow present below Wayatinah and Clark Dams, apart from dam spill, is derived from tributary inflows. The Counsel River and Beech Creek, approximately 22 km downstream Clark Dam, are the only major tributaries which join the river above Wayatinah Lagoon; upstream of Counsel River, much of the river channel is dry or comprised of long sections of pool habitat. Tributary inflows to the 6 km reach of the River Derwent downstream Wayatinah Lagoon are minor and comprise Robinson Creek, which enters approximately halfway down the 6 km reach, in addition to five small unnamed tributaries. As a result, the channel downstream Wayatinah Dam has a low baseflow and mostly comprises dry channel or long sections of pool habitat.

The Nive River is one of the main tributary rivers of the Derwent catchment and originates from Lake Nive in the Walls of Jerusalem National Park. The unregulated portion of the Nive River flows southeast for approximately 25 km to Pine Tier Lagoon, which diverts all water except spills, from the Nive River to Tungatinah power station via Bronte and Tungatinah lagoons. Below Pine Tier Lagoon, the regulated channel of the Nive River runs south for approximately 31 km to the hydro storage of Lake Liapootah. The existing Tarraleah and Tungatinah Power Stations discharge directly into the upstream end of Lake Liapootah. Apart from occasional spill, all water in Lake Liapootah is diverted to Liapootah Power Station. Below Lake Liapootah, the Nive River runs south for another 9 km before flowing into the hydropower storage of Wayatinah Lagoon. There are minimal tributary inflows within the narrow river valley; thus, most of the channel is dry. There are no wetland or floodplain habitats connected to the river channel downstream of Lake Liapootah.

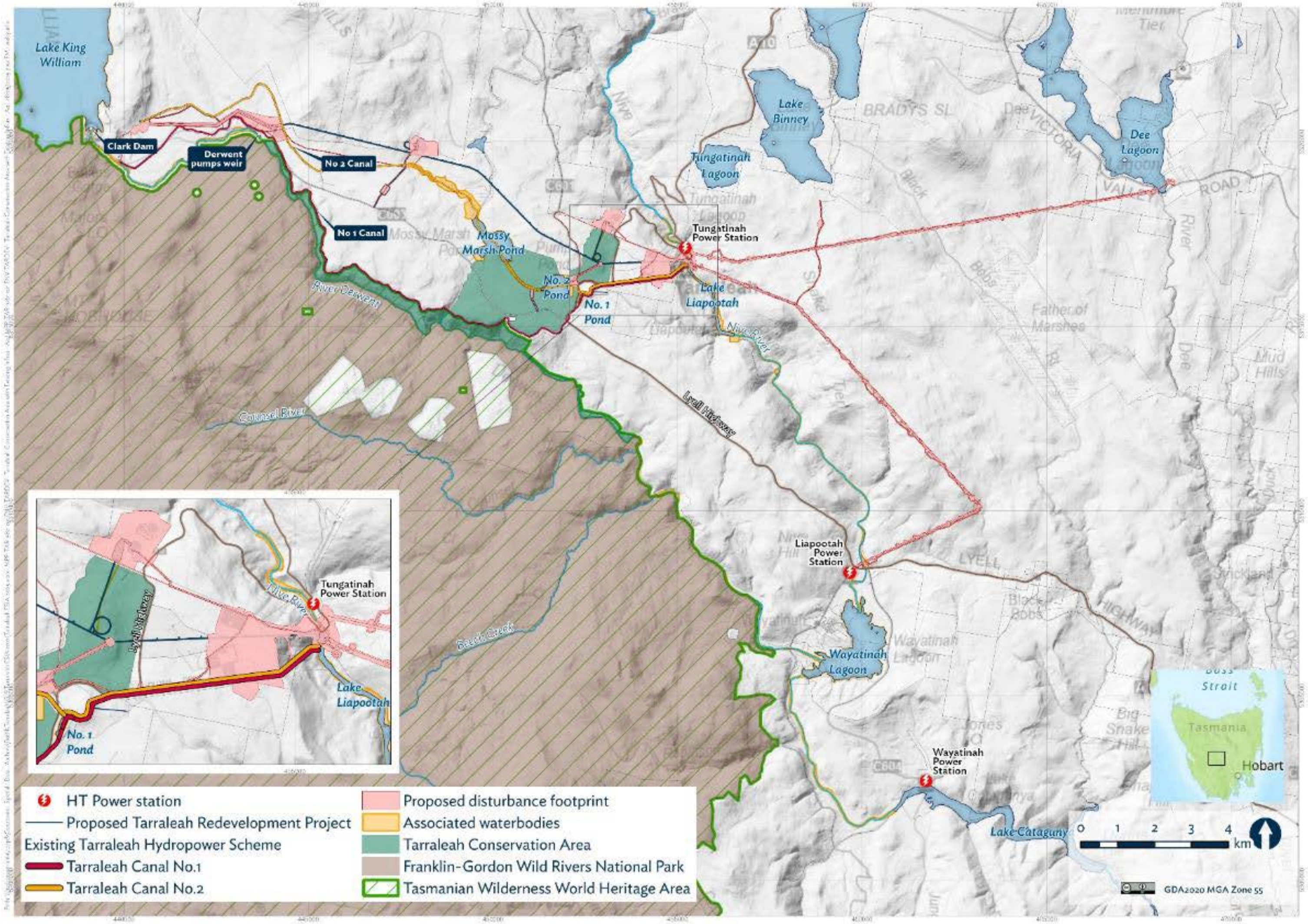

Figure 1.1: Overview of the Project showing the existing infrastructure, disturbance footprint, associated waterbodies and conservation areas.

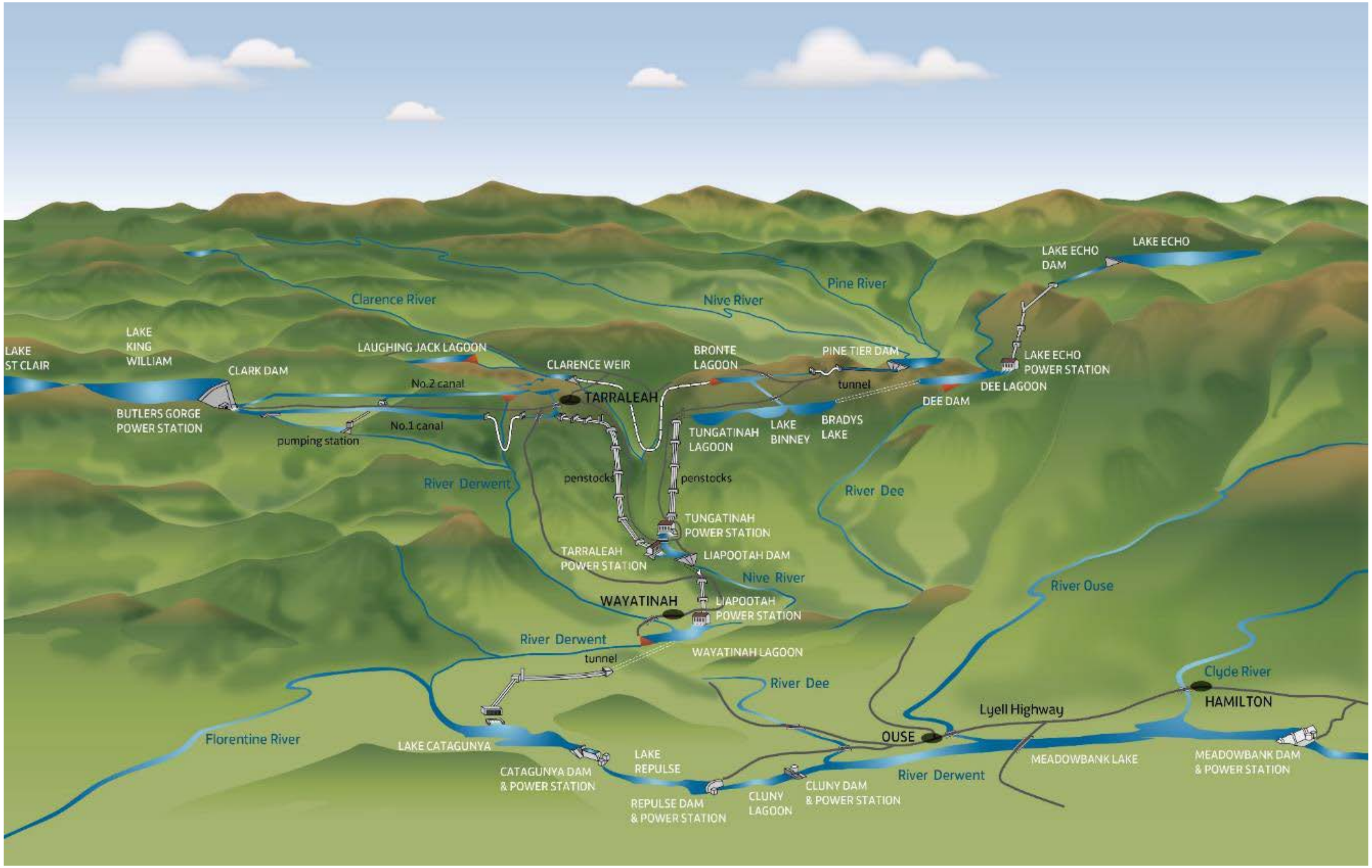

Figure 1.2: Schematic of the Derwent Hydropower Scheme.

2. Project Description

2.1 Project Description

Hydro Tasmania is proposing to redevelop the Tarraleah Hydropower Scheme to replace end of life assets and provide a more flexible and efficient scheme to ensure a reliable and safe renewable energy source into the future. The key permanent components of the Tarraleah Redevelopment Project are outlined below:

- An approximately 4.2 km **headrace pipeline** and associated service roads connecting the Lake King William tunnel (under construction) to the headrace tunnel.
- An approximately 9.8 km low pressure **headrace tunnel.**
- An approximately 2.3 km long high pressure **power tunnel** that splits into two short penstocks before entering the power station.
- A partially underground **power station** with an installed capacity of approximately 180 MW and rated flow of 60 m^3/s located adjacent to the existing Tarraleah Power Station.
- A **surge facility** consisting of a 70 m high (above ground level) surge tower and associated underground approximately 140 m high surge shaft to control water pressure in the headrace and power tunnels.
- An approximately 6 m^3/s **pumping station** and approximately 0.8 km **rising main** to transfer water from the existing No. 2 Pond to the power and headrace tunnels via the surge tower.
- A **transformer yard** and **switchyard** located close to the power station connecting the power station to the proposed transmission line.
- A new 22 kV **power supply** from the existing 22 kV network to the western, mid access and Paddy's Quarry portals, pump station, surge tower and power station will provide power during construction and operation.
- A new 220 kV **transmission line**. There are currently two transmission line options being considered:
  - A 14 km double circuit line from the existing Tungatinah Switchyard to the existing Dee Lagoon substation (northern option), or
  - A 15 km double circuit line from the proposed Tarraleah Switchyard to the existing Liapootah substation (southern option)
- **Access tunnels**, **tunnel portals** and **access roads** to provide access to the headrace and power tunnels. Excess spoil from tunnel, power station and portal excavations will be stored in one of three **permanent spoil emplacement areas** located at the western portal, mid tunnel access portal and Paddy's Quarry portals.

Construction of the Tarraleah Redevelopment Project underground works will be completed using drill and blast techniques and may be supported by a tunnel boring machine. Above ground works will be completed by conventional earth moving and mechanical excavation. To support construction the following key temporary infrastructure is proposed:

- A **construction compound** at Tarraleah Village supported by smaller construction compounds located at each of the tunnel portals and the power station. Construction compounds will include site administration facilities and workshops, handle and store materials and equipment imported to site and concrete batching and crushing and screening plant.
- Explosives for excavation work are required to be stored in a dedicated facility. Two **explosive magazines** will be located off Butlers Gorge Road.
- To facilitate construction of the power station a **temporary bridge** will built over the Nive River.
- A **workforce accommodation facility** will be constructed at Tarraleah but is not included in the scope of this assessment.

Upon the completion of works, all temporary construction sites will be rehabilitated.

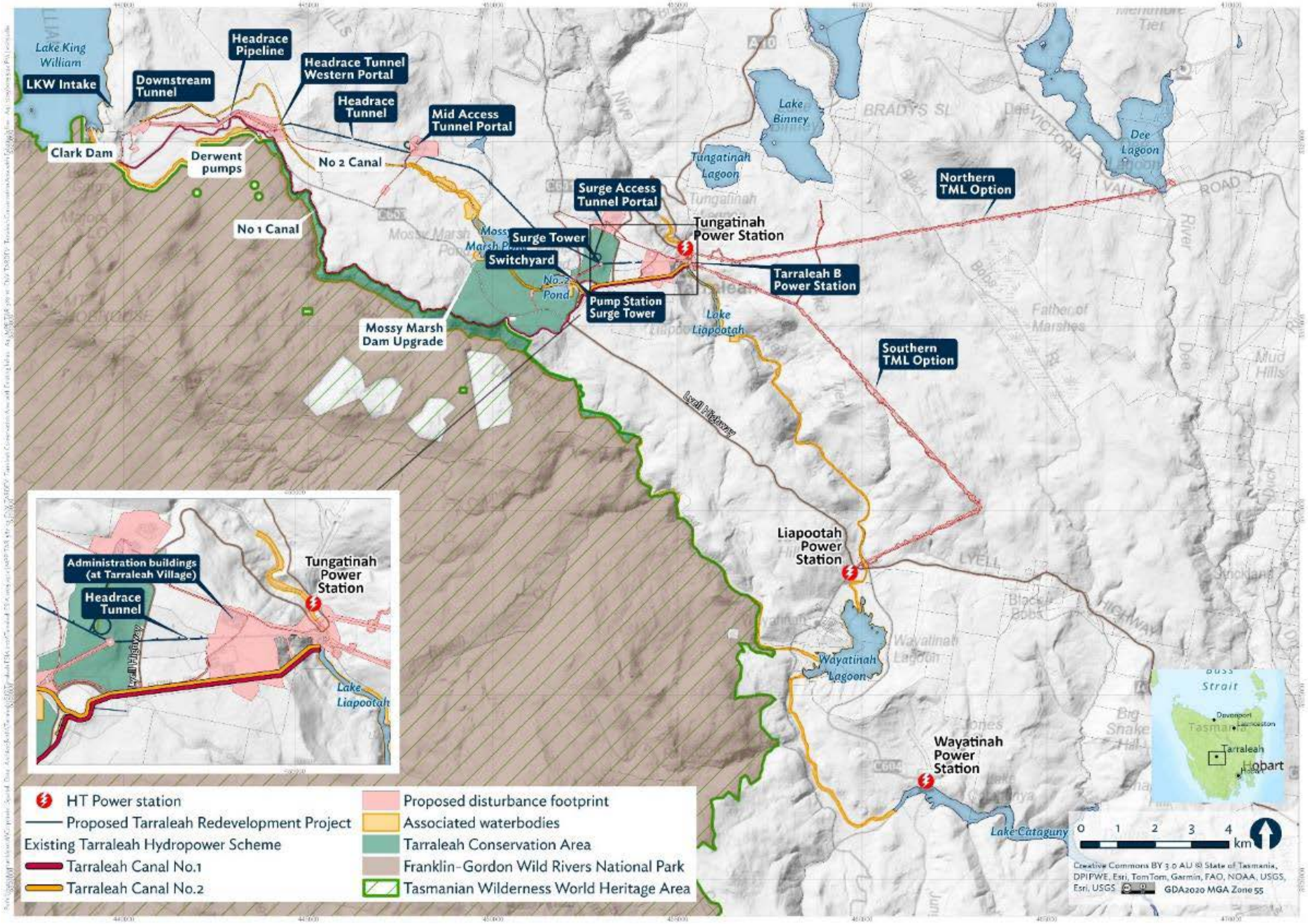

Figure 2.1: Overview of the Tarraleah Redevelopment Project and its key components

2.2 Construction requirements

The following Project construction methods and requirements have the potential to impact aquatic values through impacts to:

- Sedimentation and turbidity
    - clearing of work sites and
    - construction/upgrade of roads
    - excavation of tunnels, penstock, powerhouse including:
- Water quality
    - excavation of tunnels, penstock, powerhouse including:
        - use of Ammonium Nitrate Emulsion explosives for drill and blasting methods
        - use of concrete and grouting to line tunnels and pipelines
        - transportation of excavated material to spoil emplacement areas
    - use of concrete for hard stand areas and buildings
    - use of construction machinery (hydrocarbon, fuels, oils)
    - construction/upgrade of roads
    - wastewater and stormwater from Project work sites and its treatment/discharge
    - waste management (leachates, spills)

3. Legislative and regulatory setting

3.1 Conservation significance

The conservation significance of aquatic values within the survey area was assessed according to whether they were a:

- Species listed under the TSP Act
- Matter of National Environmental Significance (MNES) under the EPBC Act.

The requirements of each Act are outlined below.

3.1.1 *Threatened Species Protection Act 1995* (Tas)

Under the Tasmanian *Threatened Species Protection Act 1995* (TSP Act) a person must not knowingly kill, injure or collect a listed species without a permit. Three riparian and one flow dependent species (*Barbarea australis*) listed on the TSP Act are known to occur associated with the Project.

3.1.2 *Environment Protection and Biodiversity Conservation Act 1999* (Cth)

Matter of National Environmental Significance (MNES) are protected under the *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act). The EPBC Act provides for Commonwealth (Cth) involvement in development assessment and approval in circumstances where MNES could potentially be affected. MNES include:

- World Heritage properties
- National Heritage places
- Ramsar Wetlands
- Nationally threatened species and ecological communities
- Migratory species
- Commonwealth marine areas
- Nuclear actions (including uranium mining)
- a water resource, in relation to coal seam gas development and large coal mining development.

A proponent who proposes to take an action that will have or is likely to have a significant impact on MNES must refer that action to the Federal Environment Minister for assessment. The project has been referred to the Department of Climate Change, Energy, the Environment and Water (DCCEEW) for assessment of impacts on nationally threatened species (*Barbarea australis*) and the Tasmanian Wilderness World Heritage Area.

3.2 Water Management Act 1999

The *Water Management Act 1999* (Tas) (WM Act) provides for the use and management of fresh-water resources in Tasmania by:

- Promoting sustainable use and facilitating economic development of water resources;
- Recognising and fostering the significant social and economic benefits resulting from the sustainable use and development of water resources for the generation of hydro-electricity and for the supply of water for human consumption and commercial activities dependent on water;
- Maintaining ecological processes and genetic diversity for aquatic and riparian ecosystems;
- Providing for the fair, orderly and efficient allocation of water resources to meet the community's needs;
- Increasing the community's understanding of aquatic ecosystems and the need to use and manage water in a sustainable and cost-efficient manner; and
- Encouraging community involvement in water resources management.

Through looking to avoiding or minimising any water quality impacts from the Project, the Project is consistent with the objectives and requirement of the WM Act by maintaining aquatic values and processes in waterways associated with the Project.

4. Methods

4.1 Author qualifications

The aquatic ecological surveys and report writing were led by Dr William Elvey, a Senior Aquatic Scientist with Entura with over 2 decades' experience as a consultant in Australia and the United Kingdom specialising in freshwater ecosystems, eco-hydrology and environmental flows. He has provided assessment and advice to clients to meet planning, approval, and permit requirements on projects relating to the impacts of flow alteration (large and small hydropower projects, irrigation schemes, construction projects, flood schemes and wind farms), forestry, mining, agriculture, river crossings and invasive species on aquatic ecosystems in Australia and overseas. Will has undertaken numerous holistic environmental flow assessments in Tasmania, mainland Australia and in south-east Asia. He was supported in the field by Kevin Macfarlane, an Aquatic Scientist with Entura. Kevin work has focused on the fields of water health monitoring, aquatic ecology, threatened species, their life cycles and habitats both fish and macroinvertebrates. Kevin has worked within the global aquatic environment for almost the past 3 decades, having been employed within various disciplines within marine and freshwater.

Dr Lois Koehnken undertook the geomorphology surveys, assessments and report writing for the Project and contributed to the development of the proposed flow mitigation for which consideration of sediment dynamics/movement is a key component. Lois is an independent consultant with over 30 years' experience in the investigation and monitoring of geomorphology, water quality, sediment transport and hydrology in temperate and tropical river systems. She holds a PhD from Princeton University in geological and geophysical sciences and has worked in Australasia, Asia, Africa, North America and South America.

Lois has been involved in numerous Environmental Impact Assessments (EIAs), Cumulative Impact Assessments (CIAs), and Strategic Environmental Assessments (SEAs) for the hydropower sector in Australia and globally (Bhutan, Namibia, Nepal, Myanmar, Pakistan, Zambia), including the development of sediment management and sediment mining plans in hydropower impacted catchments. Lois has worked with the Mekong River Commission since 2012 as a geomorphology and water quality expert in a range of roles, including data analysis and interpretation, derivation and modelling of sediment budgets, developing guidelines for sustainable hydropower, and assessing proposed hydropower developments.

She has worked on the geomorphic characterisations of rivers for the derivation of environmental flow regimes in Asia, Southeast Asia and Africa. In Australia, Lois provides expert advice to the hydropower, mining, and Government sectors, and has been involved in geomorphic monitoring of hydropower related impacts in Tasmania since 1999. Lois has a wealth of experience in integrating and interpreting information from multi-disciplinary investigations and is skilled at presenting highly technical information to non-technical audiences, delivering field and classroom-based capacity building and conducting stakeholder consultations.

Dr Prafulla led the development of the hydrological modelling used for the aquatic assessment. Prafulla is a civil engineer at Entura with more than 2 decades of work experience and a specialist background in computational Hydrology. Prafulla has gained experience in Australia and internationally. He has worked as a researcher, a consultant and an engineer for leading organisations.

Prafulla has extensive experience in development, calibration and implementation of models in hydrology. He has developed distributed, semi distributed and lumped hydrological models intended for the use in flood risk analysis, flood forecasting and long-term flow (river yield) estimation. He has developed tools/methods for solving complex/high dimensional model calibration problems in hydrology. He has applied various forms of hydrologic models in projects of very diverse nature; these include catchment long term flow studies, short (and medium term) flow forecasting, and analysis of changes in hydrological responses to due to changes in external stimulus like fire and climate.

This report has independently reviewed by Dr Andrew Storey who is the Technical Director of the Ecology and Biodiversity division of SLR Consulting Australia, and Adjunct Associate Professor of the School of Biological Sciences, University of Western Australia. Andrew has over 28 years' experience in coordinating and undertaking research, monitoring and assessment of aquatic ecosystems, specialising in fish and invertebrate ecology and environmental flows.

4.2 Overview of approach and data inputs

The data inputs, and linkages between them, used for the assessment are shown in Figure 4.1 and summarised in text as follows:

- *Hydrological modelling outputs* are used to:
  - Review and describe the current flow regime influenced by existing hydro power schemes (baseline operation. Section 6) and the flow regime under the Tarraleah Redevelopment Project (Section 8);
  - Assess impacts on physical processes and values (Section 8);
  - Provide realistic flow scenarios for hydraulic modelling related to fluvial geomorphology (sediment transport and deposition, Section 8).
  - Determine planned high flow releases to mitigate changes during operation of the Project (Section 9).
- *Aquatic values assessment*: the flow dependent biological and physical habitat values present (Section 6);
- *Fluvial geomorphology assessment*: the sediment characteristics affected by river flow and which shape aquatic habitats (Section 6);
- *Objectives for environmental water releases* (Section 9.2.1); and
- *Hydraulic modelling*: how do different flow events behave through the survey reaches and what flow events are needed to meet the objectives (Section 8 and 9.2.3).

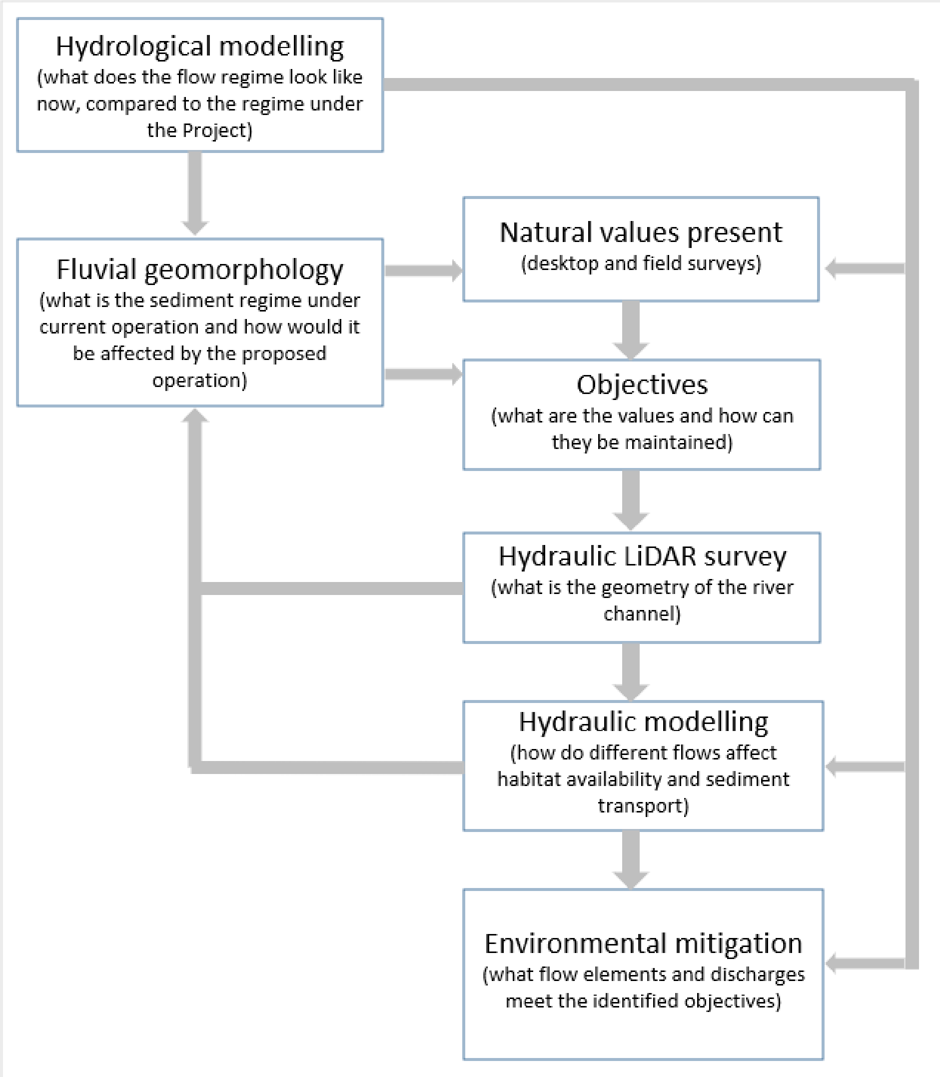

Figure 4.1: Inputs and methods used in this assessment.

4.3 Hydrological and hydraulic modelling

4.3.1 Hydrological modelling

System modelling undertaken by Hydro Tasmania (Hydro Tasmania 2025) indicates the associated river reaches which may be impacted by the Tarraleah Redevelopment Project are the River Derwent from Clark Dam to Lake Catagunya, and the Nive River from Tarraleah Power Station to Wayatinah Lagoon (Hydro Tasmania 2025).

The methods used to model spill and downstream flow regime are summarised in text below and detailed in Appendix A and B and in a separate PLEXOS modelling report undertaken for the Project (Hydro Tasmania 2025).

Water can be released from Clark Dam in three different ways:

- Spill over Butlers Gorge Weir if not all water from Butlers Gorge Power Station is captured in Canal No. 1 (not recorded)
- Releases through either of the two regulator valves (has been telemetered since 2020)
- Releases through the spillway gates (telemetered)

For the above reasons, flow below Derwent Pumps are generally used as a surrogate for total historical releases. However, it should be kept in mind that there are some natural inflows above Derwent Pumps Weir and the pumps can extract up to 2.8 cumecs from the weir.

Two hydrological models were developed to inform the environmental impact assessment for the Project:

- A rainfall runoff model coupled with a storage model was developed to represent river flow and dam spill during ***historic/current operation*** (hereafter referred to as the **baseline** or baseline operation) for the River Derwent downstream Clark Dam to Wayatinah Lagoon at locations where no observed data was available (Appendix A). The model was a modified Dynamic Real-time Inflow Prediction (DRIP) model (a rainfall-runoff model that is used by Hydro Tasmania for short term flow forecasting). The period examined for this model was 2007 to 2021. Two of the ten sites (DS Derwent Pumps 1 and DS Derwent Pumps 6) were observed data (Figure 4.4). The model was calibrated to Derwent Pumps 6. Where observed data can be used to describe baseline operation (i.e. current operation) (DS Derwent Pumps 1 and DS Derwent Pumps 6) the period was extended from 2007 to 2022 to match the 16 years of modelled record for potential future operation.
- Simulated cases for ***potential future operation*** with and without the proposed Tarraleah Redevelopment Project (Appendix B). This model was a reservoir routing model (in Hydstra modelling platform) developed to post-process dam spills generated by PLEXOS Hydro model to generate more representative spills from Clark Dam, Wayatinah Lagoon and Lake Liapootah. The natural inflows to sub-catchments located downstream of Clark dam were sourced from Inflows to Power Station Studies (Entura 2022). The spills from the dams and the natural inflows were routed along the River Derwent to provide a more representative flows at several locations downstream Clark Dam.

The baseline and potential future operation models simulated:

- spill from Clark Dam (defined as spill via the spillway gates, releases through the regulator valves and discharges from Butlers Gorge Power Station not captured by No. 1 Canal);
- flows at ten locations in the River Derwent downstream Clark Dam to Wayatinah Lagoon.

The model for potential future operation also included spill to the River Derwent from Wayatinah Dam and spill to the Nive River from Liapootah Dam. Modelling of spill for the baseline was not required at these locations as observed spill records are available from Wayatinah and Liapootah dams.

The model for potential future operation assessed two Business as Usual (BAU) and one Project case:

BAU

- <u>A00</u>: Current configuration of the Tarraleah Hydropower Scheme with additional flexibility to target higher price periods, which is how it is expected the power station would be operated in future BAU case;
- <u>A00Hist</u>: Current configuration operated similarly to historical operation;

Project

- F60: The redevelopment Project with 61 m^3/s pressurised conveyance from Lake King William to a new power station with two machines (Project case).

Due to the similarity between the model outputs for the A00 and A00Hist cases only the A00 case was used for further analysis. The outputs used for the assessment were under an interconnector configuration between Tasmania and Victoria of Basslink (existing) + Marinus 2 (projected future) with a combined capacity of 2000 MW. The hydrological model also considered decreased inflows due to climate change (Hydro Tasmania 2025). Further details of the hydrological modelling are provided in Appendix A and Hydro Tasmania (2025).

Modelled outputs for the Project were compared with BAU and baseline modelled and observed data. In addition to observed data for the two sites downstream of Clark Dam, observed spill data was available for:

- Wayatinah Dam into the River Derwent;
- Liapootah Dam into the Nive River.

There are differences in the market and climate conditions which shape the baseline flow regime compared to those modelled for potential future operation. However, this comparison is necessary to assess the context of the values present under the baseline operation to those which may occur in the future under BAU and operation of the Project.

The baseline data is not directly comparable to the modelled data for potential future operation as the baseline data reflect actual inflows in the current/historic energy market whereas the modelled outputs for the future cases are based on a simulated inflow series, incorporating some climate change impacts, in an estimated future energy market. Also, the observed baseline data is affected by power station outages which can affect dam spills while the modelling of future operation does not include the effect of outages. Additional model limitations are described in Section 4.3.3.

4.3.2 Hydraulic modelling

Two separate models were developed using the TUFLOW-HPC modelling software to represent the upper and lower River Derwent channel and banks. One model provided coverage for the River Derwent from Lake King William to Lake Catagunya and the other for the Nive River from Liapootah Dam to Wayatinah Lagoon and the River Derwent from Wayatinah Dam to Lake Catagunya.

The primary purpose of these models was to input available data, including terrain LiDAR, survey and observed channel features to determine the critical flows required to mobilise cobbles and gravels within the channel and banks. Details of the hydraulic modelling are provided in Appendix C and example visualisations of the outputs are provided below for a 1 m3/s flow (Figure 4.2) and a 60 m3/s (Figure 4.3).

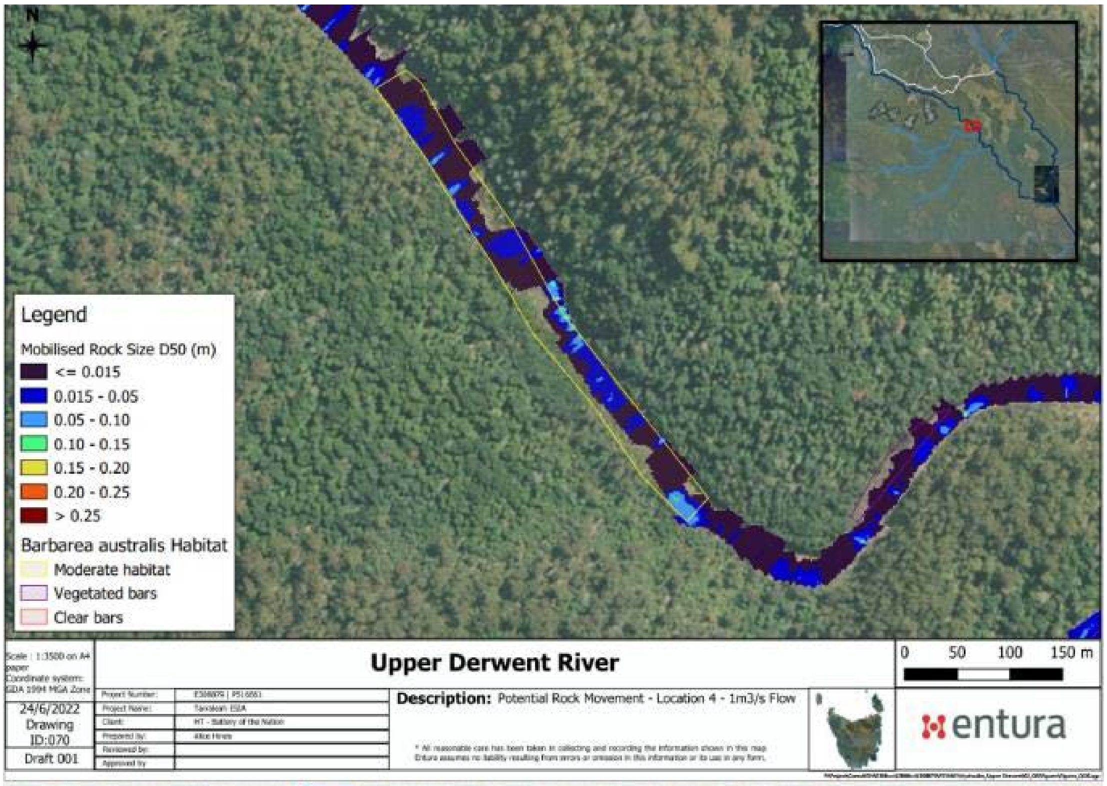

Figure 4.2: Example of estimated D_{50} sediment sizes for rock rolling under a 1 m^3/s flow in Location 4 of the River Derwent downstream Clark Dam

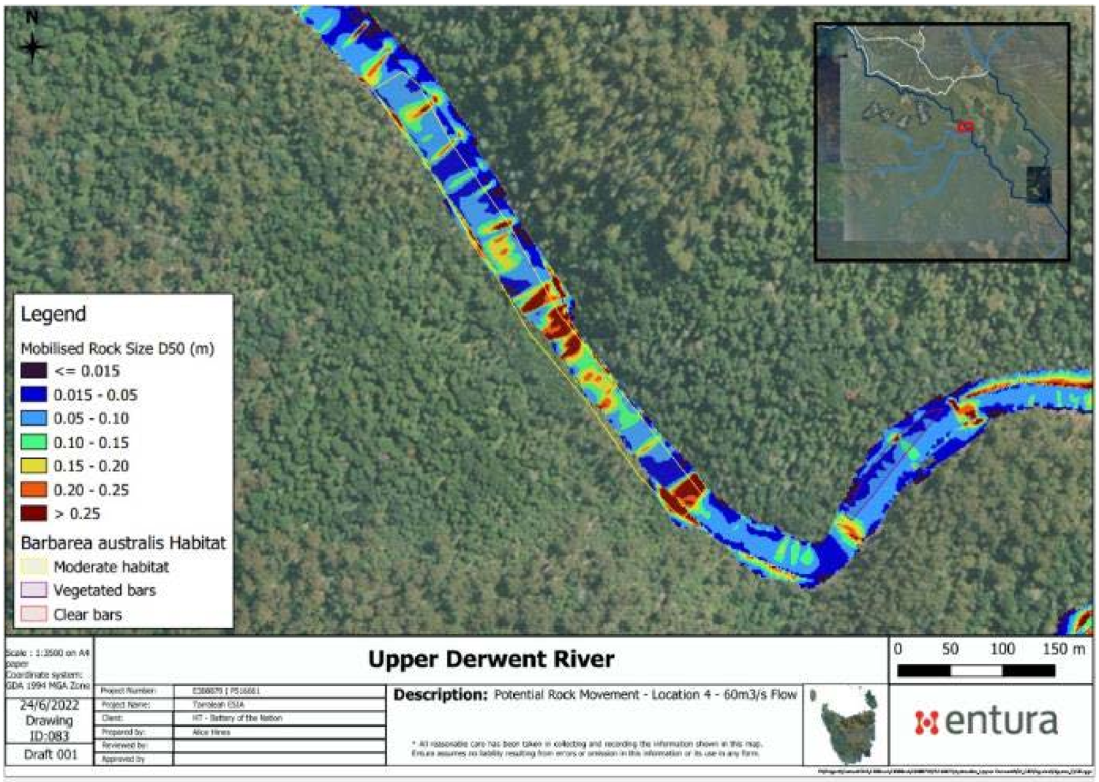

Figure 4.3: Example of estimated D_{50} sediment sizes for rock rolling under a 60 m^3/s flow in Location 4 of the River Derwent downstream Clark Dam

4.3.3 Limitations

The technical limitations of the hydrological and hydraulic models are provided in Appendix A.3; B.7 and C and in the separate PLEXOS modelling report (Hydro Tasmania 2025). This section discusses the limitations in their use for flow regime comparisons and, environmental impact and mitigation assessments.

Downstream hydrological models

A limitation in comparing the outputs of the two hydrological models (i.e. baseline and potential future operation) is that the baseline model is based on observed data at hourly time-steps while the potential future operation model is a mixture of half-hourly time-step outputs from Plexos model (spill from Clark Dam) and daily-timesteps for the tributary inflows downstream of the dam.

The use of daily or sub-daily data does not have a large impact on representation of the low flow regime; however, daily data underestimates peak flow events compared to a timeseries based on sub-daily timesteps. As discussed in Sections 6.1.2 (current flow regime) and 8.1 (impact to flow regime), dam spill is the greatest contribution to large flow events which occur in the River Derwent downstream Clark Dam. As the data for spill in the potential future operations model is at sub-daily timestep, the representation is likely to be a reasonable estimate of peak flows and would be most accurate at sites closer to Clark Dam where there are few tributary inflows. The modelling of peak flows would be least accurate for the sites downstream the Counsel River and Beech Creek, the two largest tributaries in the reach, where peak flows are underestimated in the model.

Therefore, most of the discussion of peak flow events in the River Derwent downstream Clark Dam focuses on spills over Derwent Pumps Weir where tributary inflows are only a minor contribution to peak flow events.

Modelling of spills for potential future operation

The PLEXOS simulation results in the generation of a number of pulse (sharp spill) outputs lasting for 30 minutes which are an artefact of the model. Post processing was done to smoothen/route those spikes such that they, combined with local catchment inflows, could be used to simulate more realistic flows downstream (Appendix B.3). These spills attain a more realistic hydrograph shape as they are routed[1] downstream. However, it should be noted that the spill routing is likely to be less accurate for small spills. Small spills can be managed in a number of different ways depending on the prevailing storage and market conditions associated with each release and it was not feasible to have multiple rule sets within the model which could simulate every option for managing these.

While the spill routing provides a more realistic hydrograph shape and estimate of the spill peaks simulated from the PLEXOS simulation, the duration of individual events may still have a high level of uncertainty. Therefore, analysis of the comparison duration of specific flow events/sizes durations between the baseline, Project and BAU cases are not discussed in this report. However, the duration of baseline events was analysed and used in the development of the proposed flow mitigations.

[1] River routing along the channel

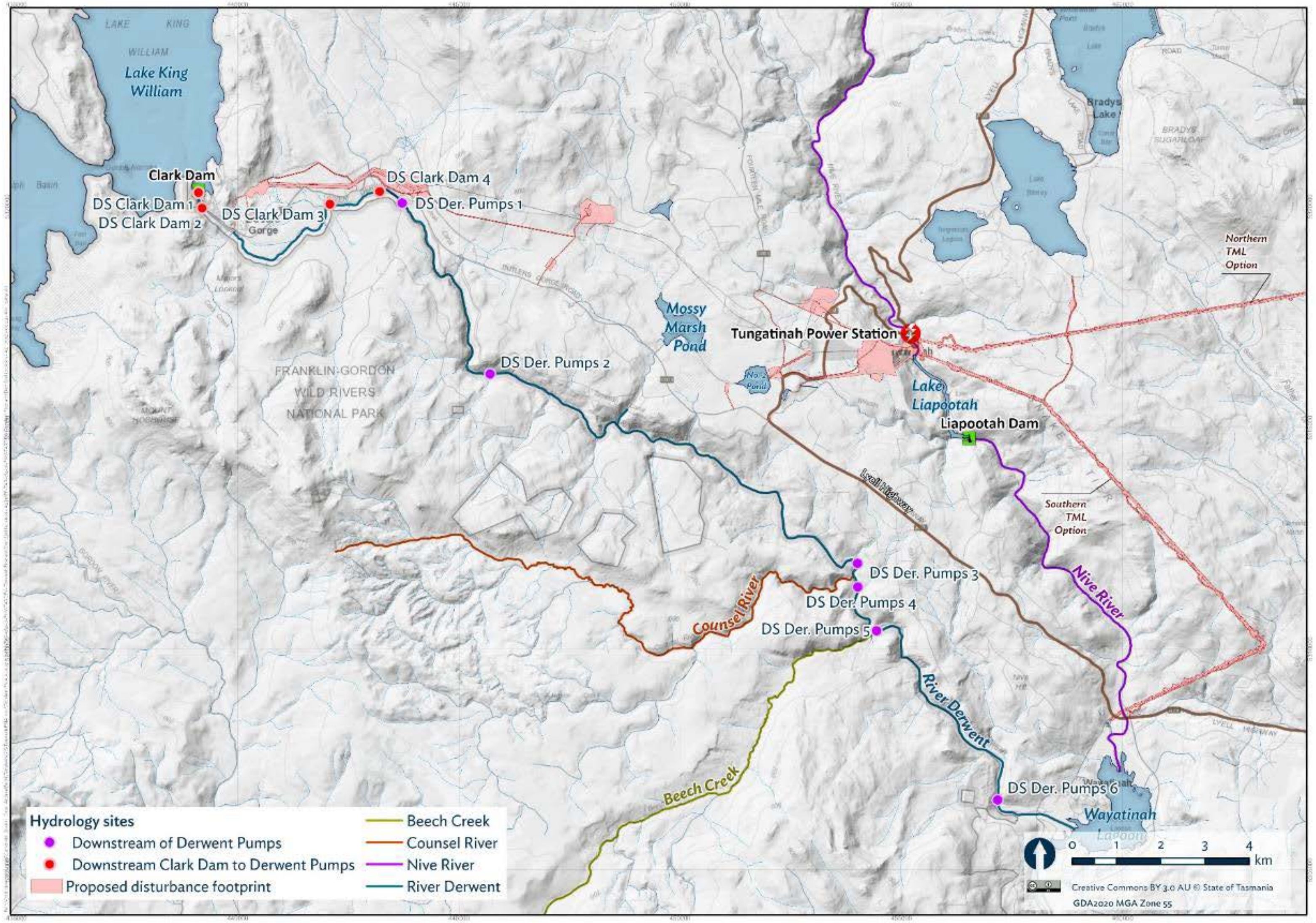

Figure 4.4: Flow and dam spill locations in the River Derwent downstream Clark Dam to Wayatinah Lagoon and Nive River downstream Liapootah Dam to Wayatinah Lagoon.

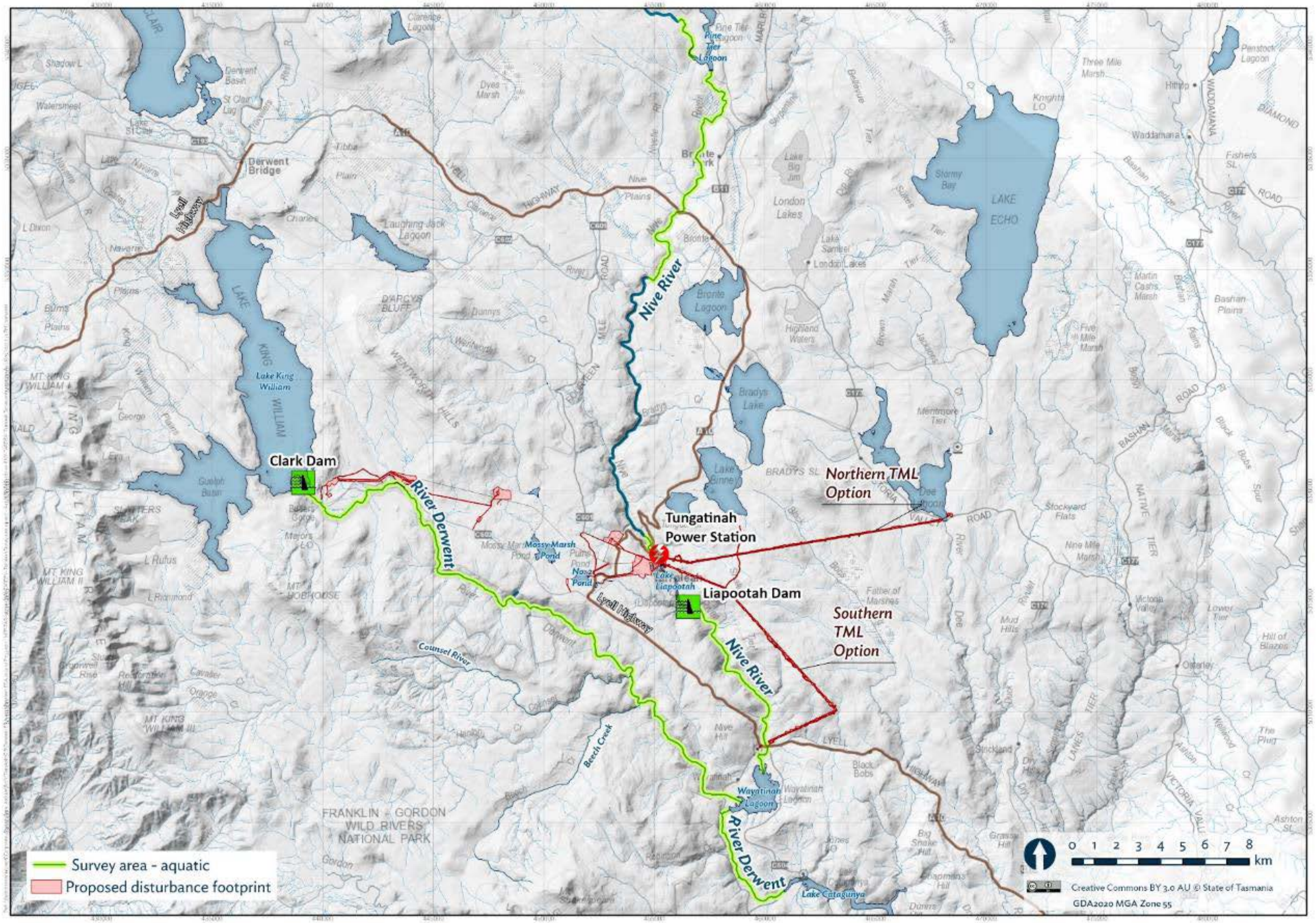

Figure 4.5: Survey area for the aquatic assessment.

4.4 Freshwater values

Information on the catchment and physical and ecological properties of the waterways was obtained from a literature review and search of online databases for listed aquatic, wetland and riparian species and communities, including the Tasmanian Natural Values Atlas (NVA) and EPBC Act Protected Matters Search Tool (PMST).

A freshwater natural values assessment, including characteristics of aquatic ecosystems that are worthy of protection, was undertaken for the Tarraleah Redevelopment Project and included:

- A review of aquatic flora and fauna data held on the Natural Values Atlas (NVA) and the EPBC Act Protected Matters Search Tool (PMST) to identify the potential for the occurrence of threatened species listed under the *Threatened Species Protection Act 1995* (Tas) (TSP Act) and the *Environment Protection and Biodiversity Conservation Act 1999* (Cth) (EPBC Act).
- Field surveys to investigate freshwater values associated with the Tarraleah Redevelopment Project and verify the potential occurrence of freshwater or flow dependent species or communities identified in the desktop assessment, including:
    - identification and assessment of any threatened aquatic, or flow dependent species or their habitats
    - identification and assessment of general aquatic values including:
        - freshwater fish
        - aquatic macroinvertebrates
        - aquatic macrophytes
        - aquatic habitat
    - fluvial geomorphology.

4.4.1 Field surveys

4.4.1.1 Assessment area

The field survey area included the associated waterbodies that hydrological modelling indicates may be impacted by the Tarraleah Redevelopment Project including the River Derwent from Clark Dam to Lake Catagunya, Nive River downstream Liapootah Dam to Wayatinah Lagoon, Lake King William, Lake Liapootah or Wayatinah Lagoon, Mossy Marsh Pond, No. 1 Pond and No. 2 Pond (Figure 1.1).

Field surveys were not undertaken in associated waterbodies with no listed aquatic values or where aquatic surveys have previously been undertaken. Thus, no field studies were undertaken in Lake King William, Lake Liapootah or Wayatinah Lagoon.

The survey area covered also included the disturbance footprint and six unnamed creeks associated with the pipeline, western portal, Paddy's Quarry and Tarraleah Village.

4.4.1.2 Fluvial geomorphology

The fluvial geomorphology of a river channel is the product of the substrate, hydrologic regime, riparian vegetation and human interferences. These attributes are described in the following sections for the river zones:

1. River Derwent downstream Lake King William to Wayatinah Lagoon, comprising three distinct reaches: River Derwent below Clark Dam to Derwent Pumps Weir; Derwent Pumps Weir to the confluence with the Counsel River; and from the Counsel River to Wayatinah Lagoon.
2. River Derwent downstream Wayatinah Lagoon to Lake Catagunya
3. Nive River downstream Lake Liapootah to Wayatinah Lagoon

A fluvial geomorphology survey was conducted in March 2022. The survey was attended by a geomorphologist, hydraulic specialist and an aquatic ecologist. The entire extent of the study reaches were flown over at low altitude by helicopter for the River Derwent downstream Clark Dam to Wayatinah Lagoon; River Derwent downstream Wayatinah Lagoon and Nive River downstream Lake Liapootah. The investigations identified discrete geomorphic zones within the River Derwent based on geologic, hydrologic and hydraulic characteristics.

Representative reaches were also accessed by helicopter for the on-ground assessment. At these reaches, riverbed condition and substrate size profiles were assessed both broadly and in terms of identifying the mobile/active areas of riverbed. This information was used in the geomorphology and aquatic values assessments and informed parameters in the development and analysis of the hydraulic models and the proposed flow mitigations.

4.4.1.3 Aquatic ecology

The field survey area included the associated waterbodies that hydrological modelling indicates may be impacted by the Tarraleah Redevelopment Project including the River Derwent from Clark Dam to Lake Catagunya, Nive River downstream Liapootah Dam to Wayatinah Lagoon, Lake King William, Lake Liapootah or Wayatinah Lagoon, Mossy Marsh Pond and No. 2 Pond (Figure 1.1). Field surveys were not undertaken in associated waterbodies with no listed aquatic values or where aquatic surveys have previously been undertaken. Thus, no field studies were undertaken in Lake King William, Lake Liapootah or Wayatinah Lagoon.

Macroinvertebrate, fish and aquatic habitat surveys were conducted in November and December 2018 at eight locations in the River Derwent and Nive Rivers and one location in the unregulated Counsel River (Table 4.1 and Figure 4.6). At each river site, a qualitative electrofishing survey was conducted; a riffle macroinvertebrate sample collected; and habitat characteristics and incidental observations of fauna recorded and photographed. Macroinvertebrate river health and habitat surveys were repeated at these sites in spring (November) 2021 and autumn (April) 2022 and included edge habitat in addition to riffle habitat. A fluvial geomorphology survey was also undertaken within the same reaches in March 2022. Mossy Marsh Pond and No. 2 Pond were surveyed in April 2019 using electrofishing and fyke nets for fish and sweep sampling for macroinvertebrates. Dates for the macroinvertebrate, fish, aquatic habitat and fluvial geomorphic surveys are shown in Table 4.2

Targeted *Barbarea australis* surveys were undertaken from December 2018 to March 2022, and covered the entire reaches downstream of Clark Dam, Lake Liapootah and Wayatinah Lagoon. These surveys provided additional opportunities to observe and record general aquatic habitat characteristics and species. Dates and locations of the targeted *Barbarea australis* surveys are shown in Table *4.6*.

Table 4.1: Riverine survey sites.

River	Site	Position and inflow status
Derwent	~1.6 km downstream of Clark Dam (P)	Upper section of reach, few inflows
	~2.5 km downstream of Derwent Pumps Weir (P)	Upper section of reach, few inflows
	~100 m upstream of Counsel River (P)	Middle section of reach, low inflows but consistent baseflow
	~50 m downstream of Counsel River (P)	Middle section of reach, high inflows and consistent baseflow
	~ 2 km upstream of Wayatinah Lagoon (P, H)	Bottom of reach, high inflows and consistent baseflow
	~500 m downstream of Wayatinah Lagoon (P)	Top of reach, few inflows
Counsel	~150 m upstream of junction with River Derwent (P, R)	Bottom of reach, unregulated river
Nive	~1 km downstream of Liapootah Dam (P)	Upper section of reach, few inflows
	~200 m upstream of Lyell Highway (P, H)	Lower section of reach, few inflows

Key: AusRivas Project (P), Historic (H) or Reference (R) survey site

Table 4.2: Macroinvertebrate, fish, aquatic habitat and fluvial geomorphic surveys for the Tarraleah Redevelopment Project.

Survey	Location	Date
Ecological (fish, macroinvertebrates and habitat)	River Derwent upstream and downstream Wayatinah Lagoon Nive River upstream Wayatinah Counsel River	November/ December 2018
Ecological (fish, macroinvertebrates and habitat)	Mossy Marsh Pond No. 2 Pond	April 2019
Aquatic/riparian habitat	River Derwent upstream Wayatinah Lagoon	March 2021
Ecological (macroinvertebrates and habitat)	River Derwent upstream and downstream Wayatinah Lagoon Nive River upstream Wayatinah Counsel River	November 2021
Aquatic/riparian habitat	River Derwent upstream Wayatinah Lagoon	March 2021 March 2022
Fluvial geomorphology	River Derwent upstream and downstream Wayatinah Lagoon Nive River upstream Wayatinah Lagoon Counsel River	March 2022
Ecological (macroinvertebrates and habitat)		April 2022
Ecological (stream habitats)	Unnamed tributaries draining the Project disturbance footprint	Sept 2024
Ecological (macroinvertebrates)	River Derwent upstream and downstream Wayatinah Lagoon Nive River upstream Wayatinah Lagoon Counsel River	November 2024

4.4.1.4 Macroinvertebrates and aquatic habitat

Riverine sampling

Freshwater macroinvertebrate communities are widely used as indicators of river health because they are sensitive to short- and long-term changes in habitat quality. All riverine macroinvertebrate sampling conducted for the Project was collected and identified following the Tasmanian protocols for the AusRivAS method and analysed using Hydro Tasmania's RIVPACS regional models (Davies 2002). The HT RIVPACS regional models provide the following condition bands which ranks the health of the invertebrate community: band X (more diverse than reference condition); band A (equivalent to reference); band B (significantly impaired); and band C (severely impaired) (Table 4.3).

A riffle kick sample of the macroinvertebrate community was collected at each site using the standard AusRivAS and Hydro Tasmania's RIVPACS method (CEPA 1994). Each sample was live-picked onsite, which involved transferring the sample from each net into a flat, white tray and picking >200 individuals from the sample over a set period (30-50 minutes); ensuring that the sample is representative of the relative abundance of each faunal group. Samples were stored in a 70% ethanol, 5% glycerol solution.

In spring 2021 and autumn 2022, sampling of macroinvertebrate communities in edge habitats (pools and backwaters in slow run habitat) was undertaken at the monitoring sites where slack-water areas are the main habitat present (i.e., sites upstream of the Counsel River inflow in the River Derwent: River Derwent downstream Wayatinah Dam; and Nive River downstream Liapootah Dam). Edge samples were processed on site in the same way described for the riffle samples.

Aquatic habitat condition of the sites was assessed using a standard assessment proforma to collect information on instream parameters (for example, sediment size classes, stream width, riparian cover and degree of snag habitat) that are inputs for the HT RIVPACS regional models.

AusRivAS samples are identified to family level; however, the 2024[2] spring samples were also identified to species level. Based on known distributions the likelihood of threatened species listed under state or Commonwealth legislation being present in these catchments is low; however, freshwater macroinvertebrates in Tasmania have a high level of endemism and endemic invertebrates are listed as species of conservation significance by the NVA database.

Riverine processing and analysis

For the riffle kick samples, Hirudinea, Oligochaeta, Arachnida and micro-crustaceans were identified to order, all other taxa were identified to family level, except for Chironomidae, which were identified to sub-family level. The level of identification was consistent with the standard AusRivAS (CEPA 1994) and HT RIVPACS method.

The HT RIVPACS regional models use seasonal (spring and autumn) and combined season (spring and autumn combined) macroinvertebrate community data and associated habitat data. The macroinvertebrate community data is analysed for:

- community structure indicated by the rank-abundance of family taxa and indicative of shifts in the relative abundance of taxa
- community composition indicated by the presence or absence of taxa and represents the wholesale gain or loss of taxa.

[2] The 2024 samples have not been run through the AusRivAS models at the time of writing.

The HT RIVPACS regional models produce an observed over expected score (O/E score) by comparing the ratio of the observed family taxa (O) at a chosen test site with the expected family taxa (E) from groups of reference sites that represent the reference condition at the time the models were developed. The models predict the likelihood of taxa occurring at a test site based on groups of reference sites with similar habitat and landscape characteristics. The HT RIVPACS regional model O/E scores are then assigned a condition band to assist with interpreting the model outputs as shown in Table 4.4 and Table 4.5.

There are no HT models for edgewater habitats, thus the Tasmanian state-wide AusRivAS predictive models were used to assess edgewater habitats in spring 2021 and autumn 2022. The edgewater models are limited to assessment of community composition assessed by presence/absence. For these analyses, single-season (spring and autumn) and combined-season models were used to derive an O/E (observed/expected) score (ausrivas.ewater.org.au). For each model, the expected taxa are calculated using a selection of reference sites from the model's database that are most likely to represent the monitoring site in a 'natural' condition based on 'predictor' variables (i.e. habitat and topographic features of the site). The O/E were calculated as the ratio of observed/expected values. The O/E scores were divided into O/E bands that describe the relative health of the river compared to the reference streams defined in the Tasmanian AusRivAS models (Krasnicki et al. 2002, DPIPWE 2018).

Mossy Marsh and No. 2 ponds

At each sampling location, a single sweep sample was collected from lake bed/edge habitat where aquatic macrophyte beds were present. The collected samples were live picked using a method that is consistent with AusRivAS edge sampling in rivers. Samples were preserved in 70% ethanol and identified to family. There is no model equivalent to AusRivAS for analysing macroinvertebrate samples from lakes.

Table 4.3: Hydro Tasmania RIVPAC regional model outputs including a technical description of how the outputs are calculated (http://ausrivas.ewater.com.au/index.php/predictive-modeling-user-manual).

Model Output	Description
NT050	The number of taxa that occur at the monitoring site. Does not include taxa that may have been observed but is not required by the model.
NTC50	The count of the number of taxa predicted to occur >50% of the time at the monitoring site based on the group of reference sites with similar habitat and topographic features that were actually collected at the monitoring site.
O/E	The proportion of the number of taxa predicted to occur compared with actual number of taxa that occurred.
Banding (X,A,B,C,)	The use of banding provides an output that provides a clear interpretation of the biological condition and river health using the 10th and 90th percentile O/E scores generated from the reference sites within each model (refer to Table 4.4 and Table 4.5) for a description of the bands.

Table 4.4: Bands and observed/expected (O/E) scores for Hydro Tasmania's (HT) presence/absence models for spring, autumn and combined season models.

Band	Definition	Spring	Autumn	Combined season
X band	More diverse than reference*	> 1.16	> 01.17	> 1.21
A band	Equivalent to reference	0.73 – 1.16	0.83 – 1.17	0.79 – 1.21
B band	Significantly impaired	0.29 – 0.72	0.49 – 0.82	0.38 – 0.78
C band	Severely impaired	0.00 – 0.28	0.16 – 0.48	0 – 0.37

* may occur for sites of exceptional natural diversity or slight nutrient enrichment

Table 4.5: Bands and observed/expected (O/E) scores for Hydro Tasmania's (HT) rank abundance models for spring, autumn and combined season models.

Band	Definition	Spring	Autumn	Combined season
X band	More diverse than reference*	> 1.19	> 1.20	> 1.11
A band	Equivalent to reference	0.78 – 1.19	0.81 – 1.20	0.78 – 1.11
B band	Significantly impaired	0.36 – 0.77	0.42 – 0.80	0.44 – 0.77
C band	Severely impaired	0.00 – 0.35	0.03 – 0.41	0.10 – 0.43

* may occur for sites of exceptional natural diversity or slight nutrient enrichment

4.4.1.5 Fish

Riverine

Riverine fish surveys were undertaken at each of the sampling sites (Table 4.2, Figure 4.6) using a Smith-Root LR24 backpack electro-fisher and the catch recorded based on a 20-min CPUE method (i.e., 20 mins of on-time on the shocker counter. Fish were identified to species, counted and released.

Mossy Marsh and No. 2 ponds

Fish surveys in these artificial storages were restricted to fyke netting as the mostly deep and fine sediment dominated shorelines precluded electrofishing. Over a single night, ten nets were set around the shoreline of each pond. The locations where the nets were set provided the most suitable habitat for fish (that is, sheltered bays with structural complexity from aquatic or fringing vegetation and woody debris). Nets were set in the afternoon and recovered the following morning, with soak times between 13 and 16 hours.

4.4.1.6 Barbarea australis

Eight targeted surveys for *B. australis* have been undertaken for the Project since 2018 (Table *4.6;* Figure 4.7). The surveys were undertaken by a two-person team walking the river margins looking for specimens by eye. All surveys were undertaken within the main growing and flowering season for *B. australis* (November to March), although mature and juvenile specimens have been observed in these reaches into late April. All specimens encountered during the surveys were recorded on a computer tablet with GPS capability using Entura's EFOS (Environmental Field Observation System), which records data using fields that are consistent with the NVA.

In addition to the geolocation of each specimen, photos and observations of surrounding substrate characteristics were noted. All observations of *B. australis* were uploaded to the NVA.

Table 4.6: Targeted *Barbarea australis* surveys undertaken within associated waterbodies of the Tarraleah Redevelopment Project.

River	Date	Location
Nive River	11 Dec 2018	500 m reach upstream lower Lyell Hwy
Nive River	18 Dec 2018	~2.5 km reach: directly downstream from Liapootah Dam ~1 km reach: upstream from Wayatinah Lagoon
River Derwent	23 Jan 2019	6 km: entire reach from Wayatinah Lagoon to Lake Catagunya
River Derwent and Nive River	29-31 Jan 2019	1 km reach: River Derwent ~1 km downstream of Clark Dam 3.5 km reach: River Derwent downstream Derwent Pumps Weir 1.2 km reach: River Derwent in the vicinity of Counsel River 4 km reach: River Derwent upstream of Wayatinah Lagoon 1.2 km reach: Nive River immediately upstream of Tarraleah Power Station 10 km reach: Nive River upstream of Tarraleah Power Station to Pine Tier Lagoon 9 km reach: entire reach Nive River downstream of Liapootah Dam to Wayatinah Lagoon
River Derwent	29 March 2021	16 km reach: entire reach from Derwent Pumps Weir to Counsel River
River Derwent and Nive River	15 Nov 2021	1 km reach: River Derwent downstream Wayatinah Lagoon 500 m reach: Nive River upstream lower Lyell Hwy
River Derwent	4 March 2022	9 km reach: downstream Counsel River to Wayatinah Lagoon

4.4.1.7 Limitations

Macroinvertebrate surveys were conducted using the National AusRivAS method which provides a qualitive assessment river health based on community metrics. More quantitative Surber sampling followed by univariate and multivariate statistical analysis could be undertaken but this is considered unlikely to change the general patterns and conclusions gained from the AusRivAS sampling. Also, the substrate in the River Derwent is dominated by small to large boulder at most of the sites which is not suitable for Surber sampling.

Aquatic field surveys were not undertaken in associated waterways with no listed aquatic values and where aquatic surveys have previously been undertaken. Thus, no field studies were undertaken in Lake King William, Lake Liapootah or Wayatinah Lagoon, where the existing operating water level ranges will not change under the Project and existing values are expected to be preserved. Aquatic surveys of Mossy Marsh Pond and No. 2 Pond were undertaken as they were larger waterbodies associated with the Project for which no aquatic surveys had previously been undertaken. As No. 1 Pond is small (only 1.7 ha) and is essentially the meeting point of No. 1 and No. 2 Canals, no surveys were undertaken of this waterbody.

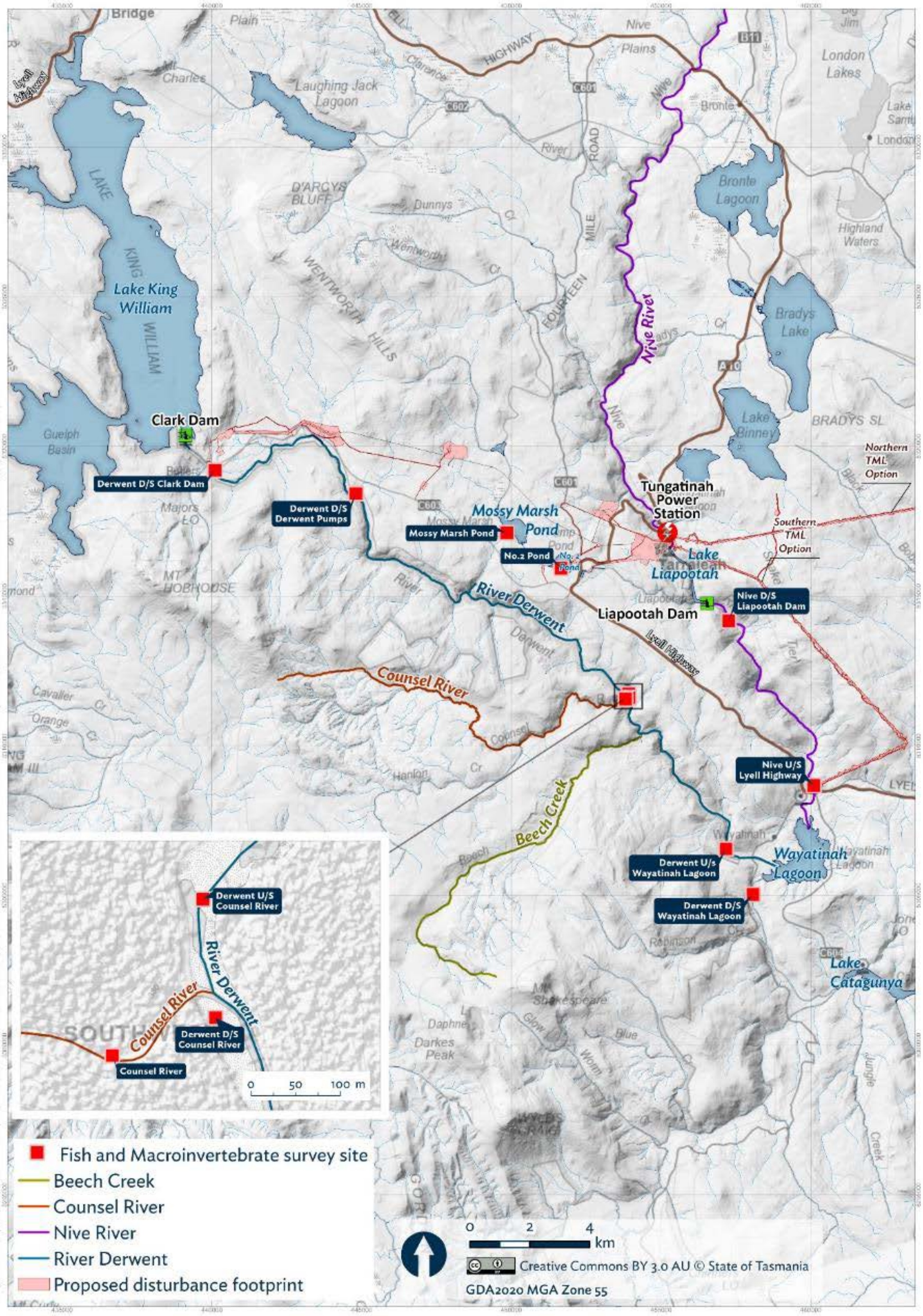

Figure 4.6: Macroinvertebrate, fish and aquatic habitat survey sites in the Derwent, Nive and Counsel River sampled during the 2018, 2021 and 2022 surveys.

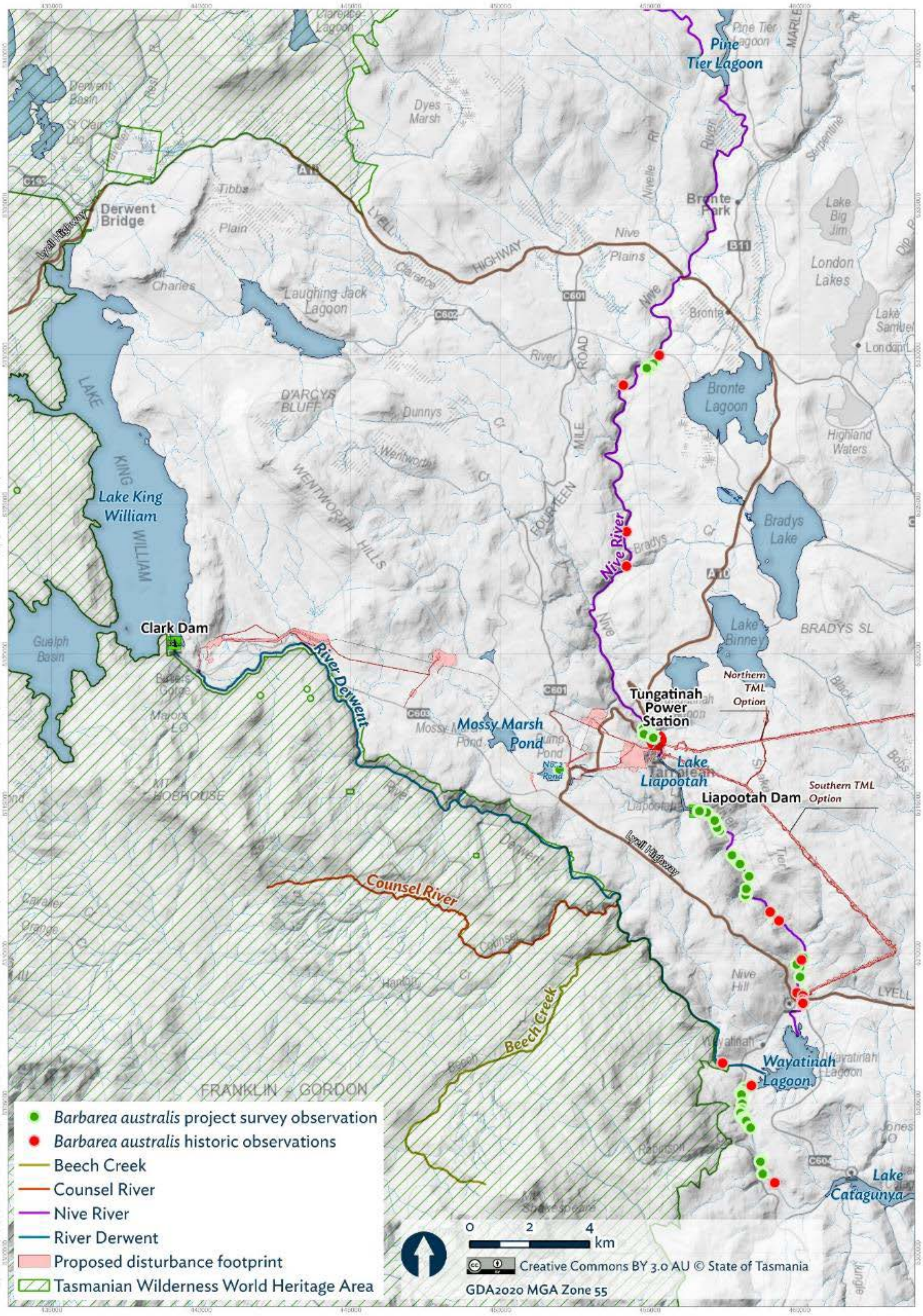

Figure 4.7: Reaches surveyed for *Barbarea australis* for the Project; observations during surveys for the Project and historic records.

5. Desktop review

5.1 Listed species

The plant, *Barbarea australis*, is the only listed flow-dependent species that has been recorded within the associated waterbodies of the Tarraleah Redevelopment Project and the only species likely to occur based on known ranges and habitat associations (Table 5.1).

Barbarea australis (native wintercress) is an annual or short-lived perennial in the Brassicaceae family and is endemic to Tasmania. *Barbarea australis* is listed as endangered under the state *Threatened Species Protection Act 1995* and endangered under the Commonwealth *Environment Protection and Biodiversity Conservation Act 1999.*

Barbarea australis is an opportunistic riparian coloniser, relying on disturbance, particularly flow disturbance, to turn over bank/bed sediments and create suitable ground for its establishment. It is most often found growing among loose gravels, pebbles and cobbles within the active river channel (Figure 5.1). Thus, mobile rock bars, either within the main channel or in flood-running side channels that are elevated above the low flow channel, are the most common location where the species is found. With sufficient high flow disturbance, these rock bars are free of competing species, or at least have a low density of competing species, which appears to be important as *B. australis* is a poor competitor (Threatened Species Section 2011). High flow events are also required to redistribute its seeds. It is likely that *B. australis* has always been locally uncommon (Threatened Species Section 2011). Small subpopulations have an increased risk of becoming extinct through chance to stochastic events or through human-induced changes that alter key habitat forming processes.

Prior to its rediscovery in the 1980s, *B. australis* was considered extinct (Threatened Species Section 2011). It has since been recorded from approximately 23 subpopulations in 11 locations, including central Tasmania (Derwent, Nive, Ouse, Shannon and Clyde river catchments and the Lake River); the north-east (St Patrick and North Esk river catchment); Central North (Mersey and Forth river catchments); in the north-west (Hellyer, Guide river catchments); and an isolated record in the far north-west near Woolnorth.

Surveys for the Project recorded recent observations of *B. australis* in the River Derwent downstream Wayatinah Lagoon and Nive River downstream Liapootah Lagoon; however, there are no recent records in the River Derwent downstream Clark Dam to Wayatinah Lagoon, as described in Section 6.5.

5.1.1 Listed species identified as potentially occurring in the Project area

Only one species, besides *B. australis*, was identified in the desktop review of the NVA and PMST databases as potentially occurring in the Project area, the Clarence galaxias (Table 5.1). No other listed aquatic species have been recorded or identified as potentially occurring within a 5 km buffer of the Project area

5.1.1.1 Clarence galaxias (Galaxias johnstoni)

The Clarence galaxias (*Galaxias johnstoni*) was identified as potentially present in the Project area through the Protected Matters Search Tool (PMST) based on records within a 5 km buffer of the Project area (Table 5.1). This species is listed as endangered under the state Threatened Species Protection Act 1995 and national Environment Protection and Biodiversity Conservation Act 1999.

Fish surveys were undertaken as part of the surveys for the Project; however, no targeted surveys were conducted for the Clarence galaxias because there is no potential for this species to be present in the waterways potentially affected by the Project. This assessment is based on the ecology of the species, its known distribution and vulnerability to introduced fish species. Senior staff at Tasmania's Inland Fishery Service (IFS) were consulted with and agreed with this assessment (Rob Freeman, Section Manager, Fisheries Management, IFS, 29th August 2024) for the reasons provided below.

Range description, ecology and known threats

The Clarence galaxias is endemic to central Tasmania where it occurs in isolated parts of the upper Derwent River catchment, including the headwaters of the Nive, Clarence and Little River catchments where it occurs in lake and streams in high altitude areas of approximately 1000 m above sea level (TSS 2006).

The species appears to prefer the shelter of rocks and boulders in lake habitats and adults primarily feed on benthic crustaceans, and juveniles on planktonic crustaceans and terrestrial insects (Crook and Sanger 1998). In flowing habitats, the species inhabits deep pools, although it spreads into other areas when water levels are high enough (TSS 2006). Adults have been observed moving from lagoons into inlet streams to spawn in spring (McDowall 2006).

All locations where populations of the species occur are free of other fish species except for Clarence Lagoon where a population of brook trout (*Salvelinus fontinalis*) is maintained through stocking (TSS 2006; IFS 2014). Introduced brown trout (*Salmo trutta*) outcompete and prey upon Clarence galaxias. Fisheries managers consider brook trout a less aggressive species than brown and rainbow trout (TSS 2006). Current populations of Clarence galaxias are protected from invasion or establishment of brown trout by some form of barrier (e.g. a waterfall or fluctuating water levels) (TSS 2006).

Populations of Clarence galaxias are prevented from re-establishing in areas downstream from where they currently occur due to the presence of brown trout across the Derwent River catchment area (TSS 2006). There are no records of Clarence galaxias in the waterways associated with the Project which range from approximately 750 mASL (near Clark Dam) to 220 mASL (River Derwent downstream Wayatinah Dam).

The closest records of Clarence galaxias to the Project area are to the northeast in a small lake and streams on the north and east draining slopes of the Wentworth Hills (Figure 5.2). This includes Lake Knight and tributaries entering Laughing Jack Lagoon and the headwaters of Wentworth Creek (a tributary of the reaches of the Nive River upstream Lake Liapootah). These records are approximately 6.7 km northeast of Clark Dam and 5 km northeast of the nearest infrastructure/works associated with the Project (Figure 5.2). There are no records of the Clarence galaxias in streams or lakes which drain the west or south slopes of the Wentworth Hills towards Lake King William or the River Derwent downstream Lake King William.

The waterbodies of the Project area include the River Derwent downstream Lake King William and the tributaries that enter the river; the Nive River up or downstream from Lake Liapootah; Lake Liapootah; Mossy Marsh; No. 2 Pond; and Wayatinah Lagoon. All these waterways are known to have self-sustaining population of brown trout and this species was by far the most abundant caught during surveys for the Project. Small populations of rainbow trout are also present in some locations.

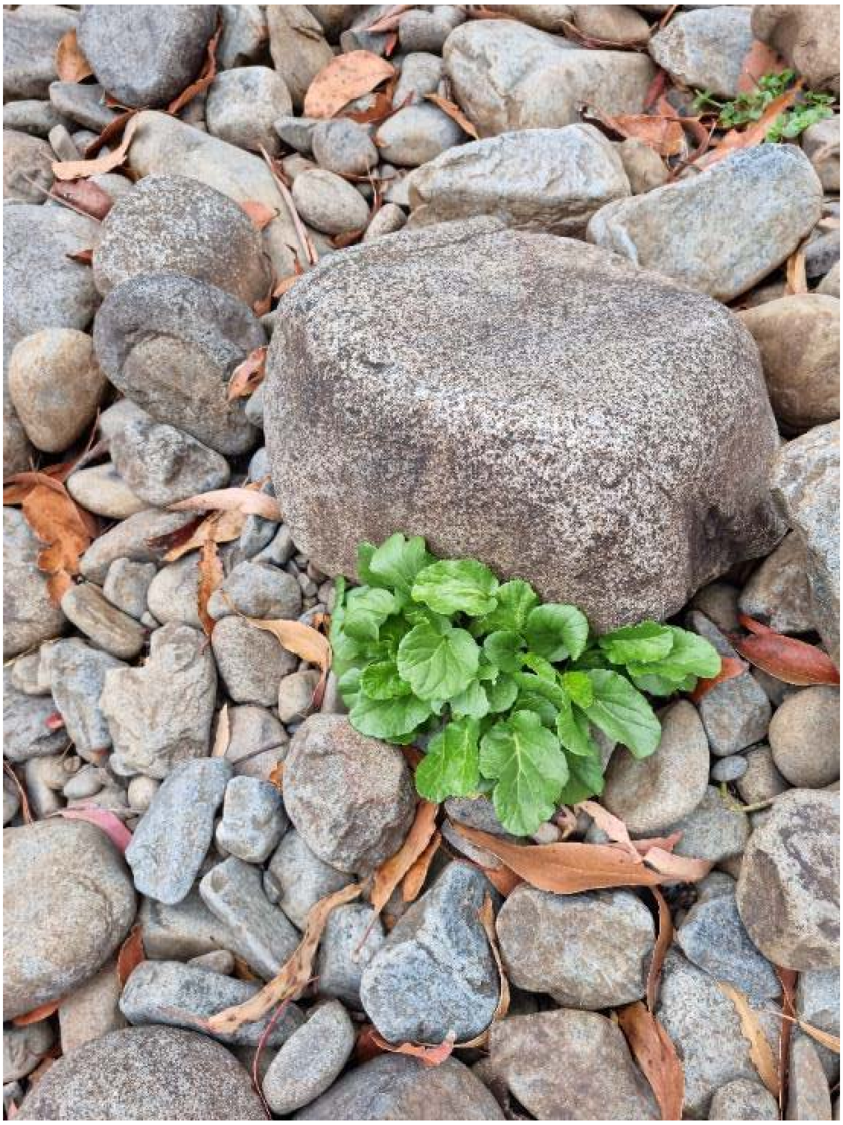

Figure 5.1: Barbarea australis growing among small cobbles and pebbles in the River Derwent downstream Wayatinah Lagoon.

