Ok Birim Tailings Storage Facility Project

Environmental and Social Impact Assessment

Appendix E

Aquatic ecology technical report

TETRA TECH COFFEY

OK TEDI MINING

Ok Birim Tailings Storage Facility Project ESIA: Baseline Aquatic Fauna Survey and Impact Assessment

June 2026

Tetra Tech Coffey

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	Click to enter a date.			

Basis of Report

This report has been prepared by SLR Consulting Australia (SLR) with all reasonable skill, care and diligence, and taking account of the timescale and resources allocated to it by agreement with Tetra Tech Coffey (the Client). Information reported herein is based on the interpretation of data collected, which has been accepted in good faith as being accurate and valid.

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Executive Summary

SLR Consulting has undertaken the Ok Birim Tailings Storage Facility (TSF) aquatic baseline survey as part of the project ESIA. The assessment supports Tetra Tech Coffey and Ok Tedi Mining Limited (OTML) in characterising existing environmental conditions and identifying potential impacts associated with the proposed TSF and the associated Ok Ma infrastructure corridor.

The TSF is intended to significantly reduce riverine disposal of tailings from 2030 onward, reducing downstream environmental and social impacts and accelerating recovery of the Ok Tedi/Fly River system by approximately two decades. Key project components include a ring-dyke TSF, an 87-km tailings pipeline, access roads, and associated infrastructure.

An initial baseline survey was undertaken in 2014/2015 as part of plans to design a TSF within the project area. The current report and surveys undertaken in 2025 build on the original surveys undertaken. Two aquatic baseline surveys were completed in August and November 2025 across 37 sites, including 14 reference and 23 potentially exposed locations, with 11 sites revisited from the 2014/15 baseline study. Assessments included water quality and sediment quality, habitat structure, aquatic macrophyte cover, macroinvertebrate assemblages, fish assemblages and tissue metal analysis in selected aquatic species.

The Ok Birim and Ok Ma catchments are characterised by intact, low-conductivity rainforest creek systems with high habitat diversity in tributaries and coarser, lower-complexity habitats in the main Ok Birim channel. Water quality was generally good, although localised exceedances of dissolved metals (Copper (dCu), Lead (dPb), Zinc (dZn), Cadmium (dCd), Arsenic (dAs)) occurred relative to ANZG (2018) guideline values. Sediment quality was similarly good, except at site OY01, where multiple metals exceeded guideline thresholds due to backwater deposition from the Ok Tedi.

A total of 44 freshwater fish species were recorded across the combined 2014/15 and 2025 datasets, with the Ok Birim main channel supporting the highest diversity and functioning as a critical refuge for species depleted in the Ok Tedi system. Species of conservation concern include:

- Fly River Rainbowfish (*Melanotaenia sexlineata*, Endangered),
- Swamp Gudgeon (*Oxyeleotris stagnicola*, Endangered),
- Kiunga Blue-eye (*Kiunga leucozona*, newly described, highly restricted),
- Ok Tedi Rainbowfish (*Melanotaenia oktediensis*, Critically Endangered) and
- Paskai's blue-eye (*Pseudomugil paskai*, only recently rediscovered, highly restricted, Critically Endangered).

Metal concentrations in fish tissues indicated:

- Copper (Cu) and lead (Pb) remained below human-health thresholds,
- Liver tissues consistently contained higher concentrations of Cd, Cu, Se and Zn and muscle samples, highlighting important tissue-specific differences for future assessments.

When realistic portion sizes (80g) were applied, all exceedances were substantially reduced, and current fish consumption poses low human-health risk.

Communities rely heavily on local creeks and springs for drinking water, washing, food preparation, sago processing, fishing, and transportation. Aquatic fauna (including fish, prawns, crayfish, and eels) are important dietary resources, with some also of cultural

significance. Significant deterioration in water quality or habitat accessibility may have social, cultural, and livelihood implications.

The proposed Ok Birim Tailings Storage Facility (TSF) and associated infrastructure corridor will result in significant localised adverse impacts, particularly during construction, while delivering major long-term regional benefits to the Ok Tedi–Fly River system through the diversion of tailings from direct riverine discharge.

Construction of the TSF will require extensive clearing within the Ok Yep headwaters, resulting in the permanent loss of spring-fed creeks, small watercourses and associated aquatic habitats. These habitats support high-value and restricted-distribution aquatic species, and their removal represents a major, irreversible local impact. Construction activities are also expected to generate elevated sediment loads and increased total suspended solids (TSS) in receiving waters, particularly the Ok Yep, leading to short- to long-term degradation of aquatic habitat and water quality of the receiving creeks.

During operation, the TSF is expected to permanently alter water quality in the Ok Yep catchment, with increases in TSS and levels of dissolved metals likely exceeding levels known to be acutely toxic, representing a negative impact for local aquatic fauna, including species of high conservation significance. Long-term protection of downstream ecosystems will depend on TSF stability, effective seepage and sediment management, and the continued removal and burial of pyrite to minimise acid and metal generation risks.

In contrast, diversion of tailings to the TSF will deliver substantial system-wide benefits to the Ok Tedi and Middle Fly River. An estimated 85–95% reduction in tailings-derived sediment inputs will significantly reduce sand and silt loading, lower riverbed aggradation in the Lower Ok Tedi and upper and middle Middle Fly and decrease TSS concentrations. These changes are expected to improve channel stability, water clarity, and aquatic habitat quality across the lower Ok Tedi and Middle Fly over decadal to longer timescales, representing a positive impact for aquatic ecology. Currently observed recovery in fish assemblages in the Middle Fly, due to a number of factors, including pyrite removal, reduced waste deposition rates, improved water quality and dredging should be further enhanced by tailings removal and associated benefits to water quality and bed aggradation.

The Ok Birim and Ok Ma systems are critical aquatic refugia for the Ok Tedi system, supporting fish species lost or in decline in the Ok Tedi and Middle Fly, and these systems will assist recolonisation following mine closure, provided they are protected from direct impacts. The amended TSF design largely avoids the Ok Birim main channel, which is considered a key positive outcome, but there is risk of impact to the Ok Ma.

The infrastructure corridor, including access roads and tailings pipeline crossings follows the alignment of the Ok Ma water course, and presents additional high-risk impact pathways. Construction and operation will increase sediment and potential contaminant runoff to the Ok Ma, while pipeline rupture events represent a low-probability but high-consequence risk with potential for severe and long-lasting ecological impacts. Effective design, monitoring, and contingency management will therefore be critical.

The Ok Yep (TSF), Ok Birim (infrastructure corridor) and Ok Ma (infrastructure corridor) systems support high-quality aquatic ecosystems with regionally important species and strong cultural value. Although baseline conditions are generally good, the assessment identifies several vulnerabilities, particularly the sensitivity of local water chemistry and the restricted distributions of threatened species.

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1.0 Introduction

1.1 Project Background

The Ok Birim Tailings Storage Facility (TSF) project is located in the remote northwestern corner of Western Province, south of the Central Cordillera Mountain range which runs east-west along the length of Papua New Guinea (PNG) (Figure 1). The tailings storage facility (TSF) is proposed approximately 1 km west of the confluence of the Ok Birim and Ok Tedi ("Ok" in the local Min language means river), and about 55 km south of the existing Ok Tedi Mine (90 km by road via the Kiunga-Tabubil Highway).

The Ok Tedi Mine at Mt Fubilan (Star Mountains) is an open-cut copper, gold and silver mine, currently owned by the PNG Government, and operated by Ok Tedi Mining Limited (OTML) since 1984. The mine lies approximately 5 km west of the Ok Tedi, a major tributary of the larger Fly River (Figure 1). For more than 40 years, the Ok Tedi Mine has practised riverine disposal of tailings and waste rock. Up until 2025, over 2 billion tonnes of mine-derived sediment have been added to the Ok Tedi/Fly River system.

With mine life now anticipated to extend to 2084, OTML proposes to store tailings on land in an engineered TSF from 2030 to reduce downstream environmental and social impacts and to support continued mine operations. This will also bring forward the gradual recovery of the Ok Tedi/Fly River system by 54 years compared to continued riverine disposal of tailings.

Key components of the project are:

- A hydro-cyclone house for separating coarse and fine tailings, with coarse underflow used for embankment construction and fine overflow directed to the TSF impoundment.
- A ring-dyke TSF comprising internal storage cells developed progressively, with embankments primarily constructed using cyclone underflow sand.
- A 85-km-long tailings delivery pipeline from the existing Tailings Pyrite Plant (TPP) at Ok Tedi Mine to the proposed TSF site, including associated pumping and piping distribution systems (i.e., one pump station at the mine site and two intermediate choke/valve stations).
- An access road corridor including three bridges and several minor water/ravine crossings.
- Ancillary infrastructure including site offices, laydown areas, workshops, maintenance stations, waste and sewage management facilities, fuel storage, as well as potential borrow area, quarry and a temporary construction accommodation camp.
- A dedicated laydown area will be constructed adjacent to the TSF to store materials for initial and progressive TSF construction works and maintenance.
- Power supply, primarily from on-site diesel generators with an installed capacity of approximately 3 MW.
- Raw water supply sourced primarily from TSF decant water during operations, supplemented by rainfall and potential abstraction from nearby watercourses to meet raw water demand for construction, dust suppression, rehabilitation activities, flush water systems and potable water (as required).

Construction of a separate 14.5 km Alice Pit–Border Post Road under the Infrastructure Tax Credit Scheme (ITCS) has commenced in North Fly District and is expected to improve accessibility for communities in Ningerum LLG and cross-border connectivity at the Yetetkun

PNG–Indonesia border post. The construction and operation of the ITCS Road are being assessed and approved separately to the project. The ITCS Road currently traverses the TSF footprint and will need to be relocated as its development progresses.

SLR was appointed by Tetra Tech Coffey (TTC) to conduct the aquatic fauna assessment as part of the environmental approval process. SLR (previously WRM) conducted initial baseline surveys for a proposed Ok Birim TSF facility in 2014/15 but due to alignment changes of the 2014 TSF footprint, partly to protect ecological values recorded at that time, and the timelapse since the initial studies were undertaken, further studies are required to re-establish the baseline commenced in 2014/15 and build on the description of the current ecological condition.

1.2 Study Objectives

The objectives of the aquatic ecology assessment are to:

- Characterise the aquatic fauna (including selected invertebrates), aquatic flora (including aquatic vegetation), water and sediment quality and habitats within the project area creeks and adjacent creeks in surrounding area.
- Define relevant background/reference sites for upstream/downstream locations.
- Predict the extent to which the proposed project components will impact (both positive and negative) the aquatic ecology of waterbodies within and downstream of the project area.

For the aquatic ecology study, the study area included the Ok Yep catchment (including small creeklines and springs within TSF Area) downstream to the confluence of the Ok Yep with the Ok Tedi, the Ok Birim catchment and main watercourses crossed by the project-related access road and pipeline along the Ok Ma (Figure 2 and Figure 3).

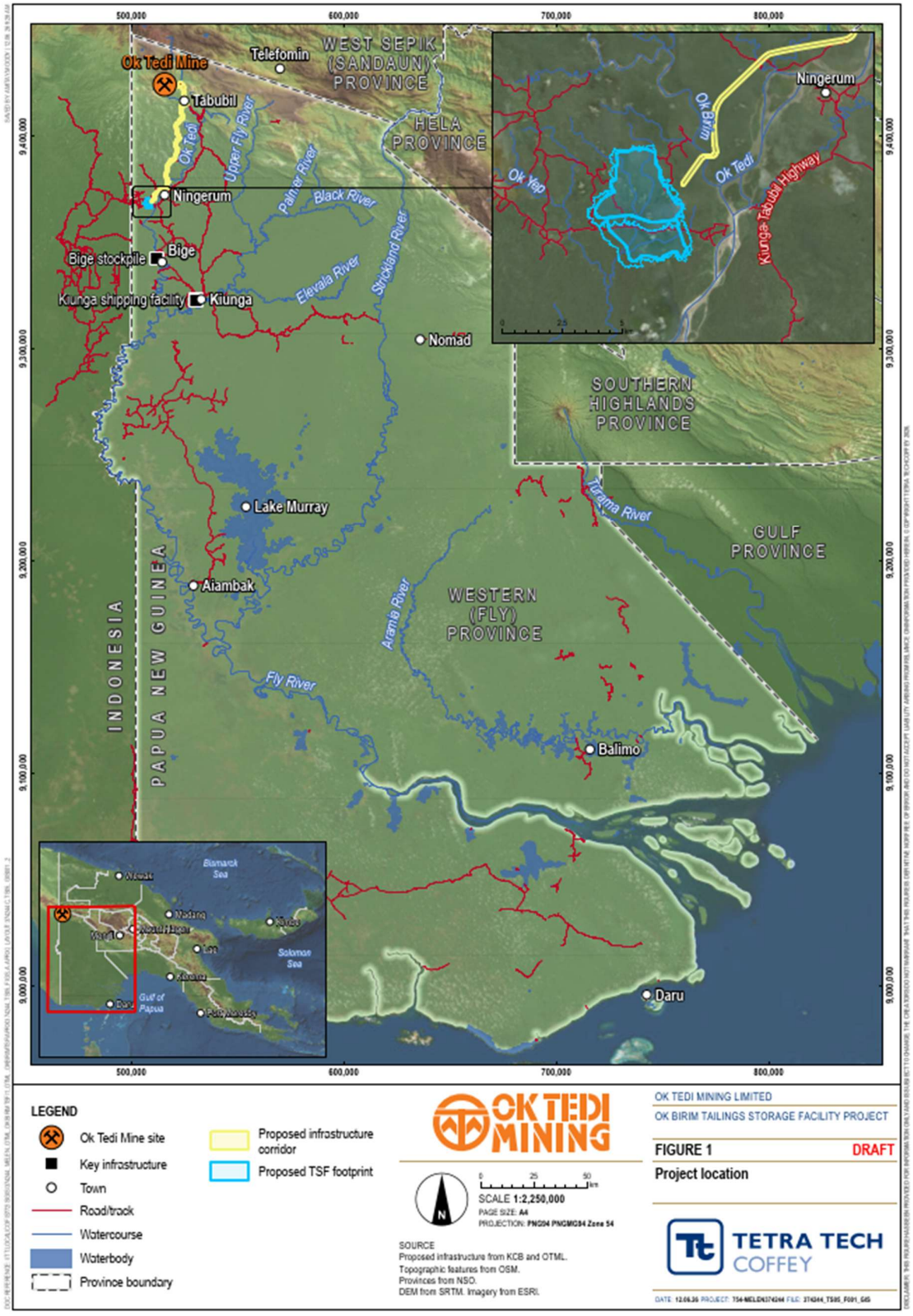

Figure 1. Project Location

2.0 Methodology

2.1 Sites and sampling design

The aim of the sampling program was to describe the aquatic ecological values of the receiving environment and establish if there will be a potential impact of the Ok Birim TSF and associated infrastructure corridor along the Ok Ma on the receiving aquatic ecosystems. The survey was conducted in two phases, an initial survey in August 2025 and a follow-up survey in November 2025. The initial survey was restricted to the northern TSF area due to access limitations (physical and community-related) to areas south of the Infrastructure Tax Credit Scheme (ITCS) road. Subsequent to the first survey, the project design was modified to include a pipeline alignment along the Ok Ma watercourse, and community issues were resolved regarding access to areas south of the ITCS road. Therefore, a second survey was conducted, which focussed on the southern TSF area and the proposed associated infrastructure that runs along the Ok Ma.

In total, 37 sites were sampled across the two surveys, with 14 reference (R) sites and 23 potentially exposed (PE) sites (Table 1, Figure 2 & Figure 3). 11 sites were retained from the 2014/15 baseline surveys (Table 1).

2.1.1 Reference sites

The identification and sampling of comparable creeklines outside (adjacent to or upstream of) the influence of the TSF and infrastructure corridor as ‘reference’ sites, to confirm if species occurring in creeks within/adjacent to the footprint, also occur outside the footprint. As well as documenting aquatic fauna present, this survey also targeted the newly described Kiunga blue-eye, *Kiunga leucozona* that was first recorded within the proposed TSF footprint area in 2014/15. Site locations were identified prior to the survey and accessed by helicopter and foot.

2.1.2 Potentially Exposed

Based on surveys conducted in 2014/15, there are several creeklines within the footprint of the Ok Birim TSF, and these sites served as a starting point to identify sites within the footprint. Because creeks within the footprint will be lost once the TSF is constructed, the survey also aimed to sample creeks adjacent to and draining the TSF. Sites within the TSF were used to identify the fauna and critical habitat likely to be lost through construction of the TSF, adjacent creeks outside the TSF will show if this fauna is represented elsewhere and will also allow comparisons with the fauna recorded in the previous survey. It is anticipated that future, post-development impact assessment/monitoring will target exposed creeklines outside but draining the TSF footprint given those within the footprint will be lost.

The associated infrastructure will include an access road and tailings pipeline from Ok Tedi mine to the proposed TSF, that will be constructed along the length of the Ok Ma watercourse and will cross various rivers and creek along the route. Proposed sites along the preliminary proposed alignment on the Ok Ma were identified based on satellite imagery and accessed by dinghy and helicopter.

Table 1. GPS locations (WGS84, UTMs) of sites sampled during 2025 surveys in each area indicating the type.

Project Component	Site	Type	Ststus (WRM 2014/15)	Site code	Date	Zone	Eastings (WGS84)	Northing (WGS84)
TSF	Ok Birim	Reference	Retained	OB1	23-07-2025	54	510119	9372680
TSF	Ok Birim	Reference	Retained	OB2	23-07-2025	54	507266	9374086
TSF	Ok Birim	Reference	Retained	OB3	23-07-2025	54	505944	9375204
TSF	Ok Hap	Reference	Retained	OB16	25-07-2025	54	505678	9369978
TSF	Ok Yep	Reference	Retained	OB17	25-07-2025	54	505366	9370104
TSF	Ok Yep	Reference	Retained	OB20	26-07-2025	54	502618	9369210
TSF	Ok Bim	Reference	Retained	OB21	26-07-2025	54	503285	9369222
TSF	Ok Trek	Reference	Retained	OB22	26-07-2025	54	504206	9369054
TSF	Ok Barap	Reference	Retained	OB24	25-07-2025	54	506785	9370839
TSF	Ok Yap	Reference	Retained	OB25	25-07-2025	54	506387	9370446
TSF	Ok Borot	Reference	New	OB26	26-07-2025	54	504657	9369140
TSF	Ok Birim	Potential Exposed	New	OB4	24-07-2025	54	510577	9369806
TSF	OK Indoknam	Potential Exposed	New	OB9B	28-07-2025	54	509085	9369975
TSF	Ok Indok	Potential Exposed	Retained	OB10	28-07-2025	54	508414	9369450
TSF	Ok Yep	Potential Exposed	New	OB27	28-07-2025	54	507611	9369166
TSF	Ok Minim	Potential Exposed	New	OB28	30-07-2025	54	506208	9367338
TSF	Ok Nawakaben	Potential Exposed	New	OB29	30-07-2025	54	506884	9367405
TSF	Ok Yep	Potential Exposed	New	OB30	30-07-2025	54	507501	9367413
TSF	Ok Yep	Potential Exposed	New	OB31	30-07-2025	54	507737	9367434
TSF	Ok Iru	Potential Exposed	New	OB32	31-07-2025	54	508321	9367219
TSF	Ok Mognet	Potential Exposed	New	OB33	31-07-2025	54	509500	9367334
TSF	Ok Mognet	Potential Exposed	New	OB34	31-07-2025	54	509711	9367309
TSF	Ok Dingyop	Potential Exposed	New	OB35	31-07-2025	54	509984	9367358
TSF	Ok Kaknat 2	Potential Exposed	New	OB36	19-11-2025	54	508923	9365094
TSF	Unknown	Potential Exposed	New	OB37	19-11-2025	54	509069	9365551
TSF	Ok Kaknat 1	Potential Exposed	New	OB38	19-11-2025	54	509440	9365159
TSF	Ok Yep	Potential Exposed	New	OY1	18-11-2025	54	507349	9361711
TSF	Ok Yep	Potential Exposed	New	OY2	18-11-2025	54	506757	9363994
Infrstaructure Corridor	Ok Ma	Reference	New	OM1	27-11-2025	54	520021	9406981
Infrstaructure Corridor	Ok Ma	Reference	New	OM3	13-12-2025	54	521012	9396350
Infrstaructure Corridor	Ok Nong	Reference	New	OM6	20-11-2025	54	519177	938861
Infrstaructure Corridor	Ok Ma	Potential Exposed	New	OM4	27-11-2025	54	521435	9395450
Infrstaructure Corridor	Ok Ma	Potential Exposed	New	OM5	20-11-2025	54	522033	9390954
Infrstaructure Corridor	Ok Ma	Potential Exposed	New	OM7	21-11-2025	54	519970	9386552
Infrstaructure Corridor	Ok Ma	Potential Exposed	New	OM8	21-11-2025	54	520464	9384366
Infrstaructure Corridor	Ok Ma	Potential Exposed	New	OM9	23-11-2025	54	520359	9383216
Infrstaructure Corridor	Ok Tara	Potential Exposed	New	OM12	25-11-2025	54	512090	9374357

