Appendix G
Water quality risk assessment

Water Quality Risk Assessment

Borumba PHES Project Exploratory Works

Prepared for: Queensland Hydro
8 September 2025
Client Reference No. BR-FW-NON-EMG-RPT-00025.1

SMEC INTERNAL REF. 30034159

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Executive Summary

This report presents an updated water quality risk assessment to support Queensland Hydro's (QH) preliminary documentation (PD) for exploratory works under the *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act) (Commonwealth) for the Borumba Pumped Hydro Energy Storage (Borumba PHES) Project. The assessment addresses amendments to exploratory works, including public submissions on the draft PD, and aligns with the risk assessment guideline of the Department of Climate Change, Energy, the Environment, and Water (DCCEEW). The general design associated with construction of project components (Project Footprint) encompasses the work areas of Borumba Dam, Kingaham Creek, Walkers Top, and Borgan, where activities such as clearing, tunnelling, geotechnical investigations, and water extraction were evaluated for their potential impacts on water quality.

The assessment identifies both potential impacts to water quality values. Key impacts include sedimentation, nutrient mobilisation, contamination from construction and operational activities, water extraction and tunnel dewatering. A risk assessment was conducted to evaluate the likelihood and consequence of each impact, both before and after implementation of management measures.

The assessment was based on the *Environmental Protection (Water) Policy 2009, Mary River Environmental Values and Water Quality Objectives, Basin No. 138, including all tributaries of the Mary River* (EPP WQOs) for moderately disturbed waters. Results indicated existing water quality issues with low dissolved oxygen and elevated nutrients across work areas, while dissolved metals and organics (i.e. hydrocarbons) were generally within water quality objective (WQO) ranges.

Groundwater quality assessment across the work areas highlighted some potential issues with any unmanaged interaction with surface water. Elevated suspended solids were common and exceedances in ammonia, total nitrogen, total phosphorus and organic nitrogen noted across all work areas. Some exceedances in dissolved metals from groundwater were noted across all work areas with nickel and arsenic elevated in the Kingaham Creek Work Area and Walkers Top Work Area, nickel, arsenic and zinc for the Borumba Dam Work Area and chromium and zinc elevated in the Borgan Work Area.

Management strategies are detailed within the Construction Environmental Management Plan (CEMP) for the exploratory works and include a number of management sub-plans that detail effective measures to avoid, reduce and manage impacts.

The report concludes that with these measures in place, most risks are reduced to low residual levels of risk. However, despite a reduced likelihood of risk with management measures in place, several impacts retain a medium residual risk due to their potential consequences. These include:

- Water quality impacts to receiving environments from sedimentation and nutrient release.
- Changes to receiving water quality via contamination from operation-associated spoil stockpiles.

To manage the risk of these potential impacts, corrective actions as per the management sub-plan under the Exploratory Works CEMP are to be utilised.

1. Introduction

QH is the proponent of the Borumba PHES Project. This Water Quality Risk Assessment evaluates the potential water quality risks associated with the exploratory works action under the EPBC Act, referral 2023/09646. The draft PD was released for public comment in February 2025. This report presents a new assessment of water quality risks based on the current scope of exploratory works. It replaces and updates the assessment completed for the draft PD (BOR-QHY-RPT-EXL-00002) by incorporating the latest design, considering any changes to the works, and addressing public feedback received on the draft PD. The Project Footprint is identified in Figure 1–1.

1.1 Works Areas

The Project Footprint for the assessment involves the area of influence from the Borumba PHES Project exploratory works activities. Exploratory works include surface geotechnical investigations (e.g. boreholes and test pitting), geotechnical excavation works to reach the location of the proposed underground cavern, and a range of temporary supporting works. These works will occur within the Project Footprint, which is wholly contained within the boundary within which Project components can be micro-sited (Project Area) and spans four (4) discrete work areas associated with major and minor waterways in the Upper Mary River sub-basin of the Mary Basin:

- Area 1 – Borumba Dam: Within Yabba Creek, a stream order 6 watercourse with permanent flow maintained by releases from Lake Borumba, located approximately 450 m downstream of the dam wall
- Area 2 – Kingaham Creek: A stream order 5 tributary entering Lake Borumba at Yabba Creek, with deeper pools, vegetated banks, and several natural barriers
- Area 3 – Walkers Top: Contains a stream order 2 tributary (locally known as Cedar Creek) with cascades, waterfalls, and underground flow sections, which discharges into Lake Borumba and ultimately Yabba Creek
- Area 4 – Borgan: Intersects Sandy Creek, a stream order 5 tributary of Yabba Creek located upstream of Lake Borumba, with a mixed bedload, vegetated bars, and good instream and riparian vegetation.

The works areas are identified in Figure 1–1.

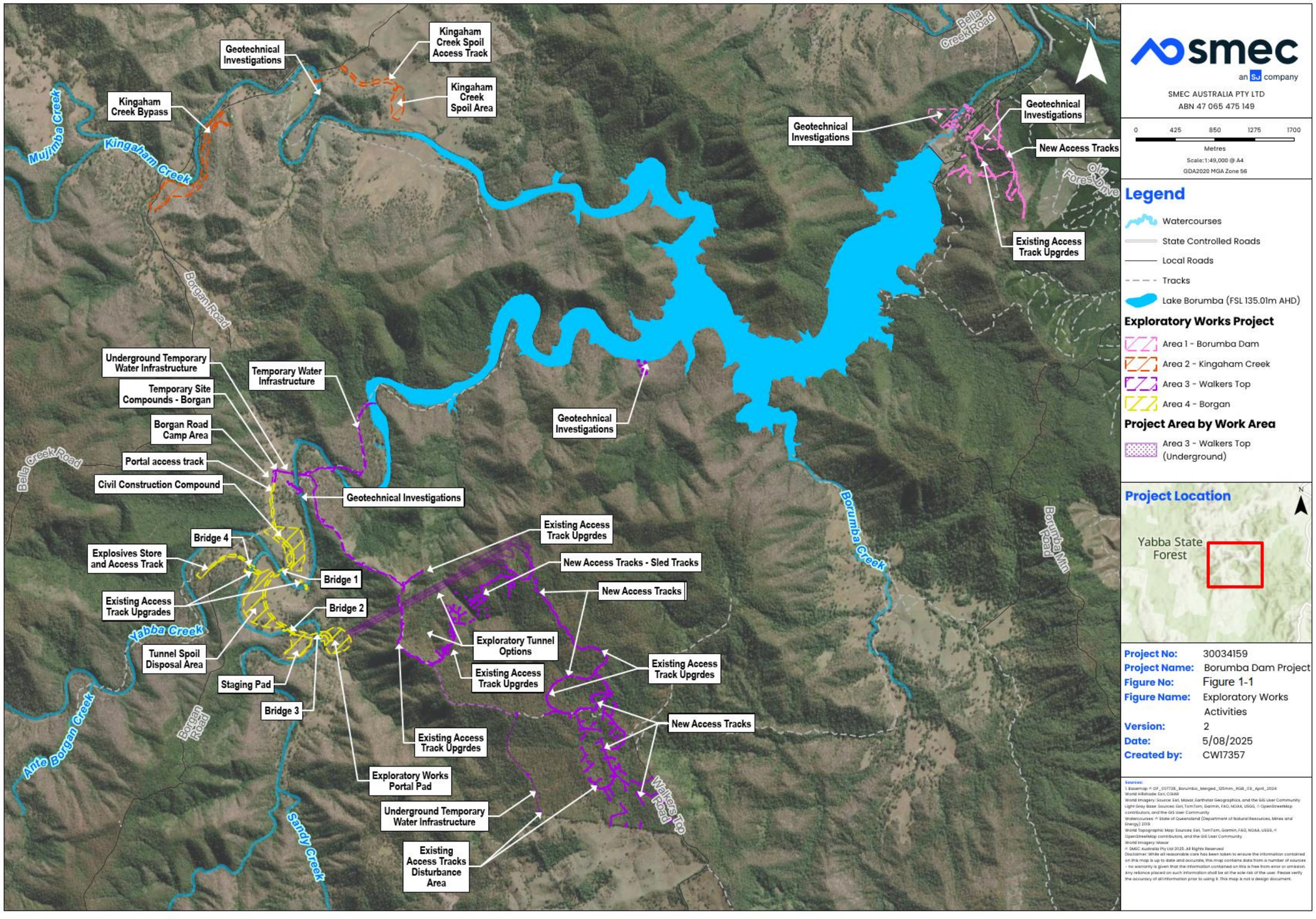

Figure 1–1: Exploratory works activities

1.2 Method of Assessment

This water quality risk assessment supports the current EPBC referral PD and addresses the risks of exploratory works to water quality values.

The structure of the assessment accords with *Section 13.12 – Potential Environmental Impacts and Risks* and *Section 4 – Evaluating Risk* of the *Environmental Management Plan Guidelines* (DCCEEW, 2024). The assessment consolidates all available information on avoidance and management measures proposed in the referral and draft PD, as well as refinements informed by updates to the Exploratory Works design and public comment on the draft PD. Project-related studies undertaken to date provide substantial information on local water and sediment quality and the existing (non-project) impacts on water quality.

An evaluation of potential risks was conducted using the DCCEEW risk assessment methodology. For each potential impact, a risk score was determined by multiplying the likelihood and consequence ratings, using the 5 × 5 risk matrix. This process generates risk qualificaton within the following risk rating categories :

- Low
- Medium
- High
- Severe.

The definitions of likelihood, consequence and risk ratings, along with the risk matrix, are provided in Appendix A.

1.3 Relevant Legislation and Documents

The following documents and legislation have been considered in this risk assessment:

Federal (Commonwealth) Legislation:

- EPBC Act.

Queensland State Legislation:

- *Environmental Protection Act 1994* (EP Act)
- *Environmental Protection Regulation 2019*
- *Water Act 2000* (Water Act)
- *Fisheries Act 1994.*

Guidelines and policies:

- *Australian and New Zealand Guidelines for Fresh and Marine Water Quality* (ANZG, 2018), Australian and New Zealand Governments and Australian state and territory governments, Canberra ACT, Australia
- *Mary River Environmental Values and Water Quality Objectives, Basin No. 138, including all tributaries of the Mary River.* Prepared under the *Environmental Protection (Water) Policy 2009* framework, Department of Environment and Resource Management, Brisbane, QLD
- *Reef discharge standards for industrial activities* (EP Act Guideline)
- *Wastewater release to Queensland waters* (EP Act Guideline)
- *Application requirements for activities with impacts to water* (EP Act Guideline).

Previous investigations and supporting documents:

- AGE (2024) Borumba PHES – EIS Groundwater Assessment.
- DCCEEW (2024) Environmental management plan guidelines.
- Ecology Management (2024) Water quality risk assessment related to Borumba Pumped Hydro Exploratory Works Preliminary Documentation. Technical memorandum prepared for QH.