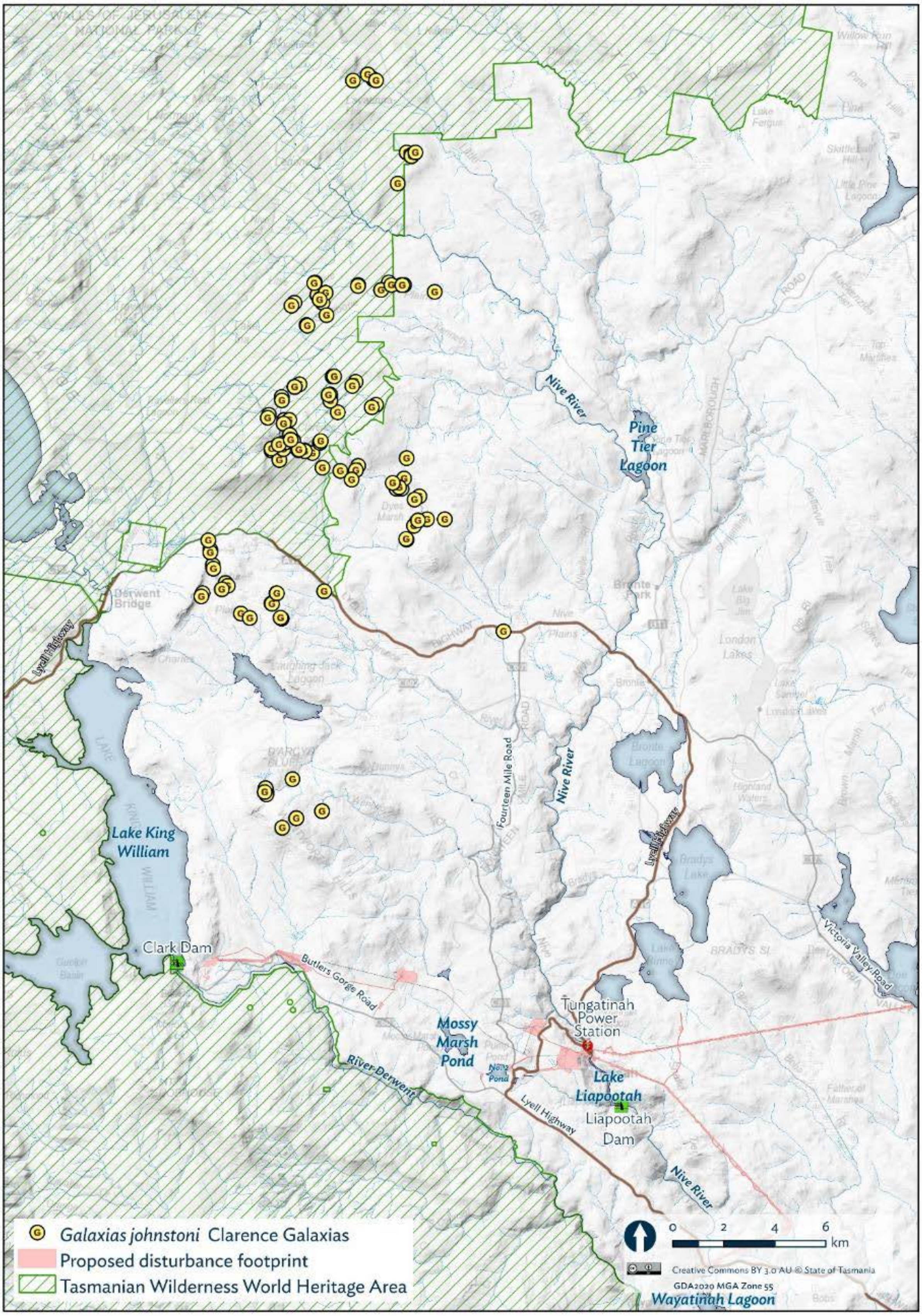

Figure 5.2: Known records of the Clarence galaxias showing its distribution in the vicinity of the Project area

Table 5.1: NVA (Natural Values Atlas), PMST (Protected Matters Search Tool) aquatic species.

Species	Common Name	Conservation Category		Source	Habitat	Potential for occurrence
		TSP Act	EPBC Act			
Flora						
Barbarea australis	Native wintercress	Endangered	Endangered	NVA	An annual or short-lived perennial herb occurring along flood-prone rocky river systems. Endemic to Tasmania, known from about 11 river systems extending from northern Tasmania to rivers flowing south from the Central Highlands (Threatened Species Section 2010).	There are 122 NVA records from the Nive River downstream Liapootah Dam and the River Derwent downstream Wayatinah Lagoon with the majority of these from surveys conducted for the Project. There are also two records from the River Derwent upstream of Wayatinah Lagoon, one record of one plant on the NVA from November 2000 and another record of two plants from 2001 in the listing statement (Threatened Species Section 2010). Species **known to occur**.
Fish						
Galaxias johnstoni	Clarence galaxias	Endangered	Endangered	PMST	A small freshwater fish to 140 mm. Restricted to the headwaters of the upper River Derwent catchment, including the Nive, Clarence and Little River catchments. Also occurs in Clarence Lagoon and Johnsons Lagoon (Threatened Species Scientific Committee 2016). The species occupies stream, marsh and lake habitats.	There are four historic records last recorded in December 1988 within 5 km of the Project survey area with poor spatial accuracy. Absent from Project area as only known to occur within headwater streams of the Nive and Clarence River catchments. Also, does not co-occur with introduced trout which compete and predate on it. Trout have been recorded in all of the waterbodies associated with the Project, thus the species **does not occur in the waterbodies affected by the Project**.

5.2 Protected areas - Tasmanian Wilderness World Heritage Area (TWWHA)

5.2.1 Tasmanian Wilderness World Heritage Area (TWWHA)

The River Derwent is within the TWWHA starting immediately downstream of Derwent Pumps Weir (which is located 6 km downstream of Clark Dam) and continues for approximately 23 km, with the downstream boundary approximately 2.8 km upstream from where the river enters Wayatinah Lagoon (Figure 1.1). The Tasmanian Wilderness is inscribed on the World Heritage List under four natural (vii, viii, ix and x) and three cultural (iii, iv, vi) criteria related to:

Natural values

- Outstanding examples representing the major stages of the earth's evolutionary history (Criterion viii)
- Outstanding examples representing significant ongoing geological processes (Criterion viii), and ecological and biological processes (Criterion ix)
- Contains superlative natural phenomena, formations or features, for instance outstanding examples of the most important ecosystems, areas of exceptional natural beauty or exceptional combinations of natural and cultural elements (Criterion vii)
- Contain the most important and significant habitats where threatened species of plants and animals of outstanding universal value from the point of view of science and conservation still survive (Criterion x).

Cultural values

- Bear a unique or at least exceptional testimony to a civilisation which has disappeared (Criterion iii)
- An outstanding example of a type of landscape which illustrates a significant stage in human history (Criterion iv)
- Directly or tangibly associated with events or with ideas or beliefs of outstanding universal significance (Criterion vi).

Natural values of the TWWHA which involve processes relevant to freshwater values include:

- Wild river systems that are free-flowing and natural
- The flow regime itself as it directly affects riparian and riverine habitats and species
- Landscape processes: for example, peak flows drive natural disturbance processes which shape riverine and riparian habitats
- Ecological processes/values including diversity, composition and structure
- Presence of rare, endemic or unique species or communities and the habitat for these species/communities.

Section 6.1 describes the River Derwent within the TWWHA and provides a summary of natural values contained in this reach i.e., hydrology, geomorphology, ecological processes, habitat and biota including protected or threatened species and communities. Evaluation against specific criteria for World Heritage Properties is found in Section 8.4.

5.3 Threatened vegetation communities

The only threatened aquatic vegetation community identified from the online searches is *Sphagnum* Peatland (ASP) listed as rare under the NC Act and found associated with Mossy Marsh Pond. *Sphagnum* peatland is also listed as an endangered ecological community under the EPBC Act where it is one of the components of the Alpine *Sphagnum* Bogs and Associated Fens community. This community is discussed in the terrestrial flora and fauna values report for the Project (Entura 2025a).

5.4 Species classified as of Conservation Significance in Tasmania

Species of special conservation significance include those with restricted distributions, are highly sensitive and vulnerable to threats and/or primitive species that are considered evolutionary relics that do not qualify for listing under the TSP Act or EPBC Act.

Platypus (*Ornithorhynchus anatinus*), which is a species that is protected throughout Australia. In Tasmania, it is protected under the *Wildlife Regulations 2010* and the NC Act. The platypus requires stable, vegetated earth banks adjacent waterbodies for construction of both resting and nesting burrows. They are widespread and common in Tasmania; however, their current and future conservation status is not easily assessed given their abundance is not readily measured across the State.

The native freshwater crayfish *Astacopsis tricornis* (Figure 5.3) and many of the freshwater macroinvertebrate species which occur in the River Derwent catchment are classified as species of conservation significance due to being endemic to Tasmania or to Tasmania and restricted areas of the mainland.

5.5 Conservation of Freshwater Ecosystem Values (CFEV)

The Conservation of Freshwater Ecosystems Values (CFEV) is a spatial database tool that provides an audit and evaluation of Tasmania's freshwater ecosystems for their conservation value and management priority. The output of the CFEV assessment provides information about the biophysical character and condition of all freshwater-dependent ecosystems. Further, an output of the CFEV assessment includes the Conservation Management Priority Potential (CMPP) represents ecosystems to protect against negative future impacts whereby CMPP2 uses the Integrated Conservation Value (ICV) as an input (i.e. accounts for presence of Special Values). This framework for this database is based around the CAR reserve design strategy.

The CFEV assessment table is provided in Appendix G for all stream segments which are within the construction disturbance footprint for the project and a summary of the Conservation Management Priority Potential is provided in Section 6.6.

Figure 5.3: Astacopsis tricornis in the River Derwent upstream Wayatinah Lagoon

6. Existing physical and biological environment

All the study reaches occur in areas that have little land use disturbance other than from production forestry along the Butlers Gorge Road and the construction and operation of hydropower assets. Therefore, most of the existing influences on aquatic habitat are due to the effects of dams on flow regimes and reduced downstream transport and resupply of sediment.

Small substrates (gravels and finer) are uncommon in all the study reaches, caused by the dams trapping these small substrates. Over time, these small fractions are mobilised by large flow events and transported out of the channel and not resupplied from reaches upstream of the dam. Sediment starvation influences the aquatic communities present as it limits the niches available for species to exploit. For example, the slack-water habitats in the study reaches have very few fines, which means there is little suitable substrate in which aquatic macrophytes can establish. The low abundance of fines also limits the suitability of available habitat for those aquatic macroinvertebrates which favour depositional habitats (Section 6.1.4.)

Table 6.1 summarises the flow regime, flow habitats, physical habitat and existing condition for each of the study reaches, with a more detailed description provided in the sections below.

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Table 6.1: Flow and habitat summary for associated waterbodies of the Tarraleah Redevelopment Project. Green rows are all the reaches within TWWHA#

Reach	Length (km)	Existing flow regime	Flow habitats	Dominant substrate	Influence on habitat
River Derwent downstream Clark Dam to Wayatinah Lagoon					
Clark Dam to Derwent Pumps Weir	6	Mainly low baseflow from minor tributaries, occasional higher flows from dam spill	Low gradient, mainly long, slow run habitats and pools	Bedrock and boulder	Lack of high flows allows dense biofilms to accumulate on the benthos, significantly degraded
Derwent Pumps Weir to Counsel River	16	Tributary inflow accumulates with distance downstream to restore baseflow and small higher flow events; however, largest flow events from dam spill	Low to moderate gradient, long slow runs and pools with small sections of riffles and short cascades	Bedrock, boulder and cobble	Lack of high flows allows dense biofilms to accumulate on the benthos, significantly degraded.
Counsel River to Wayatinah Lagoon	9	Significant tributary inflow and more natural flow regime variability including peak flows but largest flow events still from dam spill	Moderate gradient, all flow habitats present	Bedrock to pebble, but mainly bedrock, boulder and large cobble	Tributary input provides scouring flows, dense biofilms are less apparent, relatively healthy in terms of habitat condition, macroinvertebrates and freshwater crayfish. Good habitat for platypus.
River Derwent downstream Wayatinah Lagoon to Lake Catagunya					
Wayatinah Dam to Lake Catagunya	6	Very low baseflows as minor tributary inflows	Low gradient, mainly long slow runs and pool, occasional short riffle sections present	Bedrock, boulder and cobble	Lack of high flows allows dense biofilms and mats of filamentous algae to accumulate on the benthos; significantly degraded
Nive River from Tarraleah Power Station to Wayatinah Lagoon					
Nive River downstream of Tarraleah Power Station to Lake Liapootah	~0.3	Significant prolonged high discharge from Tarraleah Power Station, regulated by Pine Tier Lagoon upstream	Moderate gradient, fast riffle and run habitats	Boulder and cobble	High power station discharge provides armoured riverbed
Nive River downstream Lake Liapootah	9	Minor tributary inflows with occasional spill events	Low gradient, mainly long slow runs and pools, occasional riffles present at breaks in slope at river bends	Boulder to pebble	Channel bed mostly dewatered, very little flow regime variability in the wetted sections; significantly degraded

The boundary of the TWWHA starts immediate downstream of Derwent Pumps Weir and stops ~2.8 km upstream from Wayatinah Lagoon.

6.1 River Derwent downstream Clark Dam to Wayatinah Lagoon

6.1.1 Summary

Twenty-three km of this 31 km reach is within the TWWHA which extends from directly downstream Derwent Pumps Weir to approximately 2.8 km upstream Wayatinah Lagoon (Figure 1.1). Flow regulation has significantly altered the sediment transport, channel morphology and the condition of the biological communities, particularly in the upper and middle reaches (including the first 16 km of the 23 km of river which lies within the TWWHA) i.e. upstream of the Counsel River.

No listed aquatic species have been recorded in this reach either historically or during the surveys for the Project. Also, based on the known range of listed aquatic species in Tasmania it is highly unlikely that any occur. Freshwater species of conservation significance in Tasmania based on being phylogenetically distinct (platypus) or endemic (several invertebrate species) are present in this reach (see Section 6.1)

Three state listed riparian species have been recorded in the reaches of TWWHA (Section 6.1.7). *Barbarea australis*, a flow dependant riparian plant species, has been recorded at the bottom of this reach, downstream from the boundary of the TWWHA in 2000 and 2001. *Barbarea australis* was not found in this reach during surveys for the Project; however, patches of suitable habitat for this species occur and there are nearby populations in the River Derwent downstream Wayatinah Lagoon and in the Nive River upstream Wayatinah Lagoon (Section 6.5).

The following sections provide a detailed description of the flow regime, fluvial geomorphology and aquatic values.

6.1.2 Flow regime

Lake King William (created by Clark Dam) is the storage for the Tarraleah Power Station where water is delivered via two canals, No. 1 Canal and No. 2 Canal (Figure 1.1; Figure 1.2). Butlers Gorge Power Station is at the base of Clark Dam and discharges into the River Derwent directly for approximately 350 m before the flow is diverted by Butlers Weir into No. 1 Canal. No. 1 Canal has a capacity of 20 m^3/s and water spills back into the River Derwent when Butlers Gorge Power Station exceeds 20 m^3/s (the maximum discharge of Butlers Gorge Power Station rarely exceeds 25 m^3/s). Derwent Pumps Weir is located 6 km downstream of Clark Dam. The Derwent Pumps Station pumps up to 2.8 m^3/s from the River Derwent, comprised from spill from Butlers Weir and tributary pick up, into No. 2 Canal. No. 2 Canal currently enters Mossy Marsh Tunnel and discharges into Mossy Marsh Pond then No. 2 Pond before entering the penstocks to the existing Tarraleah Power Station.

Spill or releases from Clark Dam occur via:

- Opening the spillway gates. The combined maximum capacity of these gates is >660 m^3/s and are used to safely release water when Lake King William is at or above its full supply level.
- Opening the two regulator valves at the base of the dam (maximum discharge 78 m^3/s). Operation of these valves is the most used method to safely release water when Lake King William close to full supply level.
- Operation of Butlers Gorge Power Station. As discussed above, discharge from the power station over 20 m^3/s spills back into the River Derwent.

Spill from Derwent Pumps Weir occurs when the combined spill from Clark Dam and/or tributary pickups exceeds 2.8 m^3/s. All baseflow is derived from tributary inflows as no baseflow releases are provided from Clark Dam or Derwent Pumps Weir.

This assessment divides the River Derwent downstream Clark Dam into three distinct zones of hydrology: 1) the first six km downstream Clark Dam to Derwent Pumps Weir; 2) a 16 km reach between Derwent Pumps Weir to the Counsel River inflow; and 3) the final 9 km reach downstream the Counsel River inflow to Wayatinah Lagoon. The main focus is on Zones 2 and 3 as these reaches encompass the reaches within the Tasmanian Wilderness World Heritage Area (TWWHA) and all of the areas of suitable habitat for the listed endangered riparian plant species *Barbarea australis*, both of which are Matters of National Environmental Significance (MNES). Also, there is no observed record which captures all sources of spill directly downstream Clark Dam although there is an observed record at Derwent Pumps Weir (Section 4.3.1).

6.1.2.1 Seasonality

The observed flow data (2007 – 2022) at the bottom of the reach near Wayatinah Lagoon (*DS Derwent Pumps 6*) is representative of the seasonal patterns of the entire reach. The monthly flow statistics show a typical seasonal trend for Tasmania, with the lowest flows over summer and early autumn and the highest flows over late winter and spring (Figure 6.1). Figure 6.2 shows monthly boxplots for this site with the rarer high flow events included. The plot demonstrates that peak flows which exceed 50 m^3/s are limited to May to December and flow events that exceed 100 m^3/s mainly occur from July to October, and December, but also occur in November (Figure 6.2). Section 8.1.4 provides analysis of large flow events under current operation and those modelled during operation of the Project.

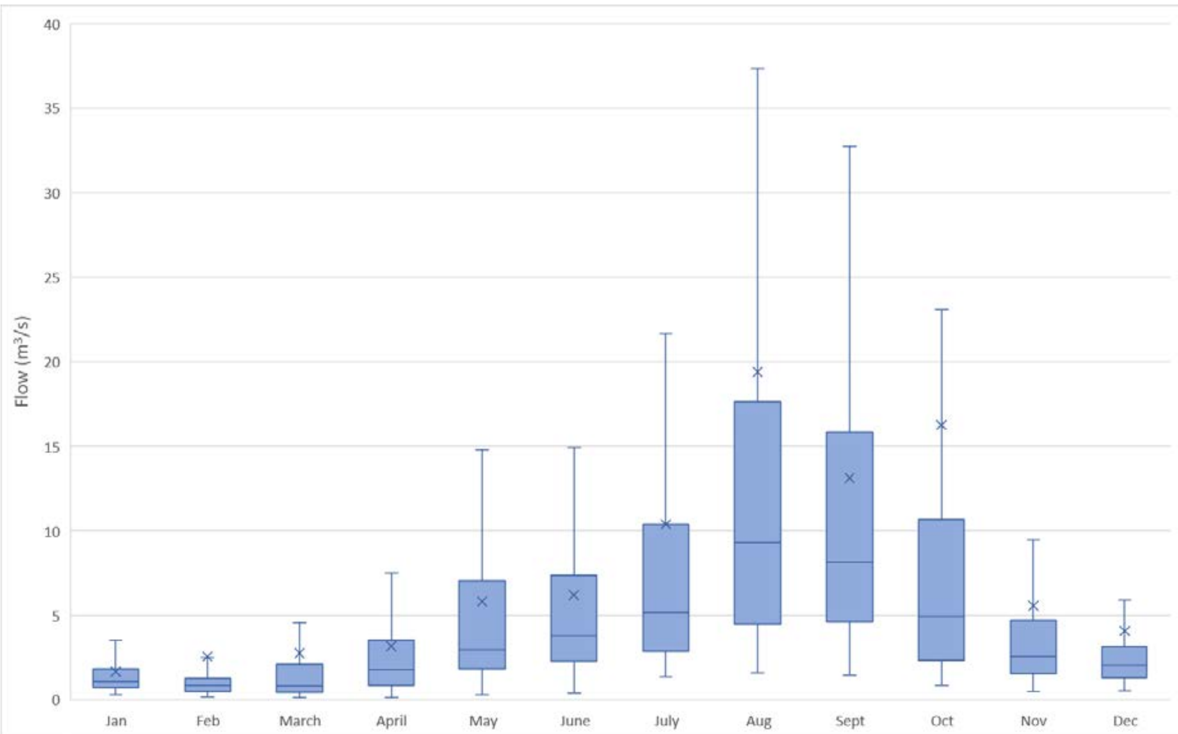

Figure 6.1: Box and whisker plot for observed baseline data at the bottom of the reach (*DS Derwent Pumps 6*) (2007 to 2022). Plot shows the monthly median (grey line), mean (x mark), the spread between the 25th and 75th quartiles (extent of the box). Outlying points (high flow events) are removed (see Figure 6.2 for these) and the whiskers represent 1.5 the interquartile range.

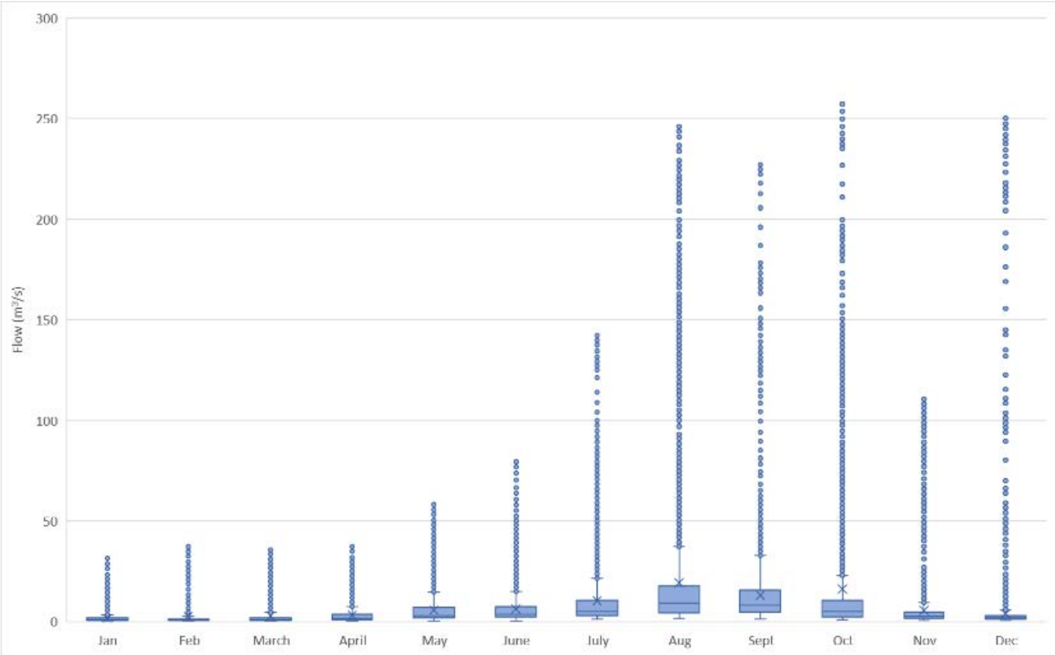

Figure 6.2: Box and whisker plot for observed baseline data at the bottom of the reach (*DS Derwent Pumps 6*) (2007 to 2022). Plot shows the monthly median (grey line), mean (x mark), the spread between the 25th and 75th quartiles (extent of the bar). The whiskers represent 1.5 the interquartile range. Dots represent the rarer high flow events.

6.1.2.2 Clark Dam to Derwent Pumps Weir (6 km reach)

Tributary pickups from Clark Dam to Derwent Pumps Weir include Coxs Creek and 12 unnamed creeks; however, several of the unnamed creeks on the northern side of the river are diverted into No. 2 Canal.

There are four modelled flow locations in this zone (Figure 4.4):

- *DS Clark Dam 1:* directly downstream the dam
- *DS Clark Dam 2:* ~350 m downstream Clark Dam and directly downstream Butlers Weir (this location is immediately downstream from where up to 20 m^3/s is diverted from the river channel into No.1 Canal
- *DS Clark Dam 3:* 4.5 km downstream Clark Dam and downstream several tributaries
- *DS Clark Dam 4*: immediately upstream Derwent Pumps Weir and 6 km downstream from Clark Dam.

The first location which represents the flow present in the River Derwent downstream of Clark Dam, minus the discharge from Butlers Gorge Power Station and water diversions to No. 1 Canal, is downstream Butlers Weir *(DS Clark Dam 2)*. The modelling estimates Butlers Weir spilled for 63 percent of the time over the whole record (Figure 6.3) ranging from 47 percent in February to 80 percent in August and September (Appendix D.1). At this location, modelled spill ranged from a few litres to 213 m^3/s, with a mean annual maximum flow of 73.7 m^3/s and a median spill of 0.5 m^3/s when spill occurred (Figure 6.3, Table 6.2).

Several small tributaries, including Coxs Creek, join the River Derwent by 4.5 km downstream Clark Dam (*DS Clark Dam 3*). The modelling indicates that these tributaries return a more permanent and higher flow to the channel, approximately doubling the high, fresh and median flow regime and provides a permanent baseflow (Figure 6.3, Table 6.2). However, peak flows were similar at this location to the site immediately downstream Butlers Weir (*DS Clark Dam 2)* (Figure 6.3, Table 6.2) because the largest flow events in the entire reach from Clark Dam to Wayatinah Lagoon are derived from dam spill (Section 8.1.4) rather than tributary inflows. This reliance on spill events for high flows is most pronounced for the reaches upstream of the Counsel River inflow because there are no large tributaries upstream of the Counsel River.

By 6 km downstream from Clark Dam (*DS Clark Dam 4*) and immediately upstream Derwent Pumps Weir (Figure 6.3, Table 6.2), additional tributary inflows increase the high to median flow regime by approximately 25 to 35 percent and the baseflow approximately doubles compared to *DS Clark Dam 3* (Figure 6.3, Table 6.2).

Figure 6.3: Flow duration curve (log) for the River Derwent downstream Butlers Weir (*DS Clark Dam 2*), 4.5 km downstream Clark Dam (*DS Clark Dam 3*) and immediately upstream Derwent Pumps Weir (*DS Clark Dam 4*) (2007 to 2022).

Table 6.2: Flow statistics for the River Derwent downstream Butlers Weir (*DS Clark Dam 2*) 4.5 km downstream Clark Dam (*DS Clark Dam 3*) and immediately upstream Derwent Pumps Weir (*DS Clark Dam 4)* (2007 to 2021).

Flow regime category	**Flow percentile/statistic**	***DS Clark Dam 2 (modelled)***	***DS Clark Dam 3 (modelled)***	***DS Clark Dam 4 (modelled)***
			m^3/s	
Peak	Maximum flow in record	*213*	*219*	*227*
	Mean annual maximum flow	*79*	*83*	*88*
	Q1	*69*	*71*	*72*
High	Q5	*6*	*9*	*12*
	Q10	*3*	*5*	*6*
Fresh	Q20	*1.3*	*2.5*	*3.7*
	Q30	*0.8*	*1.8*	*2.5*
Median	Q50	*0.04*	*1.1*	*1.4*
Baseflow	Q80	*0.00*	*0.34*	*0.67*

6.1.2.3 Derwent Pumps Weir to Counsel River inflow (16 km reach)

This zone includes three flow locations (Figure 4.4):

- *DS Derwent Pumps 1* which is directly downstream Derwent Pumps Weir (observed spill data from 2007 to 2021 from the River Derwent below pump intake flow monitoring site)
- *DS Derwent Pumps 2* which is ~ 5 km downstream from Derwent Pumps Weir and after five unnamed tributaries have joined the river (modelled data)
- *DS Derwent Pumps 3* which is 16 km downstream Derwent Pumps Weir and immediately upstream the Counsel River inflow (modelled data).

The observed spill data shows that spill occurred for 38 percent of the time over Derwent Pumps Weir (*DS Derwent Pumps 1*) which range in magnitude from 0.1 m^3/s to 226 m^3/s with a mean annual peak spill of 87 m^3/s (Figure 6.4; Table 6.3).

The spill statistics are slightly different when calculated for only the periods when spill is occurring. Over the record of observed data (2007 to 2025) range from:

- Very large spills:
  - 98%ile (spill exceeded 2% of the time): 78 m^3/s
  - 95%ile (spill exceeded 5% of the time): 37 m^3/s
- Large spills:
  - 90%ile (spill exceeded 10% of the time): 14 m^3/s
  - 80%ile (spill exceeded 20% of the time): 4.5 m^3/s
- Moderate spills:
  - 70%ile (spill exceeded 30% of the time): 3 m^3/s
- Median spill (50%ile)
  - 1.5 m^3/s

- Minor spills:
  - 30%ile (spill exceeded 70% of the time): 0.6 m^3/s
  - 10%ile (spill exceeded 70% of the time): 0.16 m^3/s

Spill at Derwent Pumps Weir was most infrequent from January through March (~ 20 percent of the time) and most frequent in August and September (~67 percent of the time) (Appendix D.3). Spills which exceed 100 m^3/s occurred from July to December, but the frequency of large spills (~ ≥ 50 m^3/s) was most common from August through October (Appendix D.3). From January to June the maximum flow ranged from 8 to 35 m^3/s (Appendix D.3).

Modelling indicates that tributary inflows 5 km downstream from Derwent Pumps Weir (at flow site *DS Derwent Pumps 2*) returned a more permanent and higher flow to the channel (Figure 6.4). Peak flows were similar at this location to the site immediately downstream Derwent Pumps Weir because the peak flows in this reach are mainly derived from Clark Dam spill and then spill at Derwent Pumps Weir, rather than from tributary inflows (Figure 6.4; Table 6.3). However, tributary inflows supply all the baseflow at this location; increase the fresh flow regime by ~ 2 to 4 times and approximately doubles the high flow regime compared to *DS Derwent Pumps 1* (Figure 6.4; Table 6.3).

The modelling indicates that tributary inflows in the next 11 km to *DS Derwent Pumps 3* (immediately upstream the inflow of the Counsel River) contributed minor additional flow compared to DS Derwent Pump 2 (Figure 6.4; Table 6.3).

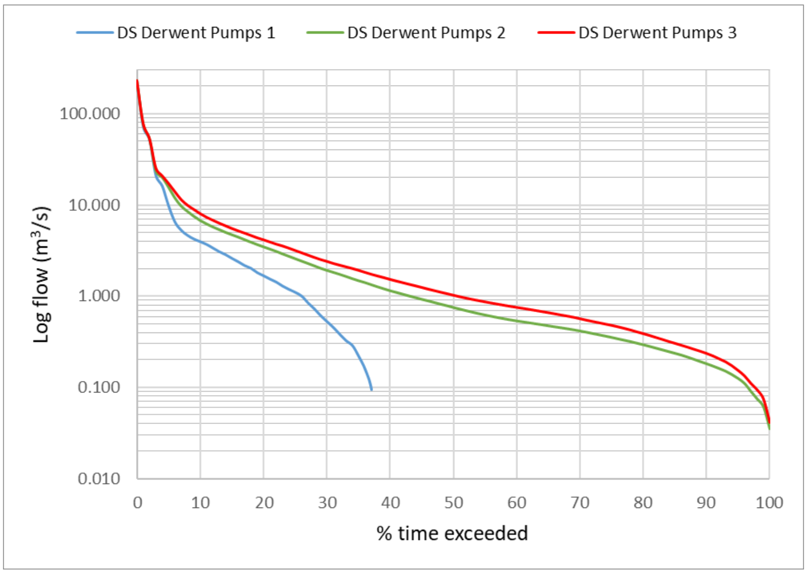

Figure 6.4: Flow duration curve (log) for the River Derwent downstream Derwent Pumps Weir (DS Derwent Pumps 1; DS Derwent Pumps 2 and DS Derwent Pumps 3, 2007 – 2022).

Table 6.3: Flow statistics for the River Derwent directly downstream Derwent Pumps Weir (*DS Derwent Pumps 1*; *DS Derwent Pumps 2* and *DS Derwent Pumps 3*, 2007 - 2021).

Flow regime category	Flow percentile/statistic	DS Derwent Pumps 1 (observed)	DS Derwent Pumps 2 (modelled)	DS Derwent Pumps 3 (modelled)
		m^3/s		
Peak	Maximum flow in record	227	234	233
	Mean annual maximum flow	87	98	100
	Q1	72	78	79
High	Q5	10	16	17
	Q10	4	7	8
Fresh	Q20	1.7	3.5	4.2
	Q30	0.5	1.9	2.4
Median	Q50	0	0.8	1.0
Baseflow	Q80	0	0.3	0.4

6.1.2.4 Counsel River confluence to Wayatinah Lagoon (9 km reach)

This section includes three flow locations (Figure 4.4):

- *DS Derwent Pumps 4* which is directly downstream the Counsel River inflow (modelled data)
- *DS Derwent Pumps 5* which is directly downstream the Beech Creek inflow (modelled data)
- *DS Derwent Pumps 6* which is near the bottom of the reach at the flow gauging site River Derwent Above Nive River' (observed data).

The Counsel River enters the River Derwent approximately 16 km downstream Derwent Pumps Weir and is the largest tributary in the reach between Clark Dam and Wayatinah Lagoon (Figure 4.4). This section begins by comparing flows at *DS Derwent Pumps 4* with that immediately upstream (*DS Derwent Pumps 3*).

Modelling indicates that the Counsel River increased the flow in the River Derwent as follows (refer to Figure 6.5):

- Approximately doubling the baseflow and median flow;
- Increasing the fresh flow regime ~ 63 percent;
- Increasing the high flow regime ~ 40 percent; and
- Increasing the mean annual maximum flow by 16 percent (Table 6.3; Table 6.4).

While the addition of the Counsel River inflows increased the size of the peak flows relative to the site immediately upstream (*DS Derwent Pumps 3*), these large events are mainly derived from dam spill (Figure 8.5).

Beech Creek is the second largest inflow between Clark Dam and Wayatinah Lagoon and flow below Beech Creek (*DS Derwent Pumps 5*) increased the baseflow to high flow regime by 16 to 37 percent, relative to the site immediately upstream (*DS Derwent Pumps 4*), and the mean annual maximum flow by 11 percent (Figure 6.5; Table 6.4). The modelling indicates that peak flows are augmented by the Counsel River and Beech Creek but the largest events are derived mainly from dam spill.

The River Derwent flows for another ~5.5 km to the river gauge site where observed flow data are available (*DS Derwent Pumps 6).* The observed data suggests there is only minor additional pick up from the four unnamed tributaries which enter downstream from Beech Creek (Figure 6.5; Table 6.4).

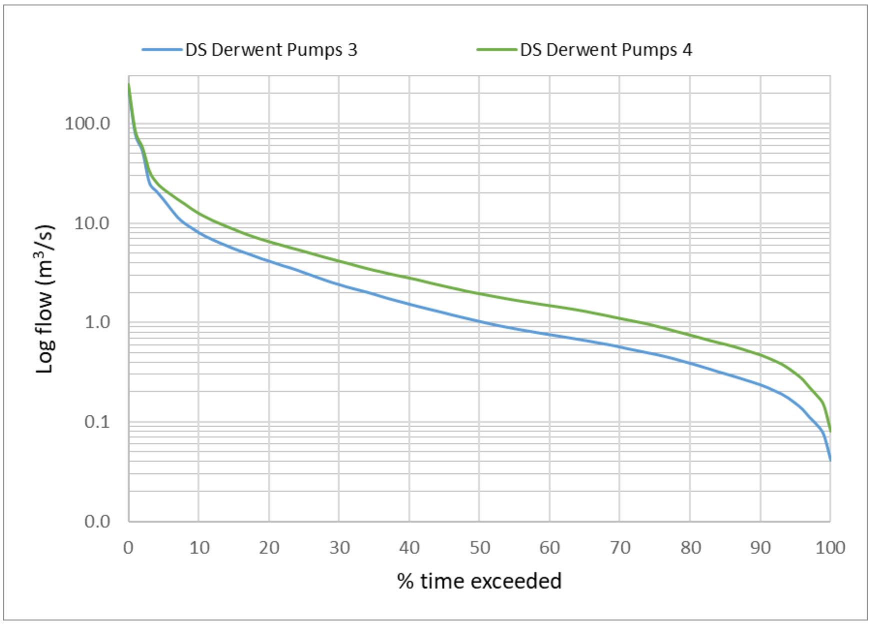

Figure 6.5: Flow duration curve (log) for the River Derwent directly upstream (*DS Derwent Pumps 3*) and downstream of the Counsel River inflow (*DS Derwent Pumps 4*) (2007 – 2022).

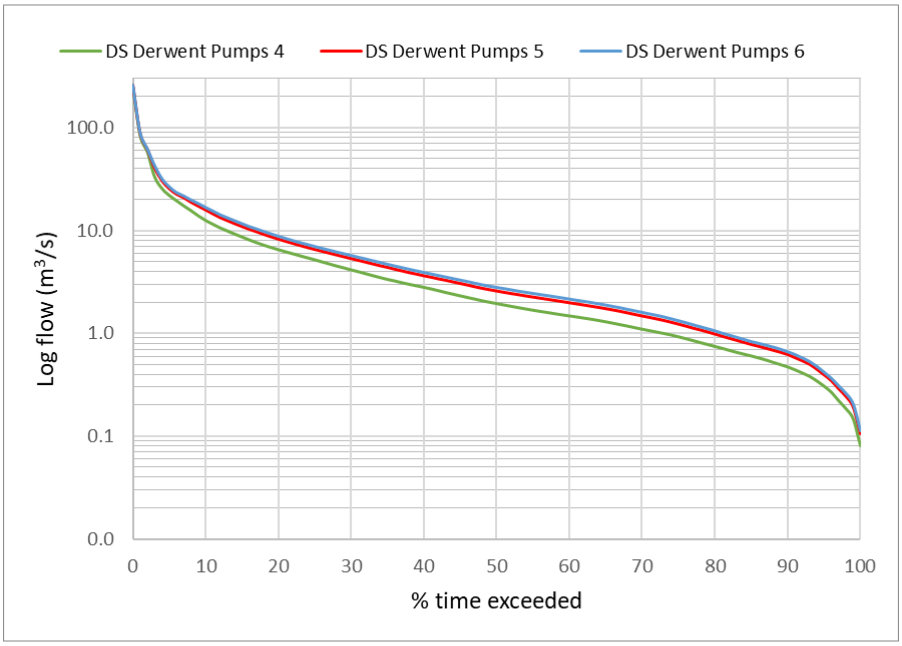

Figure 6.6: Flow duration curve (log) for the River Derwent directly downstream the Counsel River inflow (*DS Derwent Pumps 4*), downstream Beech Creek (*DS Derwent Pumps 5*) and at the Derwent above Nive flow site (*DS Derwent Pumps 6,* observed data) (2007 – 2022).

Table 6.4: Flow statistics for the River Derwent directly downstream the Counsel River inflow (*DS Derwent Pumps 4*) and downstream Beech Creek (*DS Derwent Pumps 5*) and at the Derwent above Nive flow site (*DS Derwent Pumps 6,* observed data) (2007 – 2021).

Flow regime category	**Flow percentile/statistic**	**DS Derwent Pumps 4 (modelled)**	**DS Derwent Pumps 5 (modelled)**	**DS Derwent Pumps 6 (observed)**
		m^3/s		
Peak	Maximum flow in record	247	256	258
	Mean annual maximum flow	116	128	132
	Q1	83	87	89
High	Q5	22	25	27
	Q10	13	16	17
Fresh	Q20	6.5	8.2	8.8
	Q30	4.1	5.30	5.70
Median	Q50	1.9	2.6	2.8
Baseflow	Q80	0.7	0.9	1.1

6.1.3 Fluvial geomorphology

6.1.3.1 Geology and topography

The geology of the River Derwent between Clark Dam and Wayatinah Lagoon is dominated by Jurassic dolerite, with the Derwent valley carved near the western edge of the large dolerite outcrop in Tasmania (Figure 6.7). The River Derwent channel is confined within the dolerite, with higher areas of the catchment developed on Tertiary basalts, Quaternary glacial deposits and Mesozoic Parmeneer Supergroup (PR) glacial and lacustrine deposits. Lake King William was developed in an open, flat floored glacial outwash plain.

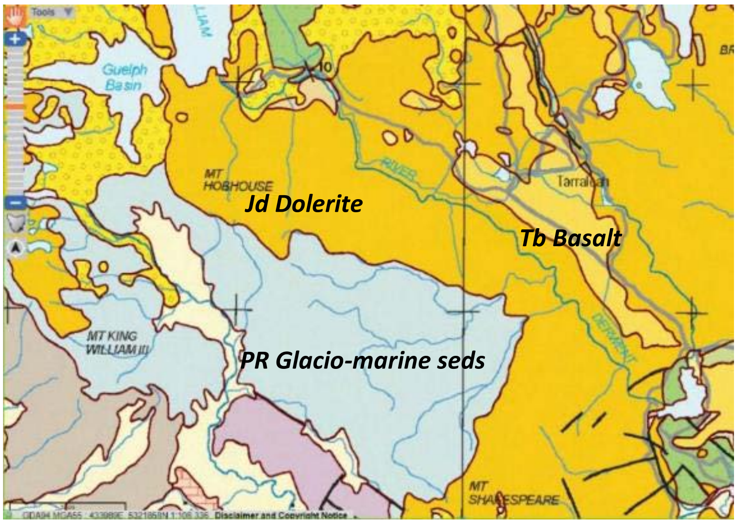

Figure 6.7: Geologic map of the River Derwent between Clark Dam and Wayatinah.

The geology controls the topography of the catchment, with the basalt to the northeast of the Derwent channel occupying the divide between the River Derwent and Nive River, and the softer Mesozoic sediments south and west of the dolerite being dissected by the Counsel River which flows into the River Derwent, and other rivers which flow southward (Figure 6.8). The LiDAR image shows the River Derwent and neighbouring Nive River deeply incised in the dolerite, with the Counsel River downcutting into the softer sedimentary strata.

The slope of the River Derwent reflects the underlying geology of the catchment, with the first 5 km downstream of Clark Dam having a low slope as the river flows through the downstream extent of the flat laying glacial outwash and onto the surface of the dolerite plateau (Figure 6.9 and Figure 6.10). As the river descends and incises through the dolerite, the slope increases, but remains relatively uniform, until the last 5 km upstream of Wayatinah Lagoon, where the slope increases. The Counsel River has a steep headwater area, then flows through a relatively flat laying area before steeply descending and joining the River Derwent. There is a step change in the Counsel River where the tributary leaves the older sedimentary strata and descends into the dolerite, creating cascades (Figure 6.12).

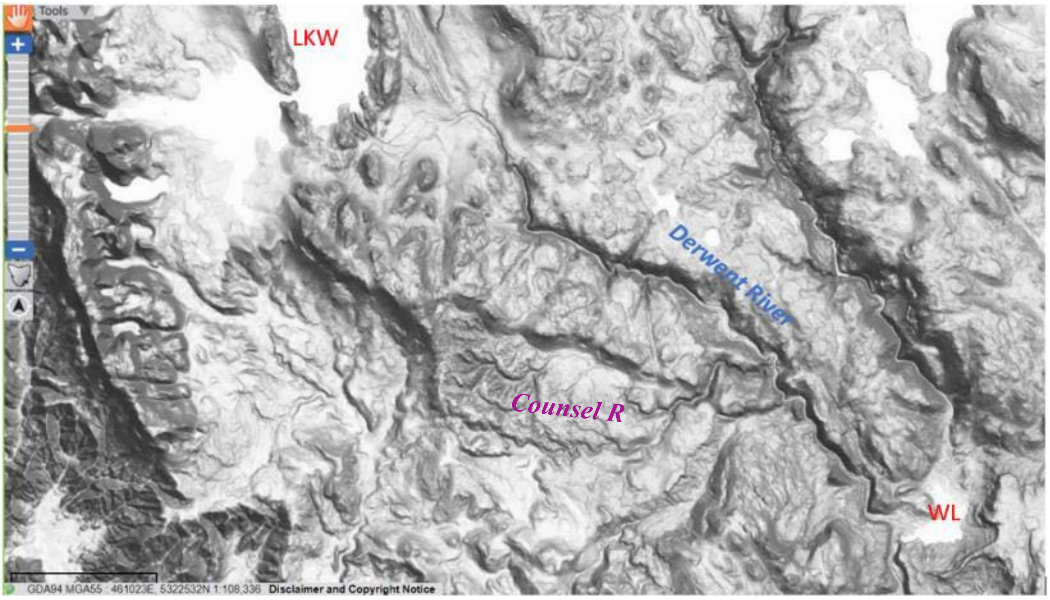

Figure 6.8: LiDAR image of the River Derwent catchment downstream of Clark Dam and upstream of Wayatinah Lagoon (LKW – Lake King William, R – River, WL – Wayatinah Lagoon).

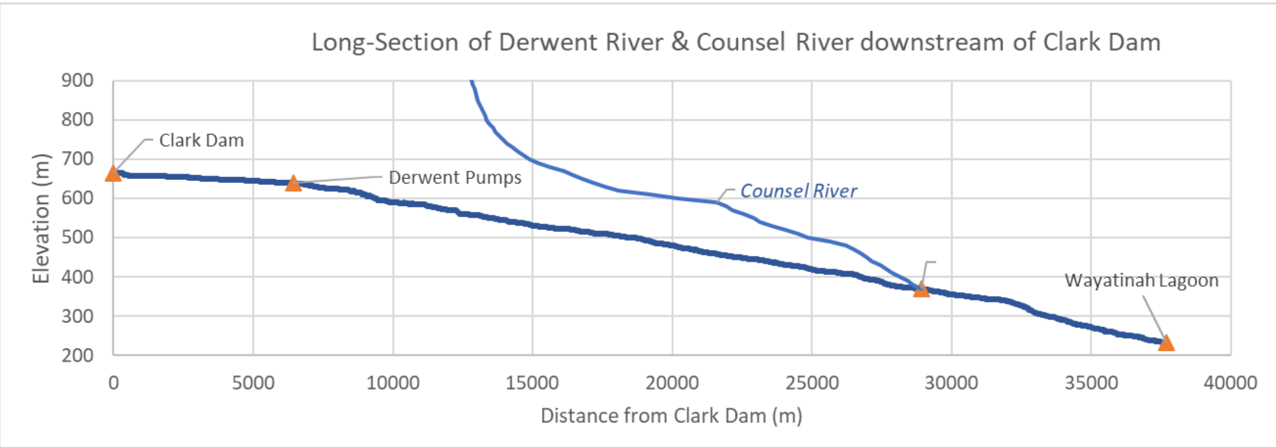

Figure 6.9: Slope of the River Derwent and Counsel River between Clark Dam and Wayatinah Lagoon.

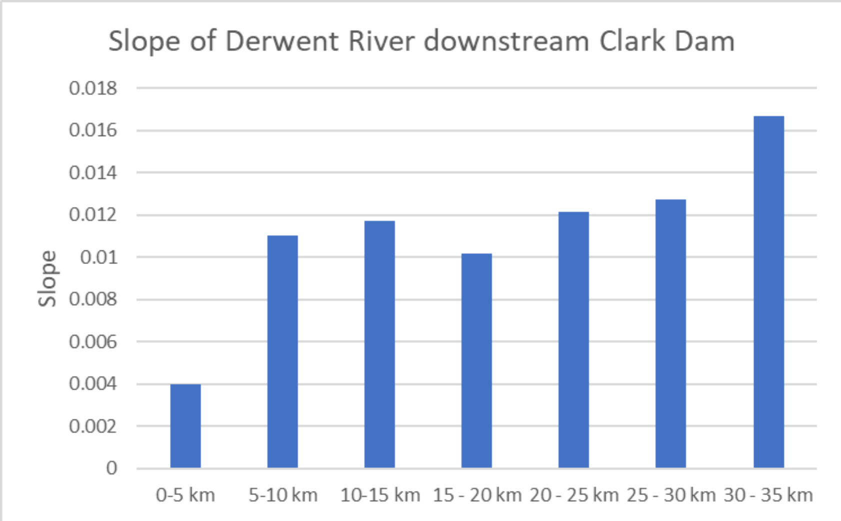

Figure 6.10: Slope of the River Derwent channel in each 5 km reach between Clark Dam and Wayatinah Lagoon.

6.1.3.2 Hydrology

The hydrology of the River Derwent downstream of Clark Dam is described in detail in Section 6.1.2. This section highlights the components of the hydrology that are important for understanding the existing condition of the river.

The River Derwent between Clark Dam and Wayatinah Lagoon has experienced altered flow regimes beginning in 1938 when a portion of the flow was diverted to feed the Tarraleah Power Station. The commissioning of additional turbines from 1943 to 1948 lead to additional flow diversions from the River Derwent. The construction of Clark Dam, Butlers Gorge Power Station, the Tarraleah canals, and Derwent Pumps in 1951 further altered the pattern and volume of flow discharged down the river. The raising of Clark Dam by 6 m in 1964 was the last major construction project affecting the flow regime.

Under current operating conditions, the regulated flow regime promotes the following responses in the river channel:

- Reducing the magnitude of flows downstream promotes channel contraction, as the lower water levels enable establishment of vegetation on the exposed riverbanks.
- Reducing the frequency of high flows further promotes channel contraction, as there are fewer flows that can remove vegetation from the channel and the vegetation has longer to establish between high flow events.
- Limiting the duration of high flows to the period of spill at Clark Dam, along with reducing the duration and magnitude of spills, determines how large a channel is maintained.
- Trapping of sediment in Lake King William reduces sediment supply downstream and the volume of mobile sediment in the river channel, and promotes channel erosion during periods of spill. As is typical for instream dams, the sand available for transport would have been removed during the first few large events following the initial impoundment.
- Reducing the magnitude and frequency of high flows reduces the size and frequency of sediment mobilisation.

The degree that these responses influence the river varies along the length of the River Derwent, as the slope and tributary inputs change. Three zones between Clark Dam and Wayatinah Lagoon are described in more detail in the following sections. Photo locations are shown in Figure 6.11.

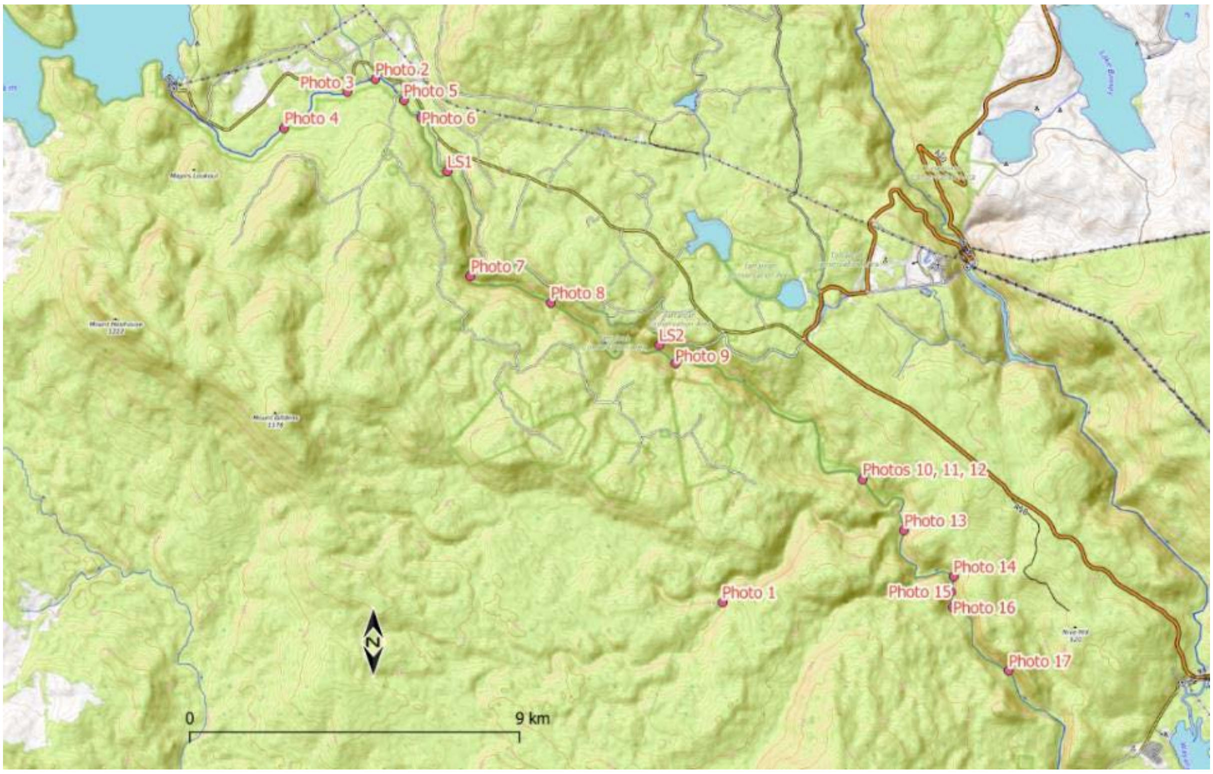

Figure 6.11: Location map for photos presented in Section 3.2.

Figure 6.12: Counsel River flowing from older sedimentary strata into dolerite area. (Photo 1 in Figure 6.11).

6.1.3.3 Clark Dam to Derwent Pumps Weir (Zone 1)

This 6 km river reach is characterised by a low slope as the river flows over the bedrock surface of the dolerite plateau (Figure 6.13). Inflows in this reach are limited to spills from Clark Dam[3], small creeks draining glacial deposits and groundwater. Sediment input to the zone is limited to input from the creeks. Figure 6.13 and Figure 6.14 show the general characteristics of the reach, including the thick vegetation extending to the water's edge. The extent of mid-stream vegetation varies, as can be seen by comparing the images in Figure 6.13. The flat-lying bedrock outcrops in the river do not support vegetation, presumably due to sufficiently frequent inundation to prevent colonisation. In contrast, higher bars support abundant vegetation. Throughout the zone, the forest vegetation extends to the water's edge, with virtually no riparian zone (Figure 6.14).

Figure 6.13: Views of the River Derwent between Clark Dam and Derwent Pumps Weir. Both views are looking upstream (Photos 2 and 3 in Figure 6.11 respectively).

[3] Spill from Clark Dam is defined in this report as; spill through the spillway gates, releases through the regulator valves and discharges from Butlers Gorge Power Station not captured by No. 1 Canal.

Figure 6.14: View facing upstream of River Derwent below Clark Dam in zone 1 (Photo 4 in Figure 6.11)

Aerial photos from 1967 and 2021 of the same reach shown in Figure 6.14 are shown in Figure 6.15. Comparing the photos shows that vegetation has increased on the mid-stream bar, and has extended from the banks into the channel, substantially reducing the size of the active channel.

Figure 6.15: (left) Aerial photo from February 1967 and (right) same location in November 2021. Flow direction is from left to right in the photos (Photo 5 in Figure 6.11).

This zone ends at Derwent Pumps Weir, where water flow is restricted by a weir, and pumped up to No. 2 Canal from the river (Figure 6.16).

Figure 6.16: Derwent Pumps Weir (upstream of bridge) restricts flow, enabling water to be pumped from the river. Flow direction is from top to bottom of photo (Photo 6 in Figure 6.11).

6.1.3.4 Derwent Pumps Weir to confluence with Counsel River (Zone 2)

Zone 2 extends about 16 km from Derwent Pumps Weir to the confluence with the Counsel River. The pumping of water from the River Derwent upstream of the weir results in a dewatered area at the top of this zone (Figure 6.17), with large reaches between pools having no surface flow under base flow conditions (e.g. no spill from Derwent Pumps Weir).

Figure 6.17: Dry channel and pool in dewatered reach downstream of Derwent Pumps Weir. Flow direction is from top to bottom of photo (Photo 7 in Figure 6.11).

The nature of the channel changes through this reach, with an increased presence of dolerite boulders and cobbles (Figure 6.18, Figure 6.19) reflecting the transition of the river off the surface of the dolerite plateau and into the incised reach. Much of the river channel is armoured by the boulders, with the present flow regime insufficient to mobilise the large blocks. Between the boulders, localised deposits of pebbles are present, which are mobile and when excavated, show additional fine material trapped below the surface layer (Figure 6.20). With distance downstream, catchment inflows increase and water flows through the deposits, creating small streams within the larger channel. The vegetation in this reach extends to the water's edge, similar to the upstream zone, with little or no riparian vegetation.

Figure 6.18: River channel between Derwent Pumps Weir and Counsel River, showing increased presence of boulders and cobbles (Photo 8 and 9 in Figure 6.11).

Figure 6.19: Ground view of River Derwent channel showing boulder fields (Photos 10 and 11 in Figure 6.11).

Figure 6.20: Mobile pebbles on lee side of large boulders (Photo 12 in Figure 6.11).

Vegetation in this zone has also encroached down the riverbanks and onto lateral and mid-stream bars in many reaches. Figure 6.21 compares aerial photos from a reach containing two pools showing an increase in vegetation in the 2021 photo as compared to the 1967 view.

Figure 6.21: Aerial photo from February 1967 (left) and from November 2021 (right). Flow direction is from top to bottom in the photos (Photo 13 in Figure 6.11).

Narrow, more confined reaches show less encroachment (Figure 6.22). Although it is difficult to be definitive due to different water levels, it appears that finer material present in the channel in 1967 has been removed by 2021.

Figure 6.22: Comparison of 1967 and 2021 aerial photos of reach downstream of Derwent Pumps Weir and upstream of Counsel River confluence (Photo 14 in Figure 6.11).

The steep dolerite riverbanks are stable throughout the river, with only two substantial landslides observed along this reach of the River Derwent, both occurring within Zone 2. Both landslides are located on an outside bend, so under cutting of thick dolerite-derived soils may be a contributing factor.

The most upstream one (Figure 6.23; LS1 in Figure 6.11), extends from the No. 2 Canal to the river, suggesting the construction of the canal may have contributed to the landslide. The second landslide, located on a very steep bank, does not appear to be related to any infrastructure (Figure 6.23; LS2 in Figure 6.11). The landslides would have delivered a limited amount of sediment to the river, but this does not appear to be an important source of sediment to the river. The landslip scars have been colonised, demonstrating stability in the recent past.

Figure 6.23: (left) Landslip 1 and Landspil 2 (right). Both are on the left bank of the river (LS1 and LS2 in Figure 6.11).

6.1.3.5 Counsel River confluence to Wayatinah Lagoon (Zone 3)

Downstream of the Counsel River confluence to Wayatinah Lagoon (9 km reach), flows are higher and more continuous, resulting in a well-defined active channel, with sufficient flow to occupy multiple channels in some areas (Figure 6.24). Vegetation encroachment has occurred, but the relatively small and discontinuous vegetation on some lateral bars suggests that floods in this zone may periodically remove vegetation, or at least prevent the accumulation of soil on the bars.

Figure 6.24: Views of river channel downstream of the Counsel River. Photos 13 and 15 in Figure 6.11.

In the lower reaches of this zone, the slope is steeper and the river is narrower, resulting in more continuous flow paths. There are fewer exposed boulders and the continuous inflow from the Counsel River results in a well-defined active channel (Figure 6.25).

The boulders and large cobbles appear immobile in this zone, similar to upstream, but pebbles and small cobbles are mobile. Similar to upstream, deposits of smaller material are concentrated on the downstream side of boulders, creating shadow deposits.

Figure 6.25: Photo of the River Derwent approximately 3.5 km upstream of Wayatinah Lagoon, in the steeper section of the river (Photo 17 in Figure 6.11).

Comparisons between 1967 aerial photos and recent Google Earth images from 2019 shows increased vegetation on the bars and banks, similar to the upstream zones. In Figure 6.26 and Figure 6.27, some of the lateral bars present in 1969 are now indistinguishable from the banks.

Figure 6.26: Comparison of aerial photos from (left) 1969 and (right) 2019 from Google Earth (Photo 14 in Figure 6.11).

Figure 6.27: Comparison of aerial photos from (left) 1969 and (right) 2019 from Google Earth (Photo 16 in Figure 6.11).

6.1.3.6 Active geomorphic processes

The River Derwent is highly modified with respect to flow and sediment delivery, but some basic geomorphic functioning of the river continues, especially downstream of the Counsel River where flow is higher and more continuous. Throughout the reach between Clark Dam and Wayatinah Lagoon, channel narrowing is occurring through the encroachment of vegetation. However, there appear to be some processes restricting the rate of encroachment, as exposed banks and bars that are denuded remain and there is a distinct active channel in the river in many reaches. These processes include:

- episodic high flows that are sufficient to remove vegetation, and / or soil that accumulates along the banks of the river.
- a reduction in sediment such that material removed during high flow events is not readily replaced, making the development of substrate suitable for colonisation a slow process and dependent on inputs from terrestrial sources rather than fluvial sources.

Within the river channel, episodic high flows are sufficient to maintain the mobility of pebbles and small cobbles, creating suitable substrate for macroinvertebrate communities. Along the margins of the channels and on the lee side of boulders, these deposits can be exposed and may be suitable for the local colonisation of terrestrial plants.

6.1.4 Aquatic habitats

The hydrological and geomorphic conditions are described in more detail in the preceding sections; however, the flow regime and sediments are also the key processes which drive habitat quality for aquatic species.

The instream habitat exhibits the influence of a reduced flow regime and sediment supply. Large immobile boulders dominate the substrate in the reaches within the TWWHA, although a narrow band of more mobile cobble, pebbles and gravels occurs within the low flow channel and the channel immediately bordering the low flow channel. A reduction in sediment mobility and size classes has a negative impact on aquatic species, particularly macroinvertebrates as it reduces the niches available for colonisation and impacts nutrient dynamics by limiting exchanges between the surface and subsurface of the bed material.

Elevated side and mid channel bars are mainly vegetated by perennial terrestrial plants and lack mobile substrate. The presence of mobile substrate increases progressively downstream due to the supply of flow and sediment from tributaries. As discussed in Section 6.1.3, there is an increase in the flow regime and sediment supply below the Counsel River inflow approximately 16 km downstream from Derwent Pumps Weir.

In the reaches immediately downstream from Derwent Pumps Weir, the channel is mainly dry in the higher gradient sections when there is no spill from Clark Dam, with either zero flow or a narrow-inundated channel (Figure 6.28; Figure 6.29). Lower gradient sections are often inundated close to the channel margins by pool or slow run habitats. The pool and run habitats from Derwent Pumps Weir to the Counsel River inflow had biofilms a few millimetres to several centimetres thick (matrix of algae, bacteria and fungi) covering most of the benthic surfaces on the seven occasions visited for the Project over 2018 to 2022 (Figure 6.30). The biofilms persist because of the infrequent occurrence of scouring high flows. Thick biofilms would affect the macroinvertebrate community that occurs in these habitats by smothering the surfaces where grazers, filter feeders and their predators would typically occur (see below for discussion of macroinvertebrate communities).

Thick biofilms were not observed in the reaches below the Counsel River inflow where the addition of a permanent and higher volume flow regime increased the quantity and quality of the aquatic habitats present. In particular, riffle and fast run habitats are prominent under baseflow condition unlike the reaches upstream of the Counsel inflow (Figure 6.31; Figure 6.32).

Large instream woody debris is generally in low abundance throughout, although occasional fallen trees have been observed in the channel. The low abundance of fine sediments due to trapping behind Clark Dam may limit suitable habitat for aquatic macrophytes, which were scarce during the Project surveys that covered the entire reach downstream from Derwent Pumps Weir.

Figure 6.28: Dry riffle immediately downstream Derwent Pumps Weir, isolated pool in foreground. Terrestrial vegetation, mainly woolly tea-tree, has encroached into the channel margins (January 2019)

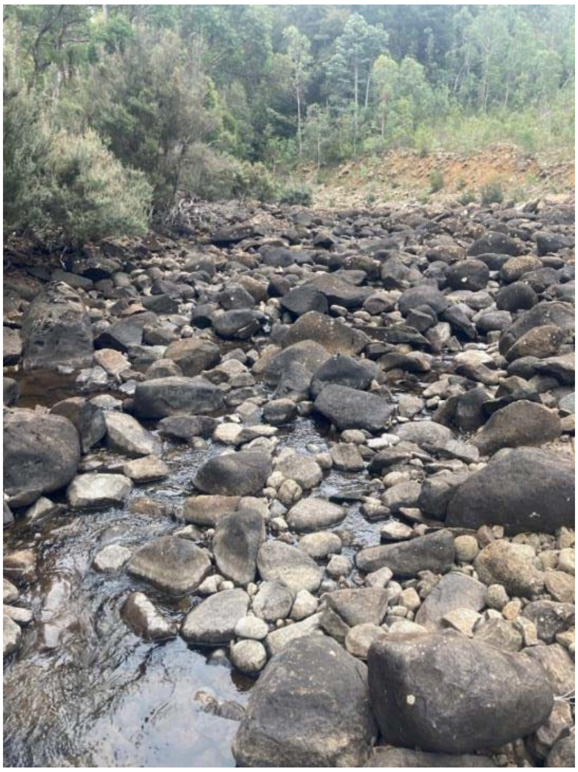

Figure 6.29: Narrow riffle 2.4 km downstream Derwent Pumps Weir (Autumn 2022)

Figure 6.30: Thick biofilms in the lower energy areas of the River Derwent upstream Counsel River (autumn 2022)

Figure 6.31: Riffle habitat improves in the River Derwent immediately downstream Counsel River (autumn 2022)

Figure 6.32: Fast run and riffle habitat in the River Derwent downstream Counsel River (spring 2021)

6.1.5 Macroinvertebrates

A total of 53 taxa were recorded across the five sites in this reach from the 2024 survey with most belonging to the orders, Trichoptera, Plecoptera and Ephemeroptera (Table E.4)[4]. Other orders included Diptera, Coleoptera, Crustacea, Gastropoda and Oligochaeta.

Twenty-four of the species identified are classed as species of conservation significance in Tasmania, mainly because they are endemic to the state, although some are endemic to south-east Australia (Table E.4). Sixteen of the endemic species belong to the Order Trichoptera (caddisflies), six to the Order Plecoptera (stoneflies), with a single species of Coleopteran (beetles) and Odonata (dragonflies). Species in the Order Ephemeroptera were also common, but the taxonomy of this group has not been well studied in Tasmania and most remain as type species.

Only once of the species recorded is classed have a restricted distribution in Tasmania, the cadis fly species *Costora luxata.* The assessment of this species as having a restricted distribution seems out of date as it has been recorded in approximately 20 different locations from the north-west to south-west of the state.

In 2024, the diversity of taxa increased with distance downstream from Clark Dam, particularly for the two sites downstream of the Counsel River. For example, the site at the bottom of the reach had nearly twice as many taxa (32) as the site a short distance downstream Clark Dam (17). The surveys undertaken

[4] The species composition is highly likely to be consistent over time, but species identifications will continue to be undertaken as the monitoring program continues.

prior to 2024 were only identified to family level but the same pattern of increasing diversity with distance downstream has been observed on all sampling occasions.

The raw data is provided in Appendix E.

6.1.5.1 AusRivAS river health condition assessment

Consistent with the assessment of habitat condition through this reach (Section 6.1.4), river health scores improved with distance downstream from Clark Dam, particularly for the two sites downstream of the Counsel River confluence which were assessed as more diverse than reference (band X) and had the highest overall family diversity (Table 6.5). Improvements in river health scores with distance downstream is highly likely caused by reintroduction of important elements of the flow regime with increasing tributary inflows and increased availability of finer mobile sediments washed in from tributaries (in particularly the Counsel River and Beech Creek).

It is likely that several consecutive months of low flows prior to sampling in autumn 2022 contributed to the drop in riffle river health scores compared to spring 2021 and spring 2018. Slow water/edge habitats are the dominant habitats present in this reach and the low scores from the Observed/Expected (O/Epa) presence/absence edge models support visual observations that these habitats are in poor condition.

The results at specific sites are provided below.

Clark Dam to Derwent Pumps Weir (Geomorphic Zone 1)

The survey site in Geomorphic Zone 1 is approximately 1.6 km downstream Clark Dam (Figure 4.6). In spring 2018, the riffle habitat was assessed as band A (equivalent to reference) for the O/Epa and O/Erk models (Table 6.5). The riffle site was again assessed as band A in spring 2021 for both models Table 6.6); however, the autumn 2022 scores fell into band B (significantly impaired) for both models and for the combined season O/Erk model (Table 6.6). The combined season O/Epa model for 2021/22 was band A (Table 6.6).

Edge sampling was also undertaken in 2021/22 and indicated severely degraded condition (band C) in spring 2021 and significantly impaired condition (band B) in autumn 2022 and for the combined season model for 2021/22 (Table 6.7).

Derwent Pumps Weir to confluence with Counsel River (Geomorphic Zone 2)

There are two sampling sites in Geomorphic Zone 2 with one approximately 2.5 km downstream Derwent Pumps Weir and ~8.5 km downstream from Clark Dam, and the other approximately 16 km downstream of Derwent Pumps Weir and ~100 m upstream of the Counsel River confluence (Figure 4.6).

In spring 2018 and spring 2021, the riffle habitat was assessed as band A (equivalent to reference) for the O/Epa and Observed/Expected rank abundance (O/Erk) models at both sites (Table 6.5, Table 6.6). However, the autumn 2022 scores fell into the significantly impaired category (band B) for both models (Table 6.6). Despite the lower autumn scores, the combined 2021/22 season scores were band A for both models (Table 6.6).

Edge sampling in 2021/21 at the site 2.4 km downstream Derwent Pumps Weir indicated significantly impaired condition (band B) for the spring 2021, autumn 2022 and combined season O/Epa models (Table 6.6). At the site immediately (~100 m) upstream of the Counsel River confluence, edge sampling fell into the significantly impaired category (band B) in spring 2021 and declined further to the severely impaired category (band C) in autumn 2022 and for the combined season model (Table 6.7).

Counsel River confluence to Wayatinah Lagoon (Geomorphic Zone 3)

There are two sampling sites in Geomorphic Zone 3 with one immediately (~50 m) downstream the Counsel River inflow and the other approximately 7.5 km downstream of the Counsel River inflow, 23.5 km downstream Derwent Pumps Weir and ~1.5 km upstream of Wayatinah Lagoon (Figure 4.6). In addition to the two sites in the River Derwent, the unregulated Counsel River was also sampled in 2018, 2021 and 2022, approximately ~150 m upstream of its confluence with the River Derwent.

In spring 2018 and 2021, the riffle habitat at the site immediately (~50 m) downstream the Counsel River was assessed as more diverse than reference (band X) (Table 6.5, Table 6.6). This site was assessed as equivalent to reference (band A) in autumn 2022 and for the 2021/22 combined season models (Table 6.6).

The site at the bottom of the reach (River Derwent ~1.5 km upstream of Wayatinah Lagoon) has previously been sampled on 12 occasions from 2008 to 2017 (site historically known as *Derwent River above Nive River*) and was assessed as equivalent to reference (band A) or more diverse than reference (band X) on each occasion and for every model except the O/Epa and O/Erk combined season model in 2010 which fell into the significantly impaired category (band B) (Figure 6.33; Figure 6.34). The results of the 2018 and the 2021/22 surveys undertaken for the Project were also indicative of the good river health scores previously reported for this site with more diverse than reference scores (band X) or equivalent to reference (band A) for all models and dates (Table 6.5; Table 6.6; Figure 6.33; Figure 6.34).

Edge sampling was not conducted in this reach as riffle habitat is more common than upstream the Counsel River inflow and better represents the habitats present; however, future surveys will include edge sampling in this reach.

In spring 2018, the riffle habitat at the Counsel River reference site was assessed as more diverse than reference (band X) for the O/Epa model and equivalent to reference (band A) for the O/Erk model (Table 6.5). This site was assessed as band X in spring 2021 and band A for autumn 2022 and combined 2021/22 O/Epa models (Table 6.6). The O/Erk models reported band A condition for spring 2021 and autumn 2022 models and band X for the combined 2021/22 model (Table 6.6).

Table 6.5: AusRivAS Presence/Absence (O/Epa) model and Rank abundance model (O/Erk) observed over expected scores, AusRivAS condition band and number of taxa present in the model for the surveys conducted in spring 2018

Site	Presence/Absence (O/Epa)			Rank abundance model (O/Erk)		
	O/E	Band	Taxa in model	O/E	Band	Taxa in model
Reference site						
Counsel River ~150 m upstream of junction with River Derwent	1.18	X	24	1.11	A	24
Regulated sites						
River Derwent downstream Clark Dam to Wayatinah Lagoon						
River Derwent ~1.6 km downstream of Clark Dam	1.01	A	23	0.90	A	23
River Derwent ~2.5 km downstream of Derwent Pumps Weir	1.11	A	23	1.13	A	23
River Derwent ~100 m upstream of Counsel River	1.08	A	19	1.03	A	19
River Derwent ~50 m downstream of Counsel River	1.20	X	25	1.25	X	25
River Derwent ~ 2 km upstream of Wayatinah Lagoon	1.27	X	27	1.27	X	27
River Derwent downstream Wayatinah Lagoon to Lake Catagunya						
River Derwent ~500 m downstream of Wayatinah Lagoon	1.05	A	20	0.87	A	20
Nive River downstream Liapootah Dam to Wayatinah Lagoon						
Nive River ~1 km downstream of Liapootah Dam	0.71	B	15	0.62	B	15
Nive River ~200 m upstream of Lyell Highway	0.54	B	17	0.43	B	17

Table 6.6: Presence absence (O/Epa) and Rank abundance (O/Erk) river health scores and bands for spring 2021, autumn 2022 and combined season 2021/22 HT regional models

Site	Presence absence (O/Epa)			Rank abundance (O/Erk)		
	Spring O/E (Band)	Autumn O/E (Band)	Comb O/E (Band)	Spring O/E (Band)	Autumn O/E (Band)	Comb O/E (Band)
Reference site						
Counsel River ~150 m upstream of junction with River Derwent	1.18 (X)	1.03 (A)	1.01 (A)	1.13 (A)	0.95 (A)	1.24 (X)
Regulated sites						
River Derwent downstream Clarke Dam to Wayatinah Lagoon						
River Derwent ~1.6 km downstream of Clark Dam	1.02 (A)	0.83 (B)	0.94 (A)	1.02 (A)	0.66 (B)	0.77 (B)
River Derwent ~2.5 km downstream of Derwent Pumps Weir	0.91 (A)	0.78 (B)	1.09 (A)	1.04 (A)	0.64 (B)	0.87 A)
River Derwent ~100 m upstream of Counsel River	1.19 (X)	0.90 (A)	0.97 (A)	1.13 (A)	0.76 (B)	0.69 (B)
River Derwent ~50 m downstream of Counsel River	1.44 (X)	1.03 (A)	0.90 (A)	1.51 (X)	0.97 (A)	1.03 (A)
River Derwent ~ 2 km upstream of Wayatinah Lagoon	1.38 (X)	1.03 (A)	0.94 (A)	1.47 (X)	1.29 (X)	0.94 (A)
Nive River downstream Liapootah Dam to Wayatinah Lagoon						
Nive River ~200 m upstream of Lyell Highway	0.27 (C)	1.03 (A)	0.93 (A)	0.36 (B)	0.90 (A)	0.59 (B)
River Derwent downstream Wayatinah Lagoon to Lake Catagunya						
River Derwent ~500 m downstream of Wayatinah Lagoon	0.97 (A)	0.65 (B)	0.96 (A)	1.00 (A)	0.65 (B)	0.67 (B)

Table 6.7: State-wide edge O/Epa scores and bands for spring 2021, autumn 2022 and combined season 2021/22 models

Sites	Spring		Autumn		Combined season	
	O/E	Band	O/E	Band	O/E	Band
Regulated sites						
River Derwent downstream Clarke Dam to Wayatinah Lagoon						
River Derwent ~1.6 km downstream of Clark Dam	0.31	C	0.59	B	0.71	B
River Derwent ~2.5 km downstream of Derwent Pumps Weir	0.49	B	0.96	A	0.81	B
River Derwent ~100 m upstream of Counsel River	0.78	B	0.5	C	0.51	C
Nive River downstream Liapootah Dam to Wayatinah Lagoon						
Nive River ~200 m upstream of Lyell Highway	0.74	B	0.64	B	0.71	B
River Derwent downstream Wayatinah Lagoon to Lake Catagunya						
River Derwent ~500 m downstream of Wayatinah Lagoon	0.63	B	0.64	B	0.68	B

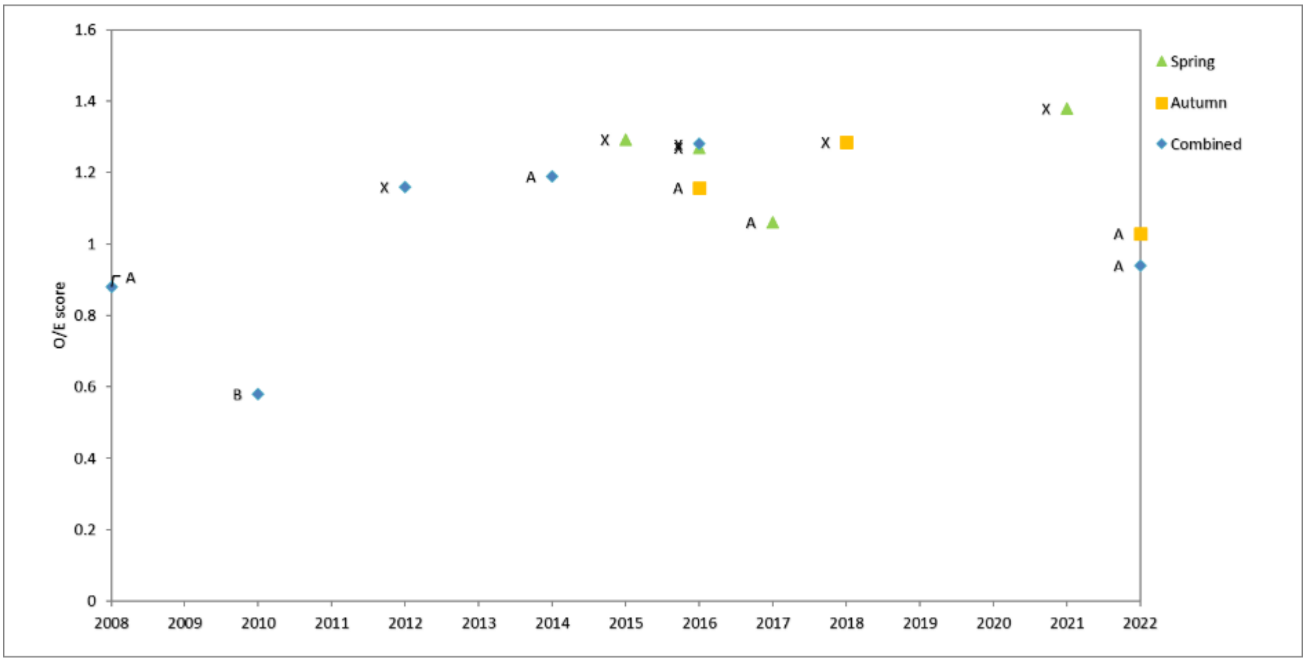

Figure 6.33: Presence absence (O/Epa) river health scores recorded for the site River Derwent ~1.5 km upstream of Wayatinah Lagoon in Geomorphic Zone 3 since 2008

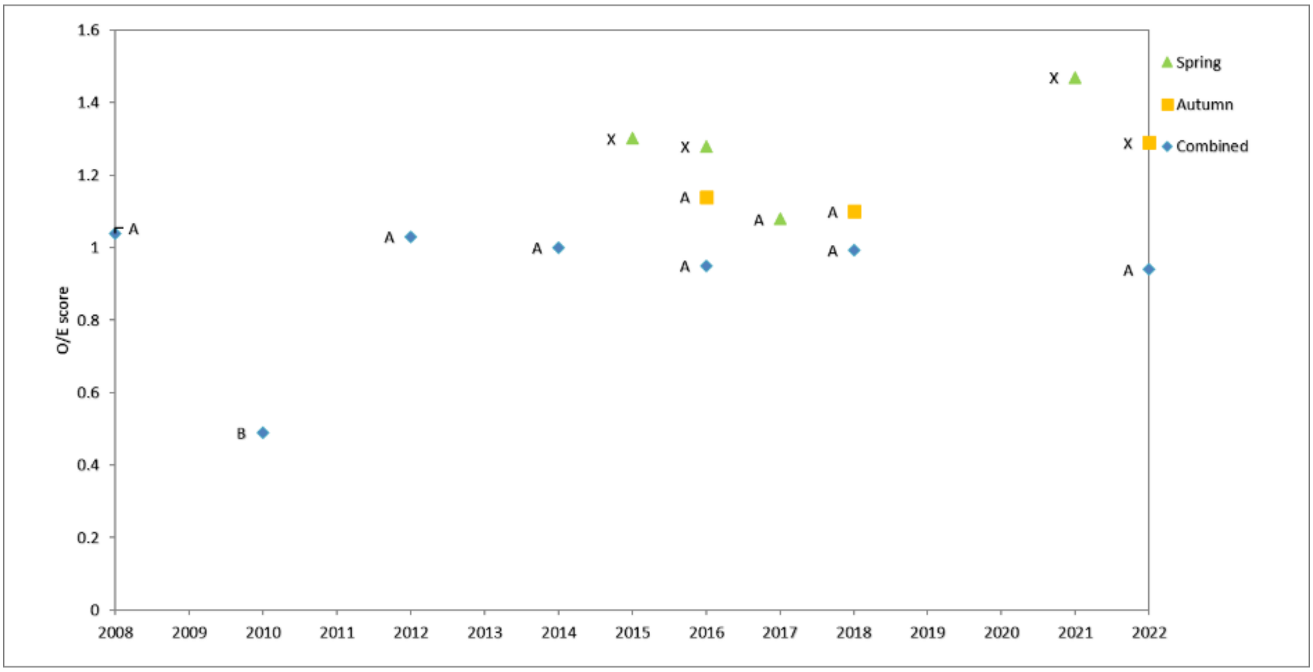

Figure 6.34: Rank abundance (O/Erk) river health scores recorded for the site River Derwent ~1.5 km upstream of Wayatinah Lagoon in Geomorphic Zone 3 since 2008

6.1.6 Fish

The diversity of native riverine fish in Tasmania is limited upstream of large instream dams because most are obligatory migratory species, needing free access to and from the marine to freshwater environment to complete their life histories.

Another major factor which limits the presence and abundance of native freshwater fish species in Tasmania is predation and competition by introduced trout which are extremely widespread in riverine and lake habitats throughout most regions of the state.

Fish diversity was very low across all survey reaches with nearly all the fish captured being introduced brown or rainbow trout (*Salmo trutta* and *Oncorhynchus mykiss*) which are stocked in the Derwent lakes and would have self-sustaining populations by spawning in rivers and tributary streams. Introduced brown or rainbow trout were the only species common to all sites (Table 6.8; Figure 6.35). The abundance of trout declined progressively upstream in the River Derwent from Wayatinah Lagoon to Clark Dam. This observation is consistent with the decreasing habitat quality with proximity to Clark Dam as a result of flow regulation.

Wayatinah Lagoon is known to contain the pest fish redfin perch (*Perca fluviatilis*), which were recorded during the Project surveys in the lower reaches of the Nive River a short distance upstream from its entry into the lagoon. Redfin perch are also highly likely to be present in the River Derwent downstream of the Saltas offtake weir which is located approximately one kilometre upstream from Wayatinah Lagoon. Redfin perch were not recorded upstream of the Saltas Weir and it is not known if the weir provides a partial or permanent barrier to this species.

There are five large dams on the River Derwent downstream of Wayatinah Lagoon that limits the native species which could be present. The River Derwent in the TWWHA (between Derwent Pumps Weir and Wayatinah Lagoon) marks the higher energy, middle and upper portion of the catchment and therefore native fish species which can be common in lowland, lower energy reaches may never have occurred in the higher energy reaches of this reach. However, this is speculative in the absence of survey information prior to the establishment of instream dams on the River Derwent.

No native fish species were recorded in any of the reaches other than a single eel (*Anguilla australis*) which was captured at the most upstream site in the River Derwent downstream of Clark Dam. Eels have occasionally been stocked into the Derwent catchment with the most recent stocking occurring in Lake King William in 1995-96 and Wayatinah Lagoon in 1999 (John Diggle IFS, personal communication). Eels cannot breed within these storages as adults are catadromous and need to migrate to and from the sea to complete their life cycle.