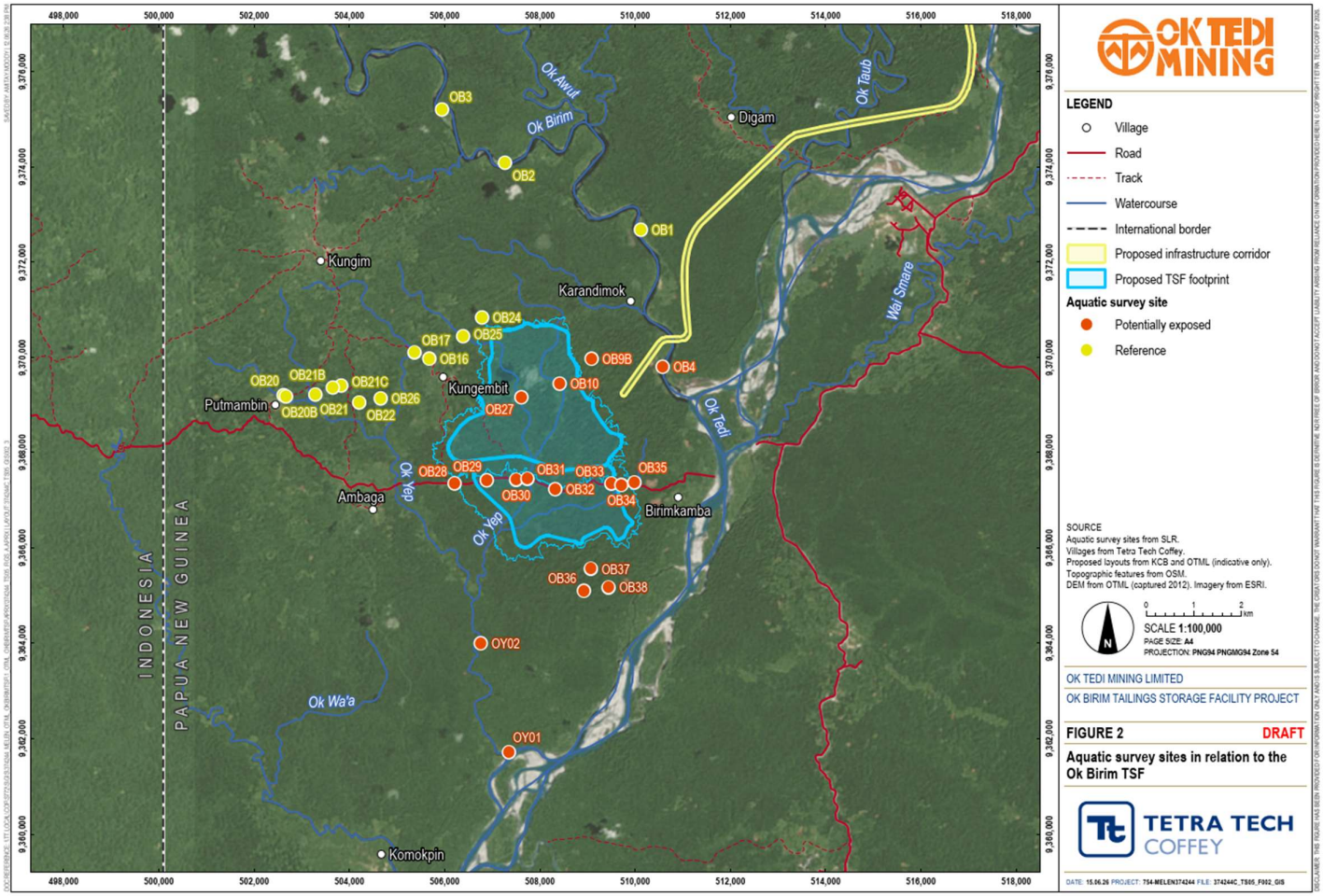

Figure 2. Aquatic Survey Sites Sampled in 2025 in relation to the Ok Birim TSF

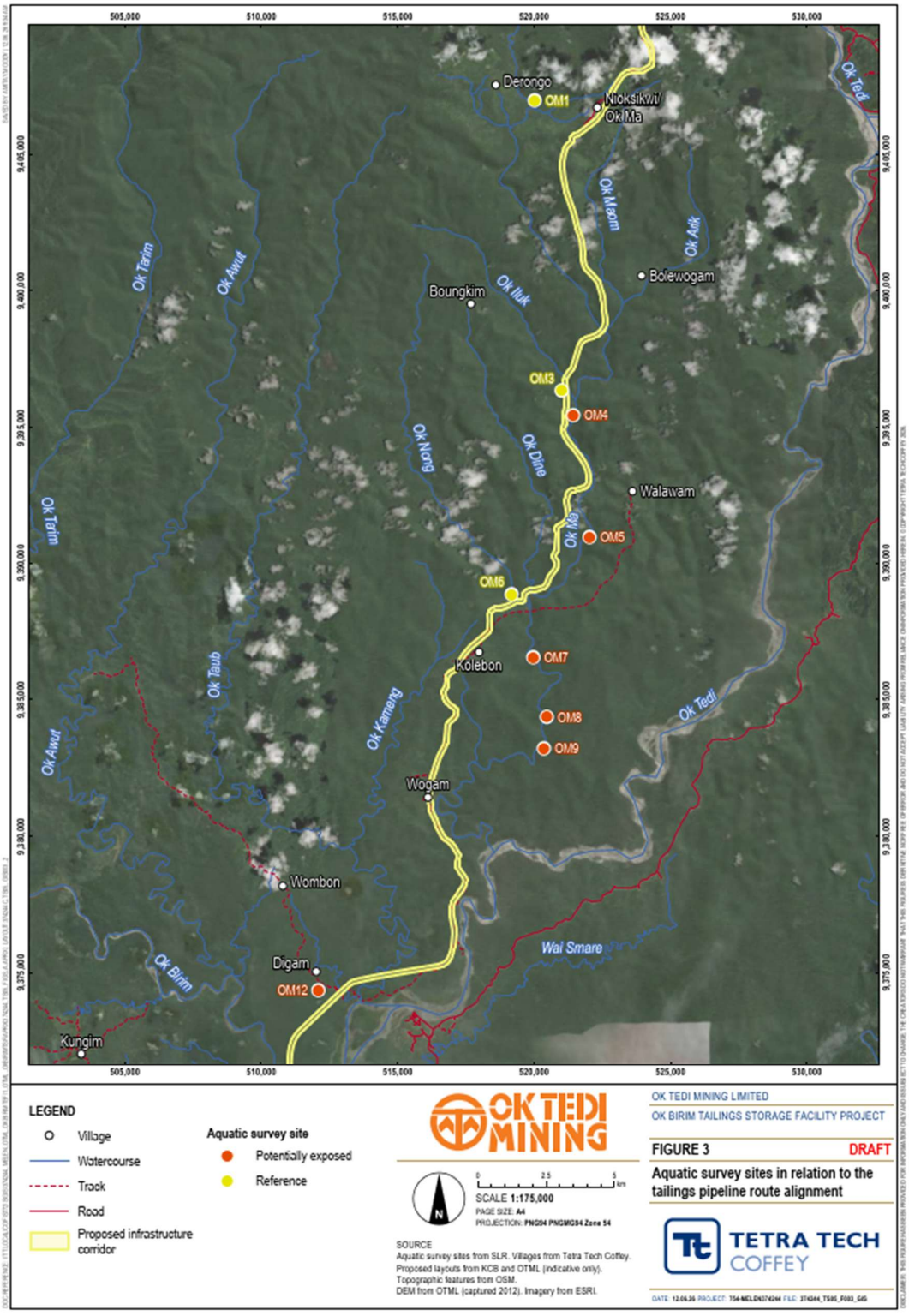

Figure 3. Aquatic Survey Sites Sampled in 2025 in relation to the infrastructure corridor

2.2 Habitat Assessment

Details of aquatic mineral substrate composition and in-stream habitat were recorded at each site. Habitat assessments are based on Australian Monitoring River Health AusRivAS protocol, a standardised rapid method for the collection of geomorphological, physical habitat, and riparian data (Parsons *et al.* 2002, Parsons *et al.* 2004). SLR has specific worksheets for this task to ensure habitat recordings between sites and systems are as comparable as possible. Habitat characteristics recorded included percent cover by inorganic sediment, submerged macrophyte, floating macrophyte, emergent macrophyte, algae, large woody debris, detritus, roots and trailing vegetation. Details of substrate composition were also recorded, including percent cover by bedrock, boulders, cobbles, pebbles, gravel, sand, silt and clay, from which mean particle size and habitat diversity were calculated.

When undertaking habitat assessments there can be a small degree of inter-operator variation in scoring habitat cover. AusRivAS acknowledges this but generally considers that the variation in habitat scoring is smaller than the differences required to fundamentally affect fauna assemblages. Erroneous variation in scoring between sites was minimised by ensuring the same person assessed habitat at all sites.

Raw data are provided in Appendix A and site photos in Appendix B.

2.3 Sediment Quality

Sediment samples were taken from the top 1-2 cm surface layer at approximately five locations along the water's edge at each site and amalgamated into one composite sample for each site for analysis of sediment metal concentration in the benthos (bottom substrate). Analyses were conducted by the OTML Environmental Chemistry Laboratory. Total concentrations of cadmium, copper, lead and zinc were analysed using a nitric acid and microwave total digest. As such, this digest will over-estimate bioavailable metals from sediments, and so will over-estimate risk when data are compared to sediment GVs that reflect bioavailable metals. Benthic sediment metals data were compared against the Australian Sediment Quality Guideline Values ANZG (2018). The ANZG (2018) guidelines provide DGVs and Guideline Values – High (GV-High) for selected metals. ANZG (2018) defines the guideline values as follows:

- "DGV: indicates the concentrations below which there is a low risk of unacceptable effects occurring, and should be used, with other lines of evidence, to protect aquatic ecosystems".
- "GV-High: provides an indication of concentrations at which you might already expect to observe toxicity-related adverse effects. As such, the GV-high value should only be used as an indicator of potential high-level toxicity problems, not as a guideline value to ensure protection of ecosystems."

Sediment DGVs are provided in Appendix C and raw data are provided in Appendix D.

2.4 Water Quality

The Australian and New Zealand Standards (AS/NZS 1998) describe National standard methods for the collection of water quality (and sediment) samples. Sampling methodology is based on the following guidelines:

- AS/NZS 5667.6:1998. Water quality - Sampling - Guidance on sampling of rivers and streams.

- AS/NZS 5667.1:1998. Water quality - Sampling - Guidance on the design of sampling programs, sampling techniques and the preservation and handling of samples.
- AS/NZS 5667.12:1999. Water quality - Sampling - Guidance on sampling of bottom sediments.

At each site a number of water quality variables were recorded *in situ* to characterise ecosystem health and assist in explaining any between-site patterns in aquatic fauna. Parameters recorded *in situ,* using portable, calibrated Hanna field meter, included pH, redox, electrical conductivity (µS/cm), dissolved oxygen (% and mg/L), turbidity and water temperature (°C). In addition, undisturbed water samples were collected for laboratory analyses of ionic composition, alkalinity, TSS, and dissolved metals. A 1 L gulp water sample was collected from each site by field personnel wearing polyethylene gloves to reduce chances of contamination. Samples were returned to the OTML laboratory at the end of each day and subsamples filtered through 0.45 µm Millipore nitrocellulose filters for metals analysis, with remaining sample used for ionic composition and TSS. Filtered samples were preserved with addition of nitric acid. All samples were submitted to the OTML Environmental Chemistry Laboratory for analysis. Raw Data are provided in Appendix E.

Water quality data were compared to Water Quality Criteria (WQC) for aquatic life protection, Environment Act 2000 (The Independent State of Papua New Guinea), and the current ANZG (2018) default water quality guideline values (DGVs) for aquatic ecosystems in tropical northern Australia (lowland rivers). However, these trigger values are indicative only, based on tropical northern Australian wetlands. It should be noted that the guidelines were developed for general application to PNG aquatic life and Australian tropical wetlands, and system-specific guidelines should be developed to determine the toxicity potential of metal concentrations in New Guinean water bodies. The DGVs for physical and chemical stressors applicable to tropical northern Australia are provided in Appendix B.

2.5 Fish Fauna

The PNG fish fauna is well recognised as being diverse, with a high degree of endemism (Allen, 1991; Allen et al 2007). Fish diversity is also used as an indicator of ecosystem health (Kaur 1991, Oberdoff and Hughes 1992, Hugueny et al. 1996, An and Choi 2003). Because fish continually inhabit the receiving water, they integrate the chemical, physical and biological histories of the river. Most fish species have a long life span and therefore reflect both long-term and current water quality. Sampling fish assemblages can be used to assess a range of environmental disturbances, such as changes in habitat, water quality and land use (Hugueny et al. 1996). Fish also tend to be the most conspicuous biota in freshwater systems, are relatively easy to sample and identify, and often provide a significant food source for local villagers.

A number of methods were used at each site to collect as many species/individuals as possible. Fish sampling methods included seine netting, gill netting and electrofishing, with methods at each site selected to maximise catch, as deemed suitable for habitat present. In the Ok Birim main channel, and selected sites on the lower Ok Ma[1], large and small mesh gill nets, large and small beach seine, and electrofishing were used. Larger mesh gill nets were a subset from the OTML standard gill net set (1” to 5” nets inclusive) and were deployed by dinghy and set overnight. Smaller species and juveniles, as well as schooling species, were targeted by beach seine (14 m net, with a 2.5 m drop and 6 mm mesh) deployed in shallow areas where there were little vegetation or minimal large woody debris. Multiple seines were

[1] Although large mesh gill nets were set in the lower Ok Ma, an overnight flood prevented nets functioning, and fish catch was minimal; catch data were not representative of species present.

conducted at each site to maximise catch. Fish were also sampled by electrofishing at each site. Electrofishing was conducted using a Smith-Root Model LR24 battery powered back-pack electrofisher. Electrofishing is an extremely useful and efficient sampling tool in streams with clear, low salinity, medium to slow flow water. All meso-habitats at each site were shocked with the intention of recovering as many species/individuals as possible. Shocking was not continuous, but targeted areas of optimum habitat, whereby the operator would shock, then move to a new habitat before shocking again, and so prevent fish being driven along in front of the electrical field. In smaller creeks a combination of electrofisher and seine net were used to maximise species of fish captured. Any decapods captured were also retained and identified.

All fish were identified in the field. Fish nomenclature followed that of Allen et al. (2007). Fish retained by large mesh gill nets were individually weighed and fork length measured, to allow comparison with data on the OTML fish catch database and allow comparison with daily intake estimates. In small creeks, the number of each species caught was recorded. All fish species recorded were compared against IUCN RedBook to determine conservation status.

Raw data are provided in Appendix F.

2.5.1 Estimates of fish yield and daily consumption from Lower Ok Birim

The Ok Birim is a significant sub catchment of the Ok Tedi, supporting a range of larger-bodied species of fish that were previously common in the nearby lower Ok Tedi (WRM, 2016), but now reduced in abundance in the lower Ok Tedi due to mine-related impacts (WRM, 2017, 2021). Given the presence of these larger-bodied fish species, the Ok Birim likely provides a small, but important subsistence fishery to local villages adjacent to the main channel. The importance of this fishery can be assessed through community health survey food consumption studies, or by assessing catch rates using standard fishing methods against documented daily intake rates of fish by local villages.

OTML have a standardised approach that has been used regularly (WRM, 2017, 2021) to assess the ability of a fishery to meet subsistence needs of the local communities. This is based on the biomass of fish catch in standard gill nets compared against estimated average daily consumption per household. Fish biomass determined from OTML gill net catch is assessed against the daily dietary intake requirement by comparing total biomass caught in individual gill nets, usually 3”, 3.5”, 4” or 5” mesh gill nets, set over a 24-hr period, to daily intake requirements. These net sizes are those commonly available and used by villagers along the Fly River. Total biomass per net / per site / per occasion is generally expressed as a percentage (%) of the daily intake requirement per household. If greater than 100% is calculated, this indicates more than the daily requirement has been caught in a net, but if less than 100% is calculated, then less than the daily requirement has been caught (i.e. if a net caught 1.3 kg of fish, and this is half the daily requirement of 2.6 kg, it would be reported as 50% of the daily requirement for that net on that occasion).

Food consumption surveys for the Middle Fly region estimate a minimum daily consumption of 2.6 kg of fish per household, comprised of a family of eight (8) individuals (i.e. 325 g/person/day) (Markson Yarrao, OTML, pers. comm.). The Middle Fly River main channel and floodplain fishery will be significantly more productive than the Ok Birim and therefore provide a higher yield. Therefore, comparison of Ok Birim fish catch using the Middle Fly daily consumption will over-estimate daily consumption for Ok Birim villages.

OTML have conducted community health surveys for parts of the Ok Tedi catchment which include measurement of daily fish consumption (Markson Yarrao, OTML, pers. comm.; Table 2). The surveys have been conducted in the Ningerum (mine-exposed) and adjacent Ok Ma (reference) areas. The Ok Ma is a much smaller system than the Ok Tedi or Ok Birim, and so would have lower fish yield, and so likely lower daily intake. Mine impacts predate the

community health surveys, meaning the consumption from the Ok Tedi at Ningerum would reflect reduced catch due to significant mine impacts in that area; fish catch biomass is reduced by ~ 95% in the Ok Tedi at Ningerum compared to pre-mine (Swales et al, 1998, 2000). The survey included total daily intake of fish by a range of people (children and adults), across several meals (i.e. breakfast and dinner) on specific days at both areas.

Mean fish consumption across Control (Ok Ma) and Impact (Ningerum) areas combined was 79.1 g/person/day. Intake within each area was comparable, with 78.3 g/person/day at Ok Ma, and 80 g/person/day at Ningerum (Table 2). This comprised fresh fish only, as no smoked fish were consumed. This consumption, as expected, is considerably lower than the Middle Fly (~80 g/person/day for Ok Ma/Ningerum cf. 325 g/person/day for Middle Fly). If it is assumed an average family in this area consists of eight people, as per the Middle Fly, and they would possess one gill net across the target mesh sizes, daily intake per family for these areas is 640 g of fish (compared to 2600 g for Middle Fly).

Given the Ok Birim has more fish species compared to either the Ok Ma or the Ok Tedi at Ningerum, use of fish catch from Ok Ma/Ok Tedi at Ningerum would be a conservatively low value for the Ok Birim area.

Table 2. Results of daily fish consumption recorded during Community Health Survey in the Ok Ma and Ningerum areas, showing location, age, gender, meal and grams wet weight consumed.

Impact /Control	Day No.	Meal	Village	Sex	Age	Body weight	Fresh fish (g) pe	Fresh fish (g) per day
Control	1	b/fast	Ok Ma	F	6	12	40	
Control	1	dinner	Ok Ma	F	6	12	40	80
Control	1	b/fast	Ok Ma	F	12	22	60	
Control	1	dinner	Ok Ma	F	12	22	30	90
Control	1	dinner	Ok Ma	F	26	48	40	40
Control	1	b/fast	Ok Ma	M	8	18	50	
Control	1	dinner	Ok Ma	M	8	18	30	80
Control	1	b/fast	Ok Ma	M	11	19	65	
Control	1	dinner	Ok Ma	M	11	19	20	85
Control	1	b/fast	Ok Ma	M	28	56	45	
Control	1	dinner	Ok Ma	M	28	56	50	95
Impact	2	dinner	Ningerum Tamaro	F	45	42	80	80
Impact	2	dinner	Ningerum Tamaro	F	47	40	80	80
Impact	2	dinner	Ningerum Tamaro	F	13	34	80	80
Impact	2	dinner	Ningerum Tamaro	M	8	24	80	80
Impact	2	dinner	Ningerum Tamaro	M	22	60	80	80
Daily Mean Total Intake (g) - both areas								**79.1**
Daily Mean Total Intake (g) - Ok Ma								**78.3**
Daily Mean Total Intake (g) - Ningerum								**80.0**

2.6 IFC Performance Standard 6: Biodiversity Conservation and Sustainable Management of Living Natural Resources

Performance Standard 6 (PS6) is part of the International Finance Corporation's (IFC) sustainability framework and establishes requirements for clients to protect and conserve biodiversity, maintain ecosystem services, and manage living natural resources sustainably. It recognizes that biodiversity and ecosystem services are fundamental to economic prosperity, human development, and sustainable development, particularly in regions where livelihoods depend on natural resources.

In accordance with IFC Performance Standard 6 natural habitat and critical habitat was identified within the project area and mapped out in this report. Natural habitats are areas composed of viable assemblages of plant and/or animal species of largely native origin, and/or

where human activity has not essentially modified an area's primary ecological functions and species composition.

Critical habitats with high biodiversity value including (i) habitat of significant importance to Critically Endangered and/or Endangered species; (ii) habitat of significant importance to endemic and/or restricted-range species; (iii) habitat supporting globally significant concentrations of migratory species and/or congregatory species; (iv) highly threatened and/or unique ecosystems and/or (v) areas associated with key evolutionary processes.

2.7 Aquatic Fauna Sample Processing for Metal Analysis

Fish and crayfish tissues were analysed for metals concentrations. Larger specimens were dissected in the OTML environment chemistry laboratory to provide tissue samples for metal analysis. Prior to dissection, the length and weight of each individual was measured to attain size classes of specimens analysed (mm fork length for fish, mm carapace length (CL) for crayfish and; weight in g). For larger specimens, one liver sample and one tissue (flesh) sample was retained, or one hepatopancreas sample and one tissue (flesh) sample per crayfish.

Epaxial white muscle tissue samples (approx. 5g wet weight.) were taken from either side of the body of individual fish using an 0.1% nitric acid cleaned scalpel to obtain sufficient biomass for laboratory analysis. Fish liver samples were also collected from larger specimens. For crayfish, tail muscle and hepatopancreas samples were dissected (again approx. 5 g wet weight per sample).

When specimens were too small for dissection, whole specimens were digested for analysis, with the aim of providing a sample wet weight of 5 g. Multiple specimens of small fish were combined where individuals were too small for an individual to provide 5 g wet weight. Multiple samples of crayfish flesh and/or hepatopancreas were also pooled within site, in order to obtain sufficient biomass for analysis.

At the OTML laboratory all samples were freeze dried, subjected to nitric acid digestion by microwave, and analysed for As, Cd, Cu, Pb, Se and Zn. All data were reported as dry weight (mg/kg). The Provisional Maximum Tolerable Daily Intake (PMTDI), Provisional Tolerable Weekly Intake (PTWI) and Provisional Tolerable Monthly Intake (PTMI) for analytes listed in the World Health Organisations JECFA evaluations were used to compare human health food consumption (WHO, 2024). These guidelines are based on wet weight consumption of food items and therefore use wet weight comparisons. Therefore a 5:1[2] conversion of OTML dry weight data was applied to derive equivalent wet weight concentrations for fish tissue metal concentrations to allow comparisons with relevant guidelines.

2.7.1 Data Analysis

Fish tissue metal concentrations were assessed spatially across sampling sites within the Ok Birim, and among the different fish species captured across the study area for each of these systems. For the spatial analysis, concentrations of metals measured in individual fish from all species sampled were grouped according to the site captured and subsequently the mean and standard error were calculated and are presented for each system separately. For the inter-species analysis, metal concentrations from individual fish were grouped per species from across the study area.

[2] All previous tissue metals analyses conducted by OTML have used a 5:1 conversion for dry weight to wet weight fish tissue metals concentrations (AW Storey, pers. comm.).

In addition to spatial and interspecific comparisons, the influence of trophic ecology on metal accumulation was assessed. Trophic position (TP) values for each species were obtained from FishBase (www.fishbase.se). Trophic position provides an indication of the relative feeding level of a species within the aquatic food web and allows evaluation of potential trophic transfer of contaminants. To examine whether metal concentrations increased or decreased with trophic level, Spearman rank correlation analyses were conducted between trophic position and metal concentrations measured in individual fish across all sites in each of the systems separately. This analysis allows assessment of potential biomagnification or biodilution processes within the fish community. Biomagnification refers to an increase in contaminant concentration with increasing trophic position, typically from dietary transfer through the food web, whereas biodilution refers to decreasing concentrations at higher trophic levels, reflecting physiological regulation, differences in exposure pathways, or dietary composition.

Arsenic was excluded from the trophic position analysis as concentrations in all samples were below analytical detection limits. Arsenic was not detected (LOR is 0.76 mg/kg) in any of the whole specimen or fish tissue samples at any of the sampled sites or in any of the different fish species in either of the sampled river systems, subsequently, as is accepted practice in bioaccumulation studies the non-detected readings were substituted by 50% of the LOR, 0.365 mg/kg. This substituted value is substantially higher than the calculated Tolerable Daily Intake values at 70 and 85 kg (Table 3). It is difficult to conclude whether these results are a true reflection of the current status due to the very high LOR 0.76 mg/kg. Therefore, all As results should be interpreted with caution and are not discussed any further.

Table 3: Provisional Maximum Tolerable Daily Intake (PMTDI), Provisional Tolerable Weekly Intake (PTWI) and Provisional Tolerable Monthly Intake (PTMI) for analytes listed in the World Health Organisations JECFA evaluations.

Analyte	PMTDI (mg/kg)	PTWI (mg/kg)	PTMI (mg/kg)	Cutoff for 70kg human (mg/day)	Cutoff for 85 kg human (mg/day)
Arsenic	0.0021			**0.147**	**0.1785**
Cadmium	0.00089		0.025	**0.0625**	**0.0759**
Copper	0.50000			**35**	**42.5**
Lead	0.00357	0.025		**0.25**	**0.3036**
Zinc	0.3-1			**70**	**85**
Selenium	**0.4 mg/day**				

2.8 Impact Assessment

This section outlines the methodology used to assess potential impacts to aquatic ecology and is consistent with Papua New Guinea regulatory requirements and international good practice.

Three assessment methods are applied depending on the environmental aspect being evaluated:

- Significance assessment used where qualitative or semi-qualitative evaluation is appropriate, to determine the significance of residual impacts after mitigation.

- Compliance standard assessment used where regulatory or international standards exist (e.g. air quality, water quality and noise) to determine whether predicted impacts may exceed acceptable limits.
- Benchmarking assessment, applied to greenhouse gas emissions to compare project emissions with PNG's national emissions inventory and assess relative contribution.

The significance assessment method is the primary focus for Ok Birim TSF aquatic ecology. Its purpose is to determine the significance of residual impacts following effective implementation of all proposed design and management measures, enabling prioritisation of sensitive values and informing environmental and social management and monitoring commitments.

This method involves three key steps:

1 Identification of environmental values and sensitivity – Environmental values potentially affected by the project are identified and assigned sensitivity rankings based on susceptibility to change, capacity to recover, replacement potential, intrinsic and societal value, intactness, uniqueness or rarity. Sensitivity categories range from "Not sensitive" to "Very high" and consider factors such as formal protection status, vulnerability, cultural importance and condition prior to disturbance.

2 Assessment of impact magnitude – The magnitude of predicted impacts after mitigation is assessed based on severity, geographic extent and duration of effects, including reversibility. Magnitude ranges from "Very low" (localised, short-term or once-off effects) to "Very high" (severe, irreversible, widespread and long-term effects).