- GHD (2025) Kingaham Creek Bypass - Revised Drainage Concept/Cut-off drain – Version 2. Technical memorandum prepared for QH.
- Hydrobiology (2022a) Borumba Dam Pumped Hydro Project - Detailed Analytical Report, Water and Sediment Quality Assessment.
- Hydrobiology (2022b) Aquatic Ecology – Borumba Pumped Hydro Project. Report prepared for QH.
- Hydrobiology (2024) Summary of results concerning fish passage in the proposed upper reservoir. Technical memorandum prepared for QH.
- SMEC. (2025a). Camp Area – Site Investigation Report. Technical memorandum prepared for QH.
- SMEC. (2025b). Laydown / Car Park Area and Civil Construction Compound – Contaminated land assessment. Technical memorandum prepared for QH.

2. Project Activities

This section provides a description of all exploratory works activities incorporated in this updated Water Quality Risk Assessment. The activities account for design updates and refinements made and further environmental information gained since previous assessments. An overview of exploratory activities is presented in Figure 1–1.

In order to differentiate activities, the activities have been grouped into phase of works as:

- Construction – required to implement operational activities for exploratory works
- Operation – required to conduct or direct operational activities.

A detailed description of each activity is provided in Section 4.2.

2.1 Construction

Some activities are considered general in nature, applying across multiple sites rather than being limited to a single work area. These include:

- Vegetation clearing and grubbing to establish compounds, laydown areas, fuel storage facilities, site offices, access tracks, and temporary infrastructure.
- Construction and removal of temporary access tracks and culvert crossings.
- Water extraction for investigation activities (via existing offtakes).
- Site wide environmental management measures, including erosion and sediment control, water treatment and discharge management, and spoil handling protocols.

The following work areas separate the activities based on the specific work areas.

Borumba Dam

- Localised access track establishment and upgrades, including vegetation clearing and grubbing.

Kingaham Creek

- Construction of Kingaham Creek Bypass including vegetation clearing and grubbing.
- Localised access track establishment and upgrades, including vegetation clearing and grubbing and watercourse crossings.
- Bypass spoil disposal.

Walkers Top

- Localised access track establishment and upgrades, including vegetation clearing and grubbing.
- Installation of temporary water infrastructure.

Borgan

- Vegetation clearing and grubbing for access, compounds, laydowns, and supporting infrastructure.
- Localised access track establishment and upgrades.
- Civil construction compound installation.
- Fuel storage facilities and site offices.

2.2 Operation

Some activities are considered general in nature, applying across multiple sites rather than being limited to a single work area. These include:

- Water extraction for investigation activities (via existing offtakes).
- Site wide environmental management measures, including erosion and sediment control, water treatment and discharge management, and spoil handling protocols.

Borumba Dam

- Geotechnical investigations
- Localised access track establishment and upgrades.

Kingaham Creek

- Geotechnical investigations
- Spoil disposal.

Walkers Top

- Geotechnical investigations
- Underground temporary water infrastructure (e.g. pipeline, tanks).

Borgan

- Geotechnical investigations
- Tunnel excavation and associated infrastructure (e.g. portal pads, staging pads, water treatment plant)
- Spoil disposal and stockpiling areas
- Fuel storage facilities and site offices.

3. Existing Environment

3.1 General Hydrology

3.1.1 Surface Waters

The Project is situated within the Upper Mary River sub-basin of the Mary Basin. The Mary Basin spans approximately 9,500 square kilometres (km^2) and is divided into 20 sub-catchments. Specifically, the Upper Mary River Basin covers around 2,700 km^2, with the catchment area upstream of Lake Borumba approximately 456 km^2.

Stream flow within the Mary Basin is highly seasonal, with significant variability from year to year, primarily driven by rainfall events. The wet season typically occurs between December and March. The basin's waterways range from smaller ephemeral creek systems to permanently flowing larger watercourses.

The Exploratory Works are located approximately 258 km from the tidal barrage located on the Mary River and 318 km from the mouth of the Mary River. The Mary River discharges into the Great Sandy Strait. The nearshore coastal environment comprises sensitive estuarine and freshwater ecosystems, with K'gari (formerly Fraser Island) a short distance offshore.

In summary, several sensitive water quality receptors are located downstream of the Project Footprint. These include:

- Great Sandy Strait Ramsar-listed wetland (~300 km downstream from Project)
- K'gari (Fraser Island) World Heritage Area (~325 km downstream from Project)
- Great Barrier Reef Marine Park, which is also world heritage-listed (~420 km downstream from Project).

These sensitive receptors are significant distances downstream of the Project and water quality impacts are therefore expected to relatively minor and effectively remediated given the distance downstream to the receptors.

Within the Project Area, there are several key watercourses and waterbodies of concern. These include:

- Lake Borumba
- Kingaham Creek
- Yabba Creek
- Cedar Creek
- Sandy Creek.

Kingaham Creek, specific to the immediate potential areas of influence from activities, maintains well vegetated, stable banks and overlays igneous geology, reducing the potential to supply sediment to downstream receiving environments. The watercourse is moderately incised with areas of deep pools (Hydrobiology 2022-2024).

Yabba Creek, specific to the immediate potential areas of influence from activities, maintains riparian vegetation with significant clearing on the alluvial flats around the area of influence with upper slopes typically well vegetated. The watercourse overlays geology comprised of a sedimentary/igneous geology indicating potential transfer of sediments to downstream sediments especially during high-flow events (Hydrobiology, 2022).

The upper slopes of the Project Footprint are characterised by stream order 1 or 2 drainage lines, typically defined by rocky, vegetated banks in moderately steep to steep gullies. Flow regimes within the proposed upper reservoir are principally comprised of short-term flow (likely ephemeral) of high velocity and relatively short-lived. Habitat assessments (conducted by Hydrobiology 2022-2024) indicate that Cedar Creek largely comprises of stepped and shallow pools separate by stretches of shallow cascades and riffles.

3.1.2 Groundwaters

An assessment by AGE (2024) has determined that the existing groundwater system relevant to the Project Area is complex, with variability in hydraulic conductivity reflecting the fractured and heterogeneous nature of the subsurface. Groundwater associated with surface waters is typically quaternary alluvium aquifers which are largely unconfined and highly permeable. These are largely narrow aquifer systems, located in proximity to main watercourses and tributaries with an average water level depth below ground level of 4.3 m (AGE, 2024).

Other groundwater units of interest include weathered and fractured rock aquifers and weathered rock aquifers with typical low or low to moderate permeability. These units form discontinuous aquifers with limited yields across the Project Footprint and range from an average water level depth below ground level of 3.0 m to 25.0 m. Typically, groundwater flow direction is expected to follow topography across the Project Area due to the unconfined nature of the aquifers and connectivity to other environments is likely to be hydraulically driven (AGE, 2024).

3.2 Water Quality

3.2.1 Surface Water Quality

3.2.1.1 General

Surface water quality in the Project Footprint is managed by the EPP WQOs. Under the policy environmental values and WQOs are scheduled across catchments and are used to identify management objectives for surface water against general water types and their respective state.

Under the corresponding waters within the policy, environmental values are the general qualities of water that make it suitable for supporting aquatic ecosystems and human water uses. Typically, the protection of aquatic ecosystem values denotes protection of other environmental values. These values are in place to protect water quality from alteration and are linked to existing conditions of water which define the management intent. These ecosystem conditions are:

- High ecological value (effectively unmodified) waters
- Slightly disturbed waters
- Moderately disturbed waters
- Highly disturbed waters.

Surface waters of relevance within the Project Area are considered moderately disturbed waters. Under the default EPP WQOs, moderately disturbed waters are defined as aquatic ecosystems that have been adversely affected by human activity to a small but measurable degree.

For moderately disturbed waters, the management intent is water quality is to be maintained, or improved where needed, to meet WQOs.

As such, while some degradation has occurred in these waters, the goal is to prevent further decline and restore water quality, where it falls short of the established objectives. These objectives are based on physical, chemical, and biological characteristics such as:

- Nutrient levels (e.g. nitrogen, phosphorus)
- Dissolved oxygen
- Turbidity
- Presence of toxicants
- Aquatic life health indicators.

A Surface Water Monitoring Program has been implemented to collect monthly background surface water quality data for the Borumba PHES Project. The location of the water quality sampling sites is shown in Appendix B as per the PD. Current surface water quality has been sourced from both sampling programs undertaken from between June 2022 to May 2025. Surface water quality has been differentiated into works areas

to obtain an understanding of existing conditions and the potential quantum of impact from project activities (refer to Appendix B for more information).

Assessment of surface water quality across waters associated with all work areas (refer to Appendix B for exact sampling site locations) identified minor issues with low dissolved oxygen. Elevated chlorophyll α and nutrient concentrations (primarily organic nitrogen and total phosphorus) were elevated within the Borumba Dam Work Area. Typically, dissolved metals or organics (hydrocarbons) adhered with WQOs across all work areas. As such, the summary data for surface water quality indicates general adherence to the current EPP WQOs.

A summary of existing water quality results is provided below, and the complete assessment is presented in Appendix B.

3.2.1.2 All work areas

Median values for benzene, toluene, ethylbenzene, xylenes, and naphthalene (BTEXN), total petroleum hydrocarbons (TPH), polycyclic aromatic hydrocarbons (PAH) and total recoverable hydrocarbons (TRH) parameters displayed:

- All parameters are all below limit of reporting (LOR) across all work areas.

Median values for all dissolved metals parameters displayed:

- No exceedances of ANZG default guideline values (DGV)s across all work areas.

3.2.1.3 Borumba Dam Work Area

Median values for in-situ monitoring parameters displayed that:

- Parameters are within default EPP WQOs.

Median values for general water quality parameters showed:

- Chlorophyll α, organic nitrogen and total phosphorus exceeded default EPP WQOs slightly within Borumba Dam Work Area.
- Total nitrogen was in exceedance of EPP WQOs within Borumba Dam Work Area.

3.2.1.4 Kingaham Creek Work Area

Median values for in-situ monitoring parameters displayed that:

- Dissolved oxygen for Kingaham Creek Work Area falls just under the minimum threshold of default EPP WQOs.
- All other parameters are within default EPP WQOs.

Median values for general water quality parameters showed:

- All parameters are within default EPP WQOs.

3.2.1.5 Walkers Top Work Area

Median values for in-situ monitoring parameters displayed that:

- Dissolved oxygen for Walkers Top Work Area falls just under the minimum threshold of default EPP WQOs.
- All other parameters are within default EPP WQOs.

Median values for general water quality parameters showed:

- All parameters are within default EPP WQOs.

3.2.1.6 Borgan Work Area

Median values for in-situ monitoring parameters displayed that:

- All parameters are within default EPP WQOs.