No other native fish were recorded and the only native species with any likelihood of being present are the climbing galaxias (*Galaxias brevipinnis*) and spotted galaxias (*Galaxias truttaceus*) as these species can form self-sustaining land-locked populations upstream of dams. There are three historical records of *G. brevipinnis* in the waterbodies associated with the Project: a record from 1965 and 1966 in the River Derwent approximately 1.4 km downstream from Clark Dam and a record from Mossy Marsh Pond in 1961. There is also a single record from Lake King William in 1960. It is possible that this species is no longer present given the age of these records and the absence of this species from the 2018 fish surveys. There are no historical records of *G. truttaceus* from the area. Introduced trout are known to outcompete and predate on native fish species and their presence may have eliminated *G. brevipinnis* and *G. truttaceus* from the area; however, further survey effort would be required to confirm this.

Overall, the surveys in the River Derwent and Nive River in 2018 suggest that the study reaches have either very low populations of self-sustaining native fish species, or that they are absent.

Table 6.8: Fish species recorded during the surveys.

Site	Species			
	Brown trout	*Rainbow trout*	*Short-finned eel*	*Redfin perch*
Riverine				
River Derwent downstream Clarke Dam to Wayatinah Lagoon				
River Derwent ~1.6 km downstream of Clark Dam	✓	✓	✓	
River Derwent ~2.5 km downstream of Derwent Pumps Weir	✓	✓		
River Derwent ~100 m upstream of Counsel River	✓	✓		
Counsel River ~150 m upstream of junction with River Derwent	✓			
River Derwent ~50 m downstream of Counsel River	✓	✓		
River Derwent ~ 2 km upstream of Wayatinah Lagoon	✓			
Nive River downstream Liapootah Dam to Wayatinah Lagoon				
Nive River ~1 km downstream of Liapootah Dam	✓			
Nive River ~200 m upstream of Lyell Highway	✓		✓	✓
River Derwent downstream Wayatinah Lagoon to Lake Catagunya				
River Derwent ~500 m downstream of Wayatinah Lagoon	✓			
Artificial ponds				
Mossy Marsh Pond	✓			
No.2 Pond			✓	

Figure 6.35: Introduced brown trout are the most common fish present in the Derwent and Nive rivers.

6.1.7 Riparian vegetation

At the upstream end of where the River Derwent enters the TWWHA, it flows through dry forest namely *Eucalyptus pauciflora* forest and woodland on dolerite (DPD). However, most of the section of river within the TWWHA flows through wet forest and rainforest communities including *Eucalyptus delegatensis* forest with broad-leaf shrubs (WDB), *Eucalyptus delegatensis* forest over rainforest (WDR) and *Nothofagus* - *Atherosperma* rainforest (RMT). In the lower section of the river, the dominant eucalypt species changes from *Eucalyptus delegatensis* to *E. obliqua* and forms *Eucalyptus obliqua* forest over rainforest (WOR).

There is no obvious strip of riparian vegetation along the River Derwent in the TWWHA with the surrounding forest continuing down to the river's edge. However, the reduced flow regime has allowed native vegetation to encroach into riverbed. The encroaching species are predominately woody shrubs and trees including *Pomaderris apetala* (dogwood), *Eucryphia lucida* (leatherwood) *Leptospermum lanigerum* (woolly tea-tree), *Acacia melanoxylon* (blackwood), *Acacia mucronata* (caterpillar wattle) and *Atherosperma moschatum* (sassafras).

While there are historical records of the MNES riparian plant species *Barbarea australis* in the River Derwent from just upstream of Wayatinah Lagoon, *B. australis* was not recorded during the targeted surveys within this reach (Table 6.9). Further detail on records and habitat for *B. australis* in the TWWHA is provided in Section 6.5.

Three other, non-water dependent, threatened flora species listed under the TSP Act were recorded within the riparian area of the River Derwent during surveys for *Barbarea australis*: *Westringia* *angustifolia* (narrowleaf westringia), (*Muehlenbeckia axillaris* (matted lignum) and *Pherosphaera hookeriana* (Mount Mawson Pine).

- *Westringia angustifolia* (narrowleaf westringia) is listed as rare under the TSP Act and was recorded at three locations along the River Derwent comprising one plant at each location. This species is often found growing in open, disturbed habitats.
- *Muehlenbeckia axillaris* (matted lignum) was recorded at one location along the River Derwent between Clark Dam and Wayatinah Lagoon. *Muehlenbeckia axillaris* is listed as rare under the TSP Act. This species if often found growing between boulders and on cobble banks on the river edge – it is not intrinsically linked to flow regimes but appears to be a poor competitor and needs open ground to establish.
- A small population of 11 plants of *Pherosphaera hookeriana* (Mount Mawson pine) was also recorded along a bank in a single location. *Pherosphaera hookeriana* is a small conifer endemic to Tasmania and listed as vulnerable under the TSP Act. This species grows in woodland, heath and scrub, typically in areas near water courses and water bodies (Threatened Species Section 2025).

The occurrences *Muehlenbeckia axillaris* (matted lignum), *Pherosphaera hookeriana* (Mount Mawson Pine), and the three *Westringia angustifolia* (narrowleaf westringia) plants on the River Derwent are associated with the operations of the of the proposed Tarraleah Redevelopment.

6.1.8 Other aquatic values

A summary of the aquatic values associated with the River Derwent downstream of Clark Dam to Wayatinah Lagoon is provided in Table 6.9. In addition to the aquatic values described above, there are two other known values: *Astacopsis tricornis* and Platypus. The native freshwater crayfish *Astacopsis tricornis* was recorded in the River Derwent between Clark Dam and Wayatinah Lagoon, with most observations downstream the Counsel River inflow.

Platypus (*Ornithorhynchus anatinus*) scats were recorded from two locations in the River Derwent downstream Clark Dam (approximately 5 km upstream from Counsel River inflow) during the surveys for *Barbarea australis*. There are historic observations of platypus from Wayatinah Lagoon and No. 2 Pond, and it is likely that this species is common throughout the Project area.

Table 6.9: Water dependent ecological values associated with the River Derwent downstream Clark Dam to Wayatinah Lagoon

Value	Existing condition	Comments
Barbarea australis (native winter cress) Threatened species (TSP and EPBC Acts)	Not found, presence uncertain, suitable habitat is present in low abundance	None recorded. In low abundance if present but tends to be in low abundance throughout its range. There is one historical record from 2000 and 2001 at the bottom of this reach. Suitable habitat is present; mainly as small patches of mobile gravels to small cobbles. Large side and mid-channel bars are mostly unsuitable as the substrate has become armoured and embedded by terrestrial plants. The best habitat is downstream of the Counsel River inflow.
Aquatic macroinvertebrates	Good in riffle habitats throughout, but likely very poor in slack water habitats in the middle to upper reaches	Upstream of the Counsel River inflow, the riffle communities vary between good and significantly impaired river health scores, but riffles are rare in the higher reaches. Slack water habitats appear degraded and edge sampling in 2021/22 assessed the condition as significantly to severely impaired. River health improves downstream of the Counsel River inflow and river health scores are equivalent to reference or better.
Native fish	Depauperate native community, potential absent other than stocked eels (*Anguilla australis)* from Wayatinah Lagoon or Lake King William	Limited to vagrant eels during surveys, *Galaxias brevipinnis* and *G. truttaceus* may be present given historic records from the 1960s, but none were recorded during the surveys. The presence of dams downstream, regulated flow regime and introduced predatory trout may have eliminated native fish populations in this reach.
Aquatic macrophytes	Scarce	Unsuitable habitat. Little accumulated fine sediment in slack water habitats to provide habitat which is probably in part due to sediment starvation caused by regulation.
Astacopsis tricornis (native crayfish)	Good in lower reaches, probably poor habitat in upper reaches	Appeared abundant in lower reaches, and were recorded in the reaches immediately upstream the Counsel River inflow
Platypus	Present	Good habitat in reaches downstream the Counsel River inflow, however, scat also recorded in the reaches upstream the Counsel River inflow.

6.2 River Derwent downstream Wayatinah Lagoon

6.2.1 Summary

Wayatinah Lagoon, a hydropower storage formed by Wayatinah Dam, is supplied by the River Derwent, the Nive River, and discharge from Liapootah Power Station. Most of the water in Wayatinah Lagoon is diverted to the Wayatinah Power Station which discharges directly into the next hydropower storage downstream (Lake Catagunya). Water in excess of the lagoons FSL spills into the original channel of the River Derwent which is present as a 6 km reach between Wayatinah Lagoon and Catagunya Lagoon (Figure 1.2).

The catchment below the dam is narrow with minor tributary inflows in the 6 km reach, including Robinson Creek, entering approximately 2.5 km downstream from the dam. There is also a minor leakage from the dam; however, no baseflow releases are provided. The large flow events that occur in this reach are derived entirely from spill events. The riparian zone is vegetated with wet eucalypt forest on both banks (WDB and WOU; TASVEG 4.0).

6.2.2 Flow regime

Wayatinah Dam was commissioned in 1957 and diverts all the flow (except spills) of the River Derwent and Nive River to Wayatinah Power Station. This section is limited to a discussion of dam spill. Modelling of tributary pick-up below Wayatinah Dam was not undertaken because only a low baseflow is present from dam leakage and minor tributary pick up through this narrow catchment. In the absence of an observed record, to allow calibration of the model, accurately modelling small sub catchments flows is difficult. Also, operation of the Project will not impact the local pickup flow contribution or the contribution of dam leakage.

However, observations made over several summers indicate that the combination of dam leakage and tributary inflows provides a permanent baseflow with sections of riffle continuing to flow after several months of minimal rainfall. Based on field observation, the baseflow during dry periods is likely to be ~ ≤ 5 l/s.

Under current operation, Wayatinah Dam spills into the river approximately 15 percent of the time, ranging from one cumec (1 m^3/s) to the largest recorded spill event of 608 m^3/s (Figure 6.36); however, spills between 200 and 350 m^3/s occur in most years. The dam has recorded spill in all months, but most occur between May and October and large spills (~≥ 50 m^3/s) mainly occur between July and October (Appendix D.5).

Spill occurred every year from 2007 to 2022 and the annual maximum flow ranged from 40 to 608 m^3/s. The mean annual maximum flow was 230 m^3/s and the median annual maximum flow was 154 m^3/s. Excluding the 608 m^3/s event, the mean annual maximum flow was 205 m^3/s.

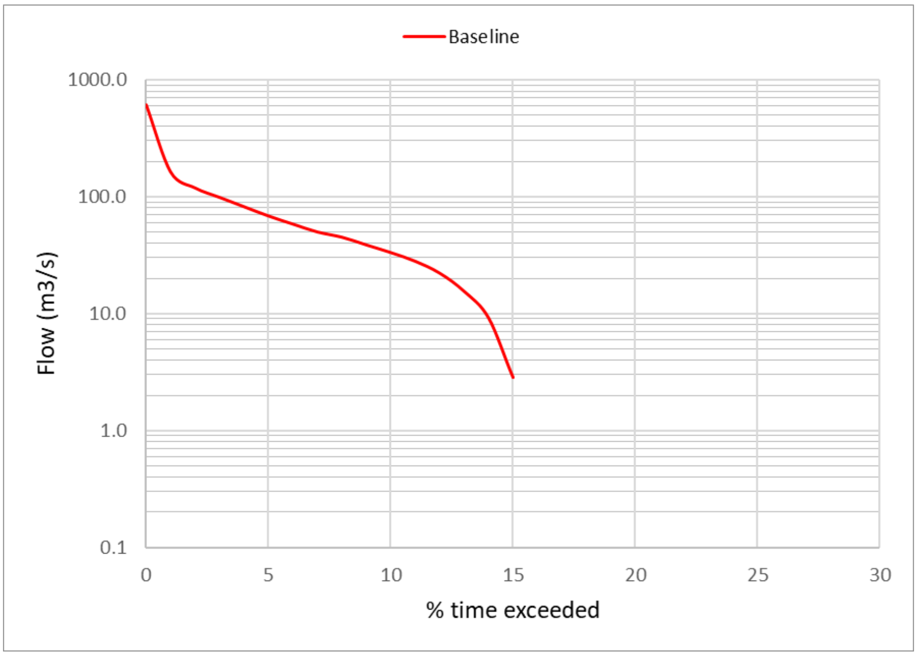

Figure 6.36: Flow duration curve (log) for spill into the River Derwent downstream Wayatinah Dam (2007 to 2022).

6.2.3 Fluvial geomorphology

Both the Nive River downstream of Liapootah Dam and the River Derwent downstream of Lake King William flow into Wayatinah Lagoon. The lagoon serves as the head pond for the Wayatinah power station, with water directed down a tunnel to the power station located at the head of Lake Catagunya (Figure 6.37). This configuration results in no inflow to the River Derwent downstream of Wayatinah Lagoon for extended periods. Spill occurs when inflows to the lagoon exceed the storage capacity of the lagoon and generating capacity of the Wayatinah Power Station. Under current operation, Wayatinah Dam spills for approximately 15 percent of the time (Section 6.2.2).

The approximately 6-km river reach between Wayatinah Lagoon and Lake Catagunya flows in a generally southerly direction. The Florentine River, which is not regulated, joins the River Derwent just upstream of Lake Catagunya. The Derwent is underlain by dolerite and the channel is bedrock confined. The channel is wider as compared to the upstream Nive or Derwent (Figure 6.37, Figure 6.38) which is attributable to this reach historically receiving input from both of these major rivers. The Derwent below Wayatinah falls approximately 70 m over the 6-kilometre reach to Lake Catagunya, with the highest slope occurring immediately downstream of Wayatinah Lagoon (Figure 6.39). Tributary inflows occur from the west, with drainage lines aligning with fault lines.

Some of the surrounding catchment of the River Derwent downstream of Wayatinah has been utilised for forestry plantation, and commercial fish hatchery has been developed on the Florentine River just upstream of Lake Catagunya (Figure 6.38).

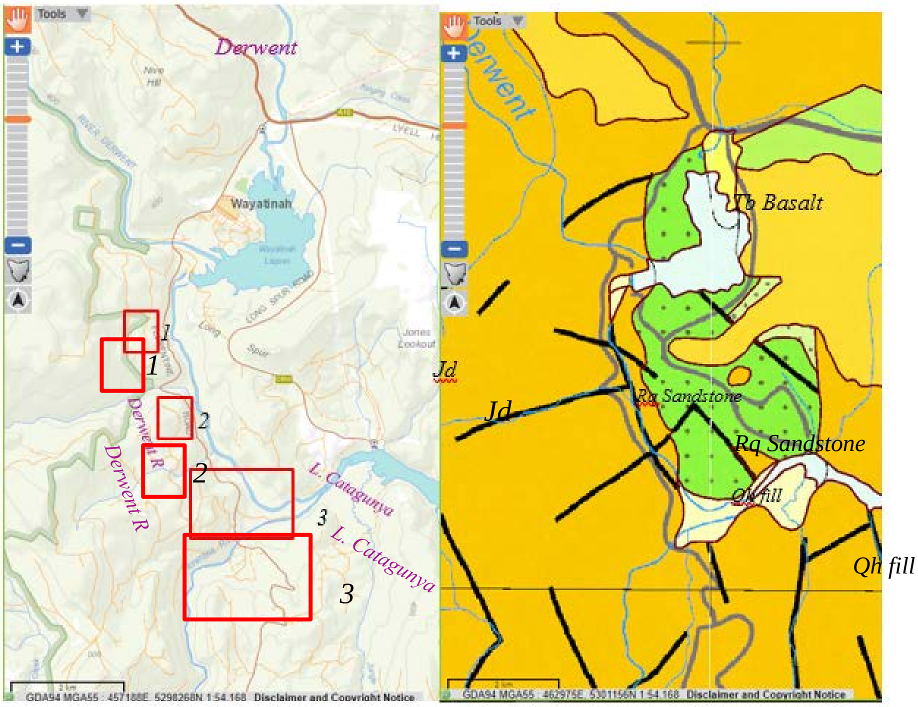

Figure 6.37: (left)Topographic map showing the River Derwent downstream of Lake King William, the Nive River, Wayatinah Lagoon, the River Derwent downstream of Wayatinah Lagoon, and Lake Catagunya. The flow in the waterways is from north to south (top to bottom of map (right) geologic map of the same area.

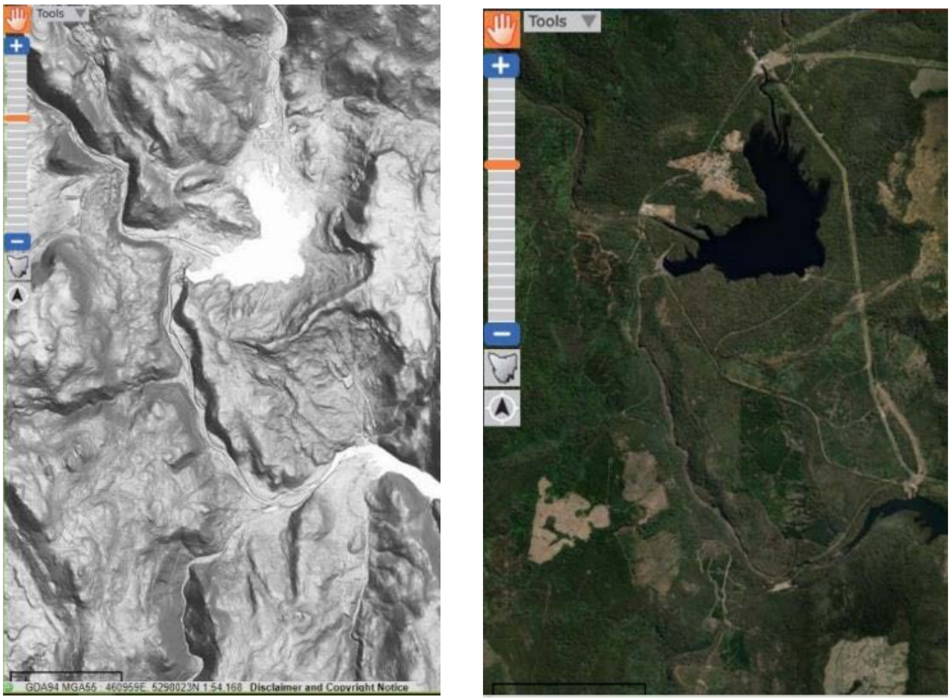

Figure 6.38: (right) Lidar image of Wayatinah Lagoon, the River Derwent downstream of Wayatinah, and Lake Catagunya and (right) aerial photograph of the same area showing land use.

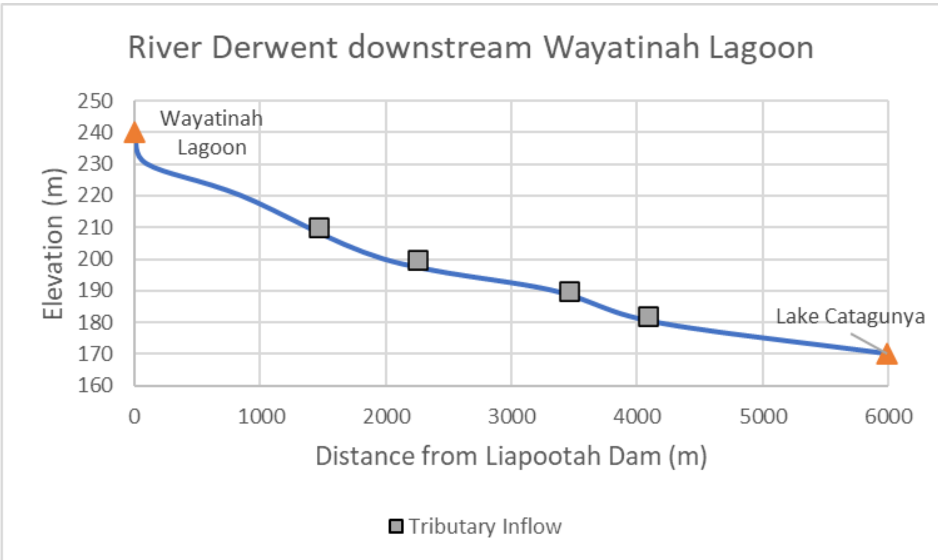

Figure 6.39: Slope of the River Derwent between Wayatinah Lagoon and Lake Catagunya and locations of small tributary inflows.

6.2.3.1 In-channel sediment characteristics

Downstream of Wayatinah Lagoon, in the steepest section of the river channel, the bed material is composed predominantly of boulders, with finer sediment deposits limited to hydraulically quiescent areas (Figure 6.40, left photo). This reach of the Derwent receives sediment input from the eroding doleritic riverbank downstream of Wayatinah Dam (Figure 6.40, right photo). Further downstream, the slope of the river decreases, and the channel is characterised by a series of pools connected by short runs. Riverbanks show the encroachment of vegetation, with large terrestrial vegetation established within what was likely the pre-regulated riparian zone, and younger vegetation present on the lower banks (Figure 6.41). This lower vegetation is periodically removed during high flow events, which would also erode the underlying banks and transport sediment downstream. Vegetation along the pools is encroaching, whist the runs between the pools have generally constricted to a narrow active channel (Figure 6.42). Similar to the upper reaches, finer sediment is confined to protected areas within the cobble and boulder dominated bed, and along the base of the fringing vegetation.

Figure 6.40: (left) River Derwent within 300 m downstream of Wayatinah Lagoon (right) eroding riverbank downstream of Wayatinah Dam.

Figure 6.41: (right) Armoured banks downstream of Wayatinah Dam (right) encroachment of vegetation onto riverbank.

Figure 6.42: (right) typical pool in lower part of River Derwent below Wayatinah (right) contraction of river channel in steeper reach between pools.

6.2.3.2 Hydrology

The hydrology of the River Derwent below Wayatinah is described in Section 6.2.2. The characteristics of the hydrology that have contributed to the existing geomorphic condition of this reach of the Derwent include the following:

- Flow in the Derwent below Wayatinah has been substantially altered through the development of the Derwent Power Scheme in both the Derwent and Nive Rivers.
- Leakage from the dam and minor tributary inflows provide a very small baseflow in the channel which appears to be present even following very dry periods.
- The dam spills for approximately 15 percent of the time and the average annual peak spill is 205 m^3/s (Section 6.2.2). The development of the power scheme has reduced the input of sediment to the rivers, limiting sediment input to the erosion of local riverbanks, and inputs from the local tributaries.

6.2.3.3 Response of the River Derwent to flow and sediment modifications

The response of the River Derwent downstream of Wayatinah Lagoon to the flow and sediment changes has been investigated by comparing historic aerial photos from February 1967 with photos obtained in 2022 for the Tarraleah Redevelopment Project. The historic photos capture conditions in the river a decade after the commissioning of the Wayatinah Power Station, and several decades after flow alterations occurred in the River Derwent so the photos do not reflect the unregulated river, but rather the river after a long period of hydropower operations. The 2022 photos only capture some areas of the river in detail due to the long shadows that were present over the river valley during the photography run. However, sufficient areas are clear to allow a reasonable assessment. The areas focussed on for comparison are shown in the red boxes in Figure 6.37.

The area shown in Box 1 is located at the downstream end of a steep straight reach where the river makes a sharp left bend (Figure 6.43). Based on the geologic map, the bend is likely following an underlying fault or other lineament. The river channel shows little change, but vegetation has increased within the upstream channel, and on the right bank bar (left side in photo).

The area shown in Box 2, downstream of a tributary confluence, shows similar changes, with vegetation encroachment on the lateral bars, but otherwise little discernible change to the channel (Figure 6.44). The area shown in Box 3 includes the confluence with the Florentine River and the upper section of Lake Catagunya (Figure 6.45). Similar to the upstream reaches, vegetation encroachment has occurred on the lateral bars, and on the shoreline of the lake. The complex morphology of the Florentine confluence has been stable over the 55-year period.

The photos suggest that any large-scale morphological changes to the river channel due to the upstream flow and sediment regulation occurred prior to 1967, and that since at least that date, the channel has been highly stable. This stability is consistent with the strong bedrock control of the river channel.

Figure 6.43: Comparison of aerial photograph from February 1967 (left) with 2022 (right) showing the area outlined in Box 1 in Figure 6.37. The direction of river flow from top to bottom in the photo.

Figure 6.44: Comparison of aerial photograph from February 1967 (left) with 2022 (right) showing the area outlined in Box 2 in Figure 6.37. The direction of river flow from top to bottom in the photo.

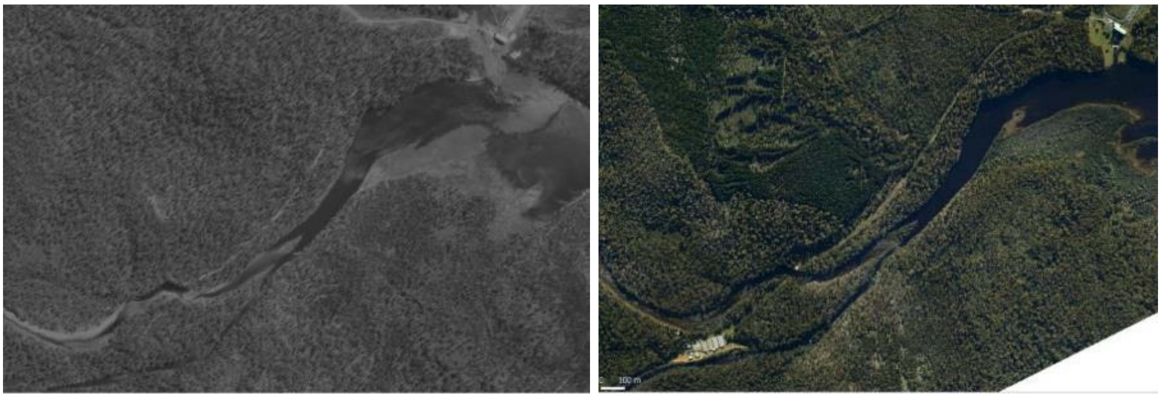

Figure 6.45: Comparison of aerial photograph from February 1967 (left) with 2022 (right) showing the area outlined in Box 3 in Figure 6.37. The direction of river flow from top to bottom in the photo.

6.2.4 Aquatic habitats

Visual assessment and collation of habitat parameters indicate that the aquatic habitats in the River Derwent downstream Wayatinah Lagoon to Lake Catagunya (~ 6 km reach) are in a poor condition due to flow diversion through Wayatinah Power Station. The habitat assessment was part of the AusRivAS macroinvertebrate river health assessments and the river health scores obtained are consistent with the visual assessment of poor habitat (Section 6.2.5).

The channel is situated in a steep, narrow valley and minor tributary inflows provides a small baseflow which may also be supplemented by groundwater inflows. However, most of the channel is either dewatered or consists of low gradient pool and slow flowing (slack water) run habitat with the benthos smothered in thick mats of filamentous algae and biofilms. Occasional, short sections of riffle habitat are present but scarce (Figure 6.46). As for the reaches downstream Clark Dam, the effects of sediment starvation are obvious with large immobile boulder dominating the riverbed. Wayatinah Dam spills approximately 16 per cent of the time (Section 6.2.2) which appears to be sufficient to keep most of the river channel clear of encroaching terrestrial vegetation and to keep some smaller cobble, pebbles and gravels mobile within an otherwise well-armoured channel. Very few fines were observed and no aquatic macrophytes were recorded.

Figure 6.46: Typical slack water habitats in the River Derwent downstream Wayatinah Lagoon.

6.2.5 Macroinvertebrates

A total of 27 taxa were recorded at this site from the 2024 survey spread among the orders Trichoptera, Plecoptera and Ephemeroptera, Diptera, Coleoptera, Crustacea, Gastropoda and Oligochaeta (Table E.4). Caddisflies (Trichoptera) were the most diverse group.

Eleven of the species identified are classed as species of conservation significance in Tasmania, mainly because they are endemic to the state, although some are endemic to south-east Australia (Table E.4). Nine of these species belong to the Order Trichoptera (caddisflies), three to the Order Plecoptera (stoneflies), with a single species of Ephemeroptera (mayfly) and Coleoptera (beetles).

None of the species recorded are classed as having a restricted distribution in Tasmania.

The raw data is provided in Appendix E.

6.2.5.1 AusRivAS river health condition assessment

This site is approximately 500 m downstream from where the channel of the Wayatinah Dam Spillway enters the River Derwent (Figure 4.6). Riffle habitat was assessed as equivalent to reference (band A) for the O/Epa and O/Erk models in spring 2018 and 2021 but declined to significantly impaired (band B) for both models in autumn 2022 (Table 6.5; Table 6.6).

Edge sampling undertaken in 2021/22 indicated significantly impaired habitat (band B) for the spring, autumn, and combined season O/Epa models (Table 6.7).

6.2.6 Fish

The impediments to upstream fish migration of native fish described in Section 6.1.6 for the reach upstream of Wayatinah also apply to this reach. Only low number of brown trout were recorded in this reach (Table 6.8).

River blackfish (*Gadopsis marmoratus*) have also been recorded in Lake Catagunya into which this reach flows. Therefore, this species may also be present in the River Derwent between Wayatinah Lagoon and Lake Catagunya. This native fish species has been introduced to the Derwent catchment from its native range in northern Tasmania. None were recorded in the River Derwent downstream Wayatinah Lagoon during the 2018 survey. Redfin perch are present in Wayatinah Lagoon and the four storages downstream from the lagoon. None were recorded during the survey but they are likely to be present.

Wayatinah Lagoon is known to contain the pest fish redfin perch (*Perca fluviatilis*), which were recorded during the Project surveys in the lower reaches of the Nive River. Redfin perch are also highly likely to be present in the River Derwent downstream of the Saltas offtake weir which is located approximately one kilometre upstream from Wayatinah Lagoon. Redfin perch were not recorded upstream of the Saltas Weir and it is not known if the weir provides a partial or permanent barrier to this species.

6.2.7 Other aquatic values

A summary of the aquatic values associated with River Derwent downstream of Wayatinah Lagoon is provided in Table 6.10. No other aquatic values were recorded in this reach, the very low baseflow and poor condition of the channel and macroinvertebrate community may suggest that platypus are absent. Although not observed, the crayfish *Astacopsis tricornis* are probably present as a detritivorous species would not be limited by scarcity of food in this reach.

Table 6.10: Water dependent ecological values associated with the River Derwent from Wayatinah Lagoon to Lake Catagunya

Value	Existing habitat condition	Comments/Assessment
Barbarea australis (native winter cress) Threatened species (TSP and EPBC Acts)	Present	Present from the spillway to a short distance upstream from Lake Catagunya, but most plants present in the upper reaches. Located in cobble bars and lee of large boulder within the zone which would be disturbed by large spill events.
Aquatic macroinvertebrates	Riffle habitats in relatively good condition measured. However slack water/slow run habitats, which are the dominant habitat throughout this reach, are impaired due to reduced flow regime and accumulation of thick biofilms,	Riffle communities vary between good and significantly impaired river health scores, but riffles are rare throughout. Slack water habitats appear degraded and edge sampling in 2021/22 assessed the condition as significantly impaired.
Native fish	Depauperate native community, potential absent other than potentially stocked eels from Wayatinah Lagoon or Lake Catagunya (*Anguilla australis)*	None were recorded. The lower Derwent storages prevent the upstream migration of native fish. *Galaxias brevipinnis* and *G. truttaceus* may be present as can reproduce as residents, but habitat quality is poor. The regulated regime and introduced predatory trout may have eliminated native fish populations in this reach.
Aquatic macrophytes	Scarce	Unsuitable habitat. Little accumulated fine sediment in slack water habitats to provide habitat which is probably in part due to sediment starvation caused by regulation.
Astacopsis tricornis (native crayfish)	Unknown	Potentially present.
Platypus	Unknown	Potentially present.

6.3 Nive River downstream Liapootah Dam

6.3.1 Summary

This reach is regulated by Liapootah Dam, which diverts most of the flow of the Nive River to Liapootah Power Station, although the dam spills every year. The baseflow is small throughout this reach as there are only minor tributary inputs from the steep river valley and there is no baseflow release from the dam. Most of the lateral channel is dry with a narrow low flow channel and in places this disappears beneath the bed of the river channel. The large flow events that occur in this reach are derived nearly entirely from spill.

The river channel is a wide (approximately 35 m), open channel where most of the riverbed width is dry under baseflow conditions. Some perennial terrestrial plants have encroached into the river channel, particularly on elevated side bars in the lower sections of the reach. However, most of the riverbed comprises bare boulders, cobbles and pebbles, which appears to provide abundant areas for colonisation by the listed riparian plant species *Barbarea australis* which occurs in this reach.

Barbarea australis is the only Matter of National Environmental Significance (MNES) in this reach and its habitat is in the riverbed and rock bars above the low flow channel and thus is unaffected by the baseflow regime. However, *B. australis* appears to rely on disturbance from higher flow events to turn over riverbed sediment, remove competitors and create suitable areas for its establishment. Higher flow events are also likely to be important for transporting and redistributing its seeds to new areas. Therefore, the section below is limited to discussion of the spill regime at Liapootah Dam as the higher flow events which occur in this reach are nearly entirely comprised of spill events.

6.3.2 Flow regime

6.3.2.1 Spill regime

Tarraleah Power Station discharges into the upstream end of Lake Liapootah on the Nive River. Liapootah Dam diverts all water (except spills) from the Nive River to Liapootah Power Station which was commissioned in 1960. There is no baseflow release and tributary inflows are minor as the catchment is steep and narrow.

As described for the River Derwent downstream Wayatinah, this section is limited to a discussion of dam spill. Modelling of tributary pick-up below Liapootah Dam was not undertaken because only a low baseflow is present from minor tributary pick up through this narrow catchment. In the absence of an observed record, to allow calibration of the model, accurately modelling small sub catchments flows is difficult. Also, operation of the Project will not impact the local pickup flow contribution or the contribution of dam leakage.

Under current operation, Liapootah Dam spills into the Nive River approximately seven percent of the time, ranging from a few cumecs to the largest recorded spill event of 633 m^3/s (Figure 6.47); however, spills of 100 to 200 m^3/s occur in most years. Liapootah Dam has recorded spill in all months but most occur over winter and spring and large spills (~≥ 30 m^3/s) mainly occur between July and October (Appendix D.5).

Spill occurred every year from 2007 to 2022 and the annual maximum flow ranged from 45 to 633 m^3/s. The mean annual maximum flow was 202 m^3/s and the median annual maximum flow was 181 m^3/s. Excluding the 633 m^3/s event, the mean annual maximum flow was 174 m^3/s.

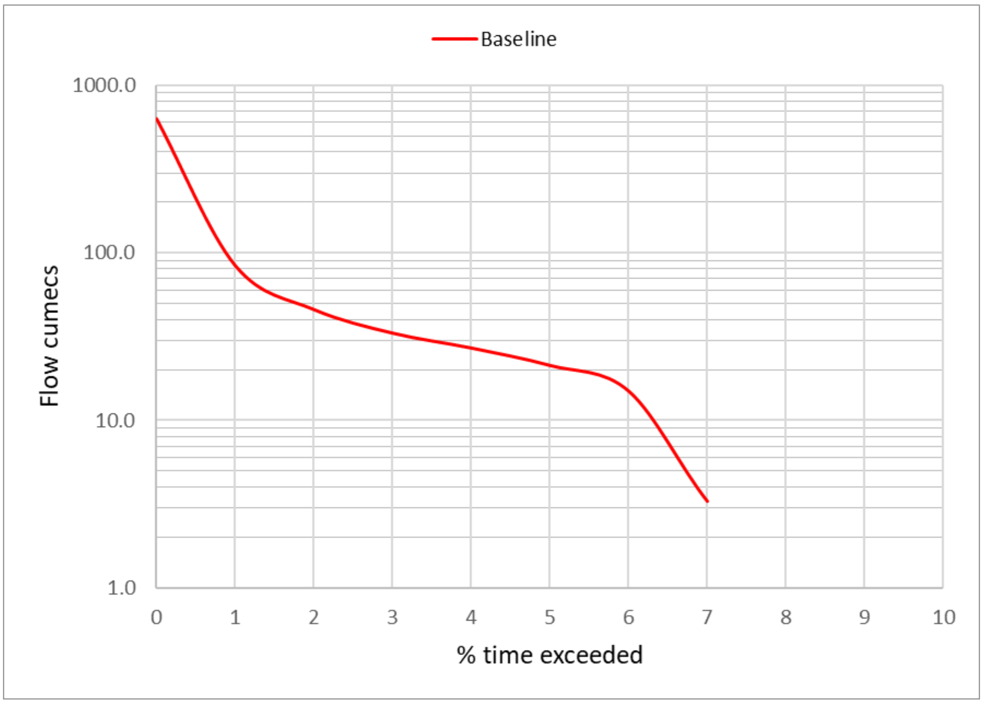

Figure 6.47: Flow duration curve (log) for the Nive River downstream Liapootah Dam (2007 to 2022).

6.3.3 Fluvial geomorphology

Downstream of Lake Liapootah, the Nive River flows for approximately 10 km before entering the Wayatinah Lagoon (Figure 6.48). Both Lake Liapootah and the Wayatinah Lagoon are artificial impoundments created as head ponds to provide water to the Liapootah and Wayatinah power stations, respectively. The river channel is incised throughout its course and flows in a generally northwest to southeast direction between the two ponds. The river decreases in elevation by almost 100 m over the 10 km, with the slope decreasing with distance downstream (Figure 6.49).

The underlying geology of the area (Figure 6.48) shows widespread dolerite, with basalt occupying the divide between the Nive and River Derwent catchments, and localised sandstone and quaternary deposits near the head of Wayatinah Lagoon. The river has incised into the underlying dolerite, creating a generally narrow valley that widens slightly upstream of Wayatinah Lagoon as it flows through the sandstone and quaternary fill (Figure 6.50). The divide between the Nive and River Derwent has been developed for forestry, but otherwise the surrounding catchment is largely undisturbed (Figure 6.50).

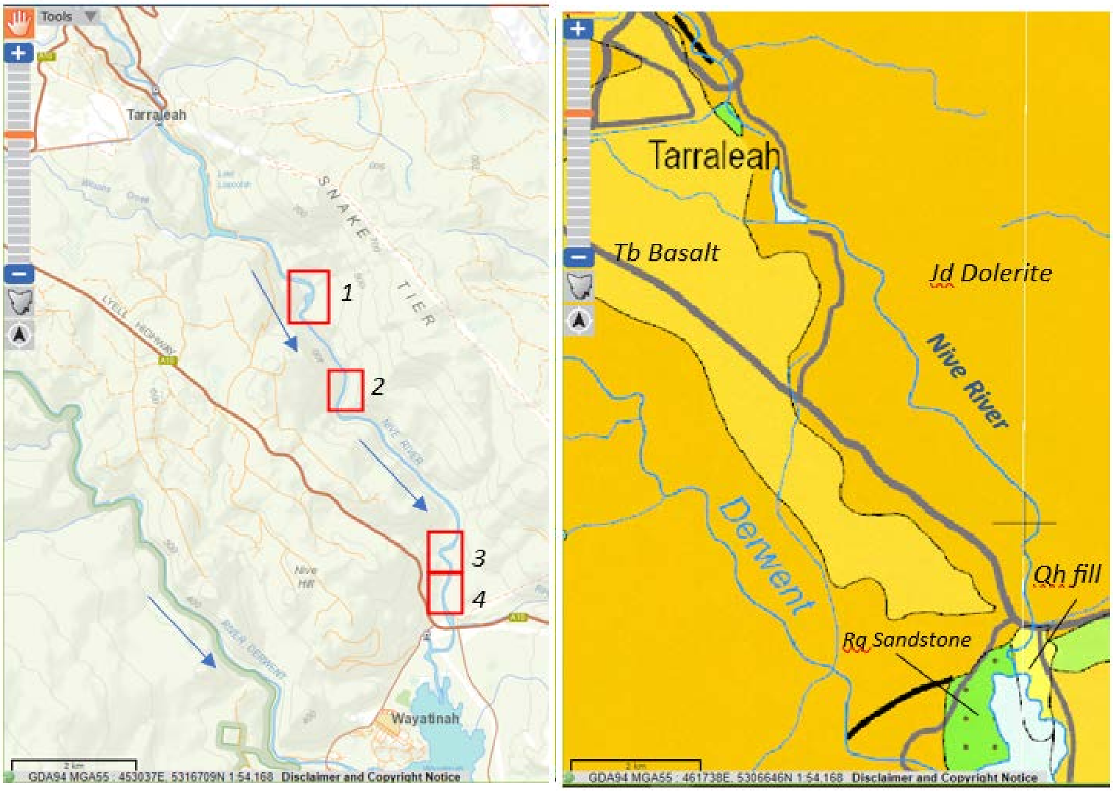

Figure 6.48: (left) Nive River between Lake Liapootah and Wayatinah Lagoon , showing topography, flow direction, and locations of comparative aerial photographs discussed in Section 6.3.3.3 (right) geologic map of the same reach of the Nive River, showing widespread Jurassic dolerite, Tertiary basalt, and Triassic sandstone in the catchment. Maps from List Map Tasmania.

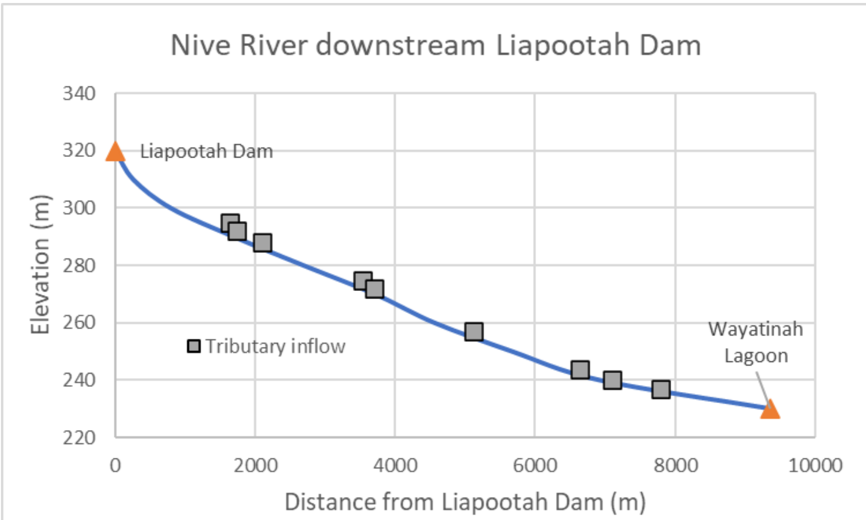

Figure 6.49: Slope of Nive River downstream of Liapootah Dam and locations of tributary inflows.

Figure 6.50: (left) Lidar image of the Nive River between Lake Liapootah and Wayatinah Lagoon showing the incised valley widening upstream of the downstream lagoon. The incised River Derwent is also shown. Aerial image of the Nive and River Derwent showing forestry activities and Wayatinah Village (right).

6.3.3.1 In-channel sediment characteristics

The bed material in the Nive River within ~0.5 kilometre downstream of the Liapootah Dam is dominated by boulders and cobbles (Figure 6.52). This is consistent with spills from Lake Liapootah transporting finer material downstream and not being subsequently replaced. Within ~1 km, sediment input to the channel increases due to erosion from the thick, weathered dolerite colluvial riverbanks (Figure 6.52). This sediment input is spatially episodic, as most of the riverbanks are well vegetated, and provide limited sediment to the system. The sediment input is also temporally episodic, as the input is largely governed by mass failure events on the banks. The re-establishment of vegetation at the base of failures indicates semi-stabilization of the banks between failure events. Additional sediment input occurs via the multiple small tributaries that enter the river. With distance downstream, the size of the bed materials generally decreases (Figure 6.53), but sporadic boulders persist over the length of the river. Finer gravels are trapped within the coarser material, frequently as shadow deposits, or along the margins of the channel. Exposed finer sediment would be expected to move relatively swiftly through the system due to the frequency of moderate and high flows, with only fine material deposited in protected areas persisting in the channel.

Figure 6.51: Nive River within 500 m downstream of Liapootah Dam.

Figure 6.52: Nive River downstream of Liapootah Dam showing sediment input from the erosion of the weathered doleritic soils.

6.3.3.2 *Hydrology of the Nive River*

The hydrology of the Nive River is described in detail in Section 6.3.2. The characteristics of the hydrology that have contributed to the existing geomorphic condition of the Nive include the following:

- Flow in the Nive River has been altered by the capture and diversion of flow from the upper Nive and Dee River catchments into the Tungatinah power station, diversion of flow in the Derwent to the Tarraleah power station and creation of Lake Liapootah downstream of the Tungatinah and Tarraleah tailraces;
- The discharge from the power stations travels a few hundred metres before entering Lake Liapootah. Additional water enters Lake Liapootah from catchment pick up in the ~29 km of the Nive River downstream Pine Tier Dam; annual spills from Pine Tier Dam; and rare spill from No. 2 Pond. Lake Liapootah holds and diverts its water to the intake for the downstream Liapootah Power Station near Wayatinah. This results in no flow entering the Nive River channel downstream of Lake Liapootah under conditions of low and moderate flows (93 percent of the time on average). During these periods the influent tributaries are the only source of water and sediment to this reach of the Nive River;

- During periods of high flow, or when the Liapootah Power Station is offline, flow from Lake Liapootah spills into the Nive River (seven percent of the time on average). These flows can be substantial (i.e. > 100 m^3/s), as they include flow from the upper Derwent via Tarraleah, and the upper Nive River catchment (Section 6.3.2).

The catchment modifications have resulted in the spill from Lake Liapootah transporting low concentrations of suspended sediment, and virtually no bedload due to the retention of sediment in the lakes and lagoons feeding Tarraleah and Tungatinah power stations, and in Lake Liapootah.

Figure 6.53: Nive River from 1 km to 9 km downstream of Liapootah Dam.

6.3.3.3 *Response of Nive River to flow and sediment alterations.*

The response of the Nive River downstream of Lake Liapootah to the flow and sediment changes has been investigated by comparing historic aerial photos from February 1967 with photos obtained in 2022 for the Tarraleah Redevelopment Project. The historic photos capture conditions in the river three decades after commissioning of the Tarraleah Power Station and seven years after the commissioning of the Liapootah Power Station, so do not reflect the unregulated river, but rather the river after a prolonged period of regulated flow. The 2022 photos only capture some areas of the river in detail due to the long shadows that were present over the river valley during the photography run. However, sufficient areas are clear to allow a reasonable assessment. The areas focussed on for comparison are shown in the red boxes in Figure 6.48.

The area encompassed by Box 1 is a right river bend characterised by a wider channel and mid-stream bar (Figure 6.54). Between 1967 and 2022 there has been an increase in the density and distribution of vegetation on the mid-stream bar and in some limited areas upstream and downstream of the bar, but the overall morphology of the river channel, shows little change. The continued presence of a secondary channel through the middle of the mid-stream bar indicates that at high flow, this channel continues to be activated. The 2022 photo shows some orange-coloured material on the right bank near the island (left side of the photo) that may reflect recent erosion of the colluvium, but the lack of colour and clarity in the historic photo makes comparison difficult (Figure 6.54).

The second set of photos (Box 2 in Figure 6.48) shows a generally straight reach upstream of a sharp bend (Figure 6.55). The overall morphology of the channel is similar in both photos. The more recent photo may show a more defined river channel through the central bar area; however, this difference could also be attributable to different water levels in river. In both photos, there appears to be a disturbed area on the right bank (left side in photo) at the downstream end of the reach (Figure 6.55). In the 2022 photo this area has an orange colour, suggesting the erosion of the colluvial banks. It is likely this area experiences high shear stresses at high flow, as the river channel sharply turns downstream. No major changes in vegetation are evident.

Prior to entering Wayatinah Lagoon, the Nive River goes through a sharp bend (Box 3) and a straight reach (Box 4) (Figure 6.48; Figure 6.56; Figure 6.57). Upstream of the bend axis, there has been some encroachment of vegetation on the left bank (right side in photo) and possible coarsening of the river channel (Figure 6.56), but overall, the channel is largely unchanged. This is consistent with a decrease in very large flow events allowing terrestrial vegetation to establish and persist within the previous riparian zone, but the moderate and high flow events preventing encroachment into the main channel. Changes downstream of the bend axis are difficult to identify due to shadows in the 2022 photo. The straight reach downstream of the bend (Figure 6.57) shows the establishment of limited vegetation clumps within the channel in the 2022 photo but otherwise little change. This reach has a lower slope as compared to the upstream sites and would experience lower river energy. The pattern and temporal duration of vegetation establishment within the channel is likely governed by the pattern of high flow events.

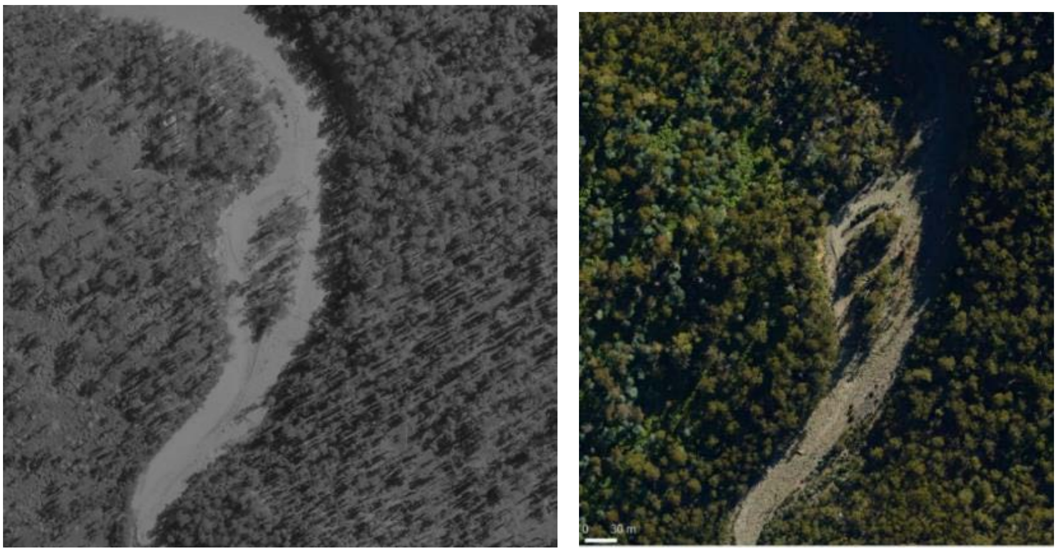

Figure 6.54: Comparison of aerial photograph from February 1967 (left) with 2022 (right) showing the area outlined in Box 1 in Figure 6.48**.** The direction of river flow from top to bottom in the photo.

Figure 6.55: Comparison of aerial photograph from February 1967 (left) with 2022 (right) showing the area outlined in Box 2 in Figure 6.48. The direction of river flow from top to bottom in the photo.

Figure 6.56: Comparison of aerial photograph from February 1967 (left) with 2022 (right) showing the area outlined in Box 3 in Figure 6.48. The direction of river flow from top to bottom in the photo.

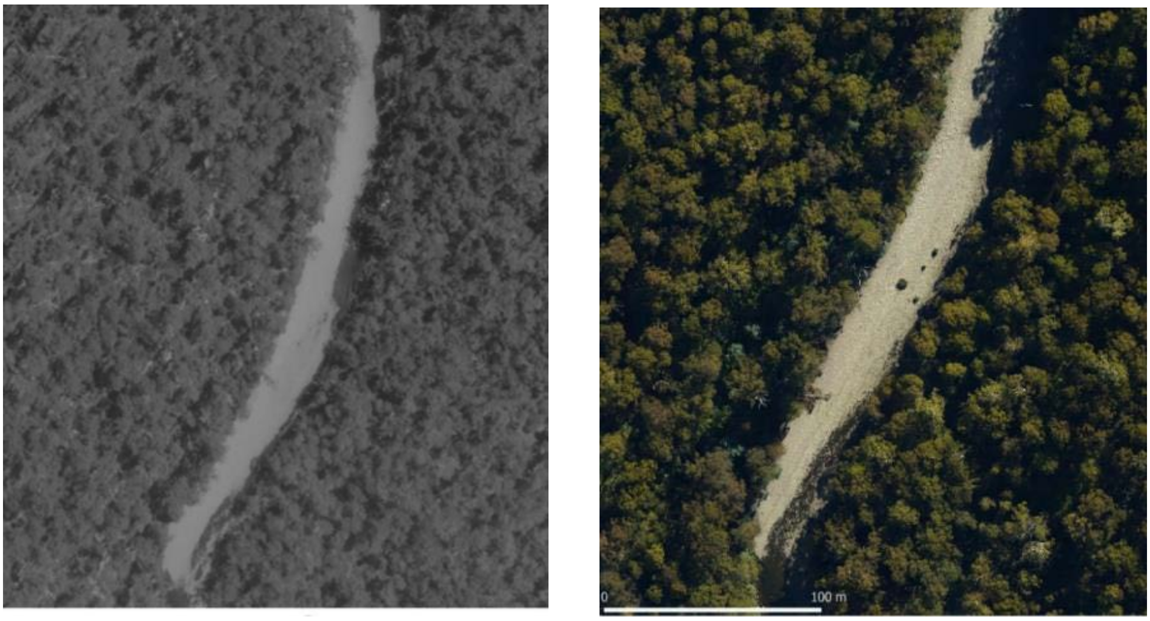

Figure 6.57: Comparison of aerial photograph from February 1967 (left) with 2022 (right) showing the area outlined in Box 4 in Figure 6.48. The direction of river flow from top to bottom in the photo

6.3.4 Aquatic habitats

Visual assessment and collation of habitat parameters indicate that the aquatic habitats in the Nive River downstream Liapootah Dam (~9 km reach) are in poor condition due to flow diversion to Liapootah Power Station. The habitat assessment was part of the AusRivAS macroinvertebrate river health assessments and the river health scores obtained are consistent with the visual assessment of poor habitat.

All the flow entering Lake Liapootah is diverted to Liapootah Power Station except during spill events which occur approximately 6 percent of the time (Section 6.3.2). A few tributary inflows provide baseflow in the 9 km reach which is situated in a steep narrow valley, with no baseflow releases provided from the dam. Most of the channel is dry and in places the small baseflow disappears beneath the river channel (Figure 6.58; Figure 6.59). There are some permanent pool habitats, but these provide poor habitat due to minor or no flow connection with riffles at their upstream and downstream ends. Riffle habitat is scarce but increases with distance downstream (Figure 6.60) and these offer the best habitat for aquatic macroinvertebrates and potentially foraging areas for platypus. Very few fine sediments were observed and no aquatic macrophytes were recorded.

Figure 6.58: Typical reach of the Nive River downstream Liapootah Dam with narrow wetted zone along the left bank (right side of photo).

Figure 6.59: Nive River downstream Lake Liapootah. Example of upper reach where low baseflow flows underneath the substrate.

Figure 6.60: Riffle habitat in the Nive River downstream Lake Liapootah near the end of the 9 km reach.

6.3.5 Macroinvertebrates

A total of 17 taxa were recorded at this site from the 2024 survey spread among the orders Trichoptera, Plecoptera and Ephemeroptera, Diptera, Coleoptera, Crustacea and Acarina (Table E.4).

Eight of the species identified are classed as species of conservation significance in Tasmania, mainly because they are endemic to the state, although some are endemic to south-east Australia (Table E.4). Three of these species belong to the Order Trichoptera (caddisflies), three to the Order Plecoptera (stoneflies), with a single species of Ephemeroptera (mayfly) and Coleoptera (beetles). None of the species recorded are classed as having a restricted distribution in Tasmania. The raw data is provided in Appendix E.

6.3.5.1 AusRivAS river health condition assessment

The site on Nive River downstream Liapootah Dam and upstream Wayatinah Lagoon is ~9 km downstream from Liapootah Dam and ~200 m upstream of the Lyell Highway (Figure 4.6), near the bottom of the reach, Figure 4.6) and has been sampled on seven occasions since 2015 (site historically known as *Nive River u/s of Wayatinah Lagoon*). Riffle habitat as this site has been rated as equivalent to reference (band A) for the O/Epa model for the three completed autumn surveys, including autumn 2022 (Table 6.6; Figure 6.61). The combined season O/Epa model in 2015/16 and 2021/22 was also assessed as band A (Table 6.6; Figure 6.61). However, the spring O/Epa model has been assessed as significantly impaired (band B) in 2015, 2016 and 2017 and severely impaired (band C) in spring 2021 (Table 6.6; Figure 6.61).

The O/Erk models show a similar pattern with the three autumn surveys undertaken reporting band A scores and all spring surveys recording significantly (band B) to severely impaired (band C) scores (Figure 6.62). All O/Erk combined season scores have been in the significantly impaired band (Figure 6.62). The reasons for the lower river health scores at this site in spring compared to autumn is not known but may relate to more frequent dam spills occurring in late winter and early spring compared to autumn. Dam spills may temporarily denude the macroinvertebrate communities at this site.

Edge sampling undertaken at this site in 2021/22 recorded significantly impaired scores (band B) for the spring, autumn, and combined season O/Epa models (Table 6.7).

An additional riffle site (Nive River ~ 1 km downstream of Liapootah Dam) was sampled near the top of this reach in spring 2018 (Figure 4.6) which was also assessed as significantly impaired (band B) for the O/Epa and O/Erk models (Table 6.5).

Figure 6.61: Presence absence (O/Epa) river health scores recorded at the site Nive River ~200 m upstream of the Lyell Highway since 2015

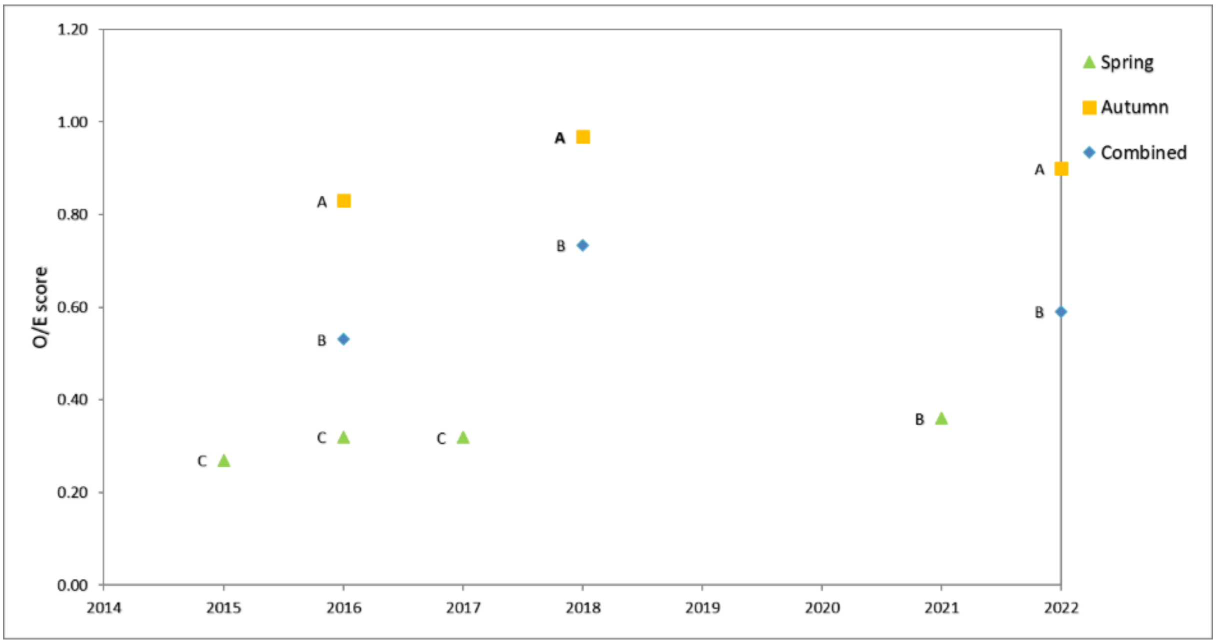

Figure 6.62: Rank abundance (O/Erk) river health scores recorded in the site Nive River ~200 m upstream of the Lyell Highway since 2015

6.3.6 Fish

The impediments to upstream fish migration of native fish described in Section 6.1.6 for the reach upstream of Wayatinah also apply to this reach. Only low number of brown trout were recorded in this reach (Table 6.8).

A single eel (*Anguilla australis*) was the only native fish captured in the Nive River which, as discussed, are only present through occasional stocking of the hydropower storages in the catchment. Introduced brown trout and redfin perch were also recorded in low numbers.

There is a low availability of aquatic habitat and diversity of habitats in this reach due to a retraction of the wetted channel under the generally very low baseflow conditions, a low diversity of flow habitats compared to those that would be present in an unregulated river of this size, and a low abundance of instream woody debris and undercut banks for cover. The impacts of flow regulation would also reduce the abundance of macroinvertebrate prey in the Nive River downstream Liapootah Dam. Overall, this reach provides poor habitat for fish.

6.3.7 Other aquatic values

A summary of the aquatic values associated with Nive River Derwent downstream Liapootah Dam is provided in Table 6.11. No platypus or *Astacopsis tricornis* have been recorded in the Nive River downstream Liapootah Dam or observed during the surveys for the Project or in the numerous other surveys for different projects. However, platypus have been recorded in Wayatinah Lagoon and both species are likely to inhabit at least the lower reaches of the river where the small baseflow is provides more wetted habitat area than occurs in the upper reaches closer to Liapootah Dam.

Table 6.11: Water dependent ecological values associated with the Nive River from Liapootah Dam to Wayatinah Lagoon

Value	Existing condition	Comments
Barbarea australis (native winter cress) Threatened species (TSP and EPBC Acts)	Present	Present from the spillway to a short distance upstream from Wayatinah Lagoon. Located in cobble bars and lee of large boulder within the zone which would be disturbed by large spill events.
Aquatic macroinvertebrates	Poor condition	Very low tributary inputs to this reach which is reflected in poor river health scores during the 2018 survey and by numerous previous assessments.
Native fish	Depauperate native community, potential absent other than stocked eels (*Anguilla australis)*	None were recorded, poor habitat quality and availability. The presence of dams downstream, regulated flow regime and introduced predatory trout and redfin perch may have eliminated native fish populations in this reach.
Aquatic macrophytes	Scarce	Unsuitable habitat. Little accumulated fine sediment in slack water habitats to provide habitat which is probably in part due to sediment starvation caused by regulation.
Astacopsis tricornis (native crayfish)	Unknown	Potentially present.
Platypus	Unknown	Potentially present.

6.4 Mossy Marsh, No. 2 and No. 1 ponds

6.4.1 Aquatic habitats

The main body of the Mossy Marsh Pond consists of shallow water up to approximately three metres depth, abundant submerged dead trees and deep layers of organic sediment. The shoreline around Mossy Marsh Pond consists mainly of thick terrestrial vegetation extending to the full-supply level with no exposed banks which reflects the stable water level since operation began over 50 years ago.

Dense aquatic macrophyte beds were recorded where fine sediments have accumulated in pockets along the northern and eastern shorelines and particularly in the vicinity of the entrance to the No. 2 Canal leading to No. 2 Pond and within the canal itself. Macrophytes recorded included plants in the genera *Myriophyllum*, *Isolepes*, *Potamogeton* and *Triglochin*, and fringing *Juncus* rushes (Figure 6.63). The inflow to Mossy Marsh Pond in the north-western corner produces a strong current and extensive areas are colonised by benthic macrophytes (dominated by *Isolepes* and *Potamogeton*) and emergent aquatic plants. The remaining shorelines consists mainly of bare, organic rich sediment and abundant dead, submerged standing and fallen trees.

No. 2 Pond has less organic silt deposits (Koehnken, 2019) and far fewer macrophyte beds than Mossy Marsh Pond, with the macrophyte beds mainly occurring in small pockets on either side of the inflow along the western shore and near the stormwater inflow on the southern margin. The majority of the pond bed and shoreline consists of pebble to boulder sized material overlain by fine iron-rich, organic poor, clay rich silt (Koehnken 2019). Submerged standing and fallen trees are common through the main body of the pond and along the shorelines (Figure 6.64).

No. 1 Pond is an enlarged canal (~ 50 - 70 m wide) which forms the meeting point of water from No. 1 Canal and the discharge from No. 2 Pond before the water for the scheme enters the penstocks to Tarraleah Power Station (Figure 6.65). No. 1 Pond is small (1.8 hectares) compared to Mossy Marsh (62 hectares) and No. 2 Pond (31 hectares) and contains concrete and rock lined banks. There is little structural diversity within No. 1 Pond, although patches of *Triglochin procera* are present. No. 1 Pond will be decommissioned prior to operation of the Project.

Water levels are relatively stable in both ponds and are not predicted to change during operation of the Project.

Figure 6.63: Macrophytes and large woody debris along the shoreline in Mossy Marsh Pond.

Figure 6.64: Typical shoreline associated with No. 2 Pond.

Figure 6.65: No. 1 Pond, No. 1 Canal enters from top left and discharge from No. 2 Pond enters from top right.

6.4.2 Macroinvertebrates

The macroinvertebrate fauna in Mossy Marsh and No. 2 ponds is typical of still-water habitats with aquatic macrophytes. Hemipterans, caddisflies (Trichoptera), damsel and dragonflies (Odonata) and dipterans were the most common taxa (Table 6.12). More taxa were recorded in No. 2 Pond than in Mossy Marsh Pond (Table 6.12) but only one sample was taken from each pond and it is likely the overall diversity of aquatic macroinvertebrates is similar between the two water bodies given their close proximity and hydrological connection. However, the overall abundance/biomass of macroinvertebrates is likely to be significantly higher in Mossy Marsh Ponds as the aquatic macrophytes beds are more extensive than in No. 2 Pond (Section 6.4).

No sampling was undertaken along areas of shoreline consisting of bare sediments and large woody debris which is the majority of the shoreline present in both ponds, particularly No. 2 Pond. These areas would likely have a lower abundance of aquatic macroinvertebrates than the macrophyte beds but likely support a subset of that fauna recorded although additional taxa might also occur, particularly dipterans which tend to dominate samples collected from lake shorelines characterised by fine sediments. Also, the abundant large woody debris may provide good habitat for some taxa in these areas and throughout the ponds.

The sampling undertaken here is likely to underestimate the biodiversity of macroinvertebrates in these ponds as they are from a single point in time from a single, defined habitat, and were taken in April when macrophytes start to die off approaching winter. Despite the limited sampling undertaken, the results demonstrate that both ponds support a fairly diverse and abundant macroinvertebrate community in the macrophyte beds, but these are a very minor component of the shoreline in No. 2 Pond which is otherwise comprised of bare substrate.

No macroinvertebrate surveys were conducted in No. 1 Pond; however, it is likely to contain a less diverse and less abundant fauna than No. 2 Pond due to the lower structural complexity of the habitats present in No. 1 Pond.

Table 6.12: Macroinvertebrate taxa identified from edge samples collected from Mossy Marsh and No. 2 ponds

Class/Order	Family/Sub-family	Genus	Mossy Marsh Pond	No. 2 Pond
Hemiptera	*Corixidae*	*Siagra*	17	16
		Agraptocorixa		7
		Juv.		18
	Veliidae	*Drepanovelia*	2	
	Notonectidae	*Anispops*	2	1
Coleoptera	*Dytiscidae*			3
Diptera	*Dixidae*		1	
	Ceratopogonidae		1	1
	Chironomidae		20	22
	Tanypodinae		4	3
Trichoptera	*Leptorceridae*		36	59
	Atriplectidae			2
Odonata	*Synthemistidae*			10
	Lestidae	*Austrolestes*	23	4
Plectoptera	*Gripopterygidae*			1
Mollusca	*Physidae*		1	11
	Sphaeriidae			1
Amphipoda	*Ceinidae*		2	
Acarina			1	1
Oligochaeta				3
		Total diversity	12	17

6.4.3 Fish

Very few fish were captured in the fyke nets at either pond with three introduced brown trout (*Salmo trutta*) captured in Mossy Marsh Pond and one native short-finned eel captured in No. 2 Pond (Table 6.8; Figure 6.66). It is likely that the fish fauna of both ponds is dominated by introduced trout and that native fish are restricted to low numbers of stocked eels and, potentially, the climbing galaxias (*Galaxias brevipinnis* for which there is a historical record in the pond from 1961).

No fish surveys were conducted in No. 1 Pond; however, brown trout are known to be present.

Figure 6.66: Large eel (*Anguilla australis*) captured in No. 2 pond.

6.4.4 Other aquatic values

No platypus or *Astacopsis tricornis* were recorded but both species are likely to inhabit Mossy Marsh Lagoon, and No.1 and No.2 ponds.

Table 6.13: Water dependent values associated with No. 2 Pond

Value	Existing condition	Comments
Aquatic macroinvertebrates	Good condition in macrophyte beds	Abundant and relatively diverse in macrophyte beds, fauna typical of still-water habitats. Shorelines with bare sediments were not sampled but fauna likely to be less diverse although the abundant large woody debris may provide good habitat for some taxa.
Native fish	Poor	A single adult eel was recorded. *Galaxias brevipinnis* and *G. truttaceus* may also be present.
Introduced fish	Depauperate native community, potential absent other than stocked eels	Few fish caught during surveys, but brown trout and stocked eels (*Anguilla australis*) are present.
Aquatic macrophytes	Abundant in patches	Aquatic macrophyte beds are mostly limited to patches to either side of the canal inlet on the western margin and the stormwater inflow on the southern margin.
Astacopsis tricornis (native crayfish)	Unknown good habitat	Potentially present.
Platypus	Good habitat, previous recorded	Highly likely to be present.

6.5 Flow dependent MNES - *Barbarea australis*

6.5.1 Summary

Surveys recorded *Barbarea australis* in the Nive River downstream Liapootah Dam to Wayatinah Lagoon and in the River Derwent downstream Wayatinah Lagoon to Lake Catagunya (Figure 4.7). *Barbarea australis* was also recorded on the dam wall of No. 2 Pond during water quality surveys in 2023. However, *B. australis* was not recorded in the River Derwent downstream Clark Dam to Wayatinah Lagoon in the surveys conducted for the Project and this species has not been recorded in this reach since the 2001.

The following section describes the general habitat associations in the reaches where *B. australis* was recorded before discussing the specifics of each reach. Table 6.14 provides a summary of the reaches surveyed and records for the Project as well as historic records for the River Derwent and Nive River.

Table 6.14: NVA records of *Barbarea australis* in the Derwent and Nive rivers. Years shaded grey are records from surveys conducted for the Project

Location	Reach length (km)	Year recorded	Number of plants	Comments
River Derwent downstream of Clark Dam to Wayatinah Lagoon	31	2000 2001	1 2[5]	Recorded in the last 1 km before the River Derwent enters Wayatinah Lagoon
River Derwent downstream of Wayatinah Lagoon to Lake Catagunya	6	2001 2012 2019 2021 2022	Not stated 30 73 35 12	Most records are from the spillway and the first few km downstream, but records extend approximately 4 km downstream from the spillway
Nive upstream of Tarraleah Power Station to Pine Tier Lagoon	21	1986 1996 1999 2018 2019	Not stated Not stated 107 19 2	Sparse records which extend from 4 km downstream Lyell Highway on the Central Plateau at 565 mAHD to immediately upstream the Tarraleah Power Station (345 mAHD) near the bottom of this reach
Nive downstream of Liapootah Dam to Wayatinah Lagoon	9	1999 2001 2005 2014 2019	Not stated 50 Not stated Not stated 53	Recorded in low numbers intermittently along all of the 9 km reach
No. 2 Pond dam wall	NA	2023	2	Observed during WQ surveys on a small patch of cobble near the dam outlet

[5] This record is not on the NVA but is cited in the listing statement for *B. australis* (Threatened Species Section 2010).

6.5.2 General habitat associations

Nearly all of the recorded observations occurred in moderate to high gradient zones on side or mid-channel bars that were dominated by gravels to small cobbles, or in the pebbles and gravels that can accumulate directly behind the downstream face of large boulders (Figure 6.67; Figure 6.68). These side/mid-channel bars and large boulder where *B. australis* were recorded were all above the low flow channel and would only be inundated during high flows. However, the root zone of all observations was in moist gravels and coarse sand, presumably through proximity to the water table associated with the watercourse.

Very few *B. australis* were recorded in low gradient habitats where long pools/slow runs occur. Despite the low baseflow in these rivers, these lower gradient habitats were typically wetted close to the channel margin, leaving little room on the banks for colonising flora species such as *B australis*. The banks in these areas also looked unsuitable for *B. australis* because the available bank area was often colonised by terrestrial flora and the substrate was comprised mainly of large immobile boulders and few smaller cobbles, pebbles and gravels where *B. australis* are mainly found. *B. australis* is known not to compete well with other plants and was typically not found in channel margins, side bars or mid-channel islands where other plants were abundant.

Flood runners are listed as suitable habitat for *B. australis* in its Flora Recovery Plan (Threatened Species Section 2011) and are created when overbank flows erode a section of the floodplain and typically leave a channel comprised of mainly coarse substrates (gravels and coarser). Flood runners were rare at the Project surveys sites which is partly because they are in gorge setting that confines the flow path. In general, flood runners are rarely formed in Hydro Tasmania’s regulated rivers because the small to moderate flood regime has been substantially reduced and exposed bars are generally vegetated by encroaching terrestrial plants which armours the rock bars and further confine the channel.

Figure 6.67: Typical location for *B. australis* on moderate gradient, cobble exposed bars in the Nive River downstream Liapootah Dam

Figure 6.68: *B. australis* in a typical location in gravels behind boulder and cobble in the Nive River downstream Liapootah Dam

6.5.2.1 River Derwent downstream Clark Dam to Wayatinah Lagoon (31 km reach)

There are only two records of *B. australis* in this reach from 2000 and 2001, approximately 1 km upstream from where the river enters Wayatinah Lagoon and downstream from the boundary where the river is no longer within the TWWHA (Figure 4.7). The populations appeared to be small with one and two plants recorded in each year, although the extent of the surveys in 2000 and 2001 is unknown (Table 6.14).

Most of the reach is difficult to survey, with vehicle access only at ~1.5 km downstream from Clark Dam; Derwent Pumps Weir (6 km downstream from Clark Dam), and at the bottom of the reach near Wayatinah Lagoon. Therefore, it is likely that this reach has received minimal survey effort historically for *B. australis*.

The entire reach from Clark Dam to Wayatinah Lagoon was surveyed specifically for *B. australis* habitat over 2019, 2021 and 2022 as part of the baseline surveys for the Project. Approximately 1 km of the 6 km reach upstream Derwent Pumps Weir was walked and surveyed for *B. australis* and the entire 6 km was flown over at low altitude by helicopter on three occasions between 2021 and 2022 to identify areas of potential habitat. The entire reach downstream Derwent Pumps Weir to Wayatinah Lagoon (25 km) was walked in sections and surveyed for *B. australis* (accessed mostly by helicopter).

From the flyovers and on-ground surveys, it was determined that the reach upstream of Derwent Pumps Weir does not appear to contain suitable habitat for *B. australis*, but that the reaches downstream do (see sections below for further detail). However, despite suitable habitat being present downstream of Derwent Pumps Weir, no *B. australis* were recorded during the surveys.

Clark Dam has influenced the suitability and extent of *Barbarea* habitat. Regulation of river by dams is known worldwide to change the flow regime downstream as well as reduce sediment supply through trapping of sediment behind the dam (Morris and Fan 1998). Both of these processes are occurring downstream of Clark Dam such that the transport of sediments to and from the channel, bars, banks and riparian corridor has been reduced.

Mobilisation of river sediments is important for creating and maintaining habitat for colonisation by *B. australis*. Flow regulation has allowed perennial terrestrial plants to colonise parts of the river channel, particularly on elevated side and mid-channel bars. The establishment of perennial plants (particularly *Leptospermum lanigerum* (woolly tea-tree), has reduced the areas which are suitable for *B. australis* by:

- directly reducing the space available for establishment of *B. australis*
- reducing the river energy near the banks and bars, which reduces the potential for sediment transport
- armouring areas of substrate, which reduces the likelihood that high flows will mobilise rock in these areas. Armouring occurs through:
    - plants trapping rock substrates around the matrix of their roots and fine sediments/organics
    - promoting accumulation of finer sediments and organics which partially or completely embedded surrounding larger sediments.

There are three distinct zones which partition the habitat quality for *B. australis* downstream Clark Dam. These zones have distinct geomorphic (Koehnken 2019), hydrological and hydraulic (Section 6.1.2) characteristics.

Zone 1: Downstream Clark Dam to Derwent Pumps Weir (6 km).

Spills occur from Clark Dam and all baseflow is derived from tributary inflows through this zone and are minor relative to the size of the channel as no baseflow releases are provided from Clark Dam (Section 6.1.2.2). This zone is relatively low gradient (approximately 0.005 slope) and comprises long sections of low energy, run habitat and higher gradient exposed bedrock sections. Side and mid channel rock bars are rare and those present are either fully vegetated with terrestrial vegetation or the large cobble and boulder substrate is armoured and embedded.

The potential habitat in this zone was assessed as unsuitable for *B. australis* due to the lack of exposed, mobile rock bars, absence of flood runners and the presence of dense terrestrial vegetation to the channel margin/top of the banks.

Zone 2: Downstream Derwent Pumps Weir to the Counsel River inflow (16 km).

The weir spills for approximately 38 per cent of the time, predominantly over winter and early spring (Section 6.1.2.3). Several small tributaries progressively enter the zone which provide a small baseflow, with no baseflow releases provide from Derwent Pumps Weir. A baseflow has been observed after several months of low rainfall through summer and early autumn approximately 2 km downstream from the weir (Section 6.1.2.3), however, at least the upper part of this zone may cease to flow during prolonged dry periods.

Lower gradient run/pools are the most prevalent flow habitats in this zone, however, shorter sections of steeper riffle habitat are relatively common compared to the zone upstream of Derwent Pumps Weir. While the bed is still armoured and sediment starved, a greater range of substrate sizes are present. Habitat suitable for *B. australis* is present, mostly as patches of gravels, pebbles, and small cobbles in the steeper sections with riffles (Figure 6.69). The patches of suitable habitat have the following characteristics:

- they are loosely packed and unimbedded, suggesting this size fraction is mobilised by the current high flow regime
- they are typically present at the downstream side of boulders, again, suggesting they are mobilised during high flows and deposited in the lower energy areas created by the downstream face of large boulders
- they occur between the low flow channel and the riverbank, or between the low flow channel and where terrestrial plants have established into the channel margin.

Elevated mid-channel and side channel bars are also present but are mostly unsuitable habitat for *B. australis* due to the establishment of terrestrial plants (as described in Zone 1).

Zone 3: Downstream the Counsel River inflow to Wayatinah Lagoon (9 km).

Habitat suitability for *B. australis* continues to be influenced by the processes described for the zones above; however, Zone 3 is in better condition due to the higher stream gradient and the addition of two large inflows.

The Counsel River is the largest inflow to the River Derwent downstream Clark Dam to Wayatinah Lagoon (Section 6.1.2.4) and there is a clear demarcation in flow and geomorphic condition of the River Derwent up and downstream from its confluence (Section 0). The only other large inflow, Beech Creek, also enters this zone 1.5 km downstream. These tributaries substantially increase the flow regime and provide most of the flow for the annual peak events in this 9 km zone when the Clark Dam is not spilling (Section 6.1.2.4). These unregulated tributaries also increase the supply of sediment to the River Derwent.

Increased flow regime and sediment supply has increased the availability and quality of habitat for *B. australis* relative to the zones upstream of the Counsel River. Most of the suitable habitat in this zone is still comprised of patchy areas where loose gravels, pebbles and small cobble have been deposited following high flows. This zone is still influenced by encroachment of terrestrial plants, including most of the side and mid-channel bars, however, there are some side bars and flood running channels which are mostly or partly free of terrestrial plants and contain areas of unembedded rock substrate which provide suitable habitat for *B. australis* (Figure 6.70, Figure 6.71).

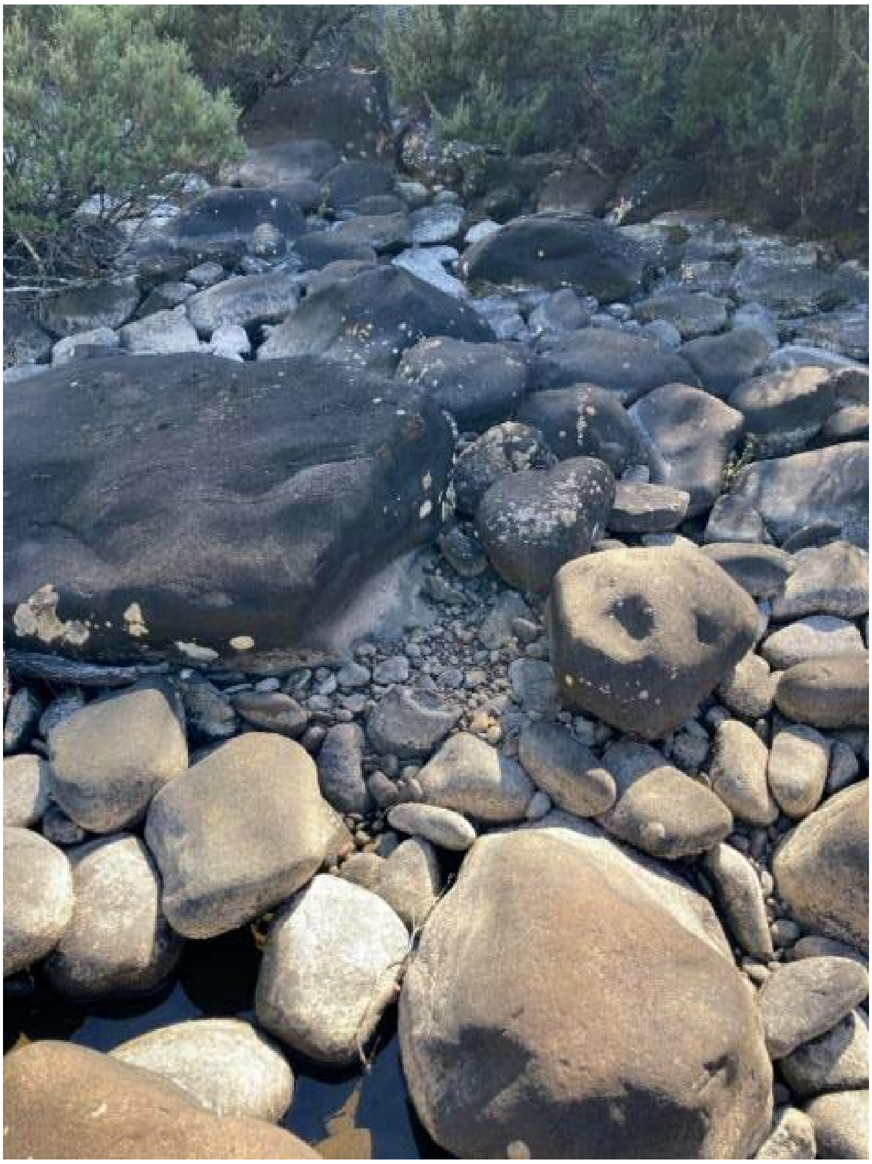

Figure 6.69: Patch of mobile gravel, pebbles and small cobbles on the downstream side of large boulders which provides suitable areas for *B. australis* in the reach between Derwent Pumps Weir and the Counsel River inflow

Figure 6.70: Mobile elevated side channels, which are mostly free of terrestrial plants, are present downstream the Counsel River inflow

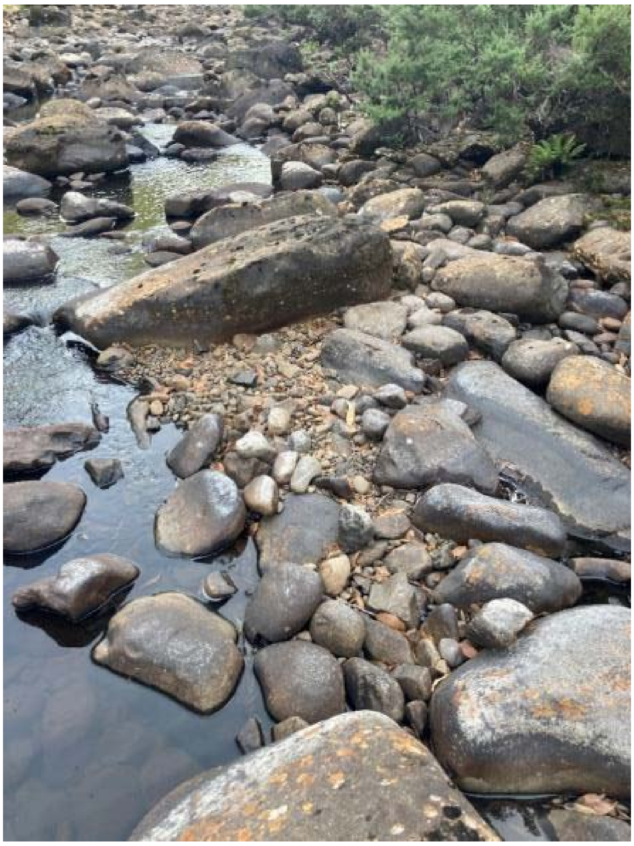

Figure 6.71: Patches of suitable mobile small substrate are more common downstream the Counsel River inflow

6.5.2.2 River Derwent downstream Wayatinah Lagoon to Lake Catagunya (6 km reach)

Wayatinah Dam diverts inflows from the River Derwent and Nive River to Wayatinah Power Station. On average, Wayatinah Dam spills approximately 16 percent of the time. Spill can occur in any month but is most common in May to October. The dam spills onto a large area of exposed bedrock and then into a rocky gorge which runs for approximately 300 m before joining the River Derwent. The catchment below the dam is narrow with only a few minor tributaries entering the 6 km reach between the Wayatinah Dam and Lake Catagunya to provide baseflow in this reach, with no baseflow releases provided from the dam. There is also minor leakage from the dam which contributes to the baseflow in this reach. The large flow events which occur in this reach, and which maintain disturbance events for *B. australis* habitat and seed dispersal, are derived nearly entirely from spill events.