3 Determination of residual impact significance – Sensitivity and magnitude ratings are combined using a significance assessment matrix to categorise residual impacts as very low, low, moderate, high or major, assuming all proposed mitigation measures are effectively implemented.

The significance assessment for predicted residual impacts is determined based on the sensitivity of affected values and magnitude of the residual impact using the significance assessment matrix presented in Table 4, assuming effective implementation of proposed measures. The residual impact significance can be categorised as very low, low, moderate, high or major.

Table 4. Significance Assessment Matrix

Magnitude Of Impact	Sensitivity Of Value				
	Not Sensitive	Low	Medium	High	Very High
Very high	Moderate	High	Major	Major	Major
High	Low	Moderate	High	Major	Major
Moderate	Low	Low	Moderate	High	High
Low	Low	Low	Low	Moderate	Moderate
Very low	Very low	Low	Low	Low	Moderate

3.0 Results & Discussion

Results from the surveys have been split into the two main project areas namely, Ok Birim TSF development area and Ok Ma infrastructure corridor development area.

Overview of mine impacts on Fly River aquatic ecology

The Ok Tedi mine, located on Mount Fubilan in the remote Star Mountains of the Western Province of Papua New Guinea, is one of the largest producers of copper concentrate in the world (Smith and Hortle, 1991; Swales *et al.,* 1999, 2000). The mine initially commenced operations in 1984 using a cyanide leachate circuit to recover gold. In 1987 the operation had a dual gold leachate/copper flotation recovery process, and by 1988 the mine had changed to copper concentrate production, with gold and silver also recovered in the concentrate (Smith and Hortle, 1991). Production has continued in this mode from 1988 to current (2026), with varying volumes of material mined over this period. In 1998 a dredge was installed at Bige to reduce channel bed aggradation in the lower Ok Tedi and upper Middle Fly, and in 2008 a pyrite stream was added to the flotation circuit to extract potentially acid forming sulphides, predominantly pyrite from the tailings stream.

Waste disposal at the Ok Tedi Mine has been controversial. The initial intention during mine development was to store tailings in a dam close to the mine, however, high rainfall (~ 10 m per annum at the mine), geological instability (limestone rock), and regular seismic activity meant that any tailings dam had a high risk of failure at some point in the future. This was evident in 1984 when the foundations of a tailing dam under construction were buried by a landslide (Swales *et al.,* 2000). Consequently, on-site waste storage was considered unfeasible. Rather than close the mine, the State of Papua New Guinea authorised disposal of waste rock and detoxified tailings directly to the Ok Tedi ('ok' in the local Min language means 'river'), a major headwater tributary of the Fly River. Consequently, the mine has always operated using riverine disposal. Volumes disposed have varied over time depending on grades, mine plan and operating constraints, but in mid-1990s approximately 120 000 metric tonnes per day (tpd) of waste rock and 80 000 tpd of tailings were discharged directly into the Ok Tedi and its tributaries to be transported downstream into the Fly River (Wood *et al*., 1994; Swales *et al.,* 2000). Regular and extensive environmental monitoring of the Fly River system has been conducted by Ok Tedi Mining Limited to examine the effects of this waste disposal on the river system and surrounding environment (Wood *et al*., 1994; Apte *et al*., 2009, Bolton *et al*., 2009, Pickup and Cui, 2009).

Changes in fish diversity, abundance and biomass in the Ok Tedi and Fly River downstream of the mine have been documented since 1983 (Swales et al., 1998, 2000). Decreasing fish catch biomass in the Fly River had been noted since the late 1980s (Smith and Morris, 1992). These changes became statistically significant declines in the early 1990s (Swales *et al*., 1998, 2000), with losses of between 65% and 96% relative to pre-mine levels in the Ok Tedi and middle Fly River channel, with the greatest reductions recorded from sites closest to the mine (Swales *et al*., 2000; Storey *et al*., 2009a). There have also been losses of species diversity in the Ok Tedi and Middle Fly River (Swales et al., 1998, 2000), although extensive fish diversity surveys in 2005, 2011, 2018 and 2024 (OTML, unpub, dat.) determined that most species still occur in tributaries or other parts of the system.

The reductions in fish biomass (and diversity) indicate significant biological effects on the river system. There were initial concerns that observed effects were due to metal toxicity to biota, given the elevated concentrations of total copper in the Fly River downstream of the mine. However, the majority of metals are particulate-associated, and therefore not readily bioavailable (Smith *et al*., 1990; Smith and Hortle, 1991), and concentrations of dissolved copper (dCu) are generally low (< 15 ug/L) (Apte 2009). Furthermore, the majority of the dissolved copper is non-labile due to the complexing capacity of the receiving waters which

are alkaline and high in dissolved organic carbon (Stauber, 1995; Stauber et al. 2009). This has been supported by a range of laboratory toxicity studies which have failed to identify acute toxic effects on Fly River species or equivalent species from northern Australia exposed to equivalent concentrations of copper found in the river channel (i.e. Smith *et al*., 1990; Smith and Hortle, 1991; Stauber, 1995; Swales *et al*., 1998, 2000).

The other major impacts in the river channel which could cause the observed declines in fish biomass were increased total suspended sediments (TSS) and riverbed aggradation resulting from the bulk disposal of mine waste and tailings to the river (i.e. Smith and Hortle, 1991; Swales *et al*., 1998, 2000). Significant bed aggradation was first recorded in the middle Ok Tedi in the early 1990s, and it soon spread to the lower Ok Tedi and into the Fly River immediately below the confluence with the Ok Tedi at D'Albertis Junction. Aggradation has subsequently progressed further into the middle Fly River (Pickup and Cui, 2009). In late 2000s there was approx. 6 m of aggradation in the middle Ok Tedi, decreasing to 4.5 m in the lower Ok Tedi and 4 m in the upper Middle Fly immediately downstream of D'Albertis Junction. Aggradation gradually reduced with distance from the confluence to the point where it was not detectable below Everill Junction (~ 220 nautical miles downstream) (Pickup and Cui, 2009). In the apparent absence of any ecotoxicity effect, bed aggradation and associated changes provide a mechanism for reductions in fish catch by impacting on fish habitat in the main channel. Although TSS is elevated and is often reported in the scientific literature as impacting on aquatic fauna, the fish fauna of the Fly River system is considered relatively tolerant of high TSS (Smith *et al.,* 1990), as are fish assemblages of many turbid, lowland tropical rivers. The Strickland River, a major tributary of the Fly River, naturally has a higher TSS concentration than the Fly, yet supports a healthy and diverse, although slightly different fish fauna (Smith *et al*. 1990). Therefore, aggradation and associated changes are thought likely of greater effect than the increased TSS. Storey et al. (2009b) demonstrated a significant inverse relationship between parameters likely to constitute or reflect aspects of fish habitat and bed aggradation in the Lower Ok Tedi and upper Middle Fly, indicating that declines in diversity and biomass of fish in the Fly River channel are most likely related to loss of habitat associated with bed aggradation. In recent years a slight, but significant recovery in fish assemblages in the upper and middle Middle Fly has been observed (SLR, 2025), correlating to improvements in water quality, and reduced bed aggradation due to a combination of factors including reduced mining rates with reduced volumes of waste material, establishment of the pyrite circuit, dredging at Bige and reduced dissolved metal levels due to higher buffering capacity.

3.1 Ok Birim TSF

3.1.1 Site Habitat Assessment

The Ok Birim TSF project area and reference tributaries, varied in morphology and substrate and habitat composition. Appendix B contains site photos.

Smaller substrates of gravel (4-16mm) and sand (1-4mm) dominated across reference forested creekline sites. Reference site OB17 was the only site that had bedrock present. Substrate within the reference sites located in the Ok Birim main channel (sites OB1, OB2 and OB3) were all classified with larger substrate composition cobbles (64-256mm) and pebbles (16-64mm).

Similar to the reference sites, the potentially exposed site located within the lower Ok Birim OB4 is currently influenced by backwater effects and sedimentation from the Ok Tedi and is downstream of the proposed tailings pipeline crossing, with risk of impact from pipeline spills or ruptures and construction activities, and the main channel had a larger substrate composition. The potential exposed forested creekline sites were all dominated by finer

substrate of gravel and sand, while the availability of clay within these creeklines were higher than the reference sites (Figure 4).

The substrate diversity was between three (3) and four (4) types at all sites, with OB17, OB24 and OY1 all had five (5) substrate types available within the creekline.

The Ok Birim main channel sites (OB1-OB4) had lower habitat diversity than other sites on smaller forested creeklines, comprised of mostly mineral substrate and a small percentage cover by detritus. Algal cover comprised of 6% of the habitat composition across all sites with sites OB2 and OB3 the only reference sites with visible algal cover.

Submerged macrophytes cover was highest at OB30 (40% cover) followed by OB33 (20% cover), with minimal floating or emergent macrophytes present across the study area (Figure 5). Mineral substrate was the dominant benthic habitat across all sites, followed by detritus. OB16, OB25, OB29, OB32 and OB34 had the highest large woody debris composition with 30% of the cover (Figure 5).

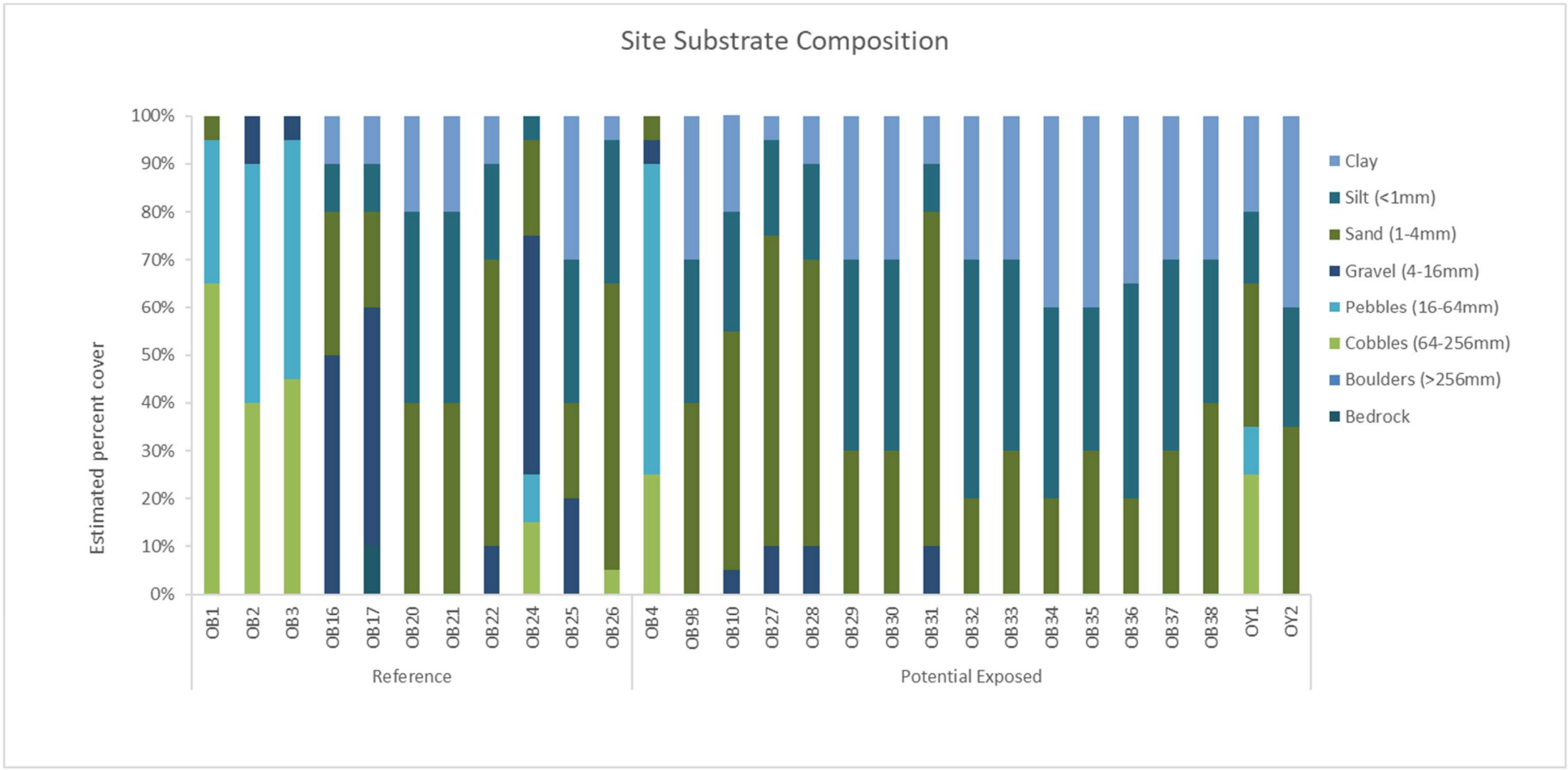

Figure 4. Ok Birim TSF site- substrate composition.

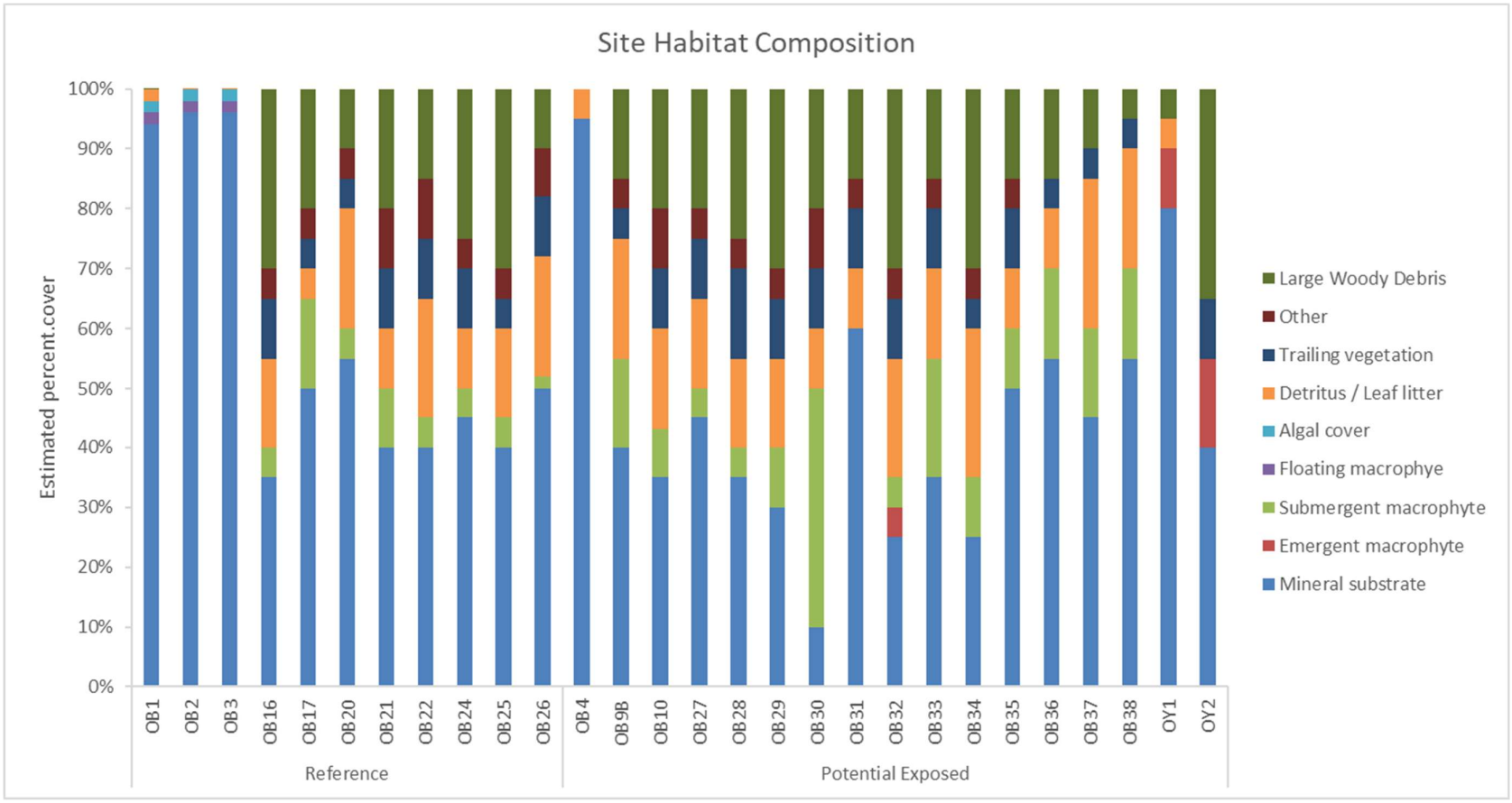

Figure 5. Ok Birim TSF site- habitat composition.

3.1.2 Aquatic Macrophyte Cover

Two species of aquatic macrophyte were observed at creekline sites during the TSF aquatic fauna surveys in 2025 (Plate 1). These were provisionally identified as a species of water lily (*Nymphaea* cf. *elleniae*), native to Papua New Guinea, and an unknown species of the genus *Vallisneria* sp., commonly known as eelgrass or tape grass (Howard Rogers pers. comms). The respective coverage of each known species, per site, as well as the overall submerged macrophyte coverage is outlined in Figure 6.

Potential exposed site OB30 had the highest macrophyte coverage with 40% of the site covered across both species.

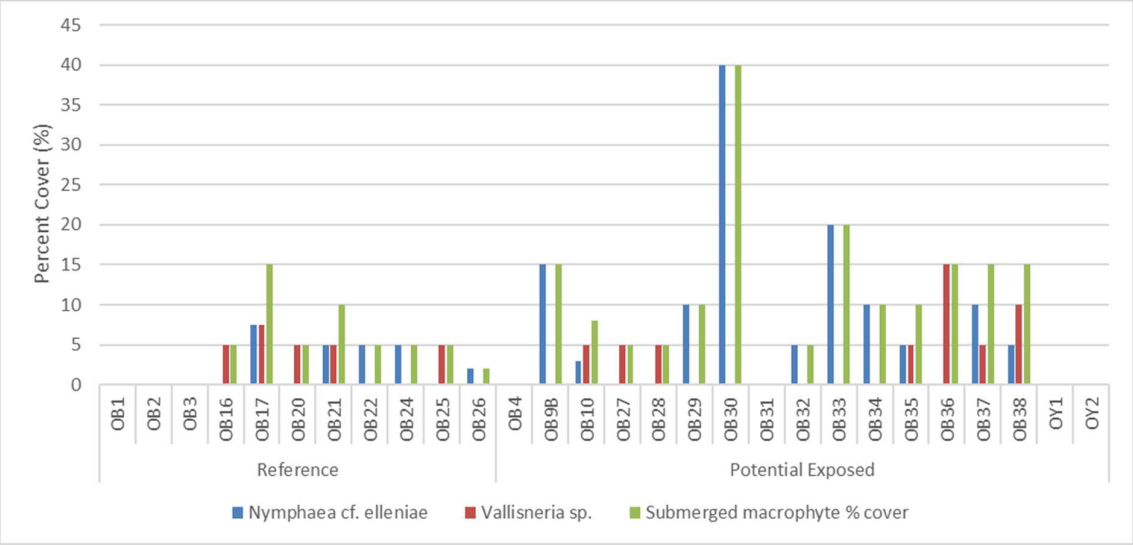

Figure 6. Percentage of macrophyte (%) cover at each site surveyed as part of the 2025 TSF aquatic fauna survey.

Plate 1. The two species of macrophyte recorded; *Nymphaea cf. elleniae* (top), and *Vallisneria* sp. (bottom) (acknowledging Howard Rogers for preliminary identifications based on field photographs).

3.1.3 Sediment Quality

Sediment samples were collected at each site and analysed for total metal concentrations at the OTML Environmental Chemistry Laboratory. Concentrations of metals on sediment were generally low but varied between sites. Some sites recorded concentrations of metals in excess of the ANZG (2018) sediment DGV, including Cd, Cu, Pb and Zn.

Cd ranged from concentrations less than detection limits (< 0.01 mg/kg) at majority of the sites) to 2.4 mg/kg at OY01. Site OY1 was the only site that exceeded the DGV but did not exceed the GV-High (Figure 8). This site is likely affected by backwater effects from the Ok Tedi under high/flood flows, with sediment from the Ok Tedi deposited into the lower reaches of the Ok Yup, resulting in the elevated sediment metal levels.

Cu concentrations ranged from 3.6 mg/kg (at reference site OB25) to 473.8 mg/kg (at potential exposed site OY1). Site OY1 had copper concentrations 7.3x higher than the DGV of 65 mg/kg and the only site that exceeded the DGV. This site also exceeded the GV-High of 270 mg/kg. The GV-High provides an indication of concentrations of metals in sediments at which you might already expect to observe toxicity-related adverse effects (ANZG, 2018). As such, the elevated levels of Cu in sediments at OY1 suggest impacts to benthic fauna would be expected. Macroinvertebrate data collected as part of this survey will be analysed to assess presence of this expected impact.

Only potential exposed site OY1 (70 mg/kg) exceeded the Pb DGV (50 mg/kg) with all other sites being below the DGV. Pb concentrations ranged from 3.4 mg/kg (at reference site OB25) to 70 mg/kg at site OY1. This level was below the GV-High for Pb.

Concentrations of Zn were in excess of the DGV (200 mg/kg), and higher than the GV-High (410 mg/kg) at potential exposed site OY1 (466.7 mg/kg), which was the highest concentrations recorded and the only exceedance of the GV-high for Zn. As noted for Cu, impacts to benthic fauna from sediment Zn would be expected at OY1. The lowest Zn concentration recorded during the current study was 19.2 mg/kg (at potential exposed site OB37)

Sediment metals concentrations at site OY1 were elevated and exceeded the GV-High for Cu and Zn. ANZG (2018) note that where a GV-High is exceeded an acute toxic response in benthic fauna would be expected. Site OY1 is located near the confluence with the Ok Tedi, where backwater effects during high-flow events are likely to promote sediment deposition within this reach. These levels are representative of metal concentrations within the Ok Tedi system. However, all sediment metals data in the current report were derived from a relatively strong nitric acid/microwave digest, as performed by the OTML Environmental Chemistry Laboratory. ANZG (2018) sediment guidelines represent bioavailable sediment metals, based on a weak acid extraction (WAE) digest. The more aggressive strong acid digest used by OTML will mobilise a higher proportion of metals off sediments than a WAE and therefore will over-estimate risk to ecological values. In future a weak acid extraction (WAE; 1M HCl) digest is recommended to reflect bioavailable metals in sediments to provide a more realistic indication of risk to aquatic ecological values. Macroinvertebrate data collected as part of this survey will be analysed to assess if an impact currently exists, reflective of the GV-High exceedance.

Figure 7. Concentration of metals within sediments (mg/kg dry weight), showing plots for Cd, Cu, Pb and Zn in comparison to DGV (broken line) and GV-High (solid line).

The percentage carbon ranged from 0.13% at reference site OB01 to 9.82 % at potentially exposed site OB35 (Figure 8). Percent total sulfur (% S) was low, with all sites recording values much lower than 2% (Figure 8). %S ranged from below the detection limit (<0.005%) at potentially exposed site OB35 to 1.19% (at potentially exposed site OY01).