Median values for general water quality parameters showed:

- All parameters are within default EPP WQOs.

3.2.2 Sediment Quality

Current sediment quality has been sourced from sampling undertaken from between June 2022 to May 2025. The sediment quality has been differentiated into works areas to obtain an understanding of the existing condition and the potential quantum of impact from project activities.

Sediment water quality assessment across all work areas highlight some minor exceedances in dissolved metals (leachate-assessed) from sediments in the Borumba Dam Work Area and Kingaham Creek Work Area. Exceedances of median values were identified elevated aluminium, antimony, boron and nickel from Borumba Dam Work Area and chromium and nickel in Kingaham Creek Work Area.

A summary of existing sediment quality results is provided below, and the complete assessment is presented in Appendix B.

3.2.2.1 Borumba Dam

Median values for all dissolved metals parameters displayed:

- Exceedances of the ANZG DVGs in aluminium, antimony, boron and nickel in Borumba Dam Work Area.
- All other dissolved metals were within ANZG DVG thresholds.

All other sediment water quality parameters assessed, inclusive of TPH and TRH, were within acceptable ANZG DVGs thresholds or under LOR.

3.2.2.2 Kingaham Creek

Median values for all dissolved metals parameters displayed:

- Data within Kingaham Creek Work Area exceeded ANZG DGVs in chromium and nickel.
- All other dissolved metals were within ANZG DVG thresholds.

All other sediment water quality parameters assessed, inclusive of TPH and TRH, were within acceptable ANZG DVGs thresholds or under LOR.

3.2.2.3 Walkers Top

All median sediment water quality parameters assessed were within acceptable ANZG DVGs thresholds or under LOR.

3.2.2.4 Borgan

All median sediment water quality parameters assessed were within acceptable ANZG DVGs thresholds or under LOR.

3.2.3 Groundwater Quality

Current groundwater quality has been sourced from sampling undertaken from between December 2023 to June 2025. The groundwater quality has been differentiated into the works areas to obtain an understanding of the existing condition and the potential quantum of impact from project activities.

Groundwater quality assessment across all work areas highlighted some potential issues where interaction with surface water may occur. Elevated suspended solids were noted from all work areas, with exceedances in ammonia, total nitrogen, total phosphorus and organic nitrogen noted across all work areas. Some exceedances

in dissolved metals (leachate-assessed) from groundwater were noted across all work areas with nickel and arsenic elevated in the Kingaham Creek and Walkers Top Work Areas, nickel, arsenic and zinc for Borumba Dam Work Area and chromium and zinc elevated in the Borgan Work Area.

A summary of existing groundwater quality results is provided below, and the complete assessment is presented in Appendix B.

3.2.3.1 All work areas

Median values for physical parameter monitoring results showed:

- Exceedance of suspended solids default EPP WQOs across all work areas.
- All other values for parameters within acceptable threshold range.

Median values for all nutrient monitoring results showed:

- Ammonia, total nitrogen, total phosphorus, organic nitrogen exceeded all default EPP WQOs across all work areas. Walkers Top Work Area has no total phosphorus data available.

3.2.3.2 Borumba Dam

Median values for all dissolved metals parameters displayed:

- Exceedance of ANZG DGVs for chromium, copper, nickel, arsenic and zinc levels.
- The groundwater is considered to be hard (i.e. high concentrations of calcium carbonate), and as such, any metal toxicity guideline exceedances are considered conservative and unlikely to result in impact.

Borumba Dam Work Area had no data available for BTEXN, TPH, PAH and TRH.

3.2.3.3 Kingaham Creek

Median values for all dissolved metals parameters displayed:

- Exceedance of ANZG DGVs for chromium, nickel, arsenic and zinc
- The groundwater is considered to be hard (i.e. high concentrations of calcium carbonate), and as such, any metal toxicity guideline exceedances are considered conservative and unlikely to result in impact.

Median values for all BTEXN, PAH, TPH, and TRH and parameters displayed:

- BTEX and PAH all below LOR.
- Temporary elevated concentrations of TPH and TRH were recorded within the Kingaham Creek Work Area across the monitoring period.

3.2.3.4 Walkers Top

Median values for all dissolved metals parameters displayed:

- Exceedance of ANZG DGVs for chromium, nickel, arsenic and zinc were in exceedance of ANZG DGVs.
- The groundwater is considered to be hard (i.e. high concentrations of calcium carbonate), and as such, any metal toxicity guideline exceedances are considered conservative and unlikely to result in impact.

Median values for all BTEXN, PAH, TPH, and TRH and parameters displayed:

- BTEX and PAH all below LOR.
- Temporary elevated concentrations of TPH and TRH were recorded within the Walkers Top Work Area across the monitoring period.

3.2.3.5 Borgan

Median values for all dissolved metals parameters displayed:

- Exceedance of ANZG DGVs for chromium and zinc levels.
- The groundwater is considered to be hard (i.e. high concentrations of calcium carbonate), and as such, any metal toxicity guideline exceedances are considered conservative and unlikely to result in impact.

Median values for all BTEXN, PAH, TPH, and TRH and parameters displayed:

- Parameters all below LOR.

3.2.4 Legacy Contamination Sites

Legacy contamination sites have been identified within the Project Area and are located within the following work areas:

- Borumba Dam
- Walkers Top
- Borgan.

These areas are currently listed on the Environmental Management Register for Queensland denoting potential contamination:

- Lot 3LX2754 – spray race, pastoral agriculture (notified for mineral processing)
- Lot 135FTY1911 – petroleum product or oil storage and waste storage, treatment or disposal
- Lot 1723L37994 – livestock dip, spray race, pastoral agriculture.

Most of the Project footprint within the Borgan Work Area (Lot 3LX2754) has been assessed, with site contamination investigations confirming no evidence of contamination in tested locations (SMEC, 2025a, 2025b). Works in this area are located away from known sources of contamination, which are generally discrete and easily identifiable, and have been avoided during design.

A livestock dip has been confirmed on Lot 16 LX1925 (not listed on the EMR). Preliminary investigations undertaken at this location did not identify contaminants exceeding adopted assessment criteria.

Identified contamination sources are largely associated with historical pastoral activities, which are typically highly localised, and the risk of cross-contamination with spoil is therefore considered low. This contamination occurs within a broader catchment that generally has good water quality due to extensive forested land. However, historical and current land uses, including grazing, some dryland cropping upstream of Lake Borumba, irrigated cropping and intensive agriculture downstream, forestry (native and introduced pine plantations), and urbanisation have contributed to elevated nutrient levels and some metals in the past (SKM, 2007, EM, 2023).

Ongoing contaminated land assessments (Aurecon, 2024, SMEC, 2025a, 2025b) confirm that these sources are recognisable and avoidable. Should contaminated spoil be encountered during exploratory works, management measures such as the separation of contaminated and uncontaminated spoil will be implemented as standard practice.

4. Potential Impacts

Potential impacts have been identified as those that may occur pre-mitigation. Design measures have been undertaken to reduce impact through avoidance. While design measures have reduced the risk, potential impacts remain as 'pre-mitigated impacts' and are then assessed against management measures to identify risk as 'post-mitigated (residual) impacts'.

4.1 Extent of Impacts

Due to the nature of activities associated with exploratory works, the area of influence from any potential water quality impact would be limited to the immediate area around project activities and respective downstream receiving environments. For the majority of activities, this downstream receiving environment extends to below Lake Borumba, to the confluence of Yabba Creek and Bella Creek.

Noting this, sensitive receptors are noted at the downstream extent of the Mary River basin. Water quality impacts are expected to relatively minor and effectively remediated with distance to these sensitive receptors.

4.2 Activities

4.2.1 Clearing and Grubbing

Vegetation clearing has been refined to be as minimal as possible to complete the activity. All vegetation clearing associated with compounds, laydown areas, fuel storage facilities, and offices will be managed in accordance with the same footprint demarcation and sequential clearing.

Vegetation clearing and grubbing has the capacity to result in mobilisation of sediment into nearby drainage lines/receiving waters. As such, it has the capacity to temporarily reduce surface water quality in localised environments and result in changes, especially in combination with existing disturbances in downstream environments.

Vegetation clearing will occur in the following disparate, localised work areas across the Project Footprint to support exploratory works activities:

- Geotechnical investigations – Borumba Dam, Kingaham Creek, Walkers Top, Borgan
- Spoil disposal area – Kingaham Creek, Walkers Top
- Site access – Kingaham Creek, Borumba Dam, Walkers Top, Borgan
- Temporary water infrastructure – Walkers Top
- Construction compounds and associated laydown areas – Borgan, Walkers Top
- Exploratory tunnel and supporting infrastructure – Walkers Top, Borgan
- Fuel storage facilities and site offices – within compound and laydown footprints at Borgan and Walkers Top.

4.2.2 Bulk Earthworks

Bulk earthworks, of varying quantities, will occur in some areas that have undergone clearing and grubbing. Bulk earthworks will be kept to a minimum to complete required design footprints. The earthworks may include ground preparation, levelling works (including cut and fill activities) and to facilitate levelling/pad construction accommodate the movement of spoil from source location to spoil management areas.

The bulk earthworks have the potential for generate dust emissions during the activity and create new sediment sources to receiving environments, where inadequate erosion and sediment control management measures are utilised.

4.2.3 Tracks and Watercourse Crossings

The draft PD contained the provision of bed level crossings at Yabba Creek and Sandy Creek to upgrade the existing access tracks. The design included a single lane (7 m wide) formed by placing diameter 50 - 100 millimetre (mm) rock on the watercourse bed. Due to the proposed traffic movements and potential for water quality impacts downstream of crossings, temporary culvert crossings will be installed near the proposed temporary bridge locations while the bridges are constructed. These will then be replaced with concrete bed level crossings once the bridges are complete.

Where a bridge is constructed, the associated temporary culvert will be removed and replaced with an improved concrete bed-level crossing that are compliant with the *Department of Primary Industries* (formerly *Department of Agriculture and Fisheries* (DAF)*) Accepted development requirements for operational work that is constructing or raising waterway barrier works* (DAF 2018) or authorised under a Waterway Barrier Works approval.

This activity is expected to result in the following outcomes:

- Limit in-stream activities to construction and removal only, with minimal in-stream maintenance required.
- No ongoing risk of mobilising sediment to downstream environs from the action of wheels on watercourse substrate.
- Significantly reduced probability of material from the vehicles ending up in the water column.

Construction of watercourse crossings have the potential to result in temporary impacts during construction activities. These include the disturbance of both terrestrial and aquatic habitats through vegetation clearing/grubbing and impacts to watercourse bed and banks, sediment runoff, accidental spills, and changes in water flow can degrade water quality, which can be exacerbated by hydrological changes due to requirements for bank works.