In the steeper sections, the small baseflow in the approximately 20 - 35 m wide river channel inundates a narrow (1 - 5 m) wetted area. In the lower gradient sections, the baseflow spreads across multiple flow paths through large boulders, or forms long, wider pool/slow runs.

Records of *B. australis* in this reach are described below and shown in Figure 4.7 and Table 6.14. The habitat suitable for *B. australis* in the main river channel occurs on the elevated boulder bars of the steeper sections and comprises mainly small cobbles, pebbles and gravels which accumulate on the downstream side of boulders as described for the reaches upstream of Wayatinah Lagoon (Figure 6.72). However, plants were also observed growing in small gaps between large cobble and boulder. Large dam spills occur in most years (Section 6.2.2) which may have limited the encroachment of perennial terrestrial vegetation into the channel in this reach.

The crest of the Wayatinah dam spillway provides a flat apron where silt, gravels, pebbles and small cobbles have accumulated. The width of the apron varies with lake level but appears to be permanently vegetated with grasses and weeds. *B. australis* has been recorded growing on the spillway apron in 2012 and during surveys for the Project in 2019, 2021 and 2022 (Figure 6.73). It is assumed that seeds from the Nive River population of *B. australis* float across Wayatinah Lagoon and are washed into the spillway gorge and then into the River Derwent during spill events.

The spillway gorge only flows when the dam spills and is mainly free of encroachment by terrestrial perennial plants due to the frequency and magnitude of large spills. Annual introduced weed species are common in this gorge; however, there are abundant patches of gravels and pebbles where *B. australis* has been recorded. The entire reach from the spillway to Lake Catagunya was surveyed in January 2019 for the Project. The survey found the highest density of *B. australis* in the spillway gorge and the first kilometre of the main channel (Figure 6.74); however, the species was also recorded 3.8 km downstream for the spillway in 2019 and 4 km downstream from the spillway in 2012 (Figure 4.7).

The 2019 survey is likely to be the only survey to cover the entire reach and that most survey effort has been in the more accessible areas of the spillway gorge and upper part of the main channel. However, observations of habitat and plant records from the 2019 survey support the theory that the most suitable habitat for *B. australis* is in the spillway gorge and upper third of the reach. As discussed in the Section 9.3.2, further surveys of the entire reach are proposed to gain more data on distribution and interannual variability of the populations in this reach.

Figure 6.72: *B. australis* growing in the lee of large boulders in the River Derwent downstream Wayatinah Lagoon (December 2018)

Figure 6.73: *B. australis* growing along the top of the Wayatinah Spillway.

Figure 6.74: Spillway channel connecting Wayatinah Dam to the River Derwent with *B. australis* plant growing in the middle foreground.

6.5.2.3 Nive River

NVA records of *B. australis* between 1986 and 2014 in the Nive River occur over an approximate 30 km reach of the river, from 3.8 km downstream from where the Nive River crosses the Central Plateau (~ 560 mASL) to the final reach of the river before it enters Wayatinah Lagoon (~ 230 mASL) (Figure 4.7). The surveys undertaken in 2018/19 for the Project found records in a similar upstream and downstream extent compared to the historical observations (Figure 4.7; Table 6.14), as described below.

Nive River upstream Lake Liapootah to Pine Tier Lagoon (21 km reach)

All the habitat which occurs in this reach is upstream of the proposed Tarraleah Redevelopment Project.

Records from the 2018/19 Project surveys consisted of populations of one and two plants and overall numbers were low with only 21 specimens recorded in the reach between Tarraleah Power Station upstream to the Lyell Highway (Figure 4.7; Table 6.14).

All historical and new observations recorded in 2018/19 are downstream of where the Lyell Highway crosses the Nive River to the west of Bronte Lagoon (Figure 4.7). No observations were recorded in the regulated reaches upstream of the Lyell highway to Pine Tier Dam despite suitable habitat being quite common in this 8 km reach. No plants were found in the unregulated sections of the Nive or Pine rivers upstream of Pine Tier Lagoon. Suitable habitat was present but uncommon in these unregulated reaches as the flow extended to the channel margins in most places. However, it should be noted that less survey effort was devoted to reference rivers and more suitable habitat may occur further upstream. These sites are also at higher elevations than the regulated river sites surveyed.

Nive River downstream Lake Liapootah to Wayatinah Lagoon (9 km reach)

This reach is regulated by Liapootah Dam which diverts most of the Nive River flow to Liapootah Power Station. Under current operation, Liapootah Dam spills approximately six per cent of the time, mostly during winter and spring but spill has been recorded in all months (Section 6.3.2). A few tributary inflows provide a small baseflow in the 9 km reach which is situated in a steep narrow valley, with no baseflow releases provided from the dam. Most of the channel is dry and in places, the small baseflow disappears beneath the river channel. The large flow events which maintain habitat for *B. australis* and seed dispersal, are derived nearly entirely from spill.

The river channel is a wide (approximately 35 m), open channel where most of the riverbed is dry under baseflow conditions. The relatively rare, steeper riffle habits only inundate a narrow (approximately 2 – 6 m) band due to the reduced flow regime. Flatter areas of riverbed form most of the wetted habitats in the form of slow runs and pool. The substrate is relatively uniform throughout this reach, other than for the first approximate 800 m which is mainly large boulder with occasional pockets of smaller substrate (Figure 6.75). The remainder of the reach is mainly comprised of small boulder, cobble and pebble which is unimbedded on the mobile bars above the low flow channel (Figure 6.76). Some perennial terrestrial plants have encroached into the river channel, particularly on elevated side bars in the lower sections of the reach. However, most of the riverbed comprises bare boulder, cobbles and pebble which appears to provide abundant areas for *B. australis*.

Historical records of *B. australis* in the Nive River between 1996 and 2014 occur in the final 3.5 km of the river upstream from Wayatinah Lagoon. The extent of the area surveyed by others is unknown; however, the upper reaches are inaccessible to the public and may not have been previously surveyed. Surveys for the Project covered the entire reach and found low numbers of plants at regular intervals throughout the reach from immediately downstream Liapootah Dam wall to immediately upstream Wayatinah Lagoon. These records support the assessment that suitable habitat is present throughout the reach. Elevated side channel bars near the bottom of the reach contained the highest density of plants where multiple plants were recorded together. Further upstream, the records comprised mainly of well-spaced individual plants. The *B. australis* population in this reach has an upstream seed source from the Nive River upstream Tarraleah Power Station (Figure 4.7; Table 6.14) and the recording of plants a short distance downstream of the spillway suggests that seeds are transported across Lake Liapootah and into the river channel downstream during spill events.

Figure 6.75: Typical reach of the Nive River downstream Liapootah Dam

Figure 6.76: Two *B. australis* (central plants with yellow flowers) growing near each other on a bar in the Nive River a short distance upstream from Wayatinah Lagoon (November 2021)

6.5.2.4 No. 2 Pond dam wall

The incidental discovery of two plants *B. australis* on the dam wall of No. 2 Pond during water quality surveys in 2023 was unexpected. The location on the dam wall is an isolated pocket of small blue metal pebble and cobbles (~10 x 3 m) which have been placed for an unknown reason. The remainder of the 450 m long dam wall comprises large cobble and boulder which is extensively vegetated by grasses. No *B. australis* have been observed elsewhere on the dam wall on numerous visits since it was first observed.

No. 2 Pond is supplied by water from Mossy Marsh Lagoon. The most likely source of the seeds for this location is through transport downstream through Mossy Marsh into No. 2 Pond. A similar mode of seed transport is thought to occur in the population of *B. australis* in the Nive River which are washed down into Wayatinah Lagoon and float onto the spillway which discharges into the River Derwent downstream from the dam (Section 6.5.2.2).

Water enters Mossy Marsh Lagoon from multiple sources including No. 2 Canal which carries water directly from Lake King William via the mini-hydropower scheme; water from Derwent Pumps Weir which is extracted from the upper reaches of the River Derwent downstream Clark Dam; small tributaries of the upper River Derwent intercepted by the canal. Mossy Marsh Lagoon also receives water from Hornes Dam which is supplied by Hornes Creek and Wentworth Creek.

There are no records of *B. australis* in any of the waterways upstream. The upper catchment of the River Derwent (mainstem and tributaries) is an unlikely source. Surveys for the Project indicate that the catchment upstream the Derwent Pumps Weir appears to be unsuitable. Tributaries on the northern/eastern side of the river appear unsuitable as exposed cobble bars are rare and dense riparian vegetation grows to the margin of the channels. Some creeks on the southern/eastern side of the river are larger and occasional cobble bars were observed. However, no *B. australis* were observed in any tributaries or the entire main channel of the river from Clark Dam to Wayatinah Lagoon despite pockets of suitable habitat being present in the main channel.

Satellite and aerial photographs of Wentworth Creek show evidence of exposed gravel bars which appear suitable for *B. australis*.

6.6 Streams within the disturbance footprint

There are few direct construction impacts of the Project on aquatic habitats. Waterways within the disturbance footprint include eleven stream crossings on the tributaries of six small unnamed streams.

Four of the streams are within the disturbance footprint of the headrace pipeline and western portal; one flows through the Paddy's Quarry spoil site; and the one through the disturbance footprint adjacent to Tarraleah Village.

Indirect construction impacts through the elevated influx of fine sediments, nutrients (i.e., nitrates from rock blasting) and pollutants from machinery may impact the watercourses described below and the streams, rivers and lakes downstream from these.

The streams directly within the disturbance footprint were assessed by a visual assessment of habitat during a site visit in September 2024; however, no faunal surveys were undertaken. The assessment of aquatic values in these streams is based on the aquatic surveys undertaken in the rivers potentially impacted by operation of the Project (Derwent and Nive), the habitat observed within the streams and relevant databases (NVA, PMST, and CFEV).

Based on known distributions, the surveys undertaken in the Derwent and Nive Rivers for this Project, and in nearby waterways for other projects, there are unlikely to be any MNES or state listed threatened aquatic species in these streams. Species which are not listed as threatened but are classified as species of conservation significance based on being phylogenetically distinct (platypus), endemic (western Tasmanian freshwater crayfish *Astacopsis tricornis* and a number of endemic species of freshwater macroinvertebrates) are likely to be present in these streams as discussed below.

The macroinvertebrate communities in the streams which are potentially impacted during construction will be sampled prior to and during construction as part of the monitoring plan for the Project (Section 9).

6.6.1 Streams 1-4: Headrace pipeline and western portal (crossings C1-9)

The headrace pipeline alignment crosses nine stream channels, feeding into four unnamed tributaries of the River Derwent (Figure 6.77). Streams 1 to 3 enter the river upstream of the Derwent Pumps Weir, while Stream 4 joins downstream of Derwent Pumps Weir (Figure 6.77). Topographic attributes of the crossings are summarised in Table 6.15.

Baseline water quality sampling of Stream 1 is being undertaken as part of the Project as a representative site for potential impacts from the headrace pipeline (Entura 2025b). Data collected to date indicates that all of the physico-chemical and nutrient parameters being collected are in the range expected for an unimpacted stream in the Upper Derwent Catchment.

Aquatic macroinvertebrates are the most ubiquitous fauna present in all the streams and include flow obligate species in the riffle sections and species suited to edge/backwater habitats in the lower gradient sections. It is likely that the community composition is similar to that recorded at the sites sampled in the River Derwent (Section 6.1.5). Macroinvertebrate sampling will be undertaken in Stream 4 prior to construction and during construction as a monitoring site for potential water quality impacts during the Project. Fishing surveys are planned prior to construction to establish a baseline dataset for fish.

The larger channels (C1, C2, C5, C6 and C9) also provide suitable habitat for platypus (*Ornithorhynchus anatinus*), crayfish (*Astacopsis tricornis*), introduced brown (*Salmo trutta*) and rainbow trout (*Oncorhynchus mykiss*). Native fish which may be present in low numbers include climbing galaxias (*Galaxias brevipinnis*) and short-finned eels (*Anguilla australis*) with the latter only present through occasional stocking of the lakes in the greater catchment. The aquatic macrophyte *Isolepis fluitans* was observed growing in the lower gradient sections of most of the channels

Where the channels flow under No. 1 Canal, they have low gradient culverts which are highly likely to be passable to platypus and all fish species except for Stream 3. Stream 3 has several culverts with high perches in its first ~ 100 m upstream of where it enters the River Derwent which would be unpassable to brown trout but would be passable to eels and climbing galaxias. Platypus and *Astacopsis tricornis* can either climb or walk around instream barriers.

The smaller crossing points (C3, C4, C7, C8 and C11) are on ephemeral drainage lines and offer only temporary aquatic habitat to macroinvertebrates, fish and platypus (Appendix G). *Astacopsis tricornis* are unlikely to occur in first order streams, such as these, which have a low abundance of rocky substrate.

6.6.1.1 Stream 1: crossings C1-3

The disturbance footprint associated with the headrace pipeline's crosses three channels on Stream 1 (Figure 6.77; Table 6.15). Channels C1 and C2 become second-order, likely permanent streams flowing through a mosaic of tea tree (*Leptospermum lanigerum*) scrub, dry eucalypt forest and woodland, and buttongrass moorland. The riparian zone is intact apart from the clearing associated with Butlers Gorge Road and No. 1 Canal. The channels are low gradient and contain alternating rocky and soft sediment substrates (Figure 6.80; Figure 6.81). C3 is a likely an ephemeral channel that offers temporary habitat to aquatic species.

The last crossing point within the disturbance footprint of the headrace pipeline (C3) is in the same setting as C1/C2 but is a much smaller 1st order stream (Figure 6.77; Figure 6.82; Table 6.15). This channel may cease flowing after prolonged dry periods; however, the aquatic macrophyte *Isolepis fluitans* was observed in low gradient sections which suggests that at least areas of pools retain water for most of the year. This channel is likely to offer semi-permanent habitat to a reduced community of aquatic macroinvertebrates and may provide temporary habitat to fish and platypus during periods of higher flows. *Astacopsis tricornis* are unlikely to occur in first order streams which have a low abundance of rocky substrate.

The CFEV Conservation management priority potential (CMPP2) for C1 and C3 (C2 is not mapped in CFEV) is moderate based on medium land security and a low to moderate ICV (Table G.1, Appendix G). Special values mapped for these crossing points[6] included the potential for highland grassy sedgeland (MGH) which is a threatened flora community in Tasmania. However, field surveys for the project determined that MGH is not present in the catchment of the headrace pipeline (Entura 2025a). The final segment of Stream 1 has a very high CMPP2 due to the potential presence of *Eucalyptus rodwayi* forest which is an RFA priority community in Tasmania. *Eucalyptus rodwayi* was recorded in this area during flora surveys for the Project (Entura 2025a).

6.6.1.2 Stream 2: crossings C4-5

There are two headrace pipeline crossing points on Stream 2 (C4/C5) which enters the River Derwent 670 m upstream from Derwent Pumps Weir (Figure 6.77). C4 is small first order drainage line which is likely to be ephemeral (Table 6.15). C5 is only a short distance upstream from where Stream 2 crosses Butlers Gorge Road and is a second order stream with a relatively large catchment area (Table 6.15, Figure 6.83). This stream occurs in a similar riparian setting to Stream 1 but is a higher gradient stream. This stream provides a variety of flow habitats with boulder, cobble and pebble substrates in riffle habitat and pebble and gravels and coarse sands in the lower gradient runs. There are no culverts on Stream 2 and there are variety of channel forms, undercut banks, flow habitats (riffle, runs and pools) and substrates (boulder to soft substrates) that provide diverse habitats for aquatic macroinvertebrates, macrophytes, fish, platypus and *A. tricornis*.

The CFEV classifications for naturalness appear to be incorrect for C4 and C5 with both assessed as significantly altered from natural condition whereas both appear to be mostly in natural condition. As a result, the CMPP2 rates for these crossing is moderate (C4) and low (C5) (Table G.1, Appendix G). By contrast the final segment of Stream 2 has a high naturalness score which contributes to the very high CMPP2 classification in addition to the mapping of *Eucalyptus rodwayi* forest which was verified as present in this area during flora surveys for the Project (Entura 2025a).

[6] Other than platypus which are mapped as potentially present for all stream sections in Tasmania.

6.6.1.3 Stream 3: crossing C6

There is one headrace pipeline crossing point (C6) on the main branch of Stream 3 which enters the River Derwent a few meters upstream from Derwent Pumps Weir (Figure 6.77). This third order stream has similar instream habitat to the last segment of Stream 2 (Table 6.15; Figure 6.84). There are a series of steep piped culverts from immediately upstream its entry to the River Derwent and Butlers Gorge Road. All the culverts have a perched drop of between 0.3 to 0.5 m from the end of the culvert to the stream bed below. It is likely that these are impassable barriers to brown trout. Native climbing galaxiids, if present, and short finned eels, would be able to pass through or around these culverts. Within the reach crossed by the headrace pipeline, the aquatic community would comprise macroinvertebrates and *Astacopsis tricornis* and potentially platypus, climbing galaxias and short-finned eels.

Despite the low naturalness score (which does not appear to be correct), the CFEV database gives C6/Stream 3 a high CMPP2 because of the mapping of *Eucalyptus rodwayi* forest and highland grassy sedgeland (Table G.1, Appendix G). As discussed above, highland grassy sedgeland is not present in the vicinity of the headrace pipeline.

6.6.1.4 Stream 4: crossings C7-9

The disturbance area of the headrace pipeline and western portal crosses the main branch of Stream 4 (C7) and two minor drainage lines (C8-9) (Figure 6.77) with the main branch dissecting the proposed western portal work site and spoil emplacement area. Stream 4 is a small second order stream (Table 6.15; Figure 6.85). The main branch may have permanent flow; however, the drainage lines are ephemeral. On the day of the site visit, C9 was barely flowing, despite high rainfalls in the preceding week, and the creek bed was not particularly distinct from the surrounding land (Figure 6.86). The main branch of the creek in the vicinity of the western portal is a low gradient channel dominated by fine sediments within a moorland, sedgeland and rushland setting. Higher gradient, rocky habitats are present downstream from the road running alongside the Derwent Pumps Pipelines, and associated road, to its juncture with the River Derwent a short distance downstream from Derwent Pumps Weir.

The steep section of this creek immediately upstream from its junction with the River Derwent may be impassable to brown trout. The aquatic values described for Stream 3 are likely to be present in Stream 4, although most of the habitat is probably sub-optimal for *Astacopsis tricornis* due to the dominance of fine substrates.

Stream 4 is not mapped as a stream layer by CFEV but is likely to have been classified similarly to Stream 3 (Table G.1, Appendix G).

6.6.2 Stream 5: Surge facility and Paddy’s Quarry spoil emplacement area (crossing C10)

The proposed site of the surge facility and Paddy’s Quarry portal and spoil emplacement area crosses the main branch of Stream 5 (C10) which is a third order tributary of the Nive River (Figure 6.78). The riparian zone of wet eucalypt forest and woodland and *Acacia dealbata* forest has already been partially cleared within the existing quarry. The stream through Paddy’s Quarry is a high gradient reach characterised by riffle and run habitats dominated by cobble, pebble and gravel substrates (Figure 6.87). Downstream from Paddy’s Quarry, the creek descends through a very steep river valley for 750 m before entering the Nive River 2.4 km upstream from Tarraleah Power Station.

The lower reaches of this stream contain marked waterfalls which would be impassable to brown trout. The main aquatic values in the vicinity of Paddy's Quarry would be macroinvertebrates, *Astacopsis tricornis* and platypus. Climbing galaxias and short-finned eels may also be present.

Crossing 10 and the last segment of Stream 5 have a high CMPP2 due to the combination of high naturalness scores, moderate (C10) to high (base of Stream 5) ICV scores and a medium land security rating (Table G.1, Appendix G).

Macroinvertebrate sampling will be undertaken in Stream 5 prior to construction and during construction as a monitoring site for potential water quality impacts during the project. Fishing surveys will also be undertaken to establish a baseline dataset for fish.

6.6.3 Stream 6: Tarraleah Village (crossing C11)

Tarraleah Village lies across a drainage line of Stream 6 which is a tributary of Wilsons Creek and the Nive River (Figure 6.79). The drainage line runs through a cleared paddock and provides no aquatic habitat (Figure 6.88). A small, piped culvert runs under Oldina drive and discharges into Stream 6 which flows for approximately 1.5 km before entering Wilsons Creek. Wilsons Creek flows for another 1.5 km before entering Lake Liapootah.

Stream 6 shows signs of eutrophication with an extensive biomass of filamentous algae observed during the site visit. There is minimal riparian vegetation as is flows past the sewage treatment ponds and the channel substrate is mainly comprised of gravels, coarse sands and fines. Stream 6 becomes progressively steeper before entering Wilsons Creek which is very steep as it descends the valley towards Lake Liapootah. Macroinvertebrates are likely to be the main aquatic values in Stream 6.

Wilsons Creek has an intact riparian zone on along its northern bank and logging coups along its southern bank. It is likely that logging activities have impacted aquatic habitats in Wilsons Creek.

CFEV gives Stream 6 a medium CMPP2 due to a combination of low land security, moderate ICV and medium naturalness score. The naturalness score attributed to this site is incorrect, the stream is severely altered from natural condition. Wilsons Creek has a very high CMPP2 due to low land tenure security and high ICV due to the presence being mapped as a Palaeobotanical site 9 Table G.1, Appendix G).

6.6.4 Wetlands within the disturbance footprint

CFEV maps five wetlands within the disturbance footprint of the headrace pipeline and western portal and two wetlands adjacent to the upstream and downstream end of Mossy Marsh Lagoon. However, TASVEG (4.0) does not map any of these areas as wetlands. Flora surveys for the Project identified the areas within headrace pipeline and western portal as eastern buttongrass moorland (TASVEG 4.0: MBE) and the areas adjacent to Mossy Marsh Lagoon as *Leptospermum lanigerum* scrub (TASVEG 4.0: SLL) (Entura 2025a).

The only wetland present within the disturbance footprint is the *Sphagnum* peatland community (TASVEG 4.0: ASP) adjacent to Mossy Marsh Lagoon. The *Sphagnum* community is discussed in Entura 2025a.

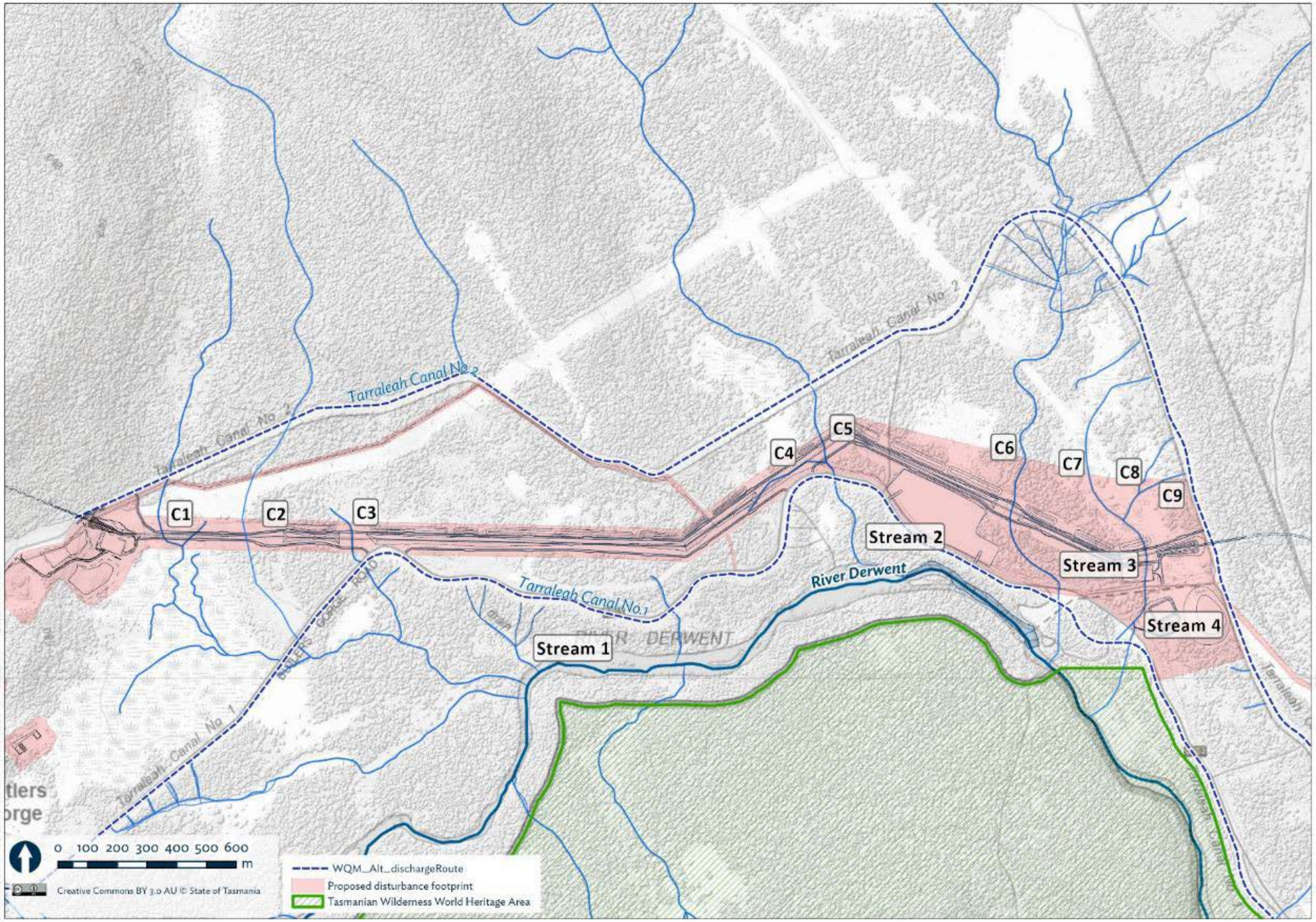

Figure 6.77: Streams 1-4 and crossings C1-9 in relation to the headrace pipeline disturbance footprint (red shading).

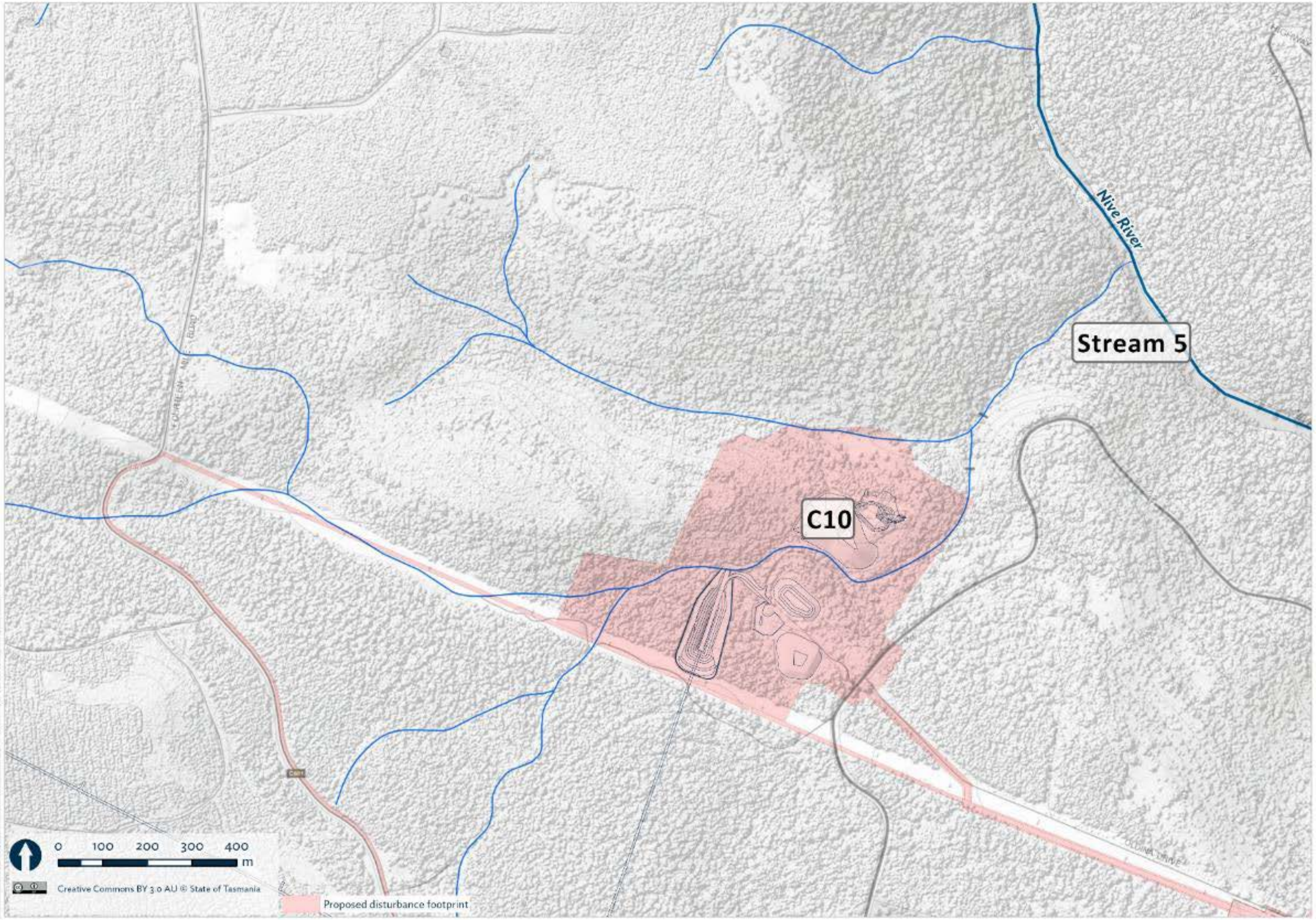

Figure 6.78: Stream 5 and crossing C10 in relation to the proposed Paddy's Quarry portal and spoil emplacement site (red shading).

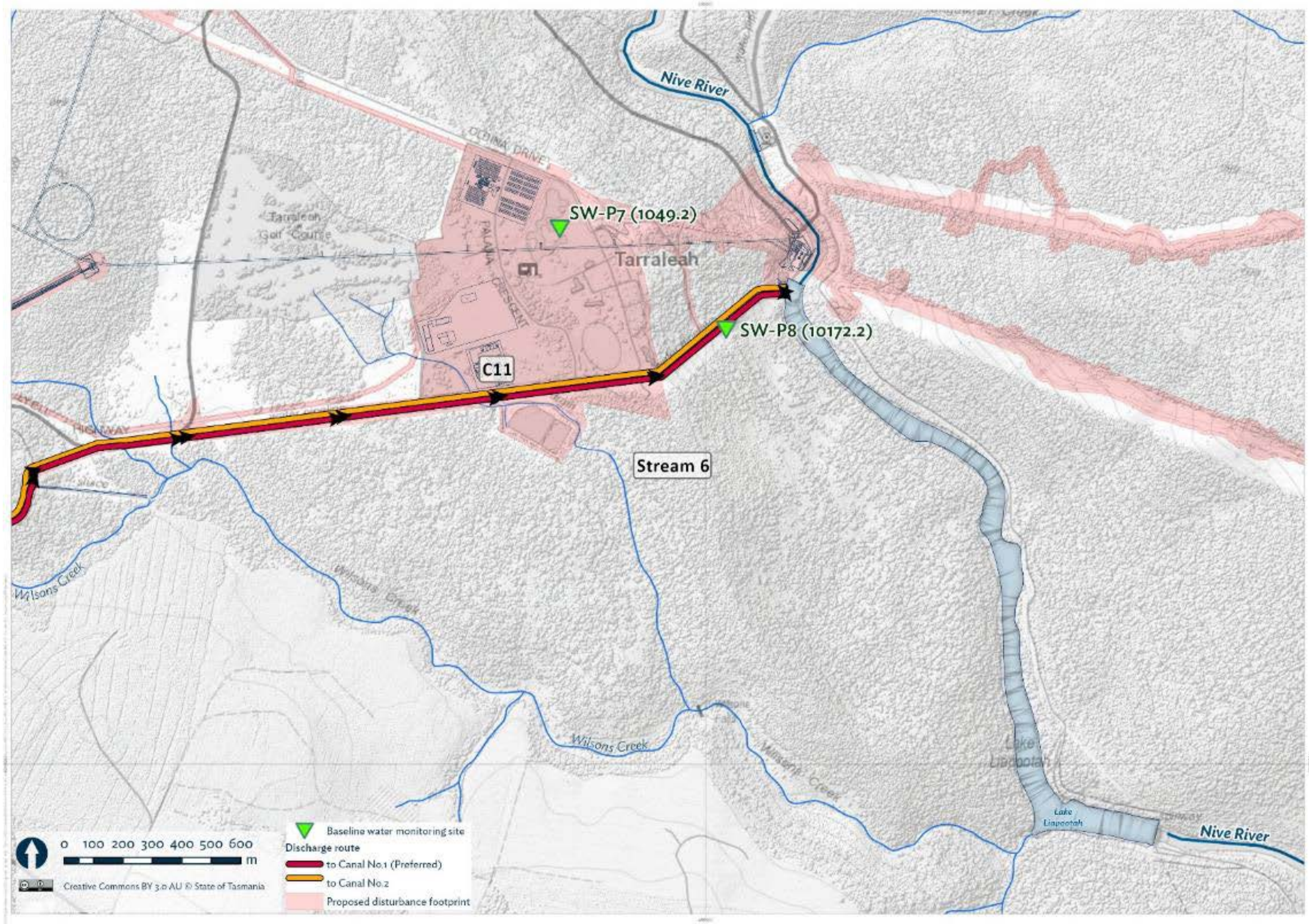

Figure 6.79: Stream 6 and crossing C11 in relation to Tarraleah Village and the power station site (red shading)

Table 6.15: Topographic features of the stream crossing points within the disturbance footprint of the Project.

Infrastructure	Stream	Crossing point/*base of stream*	Strahler stream order	Slope (rise/run)	Catchment area (km²)	Comments
Headrace pipeline	Stream 1	C1	2	0.005	3.6	Permanent stream
		C2	2	0.005	1.7	
		C3	1	0.029	0.08	Ephemeral drainage line
		Stream 1 (last reach)	*3*	*0.008*	*4.0*	*Permanent stream entering the River Derwent*
	Stream 2	C4	1	0.04	0.08	Ephemeral drainage line
		C5	2	0.01	17.4	Permanent stream
		Stream 2 (last reach)	*2*	*0.02*	*18.0*	*Permanent stream entering the River Derwent*
	Stream 3	C6	3	0.01	12	Permanent stream
		Stream 3 (last reach)	*3*	*0.02*	*12.6*	*Permanent stream entering the River Derwent*
	Stream 4	C7	1	0.005	0.36	Ephemeral drainage lines
		C8	1	0.03	0.22	
		C9	1	0.05	0.16	Likely permanent stream
		Stream 4 (last reach)	*2*	*0.06*	*1.2*	*Permanent stream*
Surge facility; Paddy's Quarry spoil	Stream 5	C10	3	0.06	4.4	Likely to be a flowing channel
		Stream 5 (last reach)	*3*	*0.23*	*5.6*	*Permanent stream entering the Nive River*
Tarraleah Village, Road crossing	Stream 6	C11	2	0.02	0.7	Ephemeral drainage line
		Wilsons Ck (last reach)	*3*	*0.15*	*9.5*	*Permanent stream entering the Nive River*

a.	b.
	

Figure 6.80: Branch of Stream 1 downstream from Crossing 1: a) upstream Butlers Gorge Road and b) downstream No.1 Canal.

a. b.

Figure 6.81: Branch of Stream 1 downstream from Crossing 2: a) upstream Butlers Gorge Road and b) downstream No.1 Canal.

a.	b.
	

Figure 6.82: Branch of Stream 1 downstream from Crossing 3: a) upstream Butlers Gorge Road and b) downstream No.1 Canal.

a.	b.
	

Figure 6.83: Branch of Stream 2 downstream from Crossing 4 & 5 a) upstream and b) downstream Butlers Gorge Road.

a.	b.

Figure 6.84: Branch of Stream 3 downstream from Crossing 6 a) upstream and b) downstream No.1 Canal.

a.	b.
	

Figure 6.85: Branch of Stream 4 downstream from crossings 7, 8, 9; a) upstream Butlers Gorge Road; and b) downstream from No. 1 Canal.

a.	b.
	

Figure 6.86: Branch of Crossing 9 downstream from No. 2 Canal.

Figure 6.87: Branch of Crossing 10 through Paddy's Quarry (Stream 5).

a.	b.
	

Figure 6.88: Crossing 11 (a), a tributary of Wilsons Creel (Stream 6) and further downstream (b) showing a straightened channel with evidence of eutrophication.

7. Impact assessment – construction

Potential water quality impacts from the construction sites and construction activities include increased turbidity, changes in pH, elevated concentrations of metals, hydrocarbon contamination and nitrate and ammonium (Entura 2025b). These potential impacts would be greatest in the direct vicinity of the disturbance area but may also impact the downstream receiving waterways which include the River Derwent and Nive River, Mossy Marsh, No. 2 and No. 1 ponds, Lake Liapootah and Wayatinah Lagoon.

The potential sources of pollutants may impact aquatic values as summarised below:

- **Fine sediments**: high inputs of fine sediments are known to degrade aquatic habitats and impact aquatic species in running waterways by smothering surface and interstitial spaces which reduces habitat suitability for many macroinvertebrates families, reduces the productivity of benthic algae, potentially clogs the gills of fish and macroinvertebrates and reduces the abundance of macroinvertebrate prey for predatory macroinvertebrates and platypus.
- **Hydrocarbons** can be directly toxic to aquatic species, result in oxygen depletion, bind to sediments to impact habitat suitability or directly smother habitats, alter water chemistry, disrupt food webs and biodiversity.
- **pH**: rapid and significant increases in pH can stress or kill aquatic species, impact biological functioning, promote algal blooms, increase the bioavailability of metals or reduce the availability of nutrients to aquatic plants.
- **Nitrates**: very high nitrate concentrations can impact aquatic species through behaviour, physiology, increased susceptibility to other stressors or direct mortality. Small increases in nitrate concentrations can lead to eutrophication which may also impact communities/ecosystems by altering the structure of food webs.
- **Metals**: elevated metals, particularly dissolved metals, can be directly toxic to aquatic life but the potential for high concentrations of any metals from the construction area is assessed as low.

The following impact assessments are provided for construction of the Project with and without the proposed mitigation measures in place.

7.1 Streams directly within the disturbance footprint

The water quality assessment determined a high potential for construction impacts on water quality in Streams 1 – 6. Erosion and sedimentation impacts are a potential for all the streams, while release of hydrocarbons and metals was assessed as a low to moderate risk (Entura 2025b). The sites with the highest potential for water quality impacts are Stream 4 which drains the area of the Western Portal and Stream 5 which drains the spoil emplacement area at Paddy’s Quarry. Streams 4 and 5 were assessed as having a high potential for elevated pH and elevated nitrates and ammonia.

Overall, if left unmitigated it is likely that decreased water quality, in particular elevated levels of fine sediment, would degrade aquatic habitats in these streams and would impact populations of aquatic macroinvertebrates, *Astacopsis tricornis*, platypus and potentially climbing galaxias.

In Streams 4 and 5, estimates of peak (~20 – 30 mg/l) and median nitrate levels indicate values which are at chronic toxicity levels for some freshwater aquatic species (NIWA 2013). The level of risk is dependent on the length of exposure and the tolerance of the species (NIWA 2013).

However, implementation of the Water Quality Management Plan (WQMP) will minimise the potential water quality impacts (Entura 2025b). The WQMP will include an Erosion and Sediment Control Plan (ESCP) and a Nitrate Management Plan (NMP). Overall, elevated inputs of sediments and nitrates and elevated pH are not expected to occur during construction and the ecology of Streams 1 to 6 are expected to remain in similar condition to current.

Preconstruction and construction monitoring for macroinvertebrates and benthic algae in Streams 4 and 5 will form part on the monitoring plan for the Project (Section 9.1).

7.1.1 Listed values

The only listed values associated with the waterways and riparian communities within and surrounding the Project area are the terrestrial plant species, *Barbarea australis*, *Westringia angustifolia, Muehlenbeckia axillaris* and *Pherosphaera hookeriana* (Mount Mawson Pine). Any construction impacts to water quality have no potential to impact these species.

Barbarea australis was recorded within the disturbance footprint for the Project on the dam wall of Tarraleah No. 2 Pond and in the Nive River near the proposed transmission line. Mitigation measures to protect these populations during construction are discussed in (Section 5.1.4 in Entura 2025a).

7.1.2 Species of conservation significance and general aquatic values

Aquatic species of conservation significance recorded include platypus, *A. tricornis* and 24 species of macroinvertebrates. The streams within the disturbance footprint would all contain at least a subset of the macroinvertebrate species classed as species of conservation significance. *Astacopsis tricornis* and platypus are also likely to be present in at least the downstream reaches of these streams. General natural aquatic values include other invertebrate species, short-finned eels (only present through stocking) and potentially climbing galaxias.

Without mitigation it is likely that construction would reduce the habitat suitability in these streams for many species and there is a potential for mortality of some individuals/species through smothering by fine sediments, toxic levels of nitrates and hydrocarbons or large elevations in pH.

With implementation of the WQMP (Entura 2025b), water quality impacts are predicted to be low. Elevated nitrates potentially pose the largest impacts at Stream 4 and 5; however, nitrate levels are predicted to remain similar to background levels with implementation of the Nitrate Management Plan (Entura 2025b). Therefore, construction is expected to have no impacts to species of conservation significance in Streams 1 – 6.

7.2 Water courses downstream from the disturbance footprint

7.2.1 River Derwent downstream Clark Dam and Wayatinah Lagoon

Poor water quality may also impact species of conservation significance and general values in the receiving waterways. For example, estimates of nitrate concentrations in the River Derwent in the absence of mitigation, at the Western Portal site, were made based on a conservative low base flow for the River Derwent (Entura 2025b). Peak nitrate loads in the River Derwent during Years 2 and 3 of construction are estimated to be > 2 mg/L with a median concentration of up to 0.29 mg/l and above the Upper Derwent SMD DGV 95th percentile value of 0.073 mg/L. Existing background nitrate concentration in the River Derwent are around 0.04 mg/L at Derwent above Wayatinah) and above the Upper Derwent SMD DGV 80th %ile (0.020 mg/L) and 95*th* %ile values (0.073 mg/L).

Nitrate concentrations of approximately 2 mg/L are approaching levels which are chronically toxic to some of the invertebrate species which are most sensitive to nitrates (based on the toxicological studies which are available in the literature). The level of risk is dependent on the length of exposure but many consecutive days at this peak level are likely to be required before toxicity could occur. Note that the estimates provided are based on modelled flow data at a site close to where Stream 4 enters the River Derwent. Increasing flow levels with distance downstream would further dilute nitrate concentrations.

The inflow of the Counsel River and Beech Creek and other smaller tributaries, significantly increase the flow regime in the final third of this reach such that dilution levels are highly likely to reduce nitrate levels to below the upper Derwent SMD DGV 95th percentile value of 0.073 mg/L. Further dilution would occur when the River Derwent enters Wayatinah Lagoon.

With implementation of the WQMP, there are expected to be minimal impacts to the water quality of the streams entering the River Derwent including minimal increases in nitrate levels in Stream 4 (Entura 2025b). Therefore, there are not expected to be any impacts to species of conservation significance, or general aquatic values, in the River Derwent or Wayatinah Lagoon resulting from poor water quality from the construction areas.

7.2.1.1 TWWHA: River Derwent downstream of Clark Dam to Wayatinah Lagoon

Potential construction impacts to the TWWHA are the same as those discussed above for species of conservation significance, and general aquatic values in the reach of the River Derwent downstream of Derwent Pumps Weir (Section 7.1.2). With implementation of the of the WQMP, construction of the Project is expected to have no impact on aquatic values in the TWWHA.

7.2.2 Nive River and Lake Liapootah

In the absence of mitigation estimates of nitrate concentrations have been estimated as follows (Entura 2025b):

- Where Stream 5 enters the Nive River approximately 2.2 upstream from the Tungatinah tailrace and 2.8 km upstream from Tarraleah Tailrace:
    - Peak nitrate concentrations in the Nive River during Year 2 are estimated to be > 2 mg/L, with a median concentration of up to 0.75 mg/l. These values are greater than existing background nitrate concentrations in the Nive River (median around 0.009 mg/L) and above the Upper Derwent SMD DGV 80th percentile (0.020 mg/L) and

95th percentile values (0.073 mg/L). Nitrate concentrations > 2 mg/L approach those which are chronically toxic for some species if maintained over long periods.

- Downstream from the Tarraleah Tailrace (2.8 km downstream from where Stream 5 enters):
  - Peak values below the tailrace in Year 2 are estimated to be > 0.04 mg/L, 2 % of the time and within the Upper Derwent SMD DGV 95*th* percentile value. Median nitrate concentrations in Year 2 as a result of works at Paddy's Quarry is estimated to be below 0.005 mg/L ,98% of the time. This concentration is below the existing background nitrate concentration in the Nive River (median concentration 0.007 mg/L at Nive River downstream of Tarraleah Power Station) and the Upper Derwent SMD DGV 80*th* percentile and 95*th* percentile values.

With implementation of the nitrate management plan Stream 5 is not predicted to deliver elevated nitrates to the Nive River upstream of Tungatinah.

Modelling of nitrate concentrations in the Nive River below the Tarraleah Tailrace has been undertaken to show the potential impact over the construction period and takes into consideration the inputs from all work sites. This modelling indicates that sufficient dilution is possible within the Nive River to maintain concentrations at levels within the 80*th* percentile DGV (0.020 mg/L) for the majority of time with only a minor (low) potential to exceed the 95*th* percentile concentration (0.073 mg/L) (Entura 2025b).

Nitrate concentrations would be further diluted when the Nive River joins Lake Liapootah. Overall, Water quality impacts from construction of the Project is predicted to have no impact on species of conservation significance, or general aquatic values, in the Nive River or in Lake Liapootah.

7.3 Other associated waterways

Options outlined in the WQMP (Entura 2025b) for discharging site water include the No. 1 and No. 2 Canals and the Nive River. No. 2 Canal discharges into Mossy Marsh Lagoon, No. 2 Pond, and No. 1 Pond before it enters the Tarraleah Power Station and the Nive River. Nitrate levels would be significantly diluted in the canals and then diluted further through the ponds. No species of conservation significance are likely to be present in the canals but macroinvertebrates, platypus and *A. tricornis* are highly unlikely to be impacted in Mossy Marsh Pond from site water that is discharged from the canals.

8. Impact assessment - operation

8.1 Flow regime: River Derwent downstream Clark Dam to Wayatinah Lagoon

Predicted to change to the flow regime and geomorphological changes which result from this are discussed first as these would drive impacts to the ecological character of the TWWHA, habitat for *Barbarea australis* and to general ecological values.

Note that in this section the description of reductions in the flow regime are presented prior to implementation of proposed flow mitigation (Section 9).

This section does not compare the duration of spill events under the different cases as the spill routing derived from the PLEXOS simulation creates a high level of uncertainty for the duration of spill events (Section 4.3.3). However, the duration of spill events for the current flow regime is reliable data because it is based on actual flow records and these were used when developing the proposed flow mitigation (Section 9).

8.1.1 Clark Dam to Derwent Pumps Weir (6 km reach)

The model outputs at *DS Clark Dam 3* indicate that operation of the Project would reduce all elements of the flow regime compared to the cases for BAU and baseline operation (Figure 8.1; Table 8.1). The peak and high flow regime are similar for the BAU and baseline operation, however, for the Project peak flows are predicted to be approximately halved, and the high flow regime substantially reduced (Figure 8.1; Table 8.1). The modelling also indicates that the Project would reduce the fresh, median and baseflow regime (Figure 8.1; Table 8.1). The reduction in small spills during the Project would mainly occur because Butlers Gorge Power Station would no longer be operating and therefore the small spills over Butlers Weir which currently occur when power station's discharge exceeded the capacity of No. 1 Canal, would be absent.

As discussed in Section 6.1.2, most of the peak and high flow regime in this upper reach is derived from spill from Clark Dam because the tributary inflows are minor. The reduction in fresh to baseflow magnitude flows indicates that the Project would reduce the frequency and magnitude of spills entering this reach. This pattern is repeated at *DS Clark Dam 4,* a further 1.5 km downstream and immediately upstream Derwent Pumps Weir (Appendix D.2).

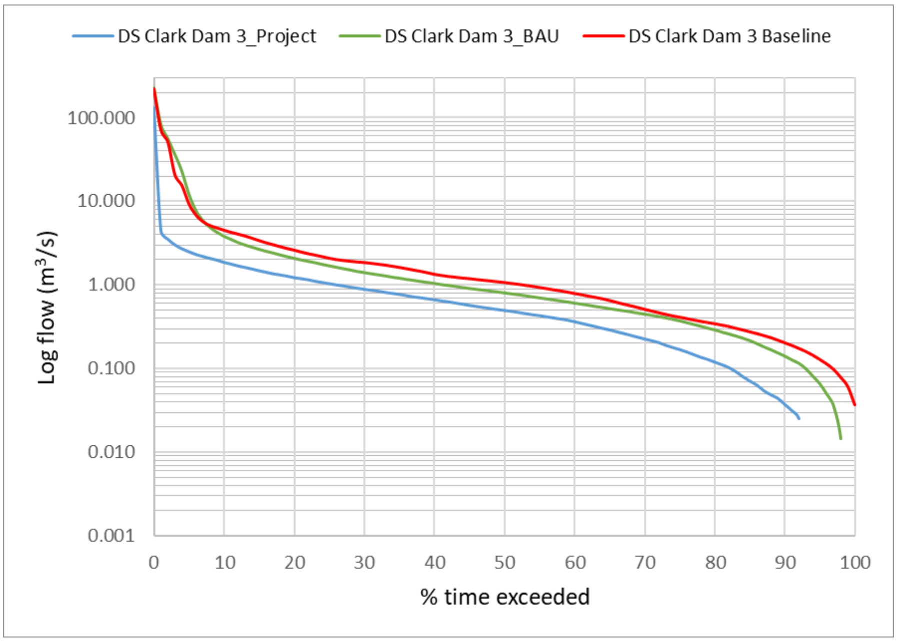

Figure 8.1: Flow duration curve (log) for the River Derwent 4.5 km downstream Clark Dam (*DS Clark Dam 3*) for baseline operation (2007 to 2022) and, BAU and operation of the Project (2029 to 2044).

Table 8.1: Flow statistics for the River Derwent 4.5 km downstream Clark Dam (*DS Clark Dam 3*) for baseline operation (2007 to 2022) and, BAU and operation of the Project (2029 to 2044).

Flow regime category	Flow percentile/statistic	Baseline (modelled)	BAU (modelled)	Project (modelled)
		m^3/s		
Peak	Maximum flow in record	218.8	225.1	130.7
	Mean annual maximum flow	83	114	43
	Q1	70.8	82.1	4.4
High	Q5	9.2	12.1	2.5
	Q10	4.5	3.8	1.9
Fresh	Q20	2.6	2.1	1.2
	Q30	1.84	1.41	0.89
Median	Q50	1.06	0.81	0.50
Baseflow	Q80	0.34	0.29	0.12

8.1.2 Derwent Pumps Weir to Counsel River (TWWHA)

This reach is the start of the River Derwent within the TWWHA and is the reach most effected by current operation as tributary inflows are minor until the Counsel River joins (Section 6.1.2.3).

Modelling of the Project case shows spills immediately downstream Derwent Pumps Weir (*DS Derwent Pumps 1*) would occur for 12 percent of the time, compared to 38 percent of the time for the observed baseline and 23 percent of the time for BAU (Figure 8.2; Table 8.2). Peak flows are also reduced for the Project case, for example the mean annual maximum flow for the Project would be 45 m^3/s compared to a mean annual maximum flow of 78 m^3/s for the observed baseline and 114 m^3/s for BAU (Table 8.2). The Q1 flow (i.e. the flow which is only exceeded for one percent of the time) of 8.5 m^3/s for the Project, is 8 to 10 times less than the observed baseline and BAU (Table 8.2). The high and fresh regime would also be reduced compared to the baseline and BAU (Table 8.2). Median and baseflow regimes are absent from this reach under the baseline operation, BAU and the Project (Figure 8.2). Section 8.1.4 provides further analysis of the change in pattern of large flow events.

As discussed, the modelling indicates that tributary inflows return a permanent baseflow to the river by 5 km downstream Derwent Pumps Weir (*DS Derwent Pumps 2*) with minor additional tributary inflows in the reach a further 11 km downstream and immediately upstream of the Counsel River inflow (*DS Derwent Pumps 3*) (Section 6.1.2.3). The median and low flow regime under the Project case would remain equivalent to that for baseline operation and BAU (Figure 8.3 and Table 8.3). However, the peak, high and fresh regime would be substantially altered by the Project, particularly the maximum flow regime where the Project would reduce:

- the mean annual maximum flow by approximately two thirds
- the Q1 flow by 5 to 6-fold.

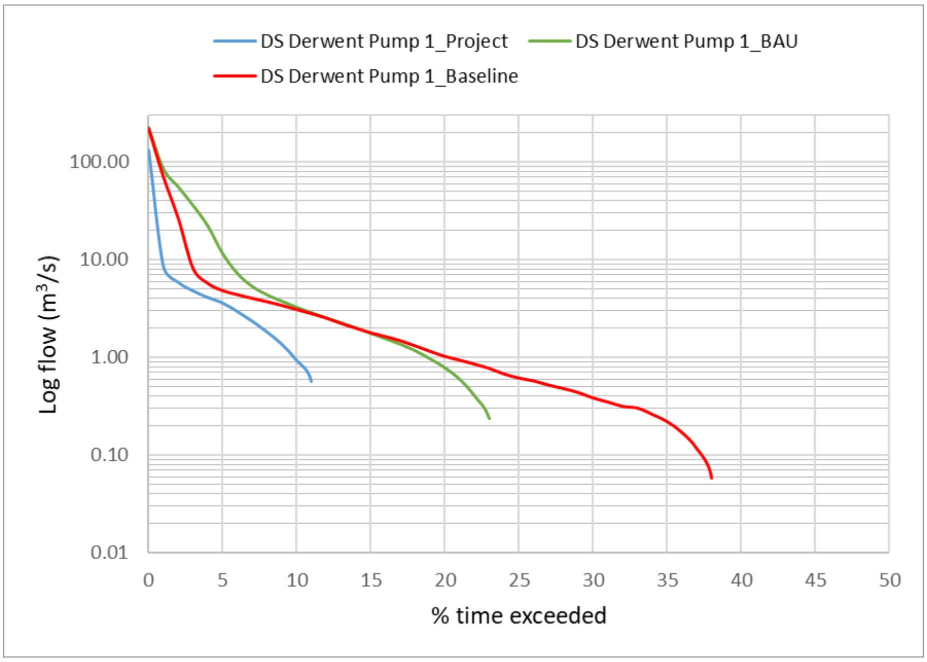

Figure 8.2: Flow duration curve (log) for the River Derwent immediately downstream Derwent Pumps Weir (*DS Derwent Pumps 1*) for baseline operation (observed data, 2007 to 2022) and, BAU and operation of the Project (2029 to 2044).

Table 8.2: Flow statistics for the River Derwent immediately downstream Derwent Pumps Weir (*DS Derwent Pumps 1*) for baseline operation (observed data, 2007 to 2022), BAU and operation of the Project (2029 to 2044) .

Flow regime category	**Flow percentile/statistic**	**Baseline (observed)**	**BAU (modelled)**	**Project (modelled)**
			m³/s	
Peak	Maximum flow in record	222.5	224.2	132.7
	Mean annual maximum flow	82	114	41
	Q1	70.5	84.1	8.5
High	Q5	4.8	11.4	3.6
	Q10	3.1	3.2	0.9
Fresh	Q20	1.0	0.8	0.00
	Q30	0.4	0.00	0.00
Median	Q50	0.00	0.00	0.00
Baseflow	Q80	0.00	0.00	0.00

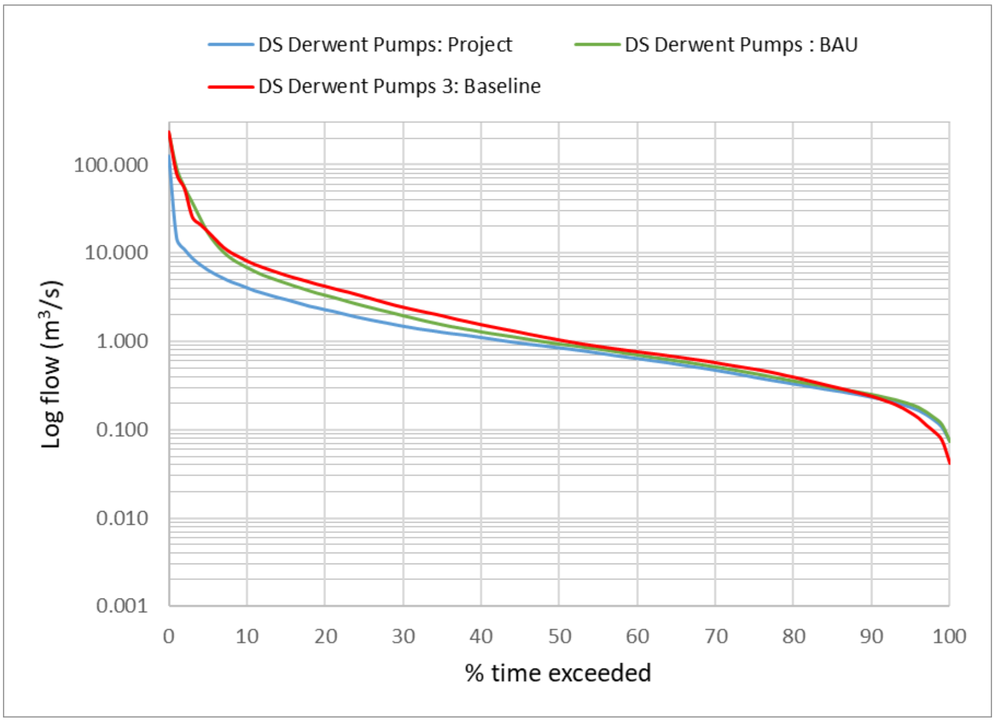

Figure 8.3: Flow duration curve (log) for the river immediately upstream the Counsel River inflow (*DS Derwent Pumps 3*) for baseline operation (2007 to 2022) and, BAU and operation of the Project (2029 to 2044).

Table 8.3 Flow statistics for the river immediately upstream the Counsel River inflow (*DS Derwent Pumps 3*) for baseline operation (2007 to 2022), BAU and operation of the Project (2029 to 2044).

Flow regime category	Flow percentile/statistic	Baseline (modelled)	BAU (modelled)	Project (modelled)
		m³/s		
Peak	Maximum flow in record	233	225	124
	Mean annual maximum flow	100	112	32
	Q2	81	90	14
High	Q5	17.5	16.8	6.1
	Q10	8.0	6.8	3.8
Fresh	Q20	4.1	3.3	2.2
	Q30	2.4	2.0	1.4
Median	Q50	1.00	0.94	0.84
Baseflow	Q80	0.38	0.36	0.33

8.1.3 Counsel River inflow to Wayatinah Lagoon (TWWHA)

The patterns described in the preceding section for the sites upstream are repeated for the three sites downstream the Counsel River (*DS Derwent Pump 4*, *DS Derwent Pump 5* and *DS Derwent Pump 6*). (Figure 8.4; Table 8.4; Appendix D.4).

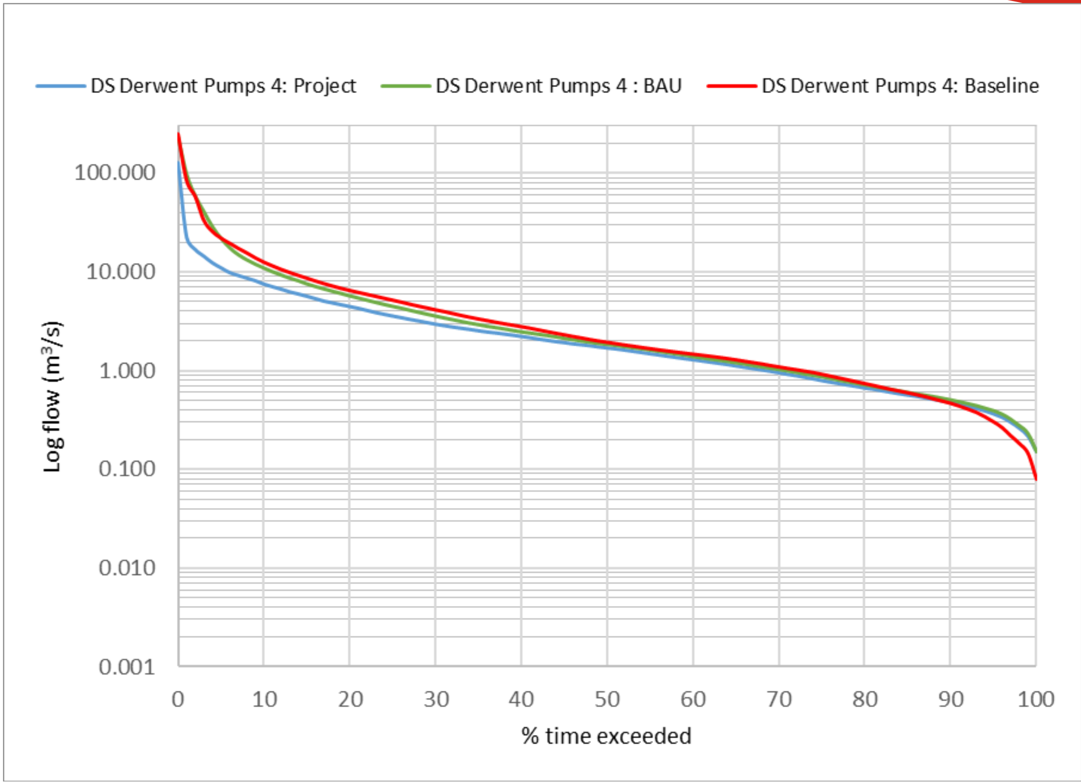

Figure 8.4: Flow duration curve (log) of the whole modelled record for the River Derwent immediately downstream the Counsel River inflow (*DS Derwent Pumps 4*) for baseline operation (2007 to 2022) and, BAU and operation of the Project (2029 to 2044).

Table 8.4: Flow statistics for modelled data for the for the River Derwent immediately downstream the Counsel River inflow (*DS Derwent Pumps 4*) for baseline operation (2007 to 2022) and, BAU and operation of the Project (2029 to 2044).

Flow regime category	**Flow percentile/statistic**	**Baseline (modelled)**	**BAU (modelled)**	**Project (modelled)**
			m³/s	
Peak	Maximum flow in record	247	233	129
	Mean annual maximum flow	116	117	39
	Q1	83	96	22
High	Q5	21.9	21.6	11.0
	Q10	12.5	10.8	7.5
Fresh	Q20	6.5	5.6	4.4
	Q30	4.1	3.5	2.9
Median	Q50	1.94	1.82	1.68
Baseflow	Q80	0.74	0.71	0.66

8.1.4 Changes in peak flows

Figure 8.5 shows the mean annual maximum flow data for each modelled flow site along the River Derwent for baseline operation, BAU and the Project from Clark Dam to Wayatinah Lagoon. While peak flows are generally increased by the tributaries downstream[7] (Section 6.1.2), the pattern of the peak events at the site immediately downstream Derwent Pumps Weir are repeated at all sites. Figure 8.5 (as discussed in Section 6.1.2.2) demonstrates that most of flow contribution to peak events occurs from spill from Clark Dam rather than tributary inflows.

The site immediately downstream Derwent Pumps Weir (*DS Derwent Pumps 1*) was selected as the focus for this assessment because:

- There is an observed record for this location (baseline);
- It is the beginning of the River Derwent within the TWWHA and reaches where there is potential habitat for the MNES riparian plant species *Barbarea australis* (Section 6.5.2.1);
- The limitations on representation of peak flows (i.e. tributary inflows modelled using daily data rather than sub daily, see Section 4.3.3 for further explanation) for the modelled future operation scenarios are insignificant for sites close to Clark Dam because the contribution of tributaries is minor in the upper reaches (Section 4.3.3).

The mean annual maximum flow downstream Derwent Pumps Weir would be approximately halved during operation of the Project (41 m^3/s) compared to baseline operation (Figure 8.6). While Figure 8.6 indicates the overall trend for reduced peak flows during the operation of the Project, there is considerable variation in peak flows from year to year for both observed and modelled records (as indicated by the large standard deviation bars in Figure 8.6):

- For the observed record the minimum annual maximum flow was 7 m^3/s; the maximum was 223 m^3/s; and the median was 58 m^3/s;
- For BAU, the minimum annual maximum flow was 12 m^3/s; the maximum was 224 m^3/s; and the median was 100 m^3/s;
- For the Project, the minimum annual maximum flow was 3 m^3/s; the maximum was 133 m^3/s; and the median was 35 m^3/s.

The mean annual maximum flow is higher for BAU case compared to baseline operation (Figure 8.6). This difference could be because the BAU case is modelled to operate in a future market where peaking operation is more prevalent. That is, the assumptions in the model for managing storages for peaking operation in the BAU case results in more water being retained in Lake King William leading up to periods when peaking operation is most valuable. The modelling suggests that operating in this way results in more frequent moderate to large spills from Clark Dam than currently occurs. The subsequent loss of generation at Tarraleah Power Station due to spills at Clark Dam would be relatively minor compared to managing the Lake King William for peaking operation when energy prices are high.

[7] Routing of spill events for the modelling of Project redevelopment between DS Derwent Pumps 1 and 3 results in small attenuation of the peak of large spills with distance downstream, contribution of larger tributary inflows from DS Derwent Pumps 4 onwards masks this effect.

8.1.4.1 Number and timing of large events

Two flow thresholds were chosen for an event analysis of peak flow events which pass Derwent Pumps Weir with the threshold based on the hydraulic analysis of flow thresholds required to move different sediment size classes:

- 60 m^3/s flow events are, on average, important for mobilising substrate up to the margins of the channel (discussed in Section 8.1.7);
- 100 m^3/s events which increase the mobilisation of larger substrates (up to small boulders), mobilise the smaller substrate beneath them, and potentially to scour perennial terrestrial plants from the channel. Together these large events are likely important to maintain the areas where the channel remains active;
- There were 14 flow events ≥ 60 m^3/s and nine events ≥ 100 m^3/s over the 16 years of observed baseline records (Table 8.5; Figure 8.7). The modelled Project case predicts five events ≥ 60 m^3/s and two events ≥ 100 m^3/s over the 16-year modelled record. Under baseline operation, an event ≥ 60 m^3/s occurred on average every second year and the greatest number of consecutive years when no event ≥ 60 m^3/s occurred was three. For the Project, an event ≥ 60 m^3/s only occurred in three of the 16-year modelled record and the longest gap between events was seven years;
- Large spill events would be more frequent under BAU than either baseline operation or the Project, with 38 events ≥ 60 m^3/s and 14 events ≥ 100 m^3/s over the 16-year record, with both flow thresholds occurring in all but two of the 16 years (Table 8.5; Figure 8.7). Multiple events would occur in most years under BAU with only two years with no event of at least 60 m^3/s (Table 8.5). The increased frequency of large spill events under BAU is due to operating in a market where peaking operation is more valuable (as discussed above).

8.1.4.2 Timing of events

Baseline spill events ≥ 60 m^3/s downstream Derwent Pumps Weir were recorded between July and December but occurred most often in October and November. The five spill events ≥ 60 m^3/s modelled for the Project occurred between September and November while for BAU, most occurred from August to November, but they also occurred in July, December and January.

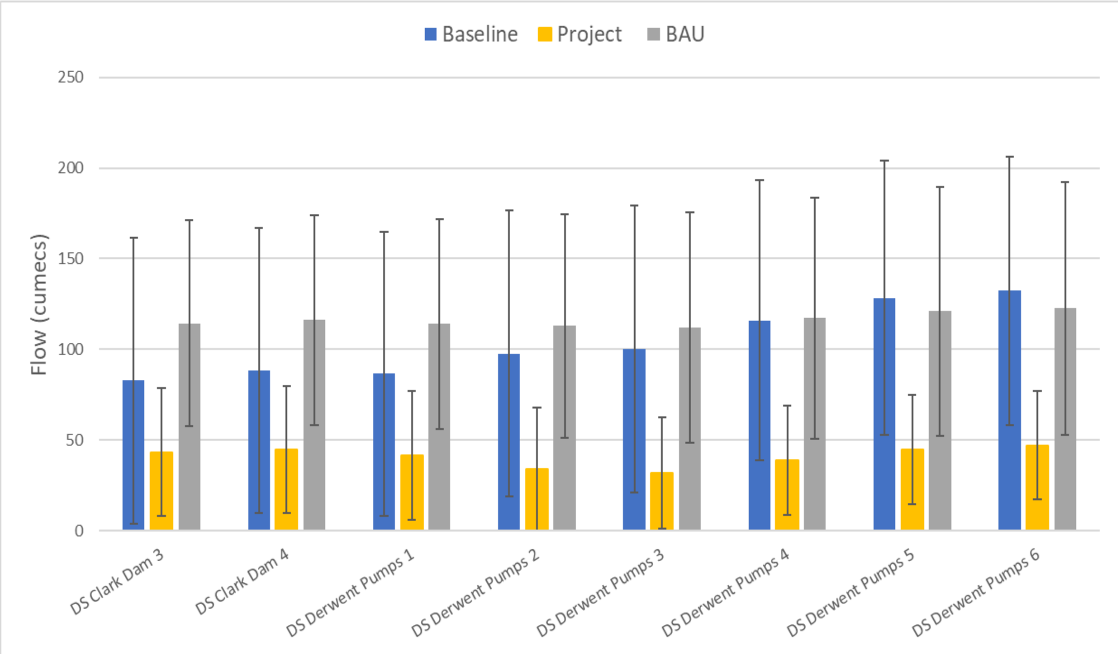

Figure 8.5: Magnitude of the mean annual maximum flow under baseline operation (modelled and observed spill, 2007 to 2022) and, BAU and operation of the Project (2029-2044) at eight locations downstream Clark Dam (error bars represent standard deviation of the mean).

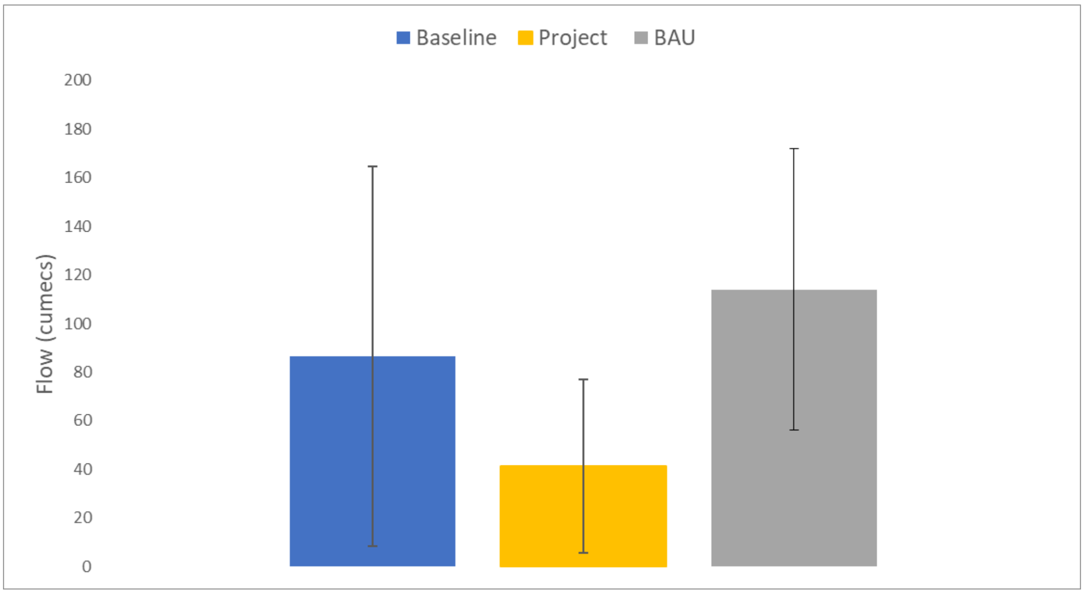

Figure 8.6 Mean annual maximum flow downstream Derwent Pump Weir (*DS Derwent Pump 1*) for baseline operation (observed data, 2007 - 2022) and, BAU and operation of the Project (2029 to 2044) (error bars represent standard deviation of the mean).

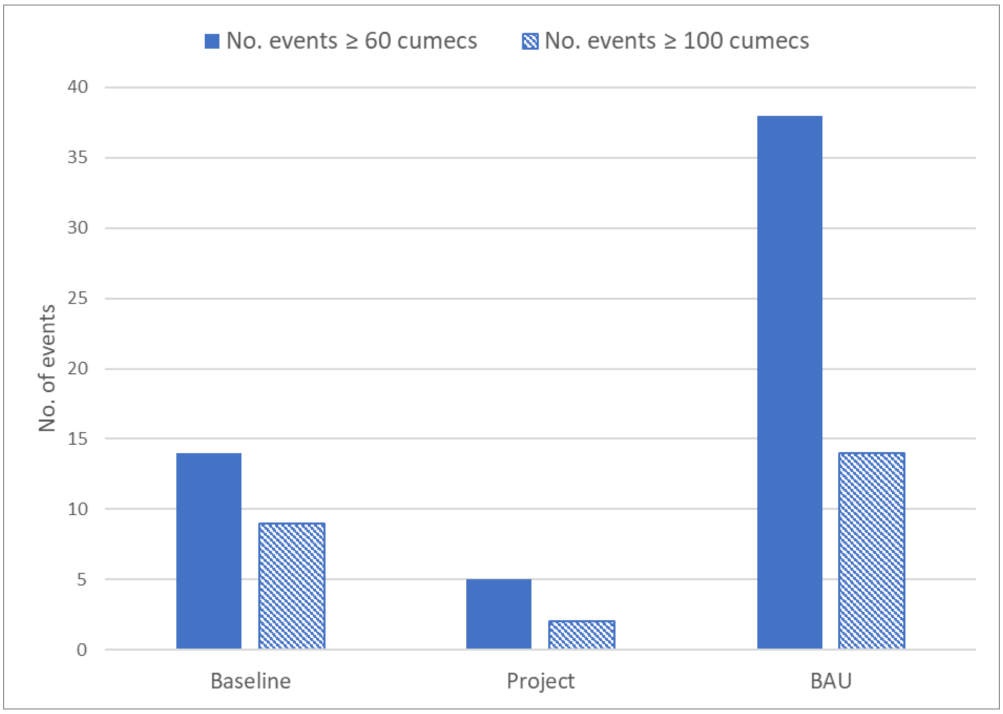

Figure 8.7: Number of ≥ 60 m^3/s and ≥ 100 m^3/s events downstream Derwent Pump Weir (*DS Derwent Pump 1*) for baseline operation (observed data, 2007 - 2022) and, BAU and operation of the Project (2029 to 2044).

Table 8.5: Analysis of 60 m^3/s and 100 m^3/s events for baseline operation (observed data, 2007 - 2022), BAU and operation of the Project (2029 to 2044) downstream Derwent Pumps Weir (*DS Derwent Pumps 1*).

Event	Description	Baseline	BAU	Project
60 m^3/s events	No. of events over 16-year record	14	38	5
	Mean number of events per year	0.9	2.4	0.3
	Number of years in 16-year record where no event occurs	8	2	13
	Greatest number of years between events	3	1	7
100 m^3/s events	No. of events over 16-year record	9	14	2
	Mean number of events per year	0.63	1	0.13
	Number of years in 16-year record where no event occurs	11	8	14
	Greatest number of years between events	3	3	11

8.1.5 Changes in fresh regime

Freshes are small and short duration higher flow events that are typically caused by a rainfall event. Freshes can perform habitat and ecological functions such as in improving water quality and mixing in pools; providing behavioural cues for invertebrate and fish species; and, cycling of organic matter and nutrients to and from areas of the riverbanks which are not inundated by the baseflow.

In the River Derwent downstream Clark Dam, freshes can also occur as a result of small spills from Clark Dam. Dam spills may be associated with elevated tributary inflows but also occur when tributary inflows are under baseflow condition. For this analysis the Q30 flow has been used to approximate the magnitude of a 'low fresh' and the Q20 flow a 'high fresh' at the flow modelling location *DS Derwent Pumps 3*. *DS Derwent Pumps 3* was used for this analysis because it is representative of the fresh regime upstream from where the Counsel River joins the River Derwent. The contribution of small spills from Clark Dam and Derwent Pumps Weir would be more important to the habitat and ecological processes of the reaches upstream of the Counsel River which do not experience the benefit of a larger tributary inflow. The analysis was repeated immediately downstream Derwent Pumps Weir (*DS Derwent Pumps 1*) which showed the same patterns as at *DS Derwent Pumps 3*.

The modelling indicated that the frequency of low freshes (2.4 m^3/s) would be reduced to an average of 7.6 per year for the Project compared to approximately 11 under baseline operation and the BAU case (Table 8.6). The frequency of high freshes (4.1 m^3/s) would be reduced by approximately half under the Project (4.6 per year) compared to the baseline (9.7 per year) and BAU (9.2 per year). There were no years under baseline operation or BAU where a low and high fresh did not occur, unlike for the Project case (Table 8.6).

As discussed, spill from Derwent Pumps Weir is a significant contributor to the high flow regime, particularly upstream of the Counsel River inflow. Multiple high and low freshes occurred every year under baseline operation and the BAU case. Under the Project, there were two years where spill from Derwent Pumps Weir did not reach the low fresh threshold and two years when a high fresh did not occur (Table 8.6). The Project resulted in a substantial reduction in freshes between January and May, with none occurring in 12 of 16 years. By contrast, at least one high and low fresh spill event was reached at Derwent Pumps Weir between January and May each year under baseline operation and the BAU case.

Table 8.6: Analysis of low and high fresh events for baseline operation (observed data, 2007 - 2022), BAU and operation of the Project (2029 to 2044) immediately downstream Derwent Pumps Weir.

Event	Description	Baseline	BAU	Project
Low fresh (2.4 m^3/s)	No. of events over 16-year record	174	172	122
	Mean number of events per year	10.9	10.8	7.6
	Number of years in 16-year record where no spill of > 2.4 m^3/s occurs at Derwent Pumps Weir	0	0	1
	Number of years in 16-year record where a low fresh occurred at Derwent Pumps Weir from January to May	16	16	3
High fresh (4.1 m^3/s)	No. of events over 16-year record	155	147	74
	Mean number of events per year	9.7	9.5	4.6
	Number of years in 16-year record where no spill of 4.1 m^3/s occurs at Derwent Pumps Weir	0	0	2
	Number of years in 16-year record where a high fresh occurred at Derwent Pumps Weir from January to May	16	16	4

8.1.6 Geomorphic processes

A detailed geomorphic assessment is provided in Section 6.1.3. The section below is a summary of the baseline condition and potential changes to geomorphic processes during operation of the Project.

The River Derwent downstream Clarke Dam to Wayatinah Lagoon is highly modified with respect to flow and sediment delivery, but some basic geomorphic functioning of the river continues, especially downstream of the Counsel River where flow is higher and more continuous (Section 6.1.2). Throughout the reach between Clark Dam and Wayatinah Lagoon, channel narrowing is occurring through the encroachment of terrestrial vegetation. However, there appear to be some processes restricting the rate of encroachment, as exposed banks and bars that are denuded remain and there is a distinct active channel in the river in many reaches. These processes include:

- episodic high flows that are sufficient to remove terrestrial vegetation, and / or soil that accumulates along the banks of the river;
- a reduction in sediment such that material removed during high flow events is not readily replaced, making the development of substrate suitable for colonisation by terrestrial vegetation a slow process and dependent upon inputs from terrestrial sources rather than fluvial sources.

Within the river channel, episodic high flow events (~40 m^3/s and higher) are sufficient to maintain the mobility of pebbles and small cobbles. Along the margins of the channels and on the lee side of boulders, these deposits can be exposed and suitable for the local colonisation of terrestrial plants, including the listed riparian plant species *Barbarea australis* (Section 6.5.2.1).

Hydrological modelling indicates that the Project would divert water from the channel of the River Derwent compared to baseline operation by reducing the volume of spill from Clark Dam, leading to reduced spill from Derwent Pumps Weir into the reaches downstream and within the TWWHA (Section 8.1.2; 8.1.3; 8.1.4). The River Derwent between Clark Dam and Wayatinah Lagoon (including reaches within the TWWHA) has experienced an altered flow regime and reduce sediment supply since 1938 when a portion of the flow was diverted to feed the Tarraleah Power Station.