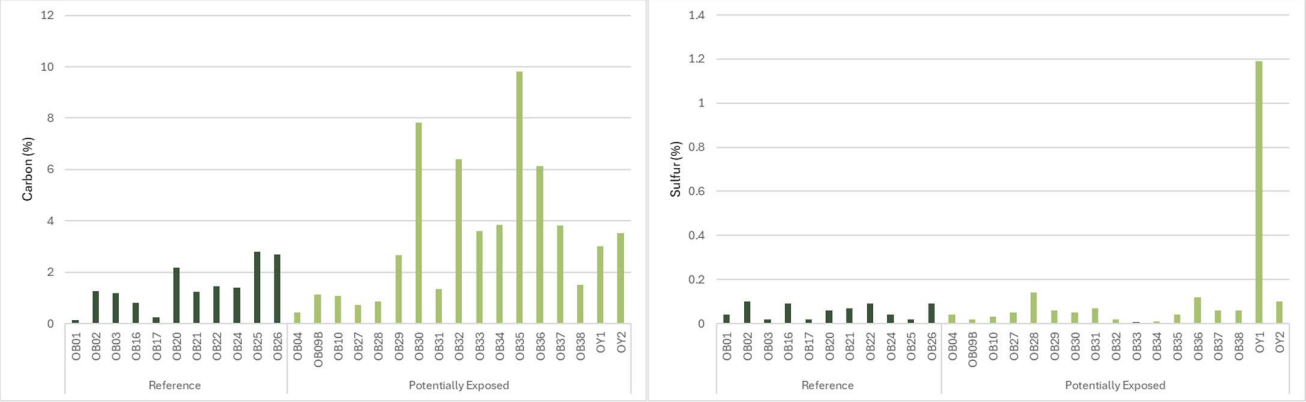

Figure 8. Percent total carbon (left) and percent sulfur (right) content within sediment collected in June 2025

The acid neutralising capacity (ANC) of sediments collected in the current study ranged from values below the limit of detection (i.e. < 0 kg H_2SO_4/t; at potential exposed sites OB9B, OB28, OB29, OB30, OB33, OB34 and OB35) to 153.3 kg H_2SO_4/t (at potentially exposed site OY1; Figure 5). ANC is a measure of a sample's ability to neutralise strong acid and essentially refers to the sample's buffering capacity (AMIRA 2002). The higher the ANC, the greater the samples capacity to neutralise acid. ANC values of zero or less than detection were recorded from OB20, OB21, OB24, OB25, OB26, OB9B, OB28, OB29, OB30, OB33, OB34 and OB35 (Figure 9). Samples from these sites suggest limited capacity to neutralise acid.

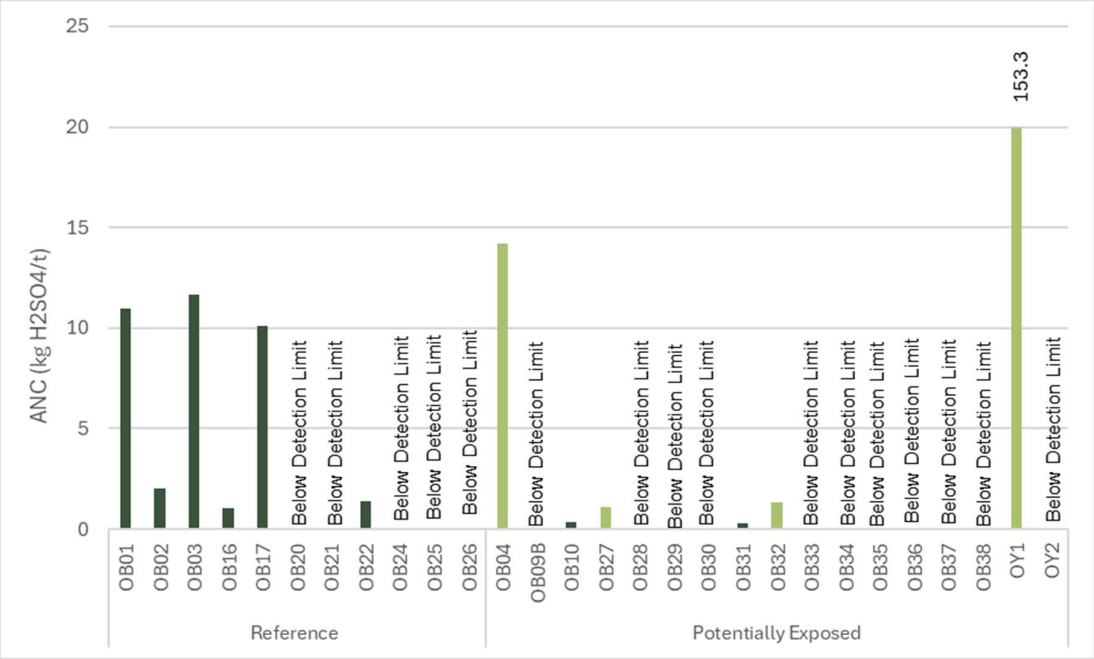

Figure 9. Acid neutralising capacity (ANC kg H2SO4/) of sediments collected at each site

The net acid producing potential (NAPP) of sediments can be determined from total S (%) and ANC using the following calculations:

Maximum Potential Acidity (MPA) = total %S *30.6

NAPP = MPA – ANC (AMIRA 2002).

NAPP values calculated for sediment samples collected in 2025 ranged from -116.92 (at potentially exposed site OY2) to 8.72 (at potentially exposed site OB30, Figure 10.

Negative NAPP values suggest the sample may have sufficient ANC to prevent acid generation (AMIRA 2002). The majority of the samples collected from potential exposed sites (i.e. OB9B, OB10, OB27, OB28, OB29, OB30, OB31, OB33, OB34 and OB35) had positive NAPP, indicating they may be naturally acid generating. Eight reference sites also recorded positive NAPP values (Figure 10).

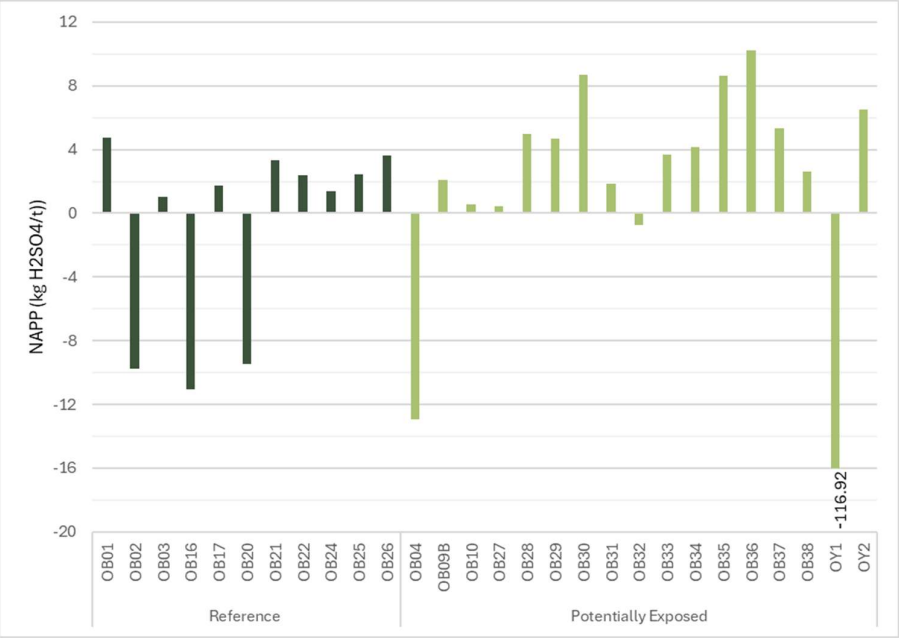

Figure 10. Net acid producing potential (NAPP, kg H_2SO_4/t) calculated for each site

3.1.4 Water Quality

Water samples were collected at each site and sent to the OTML Environmental Chemistry Laboratory for analysis. Water quality results were compared against ANZG (2018) Default Guideline Values (DGVs) for lowland tropical rivers in northern Australia and Water Quality Criteria (WQC) for aquatic life protection (The Independent State of Papua New Guinea), (Appendix B). The section below will provide detailed results on all analytes that showed elevated concentrations in comparison to DGVs.

3.1.4.1 Physico-chemistry

pH

Water was characterised by slightly acidic to slightly alkaline pH (range 5.5 – 7.94). None of the reference or potentially exposed sites had values above the upper DGV. All sites located within the main Ok Birim channel had more alkaline waters likely reflecting the alkaline geology of the mountain source of the river (Figure 11). Potentially exposed sites OB10 (5.5), OB30 (5.7), OB32 (5.5) and OB33 (5.9) were all below the lower guideline value being more acidic than the sites located in the main Ok Birim channel. The acidic pH recorded at these sites was likely due to the naturally acidic conditions of these lowland creeks which flow through dense primary rainforest, with run-off leaching through deep organic layers, with naturally high tannin/humic levels. Creeks are dominated by detrital and organic substrates, with minimal contact with alkaline geology. The naturally acidic conditions would increase risk from metals, however, the likely high organic content would counter this to some degree by providing good complexing capacity, especially for Cu and Zn.

Dissolved Oxygen (DO)

Daytime DO (% saturation) ranged from low to high across sites sampled, ranging from 58.5% at OB30 to 111% at OB11 (Figure 11). Generally the values were within the guideline values for all sites in the lower Ok Birim (OB1 – OB4) and fell below the lower DGV of 85% at reference sites OB17 (80%), OB20 (83.2%) and OB26 (78.1%) and potential exposed sites OB 28 (77.5%), OB29 (81.4%), OB30 (58.5%) OB342, (64.9%), OB33 (81.4%) and OB34 (74.3%). However, none of these values were considered low enough to be of ecological concern.

Figure 11. pH and Dissolved Oxygen Saturation (%) recorded from all sites sampled in comparison to the upper and lower ANZG 95% species protection default guideline values

Electrical Conductivity

EC was extremely low and ranged from 5 µS/cm (OB9B and OB32) to 90 µS/cm at OB02 but was generally equal to or less than 10 µS/cm at the majority of sites (Figure 12). Values recorded from all sites were well below the ANZG (2018) (i.e. < 250 µS/cm) and all were considered fresh as defined by the Department of Environment (DoE 2003)[3]. Low conductivities indicate these creeks are mostly rainfall driven, with source waters filtered through the organic forest floor. Such low EC levels are characteristic of lowland, rainforest creeks of the area, as observed is various studies conducted for OTML by WRM/SLR (WRM, 2011, 2016). As a result, endemic aquatic fauna will be adapted to very low conductivities and will likely be susceptible to osmotic stress if exposed to relatively small increases in conductivity.

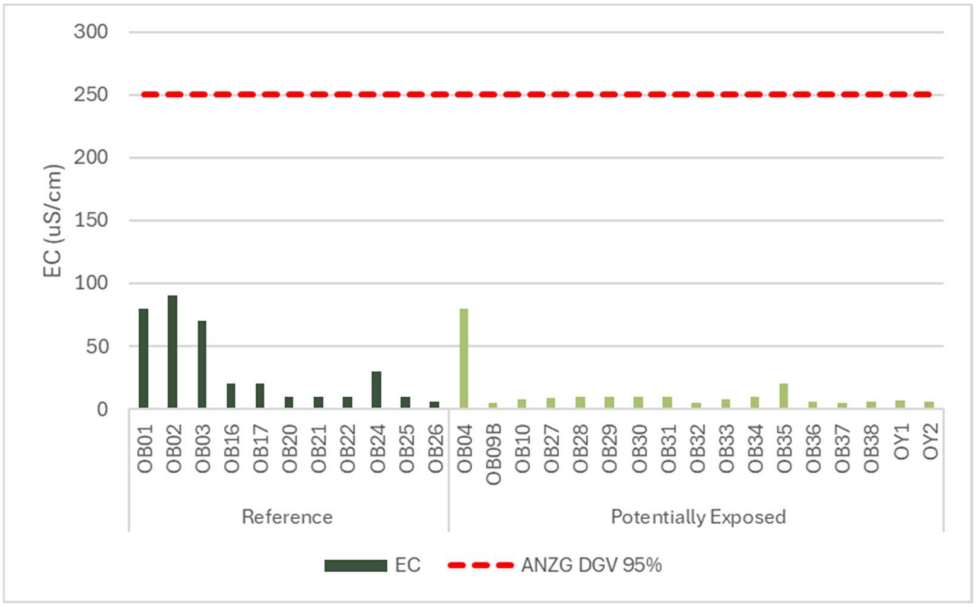

Figure 12. Electrical conductivity (µS/cm) recorded during the current study in comparison to the ANZG DGV for protection of 95% of species.

[3] Fresh defined as < 1500 µS/cm, Brackish = 1500 – 4500 µS/cm, Saline = 4500 – 50,000 µS/cm, Hypersaline > 50,000 µS/cm (DoE 2003). Classifications were presented as TDS (mg/L) in DoE (2003) so a conversion factor of 0.68 was used to convert to conductivity µS/cm as recommended by ANZECC/ARMCANZ (2000).

3.1.4.2 Metals

OTML Laboratory provided data on concentrations of dissolved chromium, copper, lead, zinc, cadmium and arsenic at reference and potentially exposed sites. Concentrations of dissolved metals ranged above and below the relevant ANZG (2018) GV for protection of 95% of freshwater species. In some instances, concentrations were below the laboratory level of detection (LOD), and for some metals the LOD was higher than the ANZG 95% species protection DGV preventing comparison of the data against the GV.

Dissolved chromium (dCr) concentrations were equal to or above the 95% species protection DGV at most sites except for potentially exposed sites OB34, OB35 OB36, OB37, OB38, OY01 and OY02. Although naturally elevated, levels didn't exceed the 90% species protection DGV.

Concentrations of dCu exceed the DGV at reference sites (OB01, OB02, OB03, OB16, OB20, OB21, OB24 and OB25) and potentially exposed (OB04, OB09B, OB27, OB30, OB32, OB36, OB37 OB38, OY01 and OY02). Site OB01 (65 ug/l) had dCu concentrations 46x higher than the DGV and the only site that showed concentrations that high. The high copper at the site seems to be an anomaly. Although dCu DGV for 95% species protection was exceeded at a number of sites, concentrations were generally less than 10 ug/L, and it is likely that the Dissolved Organic Carbon (DOC) levels of these creeks provide sufficiently high complexing capacity as to negate toxicity of Cu. ANZG (2018) have released draft updated DGVs for Cu and Zn which require data on pH and DOC as moderating factors to calculate Cu toxicity/complexing. DOC was not analysed by the OTML ECL. Future surveys should include DOC in analyses.

Concentrations of dPb in excess of the 95% GDV were recorded from potential exposed sites OB9B, OB10, OB28, OB29, OB32 and OB35, and reference sites OB01, OB02, OB03, OB16, OB21, OB22, OB24, OB25 and OB26). dPb ranged from values below the limit of detection to 21 µg/L (at OB25; Figure 13).

Concentrations of dZn were below the limit of detection (i.e. < 3 µg/L) at all sites with the exception of reference sites OB01 where Zn concentration was 69 µg/L (Figure 10), being the only site that had elevated concentrations above the DGV.

Only two sites (OB02 and OB25), both reference sites, recorded dCd concentrations greater than detection limits (i.e. < 0.10 µg/L) and in excess of the 95% GDV (0.2 ug/L). LoD for Cd was 1 ug/L, which is well above the 95% DGV of 0.2 ug/L, and so it was not possible to assess dCd levels against ANZG (2018) 95% species protection DGV.

dAs concentrations ranged from below the limit of detection (i.e. < 1 µg/L) at a number of sites to 6 µg/L at reference site OB20. Reference sites OB03, OB20 and OB21 were all in excess of the DGV while potentially exposed sites OB04, OB27, OB28, OB30 and OB35 were also above the DGV. The majority of sites were below the DGV for dAs.

Figure 13. Dissolved metal concentrations (µg/L) in comparison to the 95% ANZG (2018) guidelines showing plots for dCr, dCu, dPb, dZn, dCd and dAs, with ½ the LOD plotted for metals reported at < LOD.

3.1.5 Fish fauna

To provide a more comprehensive condition assessment of the fish fauna of the study area, fish fauna data collected during the 2014/15 baseline surveys were combined with the 2025 survey results to show the spatial distribution and occurrence of fish species across the wider project area (Figure 14). A cross-tabulation of fish species by sites is provided in Appendix F, and photos of selected species provided in Plate 2.

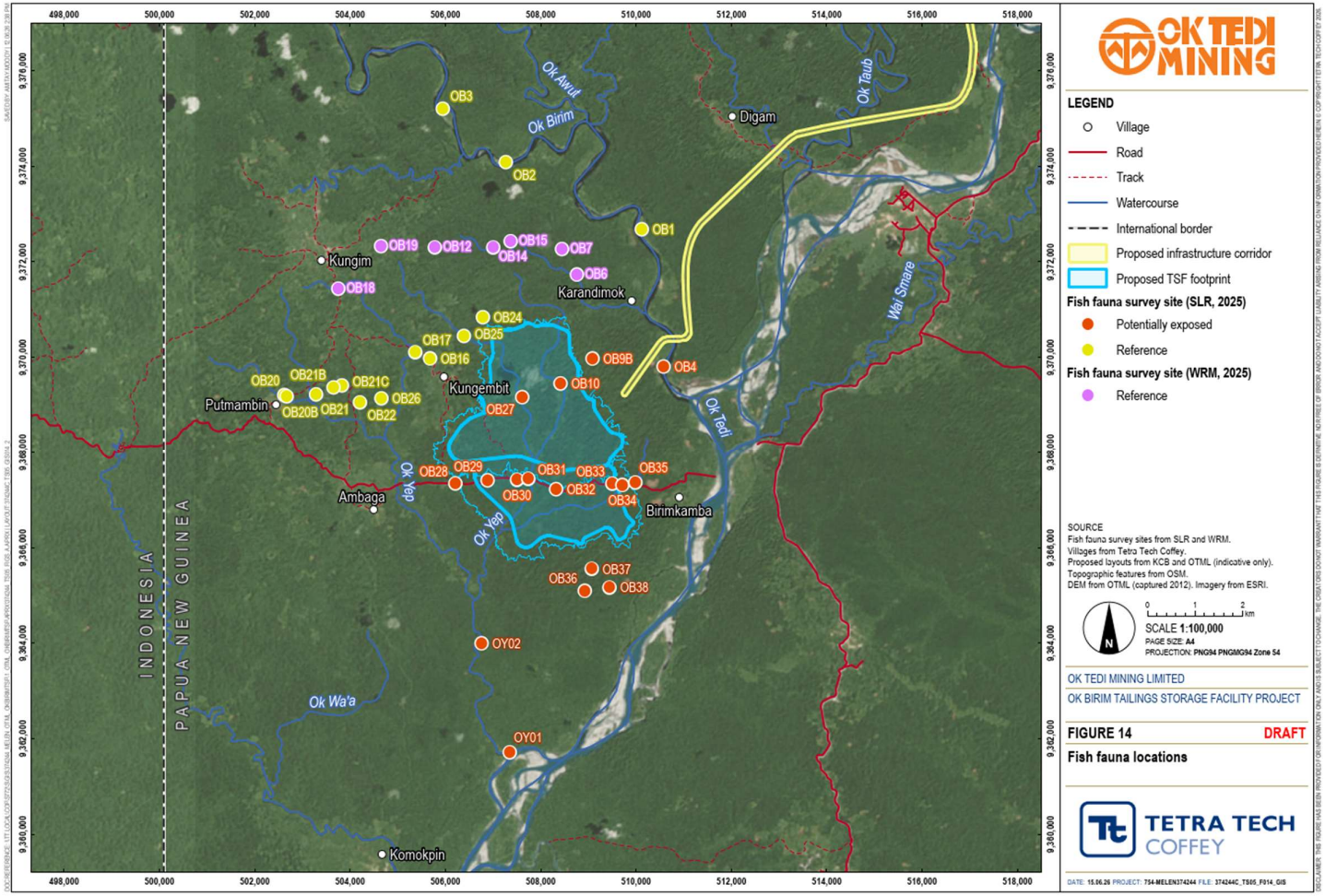

Figure 14. Sampling locations of Fish Fauna during 2014/15 and 2025 surveys

3.1.5.1 Species composition and species richness

A total of 45 freshwater species were recorded across the surveys (Appendix E). The systems likely support greater species richness than reported here as single surveys seldom capture all species at a location on a single attempt, and local landowners identified additional species of fish which they think occur in the Ok Birim using images from Allen et al. (2008). The fish fauna comprised of 44 native species and one (1) introduced species. Native fishes included species of Ambassidae (glassfishes), Apogonidae (mouth almighty), Ariidae (fork-tail catfishes), Atherinidae (hardyheads), Belonidae (longtoms), Clupeidae (herring), Eleotridae (gudgeon), Gobiidae (gobies), Hemiramphidae (garfishes), Melanotaenidae (rainbowfish), Mugilidae (mullet), Plotosidae (eel-tailed catfishes), Pseudomugilidae (blue-eyes) and Terapontidae (grunters). Introduced fish included a species of Cichlidae (cichlids).

The number of species at a site ranged from a minimum of two (2) at OB3 in 2025 (reference site on Ok Birim), and reference sites OB5 and OB7 (sampled in 2014), to a maximum of 21 at OB4 (the potential exposed site on the lower Ok Birim main channel, Figure 15).

Generally, greater number of species were recorded from the larger creeklines rather than the small forested tributary creeks, likely reflecting differences in water depth and habitat diversity. The very low conductivity characteristic of the small tributary creeks limited the effectiveness of electrofishing, while habitat complexity limited the effectiveness of seine netting, so additional species are likely present.

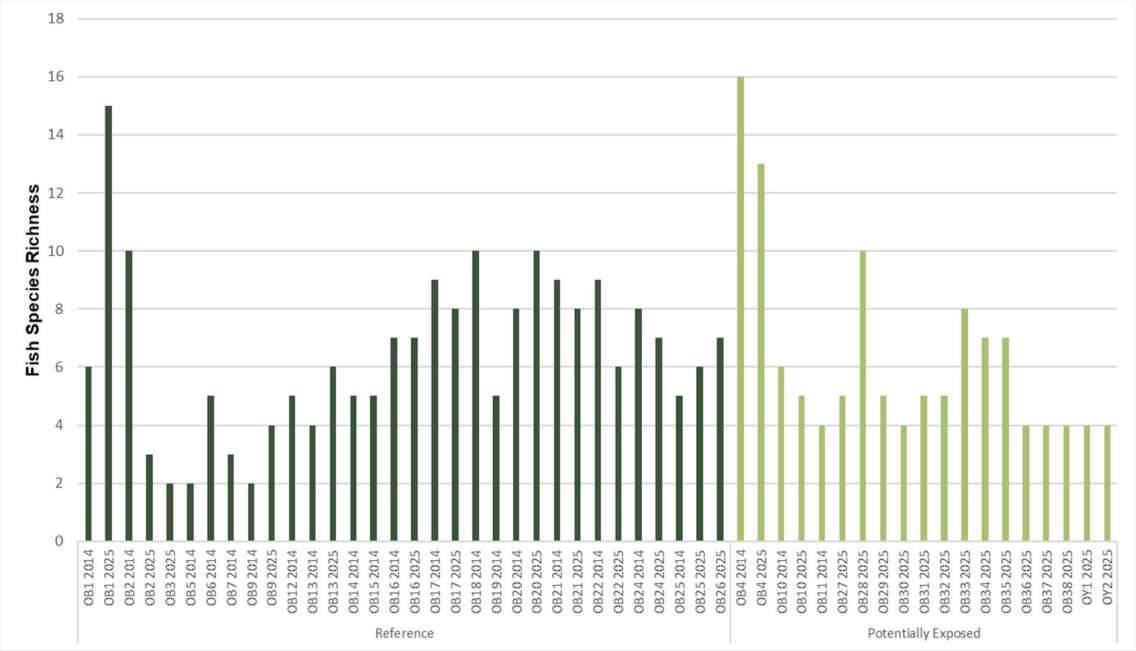

Figure 15. Fish species richness recorded from each site across 2025 and 2014/15 surveys

Main Channel (Ok Birim)

A total of 31 species was recorded from the Ok Birim main channel. Sites differed in size and habitat structure, as a result different levels of effort were expended across the sites. Catch rates in 2014/15 were higher than in 2025; in 2014/15 the river level was low, and more easily fished, than in 2025 when it was in flood and gear did not work effectively.

Several species caught at sites within the Ok Birim (OB1 – OB4) were not recorded in other sites due to factors including river size, and subsequently methodology used. Fork-tail catfish (family – Ariidae) had a higher presence in these larger, open water environments, compared to the smaller creeklines within and adjacent to the TSF footprint. The giant glassfish *(Parambassis gulliveri)*) was also only recorded in the Ok Birim.

Only one species recorded during the 2025 survey was considered invasive to the survey area, the tilapia *(Oreochromis mossambicus)*, which was collected at site OB4.

As reported previously, the lower reaches of the Ok Birim main channel are acting as a refuge for a range of species that either were once common in the main Ok Tedi channel pre-mine and have now been lost or were common in the Middle Fly and are in decline. The Ok Birim forms an important refuge area with potential for these species to recolonise the Ok Tedi post-mine closure, once habitat in the Ok Tedi has improved.