4.2.4 Tunnelling and Tunnel Dewatering

Dewatering has the potential to result in impacts to receiving environments, where groundwater is discharged to surface waters.

Predictions from the previous numerical model (AGE, 2022) estimate groundwater inflows in the range of 125 - 425 m^3/day/km of tunnel progression. An analytical model provides a broader predicted range of 55 - 1,072 m^3/day/km, with a mean value of approximately 500 m^3/day/km.

Groundwater inflow management measures will be implemented to limit inflows to approximately 2 litres(L)/second(s)/km. This management threshold is not based on modelled predictions but reflects:

- The potential for tunnel drainage to affect the groundwater table and environmental receptors.
- The technical feasibility and economic considerations associated with reducing inflows further through post-grouting.
- Constraints associated with managing excess water volumes.

Infrastructure will be established to reduce and manage this groundwater ingress into exploratory tunnels and site runoff, enabling the collection, distribution, and treatment of water. Water management infrastructure will be located at the portal pad and staging pad, with initial collection from tunnel excavation directed to a basin at the portal pad. From there, water will be transferred to a treatment plant designed to meet reuse or discharge standards. Discharge of any water to the environment or for reuse on site is to be managed through an approved procedure as determined by QH and in accordance with relevant State approvals (refer to Section 5.5).

The treatment plant, potentially incorporating reverse osmosis technology, will have a capacity of approximately 100 L/s to accommodate typical inflow fluctuations and support the Project's commitment to minimising discharge through maximised reuse. If the ingress of water into the tunnel exceeds the consumption of water, then excess water will be sent from the temporary water storage pond to the water storage tanks at the staging pad. Where water ingress into the tunnels exceeds the capacity of the storage tanks (e.g. in a large rainfall event), alternative disposal methods will be utilised (e.g. release to the environment, trucking offsite, irrigation, additional storage at another location). All releases to the environment will occur with relevant approval conditions, including applicable water quality guidelines.

4.2.5 Geotechnical Investigations

Geotechnical investigations will predominantly be comprised of geotechnical drilling, test pitting and geophysics.

Geotechnical investigations will be undertaken on existing tracks or previously cleared areas, or areas specifically cleared for this purpose. Areas of vegetation will be avoided to the greatest extent possible. To establish a drill pad, ground surface levelling to achieve suitable gradients and construction of safety bunds may be required.

Geotechnical boreholes will be drilled with either track-mounted or truck-mounted drilling rigs. Drilling in soils will be conducted using an auger or rotary drill. Temporary casing may need to be installed progressively through the soil profile to prevent the bore from collapsing.

Drilling fluids (comprising water and biodegradable liquid polymers) are required during drilling to aid in flushing cuttings from the hole, lubricating/cooling the drill bit, and stabilising the borehole walls. Water for drilling will either be brought to the site in a truck or sourced from a nearby waterway in accordance with applicable permits. Drilling fluids will be recirculated within purpose-built mud tanks during the drilling, which will allow sediments and cuttings to settle out. Throughout the drilling process, vacuum trucks or similar will be used to remove dirty water and cuttings from the mud tanks as these muds are tested and treated as regulated waste. Sediment and erosion controls such as seedless hay bales, coir logs, jute meshing, or synthetic fencing will be installed downgradient of all drill pads (and on access tracks) where overland flow may directly enter a waterway.

After drilling is complete, boreholes will be left open until all required downhole geophysical surveys and in-situ testing have been undertaken. Boreholes will then be either filled with cement grout or have groundwater monitoring instruments installed. Monitoring instruments will be secured with either a lockable steel monument or a gatic cover. At the completion of drilling, all drilling pads will be stabilised and where applicable, rehabilitated.

Test pits will be established to investigate near surface geological conditions, particularly soil and rock composition, strength, weathering and excitability. The pits will typically be excavated to refusal or practical limit of the excavator and will be completed in sequence with backfilling to occur after test-pitting is complete.

Geophysical investigations will be conducted where challenging terrain where either safety or significant impact to the environment would be required to enable geotechnical investigation. The geophysical assessment utilises non-invasive probing and utilising either seismic or electromagnetic analysis to provide information about subsurface properties.

All three methods, geotechnical drilling, test-pitting and geophysical assessments, may be utilised for geotechnical investigations. The use of test-pitting and geophysical assessments is proposed to have minor environmental impact, due to the small spatial area required and the sequential nature of assessments. As such, the principal source of impact from geotechnical investigations is considered to be from the geotechnical drilling.

Typically, the impact from geotechnical drilling is considered to be highly localised, with potential impacts largely restricted to minor clearing associated with access tracks and leveling of a drilling rig pad. Contamination or water quality degradation is also considered a potential impact due to the cycling of fluids during the drilling process. Where these fluids are dispersed into receiving waters, impacts are typically localised and diluted with incorporation into significant hydrological flow or at the confluence of other significant hydrological inputs. Noting this, the potential for significant impacts associated with the drilling fluids may result in significant impacts to localised communities through smothering and changes to water quality and is especially apparent in low-flow or standing water bodies.

4.2.6 Spoil Disposal/Stockpile Areas

Spoil disposal areas and temporary stockpiling activities are expected to be conducted within similar areas and are principally defined by the grouped material. Materials to be used on site (e.g. for concrete batching) or reinstated to the original location are considered to be temporary stockpiles whereas waste materials (e.g. excavated tunnel rock) are considered to be spoil stockpiles.

Where temporary stockpiling is required (i.e. for raw materials), these are expected to be smaller than spoil stockpiling and are will typically follow the general placement process for spoil stockpiling described alongside general spoil stockpile structuring below.

Spoil stockpile construction will follow the following steps:

- Topsoil will be stripped, set aside for reuse in covering and regressing the finished stockpile.
- Geotextile liner will be placed to the floor of the stockpile.
- Stockpile material found to be free of contaminants will be combined into the main stockpile by dozer
- As material within the stockpile reaches the designed stockpile height, that area of the stockpile will be profiled and covered (e.g. topsoil and seeded with an approved grass seed) or chemically treated.

The potential impacts associated with the spoil stockpile areas are likely to be limited to the supply of increased sediment to nearby drainage features and watercourses. The potential impacts associated with the spoil stockpile areas are likely to be largely limited to the supply of increased sediment to nearby drainage features and watercourses. There is also the potential for unexpected contamination of surplus material to occur, with minor leachate of mobilised contaminants (i.e. metals, hydrocarbons or organics) to nearby drainage features and watercourses. As such, the spoil area is sized to allow segregation of testing for contamination reducing potential impact from leachate of contaminated soil mixed with uncontaminated spoil.

A spoil stockpile area is required for the Kingaham Creek bypass construction and has been located over 100 m from Kingaham Creek in a previously grazed and disturbed area. The spoil area has been sized in order to allow for the collection and separation of materials (i.e. topsoil for re-use) with an estimated at 95,000 m^2 of stockpiled material to be generated. General erosion and sediment control measures will be implemented to prevent supply of sediment to Kingaham Creek with additional vegetation of spoil battered slopes to occur to further reduce supply of sediment to areas outside of the spoil area.

The tunnel spoil disposal area and associated exploratory tunnel infrastructure (associated with the Borgan Work Area) were relocated during the design development phase, between the referral and the publication of the draft PD, to allow adequate space for water management. The final design maintains a 50 m buffer from Yabba and Sandy Creeks, is situated in an area previously disturbed by cattle grazing, and involves vegetation clearing similar to that proposed in the draft PD.

The tunnel spoil disposal area will be sized to allow for:

- Stockpiling of:
  - Topsoil stripped from the disposal area footprint and left on site for future rehabilitation of the area.
  - Approximately 395,000 m^3 of excavated waste rock material (500 mm minus material) expected to be generated from the exploratory tunnel drilling that cannot be reused onsite (e.g. in proposed rehabilitation works such as reprofiling).
- Water management (e.g. sediment basins, water treatment plant) and vehicle washdown and hardstand areas.

Spoil stockpiles have the potential to contaminate soils, which may lead to leachate containing existing or introduced contaminants. This may result in water quality degradation if the site-impacted water is released into receiving environments. Increased sedimentation and mobilisation of other contaminants may also occur if run-off from the stockpile reaches proximal receiving environments. In addition to the spoil disposal site, temporary material stockpiles (although minor in scale to the spoil stockpiles) are expected to be located proximal to the tunnel portal access area and only have highly localised impacts on water quality.

4.2.7 Water Extraction for Investigation Activities

The design of the temporary water infrastructure was refined following the relocation of supporting infrastructure required for the exploratory works, principally access tracks and a camp. Updates included shifting the water tank farm to the western side of Yabba Creek near Borgan Road and extending the pipeline along the path of existing infrastructure and existing and proposed access tracks. Current water extraction is proposed to be obtained via an existing offtake, with access, on Yabba Creek.

Water extraction for investigation activities will be undertaken under permits obtained by QH, which regulate the allowable volumes and conditions of take to reduce the potential for over-extraction and impacts to downstream users (including environmental water). Notwithstanding these controls, highly localised hydrological changes and associated downstream effects may occur. Such changes may reduce in-situ water quality through decreased flow volumes and reduced carrying capacity relative to existing biomass. Potential impacts are expected to diminish with increasing distance from the extraction point or during periods of higher streamflow.

4.3 Phase and Impacts

Site activities may result in potential impacts across all work areas or localised within specific works areas and can be direct or indirect.

Relevant project activities are identified in Section 4.2 and are associated with the following work areas:

- Borumba Dam
- Kingaham Creek
- Walkers Top
- Borgan.

Potential impacts are summarised in Section 4.3.1 and Section 4.3.2 and have been linked to the relevant impacting activities identified in Section 4.2.

4.3.1 Construction Phase

Potential construction phase impacts are linked principally to the following general activities:

- Vegetation clearing
- Tracks and watercourse crossing
- Mass earthworks for spoil disposal areas and general infrastructure.

Impacts that may occur as a result of project activities during the construction phase include:

- Disturbance of the bed, banks and riparian zone of waterways leading to water quality degradation, expressed principally as sedimentation load increases in downstream environments associated with disturbance.
- Increased turbidity and sedimentation alongside concurrent nutrient mobilisation from general earthwork runoff.
- Contamination from site-water runoff from disturbances in areas containing potentially contaminated soils.
- Contamination of downstream receiving environments from spills released from activity areas (i.e. hydrocarbons, construction compounds).
- Raw water extraction for construction water demands resulting in changes to the localised extraction area and downstream hydrology and hydraulics leading to water quality degradation.
- Water quality impacts to receiving environments from sedimentation and nutrient release from spoil stockpiling activities.
- Contamination of environments from spills releases from activity areas (i.e. hydrocarbons).

4.3.2 Operational Phase

Potential operation phase impacts are linked principally to the following general activities:

- Ongoing spoil pad operation
- Geotechnical investigations
- Tunnel dewatering and associated water management
- Contamination from inadequate storage of fuels and other operation-associated contaminants.