The hydrology modelling indicates a pattern of reduced frequency, magnitude and duration of spills from Clark Dam under operation of the Project compared to the baseline (Section 8.1.4). Flow regime and geomorphic processes are intrinsically linked and the relationship between the high flow events and sediment transport has been long established in flowing waterways (Gordon, McMahon and Finlayson 2004). Therefore, the reduced high flow regime indicated by the modelling for the Project, without mitigation, would reduce sediment mobilisation in the river (as detailed in Sections 4.1.7 and 9.2.2). Reduced high flow and sediment mobilisation is also likely to result in accelerated encroachment of terrestrial vegetation into the river channel as high flow events currently, under baseline, limit this encroachment by scouring plants and seeds from the channel.

The following section discusses peak flow thresholds that are likely to be important for maintaining areas of mobile riverbed under operation of the Project and which were used to develop the proposed high flow mitigation (Section 9.2.1).

8.1.7 Hydraulic modelling of events that mobilise small cobbles at/near channel bars and banks

The geomorphic and hydraulic field assessment (Appendix C) determined that most of the areas of mobile riverbed comprised patches of small substrate from gravels to small cobbles up to approximately 100 mm diameter (Figure 8.9). These patches also provide the most suitable habitat for the MNES plant species, *Barbarea australis* (Section 6.5.2.1).

The hydraulic model was used to analyse movement of the sediment from coarse sand to boulders; and determine the critical flows required to mobilise small cobbles and gravels within specific reaches and areas of the riverbed defined as 'channel' and 'banks' (Appendix C). 'Banks' were defined as the rock bars directly adjacent to the edge of the toe of the riverbank and 'channel' as the approximate area of the riverbed which is inundated by baseflow conditions. The analysis of the mobilisation of small cobbles and gravels was undertaken at nine locations of approximately 400 to 700 m river length starting from approximately 4 km downstream Derwent Pumps Weir (Location 1) to immediately upstream Wayatinah Lagoon (Location 9) (Figure C.5). The locations were selected as representative of the slope and channel dimensions of the river downstream Derwent Pumps Weir to Wayatinah Lagoon

The hydraulic model indicated that:

- On average a flow of 60 m^3/s achieves mobilisation of small cobbles near the margins of the riverbank, ranging from 30 m^3/s at Location 1 to 100 m^3/s at Location 6 (Table 8.7; Table 6; Figure C.5);
- Mobilisation of small cobbles in the channel occurred on average with a 44 m^3/s flow, ranging from 5 m^3/s at Location 2 to 80 m^3/s at Locations 3 and 6 (Table 8.7; Table 6; Figure C.5);
- Mobilisation of gravels near the banks occurred on average with a 22 m^3/s flow, ranging from 5 to 40 m^3/s (Table 8.7; Table 6; Figure C.5);

- Mobilisation of gravels in the channel occurred on average at 12 m^3/s, ranging from 3 to 25 m^3/s (Table 8.7; Table 6; Figure C.5).

As discussed, the observed flow at Derwent Pumps Weir shows considerable variation in the size of the annual maximum flow between 2007 and 2022 (7 m^3/s in 2022 to 223 m^3/s in 2010) (Section 8.1.4). The variability in annual maximum flows would also result in a large variation in sediment mobilisation from year to year. However, averaged over the observed record, the annual maximum flow (82 m^3/s) for baseline operation is double that modelled for operation of the Project (41 m^3/s) (Table 8.2). Figure 8 provides a histogram of the potential for mobilisation of different sediment size classes as estimated by the outputs of the hydraulic model under an 82 m^3/s or 41 m^3/s flow event. The area of potential mobilisation of all size classes is greater under the 82 m^3/s flow, particularly for small cobble to boulder classes. Further examples of sediment mobilisation under different flows are provided in Section 9.2.2 to demonstrate the performance of the proposed mitigation compared to operation of the Project without mitigation.

The potential impacts of a reduction in sediment mobilisation on MNES values are discussed in the following section.

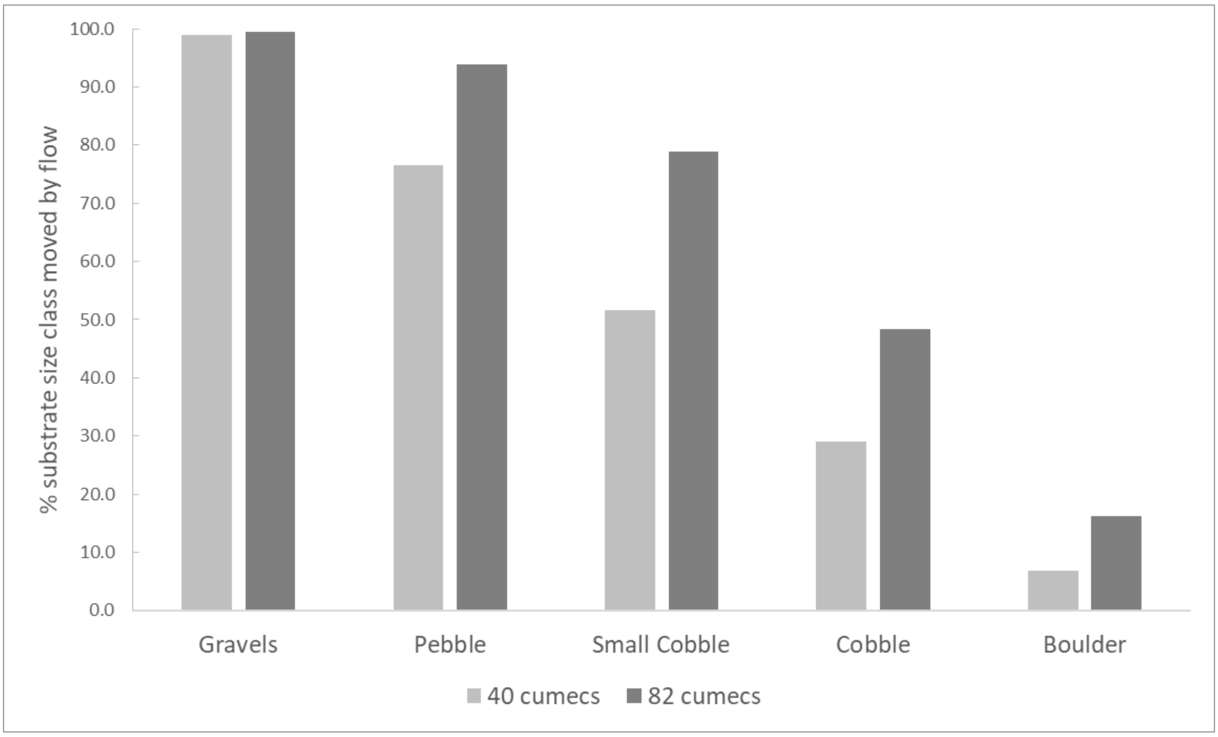

Figure 8.8: Percent of channel area where the hydraulic model estimates different size fractions have the potential to be mobilised under a 41 m^3/s and 82 m^3/s flow. The model predicted potential sediment transport capacity in each 2.25 m^2 grid cell with the model assuming all size fractions are equally available in every cell. Modelled reach was a 470 m long section (Location 4) representative of the River Derwent 900 metres upstream from the Counsel River inflow.

Table 8.7: Flow required to mobilise gravels and cobbles at channel and bank level averaged across the nine representative reaches in the hydraulic model of the River Derwent downstream Clark Dam to Wayatinah Lagoon.

Gravels (D50 1-15mm)		**Cobbles (D50 15-100mm)**	
Channel	Banks	Channel	Banks
12 m^3/s	22 m^3/s	44 m^3/s	59 m^3/s

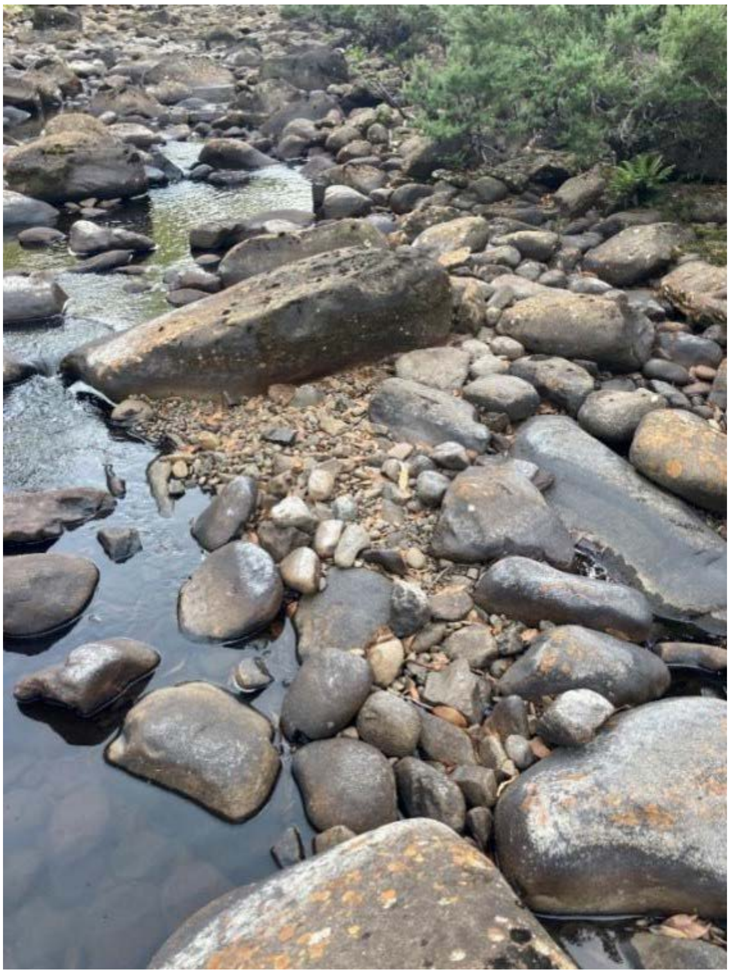

Figure 8.9: Patches of mobile substrate typically comprise gravels, pebbles and cobbles in the lee of large boulders in the River Derwent downstream from Clark Dam.

8.2 Flow Regime: River Derwent downstream Wayatinah Dam

8.2.1 Changes in spills

Modelling shows that spill frequency from Wayatinah Dam is estimated to increase to approximately 23 and 25 percent of the time respectively for BAU and operation of the Project compared to 15 percent for baseline operation (Figure 8.10). The increased spill during operation of the Project and BAU is mainly in the 1 – 10 m^3/s range; however, the magnitude of large spills (as summarised by the mean annual maximum flow, Q1 and Q5 flows) is approximately halved by the Project compared to baseline operation (Table 8.8). The magnitude of the mean annual maximum flow, Q1, and Q5 flows is also reduced under BAU, but closer to the baseline values (Table 8.8).

As described for the baseline (Section 6.2.2), most spill would also occur over winter and early spring for the Project and BAU (D.2). Under operation of the Project and BAU, spills would occur more frequently between late spring and early autumn (November to April) than recorded for baseline operation; however, this is only for spills in the 1 – 10 m^3/s range. Under baseline operation, although slightly less frequent, the magnitude of spills from November to April are generally larger than those modelled for the Project and BAU (Appendix D.2).

The results of an event analysis indicate the BAU and Project cases would increase the number of 10 m^3/s and 20 m^3/s events by two to three times compared to the baseline (Table 8.9). However, the number of events in the 50 – 75 m^3/s range would be reduced by about half under the Project, but several would still occur each year on average (Table 8.9). On average, a spill of 100 m^3/s occurred three times a year under baseline operation, but would reduce to an average of one per year under operation of the Project and 1.5 times a year under the BAU (Table 8.9). Events of 200 m^3/s occurred nearly every year, on average, under baseline operation and the modelled BAU case but would only occur approximately every five years under the Project (Table 8.9).

Table 8.8: Spill statistics for the River Derwent downstream Wayatinah Dam during baseline operation (2007 to 2022) and, BAU and operation of the Project (2029 to 2044).

Spill statistic	Baseline	BAU	Project
% Frequency of spill	15	23	25
Maximum flow in record (m^3/s)	608	359	282
Mean annual maximum flow (m^3/s)	205	162	114
Q1 (m^3/s)	162	148	96.4
Q5 (m^3/s)	68	41	33

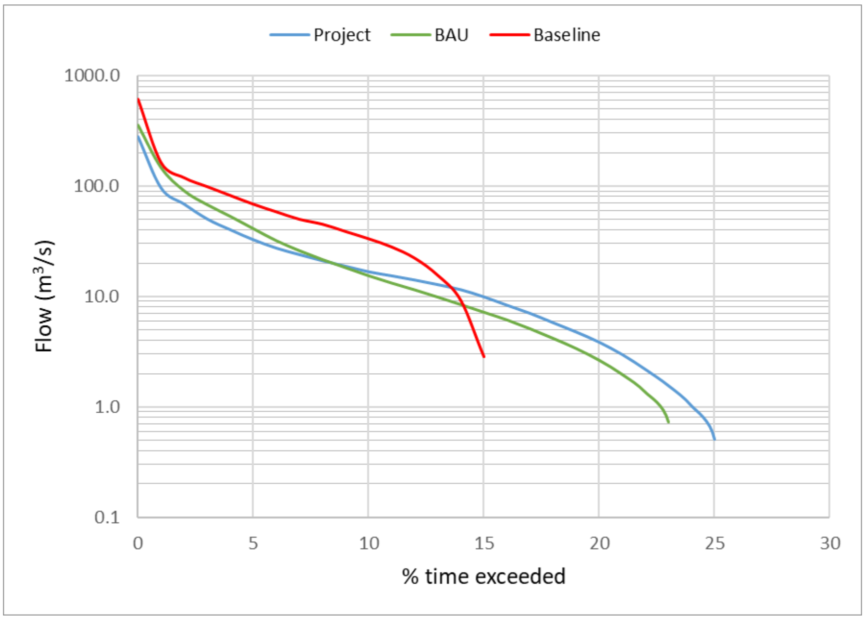

Figure 8.10: Flow duration curve (log) spill at Wayatinah Dam for baseline operation (2007 to 2022) and, BAU and operation of the Project (2029 to 2044).

Table 8.9: Mean number of events from 10 – 200 m^3/s per year for baseline operation (2007 to 2022) and, BAU and operation of the Project (2029 to 2044).

Event size (m^3/s)	Baseline operation	BAU	Project
10	7.1	25.3	21.3
20	7.1	13.8	13.3
50	5.9	4.4	3.6
75	4.3	2.7	2.3
100	3.3	1.6	1.1
200	0.9	0.8	0.2

8.2.2 Geomorphic processes

The overall reduced magnitude of large spills under operation of the Project is unlikely to result in significantly less sediment mobilisation than occurs under the observed spill regime. That is, despite being reduced, several large events in the 50 to 100 m^3/s range are still modelled to occur each year during operation of the Project. Hydraulic modelling indicates that the magnitude of the spill regime during operation of the Project will still have the potential to mobilise substrate in a way similar to current operation as discussed below. It is also expected that the ongoing erosion of the riverbanks combined with the episodic high flows will maintain discontinuous patches of loose gravels and cobbles that currently exist in the river.

Figure 8.11 shows a histogram of the potential for mobilisation of different sediment size classes for the mean annual maximum flow for baseline operation (205 m^3/s) and for operation of the Project (114 m^3/s). The results suggest that a 114 m^3/s and 205 m^3/s events have the potential to mobilises nearly 100 percent of gravels, pebbles and small cobbles in the channel (Figure 8.11). The hydraulic model indicates that a 114 m^3/s event mobilises ~15 percent less large cobble, and ~19 percent less boulders than a 205 m^3/s event (Figure 8.11). A reduced mobilisation of the large cobbles and boulders is unlikely have a significant impact on physical or ecological processes in this reach.

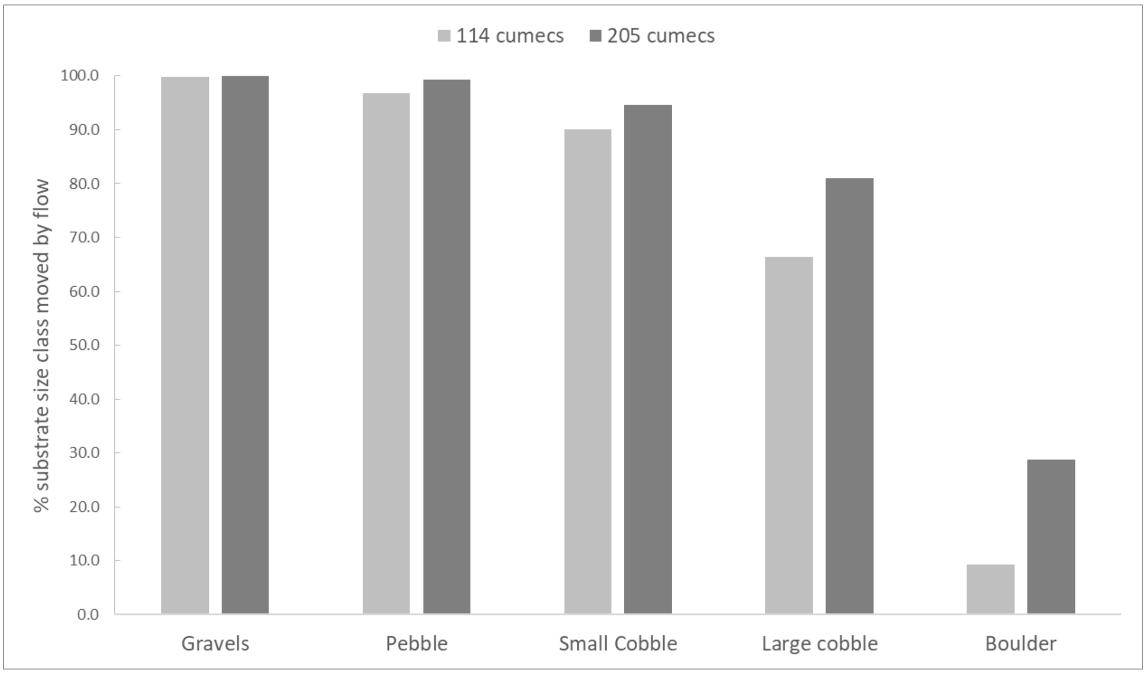

Figure 8.11: Percent of channel area where the hydraulic model estimates different size fractions have the potential to be mobilised under a 114 m^3/s and 205 m^3/s flow. The model predicts potential sediment transport capacity in grid cell, assuming all size fractions are equally available in every cell. Modelled reach is a 500 m long section representative of the River Derwent immediately downstream the spillway from Wayatinah Dam.

8.3 Flow regime: Nive River downstream Liapootah Dam

8.3.1 Changes in spills

Hydrologic modelling of the system following redevelopment of Tarraleah is summarised in Table 8.10 and Figure 8.12. The modelling suggests the following flow changes in the Nive River downstream of Lake Liapootah:

- Operation of the Project is predicted to increase the frequency of spill from Liapootah Dam from approximately seven percent under baseline operation to 15 percent of the time;
- As for the baseline (Section 6.3.2), most spills would occur from May to October under operation of the Project and BAU (Appendix D.5).
- The increased spill modelled for the Project is for events in the 1 – 20 m^3/s range and these were mainly predicted to occur between May to August (Appendix D.5);
- Mean annual peak flows are predicted to be similar to current operation with the magnitude of larger spills similar to baseline operation and BAU (other than for a single extreme event which peaked at 633 m^3/s for baseline operation) (Table 8.10).

- Large spills from Liapootah Dam usually occur annually with annual maximum spills < 100 m^3/s rare under baseline operation and the Project, and absent under BAU.

These flow changes will not directly alter the sediment supply to the Nive River and are unlikely to alter the existing geomorphic processes in the river which is particularly relevant to the assessment of potential impacts on *B. australis* (Section 8.5.5).

Table 8.10: Spill statistics for the Nive River downstream Liapootah Dam during baseline operation (2007 to 2022) and, BAU and operation of the Project (2029 to 2044).

Spill statistic	Baseline	BAU	Project
% Frequency of spill	7	11	15
Maximum flow in record (m^3/s)	633	333	292
Mean annual maximum flow (m^3/s)	174[8]	176	167
Q1 (m^3/s)	84	76	84
Q5 (m^3/s)	21	21	24

[8] The mean annual maximum flow was 202 m^3/s with the 633 m^3/s event included

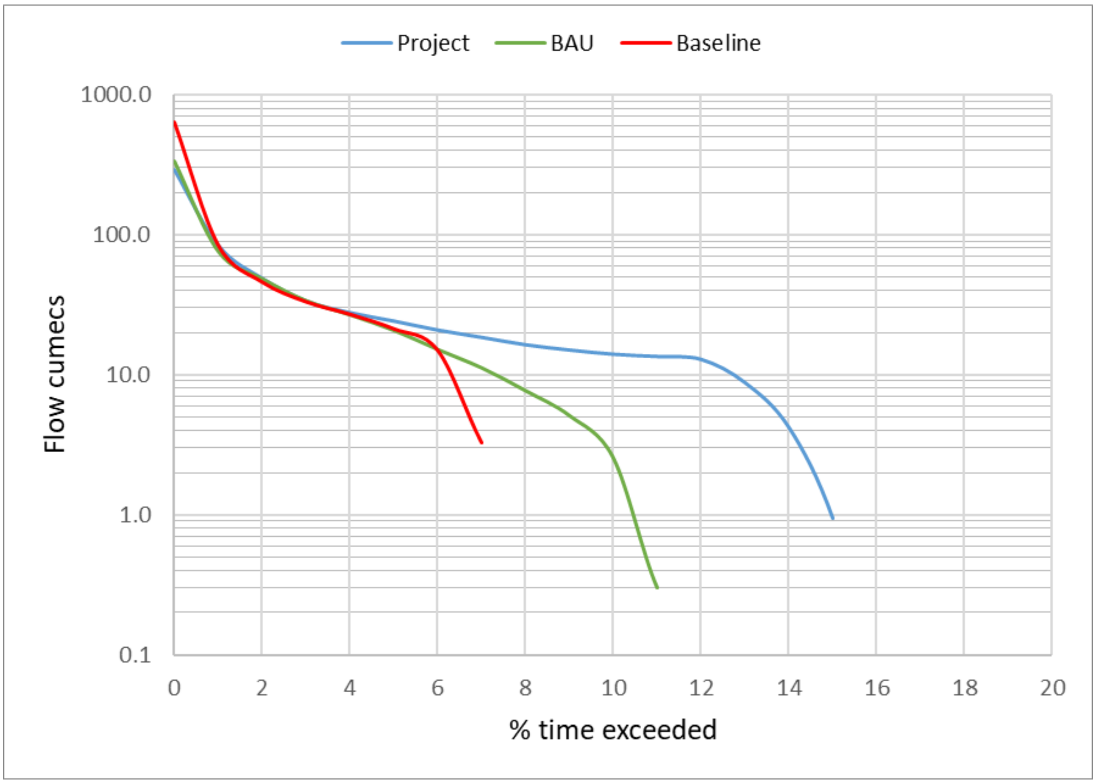

Figure 8.12: Flow duration curve (log) spill at Liapootah Dam for baseline operation (2007 to 2022) and, BAU and operation of the Project (2029 to 2044).

8.3.2 Geomorphic processes

Aside from a single extreme event under the baseline record (633 m^3/s), the magnitude of large spills (~Q5 flows and higher) is very similar between baseline operation, the Project and BAU (Table 8.9), therefore the regime of sediment mobilisation is expected to remain similar. For example, the potential for mobilisation of different sediment size classes under the mean annual maximum flows for baseline operation (174 m^3/s) and for operation of the Project (167 m^3/s) were nearly identical. Even when comparing sediment mobilisation under a 167 m^3/s and 205 m^3/s event (the mean annual maximum flow calculated for baseline operation with an extreme event included) suggests that 167 m^3/s has the potential to mobilise nearly the same amount of substrate as a 205 m^3/s event (Figure 8.13). The pattern and magnitude of flow in the river will continue to mobilise gravels and small cobbles during operation, thus maintaining similar habitats that currently exist in the channel.

The potential effects of changes in the timing of spill events on sediment mobilisation and the MNES species *B. australis* is in Section 8.5.5.

8.3.2.1 Predicted changes due to redevelopment of Tarraleah

The redevelopment of Tarraleah will not alter the sediment dynamics of the Nive River between Liapootah Dam and Wayatinah Lagoon. The Project is predicted to marginally alter the frequency of high and moderate flows in the river reach.

The existing morphology of the Nive River is controlled by episodic moderate and high flows that restrict the encroachment of vegetation into the channel, accompanied by the input of sediment from the erosion of riverbanks and tributary inflows. Given the small changes in flows predicted, there is a very low risk the geomorphology of the river will appreciably change. The pattern and magnitude of flow in the river will continue to mobilise gravels and small cobbles, thus maintaining similar habitats that currently exist in the channel.

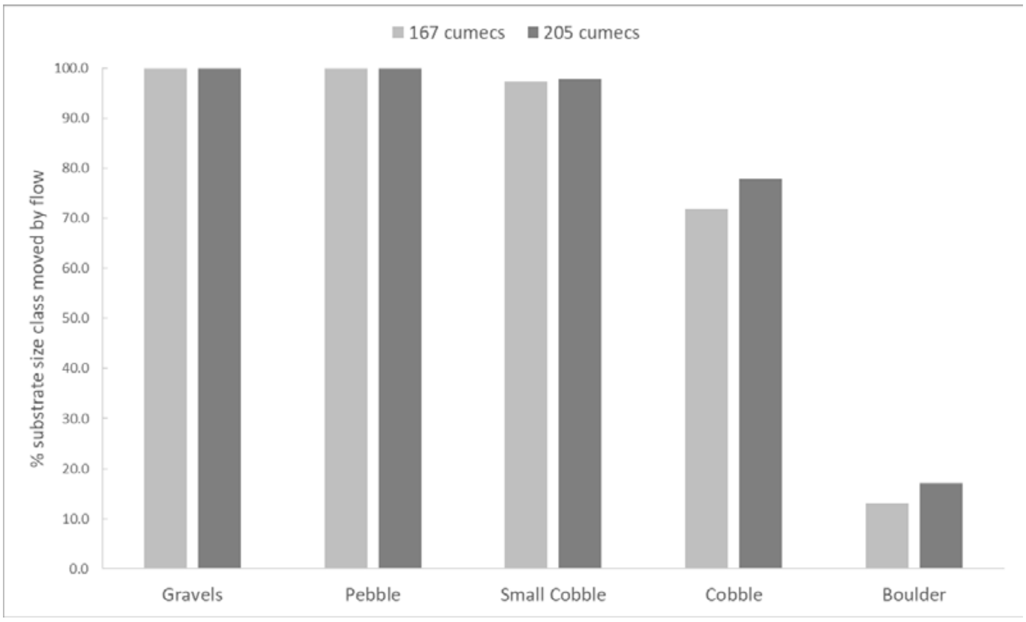

Figure 8.13: Percent of channel area where the hydraulic model estimates different size fractions have the potential to be mobilised under a 167 m^3/s and 205 m^3/s flow. The model is predicting potential sediment transport capacity in grid cell (model assumes all size fractions are equally available in every cell). Modelled reach is a ~800 m long section of the Nive River ~ 3 km downstream Liapootah Dam.

8.4 Tasmanian Wilderness World Heritage Area (TWWHA)

8.4.1 Potential impacts

Hydrological modelling indicates that the Project would result in further diversion of water from the channel of the River Derwent by reducing the volume of spill from Clark Dam (Section 8.1). This would also reduce the magnitude and frequency of spill from Derwent Pumps Weir into the reaches within the TWWHA. The flow regime in the section of the River Derwent within the TWWHA has been altered since the 1930s (Sections 5.2.1 and 6.1.2). Further diversion has the potential to impact several flow-dependent processes, habitats and ecological values as described below.

8.4.1.1 Mechanism of impact

High flow events are essential for maintaining the physical structure and biological health of river ecosystems. They ensure the dynamic nature of rivers, support diverse habitats, and promote ecological processes that sustain aquatic life as summarised below:

Physical Processes:

- Inorganic and organic transport and deposition:
  - High flow events mobilise and transport sediments, including gravel, cobbles, and boulders, which are essential for maintaining the riverbed structure.
  - Redistribution of sediments, preventing the riverbed from becoming compacted or clogged with fine materials.
  - Bank and floodplain/riparian connectivity.
  - Debris exchange through transport of large woody debris and organic material which contributes to habitat complexity.
- Channel morphology:
  - High flow events shape the river channel by eroding banks, creating new channels, and depositing sediments in different areas.
  - Maintain diverse habitats by creating pools, riffles, and bars, which are important for a diverse aquatic community.
- Scouring of vegetation:
  - High flows can scour terrestrial vegetation from the river channel, preventing encroachment and maintaining open water habitats.
  - Maintain an active and dynamic river channel.

Biological Processes:

- Habitat maintenance:
  - Mobilising sediments and maintaining channel morphology, high flow events create and sustain habitats for aquatic species
  - Ensure the availability of suitable spawning grounds and shelter for aquatic species.
- Nutrient cycling:
  - Facilitate the exchange of nutrients between the river and the floodplain/riparian zone, enhancing the productivity of both aquatic and terrestrial ecosystems.
  - Food web dynamics through the distribution of organic matter and nutrients in the channel and riparian/floodplain.
- Species dispersal and life history cues:
  - Aid the dispersal of aquatic organisms, including fish and plant seeds, promoting genetic diversity and colonisation of new areas.
  - Cues for migration, spawning and other life history cues of aquatic species.
- Water quality:
  - Flushing/diluting of pollutants and stagnant water, improving overall water quality and ecological health of the river

8.4.2 Summary of impacts under current operation

Under current operation, the reaches of the River Derwent in the TWWHA are impacted by the reduced flow regime, particularly the first 16 km downstream from Derwent Pumps Weir where the pickup from tributary inflows is minor (Section 6.1).

The availability of aquatic habitat for species in this reach is primarily supported by baseflow from tributary creeks downstream of the dam. This is because there is no baseflow release from the dam and dam spills, especially downstream from Derwent Pumps Weir, are infrequent.

However, and as discussed in the section above, higher flow events perform critical roles in habitat maintenance within the river channel and for the riparian/floodplain zone. High flows also provide life history cues for aquatic species. The reaches between Derwent Pumps Weir and the Counsel River inflow, which forms most of the river within the TWWHA are reliant on spill from Clark Dam for annual peak flow events > ~ 15 m^3/s. Also, hydraulic modelling indicates that, for most reaches, events of approximately 60m^3/s are required to mobilise gravels up to cobbles across the width of the river channel (Section 8.1.7).

The reaches downstream from the Counsel River inflow are in significantly better physical and ecological condition because the Counsel River and Beech Creek provide a more variable and larger flow regime. The macroinvertebrate community and habitat condition recorded in this reach demonstrate the clear improvement in the health of the river with increasing tributary pickup with distance downstream, particularly once the Counsel River joins (Section 6.2.5). This is a common pattern in Tasmanian catchments which are regulated by hydropower schemes in Tasmania (Davies 1999).

Under current operations, if there are no significant dam spills, the highest annual peak flow in the reaches immediately downstream from Derwent Pumps Weir can be as low as 6 - 15 m^3/s. This reduced high flow regime under current operation has impacted aquatic habitats and species as the physical processes discussed above are insufficient to maintain a healthy river. For example, from 2007 to 2025 (Figure 8.14), the largest spill at Derwent Pumps Weir did not exceed 15 m^3/s in 8 out of 19 years, and only once from 2020 to 2025. Additionally, during the same period, spills of 60 m^3/s or more (the minimum proposed annual high flow release for mitigation) occurred in only 7 of the past 19 years, with none in the last six years (Figure 8.14).

8.4.3 Predicted impacts under operation of the Project

Under operation of the Project, the already reduced high flow regime derived from dam spill would decline in frequency and magnitude compared to current operation (Section 8.1.) This reduction in spill is predicted to have negative impact on the aquatic and riparian values in this reach as detailed below

Table 8.11 shows the predicted impacts of the modelled changes to dam spill on the physical and biological processes outlined above. The table describes predicted impacts with and without the proposed high flow mitigations.

Without mitigation, the predicted reduction in spill during the operation of the Project is expected to cause a decline in all related physical and biological processes compared to current operations (Table 8.11).

The biological values impacted or potentially impacted include:

- Reduction in habitat suitable for the MNES riparian plant species *Barbarea australis*, or a reduction in populations of this species if it is present (Section 8.5.3);
- Reduced riparian condition, potentially including habitat for the state-listed pine *Pherosphaera hookeriana*, *Westringia angustifolia* and *Muehlenbeckia axillaris* (matted lignum) (Section 6.1.7);
- Reduced habitat quality and abundance of macroinvertebrate prey for platypus;
- Reduced habitat quality and food sources (macroinvertebrate and organic debris) for Tasmanian endemic crayfish, *Astacopsis tricornis;*
- Reduced habitat quality and food sources for freshwater macroinvertebrates including 25 species of macroinvertebrates classified as of conservation significance due to being endemic to Tasmania or endemic to a restricted area of Australia[9] (Section 6.1.5)
- Reduced habitat quality and abundance of macroinvertebrate prey for native fish species: *Anguilla australis* (present through stocking but cannot form self-sustaining populations in this catchment) and *Galaxias brevipinnis* if present (Section 6.1.6).

The mechanisms for impact are described in Table 8.11 and are given for operation of the Project with and without the proposed flow mitigation.

With the proposed flow mitigation, which includes the planned release of one annual event of at least 60 m^3/s and three smaller fresh events (Section 9.2.2), the physical and biological processes influenced by high flow events are expected to improve relative to current operations. Consequently, populations of macroinvertebrates, platypus, and freshwater crayfish are predicted to be at least maintained or to improve relative to current operation.

An assessment of potential impact to the TWWHA assessment against the Commonwealth significant impact criteria for World Heritage Property and National Heritage Places is found below in Section 8.4.4.

[9] None of the endemic macroinvertebrate species recorded have a restricted distribution in Tasmania.

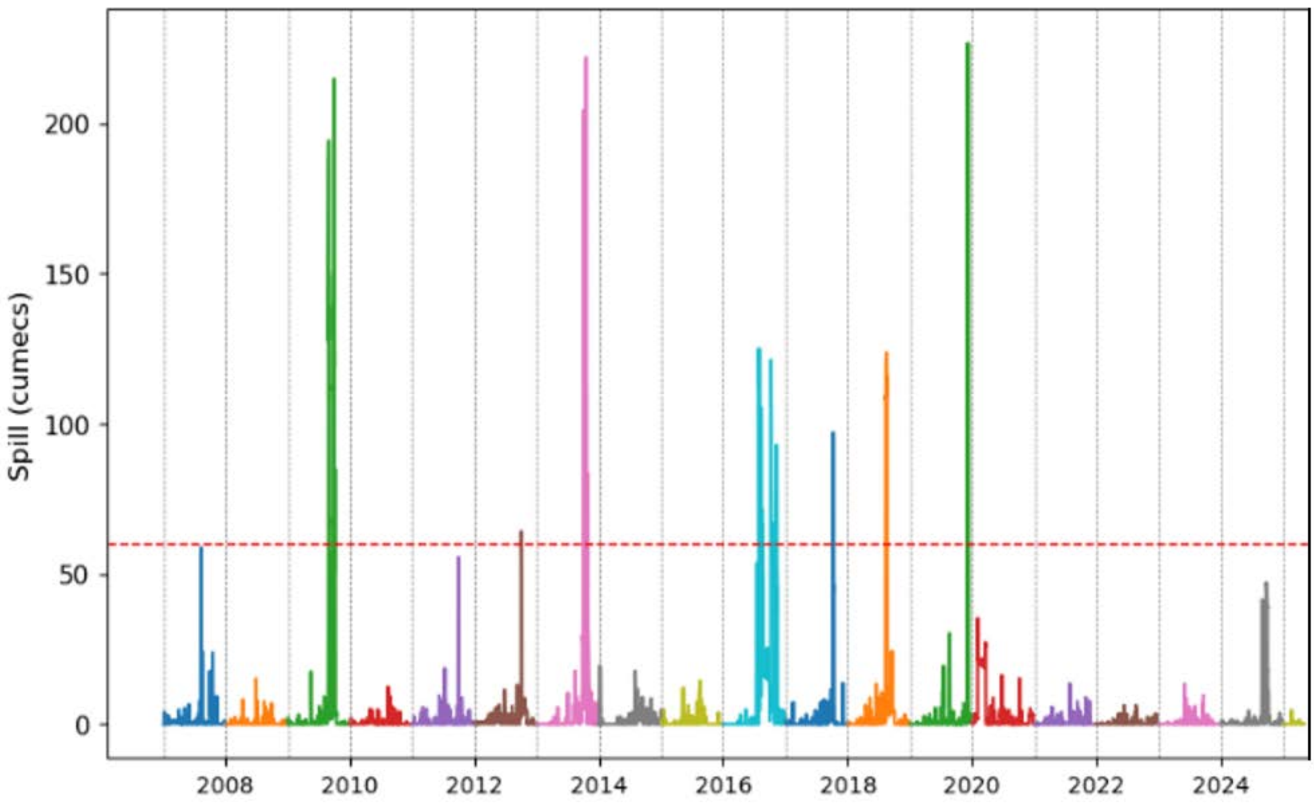

Figure 8.14: Hydrograph for spill into the River Derwent downstream Derwent Pumps Weir from 2007 to May 2025 (observed flow data). The red dotted line represents 60 m³/s

Table 8.11: Role of high flow regime in physical and biological processes and prediction of impacts of the Project before and after the proposed flow mitigation for the River Derwent downstream Clark Dam to Wayatinah Lagoon.

	Process	Role	Impacts of Project unmitigated	Impacts of Project with mitigation	Monitoring to inform condition/impact during operation
Physical processes	*Inorganic and organic material exchange*	*Structure of riverbed habitats (reach scale)*	Reduction in the size and frequency of spills would reduce the mobilisation of sediments within individual habitats and between reaches	Planned releases in the range of 60 to 100 m^3/s are proposed to mobilise substrates up to small cobbles across the full extent of the channel. Flows of this magnitude would also mobilise large cobble and boulders within a narrow band or the channel such that overall, the mobilisation and redistribution of sediments should be at least maintained compared to current	• Rock movement surveys • Operational flow monitoring (spill) • Macroinvertebrate surveys (riffle health/structure • Habitat survey associated with macroinvertebrate survey
		Redistribution of riverbed sediments (habitat unit scale)			
		Channel and riparian connectivity	Reduction in the size and frequency of spills would reduce the degree of connectivity between the channel and riparian zone	The planned high flow releases will ensure events of this size are more frequent than occurs under current operation which will also increase the frequency that high flows enter the riparian zone and promote exchanges of debris to and from the channel	• Vegetation surveys focussing on encroachment, structure and occurrence of sensitive state listed species
		Debris exchange			
	Channel morphology	*Reach scale redistribution of sediments*	Events sufficient to mobilise and distribute channel substrates would be rarer than current operation.	Planned releases in the range of 60 to 100 m^3/s are proposed to mobilise the substrates up to small cobbles across the full extent of the channel. Flows of this magnitude would also mobilise large cobble and boulders within a narrow band or the channel such that the diversity of instream habitats will be maintained	• Rock movement surveys • Operational flow monitoring (spill)
		Maintain diverse habitats	The quality of instream habitats are likely to decline, particularly riffle habitats which are the most productive habitats available in this reach		• Macroinvertebrate surveys • Habitat survey associated with macroinvertebrate survey • Operational flow monitoring (spill)
	Scour	*Removal of encroaching vegetation*	Encroachment of terrestrial vegetation is likely to accelerate	More regular high flow events (i.e. at least one annual large flow) may reduce the encroachment of terrestrial vegetation compared to current operation	• Vegetation surveys to monitor encroachment • Operational flow monitoring (spill)
		Scour accumulated biofilms from riverbed	The persistence and extent of harmful accumulated biofilms are likely to increase	More regular high flow events (i.e. at least one annual large flow and three smaller freshes) may reduce accumulation of biofilms relative to current where large flows downstream of Derwent Pumps Weir do not occur in every year	• Macroinvertebrate surveys • Habitat survey associated with macroinvertebrate survey • Operational flow monitoring (spill)
		Maintain an active river channel	The channel will be less active than under current operation	Flows large enough to mobilise parts of the riverbed will occur more frequently than under current operation	• Rock movement surveys • Operational flow monitoring (spill)
Biological processes	*Habitat maintenance*	*Mobilisation of organic and inorganic sediments for a diverse range of habitats*	Habitat conditions are likely to decline through reduced mobilisation of habitat forming organic and inorganic materials	More regular high flow events (i.e. at least one annual large flow and three smaller freshes) will increase the frequency that organic and inorganic sediments are redistributed within and between habitats compared to current operation	• Habitat survey associated with macroinvertebrate survey
		Maintain spawning habitats for aquatic species	Spawning habitats for macroinvertebrates, dispersal of species and exchanges of organic and inorganic matter within the channel and between the channel and riparian zone are all predicted to decline with a reduced spill regime	Spawning habitats for macroinvertebrates, dispersal of species and exchanges of organic and inorganic matter within the channel and between the channel and riparian zone will be maintained and may benefit from more regular high flow events	• Macroinvertebrate surveys • Habitat survey associated with macroinvertebrate survey
	Nutrient cycling	*Food web health through redistribution of organic matter within the channel and between the channel and riparian zone*			
	Species dispersal and life history cues	*Dispersal of aquatic species*			
		Cues for migration, spawning or other life history cues	Decline in higher flows will reduce events which trigger life history cues for some aquatic species	Release of annual peak flow and smaller freshes may benefit species which rely on flow cues to trigger life history stages	• Macroinvertebrate surveys
		Dispersal of plant seeds along riparian corridor	Exchange of seeds along the riparian corridor will decline	More regular high flow events (i.e. at least one annual large flow and three smaller freshes) will increase the dispersal of seeds along the riparian corridor compared to current operation	• Vegetation surveys • *Barbarea australis* surveys
	Water quality	*Flushing of pollutants and stagnant water to maintain ecological health*	Reduced flushing of stagnant water in pool sections may result in a decline in water quality.	More regular high flow events (i.e. at least one annual large flow and three smaller freshes) will increase the recharge of water through this reach	• Macroinvertebrate surveys (riffle health/structure • Spot phys-chem water sampling

8.4.4 Assessment against EPBC Act significant impact criteria

Approval under the EPBC Act is required for any action occurring within, or outside, a declared World Heritage property/National Heritage Places that has, will have, or is likely to have, a significant impact on their values. In accordance with the *Matters of National Environmental Significance - Significant Impact Guidelines* (Department of the Environment 2013), an action is likely to have a significant impact on the World Heritage values of a declared World Heritage property/National Heritage Places if there is a real chance or possibility that it will cause:

- one or more of the World Heritage/National Heritage Places values to be lost
- one or more of the World Heritage/National Heritage Places values to be degraded or damaged, or
- one or more of the World Heritage/National Heritage Places values to be notably altered, modified, obscured or diminished.

An assessment of the proposed Action against the World Heritage Properties and National Heritage Places criteria is provided in Table 8.12. Where potential impacts have been identified, proposed actions to mitigate potential impacts are discussed.

Table 8.12: Assessment against the Commonwealth significant impact criteria for World Heritage Property and National Heritage Places of operation of the Project with the proposed flow mitigation.

World Heritage Properties Criteria	National Heritage Places Criteria	Response
Natural heritage values		
Values associated with geology or landscape		
An action is likely to have a significant impact on natural heritage values of a World Heritage property associated with geology or landscape if there is a real chance or possibility that the action will:	An action is likely to have a significant impact on natural heritage values of a National Heritage place if there is a real chance or possibility that the action will:	**With mitigation, the action is unlikely to have a significant impact** on natural heritage values of a World Heritage property associated with geology or landscape as outlined below.
• Damage, modify, alter or obscure important geological formations in a World Heritage property.	• Damage, modify, alter or obscure important geological formations in a National Heritage place.	There will be no construction activities within the TWWHA.
• Damage, modify, alter or obscure landforms or landscape features, for example, by excavation or infilling of the land surface in a World Heritage property.	• Damage, modify, alter or obscure landforms or landscape features, for example, by clearing, excavating or infilling the land surface in a National Heritage place.	There will be no construction activities within the TWWHA.
• Modify, alter or inhibit landscape processes, for example, by accelerating or increasing susceptibility to erosion, or stabilising mobile landforms, such as sand dunes, in a World Heritage property.	• Modify, alter or inhibit landscape processes, for example, by accelerating or increasing susceptibility to erosion, or stabilising mobile landforms, such as sand dunes in a National Heritage place.	The geomorphology assessment and hydraulic modelling indicates that a reduced spill regime will decrease the mobilisation and redistribution of riverbed and bank sediments. This may result in further stabilisation of areas of the existing riverbed which remain mobile during current high flow events. This would be a potential impact on aquatic and riparian values in the TWWHA and on habitat suitability for the MNES riparian plant species *B. australis* which relies on disturbance by high flows to maintain habitat (refer to Section 8.5) by turning over sediments and removing competing plant species.

World Heritage Properties Criteria	National Heritage Places Criteria	Response
		Acceleration of encroachment by terrestrial vegetation would also reduce the mobility of the river channel and alter its current form. This is an existing impact which reduces the active area of the channel by decreasing the area of substrate which can be mobilised during high flow events. Accelerating encroachment would alter the form of the channel and impact availability of habitat for *Barbarea australis*. *The proposed high flow releases will ensure at least one high flow event occurs each year (i.e. an event of ≥ 60 m^3/s). Under the current spill regime, events of ≥ 60 m^3/s do not occur each year. The proposed mitigation aims to keep the mobile areas of substrate active and prevent further encroachment of terrestrial vegetation in these mobile areas.*
• Divert, impound or channelise a river, wetland or other water body in a World Heritage property.	• Divert, impound or channelise a river, wetland or other water body in a National Heritage place.	Hydrological modelling indicates that the Project would result in further diversion of water from the channel of the River Derwent by reducing the volume of spill from Clark Dam and then spill from Derwent Pumps Weir into the reaches within the TWWHA. The flow regime in the section of the River Derwent within the TWWHA has been altered since the 1930s (Sections 5.2.1 and 6.1.2). Further diversion has the potential to impact several flow dependent habitat and ecological values as discussed below. *The proposed high flow releases will ensure at least one high flow event occurs each year (i.e., an event of ≥ 60 m^3/s) plus up to three smaller fresh flow releases. The current spill regime is unpredictable with gaps of one to two years between large spills common. Introduction of annual high and fresh events is likely to be benefit to downstream habitats and species.*

World Heritage Properties Criteria	National Heritage Places Criteria	Response
• Substantially increase concentrations of suspended sediment, nutrients, heavy metals, hydrocarbons, or other pollutants or substances in a river, wetland or water body in a World Heritage property.	• Substantially increase concentrations of suspended sediment, nutrients, heavy metals, hydrocarbons, or other pollutants or substances in a river, wetland or water body in a National Heritage place;	The Project will not result in a substantially increased concentration of suspended sediment, nutrients, heavy metals, hydrocarbons, or other pollutants. There are no construction activities proposed within the TWWHA and potential construction pollution sources from nearby worksites will be effectively managed through the implementation of standard environmental management practices. One stream entering the River Derwent a short distance downstream from Derwent Pumps Weir may experience occasional elevated levels of nitrates; however, the concentrations in the stream will be diluted to very low levels when mixed with the much larger flow of the River Derwent. Thus, no impact on the aquatic values is predicted in the TWWHA section of the river.
Biological and ecological values		
An action is likely to have a significant impact on biological or ecological values of a World Heritage property if there is a real chance or possibility that the action will:	An action is likely to have a significant impact on natural heritage values of a National Heritage place if there is a real chance or possibility that the action will:	**With mitigation, the action is unlikely to have a significant impact** on biological or ecological values of a World Heritage property as outlined below.
	• Modify or inhibit ecological processes in a National Heritage place.	A reduced high flow regime may modify/inhibit the ecological process which are driven by the flow regime, including habitat provision and maintenance (disturbance events), nutrient cycling and behavioural cues. *The proposed annual high flow releases, plus up to three smaller fresh flow releases, will ensure high flow events occur more frequently than currently occurs where gaps of one to two years between large spills are common. Provision of more frequent high flow events is likely to support ecological process within the channel.*
• Reduce the diversity or modify the composition of plant and animal species in all or part of a World Heritage property	• Reduce the diversity or modify the composition of plant and animal species in a National Heritage place	Reduced habitat suitability from a reduced spill regime may reduce/modify populations of macroinvertebrates, platypus, the crayfish *Astacopsis tricornis*, potentially native fish and riparian plant species through: • fragmentation of, or damage to, habitats

World Heritage Properties Criteria	National Heritage Places Criteria	Response
		• reduced temporary inundated habitats for the above-mentioned groups • reduced water quality, particularly in pools where stagnant water may experience high temperatures and low dissolved oxygen during extended dry periods • increased accumulation of algae and biofilms in the channel which can smothering instream benthic surfaces • reduced nutrient cycling between riparian, exposed bank and instream habitats from less frequent high flow events which affect aquatic food webs. • reduced flow induced life history cues for macroinvertebrate species and potentially native fish. High flows events often provide behavioural, migration and reproductive cues for macroinvertebrates and fish. Reduced spills/high flows may also impact the character of riparian vegetation through reduction in seed dispersal, seed germination, nutrient cycling, recharge of groundwater, and survival of sapling and mature vegetation. *The proposed annual high flow releases, plus up to three smaller fresh flows, will ensure high flow events occur more frequently than currently occurs where gaps of one to two years between large spills are common. Provision of more frequent high flow events is likely to support ecological processes within the channel and prevent the potential impacts listed above.*
• Fragment, isolate or substantially damage habitat importconsant for the conservation of biological diversity in a World Heritage property.	• Fragment or damage habitat important for the conservation of biological diversity in a National Heritage place	Reduced habitat suitability from a reduced spill regime may fragment or damage habitat for macroinvertebrates, platypus, the crayfish *Astacopsis tricornis*, potentially native fish and riparian plant species as described above. *The proposed annual high flow releases, plus up to three smaller fresh flows, will ensure high flow events occur more frequently than currently occurs where gaps of one to two years between large spills are common.*

World Heritage Properties Criteria	National Heritage Places Criteria	Response
		Provision of more frequent high flow events is likely to maintain or improve aquatic and riparian habitats.
• Cause a long-term reduction in rare, endemic or unique plant or animal populations or species in a World Heritage property.	• Cause a long-term reduction in rare, endemic or unique plant or animal populations or species in a National Heritage place.	A reduced spill regime may potentially result in a long-term reduction in: • Habitat for *Barbarea australis* (native wintercress), or a population of this species if present, which is listed under the EPBC Act and Tasmanian TSP Act • The endemic native Tasmanian freshwater crayfish *Astacopsis tricornis* and 24 species of freshwater macroinvertebrates identified as species of conservation significance because they are endemic to Tasmania or have a reduced range in Australia • the endemic riparian plant species, *Pherosphaera hookeriana* (Mount Mawson pine), and *Westringia angustifolia* (narrowleaf westringia) which are both listed under the TSP Act, • *the riparian plant species Muehlenbeckia axillaris* (matted lignum) listed as rare under the TSP Act • The platypus (*Ornithorhynchus anatinus*) classified as a species of significance in Tasmania as a phylogenetically distinct fauna species. *The proposed annual high flow releases, plus up to three smaller fresh flows, is expected to maintain populations of the species listed above*
• Fragment, isolate or substantially damage habitat for rare, endemic or unique animal populations or species in a World Heritage property.	• Fragment, isolate or substantially damage habitat for rare, endemic or unique animal populations or species in a National Heritage place	A reduced spill regime may potentially fragment, isolate or damage habitat for endemic *Astacopsis tricornis*, platypus, *Pherosphaera hookeriana*, *Westringia angustifolia, Muehlenbeckia axillaris, 24* species of endemic freshwater macroinvertebrates and *Barbarea australis.* *The proposed annual high flow releases, plus up to three smaller fresh flows, is predicted to maintain habitat for the values listed above*
Wilderness, aesthetic, or other rare or unique environment values		
An action is likely to have a significant impact on natural heritage values of a	An action is likely to have a significant impact on natural heritage values of a	As there will be no construction activities within the TWWHA, the **action will not have a significant impact** on natural heritage values of a World

World Heritage Properties Criteria	National Heritage Places Criteria	Response
World Heritage property associated with wilderness, natural beauty or rare or unique environment values if there is a real chance or possibility that the action will:	World Heritage property associated with wilderness, natural beauty or rare or unique environment values if there is a real chance or possibility that the action will:	Heritage property associated with wilderness, natural beauty or rare or unique environment value.
• Involve construction of buildings, roads, or other structures, vegetation clearance, or other actions with substantial, long-term or permanent impacts on relevant values.	• Involve construction of buildings, roads or other structures, vegetation clearance, or other actions with substantial and/or long-term impacts on relevant values.	There will be no construction activities within the TWWHA.
• Introduce noise, odours, pollutants or other intrusive elements with substantial, long-term or permanent impacts on relevant values.	• Introduce noise, odours, pollutants or other intrusive elements with substantial and/or long-term impacts on relevant values.	There will be no construction activities within the TWWHA.
Cultural heritage values		
Historic heritage values		
An action is likely to have a significant impact on cultural heritage values of a World Heritage property if there is a real chance or possibility that the action will:	An action is likely to have a significant impact on historic heritage values of a National Heritage place if there is a real chance or possibility that the action will:	As there are no World Heritage or National Heritage listed historic heritage values associated with the River Derwent within the TWWHA, the action **will not have a significant impact** on the historic heritage values of a World Heritage property associated with artefacts and deposits, cultural landscapes and resources, or traditional access and use.
• Permanently remove, destroy, damage or substantially alter the fabric of a World Heritage property.	• Permanently remove, destroy, damage or substantially alter the fabric of a National Heritage place in a manner which is inconsistent with relevant values.	There are no World Heritage or National Heritage listed historic heritage values associated with the River Derwent within the TWWHA.
• Extend, renovate, refurbish or substantially alter a World Heritage	• Extend, renovate, refurbish or substantially alter a National Heritage	There are no World Heritage or National Heritage listed historic heritage values associated with the River Derwent within the TWWHA.

World Heritage Properties Criteria	National Heritage Places Criteria	Response
property in a manner which is inconsistent with relevant values	place in a manner which is inconsistent with relevant values.	
• Permanently remove, destroy, damage or substantially disturb archaeological deposits or artefacts in a World Heritage property.	• Permanently remove, destroy, damage or substantially disturb archaeological deposits or artefacts in a National Heritage place.	There are no World Heritage or National Heritage listed historic heritage values associated with the River Derwent within the TWWHA.
• Involve activities in a World Heritage property with substantial and/or long-term impacts on its values	• Involve activities in a National Heritage place with substantial and/or long-term impacts on its values.	There are no World Heritage or National Heritage listed historic heritage values associated with the River Derwent within the TWWHA.
• Involve construction of buildings or other structures within, adjacent to, or within important sight lines of, a World Heritage property which are inconsistent with relevant values.	• Involve the construction of buildings or other structures within, adjacent to, or within important sight lines of, a National Heritage place which are inconsistent with relevant values	There are no World Heritage or National Heritage listed historic heritage values associated with the River Derwent within the TWWHA.
• Make notable changes to the layout, spaces, form or species composition in a garden, landscape or setting of a World Heritage property which are inconsistent with relevant values.	• Make notable changes to the layout, spaces, form or species composition of a garden, landscape or setting of a National Heritage place in a manner which is inconsistent with relevant values.	There are no World Heritage or National Heritage listed historic heritage values associated with the River Derwent within the TWWHA.
• Alter the setting of a World Heritage property in a manner which is inconsistent with relevant values.	• Alter the setting of a National Heritage place in a manner which is inconsistent with relevant values.	A reduced operational spill regime may reduce bank erosion and result in further stabilisation and vegetation encroachment on riverine/streamside landforms. *While the planned mitigation will provide a more regular, annual spill regime to maintain natural values, it is not expected that these planned spills will have a significant negative effect on cultural values associated with the TWWHA. For example, the average magnitude of peak flows under the Project will be similar to that which has been observed historically.*

World Heritage Properties Criteria	National Heritage Places Criteria	Response
• Remove, damage, or substantially disturb cultural artefacts, or ceremonial objects, in a World Heritage property.	• Remove, destroy, damage or substantially disturb archaeological deposits or cultural artefacts in a National Heritage place.	Alteration of the current flow regime has the potential to increase erosion of any riparian archaeological deposits that may be present. *While the planned mitigation will provide a more regular, annual spill regime to maintain natural values, it is not expected that these planned spills will have a significant negative effect on cultural values associated with the TWWHA. For example, the average magnitude of peak flows under the Project will be similar to that which has been observed historically.*
• Permanently damage or obscure rock art or other cultural or ceremonial features with World Heritage values.	• Destroy, damage or permanently obscure rock art or other cultural or ceremonial, artefacts, features, or objects in a National Heritage place.	There will be no development within the TWWHA. No rock art or other ceremonial sites are known for the River Derwent section and are highly unlikely to be present due to the dominant dolerite geology and steep terrain.
	• Notably diminish the value of a National Heritage place in demonstrating creative or technical achievement.	No places demonstrating indigenous creative or technical achievement are recorded for the River Derwent section, and no changes to landforms outside the natural flood zone are anticipated.
	• Permanently remove, destroy, damage or substantially alter Indigenous built structures in a National Heritage place.	No Indigenous built structures are recorded for the River Derwent section or are likely to be present based on historical and archaeological studies of the Tasmanian uplands. No construction activities will occur within the TWWHA and no changes to landforms outside the natural river flood zone are anticipated.
	• Involve activities in a National Heritage place with substantial and/or long-term impacts on the values of the place.	The proposed mitigation aims to maintain overall health and diversity of (culturally important) plant and animal species along the river itself. No negative long-term impacts are anticipated.

8.4.4.1 Summary of impact assessment for the Tasmanian Wilderness World Heritage Area

Impact description	Water diversion and changed flow regime resulting in changes to geomorphological and ecological processes, which may in turn affect habitat availability and the abundance and diversity of aquatic and threatened biota.
Impact type	**Indirect**
Mitigation	Planned spill events of sufficient magnitude and frequency (one annual high flow release and three annual lower freshes) to maintain processes, habitat and species values in the TWWHA. Monitoring of flow releases, rock movement, vegetation encroachment, aquatic habitats and macroinvertebrate communities pre- and post-operation.
Impact significance post mitigation	**Not significant**

8.5 Barbarea australis

8.5.1 Impact criteria

There are no species-specific referral guidelines for *Barbarea australis* and this impact assessment is based on the Department of the Environment (2014a) listing advice for the species and on the relevant significant impact criteria are defined under 'critically endangered and endangered' species in the *Matters of National Environmental Significance - Significant Impact Guidelines* (Department of the Environment 2013).

The Department of the Environment (2014a) 'Approved Conservation Advice for *Barbarea australis'* lists the following as the main threats to the species:

- loss of habitat due to land clearance and invasion by exotic plants, particularly gorse (*Ulex europaeus*) and willows (*Salix* species), which exclude *B. australis*
- existing dams that modify flow regimes and may impact seed dispersal and availability of suitable habitat for recruitment
- modification of riverbanks and channels through willow removal
- forestry activity
- further dam development.

The Department of the Environment (2014a) refers to the listing advice for the *B. australis* (Threatened Species Section 2010) in stating that further dam development is the main potential threat to native wintercress due to alteration of flow regimes and reduced availability of suitable habitat for recruitment (Department of the Environment 2014).

The potential impacts of the Project on *B. australis* centre on changes to the hydrological regime. The sections below assess each reach against the significant impact criteria focusing on the 'a long-term decrease in the size of a population', and 'adversely affect habitat critical to the survival of a species'. An assessment against the remaining criteria is summarised in tables.

Changes to the spill regime that may impact *B. australis* and its habitat could occur through:

- Altered size of peak flow events. For example, lower peak flows would be expected to result in less turnover sediment and provide more opportunities for terrestrial vegetation to encroach into the channel and potentially reduce the areas suitable for *B. australis*. Lower peak flows may also result in less transportation and redistribution of the seeds of *B. australis*.
- Altered frequency of spill events. For example, less frequent spill events may also lead to reduced turnover of sediment and thus provide more opportunities for terrestrial vegetation to encroach into the channel and potentially reduce the areas suitable for *B. australis*. Alternatively, more frequent spill events may lead to increased scouring of *B. australis* plants if they occur during the species' main growing season (November to April), particularly if they occur during the peak flowering season (November to February; Threatened Species Section 2011).

- Altered timing of spill events. Spill is beneficial during the species' non-growing season but may potentially have an adverse impact (scour) during the growing season as discussed above. The threshold of flow velocity which would remove *B. australis* plants by scour is unknown but would certainly vary depending upon the growth phase of the plant and location-specific hydraulic conditions.

8.5.2 EPBC Act Significant impact assessments criteria

The following EPBC Act Significant impact assessments criteria are relevant for *B. australis*:

- Lead to a long-term decrease in the size of the population
- Reduce the area of occupancy of the species
- Fragment and existing population into two more populations
- Adversely affect habitat critical to the survival of a species
- Disrupt the breeding cycle of a population
- Modify, destroy, remove, isolate or decrease the availability or quality of habitat to the extent that the species is likely to decline
- Result in invasive species that are harmful to a critically endangered or endangered species becoming established in the endangered or critically endangered species' habitat
- Introduce disease that may cause the species to decline
- Interfere with the recovery of the species.

Under the precautionary principle, an assessment for the reach of the River Derwent downstream Clark Dam to Wayatinah Lagoon is provided even though surveys for the Project indicate that the species may no longer be present. An assessment is provided because this reach does contain areas of suitable habitat; the species has been recorded here previously and because there is a nearby population in the River Derwent downstream Wayatinah Lagoon.

8.5.3 River Derwent downstream Clark Dam to Wayatinah Lagoon

Hydrological modelling that indicates reduced peak flows for the reaches of the River Derwent downstream of Clark Dam which is entirely driven by a reduced magnitude, frequency and duration of spill from the dam (Section 8.1). The changes are summarised as following:

- BAU had more frequent medium and large spill events (events ≥ 60 m^3/s) than the observed spill. For the observed record and BAU, spills mainly occur between late autumn and early spring. The mean annual maximum flow is 83 m^3/s for the observed spill; 114 m^3/s for BAU; and 41 m^3/s for the Project (Section 8.1.4).
- Most of the suitable habitat for *B. australis* in this reach comprises loose aggregations of gravels, pebbles and small cobbles (mean grain size of 100 mm) at the downstream margin of large boulders. Hydraulic modelling indicated that, on average, a 60 m^3/s flow mobilises small cobbles to the margins of the river channel (Section 8.1.7). Fourteen spill events ≥ 60 m^3/s were observed over the 16-year duration; 38 were modelled under the BAU case and five were modelled under the Project case.
- Under baseline operation, spills ≥ 60 m^3/s or higher do not occur each year. For example, there were no spills over Derwent Pumps Weir ≥ 60 m^3/s between 2005 and 2008 and gaps

of two to three years between events are common over the available record (1989 to current).

- Under the Project, the reach of the River Derwent downstream of Clark Dam would receive less frequent and smaller spill events than occurs under current/historical operation (observed spill) or the BAU case. Without mitigation, reduced spill has the potential to have a significant impact on the availability of habitat suitable for *B. australis* in this reach.
- This species is not particularly vulnerable to changes in baseflow other than the potential for prolonged low flows to alter the wetting of gravels in which the species gravels. However, operation of the Project does not alter baseflow conditions (Section 6.1.2).

The geomorphic and hydraulic modelling impact assessment in Sections 8.1.6 and 8.1.7 and indicate that the reduced spill regime would reduce the mobilisation of the gravels to small cobbles which form patches of suitable habitat for this species. Reduced spill would also likely accelerate the establishment terrestrial vegetation into the channel. Prior to implementation of the proposed flow mitigation (summarised below) the reduced spill regime during operation of the Project has the potential to decrease the areas of suitable habitat for *B. australis* in this reach.

8.5.3.1 Proposed mitigation

The proposed measure to mitigate the impact of a reduction in spill events involves introducing planned spill events to maintain habitat for *B. australis*. The mitigation is discussed in detail in Section 99 and is summarised as follows:

1. High Flow Releases:

- **Annual Release**: Alternating annual releases of 60 m^3/s one year and up to 100 m^3/s the next year.
- **Release duration**: Each release will ramp up over one day, held at the maximum for one day, and ramp down over another day. The duration of these events is consistent with events of this size over the flow record
- **Timing**: Releases will occur outside the main growth and flowering period (November to April) for *B. australis*.
- **Natural Flow Coordination**: When possible, the releases will be timed to coincide with naturally high flows to enhance the peak flow.

2. Frequency and Impact:

- The proposed mitigation will increase the frequency of high flow events, ensuring at least one event of ≥ 60 m^3/s each year.
- Events of 60 m^3/s will mobilize substrates up to small cobbles, while 100 m^3/s will mobilize larger substrates and scour terrestrial plants.

3. Monitoring and Adjustment:

- Success will be monitored through annual surveys of rock movement, plant encroachment, species abundance, and geomorphic condition.

- If 60 m^3/s releases are insufficient, they will be increased up to a maximum 100 m^3/s until effective.

This approach aims to maintain the habitat for *B. australis* by ensuring regular high flow events that mimic natural conditions. With implementation of the proposed high flow rules the Project is predicted to have **no impact** on habitat suitable for this species. A significant impact assessment for this reach against the EPBC Act significant impact assessment criteria is provided in Appendix F.

8.5.4 River Derwent Downstream Wayatinah Lagoon

Hydrological modelling indicated that the magnitude of large spills would be reduced during operation of the Project (Section 8.2.1; Table 8.8). A reduction in sediment turnover from less spill could potentially impact habitat maintenance and availability for *Barbarea australis.* However, the geomorphic assessment determined that the overall reduced magnitude of large spills under operation of the Project is unlikely to result in less sediment mobilisation than occurs under the observed spill regime (Section 8.2.2). This assessment was made because moderate to high spills, that have the potential to mobilise gravel and small cobbles, will continue to occur within the channel (Section 8.2.2). It is also expected that the ongoing erosion of the riverbanks combined with the episodic high flows will maintain discontinuous patches of loose gravels and cobbles that currently exist in the river (Section 8.2.2).

Sediment mobilisation outputs from the hydraulic modelling support the assessment given above. For example, Figure 8.11 shows a histogram of the potential for mobilisation of different sediment size classes for the mean annual maximum flow for baseline operation (205 m^3/s) and for operation of the Project (114 m^3/s). The results suggest that a 114 m^3/s and 205 m^3/s events have the potential to mobilises nearly 100 percent of gravels, pebbles and small cobbles in the channel (Figure 8.11). The hydraulic model indicates that a 114 m^3/s event mobilises ~15 percent less large cobble, and ~19 percent less boulders than a 205 m^3/s event (Figure 8.11).

The above results suggest that the patches of mobile small substrate which provide suitable habitat for *B. australis* will be maintained by the operational spill regime of the Project.

A potential beneficial outcome of the Project in this reach is that large spills are modelled to be rarer during the growing/flowering season for *B. australis* (November to April) compared to the baseline operation (Table 8.13). The flow threshold that would remove *B. australis* plants by scour is unknown and would vary depending on the position within the channel; however, larger spills increase the potential for scour during the growing season.

Based on the hydrological, hydraulic and geomorphic assessment, operation of the scheme is **not predicted** to impact populations of *B. australis* in this reach. Because this assessment is dependent on modelling, pre- and post-commissioning monitoring of rock movement and *B. australis* populations is proposed to determine if sediment mobilisation and population patterns remain in the range which currently occur. Any impacts on *Barbarea australis* from changed spill downstream of Wayatinah Dam will be monitored for, and if necessary, adaptive management principles will be followed to ensure that there would be no negative impacts on populations of *Barbarea australis*.

Table 8.13: Size and duration of spill events during the main growing/flowering season for *B. australis* (November to April) in the River Derwent downstream Wayatinah Dam modelled under the Project and BAU cases and for the observed spill record.

Spill statistic	Baseline	BAU	Project
% Frequency of spill	5	12	8
Peak spill recorded (m^3/s)	215	100	93
Average maximum flow during growing season (m^3/s)	62	54	34
Mean number of events per growing season			
10 m^3/s	1.4	11.2	4.6
20 m^3/s	1.4	4.0	1.5
50 m^3/s	1.1	0.6	0.3
75 m^3/s	0.5	0.3	0.1

8.5.5 Nive River downstream Liapootah Dam

Mean annual peak flows are predicted to be similar to current operation with the magnitude of larger spills similar to baseline operation and BAU. Hydraulic modelling indicates that the regime of sediment mobilisation during operation of the Project is likely to be similar to current operation (Section 8.3.2; Figure 8.13).

As discussed, the Project is predicted to spill more from May to September (Section 8.3.1) which is outside the growing/reproductive season for *B. australis*. In these months the species is likely only present as a seed bank[10], and therefore additional spill would not result in a negative (scour) impact. Also, the predicted increase in spill over autumn and winter may potentially be beneficial due to the increased mobilisation of sediment and the increased likelihood of transportation and redistribution of *B. australis* seeds.

For baseline operation, spill was rare over the main growing and flowering period (November to April), however, spill has been recorded in all months, ranging from < 1 - 178 m^3/s. The flow required to scour a plant would vary depending on its location within the channel, on the size of the plant, and on the location-specific hydraulic conditions. However, hydraulic modelling indicates that flow events of approximately 10 to 20 m^3/s inundate the full extent of the channel in most reaches[11]. The hydraulic model also suggests that flow events of 10 to 20 m^3/s can mobilise a high percentage of gravels and pebbles and 20 to 30 percent of the small cobbles which are inundated (Figure 8.15). Therefore, flows of 10 to 20 m^3/s (and possibly lower) may result in the scour of plants, and scouring of plants would certainly have occurred under baseline operation.

[10] The species can persist as a short-lived perennial form that is capable of surviving over winter, but this appears to be relatively uncommon based on our observations of *B. australis*.

[11] Note that these values are different to that reporting for sediment mobilisation in the River Derwent downstream Clark Dam as the hydraulic conditions (channel geometry – shape, width and bed slope) differ.

Modelling for the Project and BAU cases indicates spill frequency would slightly increase over the growing season for *B. australis*. The key differences between the modelled and baseline records during the growing season (November to April inclusive) are shown in Table 8.14 and summarised below:

- The modelled maximum spill (111 m^3/s) and mean spill (35 m^3/s) for the Project case would be lower than for baseline operation (maximum 178 m^3/s; mean 43 m^3/s) during the growing season. The maximum and mean spill for BAU is similar to the baseline record.
- The mean number of spill events ≥ 10 m^3/s is slightly more than double for the Project compared to baseline operation. Under the BAU case, the number of events ≥ 10 m^3/s is 3.5 times higher than baseline operation.

Increased frequency of spill over the growing period during operation of the Project may result in increased scour of *B. australis*; however, the modelling also shows the magnitude of spill events would on average be smaller than spills which occurred under baseline operation (Table 8.14), which may be a benefit of the Project if it results in less scour of *B. australis* plants.

Table 8.14: Size and duration of spill events during the main growing/reproductive season (Nov – April) in the Nive River downstream Lake Liapootah modelled under the Project and BAU cases and for the baseline spill record.

Spill statistic	Baseline operation (observed)	BAU	Project
% Frequency of spill	1	4	3
Maximum flow recorded (m^3/s)	178	162	111
Mean of all spill events (m^3/s)	43	47	36
Mean number of events ≥ 10 m^3/s	4.1	14.8	9.8

Overall, there is no evidence that suggests operation of the Project will reduce the magnitude of peak annual spills that maintain habitat for *B. australis* in the Nive River downstream Liapootah Dam (Table 8.10; Figure 8.13).

An increase in smaller spills outside of the growing season expected under the Project may be a benefit. The increase in spills during the growing season during operation of the Project may impact some plants through scour; however, this may be compensated by a decrease in the magnitude of spills during the growing season compared with baseline operation. Therefore, the Project is considered **unlikely** to have a significant negative impact on *B. australis* in this reach.

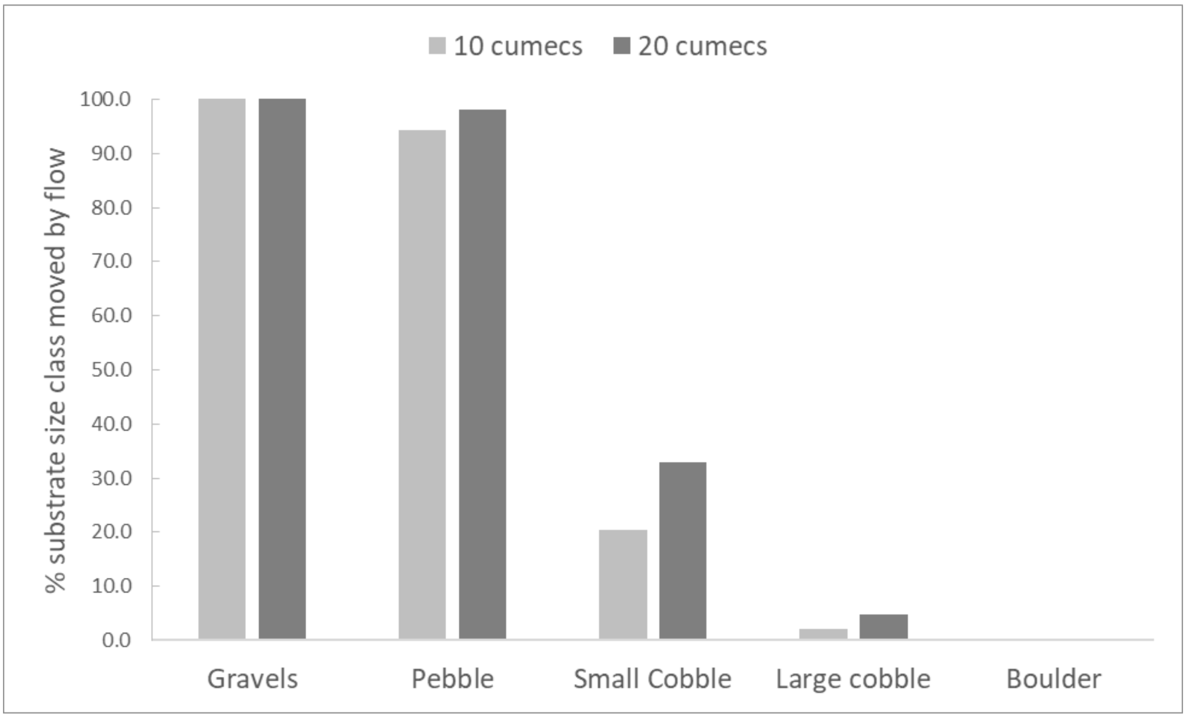

Figure 8.15: Percent of channel area where the hydraulic model estimates different size fractions have the potential to be mobilised under a 10 m^3/s and 20 m^3/s flow. The model is predicting potential sediment transport capacity in grid cell (model assumes all size fractions are equally available in every cell). Modelled reach is a ~800 m long section of the Nive River ~ 3 km downstream Liapootah Dam.

8.5.6 Summary

An EPBC Act Significant impact assessment for *B. australis* is provided in Appendix F and summarised below in Table 8.15.

Table 8.15: Summary of impact assessment for Barbarea australis.

River Derwent downstream Clark Dam	**Impact description**	Reduction in high flow regime and subsequent loss of habitat.	
	Impact type	Direct	**Indirect**
	Mitigation	-	Planned spill events of sufficient magnitude and frequency to maintain habitat.
	Impact significance post mitigation	-	**Not significant**
Nive River downstream Lake Liapootah	**Impact description**	Alteration of flow regime and subsequent loss of habitat/loss of individuals through scouring. Modelling indicates operational spill regime under the Project would be similar to the current spill regime.	
	Impact type	**Direct**	**Indirect**
	Mitigation		Monitor and offset in the event increased spill frequency over growing season has negative impact on the population; however, this is assessed as unlikely
	Impact significance post mitigation	-	**Not significant**
River Derwent downstream Wayatinah Lagoon	**Impact description**	The modelled reduction in high flow regime has the potential to result in a minor loss of habitat through reduced sediment turnover, which could potentially affect the population size. However, the geomorphology assessment and interpretation of hydrological modelling indicates that there will be minimal reduction in mobilisation of gravels to cobbles which form the majority of the suitable habitat in this reach. Therefore, operation of the Project is not predicted to impact *B. australis.*	
	Impact type	**Direct**	**Indirect**
	Mitigation	-	Monitor and apply adaptive management principles to ensure that there would be no negative impacts on populations of *Barbarea australis*
	Impact significance post mitigation	-	**Not Significant**

8.6 General aquatic values

The potential operational impacts on the aquatic environment centre on changed spill from the dams where system modelling indicates that the Project has the potential to change spill compared to current operation. The description of modelled changes in spill for each reach is provided in Sections 8.1 to 8.3.

The River Derwent downstream Wayatinah Lagoon and the Nive River downstream Liapootah Dam are similar because both reaches are relatively short (6 and 9 km respectively) and have low baseflows from the small tributary inflows (Sections 6.2 and 6.3). In these reaches all high flow events are derived from dam spill.

The flow regime in the River Derwent downstream Clark Dam is more nuanced because it is a long reach (31 km) and the relative contribution of tributary inflows is much larger to both the baseflow and high flow regime (Section 6.1). The largest flows recorded in this reach are all still derived from dam spill but large dam spills do not occur each year and there is a distinct difference in the flow regime between the reaches upstream and downstream of the Counsel River inflow (Section 6.1).

High flow events are essential for maintaining the physical structure and biological health of river ecosystems. They ensure the dynamic nature of rivers, support diverse habitats, and promote ecological processes that sustain aquatic life, summaries as follows:

Physical Processes:

- Inorganic and organic transport and deposition:
    - High flow events mobilize and transport sediments, including gravel, cobbles, and boulders, which are essential for maintaining the riverbed structure.
    - Redistribution of sediments, preventing the riverbed from becoming compacted or clogged with fine materials.
    - Bank and floodplain/riparian connectivity.
    - Debris exchange through transport of large woody debris and organic material which contributes to habitat complexity.
- Channel morphology:
    - High flow events shape the river channel by eroding banks, creating new channels, and depositing sediments in different areas.
    - Maintain diverse habitats by creating pools, riffles, and bars, which are important for a diverse aquatic community.
- Scouring of vegetation:
    - High flows can scour terrestrial vegetation from the river channel, preventing encroachment and maintaining open water habitats.
    - Maintain an active and dynamic river channel.

Biological Processes:

- Habitat maintenance:

  - Mobilising sediments and maintaining channel morphology, high flow events create and sustain habitats for aquatic species
  - Ensure the availability of suitable spawning grounds and shelter for aquatic species.
- Nutrient cycling:
  - Facilitate the exchange of nutrients between the river and the floodplain/riparian zone, enhancing the productivity of both aquatic and terrestrial ecosystems.
  - Food web dynamics through the distribution of organic matter and nutrients in the channel and riparian/floodplain.
- Species dispersal and life history cues:
  - Aid the dispersal of aquatic organisms, including fish and plant seeds, promoting genetic diversity and colonization of new areas.
  - Cues for migration, spawning and other life history cues of aquatic species.
- Water quality:
  - Flushing/diluting of pollutants and stagnant water, improving overall water quality and ecological health of the river

8.6.1 River Derwent downstream Clark Dam to Wayatinah Lagoon (TWWHA)

The River Derwent within the TWWHA comprises 23 kilometres of the 31 kilometre reach downstream Clark Dam to Wayatinah Lagoon. The description provided above (Section 8.4) for potential impacts to general aquatic values in the TWWHA apply equally to the entire reach.

8.6.2 River Derwent downstream Wayatinah Lagoon

Most of the aquatic values in this reach are maintained by the small tributary inflows which enter downstream of the dam although, as detailed above, sporadic high flow events provide important roles in the ecological health of rivers. For this reach, all high flow events are derived from dam spill.

The predicted impact of operation of the Project on physical and biological processes in this reach is detailed in Table 8.16. Data on many of these processes will be monitored for prior to and during operation as commitments to ensure that the Project is not impacting the population of the EPBC listed *B. australis* (summarised in Table 8.16 and detailed in Section 9).

The reduction in size of large annual spills through this reach is assessed as unlikely to significantly impact these processes because large channel forming spills will still occur. Also, the hydrological monitoring indicates that small spills will be more frequent than occurs under current operation which may be of benefit for aquatic habitats and species.

Overall, the habitat conditions for populations of fish, macroinvertebrates, and platypus and A. tricornis if present, are predicted to remain in a similar condition during operation of the Project as occurs under current operation.

8.6.3 Nive River downstream Liapootah Dam

Most of the aquatic values in this reach are maintained by the small tributary inflows which enter downstream of the dam although, as detailed above, sporadic high flow events provide important roles in the ecological health of rivers. For this reach, all high flow events are derived from dam spill.

The predicted impact of operation of the Project on physical and biological processes in this reach is detailed in Table 8.17. Data on many of these processes will be monitored for prior to and during operation as commitments to ensure that the Project is not impacting the population of the EPBC listed *B. australis* that occurs in this reach (Summarised in Table 8.17 and detailed in Section 9).

The spill regime predicted to remain broadly similar to current in terms of magnitude and timing (Section 8.3.1). However, the hydrological modelling indicates that spill will occur more frequently during operation of the Project, increasing from approximately 7 to 15 % of the time. The increase in spill is mainly for small events over the autumn and winter months (1 – 20 m^3/s) (Section 8.3.1).

Overall, the habitat conditions for populations of fish, macroinvertebrates, and platypus and *A. tricornis* if present, are predicted to remain in at least a similar condition during operation of the Project as occurs under current operation. The increase in smaller spills may benefit the physical and ecological processes in this reach.

Table 8.16: Role of high flow regime in physical and biological processes under current and Project flow regime for the River Derwent downstream Wayatinah Lagoon.