Small tributaries

Twenty-five species of fish and one species of crayfish were recorded from small, forested tributaries across the TSF area and adjacent lands. The general composition of species was as expected for undisturbed, healthy foothill creeks at this elevation (WRM & Hydrobiology 2007, WRM 2013), although total diversity was possibly slightly lower than anticipated. The difficulty in stunning fish with the electrofisher due to the very low conductivities likely reduced the number of species caught, with fish regularly escaping capture. Similarly, the complex nature of the habitat at each site reduced the efficiency of the seine net.

3.1.5.2 Abundance

A total of 1,994 individual fish were recorded from the 39 sites sampled across the 2014/15 and 2025 surveys, with the abundance of fish recorded varying greatly between sites (Figure 16 and Appendix F). The greatest abundance was recorded at potentially exposed site OB4 (270 individuals), followed by reference sites OB1 (144 individuals) and s OB2 (129 individuals) on the Ok Birim main channel. The highest abundance within the smaller creeklines were 126 individuals at reference site OB21 followed by OB10 (potentially exposed) with 125 individuals.

The lowest abundance recorded was at OY1 (13 individuals), followed by OB13 (15 individuals). In general, greater abundances were recorded in the main Ok Birim channel and survey sites that were sampled in both 2014/15 and 2025.

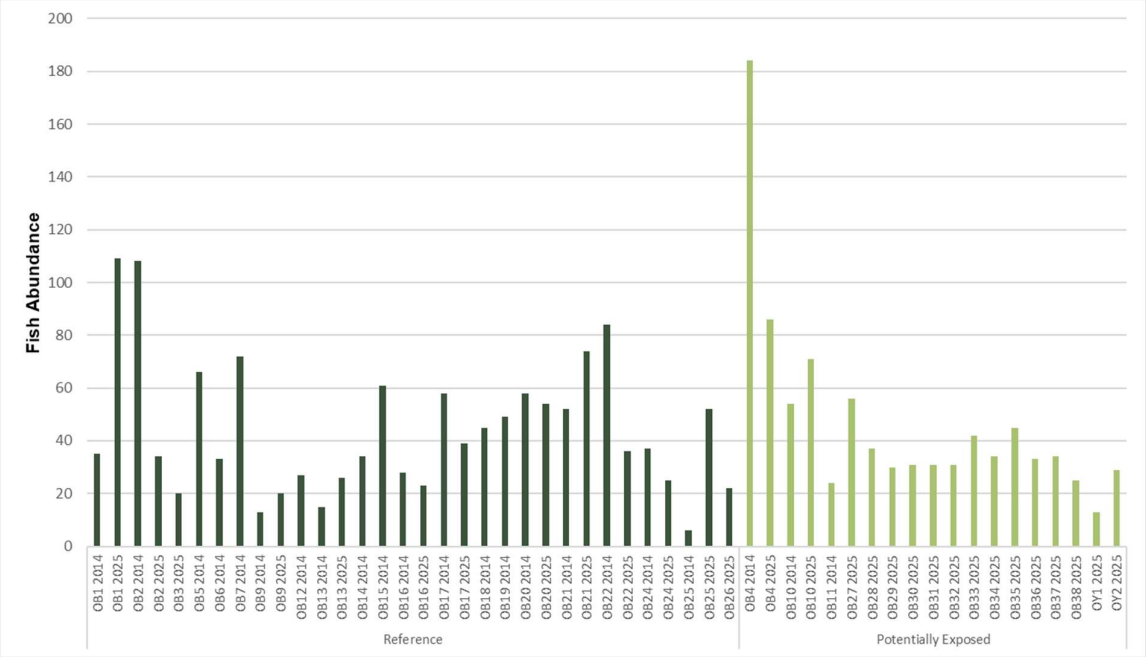

Figure 16. Total abundance of fish recorded from each site across 2025 and 2014/15 surveys

Kiunga Blue-eye (K*iunga leucozona)*

Sande's mouth almighty (G*lossamia sandei*),

Banded Mogurnda (*Mogurnda cingulata*),

Swamp Eel (*Ophisternon gutturale*),

Concave Goby (*Glossogobius concavifrons*)

Fly River Rainbowfish (*Melanotaenia sexlineata*),

Fimbriate Gudgeon (*Oxyeleotris fimbriata*)

Short-finned Tandan (*Neosilurus brevidorsalis*)

Striped-cheek Gudgeon (*Bostrychus strigogenys*),

Ok Tedi Rainbowfish (*Melanotaenia oktediensis).*

Paska's Blue Eye (*Pseudomugil paskai*) (source: Michael Hammer)

Robert's Goby (*Glossogobius robertsi*) (Source: Gerry & Mark Allen)

Swamp Gudgeon *(Oxyeleotris stagnicola)*
(Source: Gerry & Mark Allen)

Plate 2. Fish diversity observed in the Ok Birim TSF aquatic fauna baseline survey 2025.

3.1.6 Other Aquatic Fauna Observed

Five (5) individuals of *Cherax* sp (freshwater crayfish) was recorded across three (3) sites (OB28, OB33 and OB34) during the 2025 surveys. The crayfish was not identified to species level and thus no conservation status could be provided, however they are an important food source for local villages. *Cherax* sp. was kept as part of the macroinvertebrate samples to be further identified in the lab.

Local fishermen noted that freshwater crocodiles (*Crocodylus novaeguineae*) and turtles are still present within the Ok Birim.

3.1.7 Conservation Significance of Fish Species from the Ok Birim

Several species of conservation significance, as listed on the IUCN Red List, were recorded during both surveys and are included in Plate 2. The Fly River rainbowfish (*Melanotaenia sexlineata*) is currently listed globally as Endangered (EN) (listed 06 December 2019). *M. sexlineata* were recorded at 12 sites across the surveys, ten (10) reference sites (OB5, OB7, OB9, OB12, OB13, OB14, OB15, OB16, OB20 and OB21) and two (2) potentially exposed sites OB36 and OB37).

Paska's Blue Eye (*Pseudomugil paskai*) is currently listed globally as Critically Endangered (CR) (listed 04 June 2020). The species inhabits rainforest streams with abundant aquatic vegetation, in low-hill terrain at elevations of about 100-150 m. It seems to have a very specific habitat, being small, shallow, slow-flowing and either turbid or tea-coloured streams/springs with abundant aquatic vegetation and pH and temperature ranges of 6.1-6.5 and 25-26ºC. It can grow to a maximum size of about 2.5 cm SL (G.R. Allen pers. comm. 2019). It often seems to co-exist with *M. sexlineata. P. paskai* was originally recorded from the area in the early 1980s from creeks close to Kiunga, but then had not been recorded in over 40 years, before being rediscovered in 2024 from the Elevala sub catchment of the upper Fly (AW Storey, unpub. dat.). A single female specimen was recorded at site OB20B. Based on morphology, it appears to be *P. paskai*, but will be DNA sequenced to confirm. If it is not *P. paskai*, it will be a species new to science (M Hammer, NT Museum, pers comm.). According to the IUCN the species population is decreasing with limited distribution and habitat preference. The current record is from a reference site outside of the TSF footprint. Given its very specific habitat requirements, comprising very small seeps and springs, often emanating from swamps/sago swamps, additional survey effort targeting such habitat is required within and adjacent to the TSF.

While not listed, the newly described species of Kiunga blue-eye *(Kiunga leucozona*, Allen *et al.* 2024) is of significant conservation importance due to its limited distribution within the area. While this species has not formally been classified by the IUCN for conservation status, it is presumed to be of a high conservation value, due to its known limited distribution. *K. leucozona* was observed at 15 sites across all surveys, non-inclusive of the larger, open-water environments of the Ok Birim sites, which do not replicate suitable habitat / conditions for the species (Allen *et al*. 2024). The species was recoded at ten (10) reference sites (OB16, OB17, OB18, OB20, OB21, OB22, OB23 OB24, OB25 and OB26) and five (5) potentially exposed sites (OB23, OB27, OB28, OB31 and OB32). Based on extensive survey effort in the surrounding effort, and distribution of closely related species of *Kiunga* (Allen et al, 2024), this species is likely restricted to the area within and immediately adjacent to the TSF.

The swamp gudgeon *(Oxyeleotris stagnicola)* is currently listed globally as Endangered (EN) (listed 15 May 2020) by the IUCN. The species was recorded at 15 reference sites (OB7, OB9, OB12, OB13, OB14, OB15, OB16, OB17, OB18, OB20, OB21, OB22, OB23, OB25 and OB26) and six (6) potentially exposed sites (OB28, OB29, OB33, OB34, OB35 and OB36). Current classification of the gudgeon species *Oxyeleotris paucipora* / *stagnicola* observed as part of

the current aquatic fauna study is under review, with complexities around its morphological identification, particularly in the case of field surveys. Several samples will be sent to Michael Hammer, Curator of Fishes at the NT Museum for further genetic testing and analysis. There is a possibility that species of this complex could undergo a reclassification, given that the current listing of *O. paucipora* is of Least Concern (LC).

One individual eel-tailed catfish was captured from the Ok Birim main channel at the potential exposed site OB4 that appeared to be different to known species. Previous surveys on the Ok Birim recorded *Neosilurus ater* and a species referred to as *Neosilurus* sp. B. Specimens of *Neosilurus* sp. B caught from the Ok Birim in 2014/15, supported with additional specimens subsequently taken from the Ok Mart, and the upper Fly River main channel near Moian village have been DNA sequenced, and analysis show the specimens is a species new to science. This new species is currently being formally described (AW Storey, pers. comm.).

A final group of species which were commonly encountered at creeks within and adjacent to the TSF project area, for which their conservation significance requires more investigation, are those from the genus *Oxyeleotris* (family Eleotridae, gudgeons). Four species of *Oxyeleotris* were provisionally identified in this study; *O. aruensis, O. fimbriata, O. paucipora* and *O. stagnicola*. Differentiation of three of these species (*O. aruensis, O. fimbriata* and *O. stagnicola)* is challenging, as it often depends on counts of scales along the mid-line of the fish. However, the scale counts appeared to vary with fish size (i.e. species identification varied with the size of the individual), which casts some doubt on the robustness of this diagnostic feature for species differentiation. Initial genetic analysis of the specimens collected in this study by Dr Peter Unmack (National Evolutionary Synthesis Centre, North Carolina) failed to clearly differentiate any species groupings within the specimens collected. This group obviously requires more work on genetics and morphometrics to delineate each species, and until that is done, it is not possible to discern species distributions with any certainty. As such, it was not possible to assign conservation significance to the records of each of these gudgeon species (Appendix F).

3.1.7.1 Introduced Species

One introduced species was recorded during the current study, tilapia *(Oreochromis mossambicus)*. Tilapia was recorded from two sites on the Ok Birim main channel, OB1 (reference site) and OB4 (potentially exposed). There is some confusion over the origins and type(s) of tilapia in the Fly River. They are suspected to have escaped from village aquaculture schemes, and formal identification as *O. mossambicus* has not been confirmed, with O, niloticus also thought to be in PNG, as well as GIFT tilapia; genetically modified for faster growth in aquaculture. Tilapia are native to Africa, and are now one of the most widespread exotic fish species (Polhemus et al. 2004). They are highly adaptable, fast growing and tolerant of a range of environmental conditions occupying both freshwater and estuarine systems (Canonico et al. 2005). They are highly fecund and have high reproductive rates. They are also able to feed at different trophic levels making them highly effective competitors (Canonico et al. 2005). Such life-history traits allow the successful colonisation of disturbed habitats and areas which have undergone anthropogenic modification. Once established, tilapia also impact other parts of the ecosystem as they uproot aquatic plants, are known to feed on wetland taro, and reduce food supplies for native bird species (Englund and Eldredge 2001). Nelson and Eldredge (1991) reviewed the distribution and status of Tilapia (including *O. mossambicus*) in the islands of the south Pacific and Micronesia finding that once introduced, the species eventually invade most accessible freshwater, brackish and even marine (lagoon and atoll) habitats and that thereafter, the fish are virtually impossible to eliminate.

Another introduced species was recorded in 2014; the striped snakehead *Channa striata*. *C. striata was* recorded from the Ok Birim main channel site OB4 and the small tributary site on

the Ok Birim (OB21; a reference site). Striped snakehead is native to south-east Asia from India and Sri Lanka to China, Indonesia and the Philippines (Allen et al. 2008). It was first recorded from Papua New Guinea in the Bensbach River in 2000 (Allen et al. 2008), and has since become established and widespread through the Lower Fly River system to the upland streams along the Kiunga-Tabubil Highway (Storey et al. 2009). Snakeheads are known to have highly detrimental impacts on native freshwater fish populations and other aquatic fauna, and have a number of traits which make them particularly good invaders. Firstly, they have an accessory breathing organ which allows them to survive without water for months buried in mud and enables them to survive out of water when carried by people moving between villages and islands (Courtenay et al. 2004, Polhemus et al. 2004). They are also voracious predators of fish, crustaceans, frogs, snakes and insects, and are able to out-compete native species (Allen et al. 2008). Snakeheads have been implicated in the extinction of at least four fish species in Madagascar (Polhemus et al. 2004), and have been reported to have displaced the previously common native cichlid (Paratilapia) from the Madagascan central highlands and Lake Aloatra (Courtenay et al. 2004). Allen et al. (2008) noted that a noticeable reduction in native fish numbers occurs wherever this species is present.

3.1.8 Identification of Critical Habitat

The lower Ok Birim and Ok Yep sub-catchment are classified as natural habitat with minimal to no human activity that have modified the creekline apart from local villagers living a subsistence livelihood off the forest and creeks (hunting, gathering and some subsistence gardening). Ecological functioning and species composition is deemed natural.

Results in section 3.1.7 identified one Critically Endangered and two Endangered fish species within the Ok Birim and associated forested creeklines within the TSF area. Another species believed to be of significant conservation importance due to its limited distribution within the area. While this species has not formally been classified by the IUCN for conservation status, it is presumed to be of a high conservation value, due to its known limited distribution. In accordance with the IFC PS6 the Ok Birim and Ok Yep sub-catchment will be classified as critical habitat based on the species recorded during the survey. The lower Ok Birim main channel is also seen as a unique system that provides a variety of habitat for different associated aquatic fauna species.

Figure 17 shows the sites where species of conservation concern was recorded in relations to Ok Birim TSF footprint.

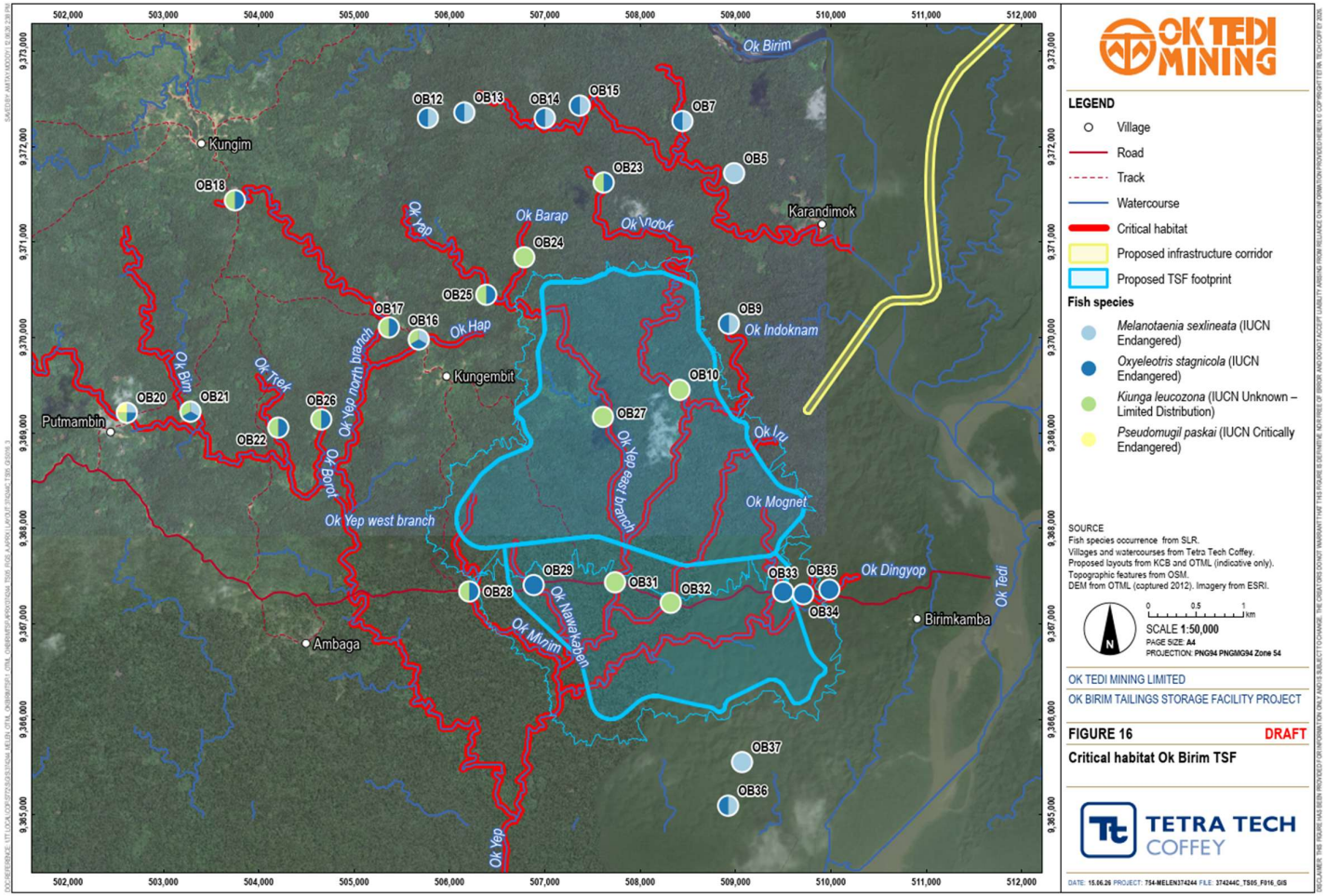

Figure 17. Critical Habitat Ok Birim TSF

3.1.9 Estimates of fish yield and daily consumption from Lower Ok Birim

In the Middle Fly River, main channel and floodplain, OTML use a standard gill net set of 13 nets, ranging in size from 1" to 7". Because of the smaller channel size, smaller fishery and lower yields, a subset of the standard gill net set historically has been set in sub catchments such as Ok Birim (sampled by OTML since 1983), Ok Ma, the Ok Mart/Wai Somare, and Ok Tedi at Ningerum. This subset consists of all nets up to and including the 5" mesh net. To maintain comparability, the same subset of nets were set for 24 hrs at two locations, OB1 and OB4, on the lower Ok Birim in July 2025. These two sites correspond to historical sites sampled on an infrequent basis since 1983 by OTML; BIR05 and BIR10 respectively. All fish retained in each net were recorded, identified, and measured (length and weight recorded). These data were compiled to provide biomass of fish in each net for the 24 hr nets set and compared to daily consumption data for Ningerum/Ok Ma. For the Middle Fly, OTML compare catch data in the 3", 3.5", 4" and 5" nets to daily intake requirements. Because catch rates and fish body sizes tend to decrease with distance further up the catchment, and so smaller mesh nets and sampling gear generally are needed to maintain catch rates, the analysis for the Ok Birim also included the 2" and 2.5" nets, providing six net sizes across the two sites (12 net/site combinations).

Table 5. Biomass (g) and percentage (%) of the 640 g of fish daily intake requirement for a family of eight for Ok Ma/Ningerum area caught by each of the target gill nets set at two locations on the lower Ok Birim in July 2025

Site	Date	2"	2.5"	3"	3.5"	4"	5"
OB1 (BIR05)	23-07-25	610 (95%)	0 (0%)	348 (54%)	2092 (327%)	0 (0%)	0 (0%)
OB4 (BIR10)	22-07-25	658 (103%)	1577 (246%)	2305 (360%)	0 (0%)	2775 (434%)	0 (0%)

Analysis of catch from the gill net sets in the Ok Birim showed catch rates were variable between nets and sites, and on five of the 12 nets/sites the catch was sufficient to meet the estimated daily intake, with one net/site meeting 95% and another 50% of the required intake. Five nets/sites failed to catch any fish. It should be noted that catch rates in general were lower than expected, and lower than observed when last sampled in 2014/15 (WRM, 2016) because the Ok Birim was in flood in July 2025. When in flood, the nets do not work as efficiently and so catch fewer fish. And this analysis includes several assumptions, firstly that the daily requirement based on the Ok Ma and Ningerum community health survey data apply to the lower Ok Birim, and that Ok Birim villagers would use gill nets. In reality a range of fishing methods likely would be used (i.e. gill nets, seine net, hook and line, spearing), and villagers would fish when water levels were low, and water was clear and catch rates were higher than recorded in 2025. Villagers, especially females and children would also collect smaller species of fish from smaller tributaries using hoop nets, fish toxicants etc. Fish catch associated with these methods were not included as part of the survey and results are likely an underestimate of village catch rates.

3.1.10 Aquatic Fauna Metal Analysis

3.1.10.1 Spatial Differences in Metal Concentrations of Fish

This section characterises the metal accumulation across the different sites sampled as part of the Ok Birim TSF study area. Figure 18 presents the average ± 1 SE concentrations for all fish species grouped per site sampled on the Ok Birim. The Cd, Cu, Pb, Se, and Zn concentrations varied spatially and did not display distinct patterns or trends and at none of the sampled sites did concentrations of Cu or Pb exceed the human health risk guideline

values. Cadmium concentrations were highest in fish from sites OB9, OB28 and OB30 and lowest at OB4, OB10 and OB7. Guideline values for Cd were only exceeded by a single individual at OB9B. Most sites show values under 0.05 mg/kg wet weight, indicating limited bioaccumulation in the sampled fish, which supports limited exposure to metals in a relatively pristine environment. Overall, cadmium does not appear to be a major contaminant of concern in this dataset, though the isolated high values would benefit from targeted follow-up sampling to confirm whether it reflects a site- or species-specific issue. Copper concentrations were highest in fish from OB31, and OB29 and lowest at OB10, OB27 and OB33. At none of the sampled sites did concentrations of Cu exceed the human health risk guideline values. Lead concentrations were highest in fish from OB31 and OB34, and lowest at OB33 and OB27. At none of the sampled sites, concentrations of Pb exceed the human health risk guideline values.

Selenium concentrations show variability across sites, however, only a single site (OB 28) had concentrations exceeding the Tolerable Daily Intake (TDI) based guideline (0.4 mg/kg/day), OB9 had the next highest concentrations for Se and the lowest concentrations were OB10 and OB32. While selenium is an essential micronutrient, the higher concentrations observed here suggest that consumption of fish from OB28 would surpass recommended intake thresholds, particularly for high consumers. However, TDI guidelines are formulated assuming an average dietary intake of metals across all food types. OTML community health surveys have shown that aside from fish, other aspects of the diet of Fly River villagers are deficient in Se, and therefore the intake of Se in fish is an important source of Se, and unlikely to be a risk, in fact, it likely helps avoid Se deficiency in villagers. Zinc concentrations were higher than (OB29) or close to (OB30 and OB31) the 70-kg and 85-kg guidance levels. Zinc concentrations were the lowest at OB4, however the hydrogeochemical modelling of seepage from the TSF shows a decrease in Zn concentrations downstream of the TSF, which would alleviate any perceived risk. Given the higher values, both Se and Zn represent key elements of interest and potential risk drivers in the assessment if exposure to either element increased as a result of the TSF development, or exposure to other food sources with higher levels of these elements.

When interpreting these results, it is important to recognise that the guideline values shown in the figures are expressed on a per-kilogram consumption basis, whereas typical fish consumption is closer to an 80g portion. This means that actual daily intakes would be approximately one-twelfth of the concentrations plotted. Applying this adjustment reduces the number of exceedances relative to the standard comparisons and no sites would exceed the relevant guideline when evaluated on an 80g serving basis. As such, the exceedances indicated by the unadjusted concentrations should be interpreted with caution, and consumption-based exposure calculations should be prioritised when assessing the potential health implications of these results. Continued monitoring of these metals remains important, however, as it enables the early detection of emerging trends, supports verification of exposure assessments over time, and ensures that any changes in environmental conditions or bioaccumulation patterns are promptly identified and managed.