Impacts are considered to potentially result from project activities. For the operational phase activities, these are considered to be:

- Changes to receiving water quality via contamination from dewatering activities associated with operations (i.e. from lead and ammonia nitrate utilised for blasting operations).
- Changes to receiving water quality via contamination from operation-associated spoil stockpiles.
- Raw water extraction for operational water demands resulting in changes to localised extraction area and downstream hydrology and hydraulics leading to water quality degradation.

5. Management Measures

All construction activities will be carried out in accordance with the Project's Construction Environmental Management Plan (CEMP). Queensland Hydro has developed a CEMP including a:

- Erosion and Sediment Control Plan (ESCP) in line with International Erosion Control Association guidelines (2008)
- Spoil Management Plan
- Waste Management Plan
- Flora and Fauna Management Plan
- Water Management Plan (including groundwater and surface waters).

Water quality will be managed utilising the key principles outlined within the CEMP and specifically the ESCP. These key objectives include:

- Minimising the extent and duration of soil disturbance, including promptly stabilising disturbed soils, maximising protective groundcover with both natural and artificial material as necessary, and applying effective erosion control.
- Controlling water movement onto and within the site, including the management of discharge rates, flow velocities and discharge points, which may include the diversion and management of clean water away from the work site through effective drainage control.
- Maximising sediment retention on site through effective sediment control.
- Controlling impacts to prevent wind and water erosion, avoiding mobilisation of additional sediment and potential contaminants from spoil stockpiles, and applying segregation of spoil stockpiles to further reduce impacts to receiving environments through effective stockpile management.

5.1 General Measures

Standard measures to protect water values are identified within the CEMP for exploratory works. These include:

- Minimising the ground disturbing footprint wherever possible, including utilising existing access tracks.
- Clearing in accordance with established environmental management guidelines.
- Placing infrastructure and investigation sites away from known or possible sources of contamination (e.g. cattle dips).
- Implement erosion and sediment control measures tailored to each disturbance area with particular attention to soils with dispersive subsoils, including limiting disturbance, the use of gypsum, and covering of dispersive material.
- Sizing erosion and sediment control components and water recycling/reuse components with appropriate redundancy/buffer capacity.
- Maintaining the erosion and sediment control components via regular removal of water after storm events and de-silting.
- Maintaining a register that details sediment basin inspections, maintenance, discharge volumes and dates, flocculation details, discharge-water quality and volumes of sediment removed.
- Scheduling works near waterways to avoid the summer months where practicable and otherwise avoiding periods of forecast rain.

- Testing of material as it arrives in the spoil disposal areas, including from the exploratory tunnel, to determine any acid producing spoil or contaminants. If found, removing contaminated material from the site and disposing at an appropriate authorised site.
- Stabilising or progressively rehabilitating cleared areas near waterways as soon as possible.
- Isolating instream activity areas using erosion control measures such as silt curtains or floating booms before instream works begin.
- Implement best practice storage and handling of hazardous materials.
- Having spill clean-up kits readily available for any spilled fuel, oils or other contaminants.
- Maximising water recycling to minimise the draw on Lake Borumba and minimise the volume of wastewater to be disposed of.
- Progressive reinstatement/rehabilitation of disturbed areas, including backfilling of geotechnical investigation sites to the pre-drilling state as soon as they are completed.
- Locating works outside the 1% Annual Exceedance Probability flood extent.

5.2 Sediment Control

Current staging of erosion and sediment controls has been described in the proposed control measures for the Project. These are summarised as follows:

- Ensure site boundary limits and no-go areas are defined - install site barrier fencing (or alternative measures) where suitable. There is to be no disturbance of any kind to the vegetation outside the project footprint.
- Establish stabilised temporary site access/egress points, using rumble grids or similar.
- Continue using the existing track layout for site facilities (e.g. car parking, hardstand laydown) and avoid any further ground disturbance until sediment, drainage and erosion controls are in place. The principle of minimum disturbance to existing vegetation is to be implemented with no-go zones isolated with appropriate barriers and signage.
- Clean and dirty water or construction runoff to be separated.
- Where required, sediment basins and clean and dirty water drains are to be constructed immediately.
- Temporary ESCs to be installed before site disturbance, where reasonable and feasible.
- Runoff control from formations/tops of fills to sediment basins via one or a combination of fill shaping, diversion drains/banks, earth bunds along top edges of fill batters, discharging to batter drains etc.
- Install sediment fences, traps and sediment filter outlets (e.g. rock filter outlets or modular sediment traps). This includes installing stabilised outlet points.
- Install containment/diversion bunds (or equivalent) and stabilise by covering with fabric (or similar). In locations where there is a fence or wall present, the wall can be used in place of containment bunds if the wall is sealed underneath so water cannot flow through
- Disturbed areas should be progressively stabilised (e.g. final design treatments such as concrete or revegetation). Where disturbed areas are not being worked for long periods (>30 days), temporary stabilisation treatments are to be considered, especially during summer (December - February).
- If required, for internal access roads/tracks (e.g. truck access road), stabilise in accordance with engineering specifications (e.g. compacted earth with road base and spray seal finish). To improve and lengthen surface stability trafficable polymers are to be applied to the surfaces (e.g. vital bon-matt or similar).

- All surfaces excluding the immediate earthworks (cut/excavation works) are to be maintained as stabilised hardstand surfaces. In locations where hardstand surfaces are not formed, or to improve and lengthen surface stability, trafficable polymers are to be applied to surfaces (e.g. vital bon-matt or similar).
- Dewatering is to be conducted as per the requirements of standard dirty water treatment and discharge requirements.
- The tracking of mud/soil material onto local roads is to be monitored and controlled (e.g. shaker/rumble grids, manual wheel washing, street sweeper etc.).
- Dust to be controlled on site and along unsealed roads with controls such as water carts and/or limiting vehicle speeds.
- Temporary controls to be inspected regularly with maintenance/repairs undertaken as required, particularly after rain events.

5.3 Spoil Disposal/Stockpile Areas

Standard sediment control measures are identified above however key specific considerations (from the current CEMP) for spoil disposal and stockpiling areas are as follows:

- The 50 m buffer between the edge of stockpile areas and Yabba Creek, Sandy Creek and Kingaham Creek watercourses is to be maintained to reduce accidental releases of leachate to surface waters.
- Clean-water diversions will be used to reduce the incidence of overland flow during rain events, contacting spoil stockpiles and becoming impacted by the stockpiles.
- Sediment control devices will be utilised to ameliorate site-impacted waters, reducing the supply of sediment to receiving environments. Measures will include sediment fencing, coir logs, catch drains, and rock check dams and will be installed downslope to capture runoff.
- Stockpiling of separate materials is to occur, specifically different materials or potentially contaminated and uncontaminated materials.
- Stockpiles will be constructed and maintained as per standard drawings from the Soils and Construction Volume 1 (Landcom, 2004) and Volume 2D (DECC, 2008).
- Spoil stockpiles are to be stabilised to achieve a C-factor (ground cover) of 0.1 (e.g. equivalent to 60% grass cover) within 10 days of formation using a temporary soil stabiliser (e.g. vital Bon-Matt P74-VR1/Stonewall), geotextile, jute matting or equivalent.
- Topsoil stockpile should be constructed to no more than 3 m high wherever possible, noting that within the spoil disposal areas the design height is to 5 m with a maximum height of 7 m possible with appropriate management measures.
- Stockpiles should be battered down to a maximum slope of 2:1 wherever possible.

5.4 Watercourse Crossing Construction

Standard controls around construction associated with the waterway are included in the current CEMP for exploratory works. These include:

- Properly protecting and signposting as environmentally sensitive areas, all waterways in or adjacent to the Exploratory Works that are excluded from the work areas.
- Minimising riparian vegetation removal where practicable and restricting access to the waterways to the minimum amount of bank length required for the activity.
- Retaining stumps in riparian zones and aquatic habitats, where practicable, to reduce the potential for bank erosion.
- Carrying out any refuelling of plant and equipment, chemical storage and decanting at least 50 m away from aquatic habitats unless otherwise approved by QH.

5.5 Water Quality (General Monitoring)

The CEMP includes standard controls for treating captured water prior to discharge. These include:

- A re-use strategy focusing on utilisation of water for construction water demand.
- Treatment and movement off-site or active discharge to receiving waters if the following water quality discharge criteria is met:
  - 50 mg/L or less TSS
  - pH 6.5 to 8.5
  - No visible trace of oils or grease.

Noting this, if water is going to be used within the site for dust-suppression or construction purposes and will drain back into the sediment capture system, it may not require treatment. Water with a high mineral content containing nitrates from the use of emulsion explosives can be reused underground as service water.

Discharge of any water to the environment or for reuse on site is to be managed through an approved procedure as determined by QH and in accordance with relevant State approvals.

The objectives will allow for the progressive management of potential impacts described in this risk assessment and align with the current surface water monitoring program, relative to monitoring location and sampling frequency.

In addition to the surface water monitoring, a similar monitoring system is to be used, aligning with the current groundwater monitoring program, relative to bore location and sampling frequency.

5.6 Water Quality (Tunnel Water Discharge)

Groundwater discharge from the tunnel will be diverted to a dirty water containment dam and routinely tested for contaminants. The dirty water dam will be periodically cleaned, and sludge disposed in tunnel spoil disposal area. Discharge water will be diverted to a water treatment plant (Reverse Osmosis Plant or similar) for treatment before transfer to storage tanks for reuse or release to the environment. General measures will also be implemented to reduce impacts on receiving environments, these include:

- Stormwater infrastructure such as diversion (catch) drains and sediment traps to intercept overland flow, to minimise sediment-laden water generation.
- Bunding for protection against contamination from spills from storage containers.
- Tanks and lined water storage, for separating and holding clean and contaminated water.
- Inflow control measures including grouting of fractures and cementation of the tunnel.

- Water with a high mineral content containing nitrates from the use of emulsion explosives can be reused underground as service water.
- A suitably licenced waste collection contractor will be engaged to collect and remove general waste materials.

6. Residual Risk Assessment

The risk assessment (refer Table 6–1) has been conducted using the following process:

- Assessment of risk to existing water quality values (identified in Section 3) from potential impacts presented in Section 4.3 - before the implementation of standard and specific management measures.
- Identification of applicable management measures presented in Section 5.
- Re-evaluation of risk to identify residual risk to existing water quality values from potential impacts with the implementation of management measures.
- Identification of specific monitoring and corrective actions associated with potential impacts.

In order to identify areas where potential impacts may occur, the associated work area was identified.