	Process	Role	Project impacts	Monitoring to inform condition
Physical processes	*Inorganic and organic material exchange*	*Structure of riverbed habitats (reach scale)* *Redistribution of riverbed sediments (habitat unit scale)*	Spills of sufficient magnitude are predicted to maintain the channel in a similar condition to current.	• Rock movement surveys • Operational flow monitoring (spill) • Macroinvertebrate surveys (riffle health/structure • Habitat survey associated with macroinvertebrate survey
		Channel and riparian connectivity *Debris exchange*	Reduction in the size of spills may reduce the degree of connectivity between the channel and riparian zone during peak flow events	No direct monitoring proposed but vegetation encroachment and habitat surveys will provide information on these processes.
	Channel morphology	*Reach scale redistribution of sediments*	Hydraulic modelling indicates that the size of peak flows during operation will be sufficient to mobiles smaller substrates (fine gravels to small/moderate cobbles similar to current operation. Large cobbles and boulders will still be mobilised but to a lesser degree than current operation	• Rock movement surveys • Operational flow monitoring (spill)
		Maintain diverse habitats	This reach is highly modified and in poor condition. The habitats present are predicted to remain during the operation of the Project	• Macroinvertebrate surveys • Habitat survey associated with macroinvertebrate survey • Operational flow monitoring (spill)
	Scour	*Removal of encroaching vegetation*	Large annual peak flows will still occur during the Project and likely sufficient to maintain encroachment at a similar level to current.	• Vegetation surveys to monitor encroachment • Operational flow monitoring (spill)
		Scour accumulated biofilms from riverbed	The frequency of smaller spills (1 – 10 m^3/s) will increase and have the potential to assist in removal of the thick and harmful biofilms which occur in this reach.	• Macroinvertebrate surveys • Habitat survey associated with macroinvertebrate survey

	Process	Role	Project impacts	Monitoring to inform condition
				• Operational flow monitoring (spill)
		Maintain an active river channel	Geomorphic conditions are predicted to remain similar to current	• Rock movement surveys • Operational flow monitoring (spill)
Biological processes	*Habitat maintenance*	*Mobilisation of organic and inorganic sediments for a diverse range of habitats*	Geomorphic conditions are predicted to remain similar to current	• Rock movement surveys
		Maintain spawning habitats for aquatic species	Large annual peak spills will still occur, and increased regime of smaller spills may be of benefit for spawning habitats for macroinvertebrates, dispersal of species and exchanges of organic and inorganic matter within the channel and between the channel and riparian zone	• Macroinvertebrate surveys • Habitat survey associated with macroinvertebrate survey
	Nutrient cycling	*Food web health through redistribution of organic matter within the channel and between the channel and riparian zone*		
	Species dispersal and life history cues	*Dispersal of aquatic species*		
		Cues for migration, spawning or other life history cues	An increased frequency of smaller spills (1 – 10 m³/s) may be of benefit for life history cues	• Macroinvertebrate surveys
		Dispersal of plant seeds along riparian corridor	Large spills sufficient for seed distribution are maintained and an increased frequency of smaller spills (1 – 10 m³/s) may also be of benefit	• Vegetation surveys • *Barbarea australis* surveys
	Water quality	*Flushing of pollutants and stagnant water to maintain ecological health*	Large spills sufficient for flushes are maintained and an increased frequency of smaller spills (1 – 10 m³/s) may be of benefit for recharging pools	• Macroinvertebrate surveys (riffle health/structure • Spot phys-chem water sampling

Table 8.17: Role of high flow regime in physical and biological processes under current and Project flow regime for the Nive River downstream Liapootah Dam.

	Process	Role	Project impacts	Monitoring to inform condition
Physical processes	*Inorganic and organic material exchange*	*Structure of riverbed habitats (reach scale)*	Spills of sufficient magnitude are predicted to maintain the channel, riparian connectivity and debris exchange in a similar condition to current.	• Rock movement surveys • Operational flow monitoring (spill) • Macroinvertebrate surveys (riffle health/structure • Habitat survey associated with macroinvertebrate survey
		Redistribution of riverbed sediments (habitat unit scale)		
		Channel and riparian connectivity		
		Debris exchange		
	Channel morphology	*Reach scale redistribution of sediments*	Hydraulic modelling indicates events sizes will maintain a similar regime of rock mobilisation in this reach	• Rock movement surveys • Operational flow monitoring (spill)
		Maintain diverse habitats	This reach is highly modified and in poor condition. The habitats present are predicted to remain during the operation of the Project	• Macroinvertebrate surveys • Habitat survey associated with macroinvertebrate survey • Operational flow monitoring (spill)
	Scour	*Removal of encroaching vegetation*	Vegetation encroachment is minimal in this reach and the annual peak flows are predicted to maintain encroachment at a similar level to current.	• Vegetation surveys to monitor encroachment • Operational flow monitoring (spill)
		Scour accumulated biofilms from riverbed	The frequency of smaller spills (1 – 20 m^3/s) will increase and have the potential to assist in scouring of biofilms	• Macroinvertebrate surveys • Habitat survey associated with macroinvertebrate survey • Operational flow monitoring (spill)
		Maintain an active river channel		

	Process	Role	Project impacts	Monitoring to inform condition
Biological processes	*Habitat maintenance*	*Mobilisation of organic and inorganic sediments for a diverse range of habitats*	Geomorphic conditions are predicted to remain similar to current	• Rock movement surveys • Operational flow monitoring (spill)
		Maintain spawning habitats for aquatic species	Large annual peak spills similar to current, and increased regime of smaller spills may be of benefit for spawning habitats for macroinvertebrates, dispersal of species and exchanges of organic and inorganic matter within the channel and between the channel and riparian zone	
	Nutrient cycling	*Food web health through redistribution of organic matter within the channel and between the channel and riparian zone*		• Macroinvertebrate surveys • Habitat survey associated with macroinvertebrate survey
	Species dispersal and life history cues	*Dispersal of aquatic species*		
		Cues for migration, spawning or other life history cues	An increased frequency of smaller spills (1 – 20 m³/s) may be of benefit for life history cues	• Macroinvertebrate surveys
		Dispersal of plant seeds along riparian corridor	Large spills sufficient for seed distribution are maintained and an increased frequency of smaller spills (1 – 20 m³/s) may also be of benefit	• Vegetation surveys • *Barbarea australis* surveys
	Water quality	*Flushing of pollutants and stagnant water to maintain ecological health*	Large spills sufficient for flushes are maintained and an increased frequency of smaller spills (1 – 20 m³/s) may be of benefit for recharging pools	• Macroinvertebrate surveys (riffle health/structure • Spot phys-chem water sampling

9. Mitigation and monitoring

9.1 Construction mitigation and monitoring

Mitigation to protect aquatic communities during the construction period revolve around protection of water quality within the disturbance footprint and in the waterways downstream from the disturbance footprint. Potential water quality impacts, mitigation and monitoring are discussed in Entura (2025b).

Ecological monitoring during the construction period includes macroinvertebrate and benthic algal sampling in two unnamed streams which have the potential to experience elevated nutrient concentrations during construction of the Project. One stream (Stream 4) drains the location of the Western Portal spoil emplacement area (Figure 6.77) and another drains the location of the spoil emplacement area at Paddy's Quarry (Figure 6.78).

The potential impact of elevated nitrates during construction are discussed in Section 7.1. Macroinvertebrate and benthic algal (primary production) monitoring will include collection of a pre-construction baseline dataset with which to compare any impacts (such as changes in community composition, diversity and abundance) during construction as outlined below and in Table 9.1.

- Studies on the toxicological data on nitrates includes a number of macroinvertebrate species and thus macroinvertebrates a likely to be useful indicator for detecting any ecological impacts from nitrates during the construction period.
- Macroinvertebrates are also the main aquatic values in the tributaries that are likely to experience elevated levels of nitrate during construction. Sampling methods will include:
    - Quantitative Survey sampling to obtain an estimate of overall abundance and abundance of targeted taxa
    - AusRivAS river health sampling to obtain a characterisation of community health (presence/absence and composition
- Elevated nitrates may also result in increased primary production and thus the surveys will also include quantitative sampling of benthic algae (Chl-*a* biomass) using the new methods developed by NRE Tas Water Management Branch
- The results will be integrated with the results of the water quality sampling being undertaken over the same period (Entura 2025b).

No construction impacts from poor water quality are predicted for the River Derwent downstream Clark Dam (Section 7.2.1). However, macroinvertebrate monitoring will be undertaken in the River Derwent at five sites downstream Clark Dam to assess the potential impacts of operational changes in the spill. This monitoring will also be undertaken during the preconstruction and construction period at the same time as proposed for Stream 4 and the location of the monitoring sites in the River Derwent are suitable for detecting and potential water quality impacts from construction.

Table 9.1: Proposed invertebrate and algal monitoring to assess construction impacts on streams within the disturbance footprint

Timing	Location	Parameter	Methods	Timing
Preconstruction	Streams 4: downstream the Western Portal spoil emplacement area # Stream 5: up and downstream the Paddy's Quarry spoil emplacement area	Macroinvertebrates	AusRivAS	Minimum of one sampling period in spring and one in autumn prior to construction
			Surber sampling	
		Primary production (Chl-*a* biomass)	Scrapes from representative substrates	
Construction	Streams 4: downstream the Western Portal spoil emplacement area # Stream 5: up and downstream the Paddy's Quarry emplacement area site	Macroinvertebrates	AusRivAS	Every spring and autumn during construction
		Primary production (Chl-*a* biomass)	Surber sampling	
			Scrapes from representative substrates	
Operation	The need for operational sampling would be triggered if impacts to macroinvertebrate communities are detected during construction and which show no upward trend during the last construction sampling event.			

There is no suitable habitat for sampling upstream of the location for the Western Portal spoil emplacement area

9.2 Operational flow mitigation

Flow releases are proposed to provide an annual peak flow event and three small fresh events for the River Derwent downstream Clark Dam. Provision of an annual peak flow of at least 60 m^3/s would increase the frequency that events of this size pass Derwent Pumps Weir compared to current operation. Overall, the proposed flow mitigation is predicted to at least maintain the aquatic values in the River Derwent downstream Clark Dam. Annual monitoring is proposed to assess the effectiveness of the proposed flow releases.

9.2.1 Objectives for mitigation of flow regime changes

Section 8.4 discusses the physical and biological process which are already impacted by current operation and the predicted further decline of these processes if the Project was operated without the flow mitigation outlined below.

The proposed measures to mitigate the predicted impacts of a reduced spill/high flow regime is to have planned annual spill events of sufficient magnitude, frequency and duration to maintain the processes, habitat and species values in the TWWHA.

Although not recorded during surveys for the Project, a potential flow dependent value in the TWWHA includes maintaining habitat for the MNES plant species *Barbarea australis*. Peak flow events which mobilise patches of gravels to small cobble would maintain the suitable habitat for *B. australis* in this reach (Section 6.1).

The objectives for flow mitigation during operation is to provide:

1. An annual Peak flow event large enough to:
    - mobilise gravel, pebbles and small cobbles in the channel, side and mid-channel bars and up to the margins of the channel over the majority of the reach (as discussed in Sections 8.1.6 and 8.1.7);
    - the potential to move larger cobble and boulder over a proportion of the channel where these elements remain mobile;
    - prevent the acceleration of the encroachment of terrestrial vegetation into the channel by limiting the establishment of new seedlings;
2. Release of three smaller annual fresh events to:
    - Provide high flow cues for aquatic species
    - Flush accumulated biofilms from the substrate
    - Flush stagnant water from pools and to refresh water quality
    - Assist in nutrient turnover and recycling
    - Recharge water supply to banks and riparian zone

The objectives of the high flow and fresh releases are summarised in Table 9.2 below.

Table 9.2: Summary of objectives to maintain riverine processes and values in the River Derwent downstream Clark Dam to Wayatinah Lagoon.

Physical/Biological	Process	Objectives	High flow release	Fresh releases
Physical processes	Structure of riverbed	Maintain the active/mobile parts of the channel to limit channel contraction	✓	
		Maintain/improve frequency of bed and bank scouring, transport and deposition of small and large sediment classes to provide diverse instream habitats	✓	✓
	Riparian/channel exchange	Introduction of inorganic and organic sediments between channel and riparian zone	✓	
	Scour	Limit the rate of encroachment terrestrial plants to limit channel contraction and bed armouring	✓	
		Removal of excessive biofilms, particularly from pools and runs	✓	✓
Biological processes	Disturbance	Flow disturbance of riverbed and riparian zone to create new areas for colonisation	✓	
	Nutrient exchange	Nutrient cycling and exchange between riparian zone and river channel	✓	
		Nutrient cycling and exchange between riverine habitats and elevated rock bars	✓	✓
	Dispersal & life histories	Dispersal and colonisation of aquatic species	✓	✓
		Dispersal and colonisation of riparian plant seeds	✓	
		High flow cues for aquatic species	✓	✓
	Water quality	Refresh water quality in stagnant areas	✓	✓
	Water supply	Wetting/recharge of riverbanks	✓	✓

9.2.2 Planned releases during operation of the Project

The proposed mitigation measures are one annual high flow release and three annual lower, fresh releases as described below:

High flow releases

To mitigate for the predicted reduction in overall spill frequency and the reduction in spill events which currently exceed 100 m^3/s, the proposed high flow release will be an alternating annual release of 60 m^3/s in one year and up to 100 m^3/s in the following year (as measured at Derwent Pumps Weir). Each release will be ramped up over one day, held at the maximum release for one day and ramped down over another day. A three-day event of flows of this size are approximately equivalent to the duration of these events past Derwent Pumps Weir under current operation.

The flow rules will be written in a way that if flow events of these sizes occur naturally then no environmental releases will be required in that year. Planned high flow releases would be provided outside the main growing and flowering period for *Barbarea australis* (November to April).

Releases up to 100 m^3/s are aimed at mobilising cobbles to the channel margin; increasing the mobilisation of substrate up to small boulders (which in turn would mobilise the smaller substate beneath them) and increasing the potential for scouring of encroaching terrestrial plants. The risk of flooding in the Lower Derwent will need to be considered on a case by case basis if/when releasing water during natural high flow events to manage risk to people's safety and damage to property.

Lower flow releases (freshes)

Hydrological modelling indicates that smaller spills (≤ 15 m^3/s) at Derwent Pumps Weir would be substantially reduced by the Project[12] (Section 8.1.2). Thus, it is proposed to provide three planned, lower flow releases for 24 hours which range from 5 to 10 m^3/s: one at the end of summer, one in the first month of winter, and one in December. As for the high flow releases, no low flow releases would be required if these events occur naturally. Provision of smaller freshes would assist in flushing algae and biofilms from instream habitats; providing high flow cues for instream species; increasing nutrient exchange between the banks and low flow channel; and recharging water supply to banks and the riparian zone.

9.2.2.1 Operational limitations/conditions where high flow releases are not released

There are some operational limitations that occasionally could affect the proposed releases. Flow releases up to 64-78 m^3/s (depending on lake level) can be made through the riparian valves. This means that releases of 60 m^3/s can be made at any lake level above normal minimum operating level (NMOL). The spillway gates have to be used for larger releases. For example, releases of a 100 m^3/s flow would rely on use of the spillway gates, and water level in Lake King William must be higher than 713.3 mASL to release the full 100 m^3/s. Modelling of lake levels during operation

[12] It is likely that a proportion of the reduction of small spills is an artefact of modelling limitations (Section 4.3); however, the mitigation would only be required if an unplanned spill event of sufficient size does not occur by the trigger dates.

of the Project indicate that there would be up to an 11 percent chance in any given year of lake levels being below 713.3 mASL within the winter/early spring window of the event.

The planned annual high flow release would not occur under the following circumstances:

- If lake level is below 712.3m the combined valves and spillway gates cannot release 100 cumecs (as discussed above);
- If a flow event ≥ than the required release for that year occurs between 1 May and 1 September (as measured at the Derwent Pumps Weir)
- if the release would lead to flooding below Meadowbank (>180 m^3/s);
- If one or both regulator valves are out of service due to unplanned or unforeseen maintenance or outages; and
- If Hydro Tasmania is managing or recovering from an incident related to natural hazards, energy security, water security or safety risk.

In the unlikely event that a required release could not be made, the maximum flow possible would be released in that year and a planned release would be scheduled for the following year.

9.2.3 Performance of rules on the flow regime during operation of the Project

High flow events provide a benefit by providing episodic disturbance for habitat maintenance, behavioural cues and increased nutrient cycling. The baseline spill regime results in up to five years between high flow events of 60 m^3/s (Section 8.1.4.1). Therefore, the planned high flow releases under operation of the Project are assessed as a potential benefit to instream and riparian values compared to current operation (Section 8.4.3).

Compared to the baseline spill regime, the proposed mitigation will:

- increase the frequency of ≥ 60 m^3/s events downstream Derwent Pumps Weir and would ensure at least one event ≥ 60 m^3/s occurs each year which does not occur currently under baseline operation (Table 8.5; Figure 9.1).
- result in similar or higher mean annual maximum flow
- avoid years with very low peak flows – for example, observed maximum flow past Derwent Pumps Weir were less than 20 m^3/s in six of the 16-year record.

As discussed, most of the mobile sediment within the River Derwent in the TWWHA, occurs amongst small patches of loose aggregations of gravels, pebble, and small cobbles. The hydraulic model indicates that events of 60 m^3/s have the potential to mobilise up to small cobbles to the channel margin through most of the 25-km reach downstream Derwent Pumps Weir. Choosing the channel margin as the target is a conservative approach as the majority of mobile substrate is in the zone between the channel margins and the low flow channel. Throughout most of the river, the riverbed close to the channel margin, and the elevated side and mid channel bars, are armoured and relatively immobile due to the influence of historic operation (Section 6.1.2). By contrast the riverbed directly adjacent to the low flow channel is more active because these areas are exposed to higher shear stress during elevated flows and are engaged more frequently than areas of riverbed upslope.

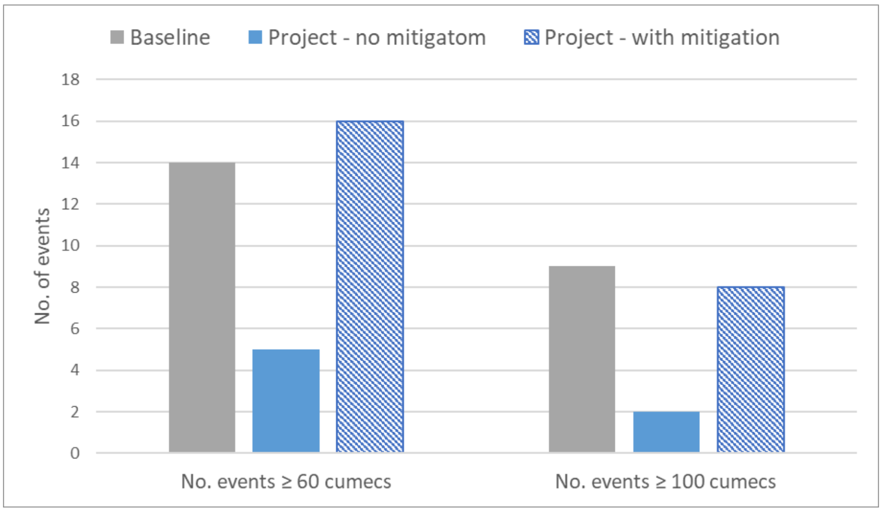

Figure 9.1: Number of events ≥ 60 m^3/s and ≥ 100 m^3/s over 16 years of record for baseline operation and for the Project with and without the proposed high flow releases.

9.3 Monitoring for operational impacts

As discussed in Section 8.4.1, the impacts of a changed flow regime involve interrelated physical and biological processes. The proposed monitoring plan has been designed to assess a subset of the key processes which will define the effectiveness of the proposed flow mitigation for the reach downstream Clark Dam and to validate the prediction that the operational spill regime will have no impact on rock mobilisation and *B. australis* populations in the Nive River downstream Liapootah Dam and in the River Derwent downstream Wayatinah Dam.

Table 9.4 below outlines locations, key parameters, frequency of monitoring and reporting and Figure 9.2 shows the location of the proposed monitoring sites. The initial plan is for annual monitoring prior to and during construction and five years of monitoring during operation. Triggers that would initiate continuation of monitoring beyond this period are discussed in Section 9.3.3. The objectives of the monitoring plan are to:

- Build a deeper understanding of baseline conditions against which change can be measured;
- Enable early detection of environmental changes, trends and impacts to inform adaptive management;
- Evaluate compliance with relevant approval conditions, performance criteria, and regulatory requirements;
- Measure the effectiveness of the proposed flow mitigation;
- Validate the predicted environmental impacts identified in the referral through data collection; and
- Support an adaptive management process whereby monitoring results are used to inform ongoing environmental performance improvements.

The sections below provide further details for each reach. The proposed monitoring outlined below either has begun (macroinvertebrate river health surveys and rock movement surveys) or will begin (*Barbarea australis* and vegetation monitoring) in 2025.

9.3.1 River Derwent downstream Clark Dam to Wayatinah Lagoon

For rock movement and vegetation monitoring three monitoring sites will be established in the River Derwent downstream of Clark Dam which are representative of the different zones in this reach (as discussed in Section 6.1.3; Table 9.3; Table 9.4). Five monitoring sites have been selected for macroinvertebrate river health monitoring in River Derwent which are representative of the zones in the river and the location of tributary inflows (Table 9.3; Figure 9.2). In addition, two reference sites have been selected to represent the mid-catchment (Counsel River) and lower catchment (Florentine River) (Table 9.3; Table 9.4).

The monitoring plan to assess any operational impacts and the success of the proposed flow mitigation includes:

- Annual reach and habitat riverbed mobilisation using rock movement surveys to examine:
  - if the substrate is being mobilised by the annual peak flow release;
  - which rock size class is being mobilised
  - which parts of the channel are mobilised
- Annual vegetation encroachment using transect and representative reach drone assessments to examine:
  - survival or removal of terrestrial seedlings growing in the channel along cross sectional transects; and
  - via coverage of plants in the channel calculated from photogrammetry survey of representative reaches
- Spring and autumn river health monitoring
  - Macroinvertebrate sampling using the AusRivAS method will be undertaken to assess any impact of changed operation and the effectiveness of the flow mitigation measures. The river health scores from pre-construction and construction will be used as a baseline to assess trends between sites and within sites over time and to assess trends during operation.
  - Maintenance of condition scores during operation, particularly for the three monitoring sites upstream of the Counsel River inflow, the sites which are most impacted by current operation would provide supporting evidence that physical and biological processes are being maintained.
- High flow monitoring
  - Planned environmental flow releases (compliance monitoring) from Clark Dam (magnitude and duration);
  - Planned releases associated with operational management (such as flood control and outages;
  - Spill recorded from Derwent Pumps Weir (continuous flow station); and
  - Flow recorded at the Derwent above Wayatinah station (continuous flow station).

Table 9.3: Rock and ecology monitoring locations in the River Derwent downstream Clark Dam and reference sites for macroinvertebrate monitoring.

Type	Site	Rock movement / vegetation	Macroinvertebrate monitoring
Project influence	River Derwent 1.6 km Downstream Clark Dam		✓
	River Derwent 2.5 km downstream Derwent Pumps Weir	✓	✓
	River Derwent Upstream Counsel River Inflow	✓	✓
	River Derwent Downstream Counsel River		✓
	River Derwent upstream Wayatinah Lagoon	✓	✓
Reference	Counsel River		✓
	Florentine River		✓

If the high flow releases of 60 m^3/s are shown not to mobilise sediments sufficient to maintain *Barbarea australis* habitat and other TWWHA values, they will be progressively increased up to 100 m^3/s until they are shown through the monitoring to be of sufficient magnitude.

If river health within the TWWHA is shown to decline, then the lower flow (fresh) releases will be reviewed and adaptively managed in terms of number, size and duration.

9.3.2 River Derwent downstream Wayatinah Lagoon and Nive River downstream Liapootah Dam

The assessment did not predict that operation of the Project will impact aquatic values in the River Derwent downstream Wayatinah Lagoon or the Nive River downstream Liapootah Dam. However, the assessment of impacts relies on the hydrological modelling being accurate. Hydrological modelling for this Project is complex due to the interdependencies of many factors, including future conditions of the national energy market and operation of multiple power stations in the Derwent-Nive scheme and in other catchments across Tasmania.

Therefore, the same suite of monitoring as described above for the River Derwent downstream Clark dam will be undertaken in these two river reaches, except for flow monitoring which will be limited to reporting on the annual pattern of dam spill (Figure 9.2).

In addition, annual surveys of the populations of *Barbarea australis* in representative 3 km reaches of the Nive River downstream of Liapootah Dam and the River Derwent downstream of Wayatinah Lagoon will be undertaken, recording the number, specific location, life stage and habitat association of each *Barbarea australis* record. Annual variation in *B. australis* populations is not well understood and the survey data will be used to assess if population dynamics during operation of the Project are consistent to those which are recorded prior to operation. The monitoring plan for these reaches are summarised in Table 9.4 and the location of monitoring sites in Figure 9.2. Note, there are no known suitable populations of *B. australis* in unregulated rivers in southern Tasmania which could serve as a reference site(s) for comparison.

9.3.3 Reporting

An annual report will be prepared to summarise the results of the monitoring data for the flow regime, sediment mobilisation, vegetation encroachment, river health (macroinvertebrates and aquatic habitats) and *B. australis* surveys.

The need for continuation of the annual flow summary report beyond an initial five years will be dependent of the needs of monitoring programs. If any of these monitoring program continue beyond the initial five years, flow monitoring data will be provided for the same period as the revised monitoring program.

Triggers for ongoing monitoring after the first five years would include:

- Flow regime:
  - Non-compliance with the release rules for operational or other reasons
- Sediment mobilisation and vegetation encroachment:
  - uncertainty in the trend (high seasonal or interannual variation), or
  - a clear declining trend in sediment mobilisation and/or clear increase in the rate of vegetation encroachment.
- *B. australis:*
  - uncertainty in the trend (high seasonal or interannual variation), or
  - a clear declining trend in the population
- Macroinvertebrates:
  - uncertainty in the trend (high seasonal or interannual variation), or
  - a clear declining trend in macroinvertebrate communities and river health scores below the bounds observed during baseline.

Table 9.4: Proposed monitoring plan to assess operational impacts in the River Derwent and Nive River.

Monitoring measure No.	Monitoring approach	Monitoring locations	Project Phase and timing			Reporting
			Pre-construction	Construction & commissioning	Operation	
1.	Geomorphology and vegetation monitoring will be undertaken to: • assess the condition (sediment mobilisation and vegetation encroachment) of the riverbed • provide baseline data for and subsequently assess the effectiveness of flow releases. The monitoring results will be used to determine if the magnitude of the planned releases need to be adjusted (capped at 100 m^3/s). • assess any impacts from changed spill regime in the Nive River downstream of Liapootah Dam and the River Derwent downstream of Wayatinah Dam to assess if any impacts on *Barbarea australis* from changed spill in this reach would occur as outlined in Monitoring measure 2. Sediment mobilisation will be monitored through rock rollover survey whereby rocks of variable sizes are painted with a highly visible paint at a set location. Following a high flow event, the same sites are visited, and	Three monitoring sites will be established in the River Derwent downstream of Clark Dam; one site in the River Derwent downstream of Wayatinah Dam; and one site in the Nive River downstream of Liapootah Dam.	Annually	Annually	Annually for five years	An annual report summarising the results of monitoring will be prepared and will be provided to the EPA/Commonwealth upon request. A review of the data after 5 years of post-commissioning monitoring will determine the need for ongoing monitoring and the frequency required (annual, biannual, etc.). Triggers for ongoing monitoring would include uncertainty in the trend (high seasonal or interannual variation), or a clear declining trend in sediment mobilisation and/or increase in vegetation encroachment.

Monitoring measure No.	Monitoring approach	Monitoring locations	Project Phase and timing			Reporting
			Pre-construction	Construction & commissioning	Operation	
	observations are made as to what size rocks have moved, and how far have they moved. Vegetation encroachment into the channel will be monitored at the same reaches as the geomorphology surveys. Vegetation survey will consist of transects at each site where % cover and species composition are recorded and a drone photogrammetry survey of the reach will be undertaken to provide an overall assessment of vegetation cover.					
2.	Surveys for *Barbarea australis* population variation will be completed, recording the number, life stage and habitat association each *Barbarea australis* record. Surveys will assist in establishing population fluxes in this opportunistic colonising species. The data will enable an assessment of whether population sizes during operation remain within the bounds observed pre-operation.	A representative approximately 3 km reach of Nive River downstream of Liapootah Dam and the River Derwent downstream of Wayatinah Lagoon	Annually	Annually	Annually for five years	An annual report summarising the results of monitoring will be prepared and will be provided to the EPA/Commonwealth upon request. After five years of operation, a review of all the relevant data inputs (population size, spill, sediment mobilisation and vegetation encroachment) will determine the need for ongoing monitoring and the frequency required. Triggers for ongoing monitoring would include uncertainty in the trend (high seasonal or interannual

Monitoring measure No.	Monitoring approach	Monitoring locations	Project Phase and timing			Reporting
			Pre-construction	Construction & commissioning	Operation	
						variation), or a clear declining trend in population size.
3.	Macroinvertebrate sampling using the AusRivAS method will be undertaken. The river health scores from -pre-construction and construction will be used as a baseline to assess trends between sites and within sites over time and to assess trends during operation (including the effectiveness of flow releases (Section 9).	Five existing monitoring sites in the River Derwent between Clark Dam and Wayatinah Lagoon. Two reference sites (Counsel and Florentine rivers): 1) Nive River downstream of Liapootah Dam 2) River Derwent downstream of Wayatinah Dam.	Spring and autumn (until there is a minimum of ten sampling events for each site)	Spring and autumn	Spring and autumn for five years	An annual report summarising the results of monitoring will be prepared and will be provided to the EPA/Commonwealth upon request. A review of all the relevant data inputs (river health scores, relative composition and diversity of the macroinvertebrate community, spill/flow data, and sediment mobilisation) will determine the need for ongoing monitoring and the frequency required. Triggers for ongoing monitoring would include uncertainty in the trend (high seasonal or interannual variation), or a clear declining trend in macroinvertebrate communities and river health scores below the bounds observed during baseline.

Monitoring measure No.	Monitoring approach	Monitoring locations	Project Phase and timing			Reporting
			Pre-construction	Construction & commissioning	Operation	
4.	Flow monitoring will be undertaken to provide summary of: • Flow releases from Clark Dam (magnitude and duration) including the environmental releases (compliance monitoring); • Flow recorded from Derwent Pumps Weir; • Flow recorded at the Derwent above Nive River; • Spill recorded at Wayatinah Dam; and • Spill recorded at Liapootah Dam	• Clark Dam • Derwent Pumps Weir • Derwent above Nive River • Wayatinah Dam • Liapootah Dam	Annual report of hourly flow data	Annual report of hourly flow data	Annual report of hourly flow data	An annual report will summarise the flows delivered and the overall flow patterns in the upper reaches (Clark Dam to Derwent Pumps Weir, downstream of Derwent Pumps Weir) and lower reaches (downstream of Counsel River inflow) of the river. Flow monitoring reporting for downstream Wayatinah and Liapootah dams will be limited to reporting on the annual pattern of dam spill. The annual report will inform associated monitoring programs and the assessment of impacts and trends. If any monitoring programs continue beyond 5 years following evaluation of monitoring triggers, then the annual flow monitoring report is to be provided for the same period as the revised monitoring program duration (The annual flow report would continue

Monitoring measure No.	Monitoring approach	Monitoring locations	Project Phase and timing			Reporting
			Pre-construction	Construction & commissioning	Operation	
						beyond this period as part of Hydro Tasmania's internal environment policies).

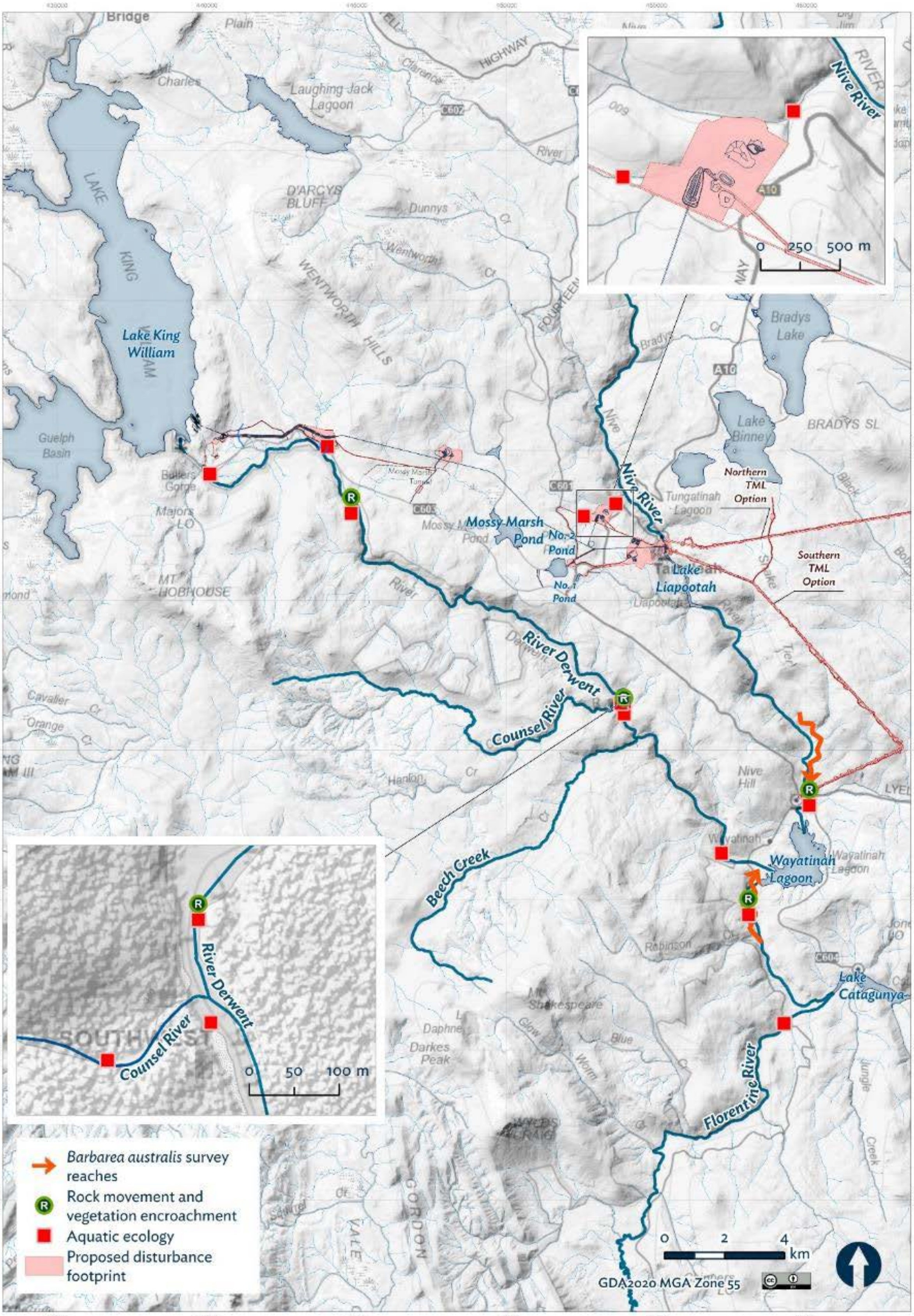

Figure 9.2: Location of proposed monitoring locations for aquatic values

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Appendices

A Hydrological modelling – Historic/current operation

A.1 Introduction

The aim of this study was to estimate flow at eight inflow points in the River Derwent, downstream Clark Dam to Wayatinah Lagoon (Figure A.1). A further two locations in this reach provided observed data with the most downstream site used to calibrate the model. The model represents the flow regime under operation of the Tarraleah Power Scheme from 2007 to 2021 to provide a baseline flow regime (Section 6). The outputs of this baseline model were used to assess changes (Section 8) in the flow regime modelled for operation of the Project (Appendix B).

No considerations for climate change were made and the inflow simulations were generated using historical climate data.

A.2 Generation of inflows

The estimation of the inflows were made using a combination of measured data at various locations and a rainfall runoff model. The rainfall runoff model applied to this study was a modified version of the Dynamic Real-time Inflow Prediction (DRIP) model used by Hydro Tasmania (HT) for the forecast of inflows in the Derwent-Nive catchment. The model was modified to include the ten inflow points along the River Derwent (Figure A.1 and Table 1.)

The model was previously calibrated to natural pickup flows[13] between Derwent Pumps Weir and the River Derwent above Nive gauging station (TS - ID 123). For this study, slight manual adjustments of a parameter (relating to the flow bias) were done to provide a reasonable visual fit to the measured hydrograph at River Derwent below Derwent Pumps Weir. Care was taken not to ‘overfit’ the measured flow. However, it has to be noted that a full calibration (adjusting values of all parameters of the model) of the model was not undertaken, for this Project.

The model to observed data fit are shown in Figure A.2, Figure A.3, Figure A.4 and Figure A.5. In general the model captures the overall flow distribution, flow volume and the shape of the hydrographs reasonably well. However, it tends to underestimate the high flow events in spring months. The scatter plot shows a small bias.

The estimation of inflows was done by splitting the River Derwent into two sections upstream and downstream of the Derwent pumps Weir.

- **Estimation of inflow in the downstream section**: For downstream section of the river, the measured flow at Derwent Pump Weir was used as an input to the modified DRIP model and routed downstream of Derwent Pumps Weir. The model simulation at River Derwent above Nive River was verified against the measured flow at that location. The comparison between the model simulation and the observed data are shown in Section A.2.1. The figures shows that the model simulation generally provides a reasonable fit to the observed data.
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[13] That is: Natural pickup flow = measured flow at Derwent above Nive – Derwent below Pumps flow.

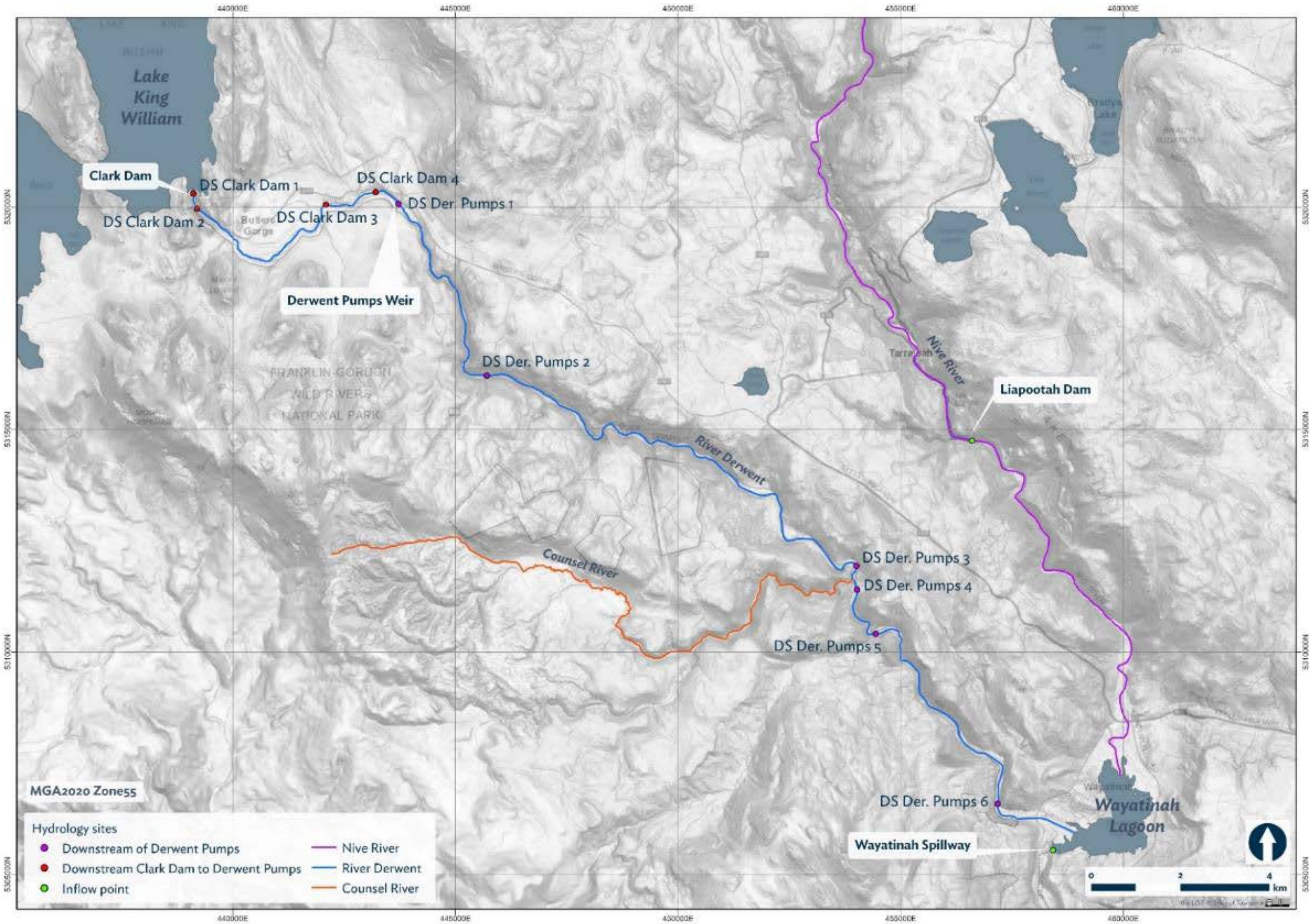


Figure A.1: Inflow locations along River Derwent

Upstream section: The flow in River Derwent upstream of the Derwent Pumps Weir is affected by flood operation releases from Clark Dam, local pickups and spills from Tarraleah canal no 1 (in Butler's Weir) as well as flow pumped to No. 2 Canal. At present there are no reliable measurements to account for the spill/releases from Clark Dam and the measured pumped discharge is only available after 2015. Therefore, the flow was estimated, indirectly, based on the back calculation of the spill from Clark Dam, simulated pumped flow from Derwent Pump station and measured flow at Derwent Pump Weir. It was found that the DRIP model calibrated at Derwent above Nive overestimated the flow at Derwent Pump Weir, therefore a bias correction factor was further applied correct the simulated inflow

The approach for estimating the flow at each inflow points (Site Name) is described in Table 1

Table 1: Description of the approach used to calculate inflows for the current scenario

Site Code	Inflow locations	Description
DS Clark Dam 1	**Below Clark Dam**	• Located directly below Clark Dam. • Clark Dam spill = Flow measured at Derwent Below Pumps + flow pumped from Derwent Pump weir – Local pickup to Derwent Pumps Weir - Spill from Butler's Weir o It was assumed that influence of pickup is negligible and flow consisted of Clark Dam spill (or release) only. o Pumped flow = measured pump flow if available (data period March 2015 till now) else, Pumped flow = MIN(Maximum Pump capacity, Derwent Pumps Weir pick up) o Derwent Pumps Weir pick up covers an area of ~ 51 km^2, and was simulated using the modified DRIP model. o Spill from Butler's Weir = BGPS release – flow measured at No. 1 Canal at Bridge number 9. – The BGPS release was calculated using a 3D level-power-discharge conversion. The power-discharge conversion for BGPS currently used in Time studio was previously deemed to be inaccurate (personal communication Stuart Allie) and BGPS machine curves currently used in TEMSIM modelling was used to estimate the discharge from BGPS.
DS Clark Dam 2	**Downstream No1 Offtake (QSite2)**	• Located directly downstream the offtake for No.1 canal, at Butlers Weir and 350 m downstream Clark Dam • The inflow point covers a local pick up of 0.28 km^2 • Flow at Site number 2 = Clark Dam Spill + local pickup + butlers spill o To calculate local pick up modelled inflow at Derwent Pumps Weir was area scaled. o Derwent Pumps Weir covers an area of ~ 51 km^2
DS Clark Dam 3	**Downstream Tribs (QSite3)**	• Located downstream tributary at coordinates 442084, 5320052. • The inflow point covers a local pick up of 29.31 km^2 • Flow at Site number 2 = Clark Dam Spill + local pickup*bias correcting factor + Butlers spill • Bias correcting factor was applied to correct for the over estimation of the flows at Derwent Pumps Weir.

Site Code	Inflow locations	Description
DS Clark Dam 4	Derwent Pumps US	• Located upstream of Derwent Pump Weir • Inflow= Measured flow at Derwent Pumps Weir + Pumped flow
DS Derwent Pump 1	Derwent Pumps DS	• Located directly downstream Derwent Pump Pond Weir • Observed flow at Derwent Pumps Weir
DS Derwent Pump 2	DS Trib	• Located ~5km downstream Derwent Pumps Weir • Inflow = Derwent Pumps Weir DS flow + modified DRIP model simulation of subcatchments D/S of Derwent Pumps Weir and US of Counsel River
DS Derwent Pump 3	Derwent US Counsel	• Located directly upstream of Counsel River • Inflow = Derwent Pumps Weir DS flow + modified DRIP model simulation of subcatchments D/S of Derwent Pumps Weir and US of Counsel River
DS Derwent Pump 4	Derwent Downstream Counsel River	• Located directly downstream Counsel River • Inflow = Derwent Pumps Weir DS flow + modified DRIP model simulation of subcatchments D/S of Derwent Pumps Weir and Counsel River subcatchment
DS Derwent Pump 5	Derwent Downstream Beech Creek	• Located downstream of the Beech Creek • Flow at downstream of Beech Creek = Derwent Pumps Weir DS flow + modified DRIP model simulation of subcatchments D/S of Derwent Pumps Weir and US of Beech Creek
DS Derwent Pump 6	Derwent Above Nive	• Located near existing gauge station at the Derwent above Nive • Observed data

A.2.1 Model calibration results

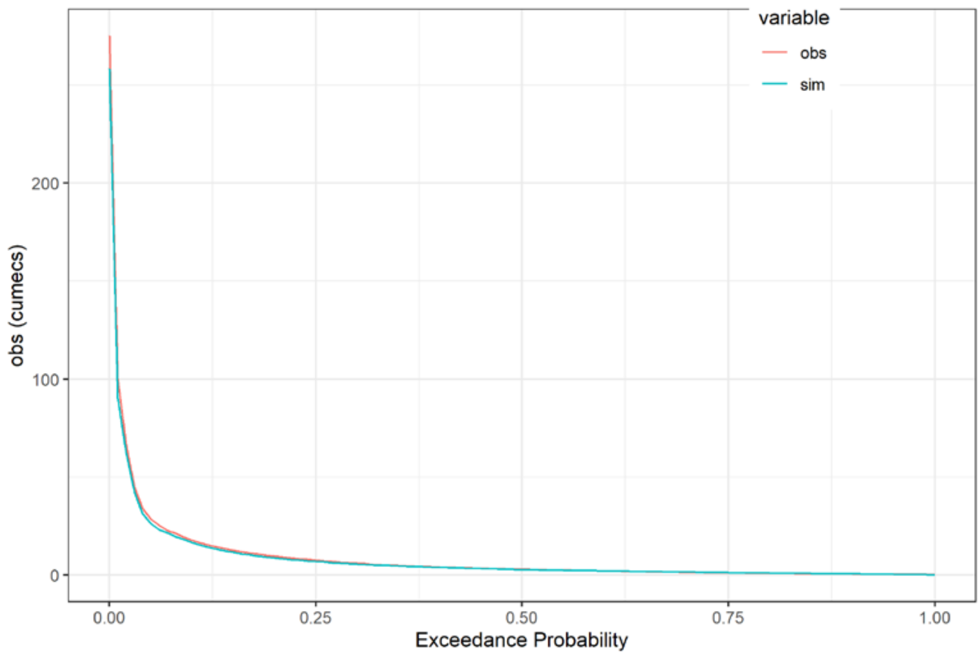


Figure A.2: Comparison between observed and simulated flow duration curves at River Derwent above Nive River (TSID 123) (DS Derwent Pumps 6)

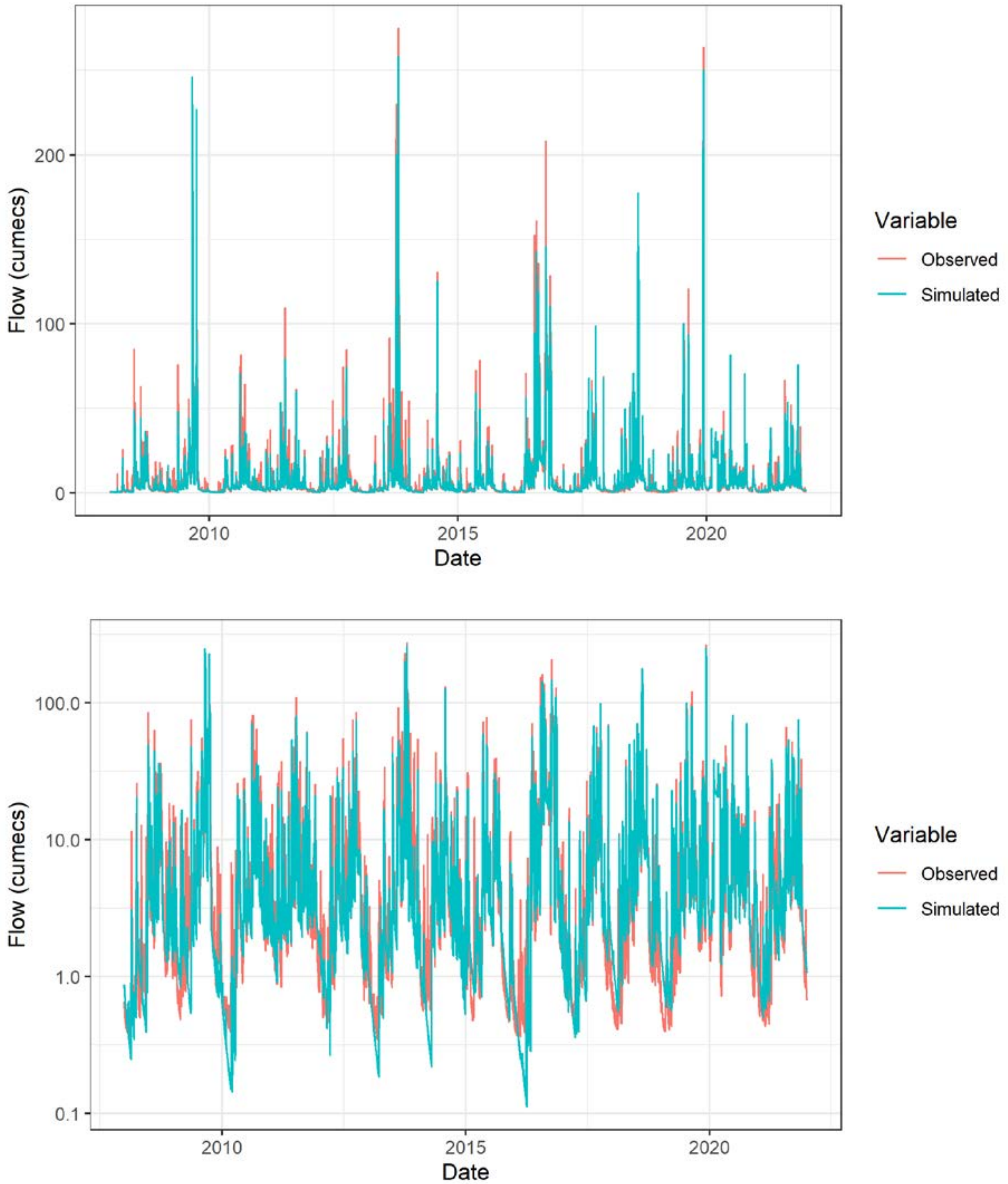


Figure A.3: Comparison between observed and simulated hydrographs at River Derwent above Nive River (TSID 123) [top = linear y axis, bottom = log y axis] (DS Derwent Pumps 6)

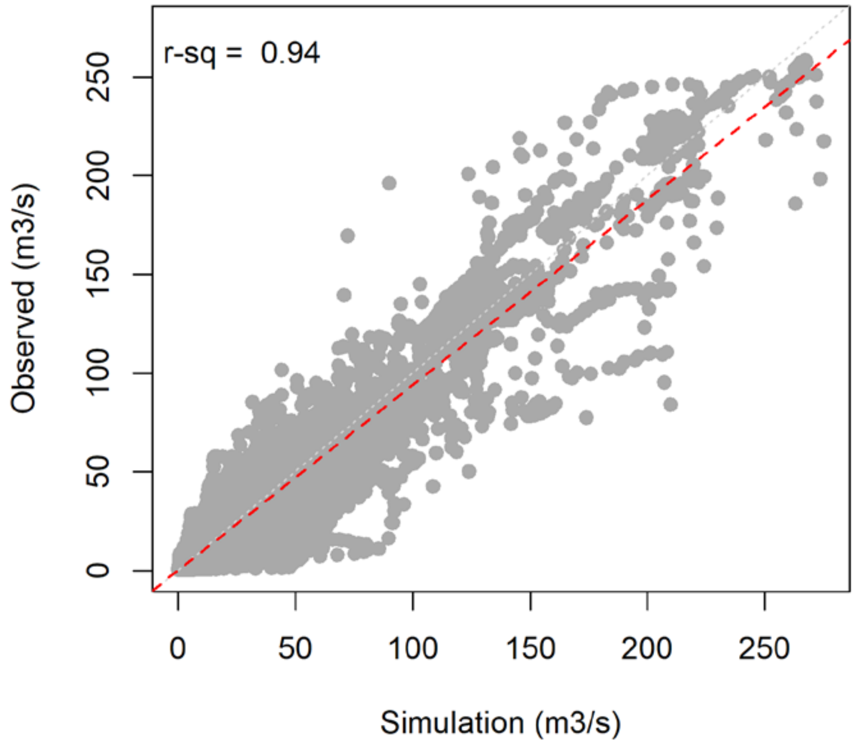
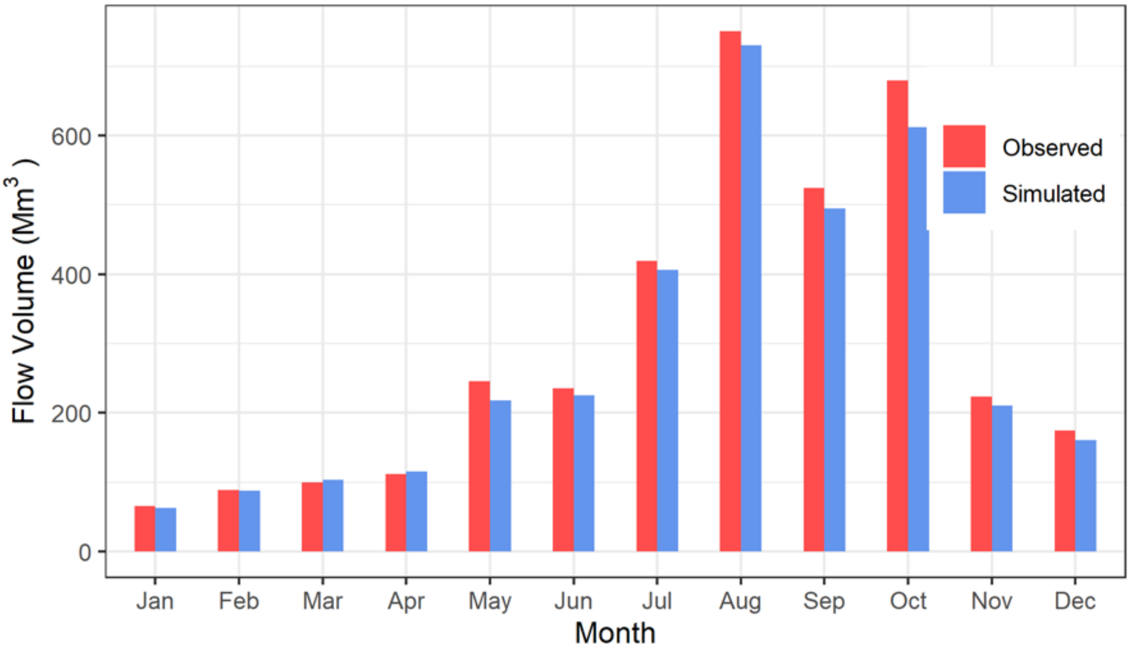


Figure A.4: Comparison between observed and simulated inflows at River Derwent above Nive River (TSID 123) (DS Derwent Pumps 6 i)



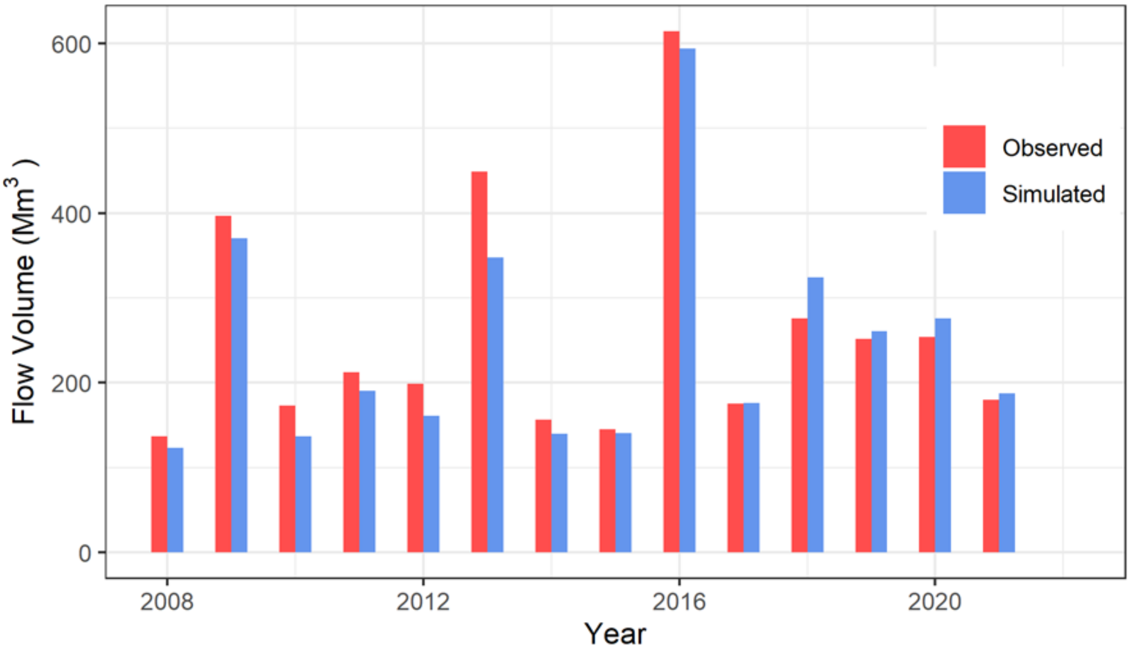


Figure A.5: Comparison of flow volume [top = monthly, bottom = yearly] observed and simulated in River Derwent above Nive River (TSID 123) (DS Derwent Pumps 6)

A.3 Assumptions/limitations

- Model calibration:
  - For this study, slight manual adjustments of a parameter (relating to the flow bias) were done to provide a reasonable visual fit to the measured hydrograph at River Derwent below Derwent Pumps Weir. Care was taken not to 'overfit' the measured flow.
  - However, it has to be noted that a full calibration (adjusting values of all parameters of the model) of the model was not undertaken, for this Project. The DRIP model was calibrated using the data prior to 2017. This has resulted in consistent over estimation of simulated yearly flow volume after year 2016 (Figure A.5).
- **Inflow sources:** The model does not consider following inflows sources to TC1.
  - **Direct catchment inflow**: Any overflow contribution of the flow to TC1 from the surrounding elevated grounds over the 'lip' (or the edge) of the canal. Entura (2018) noted that this could occur along the edge of the canal where there is sizable storage along the banks which could get ponded overflow the canal lip and enter the canal.
  - **Rain on Canal**. The storm rainfall in the length of canal or flume upstream of each inflow point was not considered.
  - Both of these inflow sources were considered to be small to make a large impact to the flow modelled in the River Derwent

A.4 References

Entura. (2018). *Tarraleah No. 1 Canal Hydraulic and Hydrologic assessment*. Cambridge, Tasmania: ENTURA-D6DAA.

Wallis, M., & Lord, B. (1994). *Tarraleah Headworks Design Review, Phase 1, Hydraulic Review*, Report No. EN-0011-CR-001. Hobart: Dams Department, Consulting Business Unit.

B Hydrological modelling – Tarraleah Redevelopment Project

B.1 Introduction

This document describes the post-processing of the simulated spill generated by PLEXOS energy model currently being used by Hydro Tasmania. The detailed description of the PLEXOS model and their outputs are provided in a separate report (Hydro Tasmania 2025).

The PLEXOS model does not have an explicit representation of the level pool routing component built-in and, in the current set of model runs, have simulated unrealistically large volume of spills (hereafter called spikes) within a short interval of time (30 minutes).

The objective of this post processing exercise was to smoothen/route those spikes such that they, combined with local catchment inflows, can be used simulate flows at ten locations along River Derwent downstream of Clark Dam and two locations immediately downstream of Lake Liapootah and Lake Wayatinah as shown in Figure A.1. The flows at these locations have been used to inform environmental assessments being carried out the Project.

B.2 Data

B.2.1 Model inputs

Inflow data for the hydrological modelling were provided by PLEXOS model outputs (Hydro Tasmania 2025). Four types of data were provided to Entura. All data were supplied at 30 min timesteps for the period from 2028 to 2050. The PLEXOS data included,

- Generator water releases: The generator water release (m^3/s) were typically power station releases at various locations of the Derwent Scheme. This data was generated by the PLEXOS models for the current scheme configuration and the Tarraleah development case (explained further in Section B.4).
- Waterway flows: Waterway flows (m^3/s) typically referred to the spillway discharges or canal flows from upstream to downstream storage.
- Storage end volume: The storage end volume (in Cubic Meters Day, CMD = 0.0864 x 10^6 m^3) referred to the storage volume at the end of each timestep. The storage end volume was used to define the initial starting position of the storage.
- Natural inflows: Natural inflows/local pickup (given in m^3/s) were provided at key inflow locations. This data was originally sourced from Inflows to Power Station studies (Entura, 2022). These natural inflows are estimated annually and are based on the combination of measured data (if available), volume balance at the points of interest, and in some cases, specific catchment yield. The inflows are derived at monthly timestep and then redistributed to daily inflows based on the observed daily flow patterns from neighbouring gauges.

B.2.2 Ratings

The storage and spillway discharge ratings curved for Lake King William, Lake Liapootah and Wayatinah Lagoons were obtained from TimeStudio. The ratings used in the DRIP/DSEP models were used for this study. The discharge rating of Lake Liapootah is based on the operating rule with the target level of 341.78 m. The rules adopted are consistent with the Liapootah DSEP models.

B.3 Post-processing approach

The post processing consisted of applying two processes: reservoir routing or smoothing using disaggregation (in some case, aggregation). The former was used to simulate spills in Lake King William, Wayatinah Lagoon and Lake Liapootah, while the later was applied to Pine Tier, Mossy Marsh, Clarence Weir and No 1 Pond.

B.3.1 Lake King William (LKW)

The post processing of PLEXOS spill in LKW involved using a level pool reservoir routing model to simulate spills from Clark Dam. The routing model used power station discharges and valve releases generated by PLEXOS. The PLEXOS storage end volumes were also used to define initial starting point (a time offset was applied to ensure the routing model was initialised at the same starting level as the PLEXOS model). A more detailed explanation of the model is given in Section B.5.

The PLEXOS model, however, also generated spill discharges at times they were operating below Full Supply Level (FSL). The below FSL spill from PLEXOS accounted for a significantly large volume of water being evacuated from LKW, which would not be accounted by a reservoir routing model. These were taken into consideration, indirectly, as additional valve release and power station release from Clark dam using a process that is described below:

- The spill from PLEXOS was first pre-processed to identify and estimate the below FSL spills.
  - The identification of below FSL spill were based on two separate PLEXOS model simulations; the Short Term (ST) and Medium Term (MT) simulations.
    - The ST model was a fine resolution model that involved optimisation and volume balance conducted at 30 minute timestep, and a more representative representation of the energy/revenue generation in the future market. However, ST also contained below FSL spills.
    - The MT represented a coarser resolution model (optimisation and volume balance conducted weekly) but a more representative simulation of spill at weekly time step with no below FSL spills.
  - Weekly spill volume difference (referred to excess; excess = weekly ST spill volume - weekly MT spill volume) between ST and MT was calculated.
  - Below FSL spill volumes were estimated as excess volume when two criteria (given below) were satisfied.
    - Excess is greater than zero and
    - LKW Level is below 95% of the FSL.
- The below FSL spill (excess) from LKW was added to the power station releases and disaggregated over the week. The power station releases (with the addition of the disaggregated release) from LKW was further constrained by the maximum release capacity of the power station.
  - In cases where the maximum capacity of the power station was exceeded, the surplus volume of water was released through the LKW regulating valves, which was also constrained by the maximum release capacity of the valve.

B.3.2 Pine Tier

The PLEXOS Pine Tier spill was much higher than the expected values and caused unexpected spill discharges at Lake Liapootah. Therefore, the Pine Tier Spill discharge was aggregated to weekly timesteps to avoid the unexpected spike in the data.

B.3.3 Mossy Marsh, No 1 Pond and Clarence spill

Mossy Marsh, No. 1 Pond and Clarence spill provided by PLEXOS models, which were used as inputs to Lake Liapootah, contained spikes that resulted in unreasonably high spills from Lake Liapootah. These were aggregated to daily timesteps to eliminate the unexpected spike in the data.

B.3.4 Wayatinah and Lake Liapootah

The post processing of PLEXOS spills in Liapootah and Wayatinah involved using a level pool reservoir routing model to simulate spills.

Additionally, the routed spills from Lake Liapootah resulted in unnatural oscillating (sawtooth like) spill patterns. This was caused by the storage trying to maintain a target level of 341.78 m (as per the Lake Liapootah storage operating rule) combined with relatively sensitive portion of storage discharge curve (affected by gate operation) that released high discharge spills at very small increases in lake levels (around the target level). These spikes were smoothened by aggregating the spills to hourly time steps.

B.4 Modelling Scenarios

The PLEXOS outputs were used for three scheme configurations:

BAU

- A00: Current configuration of the Tarraleah Hydropower Scheme with additional flexibility to target higher price periods, which is how it is expected the power station would be operated in future (BAU case)
- A00Hist: Current configuration operated similarly to historical operation (i.e. baseload type operation)

Project

- F60: The redevelopment Project with 61 m3/s pressurised conveyance from Lake King William to a new power station with two machines (Project case).

Each configuration had three realisations (Figure B.1; Figure B.2).

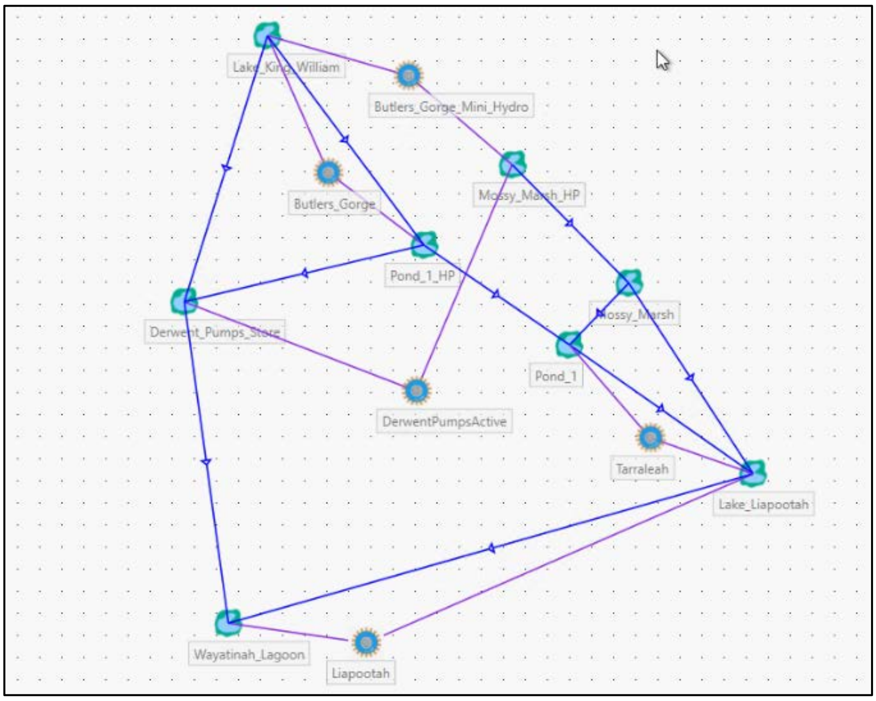


Figure B.1: Model Configuration for A00 scenario

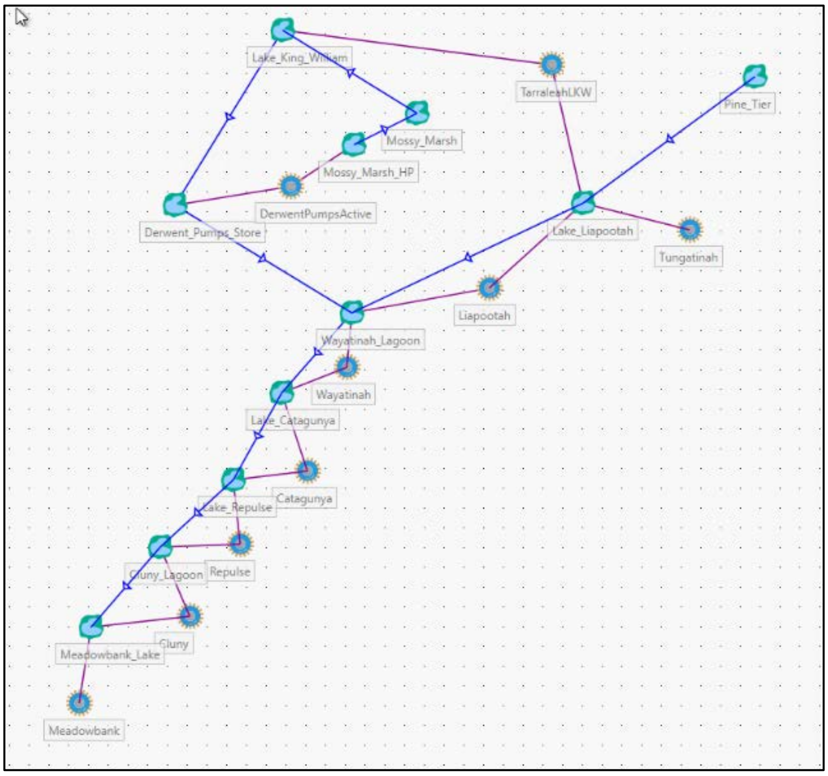


Figure B.2: Model configuration for F60 scenario

B.5 Hydrological model

A hydrological model was developed (in Hydstra modelling platform) to simulate spill at LKW, Lake Liapootah and Wayatinah Lagoon and discharges at ten locations downstream of LKW (Figure B.3). The inputs, outputs and some important features of the model are described in the sections below.

B.5.1 Hydrological model description

Model schematic

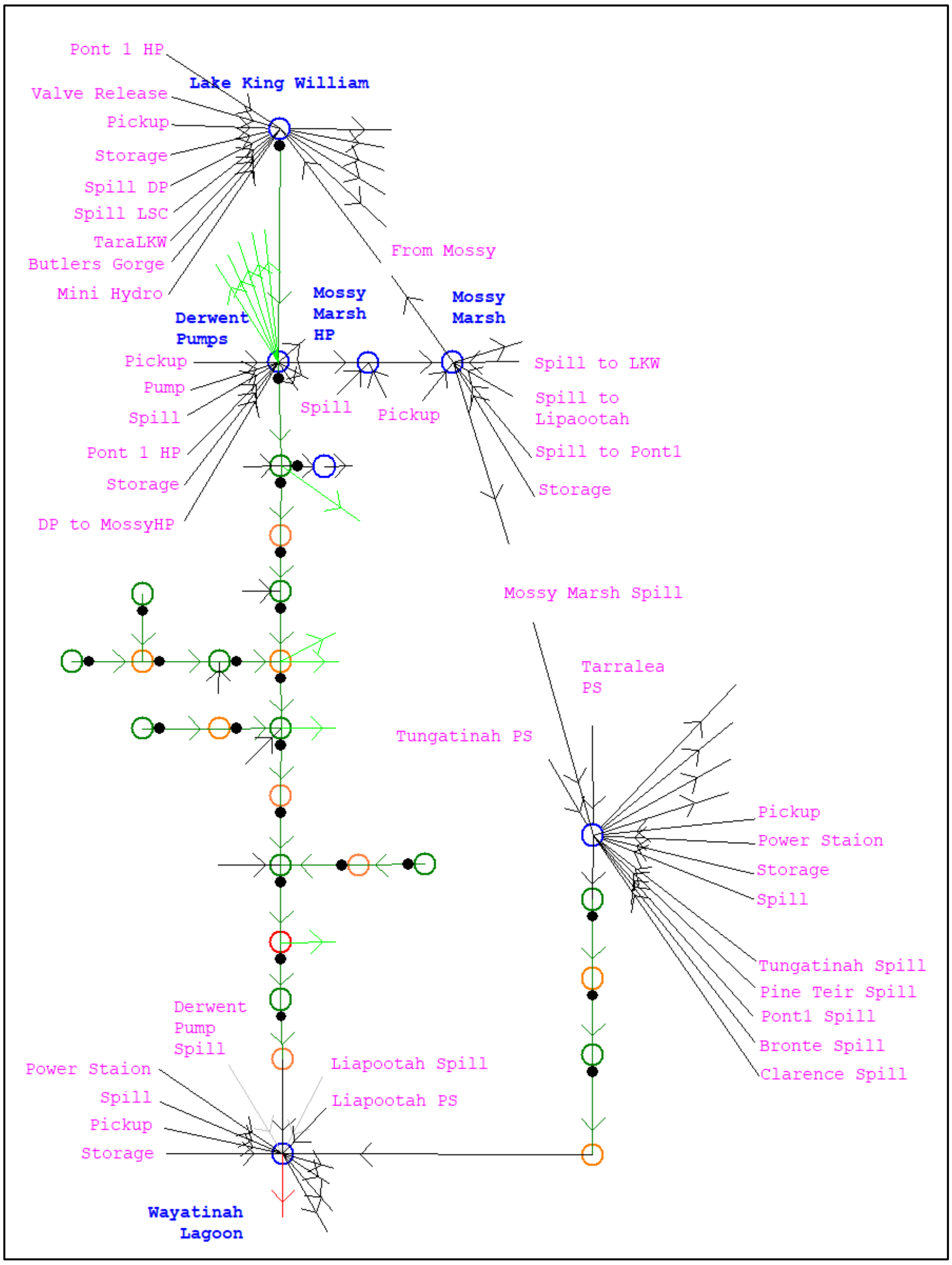


Figure B.3: Hydrological (hydstra) model schematic

Inputs, outputs and key features of the model

- LKW: modelled using reservoir routing.
  - Inflows – Natural pickup, Spill from Lake St Clair, Mossy marsh pump (only for F60 scenario)
  - Release – Tarraleah (for F60 scenarios), Butlers Gorge (for A00 scenarios), Mini hydro (for A00 scenarios), Valve release (for A00 scenarios)
  - Release input data from PLEXOS was adjusted as described in Section B.3.1.
  - The Nominal Minimum Operating Level (NMOL) for Lake King William was set to 703.00 mSL for F60 scenario. The release (Tarraleah) was stopped when the water level reached 703.00 mSL. For A00 scenarios, the current NOML was adopted (~690.6 mSL) for Lake King William. The Nominal Minimum Operating Level (NMOL) for Wayatinah was set to 230.28 mSL for A00 scenario. Lake Liapootah was operated at their current NOML for both scenarios.
  - Pre-emptive releases rules as per the LKW Storage Operating Rule (Table 2) were implemented (for A00 scenario).

Table 2: LKW pre-emptive release rule

Lake King William Level (mSL)	Machine + Bypass Discharge (m^3/s)	Spillway Discharge (m^3/s)	Total Discharge (m^3/s)
719.74-719.93	up to 105	Nil	up to 105
719.94-720	105	up to 175	105 to 280
720.01-720.09	105	175 to 350	280 to 455
720.1-720.24	105	350 to 660	455 to 765

- Derwent Pumps Weir: modelled using water balance (without level pool routing).
  - Inflows - Natural pickup, Spill from LKW, Valve release (for A00 scenarios).
  - Releases/spills – Derwent Pumped flow to Mossy Marsh
    - The Derwent Pump release was limited by the inflows, storage and the PLEXOS values as give in the below equation.
      - *Derwent Pump = min{ (Total Inflows + Available Water in the Storage), PLEXOS Value}*
    - Any access water was stored or spilled when the Derwent Pump storage was full.
- Mossy Marsh: modelled using water balance (without level pool routing)
  - Inflows - Natural pickup, Derwent Pump
  - Release/spills - Mossy Marsh (to LKW for scenario F60), to No 1 Pond (spill), to Liapootah (spill)
    - The Mossy Marsh release was limited by the inflows, storage and the PLEXOS values as give in the below equation.

      Mossy Marsh Pump = min{ (Total Inflows + Available Water in the Storage), PLEXOS Value}
  - Any access water was stored or spilled if the Mossy Marsh storage was full.

- Lake Liapootah: modelled using reservoir routing.
  - Inflows – Natural pickups, Mossy Marsh spill, Pont1 spill, Pine Tier spill, Tungatinah spill, Bronte spill, Clarence spill, Tungatinah power station release, Tarraleah power station release.
  - Release – Liapootah power station release.
  - Tarraleah inflows were adjusted as described in Section B.3.1.
  - Pine Tier spill from PLEXOS were aggregated to weekly to eliminate unreasonable spikes in the data as describe in Section B.3.2.
  - Mossy Marsh, Clarence and Pont1 spill inputs from PLEXOS were aggregated to daily to eliminate unreasonable spikes in the data as describe in Section B.3.3.
  - The Liapootah storage discharge rating was based on the operating current operation rule with a target storage position of 341.78 mSL. This rating was similar to the rating that is used in the DSEP models.
  - The Liapootah spill generated from Hydstra model is aggregated to hourly timestep to eliminate unreasonable spike in the data as described in Section B.3.4.
- Reservoir routing was applied at Wayatinah Lagoon
  - Inflows – Natural pickup, Derwent pump spill, Lake Liapootah spill, Liapootah power station release.
  - Release – Wayatinah power station
  - The Nominal Minimum Operating Level (NMOL) for Wayatinah was set to 230.28 mSL for A00 (and A00Hist) scenarios
- Discharges at 10 points (see Figure A.1) downstream of Lake King William were also estimated were estimated by area scaling (the natural pickup) and channel routing as explained in Table 3

Table 3: Description of the approach used to calculate discharges at the reporting points

Reporting Point	Description
DS Clark Dam 1	• Located directly below Lake King William. • DS Clark Dam 1= Lake King William Spill + Valve Release (Project) • DS Clark Dam 1= Lake King William Spill + Valve Release + Butlers Gorge PS discharge (A00) •
DS Clark Dam 2	• Located directly downstream the offtake for No. 1 canal, at Butlers Weir. • The inflow point covers a local pick up of 0.28 km^2 • DS Clark Dam 2 = Lake King William Spill + Valve Release + Natural pickup o To calculate Natural pick up at this point, the natural pickup at Derwent Pumps Weir was area scaled. o Natural pickup = Derwent Pumps Weir pickup *0.28/51.33 o Derwent Pumps Weir covers an area of 51.33 km^2 • No channel routing applied (negligible routing length)
DS Clark Dam 3	• Located downstream tributary at coordinates 442 084, 5 320 052. • The inflow point covers a natural pickup of 29.31 km^2 • DS Clark Dam 3 = Lake King William Spill + Valve Release + Natural pickup

Reporting Point	Description
	o Natural pickup = Derwent Pump pickup *29.31/51.33
DS Clark Dam 4	• Located just upstream of Derwent Pumps Weir • DS Clark Dam 4 = Total inflow at Derwent Pumps Weir
DS Der. Pump 1	• Located directly downstream Derwent Pumps Weir • DS Der. Pump 1 = Derwent Pumps Weir Spill
DS Der. Pump 2	• DS Der. Pump 2 = Derwent Pumps Weir Spill + Natural pickup o To calculate Natural pick up at this point, the natural pickup at Wayatinah was area scaled. o Natural pickup = Wayatinah pickup * 30.27/234.18 o Local catchments area at the point of interest = 30.27 km^2. Wayatinah covers an area of 234.18 km^2
DS Der. Pump 3	• Located directly upstream Counsel River • DS Der. Pump 3 = DS Der. Pump 2 + Natural pickup o To calculate Natural pick up at this point, the natural pickup at Wayatinah was area scaled. o Natural pickup = Wayatinah pickup * 27.68/234.18 o Local catchments area at the point of interest = 27.68 km^2. Wayatinah covers an area of 234.18 km^2
DS Der. Pump 4	• Located directly downstream of Counsel River • DS Der. Pump 4 = DS Der. Pump 3 + Natural pickup o To calculate Natural pick up at this point, the natural pickup at Wayatinah was area scaled. o Natural pickup = Wayatinah pickup * 57.34/234.18 o Local catchments area at the point of interest = 57.34 km^2. Wayatinah covers an area of 234.18 km^2
DS Der. Pump 5	• Located downstream of the Beech Creek • DS Der. Pump 5 = DS Der. Pump 4 + Natural pickup o To calculate Natural pick up at this point, the natural pickup at Wayatinah was area scaled. o Natural pickup = Wayatinah pickup * 45.21/234.18 o Local catchments area at the point of interest = 45.21 km^2. Wayatinah covers an area of 234.18 km^2
DS Der. Pump 6	• Located near existing gauge station at the Derwent above Nive • DS Der. Pump 6 = DS Der. Pump 5 + Natural pickup o To calculate Natural pick up at this point, the natural pickup at Wayatinah was area scaled. o Natural pickup = Wayatinah pickup * 19.64/234.18 • Local catchments area at the point of interest = 19.64 km^2. Wayatinah covers an area of 234.18 km^2

B.6 Comparison of model outputs

The final hydrological model (hereafter called Hydstra model) was run for two configurations (A00_ML2, and F60) and three realisations/samples. Due to the similarity between the results for the A00 and A00Hist cases only the A00 case was used for further analysis.

The following results were produced for all considered cases and PLEXOS model realisations (samples)

B.6.1 Comparison of storage levels and spills

Comparison of the water levels and spill discharges between Hydstra and PLEXOS at LKW, Lake Liapootah and Wayatinah Lagoons, covering the simulation period 2029 to 2045, are provided in Figure B.5 to Figure B.13). A sample plot (A00_ML2, Sample1) for a shorter duration is also shown in Figure B.4.

In general, the plots show that

- PLEXOS models produce more frequent spills compared to the Hydstra. The Hydstra model is able to reproduce the PLEXOS storage level reasonably well over the entire period. The spill generated by Hydstra model are generally less than 200 m^3/s, which is within the currently occurring range (note that the Hydstra spill are plotted against the y-axis scale on the left).
- Figure B.4 shows the comparison at a shorter time scale and during the period when PLEXOS generates spill below the FSL. The figure shows that the water levels tracked slightly above the PLEXOS water levels at Lake King William. This is explained by volume of water removed from the storage during spill in PLEXOS model compared to Hydstra. Once, the Hydstra water level reaches FSL (and spill) the water levels track very close to each other.
- In Liapootah water levels (from both PLEXOS and Hydstra), show rapid fluctuations in the level, which is expected for such a small storage.
- Similar to LKW, Wayatinah water levels tracked close to each other when PLEXOS is not spilling below FSL.
- The frequency of spilling in F60 is less than that that of A00, which is as expected for a larger capacity conveyance.