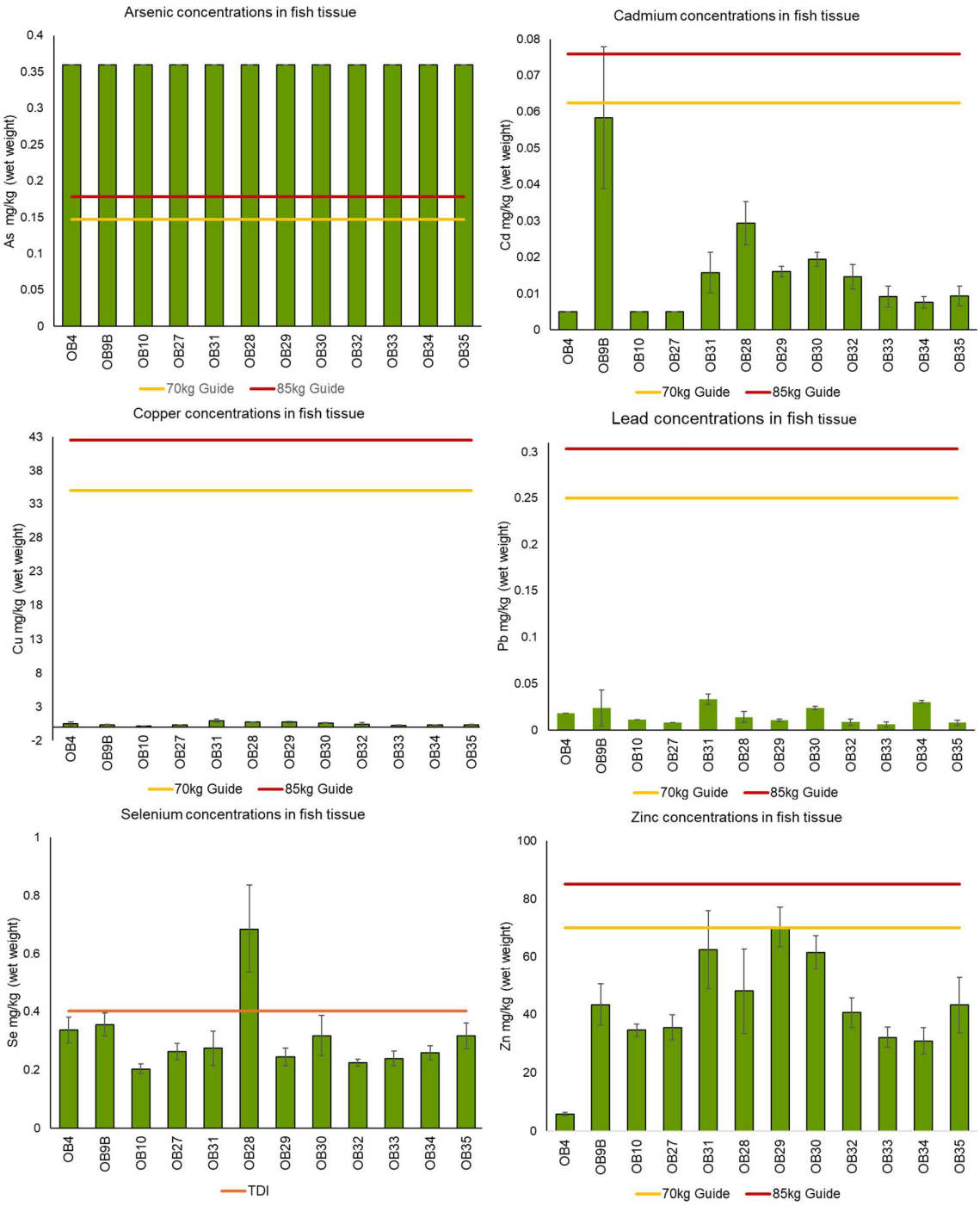

Figure 18: Concentrations of selected elements in fish tissues (dissected dorso-lateral muscle) from OB4, and whole fish specimens collected from all other sites on Ok Birim.

3.1.10.2 Species differences in metal concentrations

This section characterises the metal accumulation across the different species sampled. Figure 19 and Figure 20 present the average (± 1 SE) concentrations for each species across sites sampled on the Ok Birim. Arsenic was below detection for all specimens and therefore was invariate and not analysed further. All other metals (Cd, Cu, Pb, Se, Zn) varied among species but did not display distinct cross-species patterns, and for no species sampled from sites on the Ok Birim did concentrations of Cu or Pb exceed the human-health risk guideline values (as indicated in Table 3). Copper concentrations were low to moderate across species, and for none of the fish species did Cu exceed the relevant guideline values. Copper concentrations in crayfish (*Cherax* sp.), were elevated however this is to be expected as they have naturally high Cu concentrations because copper (haemocyanin) forms the basis of their blood, as opposed to iron (haemoglobin). Lead concentrations were similarly low, remaining below guideline thresholds for all species, even within crayfish.

Cadmium concentrations were generally low across most species (many means < 0.05 mg/kg wet weight), with only two species as well as the crayfish showing elevated values that approached or exceeded the guidelines. Guideline values for Cd were exceeded by crayfish and a single individual of *Mogurnda cingulata*, but the majority remained below 0.05 mg/kg, indicating limited bioaccumulation in most of the sampled taxa. Overall, cadmium does not appear to be a major of concern in this dataset, though the isolated high values would benefit from targeted follow-up sampling to confirm whether it reflects species-specific physiology, feeding ecology, or sample-size artefacts.

Selenium concentrations show considerable variability among species, and six of the 16 fish species exhibited concentrations higher than the Tolerable Daily Intake (TDI) based guideline (0.4 mg/kg/day), indicating that selenium is one of the more consistently elevated metals in the dataset. These six species in descending order were *Oxyeleotris stagnicola*, *Glossogobius concavifrons, Morgunda cingulata, Neosilurus ater, Parambassis gulliveri* and *Oxyeleoteris aruaensis.* While selenium is an essential micronutrient, the exceedances observed here suggest that consumption of fish from the majority of species assessed would surpass recommended intake thresholds, particularly for high consumers. However, as noted above, dietary intake from other sources is deficient in Se, and guidelines assume a balanced diet, with average intake of metals from other sources as well as from the target food item. Therefore, relatively high levels of Se in fish, especially whole fish will likely compensate for Se deficiency in other food items. Zinc concentrations varied considerably across most species, with individuals of only a single species (*Craterocephalus nouhuysi*) exceeding the 70-kg guidance (PMTDI) value. As mentioned in the previous section both Se and Zn represent key elements of interest and potential risk drivers in the assessment, not only spatially but inter-species.

As mentioned in the previous section when interpreting these results, it is important to recognise that the guideline values shown in the figures are expressed on a per-kilogram consumption basis, whereas typical fish consumption is closer to an 80 g portion. This means that actual daily intakes would be approximately one-twelfth of the concentrations plotted. Applying this adjustment eliminates all exceedances for all relevant metals relative to the standard comparisons. As mentioned previously, the exceedances indicated by the unadjusted concentrations should be interpreted with caution, and consumption-based exposure calculations should be prioritised when assessing the potential health implications of these results. As per the site-based assessment continued monitoring of these metals remains important, as it enables the early detection of emerging trends, supports verification of exposure assessments over time, and ensures that any changes in environmental conditions or bioaccumulation patterns are promptly identified and managed. These data provide a sound baseline for ongoing monitoring of project implementation.

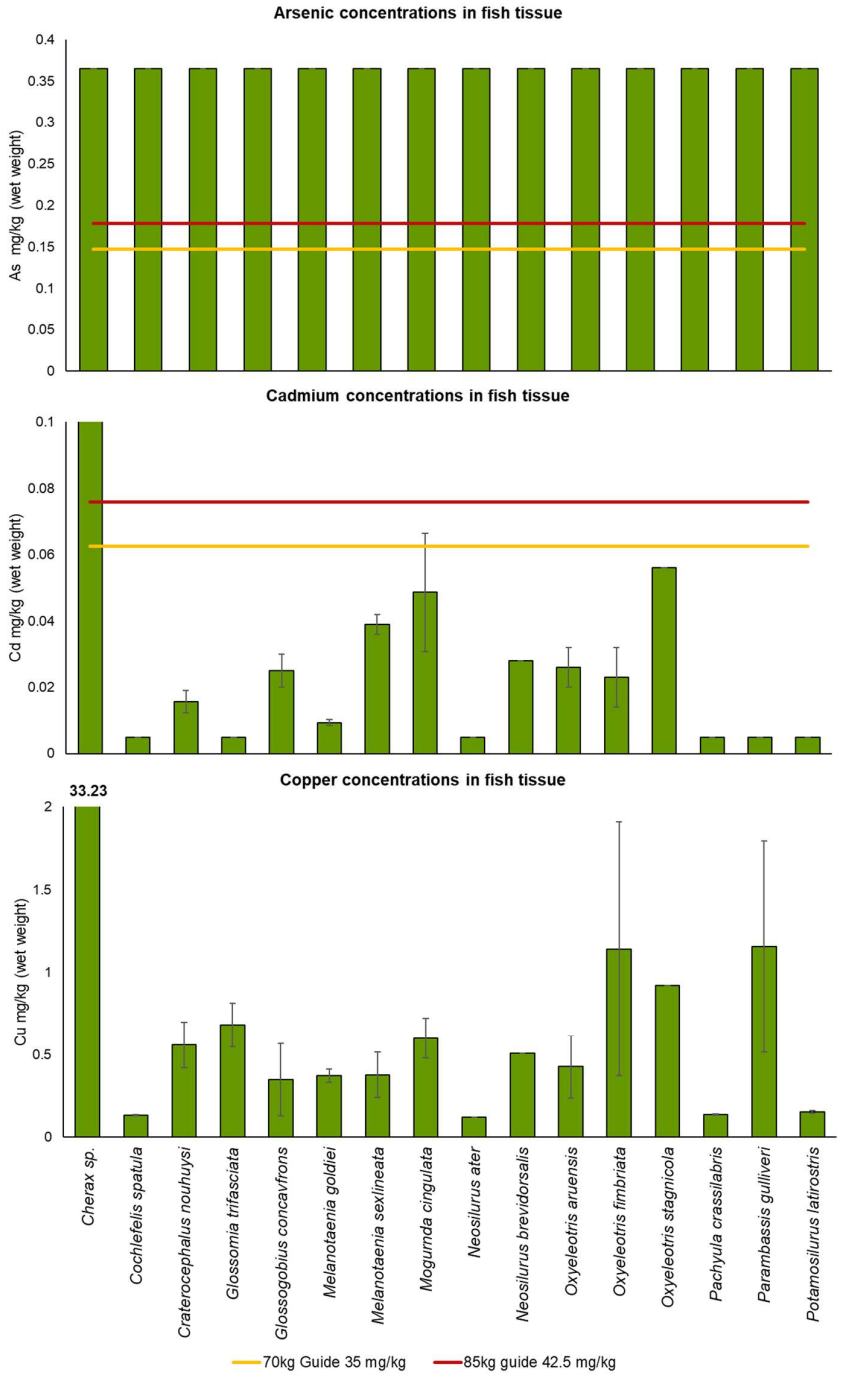

Figure 19: Arsenic, cadmium, and copper concentrations in fish tissue across fish species collected from sites on Ok Birim, with mean values (± SE) shown for each species and guideline thresholds indicated for 70 kg and 85 kg consumers.

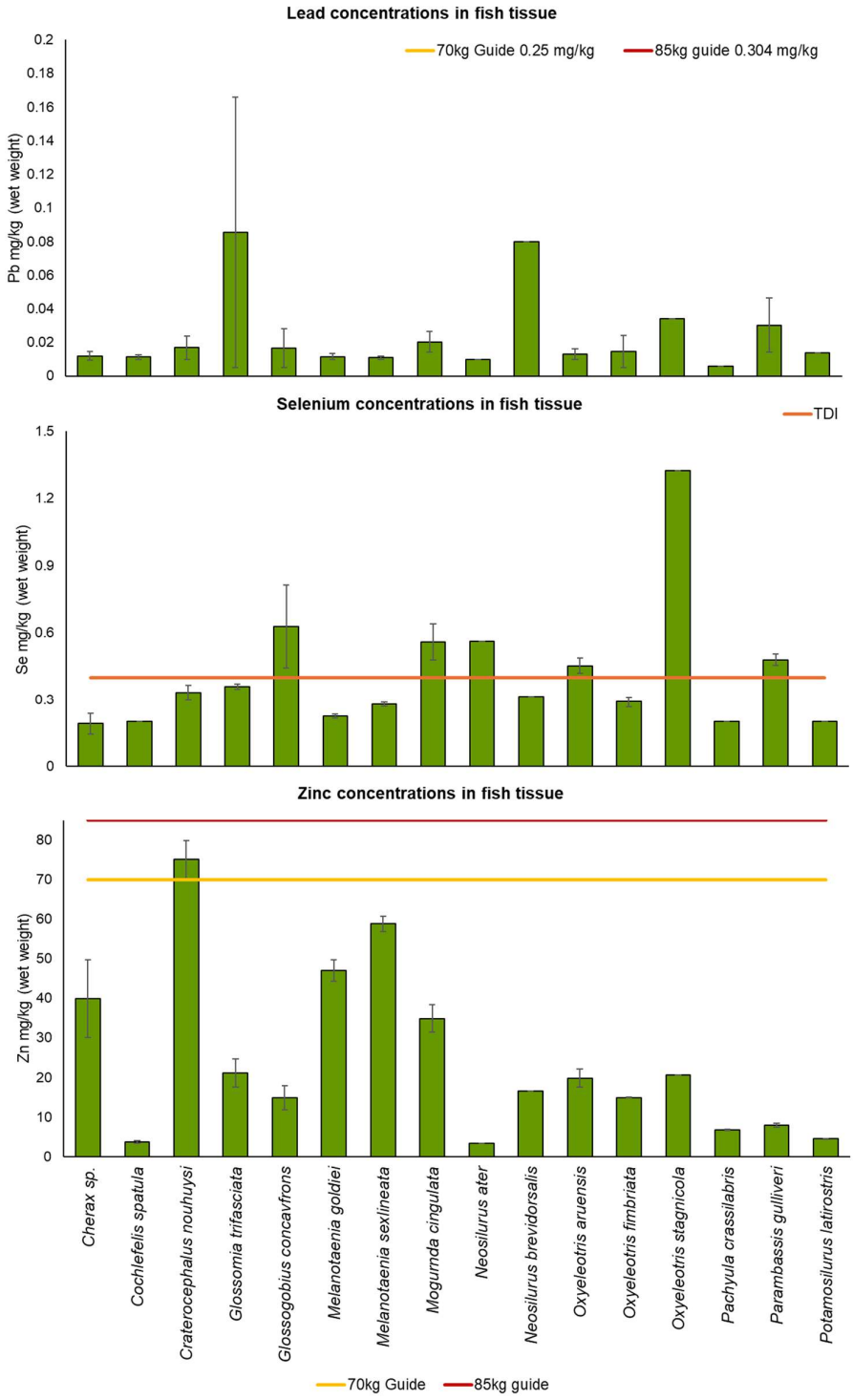

Figure 20: Lead, selenium, and zinc concentrations in fish tissue across fish species collected from sites on Ok Birim, with mean values (± SE) shown for each species and guideline thresholds indicated for 70 kg and 85 kg consumers.

3.1.10.3 Muscle vs. Liver Metal Concentrations

This section compares metal accumulation between muscle and liver tissues in fish collected from site OB4, the only site where fish were sufficiently large to allow dissection of muscle and liver samples. Across all species combined, arsenic concentrations did not differ significantly ($p = 0.167$) between muscle 0.365 mg/kg and liver 0.334 mg/kg. tissue, which is expected given that arsenic in fish typically occurs in relatively uniform organic forms that do not preferentially accumulate in specific tissues. Similarly, lead showed no significant tissue-level differences ($p = 0.147$), with corresponding mean concentrations of muscle: 0.018 mg/kg and liver: 0.034 mg/kg., indicating limited hepatic sequestration and consistent distribution in fish tissues at this site.

In contrast, cadmium, copper, selenium, and zinc were all significantly higher in liver tissue relative to muscle. Cadmium concentrations were elevated in the liver (muscle = 0.005 mg/kg, liver = 0.553 mg/kg; $p = 0.01$), as were copper (muscle = 0.529 mg/kg, liver = 3.582 mg/kg; $p = 0.017$), selenium (muscle = 0.335 mg/kg, liver = 2.114 mg/kg; $p = 0.003$), and zinc (muscle = 5.918 mg/kg, liver = 263.09 mg/kg; $p = 0.011$). This pattern aligns with established toxicokinetic behavior, as the liver is the primary site for metal storage, detoxification, and metallothionein binding. The consistently elevated hepatic concentrations across species indicate active regulation and biotransformation of these metals, with muscle tissue representing only a minor sink by comparison.

These trends were generally consistent across nearly all species analysed. The only exception was *Parambassis gulliveri*, in which both lead and zinc concentrations were lower in the liver than in muscle tissue; Pb: Liver = 0.01 mg/kg and Muscle = 0.03 mg/kg, Zn: Liver = 4.72 mg/kg and Muscle = 7.91 mg/kg. This is contrary to the pattern observed for all other taxa. This species-specific deviation may reflect differences in metabolic rate, feeding ecology, or lead and zinc regulation pathways relative to the other species sampled, and it warrants further investigation through targeted sampling or larger sample sizes.

These results demonstrate clear tissue-specific partitioning for Cd, Cu, Se, and Zn, with the liver consistently acting as the dominant reservoir for these metals at site OB4. In contrast, As and Pb show no tissue-level differentiation, suggesting limited hepatic accumulation or a more uniform distribution within the organism. The differences in tissue burden should be considered when interpreting risk assessments or comparing datasets derived from differing tissue types, as reliance on muscle alone would underestimate the body burden i.e. concentrations of key metals.

3.1.10.4 Metal Concentrations – Effect of Trophic Position

Relationships between trophic position and metal concentrations in fish tissue were evaluated using Spearman rank correlation analyses across all sampled sites on Ok Birim (see Table 6). Arsenic was excluded from this analysis as concentrations in all samples were below analytical detection limits.

Significant positive correlations were observed between trophic position and concentrations of cadmium (Spearman $\rho = 0.579$, $p < 0.001$, $n = 40$), copper (Spearman $\rho = 0.238$, $p = 0.029$, $n = 85$), lead (Spearman $\rho = 0.348$, $p = 0.015$, $n = 48$) and selenium (Spearman $\rho = 0.751$, $p < 0.001$, $n = 77$). These results indicate that individuals occupying higher trophic positions tend to exhibit greater concentrations of these metals, suggesting potential trophic transfer and accumulation within the food web and that the accumulation of these metals may be influenced more strongly by trophic transfer than species-specific physiology, exposure pathways, or local environmental conditions. Scatter plots illustrating the relationships between trophic position and cadmium and selenium concentrations are presented in Figure 21. In contrast,

zinc concentrations demonstrated a significant negative relationship with trophic position (Spearman ρ = -0.366, p < 0.001, n = 85), indicating that fish occupying lower trophic positions generally exhibited higher zinc concentrations than predatory species. The relationship between trophic position and zinc concentration is illustrated in Figure 21. No significant correlations were observed between trophic position and concentrations of copper (Spearman ρ = 0.118, p = 0.203) or lead (Spearman ρ = 0.125, p = 0.177), suggesting that accumulation of these metals may be influenced more strongly by species-specific physiology, exposure pathways, or local environmental conditions rather than trophic transfer.

Overall, these findings suggest that trophic ecology influences the accumulation of certain metals within fish communities in the project area, with evidence of increasing concentrations of cadmium, copper, lead and selenium at higher trophic levels, while zinc concentrations appear to be greater in species occupying lower trophic positions. These patterns are consistent with differences in metal uptake, regulation, and dietary exposure pathways among fish species occupying different positions within the aquatic food web.

Table 6: Spearman rank correlations between Trophic position and Metal concentrations for fish species collected from Ok Birim.

Spearman Rank Correlations – Trophic Position vs. Metal concentration					
	Cadmium	Copper	Lead	Selenium	Zinc
Spearman's rho	**0.579**	**0.238**	**0.348**	**0.751**	**-0.366**
p-value	<0.001	0.029	0.015	<0.001	<0.001
N	40	85	48	77	85

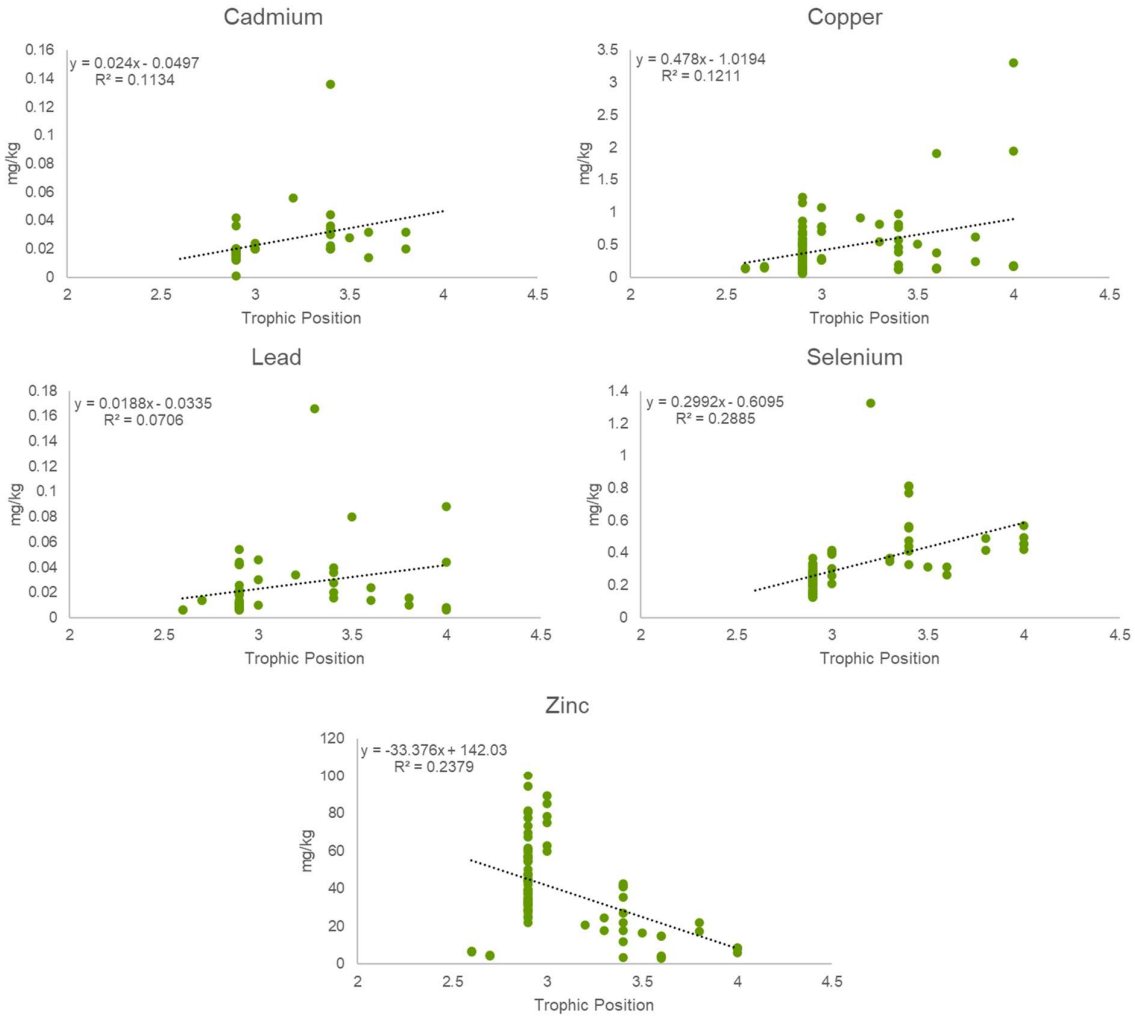

Figure 21: Scatter plots indicating linear relationships between trophic position and metal concentrations (cadmium, copper, lead, selenium, and zinc) of individuals fish sampled from selected sites across Ok Birim. Each panel shows observed values with a fitted regression line, corresponding equation, and R^2 value.