Table 6–1: Residual risk assessment

Environmental value impacted	Key Potential Impact Pathways	Risk (prior to controls)			Residual Risk (post controls)			Additional Management Measures
		Likelihood	Consequence	Risk	Likelihood	Consequence	Risk	
Construction Phase								
Surface water quality	Areas of relevant activity: • All work areas. Disturbance of bed, banks and riparian zone of waterways leading to water quality degradation, expressed principally as increased sediment load in downstream environments associated with disturbance.	Likely	Moderate	Medium	Unlikely	Moderate	Low	Not considered due to Low Risk with implementation of standard activity practices and management measures.
	Areas of relevant activity: • All work areas. Increased turbidity and sedimentation alongside con-current nutrient mobilisation from general earthwork runoff.	Possible	Moderate	Medium	Possible	Minor	Low	Not considered due to Low Risk with implementation of standard activity practices and management measures.
	Areas of relevant activity: • All work areas. Contamination from site-water runoff from disturbances and stockpiling in areas containing potentially contaminated soils.	Unlikely	High	Medium	Rare	High	Low	Not considered due to Low Risk with implementation of standard activity practices and management measures.
	Areas of relevant activity: All work areas. Contamination of downstream receiving environments from spills releases from activity areas (e.g. hydrocarbons, construction compounds).	Unlikely	High	Medium	Rare	High	Low	Not considered due to Low Risk with implementation of standard activity practices and management measures.
	Areas of relevant activity: • Borumba Dam. • Walkers Top. Raw water extraction for construction water demands resulting in changes to localised extraction area and downstream hydrology and hydraulics leading to water quality degradation.	Unlikely	Minor	Low	Rare	Minor	Low	Not considered due to Low Risk with implementation of standard activity practices and management measures.
	Areas of relevant activity: • All work areas. Water quality impacts to receiving environments from sedimentation and nutrient release from spoil stockpiling activities.	Possible	High	Medium	Unlikely	High	Medium	Implementation of corrective actions where regional water quality objectives indicate potential impact from activity. Responses expected to include: • Rectification of management measures controlling site-impacted waters. • Pause and investigation of site discharge to receiving waters (i.e. sediment basins). • Pause and investigation of water source for construction water. • Investigations of upstream water sources to identify any non-site water quality issues.
	Areas of relevant activity: • Borumba Dam. • Walkers Top. • Borgan. Contamination of environments from spills releases from activity areas (i.e. hydrocarbons).	Unlikely	High	Medium	Rare	High	Low	Not considered due to Low Risk with implementation of standard activity practices and management measures.

Environmental value impacted	Key Potential Impact Pathways	Risk (prior to controls)			Residual Risk (post controls)			Additional Management Measures
		Likelihood	Consequence	Risk	Likelihood	Consequence	Risk	
Operation Phase								
Surface water quality	Areas of relevant activity: • Borumba Dam • Borgan. Changes to receiving water quality via contamination from dewatering activities associated with operations (i.e. from lead and ammonia nitrate utilised for blasting operations).	Likely	High	High	Unlikely	Moderate	Low	Not considered due to Low Risk with implementation of standard activity practices and management measures.
	Areas of relevant activity: • Borumba Dam • Kingaham Creek • Borgan. Changes to receiving water quality via contamination from operation-associated spoil stockpiles.	Possible	High	Medium	Unlikely	High	Medium	Implementation of corrective actions where regional water quality objectives indicate potential impact from activity. Responses expected to include: • Rectification of management measures controlling site-impacted waters. • Pause and investigation of site discharge to receiving waters (i.e. sediment basins). • Pause and investigation of water source for construction water. • Investigations of upstream water sources to identify any non-site water quality issues.
	Areas of relevant activity: • Borumba Dam. • Walkers Top. Raw water extraction for operational water demands resulting in changes to localised extraction area and downstream hydrology and hydraulics leading to water quality degradation.	Unlikely	Minor	Low	Unlikely	Minor	Low	Not considered due to Low Risk with implementation of standard activity practices and management measures.

7. Conclusion

This report presents an updated water quality risk assessment to support QH PD for exploratory works under the EPBC Act for the Borumba PHES Project. The assessment addresses amendments to exploratory works, incorporates public submissions on the PD, and aligns with DCCEEW risk assessment guidelines. The Project Footprint encompasses the work areas of Borumba Dam, Kingaham Creek, Walkers Top, and Borgan, where activities such as clearing, tunnelling, geotechnical investigations, and water extraction were evaluated for their potential impacts on water quality.

Existing environments related to water quality were assessed across the Project Footprint, differentiated by the works areas as follows:

- Borumba Dam
- Kingaham Creek
- Walkers Top
- Borgan.

The assessment was based on the EPP WQOs for moderately disturbed waters and assessed surface water, groundwater and sediments.

Potential impacts of activities were identified across the Project Area and within each local work area receiving environment. These impacts were categorised into construction and operation phases and assessed both before and after the implementation of management measures to identify the residual impacts on environmental values.

Overall, the assessment identified the following impacts had a medium residual risk of impact. These included:

- Water quality impacts to receiving environments from sedimentation and nutrient release.
- Changes to receiving water quality via contamination from operation-associated spoil stockpiles.

Notably, these impacts retained a medium residual risk of impact due to the consequence of potential impact occurring, even with the likelihood decreasing with the implementation of management measures. In order to reduce risk corrective actions as part of a management sub-plan under the exploratory works CEMP are identified as the primary management tool for managing the residual risk.

All other impacts were identified as a low residual risk of impact.

8. References

- AGE (2024) Borumba PHES – EIS Groundwater Assessment.
- Aurecon (2024). Borumba PHES Project – Environmental Study – Land Resources. Contaminated Land Technical Report. Project reference number P525308.
- DCCEEW (2024) Environmental management plan guidelines.
- GHD (2025) Kingaham Creek Bypass - Revised Drainage Concept/Cut-off drain – VERSION 2. Technical memorandum prepared for QH.
- Hydrobiology (2022a) Borumba Dam Pumped Hydro Project - Detailed Analytical Report, Water and Sediment Quality Assessment.
- Hydrobiology (2022b) Aquatic Ecology – Borumba Pumped Hydro Project. Report prepared for QH.
- Hydrobiology (2024) Summary of results concerning fish passage in the proposed upper reservoir. Technical memorandum prepared for QH.
- EM (2023). Water quality risk assessment related to Borumba Pumped Hydro Exploratory Works Preliminary Documentation. Brighton: Ecology Management Pty Ltd. Technical memorandum prepared for QH.
- SMEC (2025a). Camp Area – Site Investigation Report. Technical memorandum prepared for QH
- SMEC (2025b). Laydown / Car Park Area and Civil Construction Compound – Contaminated land assessment. Technical memorandum prepared for QH.

Appendix A

Risk Assessment Criteria

Table 8–1: Assessment ratings for likelihood of potential impacts

Rating	Likelihood of occurrence
Highly Likely	Is expected to occur
Likely	Will probably occur during the period of approval
Possible	Might occur during the period of approval
Unlikely	Could occur period of approval but considered unlikely or doubtful
Rare	May occur in exceptional circumstances

Table 8–2: Ratings used to assess the consequences of potential impacts

Rating	Consequence of occurrence
Critical	Severe widespread loss of environmental amenity and irrecoverable environmental damage.
Major	Major loss of environmental amenity and real danger of continuing.
High	Substantial instances of environmental damage that could be reversed with intensive efforts.
Moderate	Isolated but substantial instances of environmental damage that could be reversed with intensive efforts.
Minor	Minor incident of environmental damage that can be reversed.

Table 8–3: Environmental risk matrix, showing risk score and level of risk

		Likelihood				
		Rare	**Unlikely**	**Possible**	**Likely**	**Highly Likely**
Consequence	**Minor**	Low	Low	Low	Low	Medium
	Moderate	Low	Low	Medium	Medium	High
	High	Low	Medium	Medium	High	High
	Major	Medium	High	High	High	Severe
	Critical	High	High	Severe	Severe	Severe

Appendix B

Water Quality Summary Assessment

Technical Memorandum

Memo No.	Appendix B	**Date of Issue**	9 September 2025
Subject	Water Quality Risk Assessment – Existing Baseline Water Quality	**Discipline**	ENV
Project Title	Borumba PHES	**Project No.**	30032677
Document No.	Appendix B	**Revision**	1
Author	Benjamin Ansell, Environmental Scientist		
Reviewed by	James Bone	**Approved by**	Mellissa Zulpo
Prepared for	Queensland Hydro	**Attention to**	Nirvana Searle, Kylie McPherson
Attachments	NIL		

1. Purpose/Introduction

The purpose of this appendix is to present a factual summary and analysis of contemporary water quality monitoring data across all work areas associated with exploratory works for Queensland Hydro's (QH) Borumba Pumped Hydro Energy Storage (Borumba PHES) Project. This appendix was prepared to contribute to the broader risk assessment being undertaken for the exploratory works final preliminary documentation required to address the approval requirements the *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act) (Commonwealth).

The data assessed in this memorandum were collected by SMEC, Hydrobiology and AGE. The information presented in this memorandum provides a baseline understanding of surface water, groundwater and sediment quality for addressing risk to water quality from exploratory works activities.

2. Site details

The general design associated with construction of project components (Project Footprint) encompasses all work areas including:

- Borumba Dam
- Kingaham Creek
- Walkers Top
- Borgan.

Water, sediment and groundwater quality monitoring sites assessed within this appendix were allocated to each work area based on their proximal locations.

2.1 Data Sources and Assessment

The data was assessed based on spatial relevance to each work area, with a total of 26 surface water and sediment monitoring sites and 22 groundwater bores selected for assessment. All water quality data was collected in accordance with the *Queensland Department of Environment, Tourism, Science and Innovation: Monitoring and Sampling Manual* and laboratory samples analysed by a NATA accredited laboratory.

2.1.1 Surface Water Quality Monitoring

A Surface Water Monitoring Program has been implemented to collect monthly background water quality data for the Borumba PHES Project. Sampling locations, shown Figure 2–1, include sites upstream and downstream of potential impact areas in Yabba Creek (upstream and downstream of Lake Borumba), Kingaham Creek, Sandy Creek, and the Mary River. These sites were identified as their respective water type under the *Environmental Protection (Water) Policy 2009*, *Mary River Environmental Values and Water Quality Objectives, Basin No. 138, including all tributaries of the Mary River* (EPP WQOs).

The background data was used to inform existing environmental baseline values. Monitored parameters include physicochemical indicators (dissolved oxygen, pH, conductivity, turbidity), nutrients, total suspended solids, metals (total and dissolved), hydrocarbons, oil and grease, pesticides, and *E. coli*. Sampling locations were selected to align with previous assessments where possible and meet Queensland Water Quality Guidelines (QWQG) reference site criteria.

The data obtained through this structured program provide a reliable and representative baseline for delineating existing water quality conditions across the work areas.