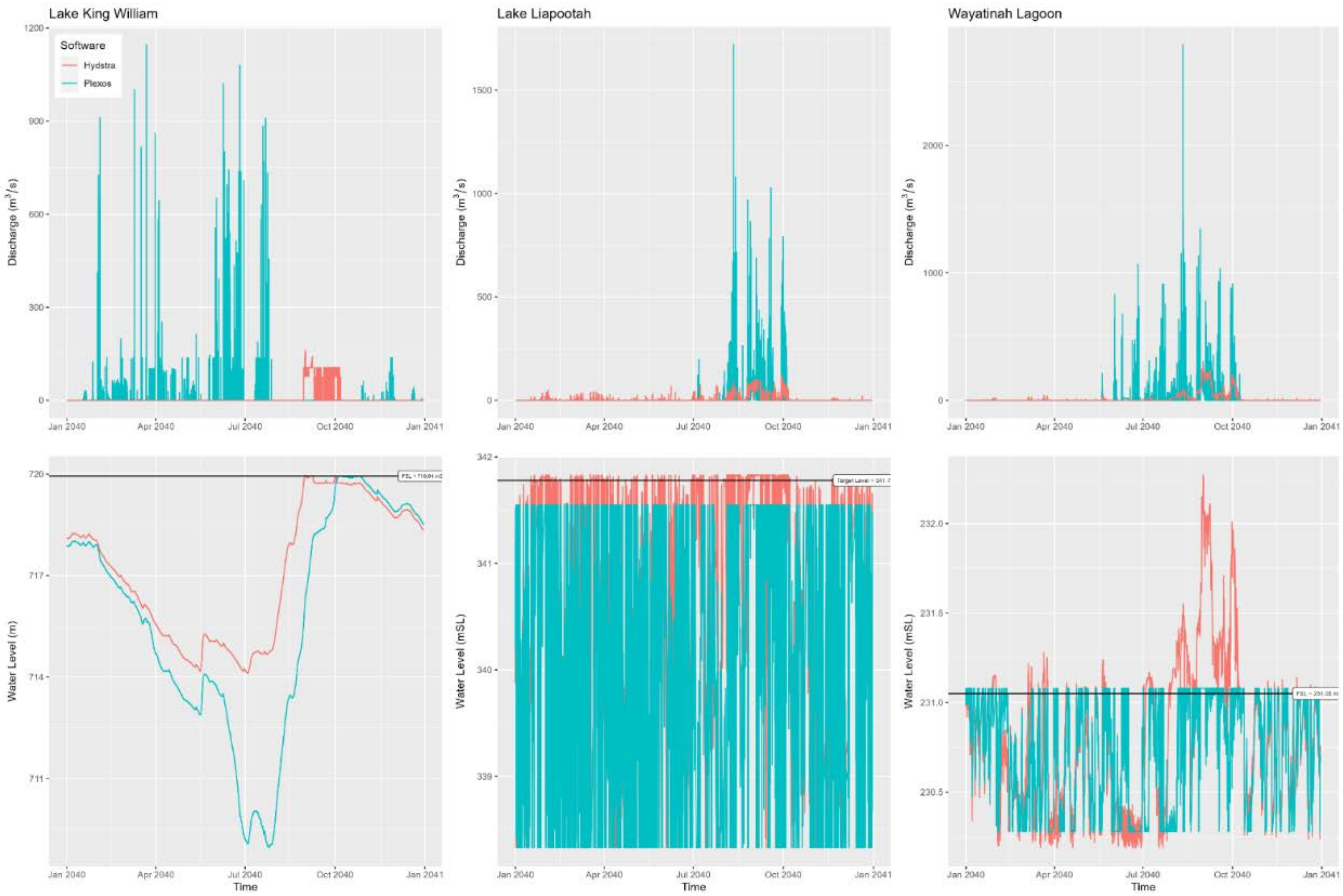


Figure B.4: Water level and spill comparison plot. Scenario: ST_Model P02.1e_T02_Tarra_A00_ML2_22Y3FB_k4_maxLSC_noLKWvalve_BGmax Solution_Sample 1

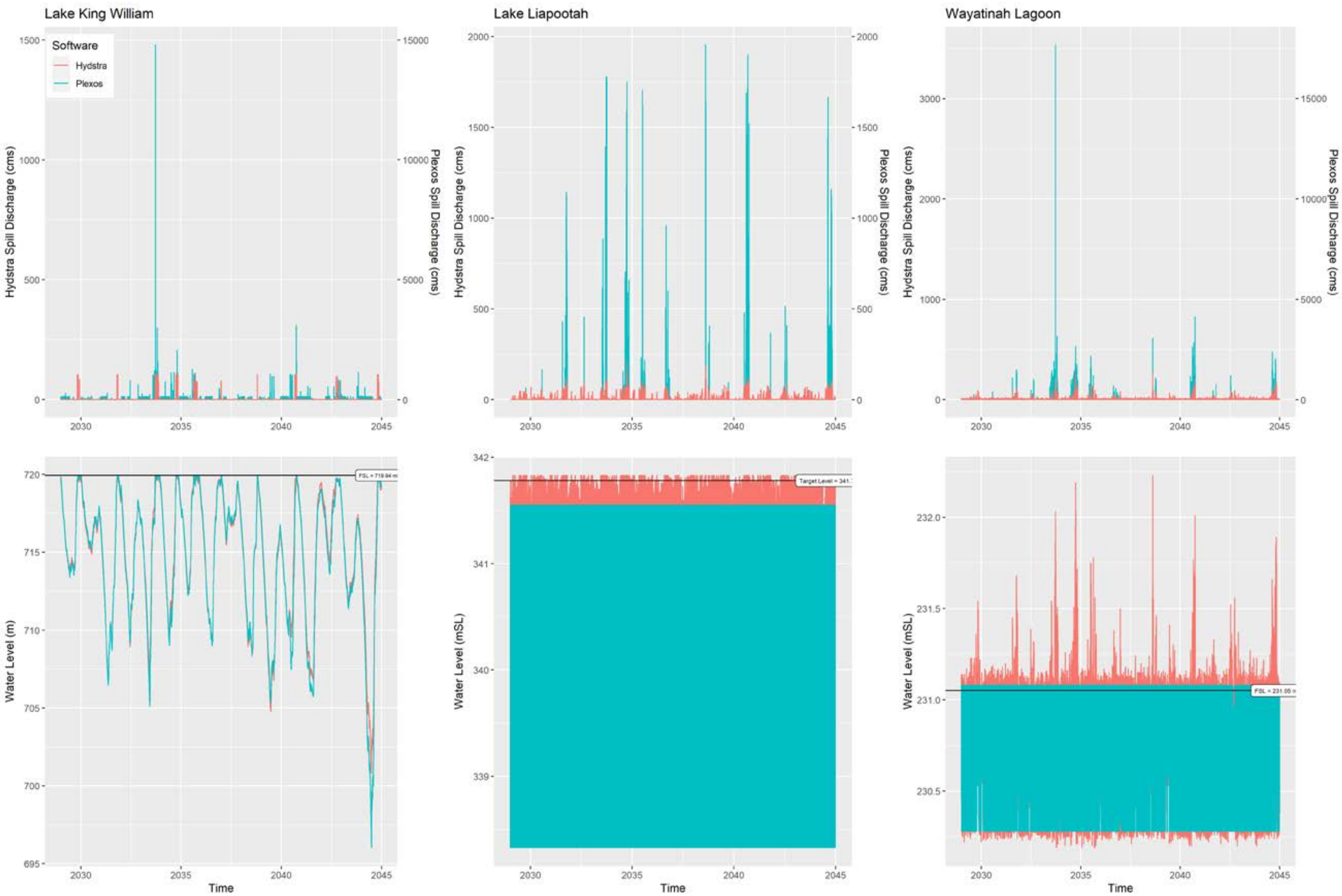


Figure B.5: Water level and spill comparison plot – Sample: ST_Model P02.5_T02_Tarra_A00_ML0_22Y3FB_k4_maxLSC_noLKWvalve Solution_Sample 1

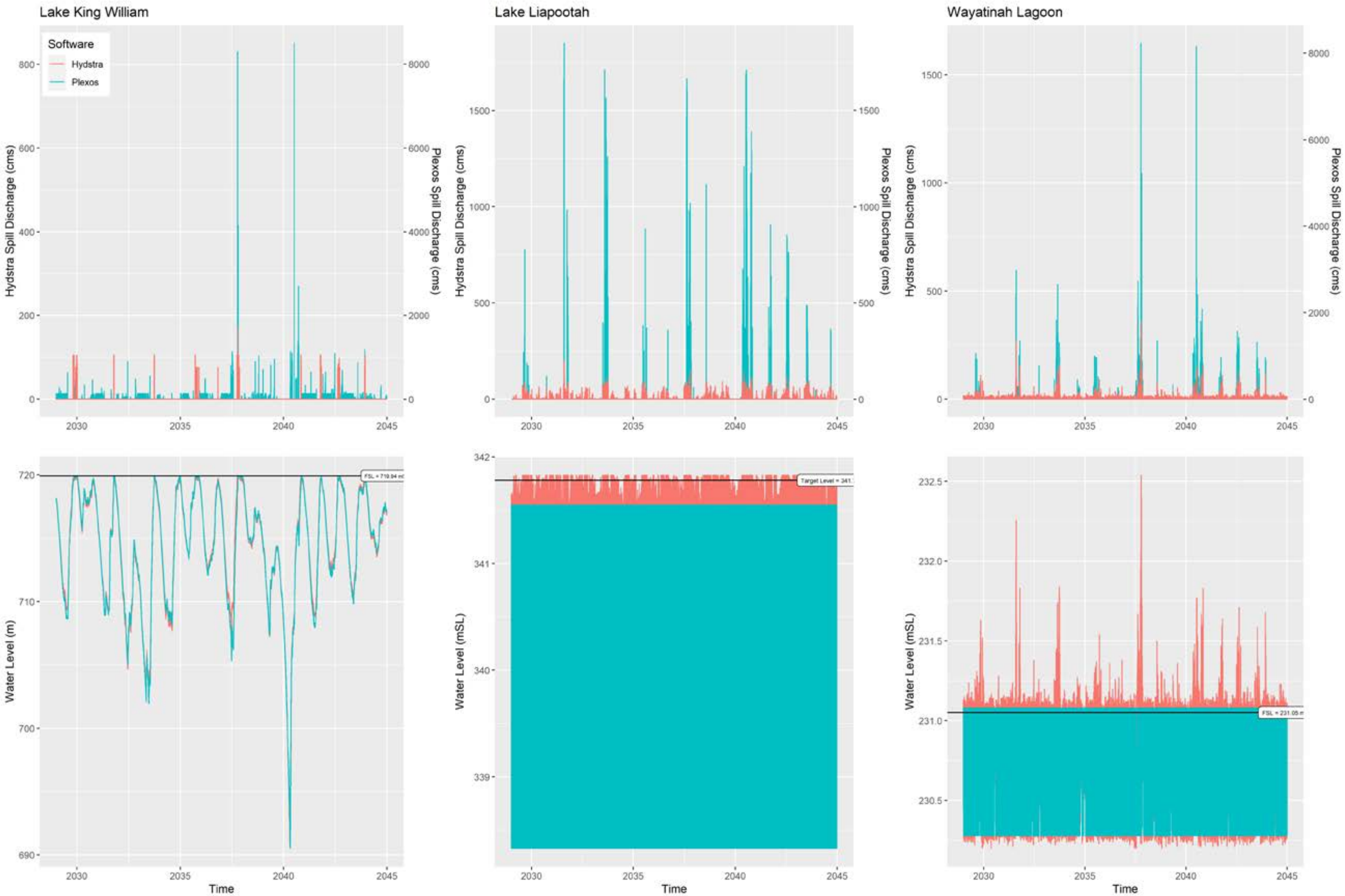


Figure B.6: Water level and spill comparison plot – Sample: ST Model P02.5_T02_Tarra_A00_ML0_22Y3FB_k4_maxLSC_noLKWvalve Solution Sample 2

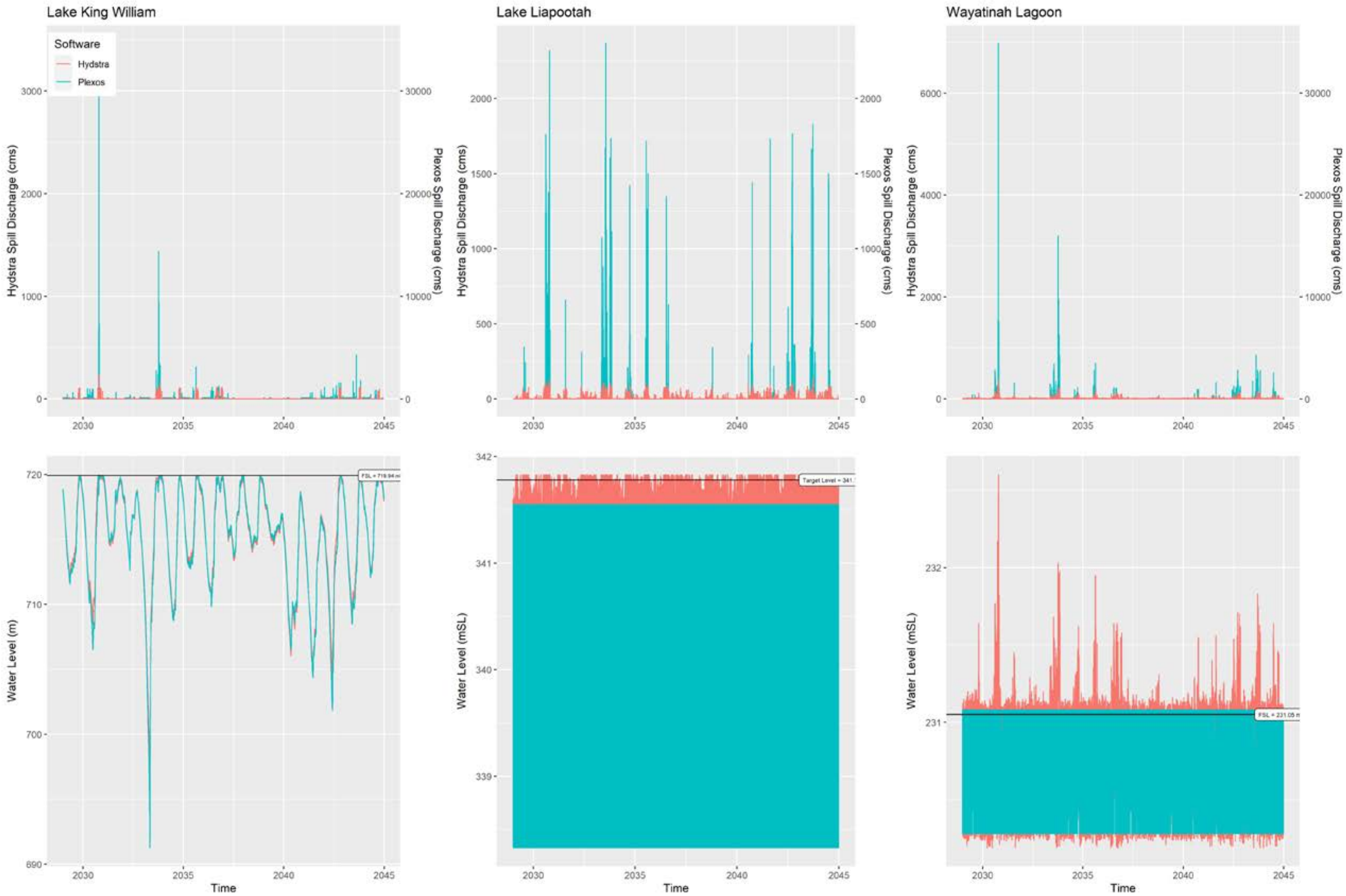


Figure B.7: Water level and spill comparison plot – Sample: ST Model P02.5_T02_Tarra_A00_ML0_22Y3FB_k4_maxLSC_noLKWvalve Solution Sample 3

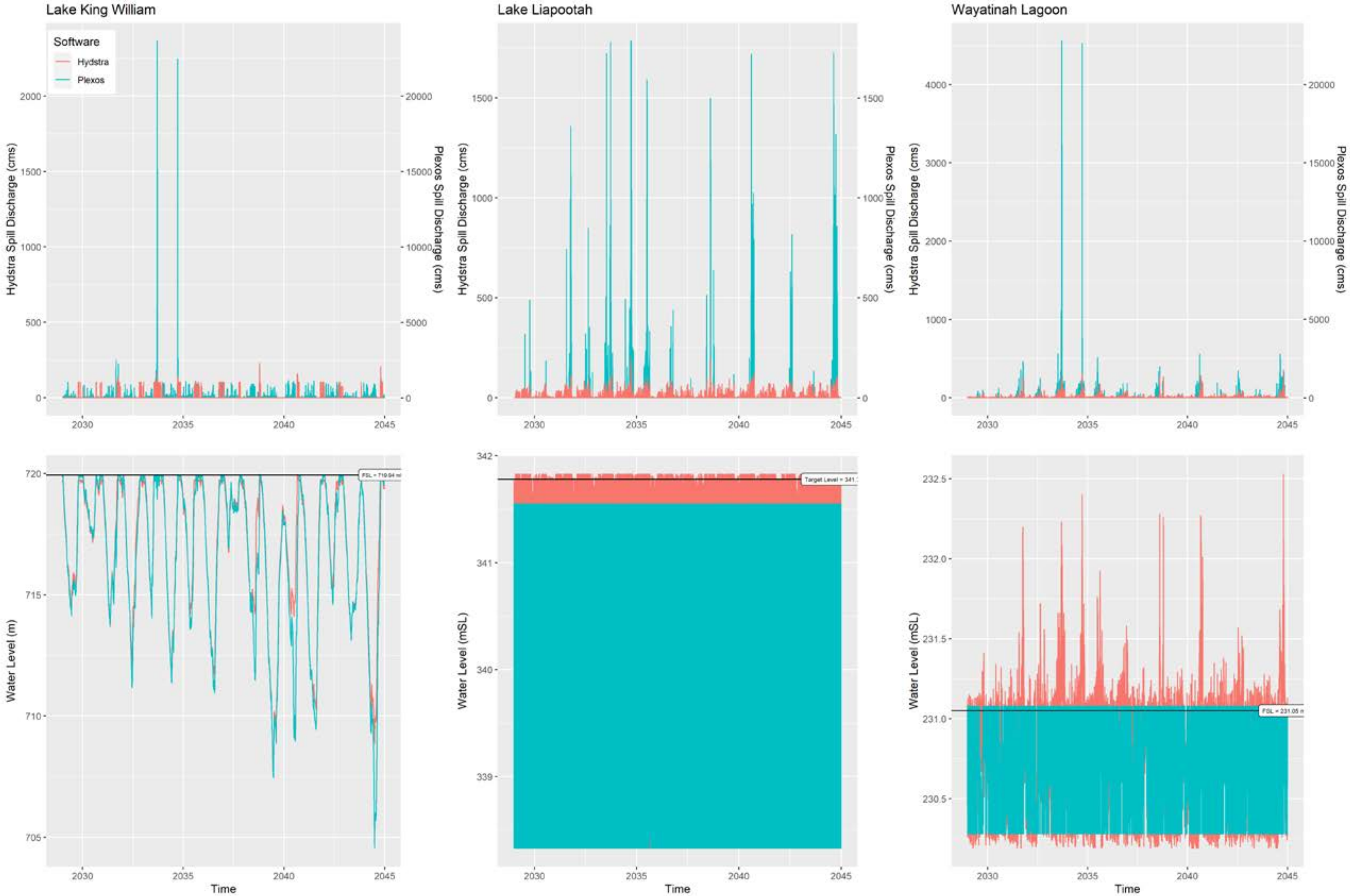


Figure B.8: Water level and spill comparison plot – ST Model P02.1e_T02_Tarra_A00_ML2_22Y3FB_k4_maxLSC_noLKWvalve_BGmax Solution Sample 1

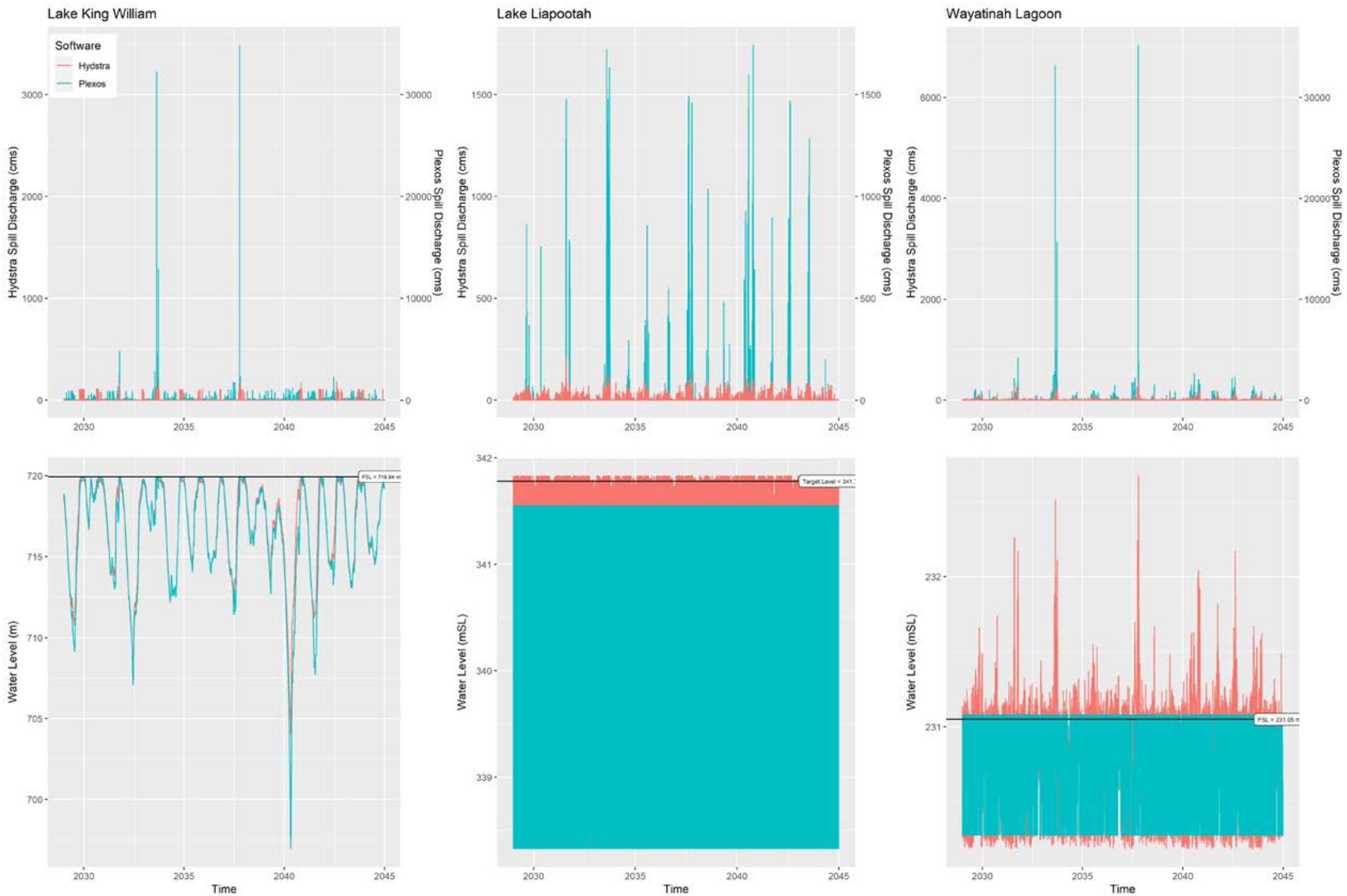


Figure B.9: Water level and spill comparison plot – ST Model P02.1e_T02_Tarra_A00_ML2_22Y3FB_k4_maxLSC_noLKWvalve_BGmax Solution Sample 2

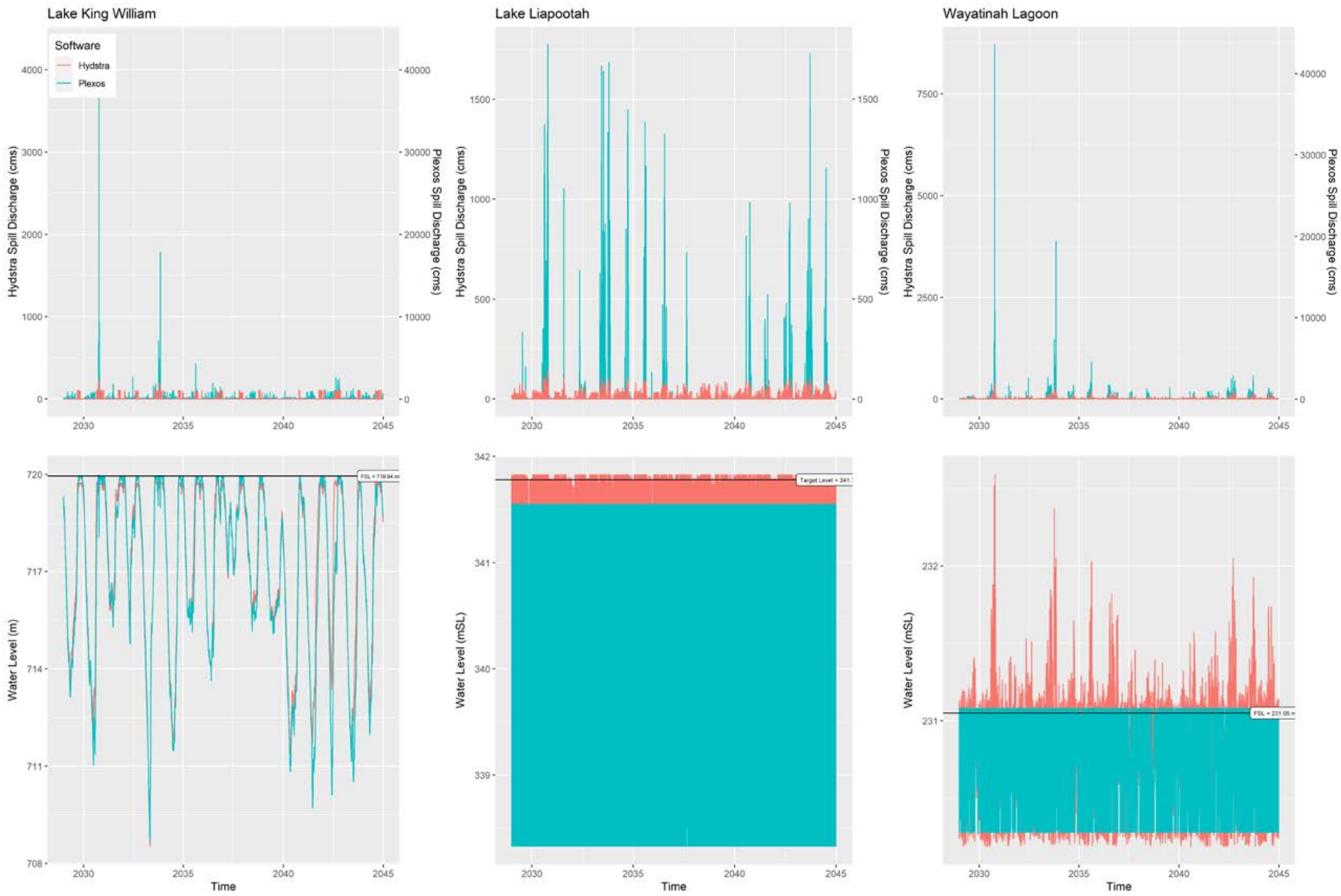


Figure B.10: Water level and spill comparison plot – ST Model P02.1e_T02_Tarra_A00_ML2_22Y3FB_k4_maxLSC_noLKWvalve_BGmax Solution Sample 3

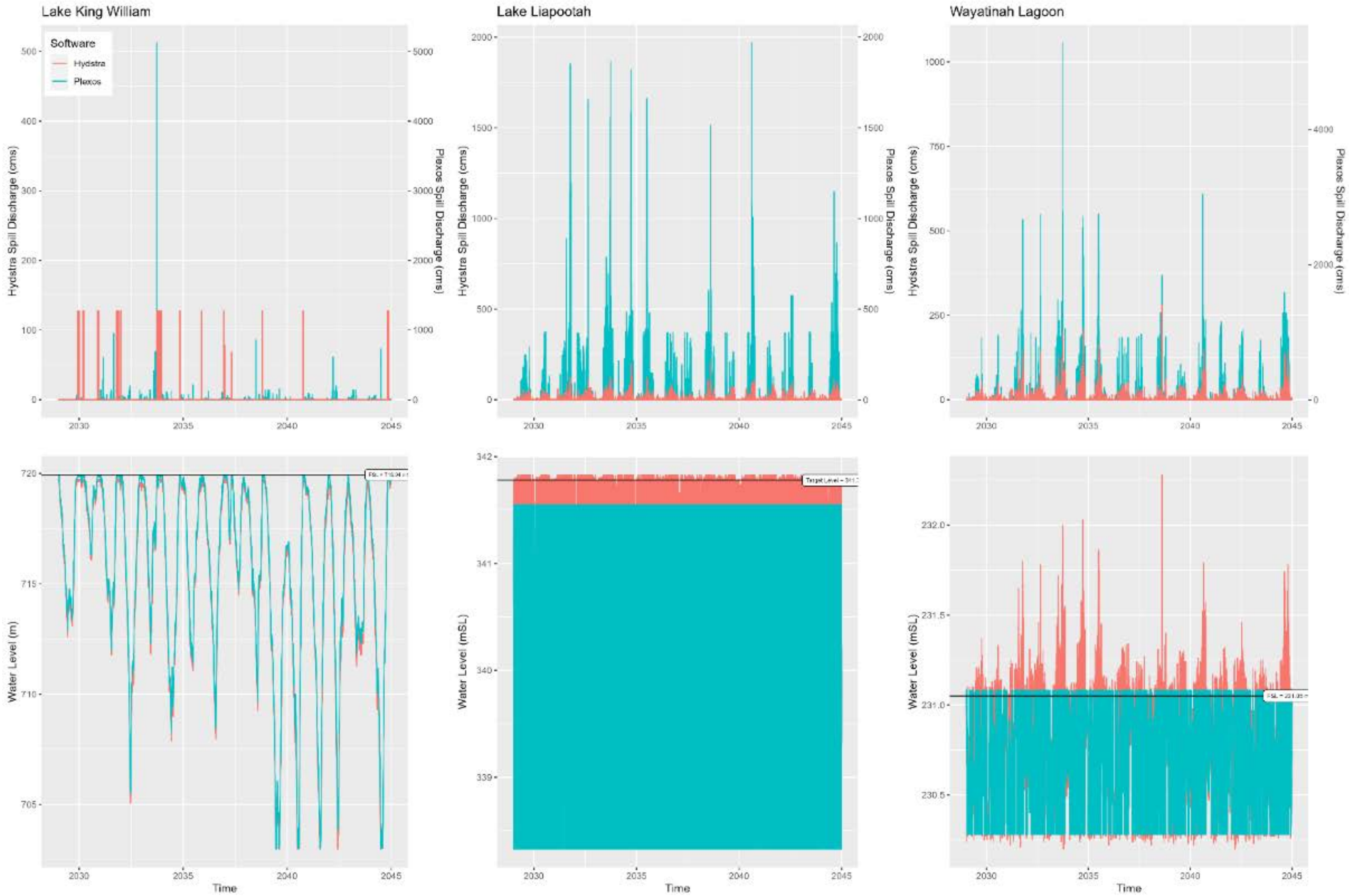


Figure B.11: Water level and spill comparison plot – ST Model P02.1_T02_Tarra_F60_ML2_22Y3FB_k4_maxLSC Solution Sample 1

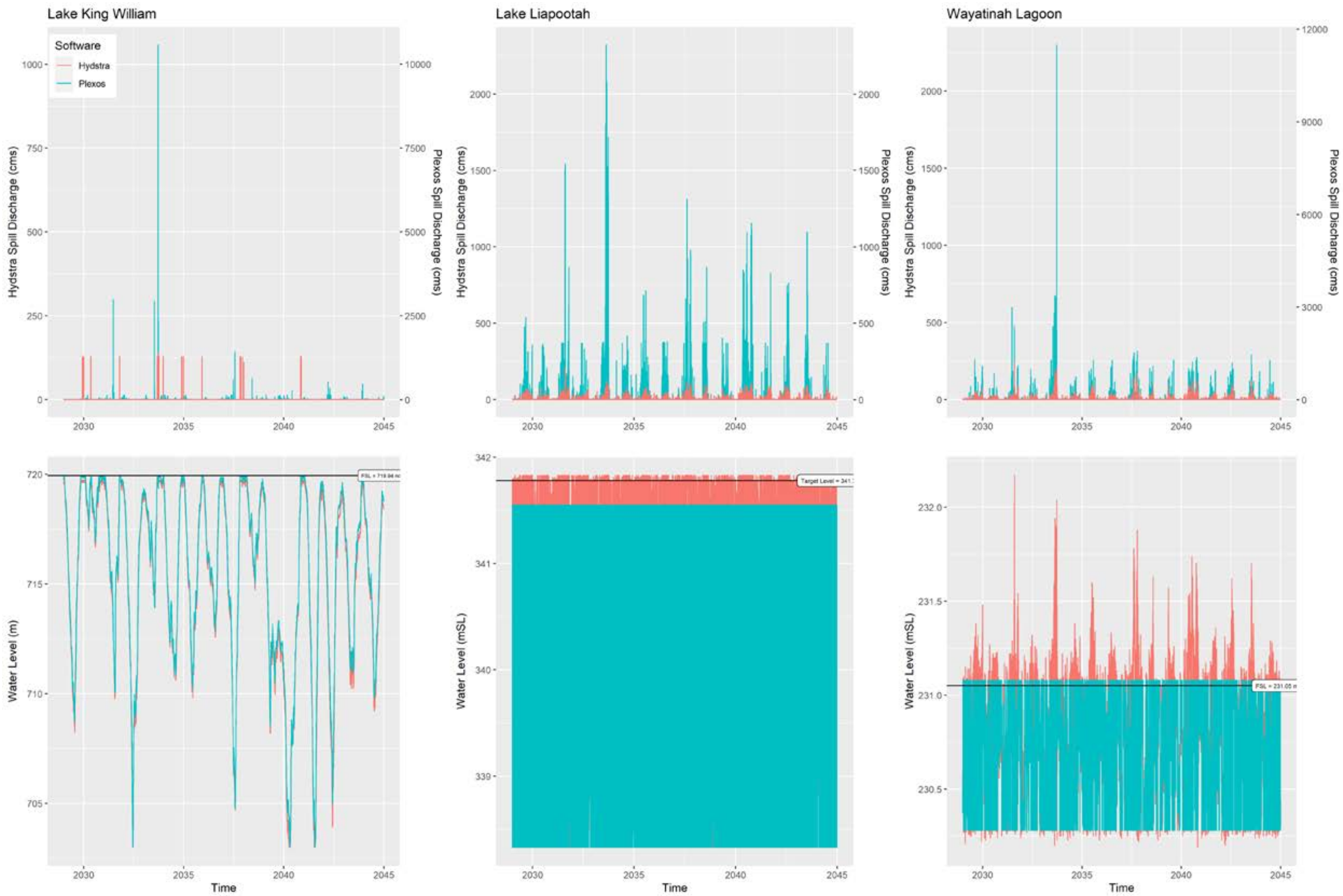


Figure B.12: Water level and spill comparison plot – ST Model P02.1_T02_Tarra_F60_ML2_22Y3FB_k4_maxLSC Solution Sample 2

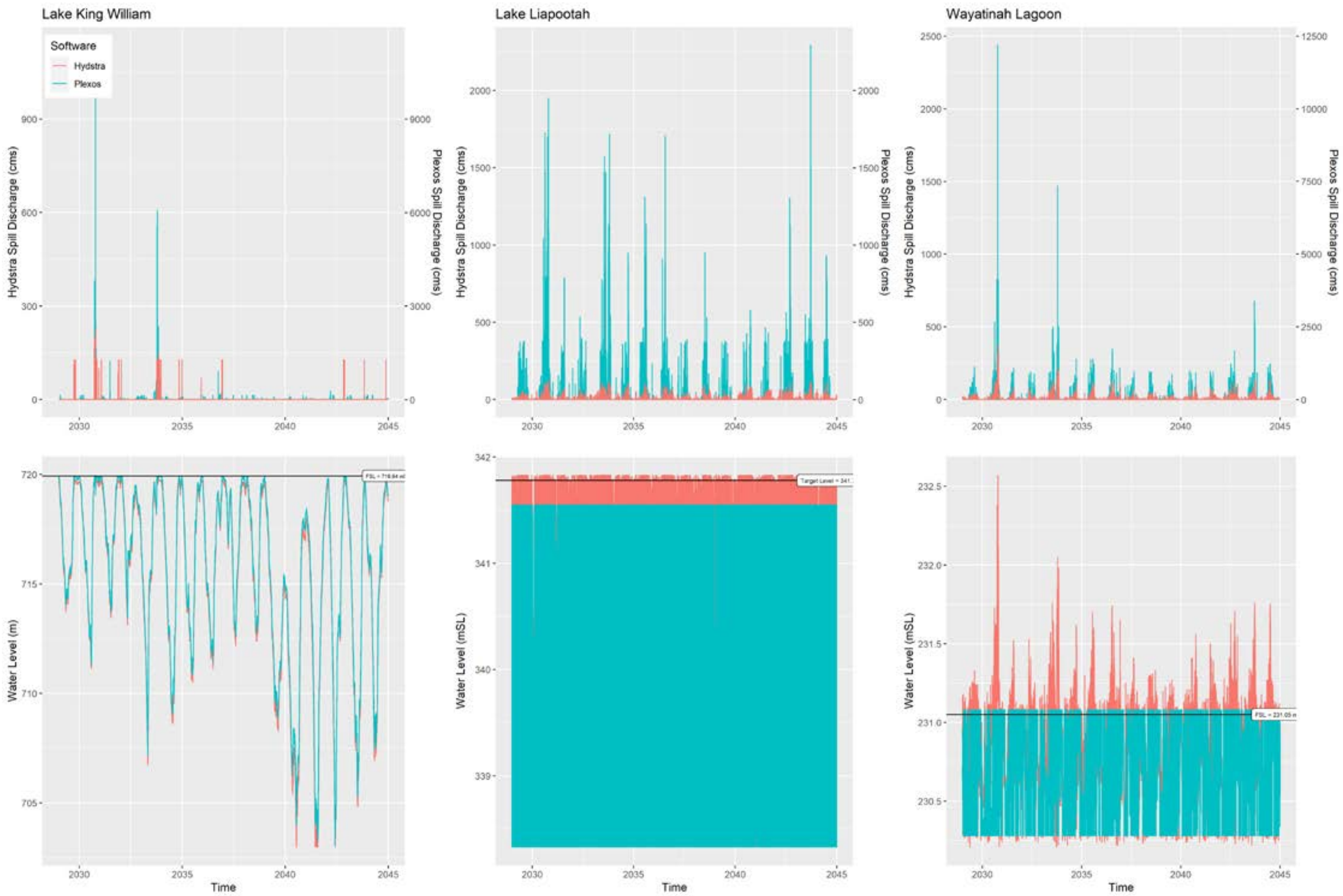


Figure B.13: Water level and spill comparison plot – ST Model P02.1_T02_Tarra_F60_ML2_22Y3FB_k4_maxLSC Solution Sample 3

B.6.2 Comparison of annual spill volume plots

Comparison of the annual spill discharges between Hydstra and PLEXOS at Lake King William, Derwent Pumps Weir, Lake Liapootah and Wayatinah Lagoons are shown in Figure B.14 to Figure B.22.

- In general, the spill volume from Hydstra in at Lake King William is slightly lower than PLEXOS, but that is due to below FSL spill being transferred to Tarraleah power station.
- The spill volume from Hydstra in at Derwent Pumps Weir is slightly lower than PLEXOS (for F60 scenarios) and slightly higher (for A00 scenarios).
- In contrast, the spill volume from Lake Liapootah and Wayatinah Lagoons are slightly higher than the PLEXOS spill volumes.

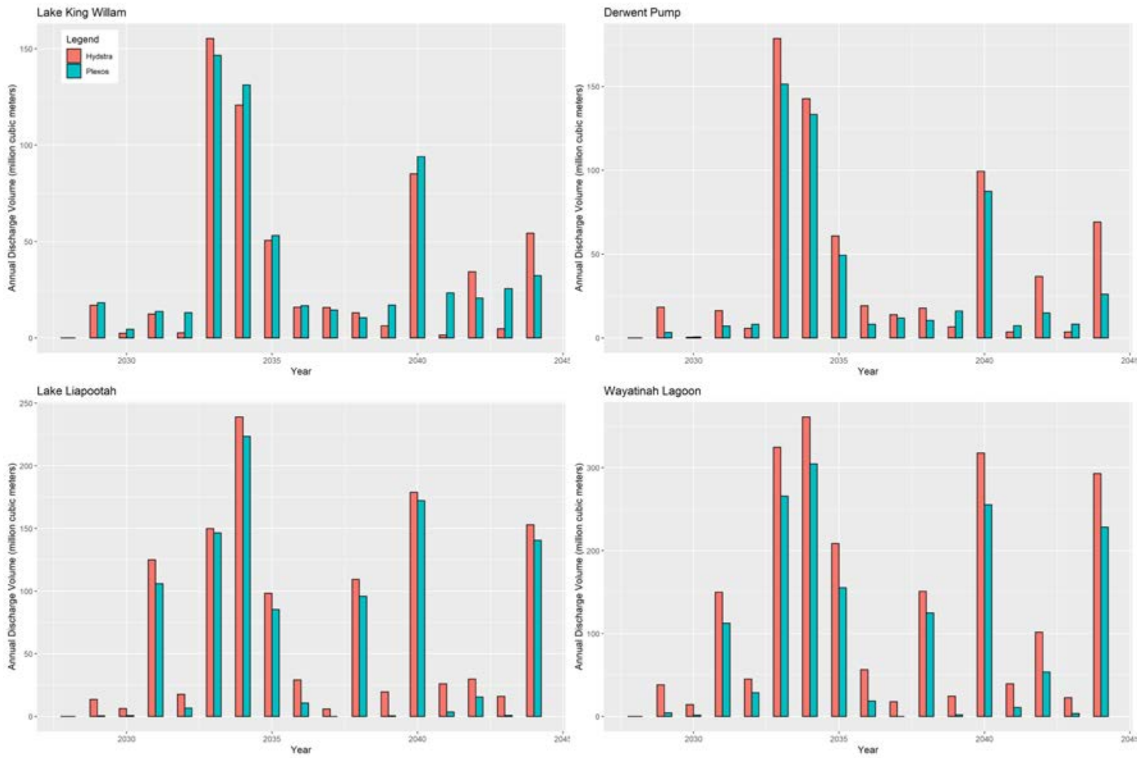


Figure B.14: Annual spill volume comparison plot – Sample: ST Model P02.5_T02_Tarra_A00_ML0_22Y3FB_k4_maxLSC_noLKWvalve Solution Sample 1

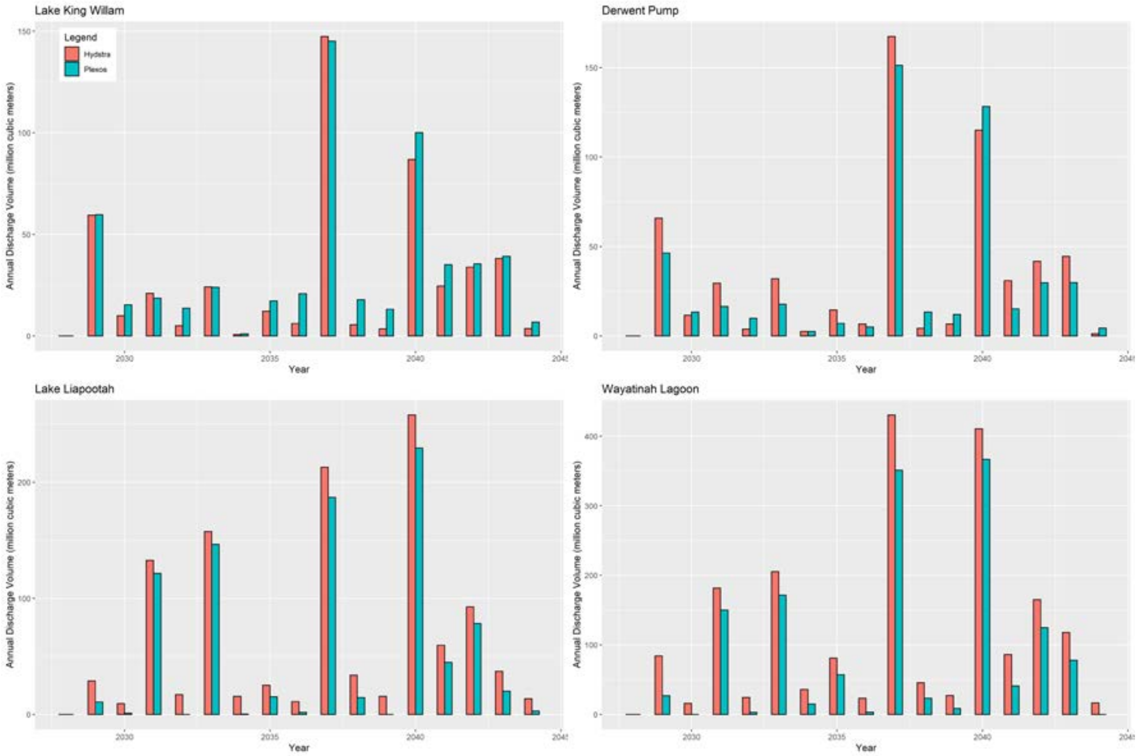


Figure B.15: Annual spill volume comparison plot – Sample: ST Model P02.5_T02_Tarra_A00_ML0_22Y3FB_k4_maxLSC_noLKWvalve Solution Sample 2

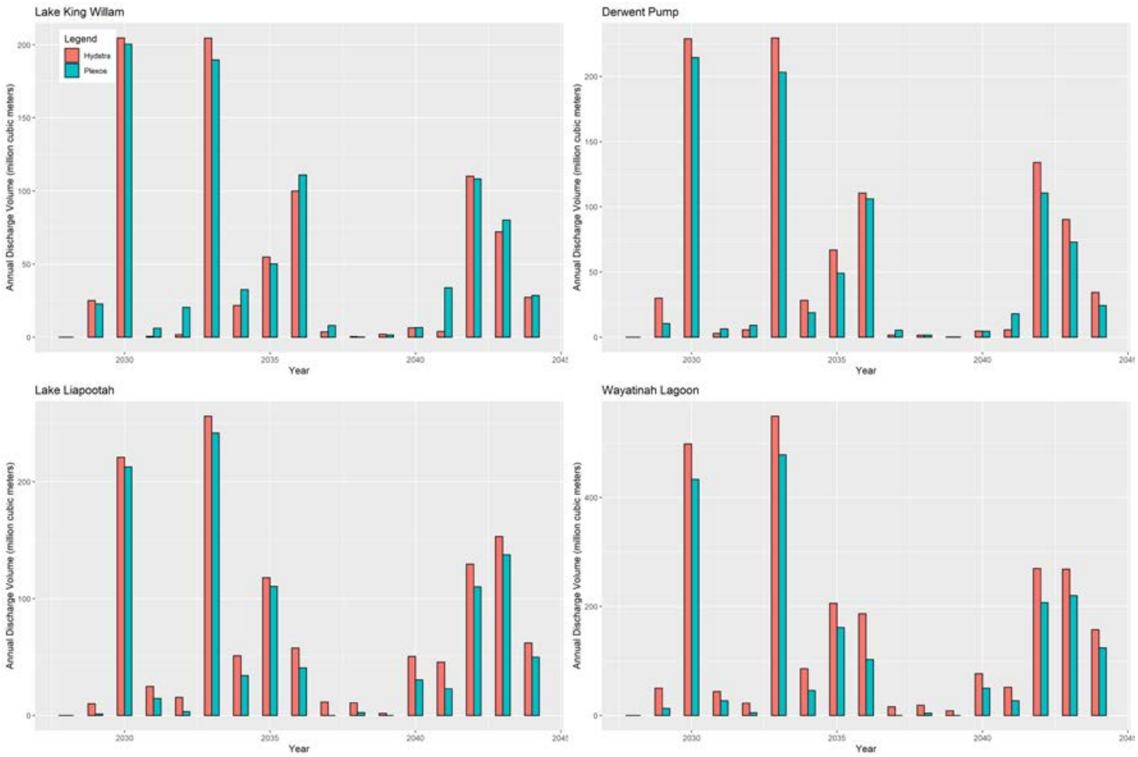


Figure B.16: Annual spill volume comparison plot – Sample: ST Model P02.5_T02_Tarra_A00_ML0_22Y3FB_k4_maxLSC_noLKWvalve Solution Sample 3

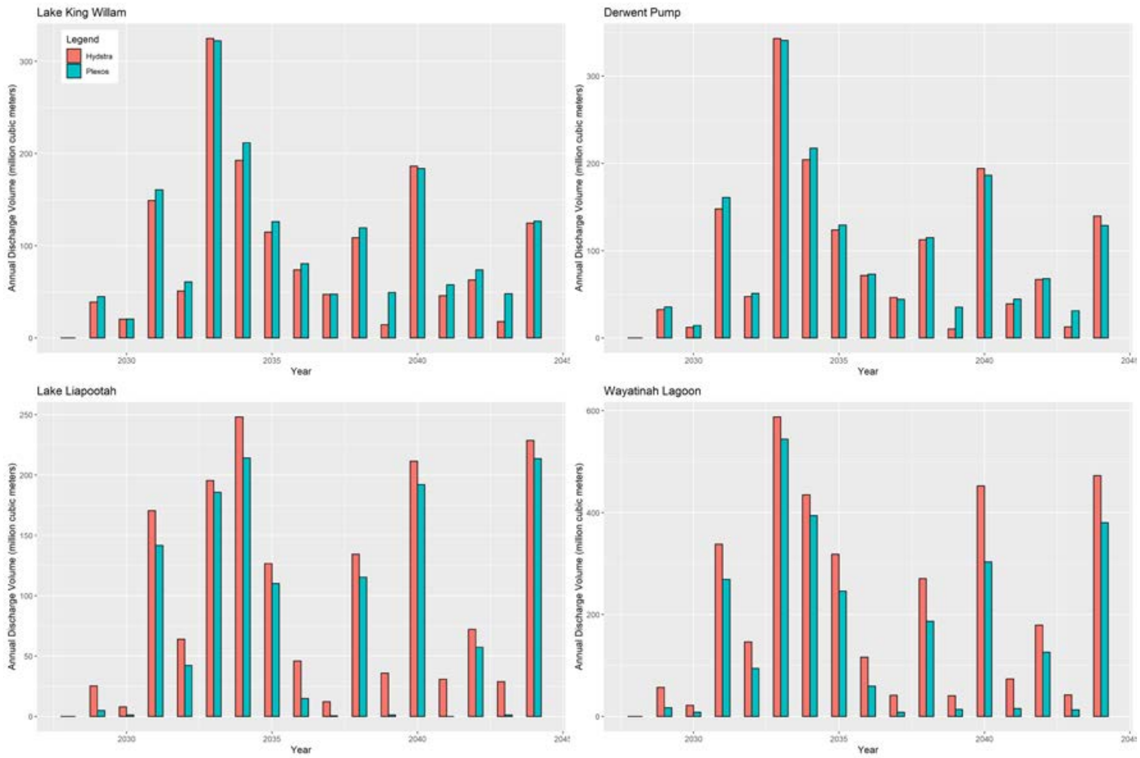


Figure B.17: Annual spill volume comparison plot – ST Model
P02.1e_T02_Tarra_A00_ML2_22Y3FB_k4_maxLSC_noLKWvalve_BGmax Solution Sample 1

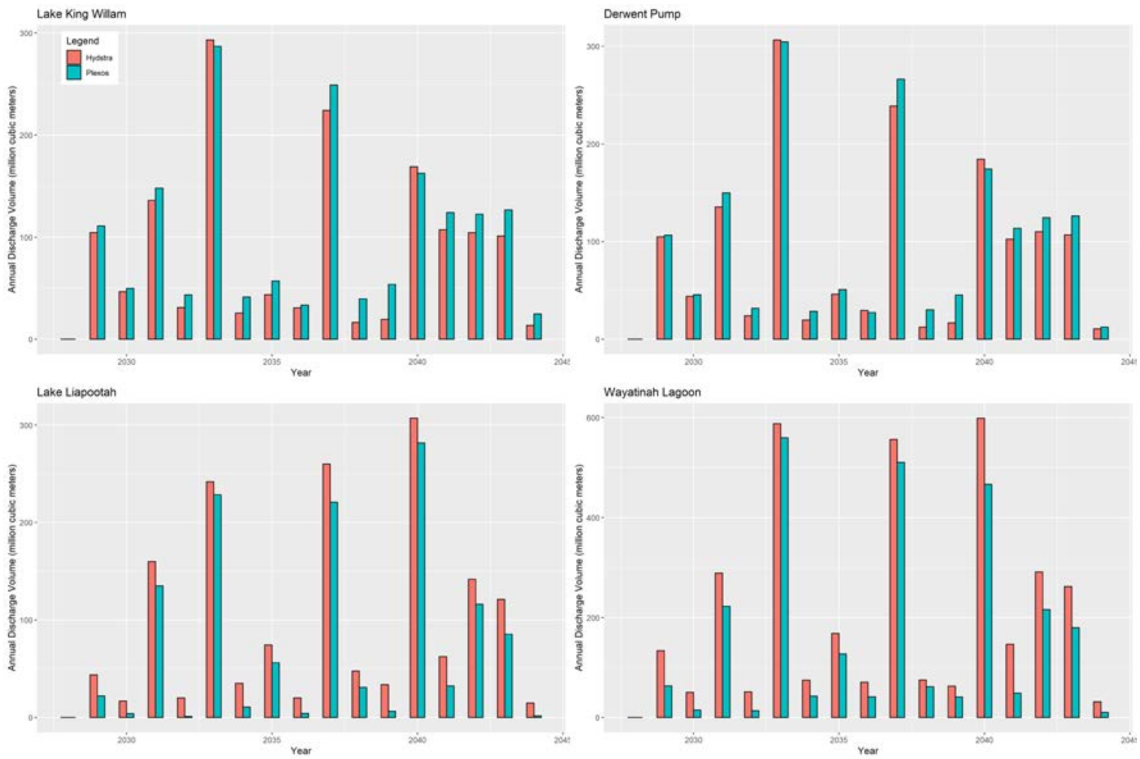


Figure B.18: Annual spill volume comparison plot – ST Model
P02.1e_T02_Tarra_A00_ML2_22Y3FB_k4_maxLSC_noLKWvalve_BGmax Solution Sample 2

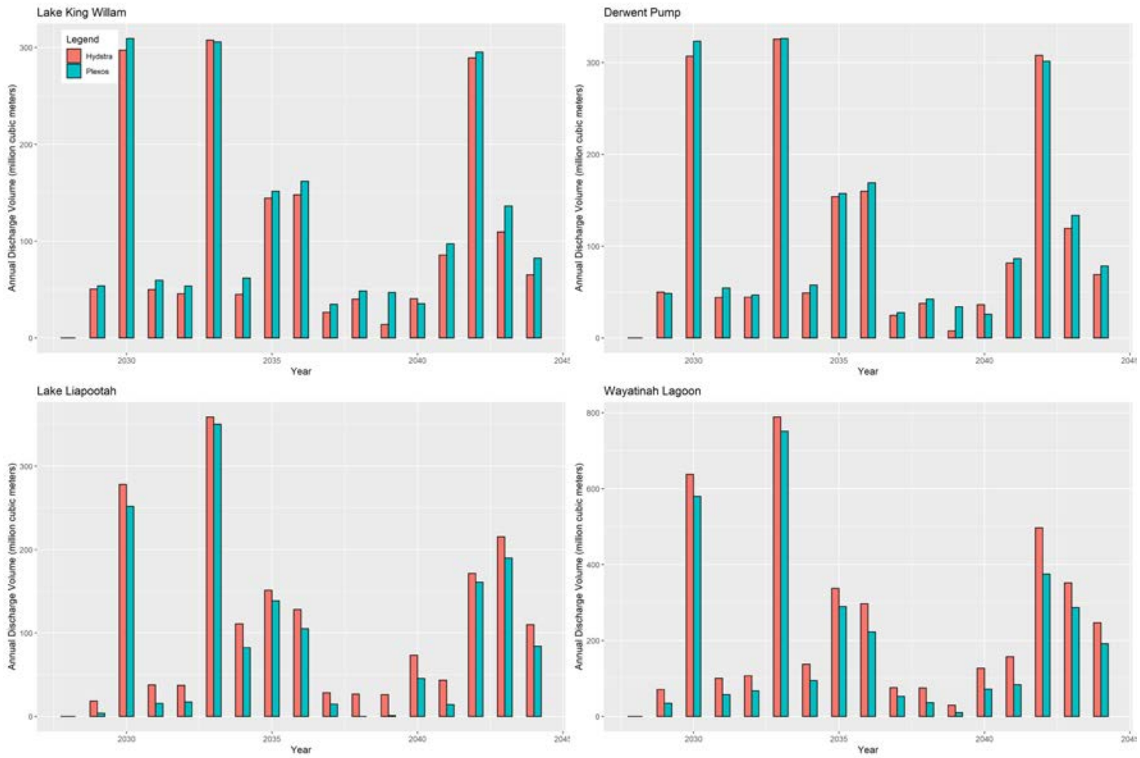


Figure B.19: Annual spill volume comparison plot – ST Model
P02.1e_T02_Tarra_A00_ML2_22Y3FB_k4_maxLSC_noLKWvalve_BGmax Solution Sample 3

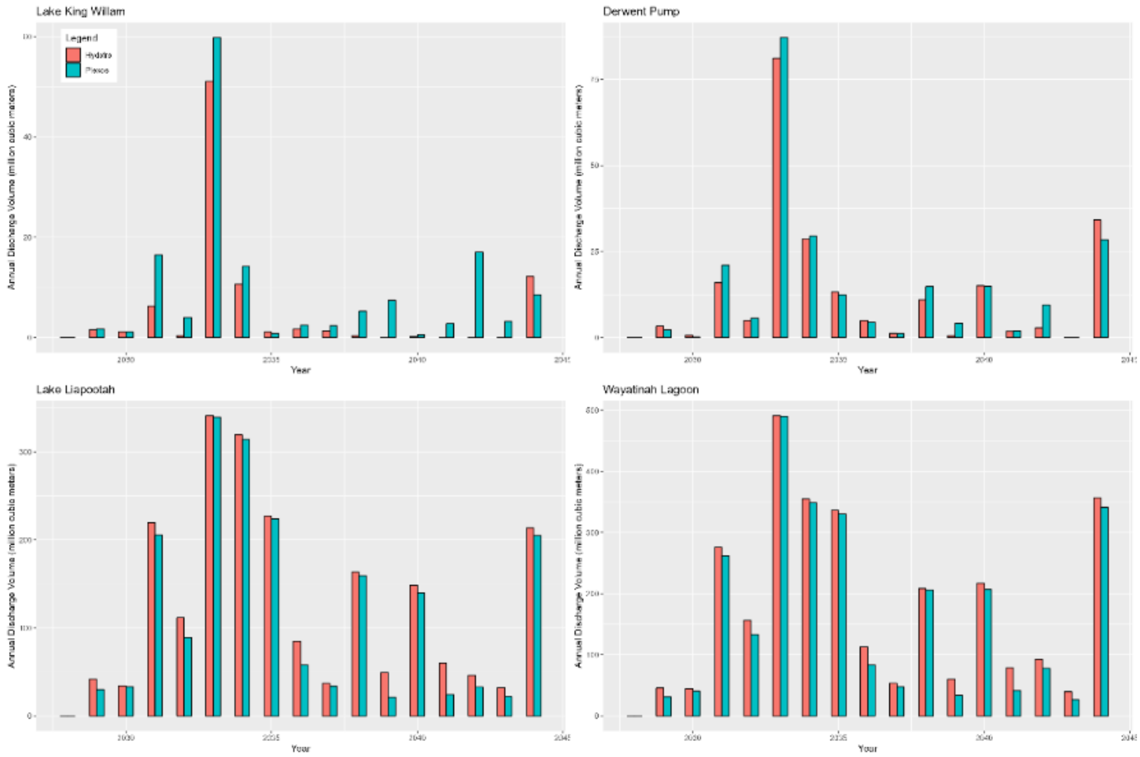


Figure B.20: Annual spill volume comparison plot – ST Model
P02.1_T02_Tarra_F60_ML2_22Y3FB_k4_maxLSC Solution Sample 1

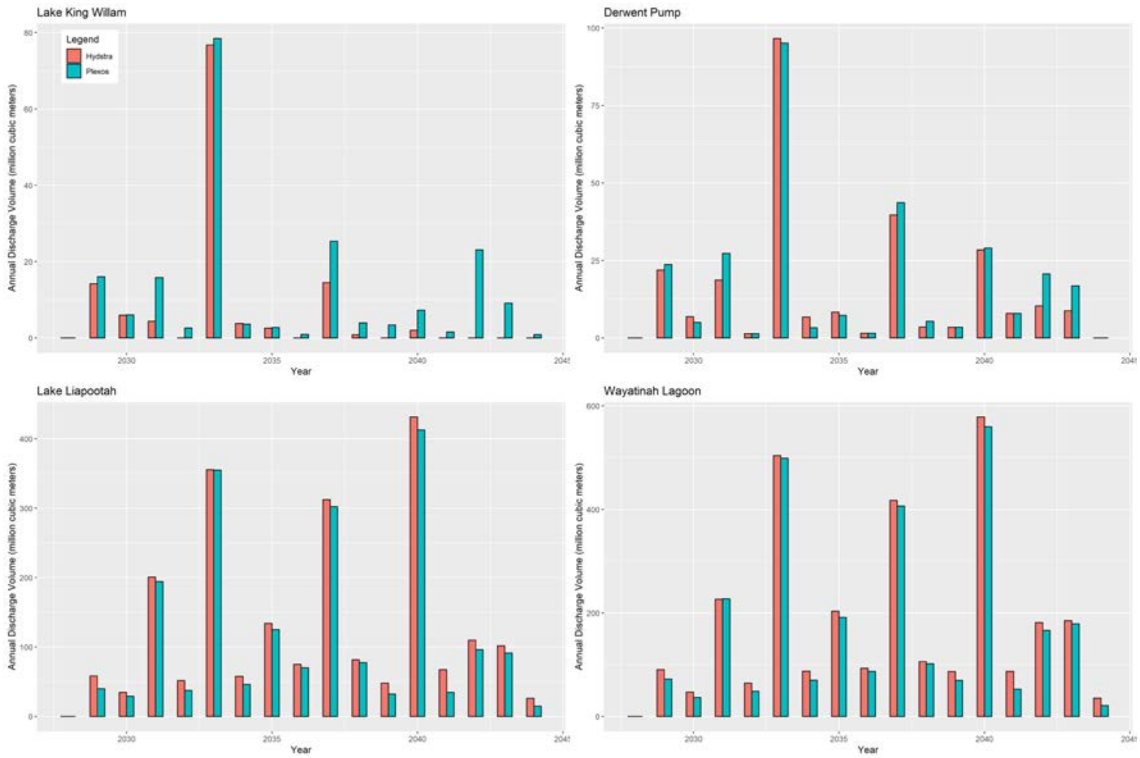


Figure B.21: Annual spill volume comparison plot – ST Model P02.1_T02_Tarra_F60_ML2_22Y3FB_k4_maxLSC Solution Sample 2

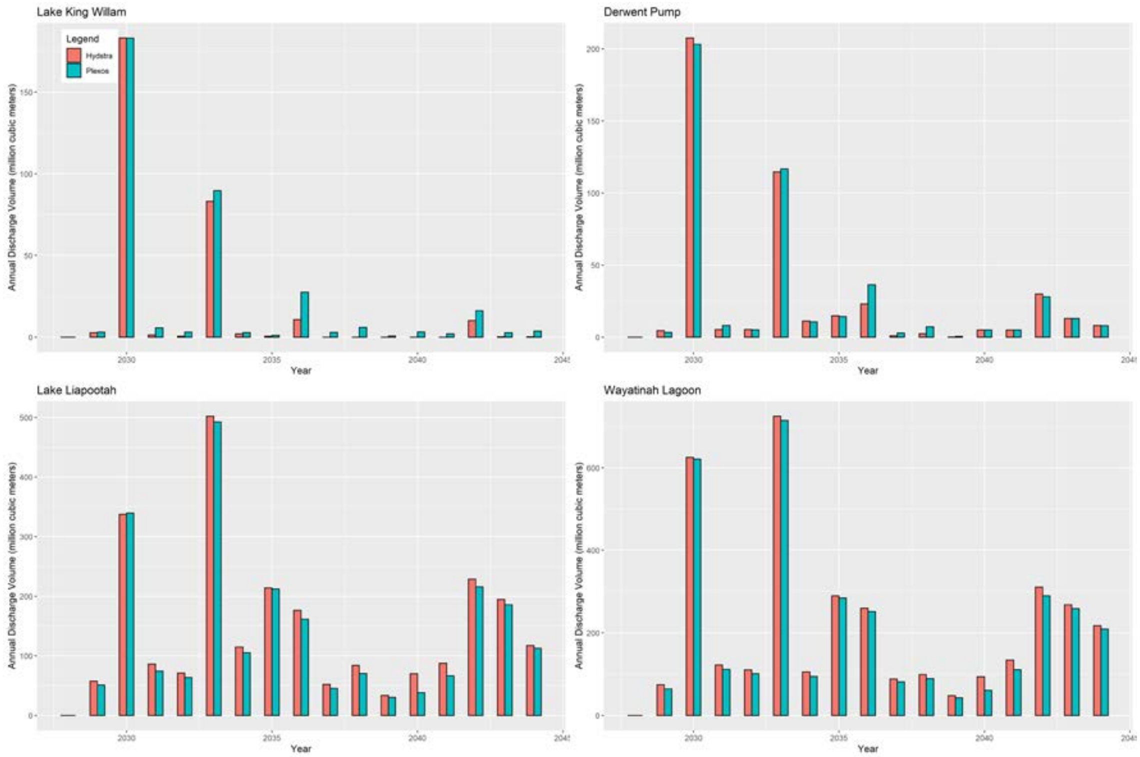


Figure B.22: Annual spill volume comparison plot – ST Model P02.1_T02_Tarra_F60_ML2_22Y3FB_k4_maxLSC Solution Sample 3

B.6.3 Generation of flow hydrographs in River Derwent downstream of Clark Dam

Hydrographs covering the 2029 to 2044, were prepared at the 10 reporting points below Clark Dam was generated (not shown) for the environmental impact assessment.

Hydrographs for a shorter duration (01-08-2035 to 01-09-2035) is shown in Figure B.23. The figure shows that the local pickup contributes to the discharges in the first half of the event (01-08-2038 to 13-08-2038) and the spill from Lake King William primarily contributes to the second half of the event (13-08-2038 to 25-08-2038). The figure shows the impact of channel routing as the flow event progresses downstream.

The PLEXOS simulation, pre-emptive releases as per the reservoir operation rules and the post processing of spill as implemented in Section B.3, results in generation of a number of pulse outputs (sharp spill) lasting for 30 minutes. These pulse releases are the artefact of the model simulation. These spills attain a more realistic hydrograph shape as they are routed downstream, downstream of Derwent Pumps Weir.

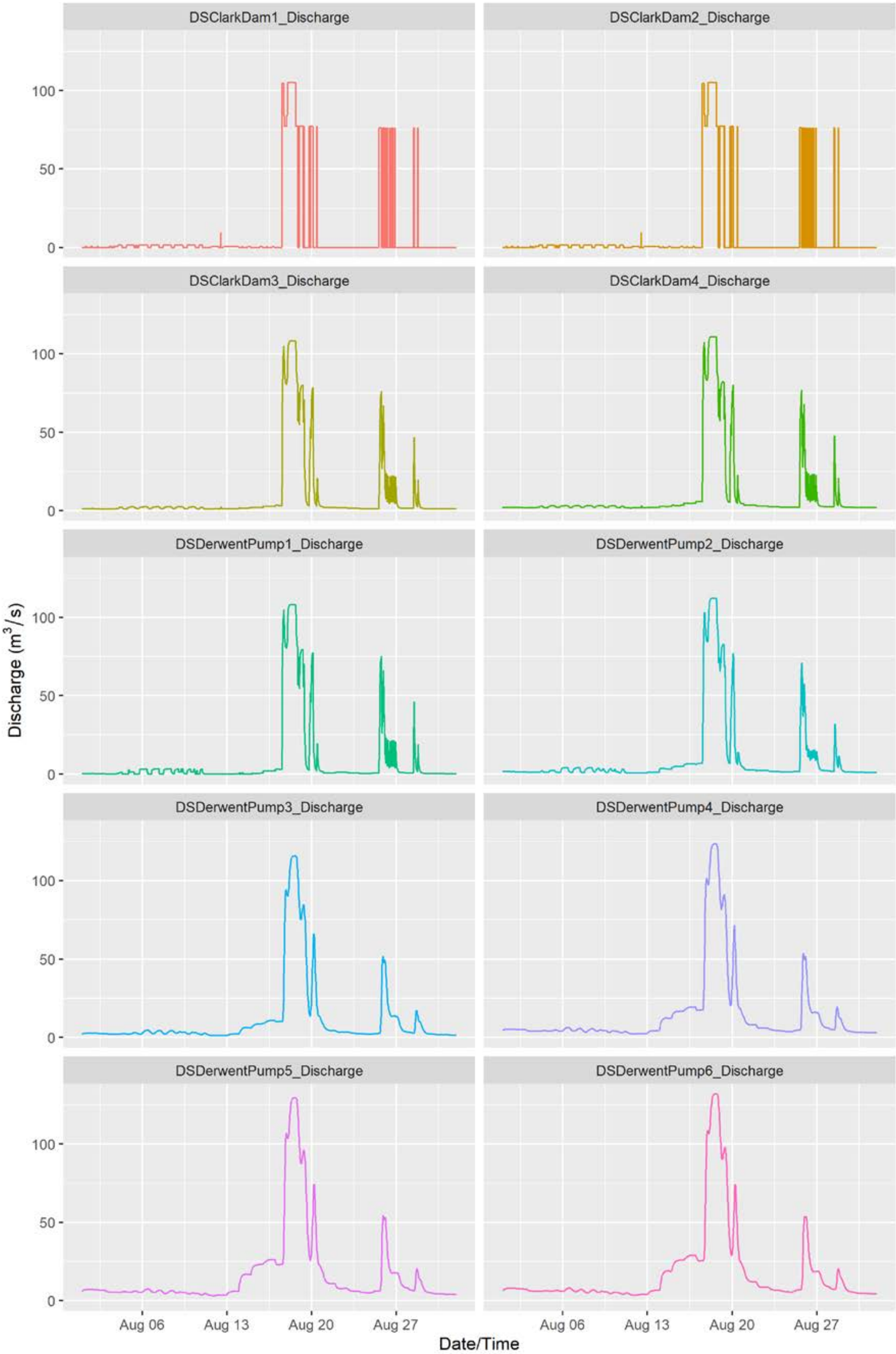


Figure B.23: hydrograph at the reporting locations for selected event in 2038 (Scenarios : ST Model P02.5_T02_Tarra_A00_ML0_22Y3FB_k4_maxLSC_noLKWvalve Solution Sample 1)

B.7 Limitations of the study

- **Natural inflow to the catchments:** The natural pickups provided for this work are from the inflows to power station studies. The natural inflows provide reasonable estimates of flows at monthly timescales but tend to underestimate the peaks at finer temporal scales. Additionally, the daily inflows were derived by multiplying the normalised daily flow patterns by the monthly flow values. This causes the daily flow hydrographs to contain step changes which, at times, do not reflect natural hydrograph shape.
- **Future climate:** The representation of the future climate was done by scaling the inflows to power station data by ~0.3 % every year. Multiplying by a scaling factor, accounts for the reduction of inflows over time, however it also results in shrinking the variance (variability) of the distribution (inflow series). Additionally, it does not correctly represent the changes in the occurrence frequency of the events (both floods and droughts).
- **Generation of Pickup inflows in the River Derwent:** The simulation of the contribution of pick-up inflows along the River Derwent downstream of Clark Dam was done by applying a scaling factor (ratio of areas at two catchments) to the natural inflows at Derwent Pumps Weir or Wayatinah Lagoon. Use of rainfall runoff model, and future projections were not considered for this study.

B.8 References

Entura (2022). *Inflows to Power Station Year 2021-22 Update - Entura Report*.

Hydro Tasmania 2025. *Tarraleah Redevelopment Modelling for Environmental Assessment* – Hydro Tasmania Report.

C Hydraulic modelling

C.1 Hydraulic Model development

Two separate models were developed using the TUFLOW-HPC modelling software to represent the upper and lower River Derwent channel and banks. The model extents were separated to provide coverage for the River Derwent from Lake King William to Lake Catagunya and The Nive River from Liapootah Dam to Wayatinah Lagoon reaches.

The primary purpose of these models was to input available data, including terrain LiDAR, survey and observed channel features to determine the critical flows required to mobilise cobble and gravel within the channel and banks.

The following sections summarise key model inputs and the adopted data of the model development

C.1.1 Lake King William to Wayatinah Lagoon

The TUFLOW model extends from downstream of Clark dam at Lake King William to the Wayatinah Lagoon. The model extent has been provided for reference in Figure C.1.

Figure C.1: TUFLOW hydraulic model extent – Clark dam to Wayatinah Lagoon

C.1.2 Liapootah Dam to Wayatinah Lagoon and Wayatinah Dam to Lake Catagunya

The Nive River from Liapootah Dam to Wayatinah Lagoon and the River Derwent from Wayatinah Dam to Lake Catagunya was treated as one model and was developed using a truncated version of the lower Derwent hydraulic model build with modifications to the adopted materials to represent the observed rock and gravel more accurately at the location. Further details of the adopted model are provided in the *Lower River Derwent hydrology and hydraulic model development calibration report (Entura 2022)*.

The TUFLOW model extends from Liapootah dam through Wayatinah Lagoon and towards Lake Catagunya. The model extent has been provided for reference in Figure C.2.

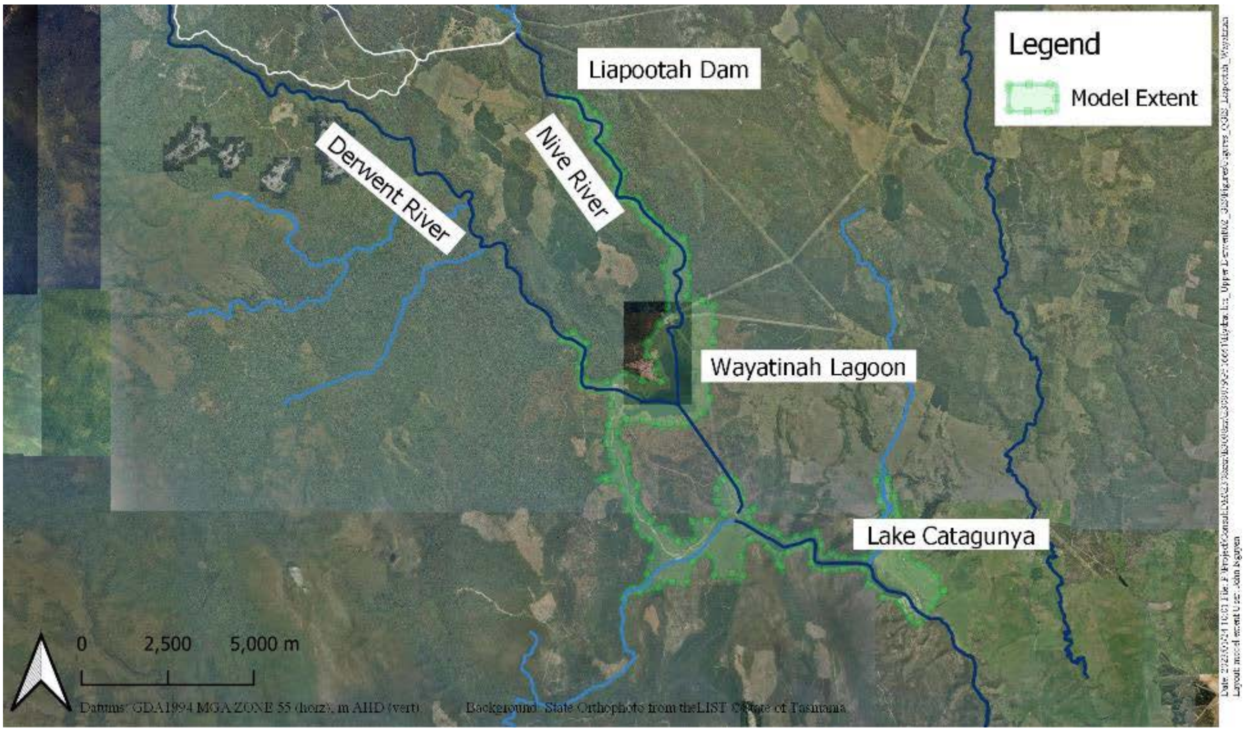


Figure C.2: TUFLOW hydraulic model extent – Liapootah Dam to Wayatinah Lagoon to Lake Catagunya

C.1.2.1 Topography

For both models, the elevation data used for the models were sourced from publicly available LiDAR repositories from DPIPWE (2019) and Forestry Tasmania (2014). The LiDAR adopted has horizontal and vertical accuracy of 0.15m.

The reservoir at Wayatinah Lagoon was represented by digitised contours based on electronic plans, while no bathymetric data was available for Lake Catagunya.

Both models utilised TUFLOW Quadtree computation cell size to provide more refined calculations within the channel whilst maintaining an efficient model run time by permitting a coarser resolution in the floodplain.

For the Lake King William to Wayatinah Lagoon model, a 1.5m grid cell size was adopted for the channel and the remaining model extent adopted an 8m grid cell size. While for the Liapootah to Catagunya model, a 0.935m grid cell size was adopted for the channel and the remaining model extent adopted a variable grid cell size between 30 m to 3.75 m.

C.1.2.2 Materials and Mannings 'n'

A materials layer was developed in GIS to represent the different land types within the receiving channel and floodplain. Best estimate Manning's n values based on Chow (1959) and AR&R Project 15 guidelines (Babister *et al.*, 2012) were used to represent surface roughness in the TUFLOW model. Land type was classified using available aerial photography. Table 4 provides a summary of the adopted land types and Mannings 'n' values.

Mannings 'n' values for the channel were estimated based on an approximate D50 (i.e. where 50% of the rock sizes are smaller than the mean rock size) estimated based on field observations (Section C.5.2). The methodology for estimating a depth varying mannings 'n' is provided for reference in C.5.1. An averaged Froude number of 0.5 was adopted for all flow depths for the estimation of channel mannings 'n' values.

The D50 for the Lake King William to Wayatinah Lagoon was observed to be approximately 100 mm, while the Liapootah to Catagunya reaches were observed to be approximately 250 mm.

Table 4: Materials and Mannings 'n'

Land type description	**Mannings 'n'**	
Site	Lake King William to Wayatinah Lagoon	Liapootah dam to Lake Catagunya
Channel	If d<0.15, 0.09 (50 mm), if d>0.5, 0.04 (100 mm)	If d<0.25 0.099 (50 mm), if 1,0.051 (250 mm)
Grassed areas	0.035	0.035
Commercial (low density)	0.15	0.15
Rural residential	0.08	0.08
High density vegetation	0.12	0.12

C.1.2.3 Boundary conditions and flows

For both models, the upstream boundary of the hydraulic model is a Flow vs Time boundary. A steady state flow has been applied at the upstream boundary of the model. The flows assessed in the models are presented in Table 5. The flows assessed are within the range of observed flows in these reaches.

Table 5: Flow rates assessed in the hydraulic models

Lake King William to Wayatinah Lagoon	Liapootah dam to Lake Catagunya
1 m^3/s	10 m^3/s
3 m^3/s	20 m^3/s
5 m^3/s	30 m^3/s
10 m^3/s	50 m^3/s
15 m^3/s	70 m^3/s
20 m^3/s	100 m^3/s
25 m^3/s	125 m^3/s
30 m^3/s	150 m^3/s
35 m^3/s	175 m^3/s

Lake King William to Wayatinah Lagoon	Liapootah dam to Lake Catagunya
40 m^3/s	200 m^3/s
45 m^3/s	250 m^3/s
50 m^3/s	300 m^3/s
55 m^3/s	350 m^3/s
60 m^3/s	400 m^3/s
65 m^3/s	450 m^3/s
70 m^3/s	500 m^3/s
75 m^3/s	
80 m^3/s	
85 m^3/s	
90 m^3/s	
95 m^3/s	
100 m^3/s	
125 m^3/s	
150 m^3/s	
175 m^3/s	
200 m^3/s	
225 m^3/s	
250 m^3/s	

Both models utilise a Flow vs Level boundary for the hydraulic downstream boundary.

For the upper Lake King William to Wayatinah Lagoon model, the boundary is representative of the spillway flow out of Wayatinah Lagoon. While for the Liapootah dam to Lake Catagunya dam, it is presentative of the spillway flow downstream of Catagunya dam.

The potential effects of the Wayatinah Lagoon ponding have not been considered for this modelling. It is understood that backwatering of the Derwent as a result of ponding in Wayatinah Lagoon occurs very infrequently and it is expected the flows of interest are most likely to coincide with Wayatinah Lagoon at its normal operating level.

While for the Liapootah model, the downstream boundary is located far downstream of the Catagunya dam and is not expected that the effects of the boundary condition would cause backwatering in Catagunya dam for all flow events modelled.

C.2 Development of rock rolling results

The depth and flow velocity results from the TUFLOW hydraulic models were used to estimate a D_{50} particle size that is likely to "just be moved" following the critical shear stress method outlined in the CHUTE riprap design user manual (CRC for Catchment Hydrology, 2003). It should be noted that this approach is valid for particle sizes of 6mm and larger. The approach adopted has been provided for reference in Section C.5.1.

Maps showing the D_{50} sediment sizes that will just be moved were prepared for the modelled flows. An example of these maps have been provided for reference in Figure C.3 and Figure C.4.

Full body maps for the all the flows analysed have not been developed; however, the outputs of the hydraulic analysis were used in the assessments of these reaches (Section 8.1.7).