3.1.11 Social Use Observations

When sampling sites across and adjacent to the TSF, general discussions were had with villagers assisting the survey team, on their everyday use of the creeks.

Apart from differences in use due to the size of the creek (i.e. bigger creeks for canoe transport, or supporting larger fish), there didn't appear to be any differentiation amongst creeks across and adjacent to the TSF in terms of resource use. It is noteworthy that all creeks sampled had local language names, and although not addressed in the current survey it is possible that some creeks have particular cultural significance.

3.1.11.1 Freshwater Use

All villages that were visited had rainwater tanks, collecting water either off bush huts that had a corrugated iron roof, or off haus wind, however villagers still used springs and creeks for drinking water. Locations of 'springs' and groundwater sources supporting the springs were not identified, as this was outside the current scope. At Karandimok however, a small spring with a bamboo 'spout' was observed emanating from a high bank close to where the canoes / dinghies were tied up. Villagers mentioned other springs close by in the bush, which are commonly used for drinking water and washing. Creeks in general were used for drinking water, and washing, as well as the washing of sago during the manufacturing process, as observed in several locations across the TSF where sago palm was present and had been felled / processed.

3.1.11.2 Food

Villagers would collect prawns (*Macrobrachium sp*.), crayfish (*Cherax sp*.), small and large fish, and eels from creeks. Larger fish tended to be collected from larger creeks and the main Ok Birim channel, likely reflecting the carrying capacity of these larger water courses. Eels were mentioned specifically, likely having a high significance, probably because of their size (growing up to 1m+ in length) and their rarity. Villagers mentioned two 'types' of eels were present, likely Indonesian Shortfin Eel *(Anguilla bicolor)*, and Giant Mottled Eel *(Anguilla marmarata)*, both of which have been recorded from the upper Fly River catchment. Fishing methods such as hook and line, and gill netting would be used for fishing in the larger Ok Birim, as well as diving / spearing when water levels were low, and water was clear. In smaller creeks, small fish would be collected with hoop nets made of cane / sapling and bush rope / twine. Rainbowfish, gudgeons and hardyheads would be the species most likely caught this way given their abundance and size. Gobies, being a bottom dwelling species would be more difficult to capture. Additionally, blue eyes are likely too small to be captured by the relatively coarse bush nets. Larger fish were caught by diving using 'eye glasses' (swimming goggles) and spear. Fish caught this way likely included larger rainbowfish, grunters, eels, and larger gudgeons and gobies. Locally grown derris root, a natural fish toxicant, was also used by villagers to capture fish. The root is collected from the bush/gardens where it is specifically grown for this purpose, macerated and washed in a pool in the creek to release the sap/toxin which incapacitates the fish. Villagers also sought larger crayfish and prawns when fishing, especially amongst snags / debris dams, usually by spearing them.

Once caught, small fish would be wrapped in a broad leaf and heated over a fire and then eaten whole. Community health studies in the Middle Fly River have shown that this is an important source of calcium and selenium, especially for children. The same is likely true here. Larger fish would be cooked whole on the fire, and the whole fish eaten, often with sago and other staples (banana etc).

Crocodile and turtle were reported as caught and eaten, especially in the dry season when water levels were low and water clarity good, however this was only mentioned by villagers for the Lower Ok Birim. In the Middle Fly River, turtles are caught using pits dug on sandy banks to entrap females coming out of the water to dig nests and lay eggs, also occurring in the dry season.

Although not discussed specifically with villagers, based on Awin and Faiwol villages in the adjacent upper catchment, certain fish likely have specific cultural importance and may have restricted use. For example, large eels are not common, and highly prized, and in upper catchment only eaten by older males.

No mention was made of collecting any aquatic plants for consumption. In addition, freshwater mussels do not appear to occur in the smaller creeks in the Ok Birim area.

3.1.11.3 Transportation

Generally, the smaller creeks across the TSF were too small to be used for transport, however, the Ok Yep is used to access Ambaga village by canoe and dinghy from the Ok Tedi, with access only possible when water levels are high. The Ok Birim is a major transport route to villages adjacent to the TSF (i.e. Karandimok), but also villages further upstream on the Ok Birim.

3.2 Ok Ma Associated Infrastructure Corridor

3.2.1 Site Habitat Assessment

The Ok Ma project area and reference tributaries, varied in morphology and substrate and habitat composition.

Substrate across potential reference sites was dominated by a mix of larger substrate cobbles (64 – 256 mm) and smaller substrate Sand (1-4mm). Reference sites OM3 and OM6 both had bedrock present.

Potentially exposed site OM4 was the only site that had boulders (>256mm) present. Majority of the sites had larger substrate present with sand and silt between the larger substrate (Figure 22).

The substrate diversity was between four (4) and eight (8) types at all sites, with OM3, OM6, OM7 and OM12 having all five (5) substrate types present within the creekline.

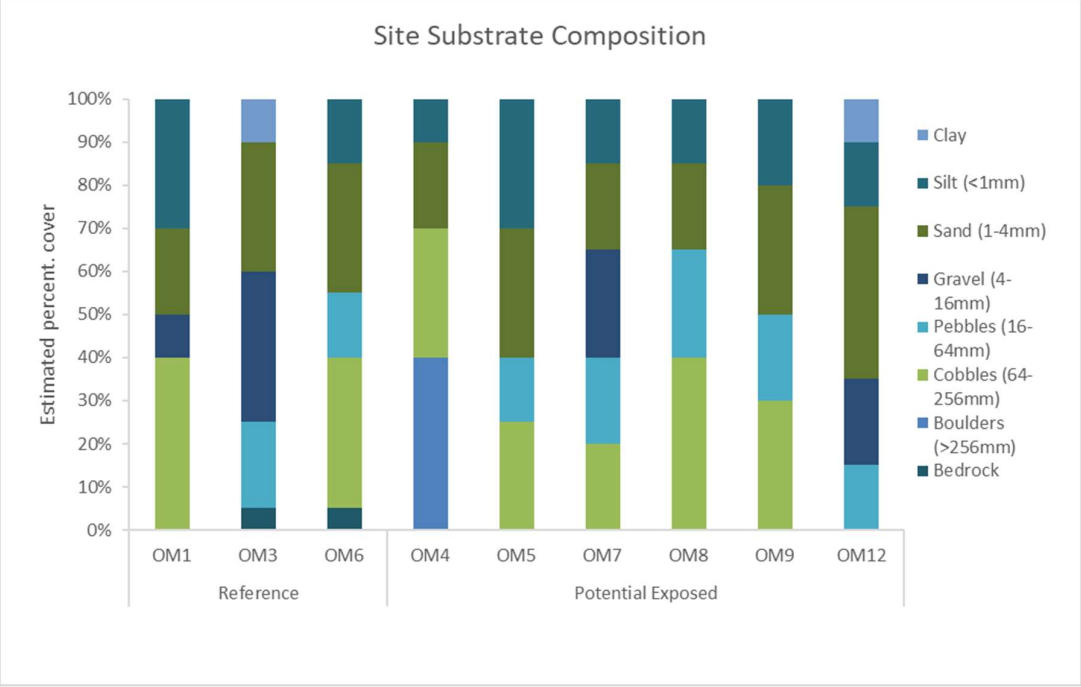

Figure 22: Ok Ma site- substrate composition.

The Ok Ma sites were comprised mostly of mineral substrate, with a small percentage cover by detritus. Reference site OM3 is the only site that had algal cover making up 25% of the substrate cover at the site. Large woody debris was present at all sites with potentially exposed site OM12 having the largest composition (20%) across all sites.

Submerged macrophytes cover was highest at OM3 (10% cover) followed by OM12 (5% cover), and were the only two sites within the Ok Ma that had submerged macrophytes available.

Reference site OM3 had the highest habitat diversity (7 types) followed by potentially exposed site OM12 (5). The lowest habitat diversity was recorded at potentially exposed site OM5 (2) (Figure 23).

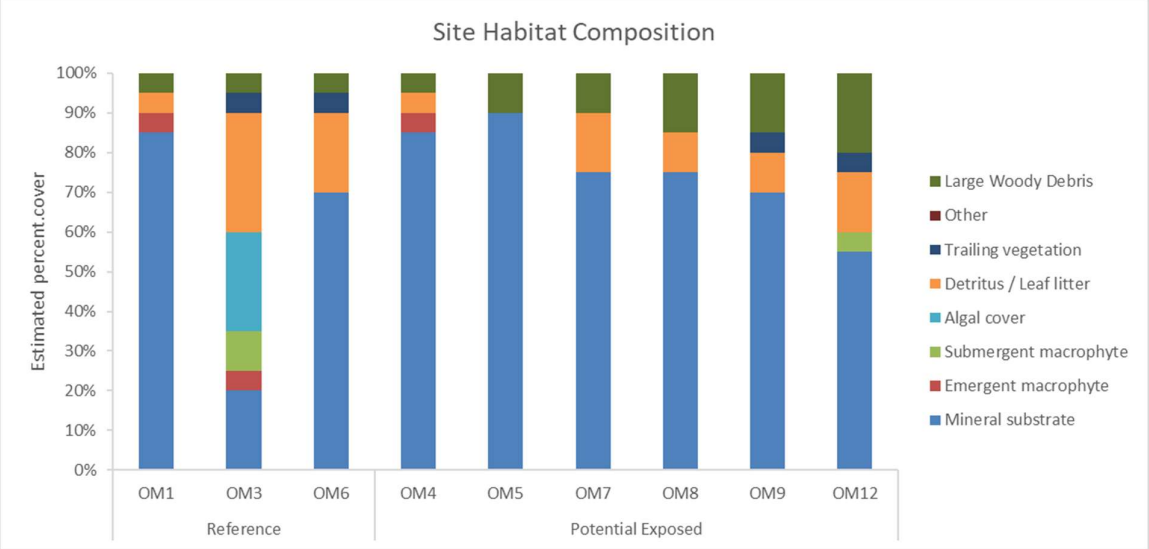

Figure 23: Ok Ma site- habitat composition.

3.2.2 Aquatic Macrophyte Cover

The same two species of macrophyte observed in the Ok Birim TSF creeks were again observed at creekline sites within the Ok Ma during the aquatic fauna survey 2025 (Plate 1). One species of water lily (*Nymphaea* cf. *elleniae*), native to Papua New Guinea, and an unknown species of the genus *Vallisneria* sp., commonly known as eelgrass or tape grass (Howard Rogers pers. comms).

Reference site OM3 (10% cover) had both species of macrophyte present in equal representation across the site. Potentially exposed site OM12 had 5% of macrophyte cover across one species (*Vallisneria* sp.). No other site within the Ok Ma had any macrophyte cover present, and there was no macrophyte observed in the main channel of the Ok Ma; in the Ok Birim macrophyte also only occurred in the slower-flowing, smaller rainforest creeks across the TSF area and not in the main channel.

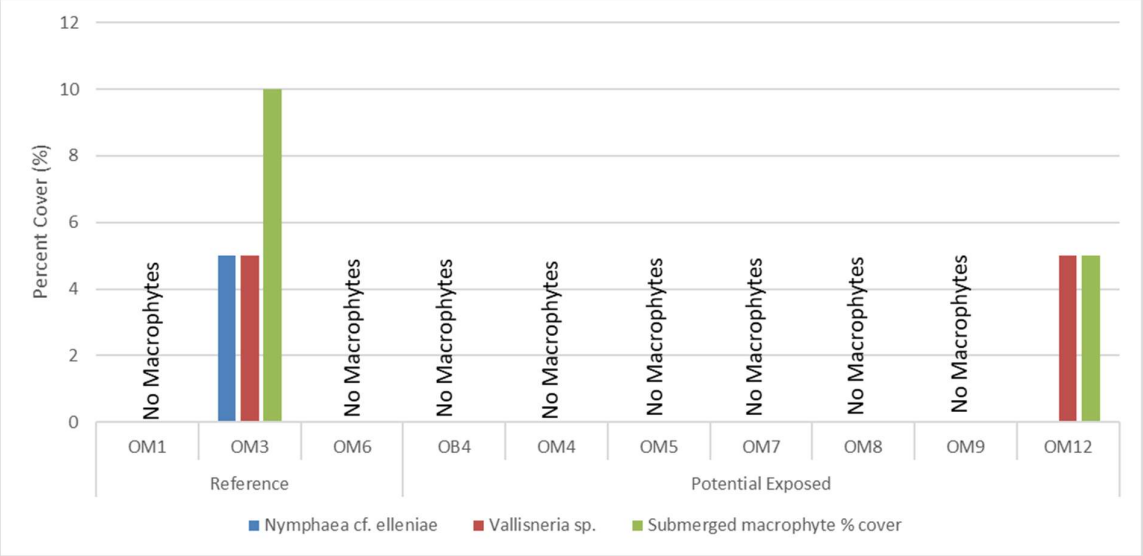

Figure 24. Percentage of macrophyte (%) cover at each Ok Ma study site surveyed as part of the 2025 aquatic fauna survey.

3.2.3 Sediment quality

Sediment samples were collected at each site and analysed at the OTML analytical laboratory. Concentrations of sediment total metal concentrations were generally low but varied between sites. Some sites recorded concentrations of metals in excess of the DGV, including copper (Cu), lead (Pb) and zinc (Zn).

Sediment Cd concentrations were less than detection limits (< 0.01 mg/kg) at all sites sampled along the Ok Ma. Cu concentrations ranged from 4.8 mg/kg (at reference site OM1) to 50.6 mg/kg (at reference site OM3). All sites were below the DGV of 65 mg/kg during the 2025 surveys.

No sites exceeded the Pb DGV (50 mg/kg), with potentially exposed site OM12 having the highest concentration (9.7 mg/kg) (Figure 25).

Concentrations of Zn ranged from 104 mg/kg (at potentially exposed site OM12) to 45.6 mg/kg (potentially exposed site OM5). No sites surveyed in 2025 exceeded the DGV concentration of 200mg/kg (Figure 25). And no sediment metal concentrations in the Ok Ma study area exceeded the GV-high concentration for each metal respectively.

Figure 25. Concentration of metals within sediments (mg/kg dry weight), showing plots for Cu, Pb and Zn in comparison to DGVs (NB all data for Cd were less than LOD and therefore not plotted).

The percentage carbon ranged from 0.69% at reference site OM3 and potentially exposed site OM9, to 2.53 % at potentially exposed site OM12 (Figure 26). Percent total sulfur (% S) was low, with all sites recording values less than 1% (Figure 26). %S ranged from 0.05% at reference site OM6 and potentially exposed site OM9, to 0.21% at reference site OM1.

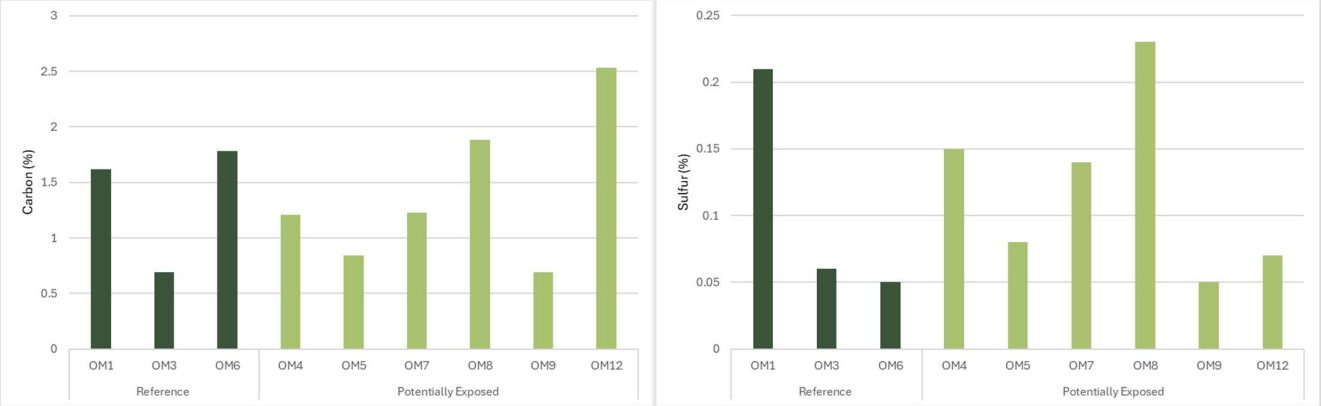

Figure 26. Percent total carbon (left) and percent sulfur (right) content within sediment collected in November 2025

The acid neutralising capacity (ANC) of sediments collected from the Ok Ma study area ranged from values below the limit of detection (i.e. < 0 kg H_2SO_4/tonne; at potential exposed sites OM12) to 55.38 kg H_2SO_4/tonne (at reference site OM1; Figure 27). ANC is a measure of a sample's ability to neutralise strong acid and essentially refers to the sample's buffering capacity (AMIRA 2002). The higher the ANC, the greater the sample's capacity to neutralise acid. ANC values of zero or less than detection were recorded from OM12 (Figure 27). Samples from these sites suggest limited capacity to neutralise acid.

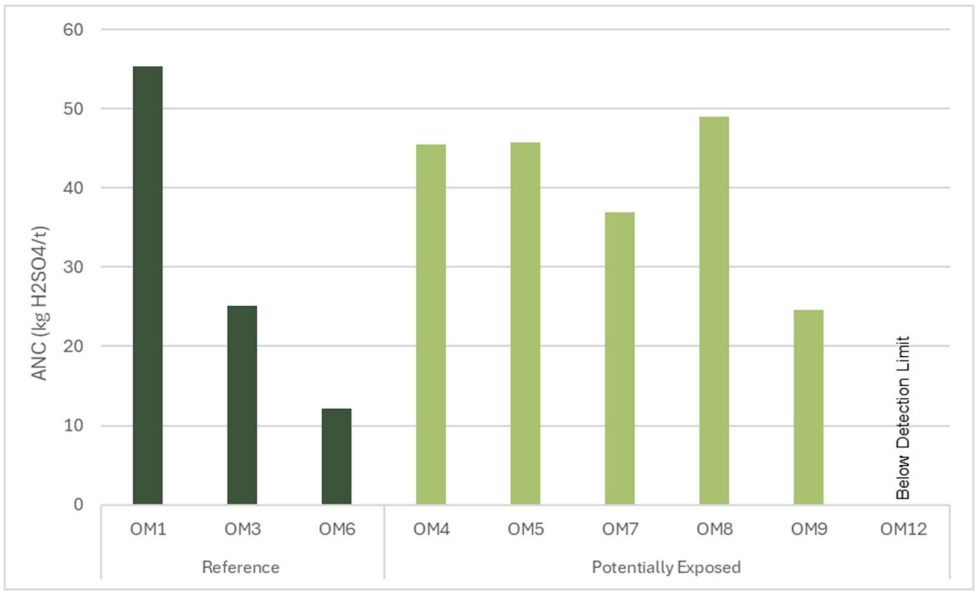

Figure 27. Acid neutralising capacity (ANC kg H_2SO_4/tonne) of sediments collected at each site

The net acid producing potential (NAPP) of sediments can be determined from total S (%) and ANC using the following calculations:

Maximum Potential Acidity (MPA) = total %S *30.6

NAPP = MPA – ANC (AMIRA 2002).

NAPP values calculated for sediment samples collected in 2025 ranged from -48.95 (at reference site OM1) to 4.02 (at potentially exposed site OM12, Figure 28).

Negative NAPP values suggest the sample may have sufficient ANC to prevent acid generation (AMIRA 2002). All reference and potentially exposed sites have negative NAPP values except for potentially exposed site OM12 which has a positive NAPP value, indicating that the site may be naturally acid generating.

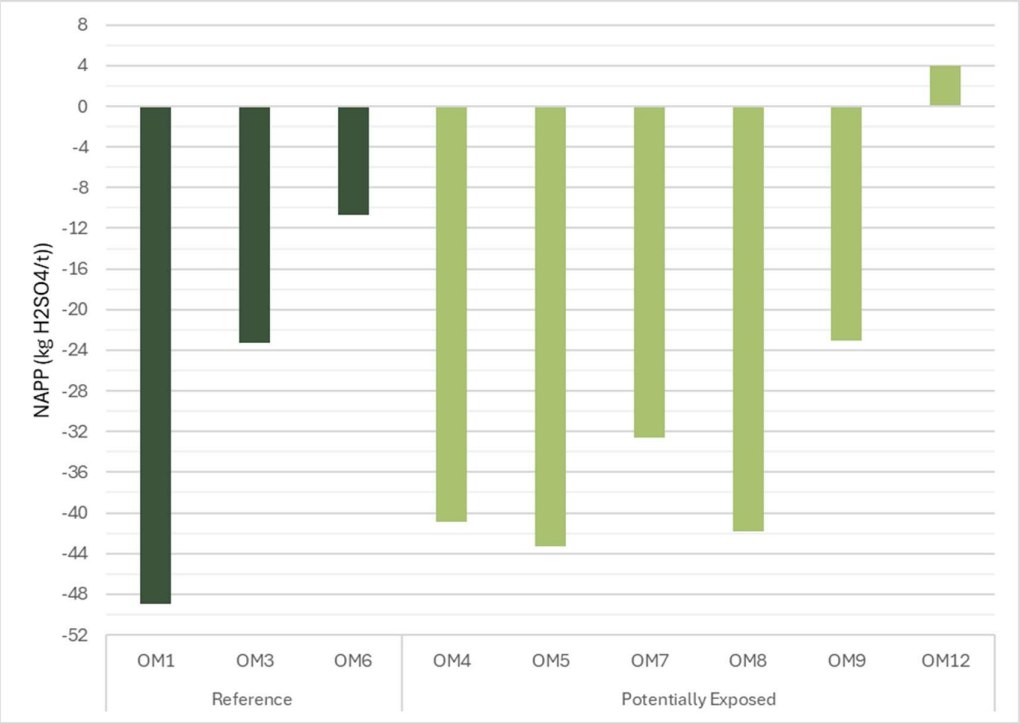

Figure 28. Net acid producing potential (NAPP, kg H_2SO_4/t) calculated for each site

3.2.4 Water Quality

3.2.4.1 Physico-chemistry

pH

Water was characterised by alkaline pH, with one site slightly below neutral (range 6.7 – 8.1). No reference sites exceeded the upper DGV limit (8.0), while potentially exposed sites OM4, OM5, OM7, OM8 and OM9 all had pH of 8.1 that marginally exceeded the upper DGV. All sites located within the main Ok Ma channel were alkaline (Figure 29). None of the Ok Ma sites had pH levels below the lower DGV indicating more alkaline waters than the Ok Birim sites. As the Ok Ma is a larger creek, arising in upland catchment, with a lot more contact with alkaline geological features that could contribute to the pH and assumed to be normal for the Ok Ma.

Dissolved Oxygen (DO)

Daytime DO (% saturation) ranged from 72.5% at OM8 to 168.1% at OM4 (Figure 29). Reference site OM1 and potentially exposed sites OM5, OM9 and OM12 were all within the guideline values, while potentially exposed site OM8 fell below the lower DGV, but not low enough to be considered of ecological concern. All other sites (reference and potentially exposed) were above the upper DGV during the survey.