2.1.2 Additional Data

A surface water sampling campaign was undertaken by Hydrobiology as part of the Environmental Impact Assessment for the Borumba PHES – Main Works. The locations are presented in Figure 2–1.

Hydrobiology has collected data monthly since February 2024, along with two early rounds conducted in June and November 2022. As this data is relevant for the water types associated with the project, these have been included in the assessment of existing water quality.

With respect to aquatic ecology and water/sediment quality, the field sampling sites were upstream, within and downstream of Lake Borumba, including multiple tributaries and the area of the proposed upper storage, and the Mary River above and below the junction with Yabba Creek (refer to Figure 2–1).

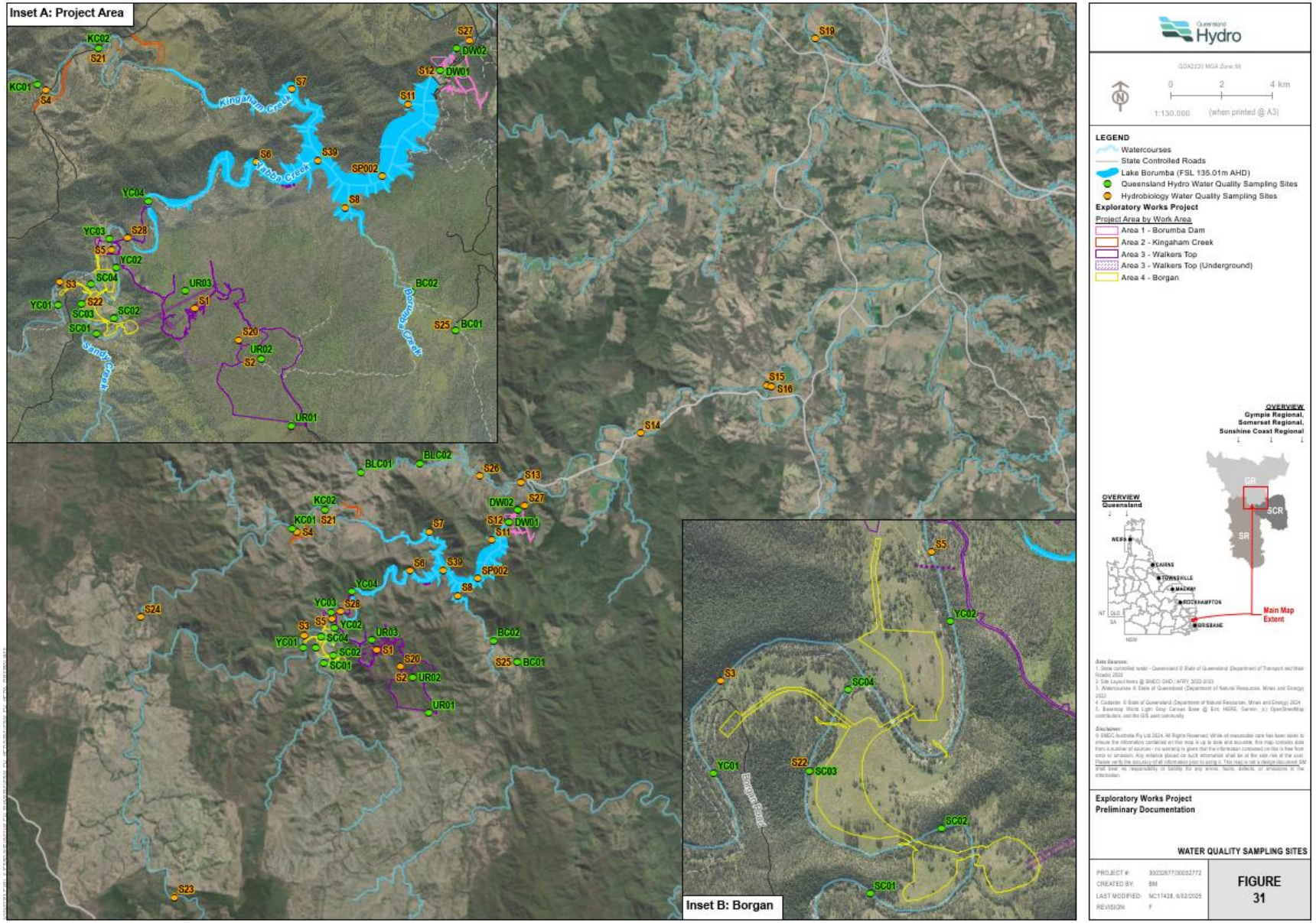

Figure 2–1: Surface water monitoring locations (Figure 31 from QH, 2024)

2.1.3 Sediment Quality

Sediment quality data has been sourced from the *Environmental Baseline Monitoring – Surface Water and Sediment Quality Monitoring Report (Rev A)*, prepared by GHD in 2023 for Queensland Hydro. This report documents the initial phase of sediment and surface water monitoring conducted to inform the environmental baseline for the Borumba PHES Project.

Sediment samples were collected in accordance with the same monitoring plan and at the same sites established for surface water quality assessment (refer to Figure 2–1). The selected sites covered representative upstream, downstream, and reservoir locations within the Yabba Creek catchment and Borumba Dam.

Sampling followed the Queensland Government's *Monitoring and Sampling Manual 2018: Environmental Protection (Water and Wetland Biodiversity) Policy 2019 (EPP (Water and Wetland))*, with specific procedures aligned to Section 14 – Sediment Sampling. Analytical parameters included a suite of metals and metalloids, particle size distribution, and total organic carbon, enabling assessment of both geochemical and physical characteristics of deposited material.

The sediment monitoring component was designed to be repeated seasonally, with results intended to inform temporal trend analysis and support the ecological risk assessments in conjunction with surface water quality data from the same locations.

2.1.4 Groundwater Quality

The groundwater data has been sourced from the Borumba Dam PHES Field Investigation Factual Report – v02.01, prepared by Australasian Groundwater and Environmental Consultants (AGE, 2022) on behalf of Queensland Hydro. The report documents site investigations undertaken to support the conceptualisation of hydrogeological conditions and to inform environmental approvals for the Borumba PHES Project.

As part of the investigation, 22 groundwater monitoring bores were drilled (refer to Figure 2–2constructed, and developed across the boundary within which project components can be micro-sited (Project Area) between December 2023 and July 2024. Drilling methodologies included auger, air rotary, wash boring, and diamond coring, selected based on geological conditions and safety considerations, particularly in serpentinite-bearing areas. Bore construction was completed in accordance with the Minimum Construction Requirements for Water Bores in Australia (NUDLC, 2020).

Water quality sampling was undertaken over a three (3) month monitoring period following bore development. Samples were collected for laboratory analysis of general field chemistry parameters. All sampling and handling procedures were consistent with standard environmental monitoring protocols.

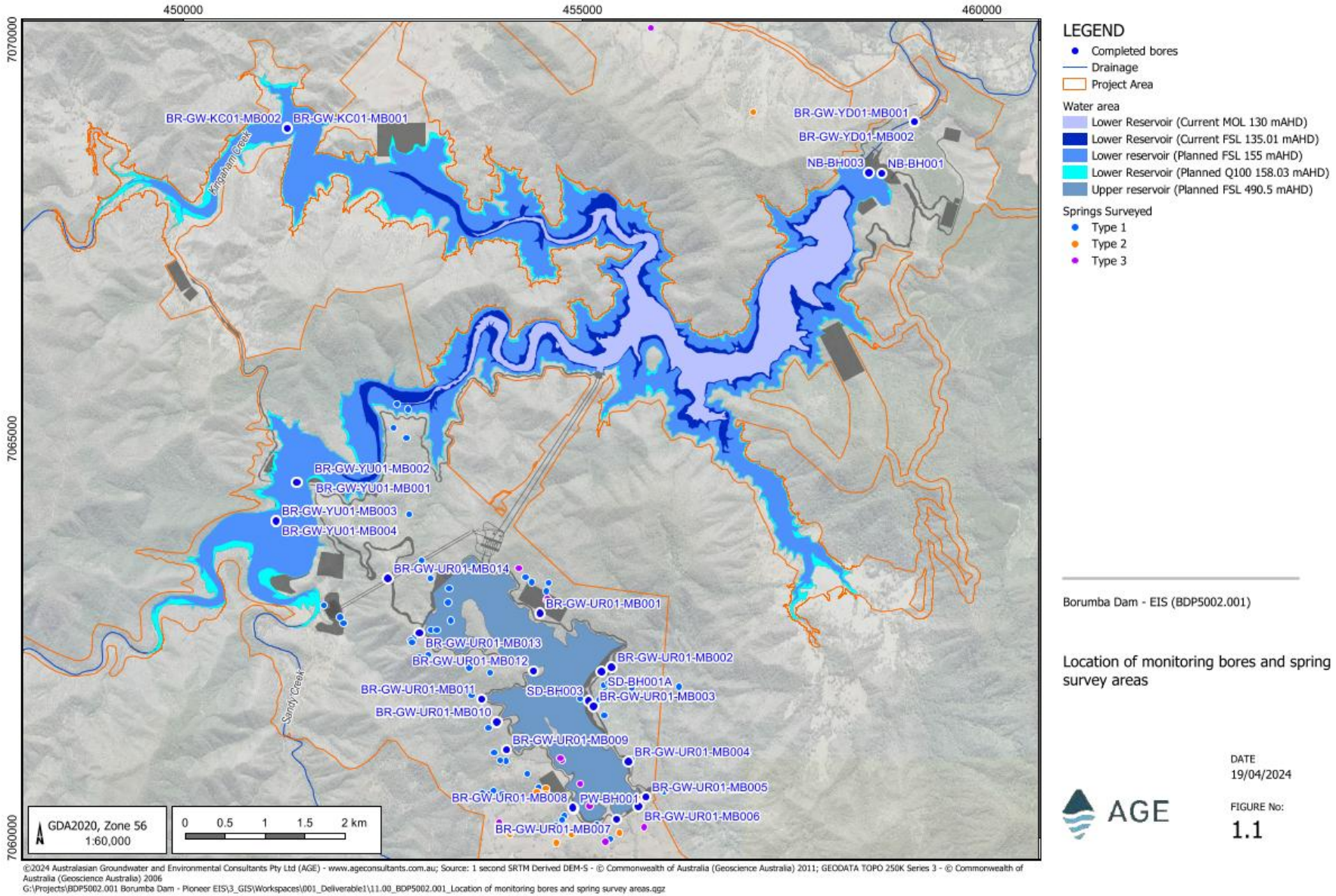

Figure 2–2: Groundwater Monitoring locations (Figure 1.1 from AGE, 2022)

3. Data Assessment

3.1 Surface water quality

3.1.1 Preliminary Assessment and Data Exclusions

Surface water quality data for this assessment has been compiled from two (2) monitoring programs. The two (2) datasets were combined to provide a more complete spatial and temporal representation of surface water conditions across work areas.