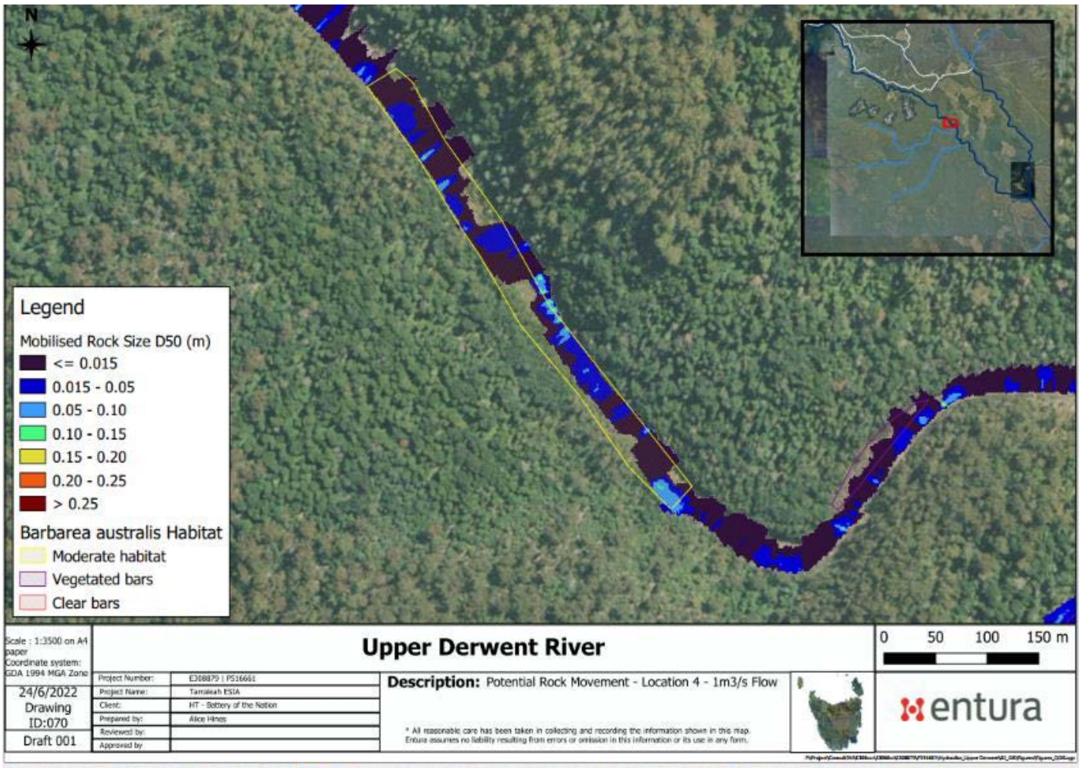


Figure C.3: Example of estimated D_{50} sediment sizes for rock rolling under a 1 m^3/s flow in Location 4 of the River Derwent downstream Clark Dam

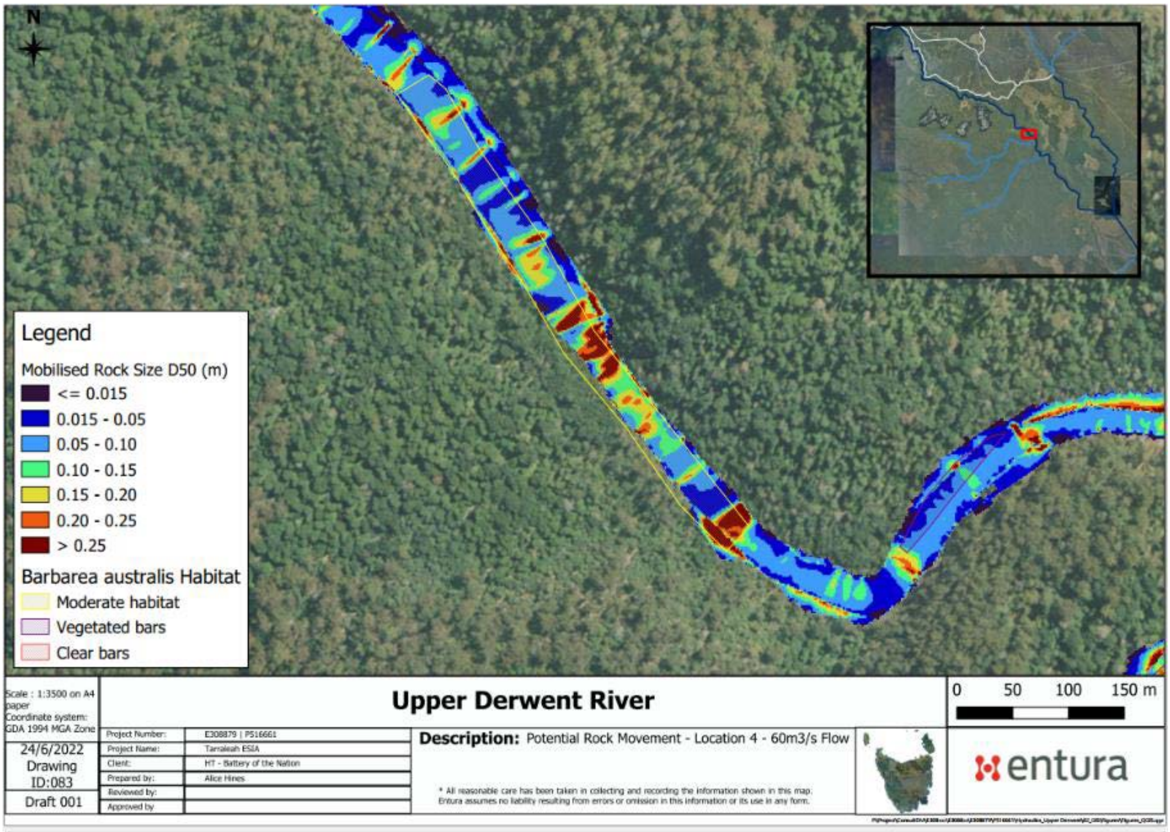


Figure C.4: Example of estimated D_{50} sediment sizes for rock rolling under a 60 m^3/s flow in Location 4 of the River Derwent downstream Clark Dam

C.3 Model outcomes

The following section only assesses the rock movement and flow context for the Lake King William to Wayatinah Lagoon. The outcomes of modelling for the Nive River downstream Liapootah Dam to Wayatinah Lagoon and River Derwent downstream Wayatinah Dam to Lake Catagunya reaches are discussed in Sections 8.2.2 and 8.3.2 of the main report.

C.3.1 Assessment of rock movement

Table 6 summarises the model outcomes with respect to potential rock movement of cobbles and gravels at the nine locations of interest in the River Derwent downstream Derwent Pumps Weir to Wayatinah Lagoon. The nine locations were between a ~ 400 to 700 m long reach and were selected as representative of the slope and channel dimensions downstream Derwent Pumps Weir (Figure C.5). These were also locations where mobile areas of gravels to small cobbles are on side channel bars are present which are of interest to the geomorphic and habitat assessments undertaken for the Project.

Table 6: Rock Movement Outcomes for the River Derwent downstream Derwent Pumps Weir to Wayatinah Lagoon

	Gravels (D50 1-15mm)		Cobbles (D50 15-100mm)	
	Channel mobilisation[1]	**Bank mobilisation[2]**	**Channel mobilisation[1]**	**Bank mobilisation[2]**
Location 1	3 m^3/s	5 m^3/s	15 m^3/s	30 m^3/s
Location 2	3 m^3/s	20 m^3/s	5 m^3/s	30 m^3/s
Location 3	20 m^3/s	20 m^3/s	80 m^3/s	80 m^3/s
Location 4	10 m^3/s	30 m^3/s	55 m^3/s	75m^3/s
Location 5	15 m^3/s	25 m^3/s	50 m^3/s	50 m^3/s
Location 6	25 m^3/s	35 m^3/s	80 m^3/s	100 m^3/s
Location 7	15 m^3/s	40 m^3/s	55 m^3/s	65 m^3/s
Location 8	3 m^3/s	10 m^3/s	20 m^3/s	40 m^3/s
Location 9	10 m^3/s	15 m^3/s	35 m^3/s	60 m^3/s

[1] Flow at which rock mobilisation occurs within channel
[2] Flow at which rock mobilisation occurs on banks

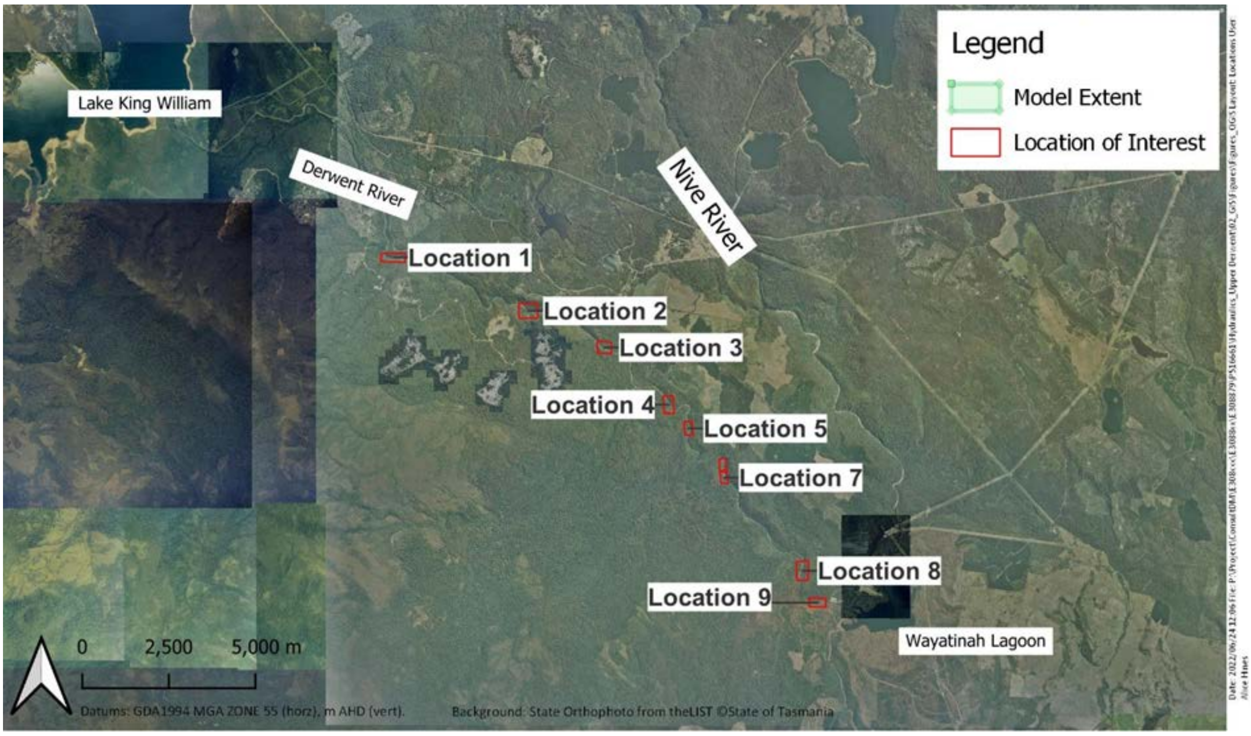


Figure C.5: Upper River Derwent Locations of Interest

C.4 References

ARR (2016) *Regional Flood Frequency Estimation Model* accessed on 16th August 2021.

Babister, M., Ball, J., Barton, C., Bishop, W., Gray, S., Jones, R. H., McCowam, A., Murtagh, J., Person, B., Phillips, B., Rigby, T., Retallick, M., Smith, G., Syme, B., Szylkarski, S., Thompson, R. and Weeks, B., (2012) *Australian Raingall & Runoff Revision Project 15: Two-dimensional Modelling in Urban and Rural Floodplans, AR&R Report Number P15/S1/009.*

Chow, V. (1959). *Open-channel hydraulics*. New York: McGraw-Hill.

NSW Imagery (2021). *NSW Imagery Web Service* accessed on 17th August 2021.

Premise (2021). *Environmental Assessment: Winburndale Dam Water Supply Works Approval – Amendment for clarification of conditions.* Report No.:2211235/EA, Rev:001E; 15 January 2021.

C.5 Attachments

C.5.1 Rock movement calculations

Blodgett (1986a) proposed a relationship for Manning's roughness coefficient, n, that is a function of the flow depth and the relative flow depth (d_a/D_{50}) as follows:

$$n = \frac{\alpha\, d_a^{1/6}}{2.25 + 5.23 \log\left(\frac{d_a}{D_{50}}\right)} \qquad (6.1)$$

where,

- n = Manning's roughness coefficient, dimensionless
- d_a = average flow depth in the channel, m (ft)
- D_{50} = median riprap/gravel size, m (ft)
- α = unit conversion constant, 0.319 (SI) and 0.262 (CU)

Equation 6.1 is applicable for the range of conditions where $1.5 \le d_a/D_{50} \le 185$. For small channel applications, relative flow depth should not exceed the upper end of this range.

Figure C.6: Manning's 'n' estimate for rock size where flow depth > 1.5*D50

Some channels may experience conditions below the lower end of this range where protrusion of individual riprap elements into the flow field significantly changes the roughness relationship. This condition may be experienced on steep channels, but also occurs on moderate slopes. The relationship described by Bathurst (1991) addresses these conditions and can be written as follows (See Appendix D for the original form of the equation):

$$n = \frac{\alpha\, d_a^{1/6}}{\sqrt{g}\, f(Fr)\, f(REG)\, f(CG)} \tag{6.2}$$

where,

- d_a = average flow depth in the channel, m (ft)
- g = acceleration due to gravity, 9.81 m/s^2 (32.2 ft/s^2)
- Fr = Froude number
- REG = roughness element geometry
- CG = channel geometry
- α = unit conversion constant, 1.0 (SI) and 1.49 (CU)

Equation 6.2 is a semi-empirical relationship applicable for the range of conditions where $0.3<d_a/D_{50}<8.0$. The three terms in the denominator represent functions of Froude number, roughness element geometry, and channel geometry given by the following equations:

$$f(Fr) = \left(\frac{0.28Fr}{b}\right)^{\log(0.755/b)} \tag{6.3}$$

$$f(REG) = 13.434\left(\frac{T}{D_{50}}\right)^{0.492} b^{1.025(T/D_{50})^{0.118}} \tag{6.4}$$

$$f(CG) = \left(\frac{T}{d_a}\right)^{-b} \tag{6.5}$$

where,

- T = channel top width, m (ft)
- b = parameter describing the effective roughness concentration.

The parameter b describes the relationship between effective roughness concentration and relative submergence of the roughness bed. This relationship is given by:

$$b = 1.14\left(\frac{D_{50}}{T}\right)^{0.453}\left(\frac{d_a}{D_{50}}\right)^{0.814} \tag{6.6}$$

Equations 6.1 and 6.2 both apply in the overlapping range of $1.5 \le d_a/D_{50} \le 8$. For consistency and ease of application over the widest range of potential design situations, use of the Blodgett equation (6.1) is recommended when $1.5 \le d_a/D_{50}$. The Bathurst equation (6.2) is recommended for $0.3<d_a/D_{50}<1.5$.

Figure C.7: Manning's 'n' estimate for rock size where flow depth < 1.5*D50

C.5.2 Field photos

Location 4 – Lake King William to Wayatinah Lagoon

Nive River: Liapootah Dam to Wayatinah Lagoon

River Derwent: Wayatinah Dam to Lake Catagunya

D Flow duration curves

D.1 River Derwent downstream Clark Dam to Derwent Pumps Weir

D.2 Clark Dam to Derwent Pumps Weir

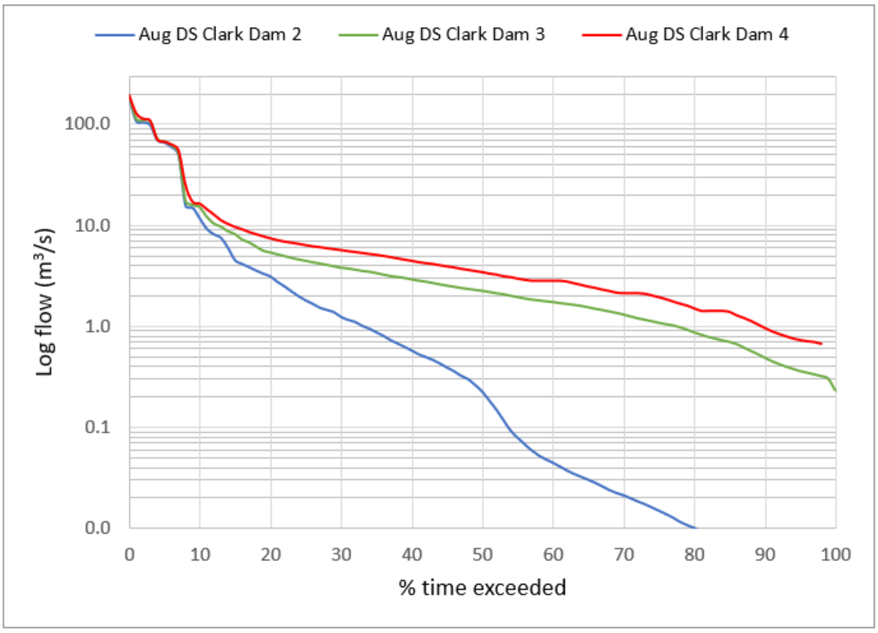


Figure D.1: Flow duration curve (log) for February and August in the River Derwent downstream Butlers Weir (*DS Clark Dam 2*), 4.5 km downstream Clark Dam (*DS Clark Dam 3*), and immediately upstream Derwent Pumps Weir (*DS Clark Dam 4*) for baseline operation (2007 to 2022).

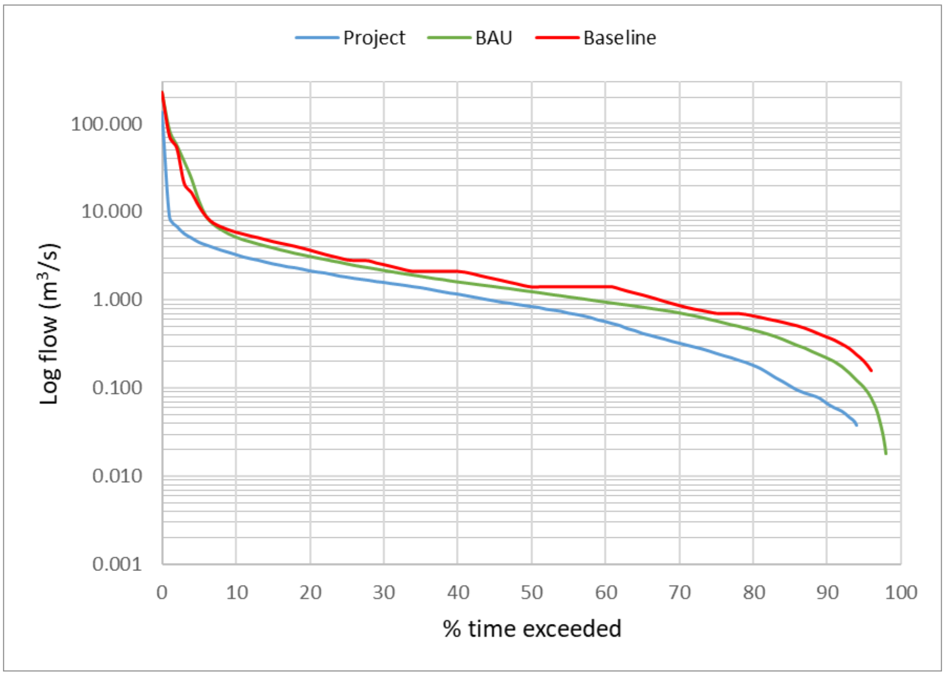


Figure D.2: Flow duration curve (log) for the River Derwent 6 km downstream Clark Dam (*DS Clark Dam 4*) for baseline operation (2007 to 2022) and, BAU and operation of the Project (2029 to 2044)

D.3 River Derwent downstream Derwent Pumps Weir to Counsel River

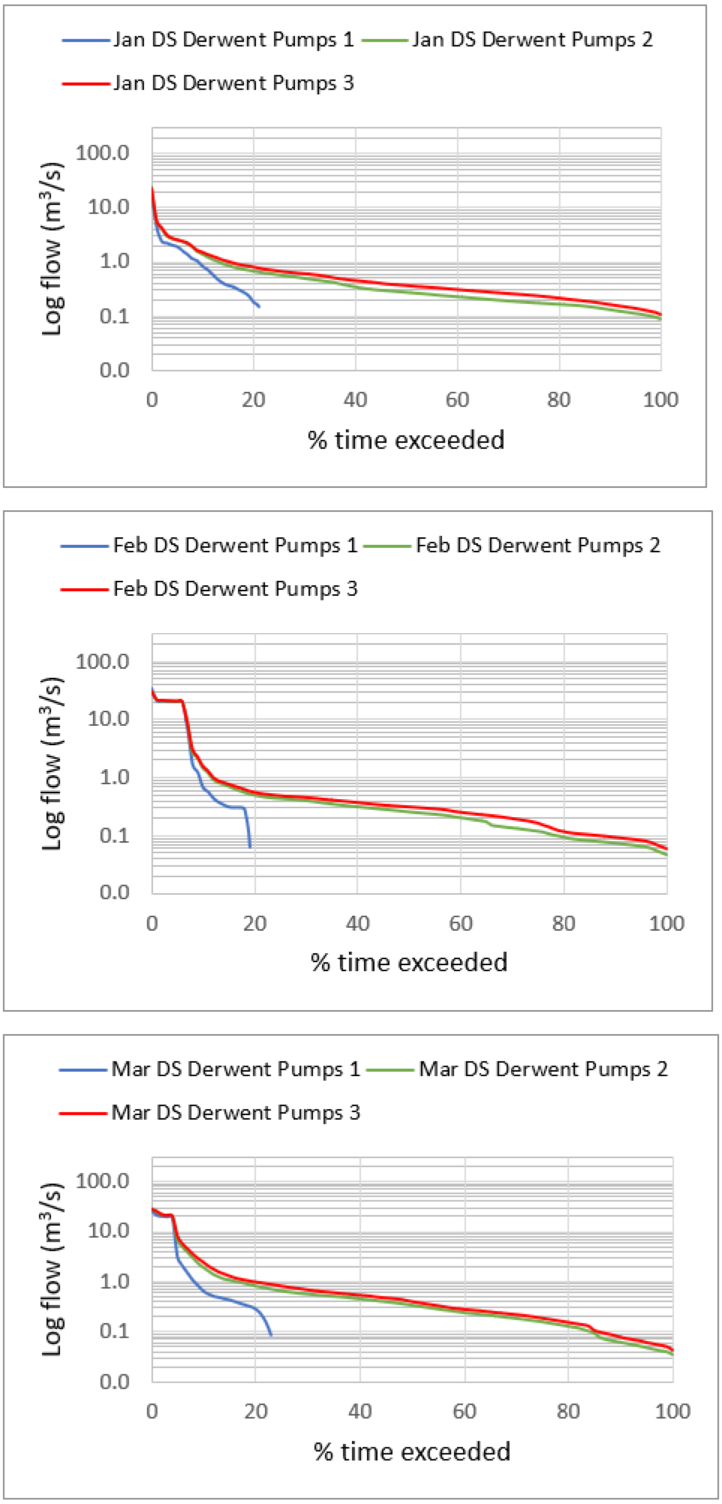


Figure D.3: Flow duration curve (log) for January, February and March in the River Derwent downstream Derwent Pumps Weir for baseline operation (DS Derwent Pumps 1; DS Derwent Pumps 2 and DS Derwent Pumps 3, 2007 – 2022)

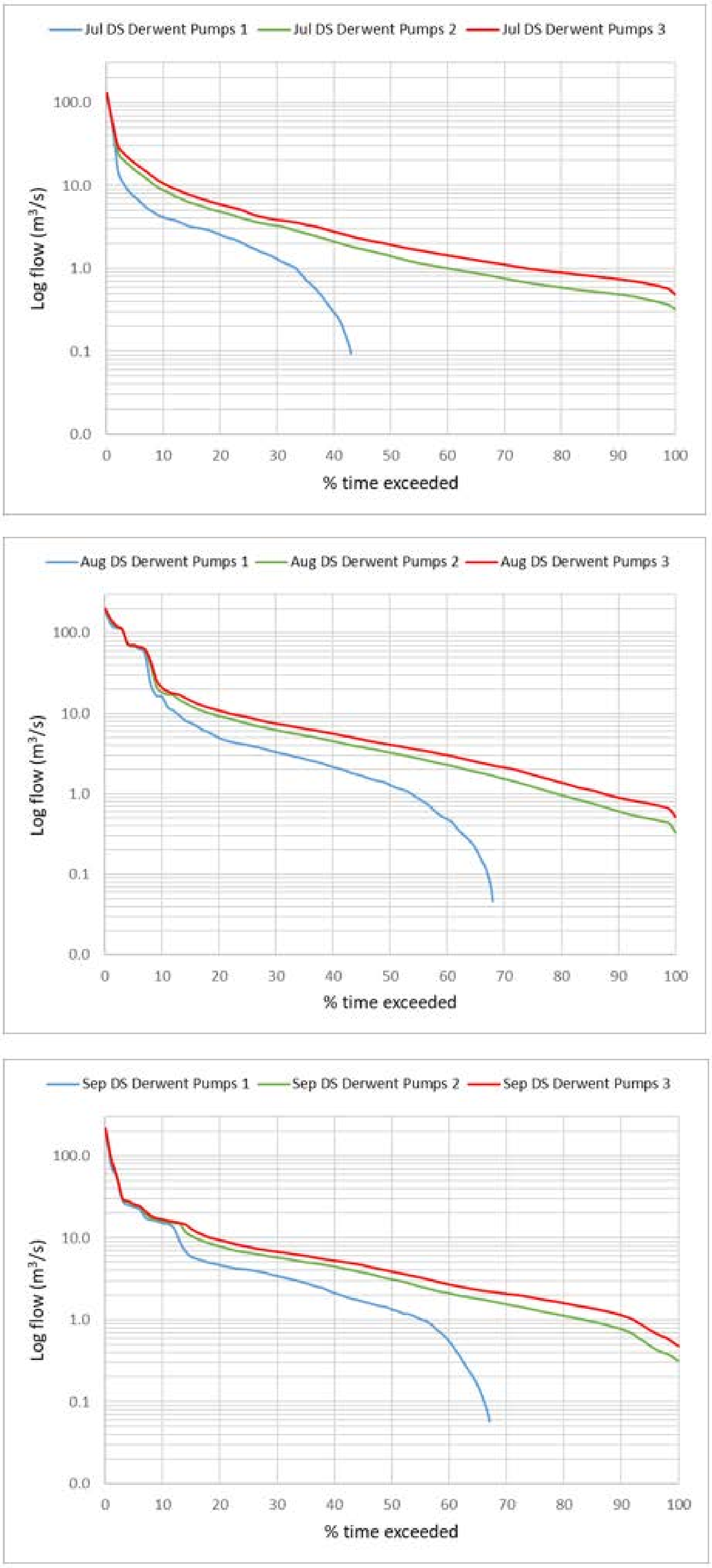


Figure D.4: Flow duration curve (log) for July, August and September in the River Derwent downstream Derwent Pumps Weir for baseline operation (DS Derwent Pumps 1; DS Derwent Pumps 2 and DS Derwent Pumps 3, 2007 – 2022)

D.4 River Derwent downstream Counsel River to Wayatinah Lagoon

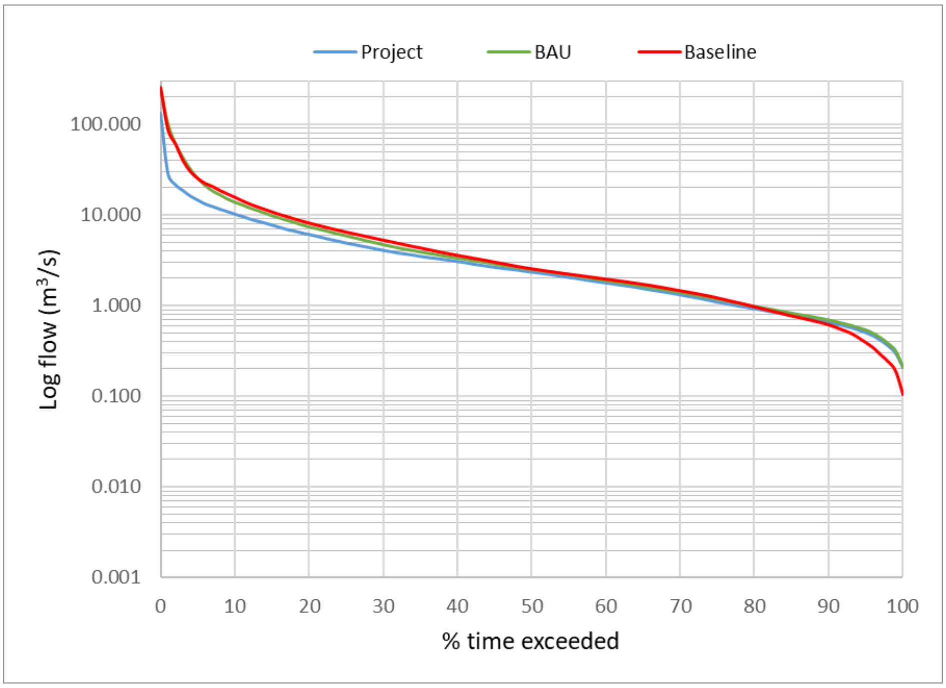


Figure D.5: Flow duration curve (log) of the whole modelled record for the River Derwent downstream Beech Creek (*DS Derwent Pumps 5*) for baseline operation (2007 to 2022) and, BAU and operation of the Project (2029 to 2044)

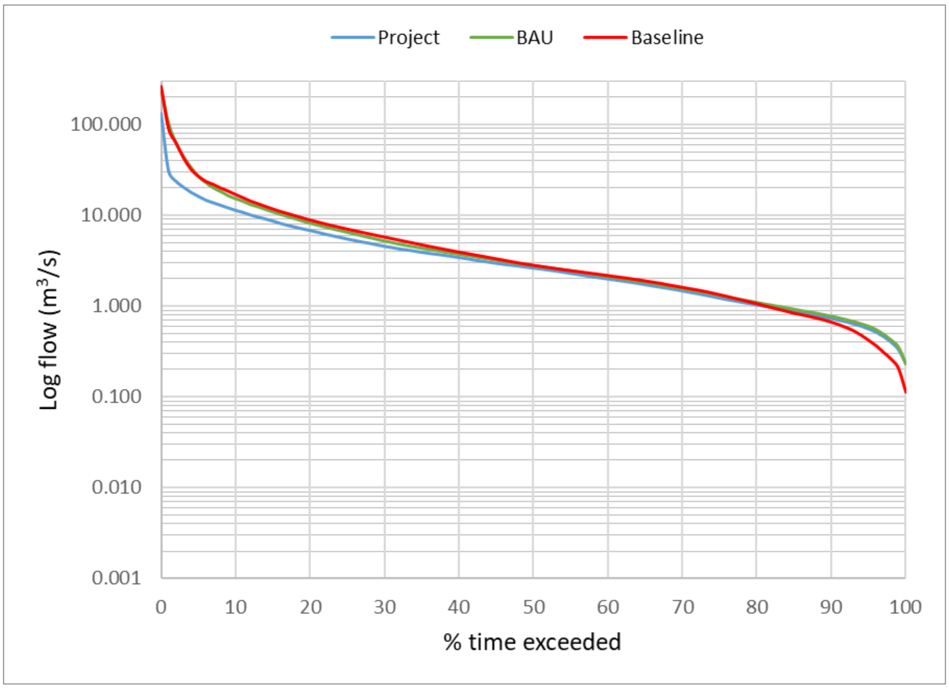
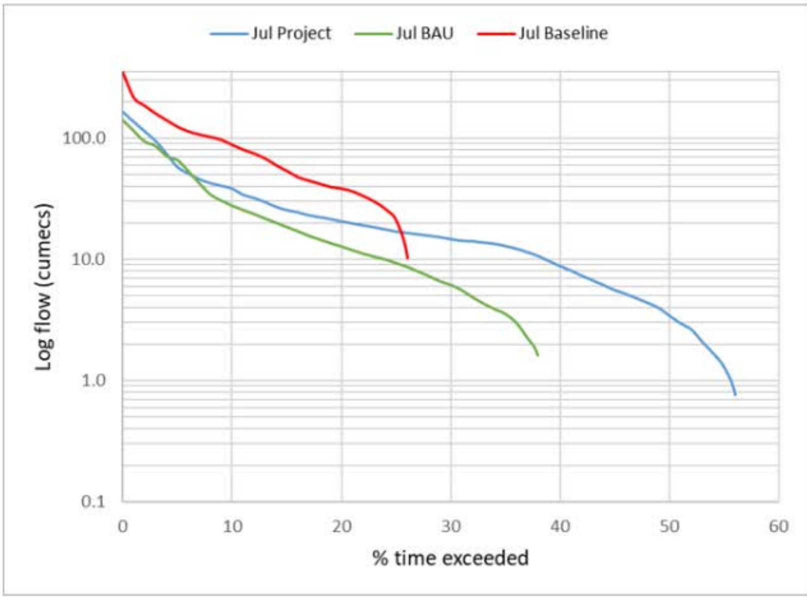


Figure D.6: Flow duration curve (log) of the whole modelled record at the Derwent above Nive flow site (*DS Derwent Pumps 6*) for baseline operation (2007 to 2022, observed data) and, BAU and operation of the Project (2029 to 2044)

D.5 River Derwent downstream Wayatinah Dam



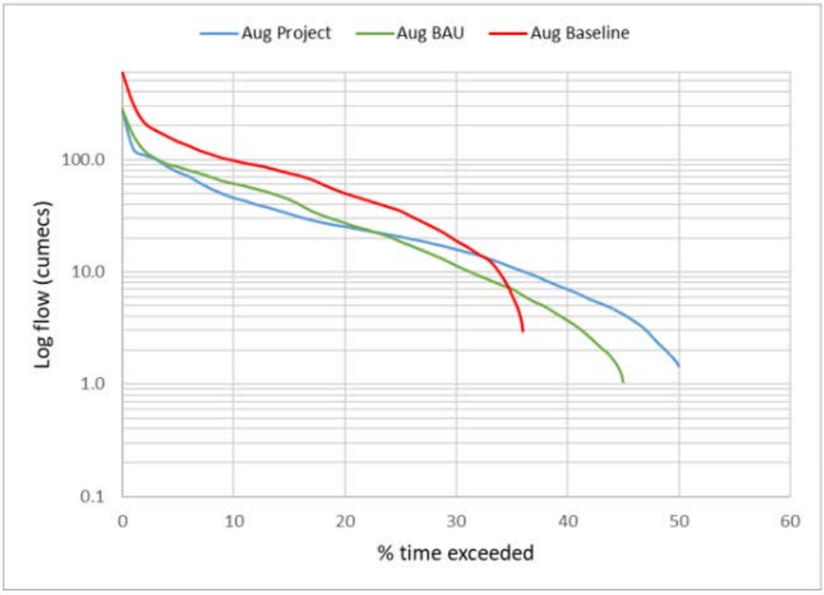
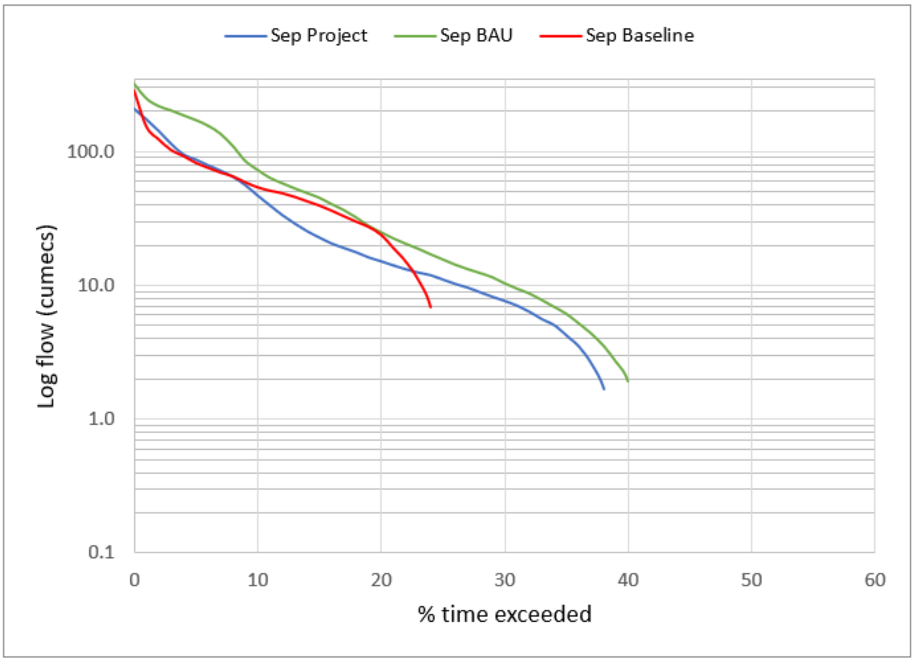


Figure D.7: Flow duration curves (log) for July and August in the River Derwent downstream Wayatinah Dam for baseline operation (2007 to 2021, observed data) and, BAU and operation of the Project (2029 to 2044)



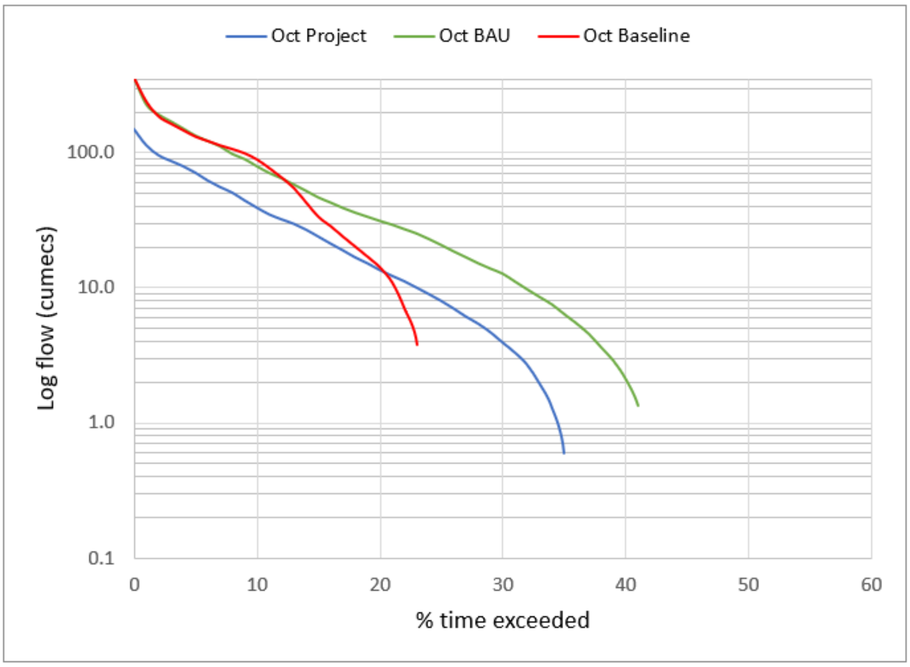


Figure D.8: Flow duration curves (log) for September and October in the River Derwent downstream Wayatinah Dam baseline operation (2007 to 2022, observed data) and, BAU and operation of the Project (2029 to 2044)

D.6 Nive River downstream Liapootah Dam

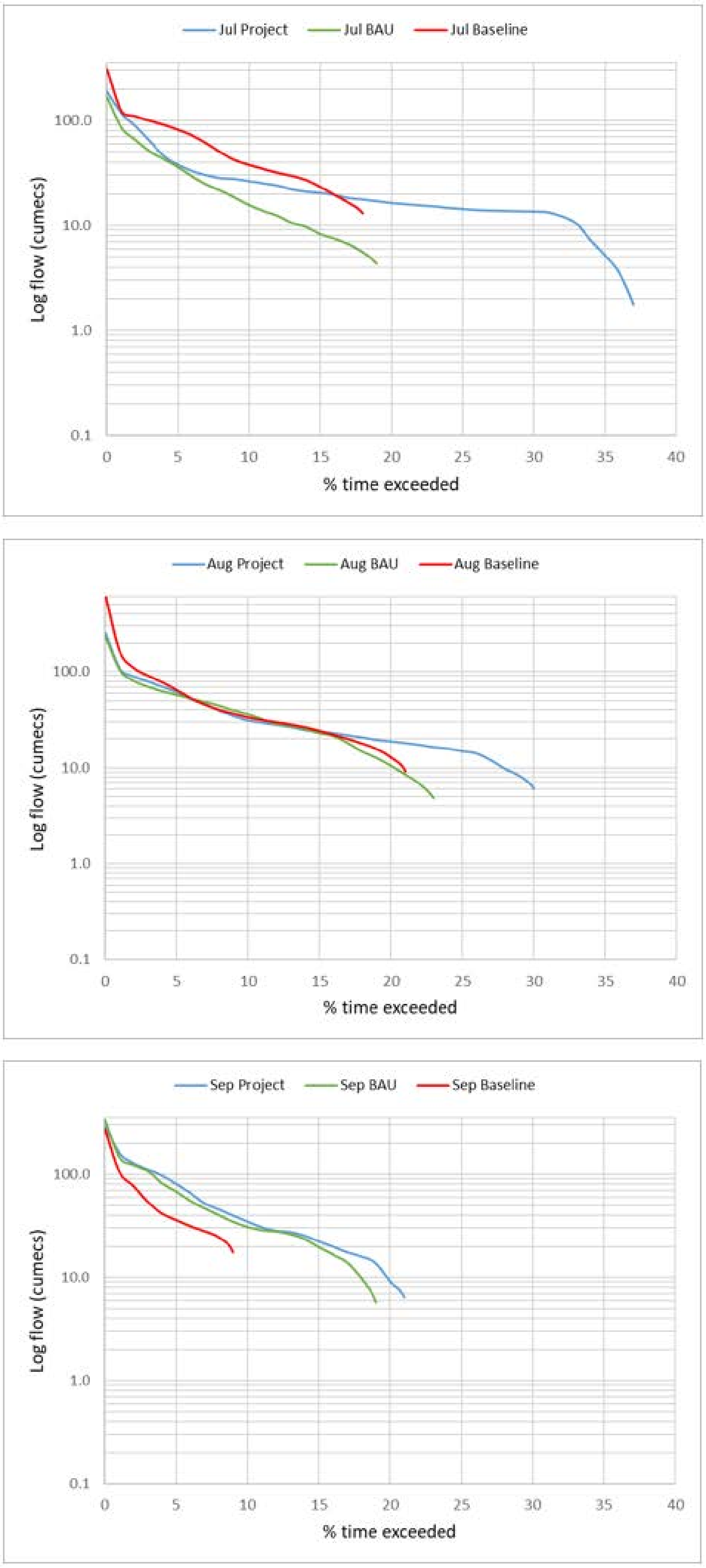


Figure D.9: Flow duration curves (log) for July to September in the Nive River downstream Liapootah Dam for baseline operation (2007 to 2022, observed data) and, BAU and operation of the Project (2029 to 2044

E Raw macroinvertebrate data

Table A.7: Raw macroinvertebrate data for collected during AusRivAS monitoring in spring 2018

Phylum/Class/Order	Family/Sub-family	Derwent 1.6 km downstream Clark Dam	2.5 km downstream Derwent Pumps Weir	Derwent upstream Counsel River	Counsel River	Derwent downstream Counsel River	Derwent Above Wayatinah	Derwent downstream Wayatinah Lagoon	Nive downstream Liapootah Dam	Nive at Wayatinah
Oligochaete		5	5	4	3	3	10	1	3	2
Platyhelminthes		1								
Acarina	Hydracarina	6	3	1	12	1	4	22	3	2
Amphipoda	Paramelitidae		1	3	4		1		2	
Isopoda	Phreatoicidea							1		
Mollusca	Planorbidae							3	1	
	Hydrobiidae	1	2			1		12	5	4
Odonata	Telephlebiidae	1	1	1	7	1	2			
Plectoptera	Eustheniidae	12	19	26	23	25	21		1	12
	Austroperlidae				1					
	Gripopterygidae	8	18	3	31	23	5	12	5	5
	Leptophlebiidae	33	38	26	32	16	33	1	29	45
	Baetidae		1	14	1	17	39	3		58
Diptera	Chironomidae	16	21	15	48	52	22	56	133	5
	Simuliidae	109	14	7	6	3	4	3	2	4
	Tipulidae				4		1	1		
	Athericidae					1	3			

Phylum/Class/Order	Family/Sub-family	Derwent 1.6 km downstream Clark Dam	2.5 km downstream Derwent Pumps Weir	Derwent upstream Counsel River	Counsel River	Derwent downstream Counsel River	Derwent Above Wayatinah	Derwent downstream Wayatinah Lagoon	Nive downstream Liapootah Dam	Nive at Wayatinah
	Blephariceridae					1				
	Ceratopogonidae	1								
	Empididae				1					
Trichoptera	Calocidae	3	1				4			
	Conoesucidae	19	7	3	34	24	8	19		1
	Helicophidae				2	1				
	Helicopsychidae			3		4	58			
	Hydrobiosidae	35	4	37	46	24	17	14	8	10
	Hydropsychidae	13	4		7			6		6
	Hydroptilidae		2			7	17	8	2	
	Leptoceridae	9	15	15	5	9	19			14
	Philorheithridae	1	1		7	1	15			
	Philopotomidae		28							
	Polycentropidae								5	1
Coleoptera	adult Elmidae	23	6	5	5	5	10	6	3	
	Larval Elmidae	1		2	1		3			
	Psephenidae	5	39	23		7	9	2	1	9
	Hydrophilidae					1				
	Number of taxa	17	18	16	19	19	21	14	12	13

Table E.8: Raw macroinvertebrate data for collected during AusRivAS monitoring in spring 2021

Class	Order	Family	Derwent 1.6 km downstream Clark Dam	2.5 km downstream Derwent Pumps Weir	Derwent upstream Counsel River	Counsel River	Derwent downstream Counsel River	Derwent Above Wayatinah	Nive u/s Wayatinah	Derwent d/s Wayatinah
Bivalvia	Pholadida	Sphaeriidae	2							
Gastropoda	Littorinimorpha	Tateidae	1	6	16					4
		Planorbidae			1					
Platyhelminthes	Tricladida	Dugesiidae				1				
Annelida	Oligochaeta		12	1	2	4	3	5		1
Arachnida	Acarina	Hydracarina	3	3	2	1	3	3		6
Crustacea	Amphipoda	Paramelitidae	1	1	3	3	1	3		
	Isopoda	Phreatoicidae								2
Insecta	Diptera	Empididae				1				
		Simuliidae	1	4	3	8	2	2	46	25
		SF: Chironominae	14	16		2	3	5	2	
		SF: Orthocladiinae	21	38	47	35	40	12	22	63
		SF: Podonominae	1			4	2	2	12	
		SF: Tanypodinae		1	1			3		
		SF: Diamesinae				4	5			
		Tipulidae				1	4	1		
		Blephariceridae					1			
	Plecoptera	Eustheniidae	2	39	18	27	22	46	6	4
		Gripopterygidae	12	40	5	31	12	22	128	25
		Notonemouridae	1							1
	Ephemeroptera	Leptophlebiidae	25	38	14	24	28	80	15	8
		Baetidae			3	1	12	79	3	6
	Trichoptera	Atriplectididae						1		

Class	Order	Family	Derwent 1.6 km downstream Clark Dam	2.5 km downstream Derwent Pumps Weir	Derwent upstream Counsel River	Counsel River	Derwent downstream Counsel River	Derwent Above Wayatinah	Nive u/s Wayatinah	Derwent d/s Wayatinah
		Conoesucidae	35			62	57	5		2
		Ecnomidae						1		
		Glossosomatidae						2		
		Helicophidae					1			
		Helicopsychidae				1	1	10		
		Hydrobiosidae	18	36	20	35	22	40	54	24
		Hydropsychidae	59	7	1	2	26	10	2	22
		Hydroptilidae			1		2	2		
		Leptoceridae		5	3	7	6	43	1	
		Limnephilidae				1	1			
		Philorheithridae	6			7	1	8		
		Philopotamidae			2		2			
		Polycentropidae		4			2	1		2
	Coleoptera	Elmidae (adults)	5	2	2	4		9		2
		Elmidae (larvae)		1			1	1		
		Scirtidae	1		3					
		Psepheniidae	1	1	3	1	5	2		33
	Odonata	Telephlebiidae				7	2	1		

Table E.9: Raw macroinvertebrate data for collected during AusRivAS monitoring in autumn 2022

Class	Order	Family	Derwent 1.6 km downstream Clark Dam	2.5 km downstream Derwent Pumps Weir	Derwent upstream Counsel River	Counsel River	Derwent downstream Counsel River	Derwent Above Wayatinah	Nive u/s Wayatinah	Derwent d/s Wayatinah
Gastropoda	Littorinimorpha	Tateidae		1				1	3	
	Hygrophila	Planorbidae						1		
Annelida	Oligochaeta		7			1	1	3		
Arachnida	Acarina	Hydracarina		2	1	3	1	3	4	
Crustacea	Amphipoda	Paramelitidae	1		5		1	1		3
	Isopoda	Phreatoicidae						1		
Insecta	Diptera	SF: Orthocladiinae	2	8		4	9	2	1	41
		SF: Chironominae			2	1	5	5		
		SF: Podonominae				1		1		
		Simuliidae	1	88					9	3
	Plecoptera	Eustheniidae		23	104	27	31	64	7	
		Gripopterygidae	11	2	6	26	8	6	1	2
		Notonemouridae	3							
	Ephemeroptera	Leptophlebiidae	40	10	3	8	8	28	7	1
		Baetidae			11	52	9	46	9	
	Trichoptera	Calocidae				3		2		
		Conoesucidae	172		5	11	15	12		3
		Ecnomidae						1		
		Glossosomatidae						2		
		Helicophidae				1				
		Helicopsychidae						21		

Class	Order	Family	Derwent 1.6 km downstream Clark Dam	2.5 km downstream Derwent Pumps Weir	Derwent upstream Counsel River	Counsel River	Derwent downstream Counsel River	Derwent Above Wayatinah	Nive u/s Wayatinah	Derwent d/s Wayatinah
		Hydrobiosidae	36	25	17	9	24	16	20	23
		Hydropsychidae	9		8	19	75	14	19	7
		Hydroptilidae	1	1			1	8		68
		Leptoceridae	2		2	10	5	40	2	
		Philorheithridae	11			7	11	10		
	Coleoptera	Elmidae (adults)	16	4	2	8	1	19	3	
		Elmidae (larvae)				1	2	1		
		Psepheniidae		3	18		2	13	3	19
	Odonata	Telephlebiidae			3		4			

Table E.10: Raw macroinvertebrate data for collected during AusRivAS monitoring in spring 2024. Species shaded green are endemic to Tasmania and species shaded orange are endemic to a south-east of Australia.

					Derwent River downstream Clark Dam							
Sub-phylum, Class or Sub-class	**Order**	**Family**	**Genus**	**species**	Der. d/s Clark Dam	Der. d/s Pumps	Der. u/s Counsel	Der. d/s Counsel	Der. u/s Wayatinah Lagoon	Der. d/s Wayatinah Lagoon	Nive River u/s of Wayatinah Lagoon	Counsel River
Insecta	Trichoptera	Hydrobiosidae	*Taschorema*	*ferulum*	6	1			4	9	7	
			Taschorema	*apobamum*	1				7			3
			Taschorema	*asmanum*				1				
			Ethochorema	*nesydrion*	2		1					
			Ulmerochorema	*rubiconum*	23	15	1		1	6	6	
			Taschorema	*evansi*					1	1		
			Apsilochorema	*obliquum*	2							
			Moruya	*opora*			15	14	3	1		16
		Leptoceridae	*Notalina*	*bifaria*		1		1	16		21	
			Notalina	*AV1*	1	3	7	1	15		6	1
			Oecetis	*sp.*					1			
		Hydropsychidae	*Asmicridea*	*AV1*	44	3		3	2	12		1
			Cheumatopsyche	*AV3*		9		1			2	
		Philopotamidae	*Hydrobiosella*	*waddama*		14	2		15	9		
		Conoesucidae	*Conoesucus*	*digitiferus*	1							
			Conoesucus	*norelus*		2		8	2			14
			Costora	*delora*				1				1

Sub-phylum, Class or Sub-class	Order	Family	Genus	species	Derwent River downstream Clark Dam							
					Der. d/s Clark Dam	Der. d/s Pumps	Der. u/s Counsel	Der. d/s Counsel	Der. u/s Wayatinah Lagoon	Der. d/s Wayatinah Lagoon	Nive River u/s of Wayatinah Lagoon	Counsel River
			Costora	*luxata*	7							
			Lingora	*aurata*					3	1		
			Matasia	*satana*						1		
		Philorheithridae	*Tasmanthrus*	*sp.*		1		1	6			4
			Kosrheithrus	*remulus*	4							
		Helicopsychidae	*Helicopsyche*	*murrumba*			2	2	5			1
		Calocidae	*Tamasia*	*variegata*					2			
		Polycentropodidae	*Plectrocnemia*	*sp.*						3	1	
		Ecnomidae	*Ecnomus*	*sp.*					1			
		Hydroptilidae	*Maydenoptila*	*sp.*			1	2				
			Hellyethira	*sp.*		1						
	Plectoptera	Eustheniidae	*Eusthenia*	*costalis*	1	26	17	14	10	3	65	25
		Gripopterygidae	*Cardioperla*	*incerta*	2	4	5	5		1		3
			Dinotoperla	*serricauda*		5		1	1	7	3	
			Leptoperla	*varia*		3		6				1
			Riekoperla	*triloba*				5				18
			Trinotoperla	*inopinata*				1				
			Trinotoperla	*zwicki*							2	1
		Notonemouridae	*Austroceroides*	*sp.*				1	1			

					Derwent River downstream Clark Dam							
Sub-phylum, Class or Sub-class	**Order**	**Family**	**Genus**	**species**	Der. d/s Clark Dam	Der. d/s Pumps	Der. u/s Counsel	Der. d/s Counsel	Der. u/s Wayatinah Lagoon	Der. d/s Wayatinah Lagoon	Nive River u/s of Wayatinah Lagoon	Counsel River
	Ephemeroptera	Leptophlebiidae	*Nousia*	*sp AV7*	47	23	9	35	9	2	2	21
			Tillyardophlebia	*sp AV2*		3			11	8	34	
			Austrophlebioides	*sp AV4*			1		13			
			Garinjuga	*sp AV1*				1				
		Baetidae	*Offadens*	*hickmani*			63	29	2			1
			Offadens	*baddamsae*						2	39	
	Diptera	S.F. Orthocladiinae				1	1	31	36	47		37
		S.F. Chironominae				2	1	1	1	2	29	
		S.F. Simuliidae				3	5	5		13	4	8
		S.F. Diamesinae						7	3			20
		S.F. Tanypodinae			1	1			1	1		
		Empididae						3	2			
		Ceratopogonidae								1		
		Tipulidae										
	Coleoptera	Elmidae	*Austrolimnius*	*sp.*	4	4	2		17	3	1	
			Notriolus	*sp.*				1		1		
		Psephenidae	*Sclerocyphon*	*secretus*	2	1	7		2	10	3	1
	Odonata	Telephlebiidae	*Austroaeschna*	*hardyi*			2					2

Sub-phylum, Class or Sub-class	Order	Family	Genus	species	Derwent River downstream Clark Dam							
					Der. d/s Clark Dam	Der. d/s Pumps	Der. u/s Counsel	Der. d/s Counsel	Der. u/s Wayatinah Lagoon	Der. d/s Wayatinah Lagoon	Nive River u/s of Wayatinah Lagoon	Counsel River
Crustacea	Amphipoda	Paramelitidae						3	2			3
	Isopoda	Phreatoicidae								2		1
Rhabditophora	Tricladida	Dugesiidae							2			
Arachnida	Acarina							2		1	2	
Gastropoda	Littorinimorpha	Tateidae	*Austropyrgus*	*sp.*	1					2		3
										2		
Oligochaeta					3	1		9	9	2		
				Total diversity	17	22	18	29	32	27	17	23

F EPBC Act Significant impact assessment for *Barbarea australis*

Table F.1: EPBC Act Significant impact assessment for native wintercress (*Barbarea australis*) habitat in the River Derwent downstream Clark Dam to Wayatinah Lagoon.

Topic	Criteria	Assessment
EPBC Act status	**Endangered**	
Life history and occurrence	Distribution and general habitat requirements	*Barbarea australis* has been recorded in central Tasmania (Derwent, Nive Ouse, Shannon and Clyde river catchments and the Lake River); the north-east (St Patrick and North Esk river catchment); Central North (Mersey and Forth river catchments); in the north-west (Hellyer, Guide river catchments); and an isolated record in the far north-west near Woolnorth. *Barbarea australis* is found near river margins, creek beds and along flood channels in shallow alluvial silt on rock slabs, rocky ledges, or between large cobbles. Population sizes are typically no more than 50 mature individuals (Threatened Species Section 2011). It is likely that the species has always been locally uncommon (Threatened Species Section 2011).
	Ecology	*Barbarea australis* is an annual or short-lived (perhaps biennial) perennial herb in the Brassicaceae family, occurring along flood prone rocky river systems (Threatened Species Section 2011). It is largely reliant on germination of seed for recruitment and population persistence and is a prolific seed. After disturbance such as flooding, hundreds of seedlings can emerge in resultant gaps in winter and early spring. However, few generally survive to maturity due to browsing (mainly by native species) and disturbance by natural flood events. In the wild, bare ground is required for recruitment (Threatened Species Section 2011).
	Occurrence within the Project area	*B. australis* has been recorded in the River Derwent upstream of Wayatinah Lagoon in 2000 and 2001 but more recent surveys did not record this species. However, suitable habitat is present and nearby populations occur in the River Derwent downstream Wayatinah Lagoon. *Barbarea australis* was recorded in the River Derwent downstream Wayatinah Lagoon and in the Nive River downstream Liapootah Dam where the southern transmission line option would span the Nive River. *B. australis* occurs upstream of Liapootah Dam but this population is upstream of the influence of the Project. *B. australis* also occurs on the upstream face of the dam wall above the existing outflow pipe at the No. 2 Pond within the disturbance footprint of the Project.

Topic	Criteria	Assessment
Threats and recovery	Generally recognised threats to the species	• Loss of habitat during land clearance and invasion by exotic plants • Modification of flow regimes by dams and willows impacting seed dispersal and habitat suitability • Forestry activity
	Recovery actions	The approved conservation advice for *Barbarea australis* (Department of Environment 2014) lists the following priorities for recovery and threat abatement: Habitat loss/Disturbance and Modification: • Monitor known populations • Identify populations of high conservation priority • Minimise adverse impacts from land use at known locations • Manage water flows and habitat for native wintercress to boost seed production and dispersal • Investigate and implement formal conservation arrangements • Manage any other known, potential or emerging threats such as new dam construction to minimise impacts on habitat Invasive weeds: • Implement management plans for the control of gorse and willows • Ensure chemicals or other mechanisms used to eradicate weeds do not have a significant adverse impact on native wintercress Trampling, Browsing or Grazing: • Where appropriate, manage total grazing pressure in riparian areas where the species occurs through exclusion fencing or other barriers Conservation information: • Raise awareness of native wintercress within the local community, particularly land holders and managers Enable recovery of additional sites and or populations: • Investigate options for linking, enhancing or establishing additional populations • Implement national translocation protocols if establishing additional populations is considered necessary and feasible.

Topic	Criteria	Assessment
Impact description	The Matters of National Environmental Significance Significant impact guidelines 1.1 defines a significant impact to be likely if there is a *real or not remote chance or possibility* of happening. *B. australis* was not recorded in the River Derwent between Clark Dam and Wayatinah Lagoon and have only been recorded in this reach in 2000 and 2001. Numerous surveys have been conducted in this reach since 2019 and our assessment is that it is unlikely that the species is present. However, suitable habitat in the form of small patched of mobile gravels to small cobbles are present. A reduced spill regime during the Project has the potential to reduce the availability of these small patches of mobile sediment. The proposed flow mitigation will ensure annual high flows are delivered down this reach to maintain the mobility of the small gravels to cobbles which form the suitable areas of habitat for this species. The impact assessment provided below is provided in the context of operation of the Project with delivery of the proposed high flow mitigation. The potential direct impacts of the Project on two populations of *B. australis* that fall within the direct disturbance footprint are addressed in the Tarraleah Redevelopment Terrestrial Ecology Assessment (Entura 2025a).	
Significant impact assessment (EPBC Act Policy Statement 1.1, DEWHA 2013).	Lead to a long-term decrease in the size of a population	Survey information indicates that this species may no longer present in this reach. However, implementation of the proposed high flow releases will maintain areas of mobile gravels to cobbles which form the most suitable habitat for *B. australis* in this reach. Thus, operation of the Project is **unlikely** to lead to a long-term decrease in population size, reduce the area of occupancy, fragment the population, impact critical habitat, disrupt the breeding cycle, modify/destroy/remove/isolate or decrease habitat availability or quality of the in the River Derwent downstream Clark Dam to Wayatinah Lagoon.
	Reduce the area of occupancy of the species	
	Fragment an existing population into two or more populations	
	Adversely affect habitat critical to the survival of a species	
	Disrupt the breeding cycle of a population	
	Modify, destroy, remove or isolate or decrease the availability or quality of habitat to the extent that the species is likely to decline	
	Result in invasive species that are harmful to a critically endangered or endangered species becoming established in the endangered or critically endangered species' habitat.	There are no construction activities directly in or adjacent to the River Derwent downstream Clark Dam; however, construction of the western pipeline is within the northern part of the catchment which drains into the river. The implementation of hygiene measures as part of the Project Construction Environmental Management Plan to prevent the introduction of weeds and diseases means that the Project is **unlikely** to result in the introduction of harmful or invasive species.

Topic	Criteria	Assessment
	Introduce disease that may cause the species to decline,	The implementation of hygiene measures as part of the Project Construction Environmental Management Plan to prevent the introduction of weeds and diseases means that the Project is **unlikely** to result in the introduction of disease that may cause a species to decline.
	Interfere substantially with the recovery of the species	Operation of the Project is **unlikely** to interfere with recovery of the species the suitable habitat that is present in this reach will be maintained should the species be present or recolonise this reach.
Conclusion	**The proposed action is unlikely to have a significant impact on the *B. australis* as habitat will be at least maintained by the proposed flow mitigation**	

Table 2: EPBC Act Significant impact assessment for native wintercress (*Barbarea australis*) habitat in the River Derwent downstream Wayatinah Lagoon

Topic	Criteria	Assessment
EPBC Act status	**Endangered**	
Life history and occurrence	Distribution and general habitat requirements	*Barbarea australis* has been recorded in central Tasmania (Derwent, Nive Ouse, Shannon and Clyde river catchments and the Lake River); the north-east (St Patrick and North Esk river catchment); Central North (Mersey and Forth river catchments); in the north-west (Hellyer, Guide river catchments); and an isolated record in the far north-west near Woolnorth. *Barbarea australis* is found near river margins, creek beds and along flood channels in shallow alluvial silt on rock slabs, rocky ledges, or between large cobbles. Population sizes are typically no more than 50 mature individuals (Threatened Species Section 2011). It is likely that the species has always been locally uncommon (Threatened Species Section 2011).
	Ecology	*Barbarea australis* is an annual or short-lived (perhaps biennial) perennial herb in the Brassicaceae family, occurring along flood prone rocky river systems (Threatened Species Section 2011). It is largely reliant on germination of seed for recruitment and population persistence and is a prolific seed. After disturbance such as flooding, hundreds of seedlings can emerge in resultant gaps in winter and early spring. However, few generally survive to maturity due to browsing (mainly by native species) and disturbance by natural flood events. In the wild, bare ground is required for recruitment (Threatened Species Section 2011).
	Occurrence within the Project area	*Barbarea australis* was recorded in the River Derwent downstream Wayatinah Lagoon and in the Nive River downstream Liapootah Dam. B. australis also occurs upstream of Liapootah Dam but this population is upstream of the influence of the Project. *B. australis* has not been recorded in the River Derwent upstream of Wayatinah Lagoon since 2001
Threats and recovery	Generally recognised threats to the species	• Loss of habitat during land clearance and invasion by exotic plants • Modification of flow regimes by dams and willows impacting seed dispersal and habitat suitability • Forestry activity
	Recovery actions	The approved conservation advice for *Barbarea australis* (Department of Environment 2014) lists the following priorities for recovery and threat abatement: Habitat loss/Disturbance and Modification: • Monitor known populations • Identify populations of high conservation priority

Topic	Criteria	Assessment
		• Minimise adverse impacts from land use at known locations • Manage water flows and habitat for native wintercress to boost seed production and dispersal • Investigate and implement formal conservation arrangements • Manage any other known, potential or emerging threats such as new dam construction to minimise impacts on habitat Invasive weeds: • Implement management plans for the control of gorse and willows • Ensure chemicals or other mechanisms used to eradicate weeds do not have a significant adverse impact on native wintercress Trampling, Browsing or Grazing: • Where appropriate, manage total grazing pressure in riparian areas where the species occurs through exclusion fencing or other barriers Conservation information: • Raise awareness of native wintercress within the local community, particularly land holders and managers Enable recovery of additional sites and or populations: • Investigate options for linking, enhancing or establishing additional populations • Implement national translocation protocols if establishing additional populations is considered necessary and feasible.
Impact description	The Matters of National Environmental Significance Significant impact guidelines 1.1 defines a significant impact to be likely if there is a *real or not remote chance or possibility* of happening. Hydrological modelling indicated that the magnitude of large spills would be reduced during the Project (Section 8.2.1; Table 8.8). A reduction in sediment turnover from less spill could potentially impact habitat maintenance and availability for *Barbarea australis.*	

Topic	Criteria	Assessment
Significant impact assessment (EPBC Act Policy Statement 1.1, DEWHA 2013).	Lead to a long-term decrease in the size of a population	Despite a reduction in the magnitude of peak annual spill, large annual spills will continue to occur from Wayatinah Dam. The geomorphic and hydraulic assessments concluded that sediment mobilisation and channel morphology was likely to remain similar during operation of the Project as under current operation. The spill regime during operation poses no risk to the transport of seeds of *B. australis*, either within the channel or from Wayatinah Lagoon and over the spillway into the channel. Thus, operation of the Project is **unlikely** to lead to a long-term decrease in population size, reduce the area of occupancy, fragment the population, impact critical habitat, disrupt the breeding cycle, modify/destroy/remove/isolate or decrease habitat availability or quality of the population in this reach.
	Reduce the area of occupancy of the species	
	Fragment an existing population into two or more populations	
	Adversely affect habitat critical to the survival of a species	
	Disrupt the breeding cycle of a population	
	Modify, destroy, remove or isolate or decrease the availability or quality of habitat to the extent that the species is likely to decline	
	Result in invasive species that are harmful to a critically endangered or endangered species becoming established in the endangered or critically endangered species' habitat.	There are no construction activities directly in or adjacent to the River Derwent downstream Wayatinah Dam; however, construction of the western pipeline is within the northern part of the catchment which drains into the River Derwent which flows into Wayatinah Lagoon. The implementation of hygiene measures as part of the Project Construction Environmental Management Plan to prevent the introduction of weeds and diseases means that the Project is **unlikely** to result in the introduction of harmful or invasive species.
	Introduce disease that may cause the species to decline,	The implementation of hygiene measures as part of the Project Construction Environmental Management Plan to prevent the introduction of weeds and diseases means that the Project is **unlikely** to result in the introduction of disease that may cause a species to decline.
	Interfere substantially with the recovery of the species	Operation of the Project is **unlikely** to interfere with recovery of the species as the channel forming processes which maintain the existing population will remain similar to current
Conclusion	**The proposed action is unlikely to have a significant impact on the *B. australis* as the spill regime during operation is assessed to maintain channel forming processes seed distribution similar to current operation.**	

Table 3: EPBC Act Significant impact assessment for native wintercress (*Barbarea australis*) habitat in the Nive River downstream Liapootah Dam

Topic	Criteria	Assessment
EPBC Act status		**Endangered**
Life history and occurrence	Distribution and general habitat requirements	*Barbarea australis* has been recorded in central Tasmania (Derwent, Nive Ouse, Shannon and Clyde river catchments and the Lake River); the north-east (St Patrick and North Esk river catchment); Central North (Mersey and Forth river catchments); in the north-west (Hellyer, Guide river catchments); and an isolated record in the far north-west near Woolnorth. *Barbarea australis* is found near river margins, creek beds and along flood channels in shallow alluvial silt on rock slabs, rocky ledges, or between large cobbles. Population sizes are typically no more than 50 mature individuals (Threatened Species Section 2011). It is likely that the species has always been locally uncommon (Threatened Species Section 2011).
	Ecology	*Barbarea australis* is an annual or short-lived (perhaps biennial) perennial herb in the Brassicaceae family, occurring along flood prone rocky river systems (Threatened Species Section 2011). It is largely reliant on germination of seed for recruitment and population persistence and is a prolific seed. After disturbance such as flooding, hundreds of seedlings can emerge in resultant gaps in winter and early spring. However, few generally survive to maturity due to browsing (mainly by native species) and disturbance by natural flood events. In the wild, bare ground is required for recruitment (Threatened Species Section 2011).
	Occurrence within the Project area	*Barbarea australis* was recorded in the River Derwent downstream Wayatinah Lagoon and in the Nive River downstream Liapootah Dam. B. australis also occurs upstream of Liapootah Dam but this population is upstream of the influence of the Project. *B. australis* has not been recorded in the River Derwent upstream of Wayatinah Lagoon since 2001
Threats and recovery	Generally recognised threats to the species	• Loss of habitat during land clearance and invasion by exotic plants • Modification of flow regimes by dams and willows impacting seed dispersal and habitat suitability • Forestry activity
	Recovery actions	The approved conservation advice for *Barbarea australis* (Department of Environment 2014) lists the following priorities for recovery and threat abatement: Habitat loss/Disturbance and Modification: • Monitor known populations • Identify populations of high conservation priority • Minimise adverse impacts from land use at known locations

<table>
<tr><th>Topic</th><th>Criteria</th><th>Assessment</th></tr>
<tr><td></td><td></td><td>Manage water flows and habitat for native wintercress to boost seed production and dispersal
Investigate and implement formal conservation arrangements
Manage any other known, potential or emerging threats such as new dam construction to minimise impacts on habitat
Invasive weeds:
Implement management plans for the control of gorse and willows
Ensure chemicals or other mechanisms used to eradicate weeds do not have a significant adverse impact on native wintercress
Trampling, Browsing or Grazing:
Where appropriate, manage total grazing pressure in riparian areas where the species occurs through exclusion fencing or other barriers
Conservation information:
Raise awareness of native wintercress within the local community, particularly land holders and managers
Enable recovery of additional sites and or populations:
Investigate options for linking, enhancing or establishing additional populations
Implement national translocation protocols if establishing additional populations is considered necessary and feasible.</td></tr>
<tr><td>Impact description</td><td colspan="2">The Matters of National Environmental Significance Significant impact guidelines 1.1 defines a significant impact to be likely if there is a real or not remote chance or possibility of happening.

Changed spill regime could impact the population in this reach. Increased spill over the summer growing season during operation could increase scour of growing plants compared to current.</td></tr>
</table>

Topic	Criteria	Assessment
Significant impact assessment (EPBC Act Policy Statement 1.1, DEWHA 2013).	Lead to a long-term decrease in the size of a population	The annual peak flows are predicted to be similar to current operation with the magnitude of larger spills similar to baseline operation and BAU. Hydraulic modelling indicates that the regime of sediment mobilisation during operation of the Project is likely to be similar to current operation. The slight increase (2% increase) in spill over the summer growing season is unlikely to results in significantly greater scour of plants than occurs during current operation. Also the hydrological modelling suggests that the magnitude of spill events during the growing season would on average be smaller than spills which occur under baseline operation. Thus, operation of the Project is **unlikely** to lead to a long-term decrease in population size, reduce the area of occupancy, fragment the population, impact critical habitat, disrupt the breeding cycle, modify/destroy/remove/isolate or decrease habitat availability or quality of the population in this reach
	Reduce the area of occupancy of the species	
	Fragment an existing population into two or more populations	
	Adversely affect habitat critical to the survival of a species	
	Disrupt the breeding cycle of a population	
	Modify, destroy, remove or isolate or decrease the availability or quality of habitat to the extent that the species is likely to decline	
	Result in invasive species that are harmful to a critically endangered or endangered species becoming established in the endangered or critically endangered species' habitat.	There are no construction activities directly in or adjacent to the Nive River downstream Liapootah Dam; however, construction of the new power station is directly adjacent to the Nive River a short distance upstream from where it enters Lake Liapootah. The implementation of hygiene measures as part of the Project Construction Environmental Management Plan to prevent the introduction of weeds and diseases means that the Project is **unlikely** to result in the introduction of harmful or invasive species.
	Introduce disease that may cause the species to decline,	The implementation of hygiene measures as part of the Project Construction Environmental Management Plan to prevent the introduction of weeds and diseases means that the Project is **unlikely** to result in the introduction of disease that may cause a species to decline.
	Interfere substantially with the recovery of the species	Operation of the Project is **unlikely** to interfere with recovery of the species as the channel forming processes which maintain the current population will be similar to that which occur under current operation.
Conclusion	**The proposed action is unlikely to have a significant impact on the *B. australis* as the spill regime during operation is assessed to maintain channel forming processes seed distribution similar to current operation.**	

G Conservation of Freshwater Ecosystems Values (CFEV)

Table 5: Conservation of Freshwater Ecosystem Values (CFEV) for river segments that are within the proposed.

Name	RS_ID	Name	Strahler stream order	Integrated conservation value (Special Values, RS_ICV)	Representativeness (R) and Distinctiveness (D)			Naturalness (N, RS_NSCOR_C)	Land tenure security (RS_LTS)	Conservation management priority potential (RS_CMPP2)
					Representative Conservation Value (R, RS_RCV)	**Important Biophysical Class (D, RS_CLASSN)**	**Important Biophysical class description (D, RS_CLASSN)**			
Stream 1	211999	Crossing 1	1	Moderate[2]	C	*T36*	Upland rainforest wet eucalypt forest, woodland and sedgy grasslands of the Southern Central Plateau.	Medium (0.62): River section in near-natural condition.	Medium	Moderate
	NA	Crossing 2	CFEV database does not map this stream but likely to be very similar to other segments for Stream 1							
	212040	Crossing 3	1	Low[1]	C	*T36*	Upland rainforest wet eucalypt forest, woodland and sedgy grasslands of the Southern Central Plateau.	Medium (0.78): River section significantly altered from natural condition	Medium	Moderate
	12017	Final segment of Stream 1	3	Very high[3]	A	*G21*	Strongly glaciated plateau in headwater; Glacial till and outwash plains; Inland slopes in lower catchments	High (0.87): River section in near-natural condition.	Medium	Very high
Stream 2	212151	Crossing 4	1	Low[1]	C	*G21*	Strongly glaciated plateau in headwater; Glacial till and outwash plains; Inland slopes in lower catchments	Medium?[2] (0.78) River section significantly altered from natural condition	Medium	Moderate
	212169	Crossing 5	1?	Low[1]	C	*G21*	Strongly glaciated plateau in headwater; Glacial till and outwash plains; Inland slopes in lower catchments	Low?[2] (0.12): River section severely altered from natural condition.	Medium	Low
	212155	Final segment Stream 2	1?	High^	C	*T36*	Upland rainforest wet eucalypt forest, woodland and sedgy grasslands of the Southern Central Plateau.	High (0.87): River section in near-natural condition.	Medium	High
Stream 3	212180	Crossing 6	3	High[4]	C	*T36*	Upland rainforest wet eucalypt forest, woodland and sedgy grasslands of the Southern Central Plateau.	LOW?[2] (0.21): River section severely altered from natural condition.	Medium	High
Stream 4	NA	Crossings 7 - 9	CFEV database does not map this stream but likely to be very similar to Stream 3							
Stream 5	212908	Crossing 10	3	Moderate[1]	B	*G21*	Strongly glaciated plateau in headwater; Glacial till and outwash plains; Inland slopes in lower catchments	High (0.87): River section in near-natural condition	Medium	High
	212909	Final segment of Stream 5	3	High[5]	B	*G21*	Strongly glaciated plateau in headwater; Glacial till and outwash plains; Inland slopes in lower catchments	High (0.87): River section in near-natural condition	Medium	High
Stream 6	212849	Crossing 11	1	Moderate[1]	B	*G21*	Strongly glaciated plateau in headwater; Glacial till and outwash plains; Inland slopes in lower catchments	Medium (0.61): River section significantly altered from natural condition.	Low	Medium

[1]Special Values: Platypus (*Ornithorhynchus anatinus):* phylogenetically distinct species
[2]Special Values: Platypus (*Ornithorhynchus anatinus):* phylogenetically distinct species; highland grassy sedgeland: Priority Flora Communities
[3]Special Values: Platypus (*Ornithorhynchus anatinus):* phylogenetically distinct species; *Eucalyptus rodwayi* forest: Threatened Flora Communities
[4]Special Values: Platypus (*Ornithorhynchus anatinus):* phylogenetically distinct species; *Eucalyptus rodwayi* forest: Threatened Flora Communities; highland grassy sedgeland: Priority Flora Communities
[5]Special Values: Platypus (*Ornithorhynchus anatinus)* mountain shrimp (*Anaspides tasmaniae*): phylogenetically distinct species
?[1] Stream order appears to be incorrect, at least a 2nd order stream; ?[2] Naturalness score appears to be incorrect - stream appears to be in a near-natural condition.?[3] Naturalness score is incorrect – the stream is severely altered form natural condition.

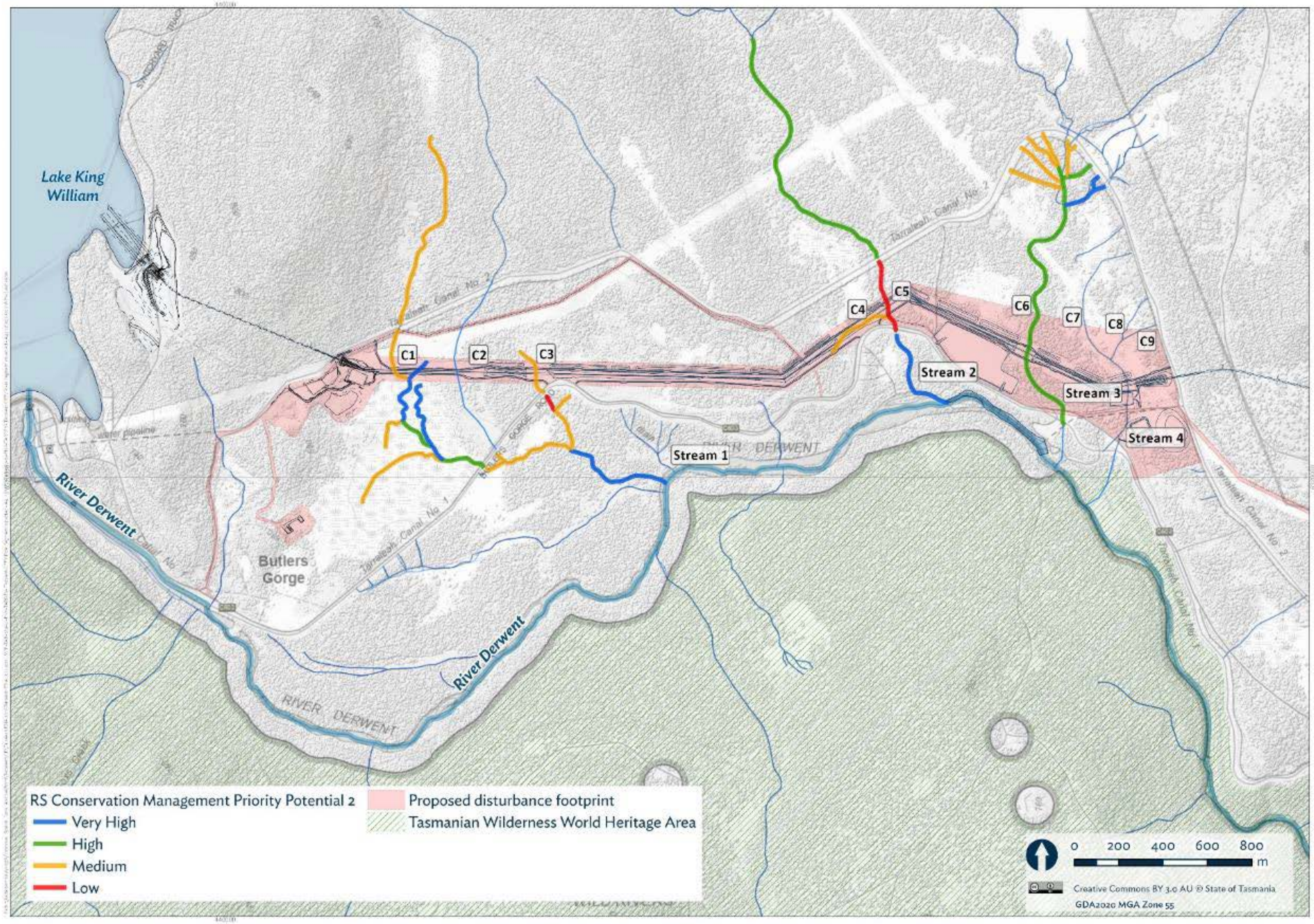


Figure G.1: CFEV mapping of stream segments for CMMP2 for Streams 1 - 4

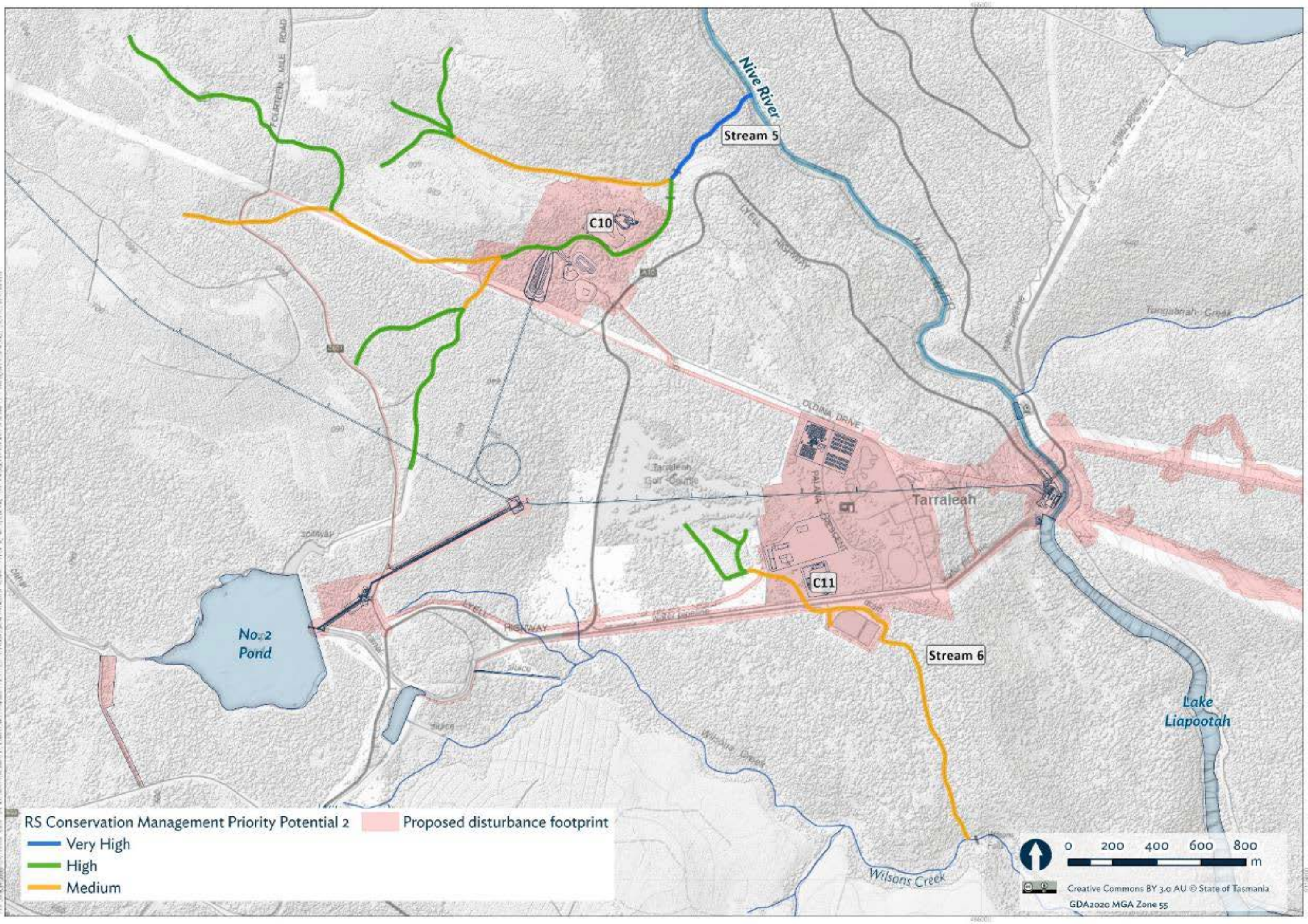


Figure G.2: CFEV mapping of stream segments for CMMP2 for Streams 5 – 6