Sites located outside the designated work areas were excluded from this assessment to maintain alignment with the area of operational influence. Additionally, the number of sites within each work area varied, meaning data point density was not consistent across the Project footprint. However, the data available were considered fit for purpose for the background water quality assessment.

The following work areas were assessed:

- Borumba Dam
  - Downstream of Yabba Creek (DW01, DW02, S12, S27)
  - Borumba (S6, S7, S8, SP002, S39, S11).
- Kingaham Creek
  - Kingaham Creek (S4, S21, KC01, KC02)
- Walkers Top
  - Unnamed Creek – Downstream (UR01, UR02, S2, S20)
  - Unnamed Creek – Upstream (UR03, S1)
- Borgan
  - Sandy Creek (S22, SC01, SC02, SC03, SC04).

3.1.2 Temporal Coverage and Sampling Frequency

Comparability across the various work areas is limited by differences in sampling frequency, duration, and timing of data collection, however comparison was considered robust for preliminary analysis. Noting this, these factors influence the ability to draw reliable temporal inferences or detect hydrological responses to seasonal or episodic events. Key details of each dataset are outlined below:

Hydrobiology Data

- Two discrete sampling events: June 2022 and November 2022.
- Targeted early and late dry season conditions.
- Limited temporal resolution restricts the ability to identify seasonal trends or event-based variability.
- Not representative of extreme flow conditions or inter-annual variation.
- Provides initial baseline reference.

SMEC Data

- Fifteen monthly sampling events conducted between November 2023 and February 2025.
- Captures wet and dry season transitions.
- Suitable for characterising short-term seasonal variability and informing operational assessments.

3.1.3 Measurable Parameters

The following parameters were included:

- pH
- Electrical conductivity
- Turbidity
- Dissolved oxygen
- Total dissolved solids
- Total suspended solids
- Total hardness as $CaCO_3$
- Chlorophyll α
- Ammonia
- Total nitrogen
- Nitrate
- Nitrite
- Kjeldahl nitrogen total
- Organic nitrogen
- Nitrite + nitrate
- Total phosphorus
- Reactive phosphorus
- Dissolved organic carbon
- Filtered metals (aluminium, antimony, arsenic, boron, cadmium, cobalt, chromium (III+VI), copper, lead, manganese, mercury, nickel, zinc, lithium, iron, selenium, tin, uranium, vanadium)
- Hydrocarbons and organics: total petroleum hydrocarbons (TPH) (C10–C36), total recoverable hydrocarbons (TRH) (C6–C10), polycyclic aromatic hydrocarbons (PAHs), benzene, toluene, ethylbenzene, xylene (m & p), naphthalene (BTEXN)
- Microbiological: *E. coli*, thermotolerant coliforms
- Pesticides: glyphosate.

3.2 Groundwater Quality

3.2.1 Preliminary Assessment and Data Exclusions

Groundwater quality data for the Borumba PHES was collected via a purpose-drilled network of 22 monitoring bores constructed between September and December 2023. All groundwater data referenced in this memorandum is drawn from the *Borumba Dam PHES Field Investigation Factual Report – v02.01* (AGE, 2024). The monitoring program was designed to characterise baseline groundwater conditions and support hydrogeological conceptualisation within the Project Area.

The dataset is limited by the number of sampling rounds conducted post-bore development, as well as variations in lithology, hydraulic conditions, and construction details between bore locations. While bores were distributed across a range of geological units, sampling frequency was limited to a single round per bore during the baseline period, restricting the ability to assess temporal variability or recharge-related fluctuations. Automated loggers were deployed for continuous EC and water level measurement, but only discrete water quality sampling data are considered in this assessment.

No formal data normalisation or spatial interpolation has been undertaken.

3.2.2 Temporal Coverage and Sampling Frequency

- Sampling occurred between late 2023 and early 2024, following bore development
- Each bore was sampled once during the baseline period
- Temporal data resolution is insufficient to identify seasonal trends, event-based variation, or long-term groundwater chemistry changes.

3.3 Sediment Quality

3.3.1 Preliminary Assessment and Data Exclusions

Sediment quality data has been extracted from the *Environmental Baseline Monitoring – Surface Water and Sediment Quality Monitoring Report, Rev A* (GHD, 2023). Sediment sampling was undertaken at the same locations used for surface water quality monitoring, providing datasets located at the same sites to support integrated water quality assessment across the catchment.

Sediment data is limited by spatial coverage (site access and depositional environment suitability) and the nature of surficial sampling, which targets recently deposited material rather than deeper or historical sediment layers. All samples were collected from the top 0 - 2 centimetres of sediment, which reflects short-term depositional and water column influences. The dataset is suitable for baseline screening but may not represent broader sediment geochemistry or long-term accumulation patterns.

No data were excluded from this assessment. Parameters have been reviewed in their original form without transformation or normalisation.

3.3.2 Temporal Coverage and Sampling Frequency

- Sediment sampling was completed in conjunction with surface water quality monitoring events.
- Sampling occurred as part of a single field campaign under baseline (non-flood) flow conditions.
- Temporal coverage is currently limited to a single event and does not support seasonal or long-term comparison.
- Repeat sampling is planned under future phases to build a more robust temporal dataset.

4. Results

4.1 General normalisation

Summary statistics for each work area is detailed below under:

- Surface water quality - refer Section 4.2
- Sediment quality - refer Section 4.3
- Groundwater quality – refer Section 4.4.

4.2 Surface Water Quality

The water quality monitoring provided an overview of baseline conditions across each work area. Results below the reporting level (i.e. <10) were halved for summary statistics calculations, following the QWQG. As Hydrobiology data was only sampled from two (2) sampling events, the limit of reporting (LOR) level was retained to avoid introducing artificial precision and to transparently reflect the uncertainty associated with limited sampling frequency, in line with Australian and New Zealand Guidelines for Fresh & Marine Water Quality Guideline (ANZG) recommendations for data below detection limits.

4.2.1 Summary Statistics

Median values for *in-situ* monitoring parameters displayed that:

- Dissolved oxygen for Kingaham Creek and Walkers Top Work Areas falls just under the minimum threshold of default EPP (Water and Wetland) WQOs.
- All other parameters are within default EPP (Water and Wetland) WQOs.

Median values for general water quality parameters showed:

- Chlorophyll α, organic nitrogen and total phosphorus exceeded default EPP (Water and Wetland) WQOs slightly within Borumba Dam Work Area.
- Total nitrogen was in exceedance of EPP (Water and Wetland) WQOs both downstream of Borumba Dam (Yabba Creek) and within Borumba Dam. It is noted that downstream (Yabba Creek) this is still considered a part of the Borumba Dam Work Area.

Median values for all dissolved metals parameters displayed:

- No exceedances of ANZG default guideline values (DGV) across all work areas.

Median values for all BTEXN, TPH, and TRH and parameters displayed:

- BTEXN, PAH, TRH and TPH are all below LOR across all work areas.

4.3 Sediment Quality

Sediment quality assessed across all work areas was evaluated through analysis of the <2 mm sediment fraction and compared against the ANZG DGVs. These DGVs provide conservative screening thresholds to assess the potential for ecological impact. In line with guidance provided in Section 1.1.1 of the ANZG framework, comparisons were made only to the DGVs and not the GV-high values, as the latter are not intended to ensure ecosystem protection and are instead indicative of potential high-level toxicity. The focus of this report is on presenting a factual account of measured sediment quality and its alignment with the applicable DGVs.

4.3.1 Summary Statistics

Median values for all dissolved metals parameters displayed:

- Exceedances to ANZG DVGs in aluminium, antimony, boron and nickel in Borumba Dam Work Area. Nickel was in exceedance downstream of Borumba Dam (Yabba creek) which is also considered within the same work area.

- Data within Kingaham Creek Work Area exceeded ANZG DGVs in chromium and nickel.
- All other dissolved metals across all work areas were within ANZG DVG thresholds.

4.4 Groundwater Quality

Groundwater quality results were compared against relevant guideline values sourced from the relevant EPP (Water and Wetland) for general water quality indicators and from the ANZG for toxicants, using surface water default guideline values where appropriate.

The groundwater quality assessed across all work areas is characterised as hard, which significantly reduces the bioavailability and toxicity of certain metals. As such, any exceedances of metal-related DGVs have been classified as *conservative* and are considered unlikely to result in ecological impact. These comparisons provide a precautionary assessment framework, with the understanding that groundwater is not directly managed for aquatic ecosystem protection but may contribute to baseflow in connected surface water systems.

4.4.1 Summary Statistics

Median values for physical parameter monitoring results showed:

- Exceedance of suspended solids default EPP (Water and Wetland) default WQOs across all work areas.
- All other median values for parameters within acceptable range.

Median values for all nutrient monitoring results showed:

- Ammonia, total nitrogen, total phosphorus, organic nitrogen exceeded all EPP (Water and Wetland) default WQOs across all work areas where presented. Walkers Top has no total phosphorus data available whilst Borumba Dam had no available data on organic nitrogen to compare against default WQOs.

Median values for all dissolved metals parameters displayed:

- Universal exceedance of ANZG DGVs for chromium and zinc levels across all work sites.
- Nickel and arsenic were in exceedance of ANZG DGVs within Kingaham Creek and Borumba Dam Work Areas.
- Copper was also in exceedance of ANZG DGVs for Borumba Dam Work Area.
- Current water indicates as hard so metal water toxicity exceedances are labelled as ‘conservative’ and unlikely to cause impact.

Median values for all BTEXN, TPH, and TRH and parameters displayed:

- BTEX all below LOR across all work sites.
- Significant, but temporary increases in TPH and TRH within Walkers Top and Kingaham Creek across monitoring period.

5. References

- AGE (2022) Borumba Dam PHES Field Investigation Factual Report – v02.01
- AGE (2024) Borumba PHES – EIS Groundwater Assessment.
- ANZG (2018). Australian and New Zealand Guidelines for Fresh and Marine Water Quality, Australian and New Zealand Governments and Australian state and territory governments, Canberra ACT, Australia
- DERM (2010). Environmental Protection (Water) Policy 2009: Mary River environmental values and water quality objectives, Basin no. 138 including all tributaries of the Mary River
- GHD (2023) Environmental Baseline Monitoring – Surface Water and Sediment Quality Monitoring Report (Rev A)
- GHD (2025) Kingaham Creek Bypass - Revised Drainage Concept/Cut-off drain – VERSION 2. Technical memorandum prepared for Queensland Hydro.
- Hydrobiology (2022a) Borumba Dam Pumped Hydro Project - Detailed Analytical Report, Water and Sediment Quality Assessment.
- QH (2024) Borumba Pumped Hydro Energy Storage Project – Exploratory Works Preliminary Documentation

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