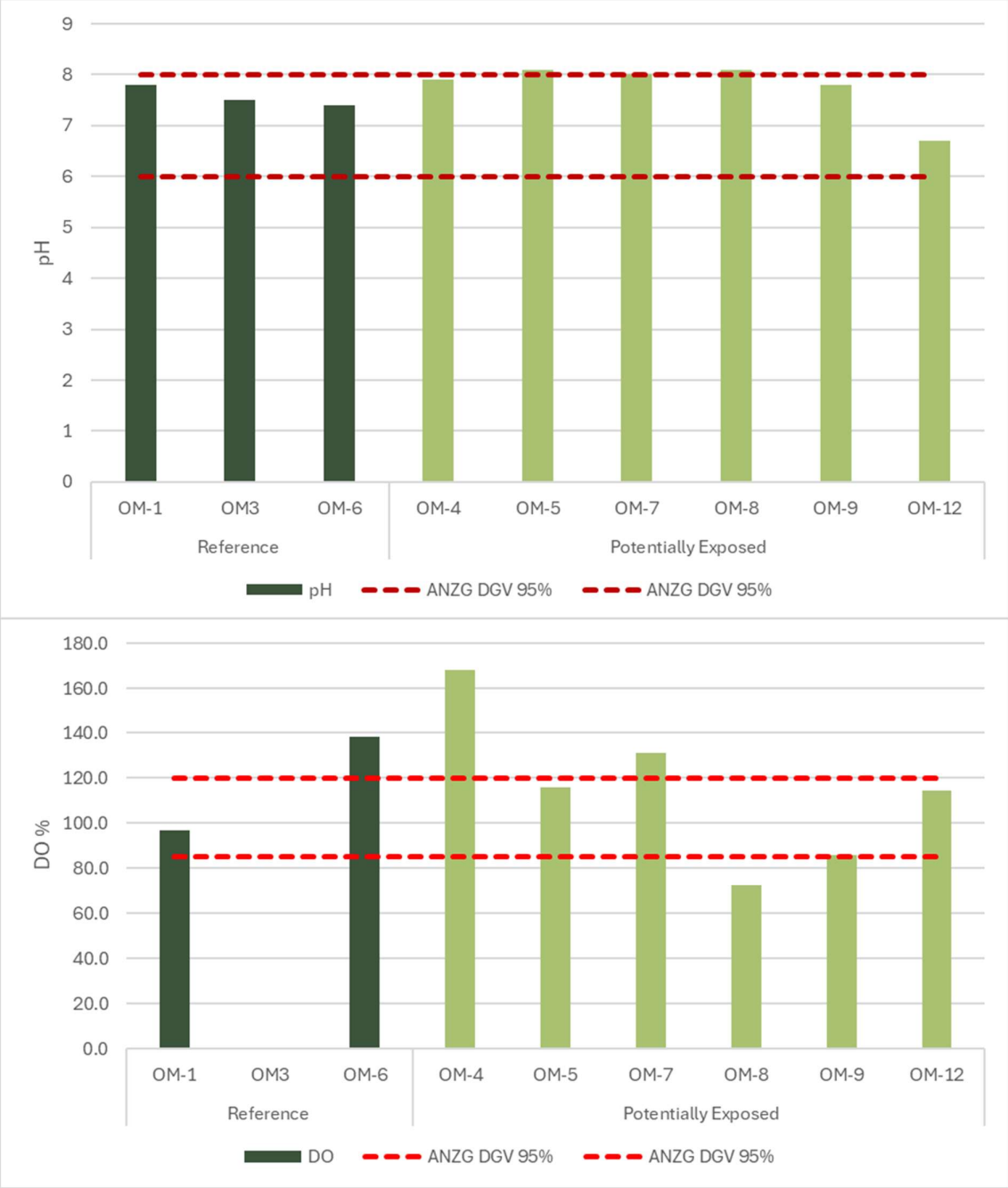

Figure 29. pH and Dissolved Oxygen Saturation (%) recorded from all sites sampled in comparison to the ANZG 95% default guideline values. **Note: no DO measurement was taken at OM3 due to malfunction of the probe**

Electrical Conductivity

EC ranged from 20 µS/cm at OM12, to 100 µS/cm at OM1, OM4 and OM5 (Figure 30). Values recorded from all sites were below the ANZG (2018) DGV (i.e. < 250 µS/cm) and all were considered fresh as defined by the Department of Environment (DoE 2003)[4].

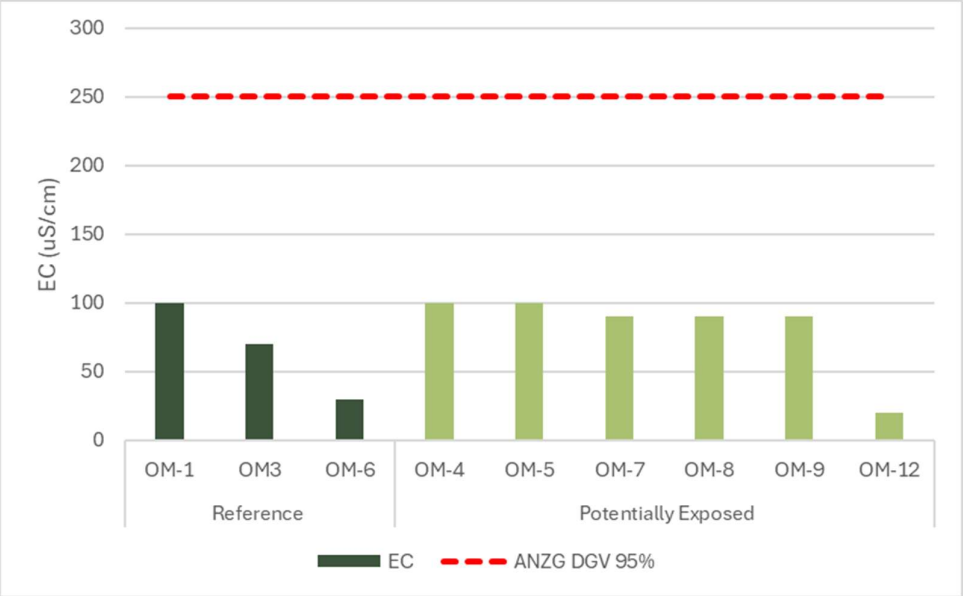

Figure 30. Electrical conductivity (µS/cm) recorded from Ok Ma during the current study in comparison to the ANZG DGV 95%

3.2.4.2 Metals

Concentrations of dissolved chromium, copper, lead, zinc, cadmium and arsenic were measured across reference and potentially exposed sites. Concentrations of most dissolved metals, with the exception of Cu, were either below the limit of detection or below the relevant ANZG (2018) DGV for protection of 95% of freshwater species (Figure 31).

LOD for dCr was 0.9 ug/l compared to the 95% species protection DGV of 1.0 ug/L. Concentrations at all sites were less than the LOD, with the exception of OM3. All sites were therefore below the DGV except reference site OM3 where dCr was 1 ug/l and equal to the DGV.

Concentrations of dCu exceeded the DGV at reference sites OM1 and OM6, and at six (6) potentially exposed sites (OM4, OM5, OM7, OM8, OM9 and OM12). Site OM5 (10 ug/l) had dCu concentrations 7x higher than the 95% species protection DGV, and was the highest concentration recorded from the Ok Ma sites. dCu at OM5 was higher than the 80% species protection GV (1.3 ug/l). Elevated dCu is perhaps not unexpected as the Ok Ma arises close to Mt Fubilan and the Ok Tedi mine, a naturally mineralised area.

[4] Fresh defined as < 1500 µS/cm, Brackish = 1500 – 4500 µS/cm, Saline = 4500 – 50,000 µS/cm, Hypersaline > 50,000 µS/cm (DoE 2003). Classifications were presented as TDS (mg/L) in DoE (2003) so a conversion factor of 0.68 was used to convert to conductivity µS/cm as recommended by ANZECC/ARMCANZ (2000).

All dPB concentrations across reference and potentially exposed sites were below the detection limit of 0.7ug/l, which was lower than the DGV.

Concentrations of dZn ranged from values below the limit of detection (i.e. < 0.7 µg/L) to 2 µg/L at potentially exposed site OM8 (Figure 10), with all sites below the DGV of 8 µg/L.

Concentrations of dCd at all sites were lower than the OTML laboratory LOD (<0.6 ug/L), which was higher than the DGV value of 0.2 ug/L. Therefore, it was not possible to assess exceedances of the 95% species protection DGV for dCd for Ok Ma sites. The LOD sits between the 90% (0.4 ug/L) and 80% (0.8 ug/L) species protection DGV, so therefore, conservatively, dCd exceeded the 90% species protection GV.

dAs concentrations ranged from below the limit of detection (i.e. < 0.4 µg/L) at the majority of sites, to 1 µg/L at reference site OM1 and potentially exposed sites OM5 and OM7. The LOD was lower than the 95% species protection DGV. Reference sites OM3 and OM6 and potentially exposed site OM4, OM8, OM9 and OM12 were all below the LOD. All sites were below the 95% species protection DGV.

Figure 31. Dissolved metal concentrations (µg/L) in comparison to the 95% ANZG (2018) guidelines showing plots for dCr, dCu, dPb, dZn and dAs

3.2.5 Fish Fauna

3.2.5.1 Species composition and species richness

A total of 16 freshwater species were recorded from the Ok Ma sites (Appendix F) during the current study. The systems likely support greater species richness than reported here as single surveys seldom capture all species at a location on a single attempt, and local landowners identified additional species of fish which they think occur in the Ok Birim using images from Allen et al. (2008). All were native species, including Apogonidae (mouth almighty), Atherinidae (hardyheads), Clupeidae (herring), Eleotridae (gudgeon), Hemiramphidae (garfishes), Melanotaenidae (rainbowfish), Plotosidae (eel-tailed catfishes) and Terapontidae (grunters). Ok Tedi Rainbowfish (*Melanotaenia oktediensis*, Toothed River Herring (*Clupeoides papuensis*) and Striped-cheek Gudgeon (*Bostrychus strigogenys*) were only recorded from the Ok Ma main channel during the 2025 survey, and not from tributary creeks. No invasive species were recorded from the Ok Ma main channel.

The number of species ranged from three (3) at OM1 (reference site) and OM5 (potentially exposed), to nine (9) at OM9 (the potential exposed site, Figure 32). The Ok Ma main channel was an open channel with deeper and fast flowing water which limited the effectiveness of electrofishing, while habitat complexity limited the effectiveness of seine netting. OTML large mesh nets were set at OM4 and OM5, but an overnight flood entangled and swept the nets into riparian vegetation with zero catch. OTML have sampled the lower Ok Ma in early 1980s (1983-1986) recording 13 species, and again in 1992 and 1993 recording nine species. In general, the Ok Ma provided different habitat availability for fish species in comparison to the Ok Birim and associated smaller creeklines.

OTML data indicate that the Ok Ma main channel also acted as a refuge for a range of species that either were once common in the main Ok Tedi channel pre-mine and have now been lost or were common in the Middle Fly and are in decline. Ok Ma appears to form an important refuge area with potential for these species to recolonise the Ok Tedi post-mine closure, once habitat in the Ok Tedi has improved.

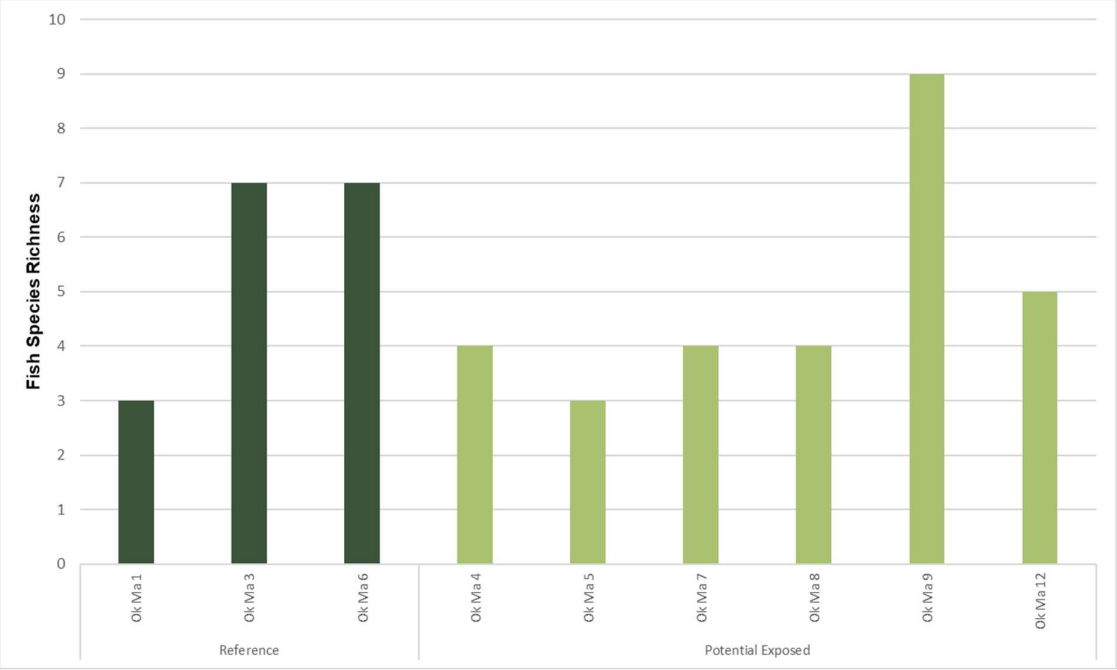

Figure 32. Fish species richness recorded from each site in the Ok Ma study area

3.2.5.2 Abundance

A total of 238 individual fish were recorded from the nine (9) Ok Ma sites sampled in Nov-25, with some variation in fish abundances recorded between sites (Figure 33 and Appendix F). The greatest abundance was recorded at reference site OM6 (58 individuals), followed by OM3 (57 individuals). The lowest abundance recorded was at OM5 with seven (7) individuals, followed by OM7 with 10 individuals. The Ok Ma was in flood during sampling of the lower Ok Ma sites (OM7, OM6, OM5) which reduced the efficiency of gill nets and reduced the catch rates within the Ok Ma main channel.

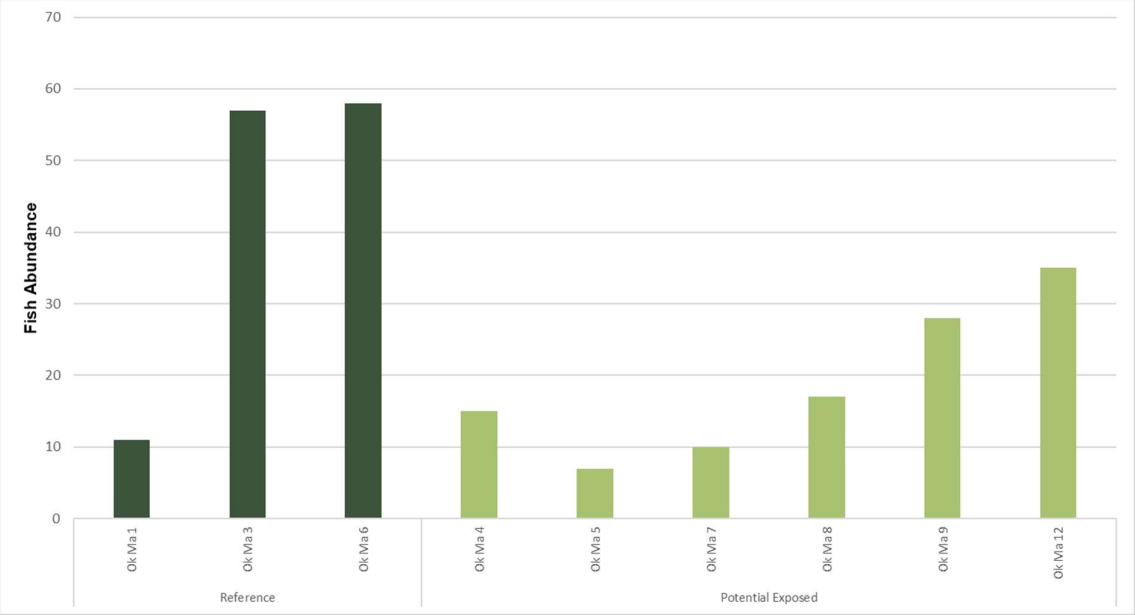

Figure 33. Total abundance of fish recorded from each site in the Ok Ma study area.

3.2.6 Other Aquatic Fauna Observed

Various sightings of freshwater crocodiles (*Crocodylus novaeguineae*) were recorded during the sampling of the lower Ok Ma. *C. novaeguineae* prefers freshwater habitats and is found throughout most of New Guinea's vast system of freshwater rivers, swamps and marshes. According to the IUCN Red List *C. novaeguineae* is listed as least concern. The species of crocodile was previously more common within the Ok Tedi main channel, and the Ok Ma channel, as with the Ok Birim, provides a refuge area.

3.2.7 Conservation significance of fish species recorded Ok Ma

The Ok Tedi Rainbowfish *(Melanotaenia oktediensis)* is listed as Critically Endangered (CR) by the IUCN (listed 4 December 2019) and was recorded within the upper/mid Ok Ma Channel (OM1, OM5 and OM6). The species has restricted extent of occurrence, and the population has been severely fragmented due to the Ok Tedi Mine and is now found only in tributaries between which there is little dispersal. The Ok Ma channel, a tributary of the Ok Tedi provides a refuge for the species as the channel is not currently impacted by the mining operations.

Glossogobius robertsi (Robert's Goby) is listed as Near Threatened by the IUCN (listed 5 December 2019). This species occurs in both turbid lowland rivers and small, clear mountain tributaries between elevations of about 50-600 m. It is most commonly encountered in high elevations in rocky streams with variable flow in mountainous terrain. It can reach a maximum size of 13.5 cm SL (G.R. Allen pers. comm. 2019). *G. robertsi* were recorded at four (4) sites within the Ok Ma channel (OM3, OM7, OM8 and OM9). The species was recorded within the Ok Ma previously in 2011.

Photographs of these conservation-significant species recorded during the survey are provided in Plate 2.

3.2.7.1 Introduced species

No introduced species were recorded within the Ok Ma channel.

3.2.8 Identification of Critical Habitat

The Ok Ma is classified as natural habitat with minimal to no human activity that have modified the creekline. Ecological functioning and species composition is deemed natural.

Results in section 3.2.7 identified one Critically Endangered and one Near Threatened fish species within the Ok Ma. In accordance with the IFC PS6 the Ok Ma will be classified as critical habitat based on the species recorded during the survey. The Ok Ma is also seen as a unique system that provides a variety of habitat for different associated aquatic fauna species.

Figure 34 shows the sites where the species of conservation concern was recorded in relations to the proposed infrastructure corridor.

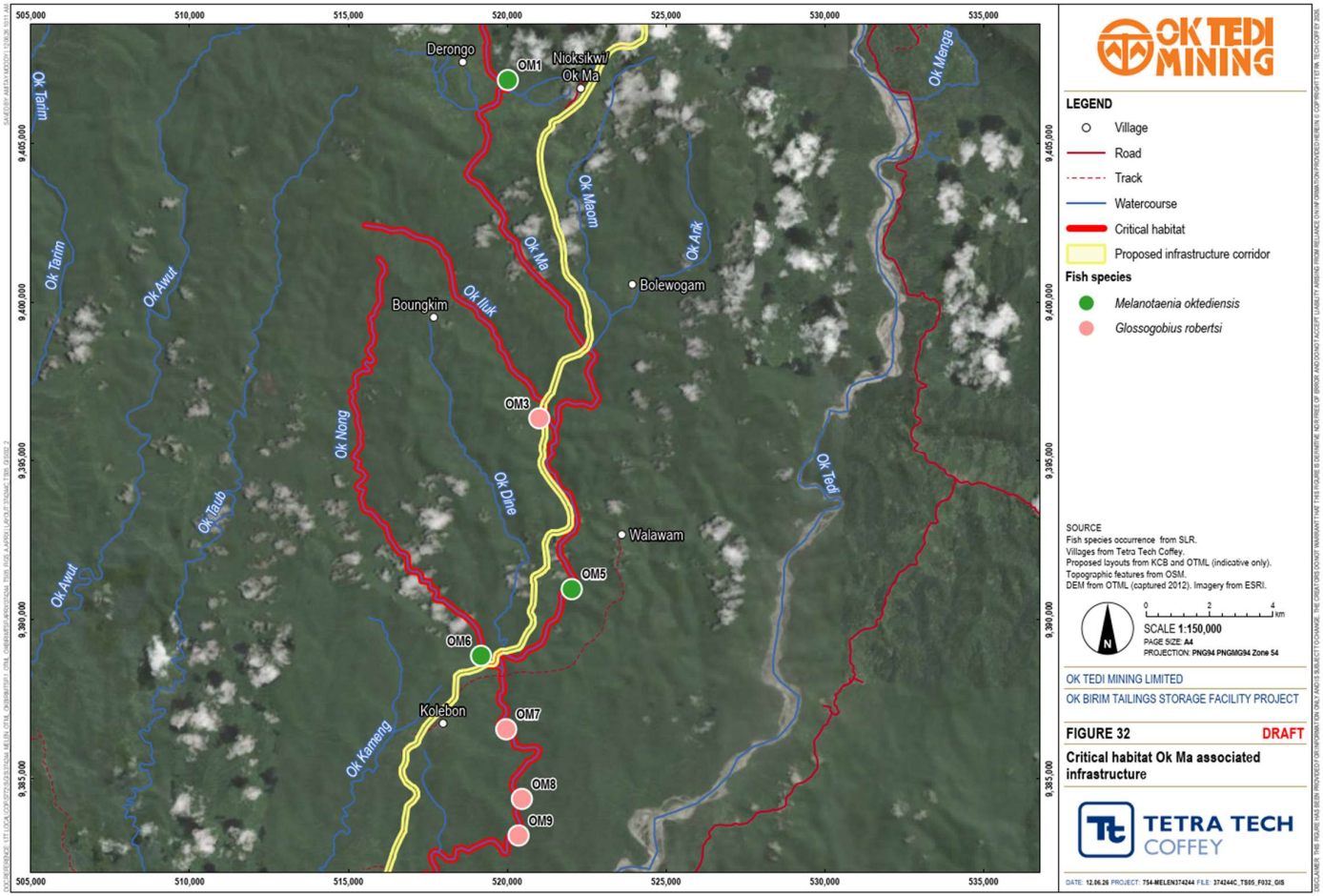

Figure 34. Critical Habitat associated with the Ok Ma Infrastructure Corridor

3.2.9 Aquatic Fauna Metal Analysis

3.2.9.1 Spatial differences in metal concentrations of fish

This section characterises the metal accumulation across the different sites sampled on Ok Ma. Figure 35 presents the average (± 1 SE) concentrations for all fish species grouped per site sampled on the Ok Ma. Concentrations of Cd, Cu, Pb, Se, and Zn varied spatially and did not display distinct patterns or trends, and at none of the sampled sites did concentrations of Cd, Cu, Pb or Zn exceed the human health risk guideline values. Cadmium concentrations were highest in fish from sites OM4 and OM9 and lowest at OM3 and OM12. All sites showed values under 0.05 mg/kg wet weight, indicating limited bioaccumulation in the sampled fish, which supports limited exposure to metals in a relatively pristine environment. Overall, cadmium does not appear to be a major contaminant of concern in this dataset, though the isolated high values detected elsewhere warrants targeted follow-up sampling to confirm whether it reflects a site- or species-specific issue.

Copper concentrations were highest in fish from OM4 and OM9 and lowest at OM1 and OM3, and at none of the sampled sites did concentrations of Cu exceed the human health risk guideline values. Lead concentrations were highest in fish from OM4 and OM9, and lowest at OM3 and OM12, and at none of the sampled sites did concentrations of Pb exceed the human health risk guideline values. Similarly, at none of the sampled sites did concentrations of Zn exceeded the human health risk guideline values, and were highest in fish from OM4 and OM3 and lowest from OM12. Selenium concentrations showed variability across sites and had concentrations in whole specimen fish samples exceeding the Tolerable Daily Intake (TDI) based guideline (0.4 mg/kg/day) at three of the five sites, OM12, OM1 and OM4. While selenium is an essential micronutrient, the higher concentrations observed here suggest that consumption of fish from these three sites would surpass recommended intake thresholds, particularly for high consumers. However, as previously pointed out, OTML community health surveys have shown that aside from fish, other aspects of the diet of Fly River villagers are deficient in Se, and the intake of Se in fish is an important source of Se.

When interpreting these results, it is important to recognise that the guideline values shown in the figures are expressed on a per-kilogram consumption basis, whereas typical fish consumption is closer to an 80 g portion (section 2.5.1). This means that actual daily intakes would be approximately one-twelfth of the concentrations plotted. Applying this adjustment eliminates the number of exceedances relative to the standard comparisons, and no sites would exceed the respective guideline. As such, the exceedances indicated by the unadjusted concentrations should be interpreted with caution, and consumption-based exposure calculations should be prioritised when assessing the potential health implications of these results.

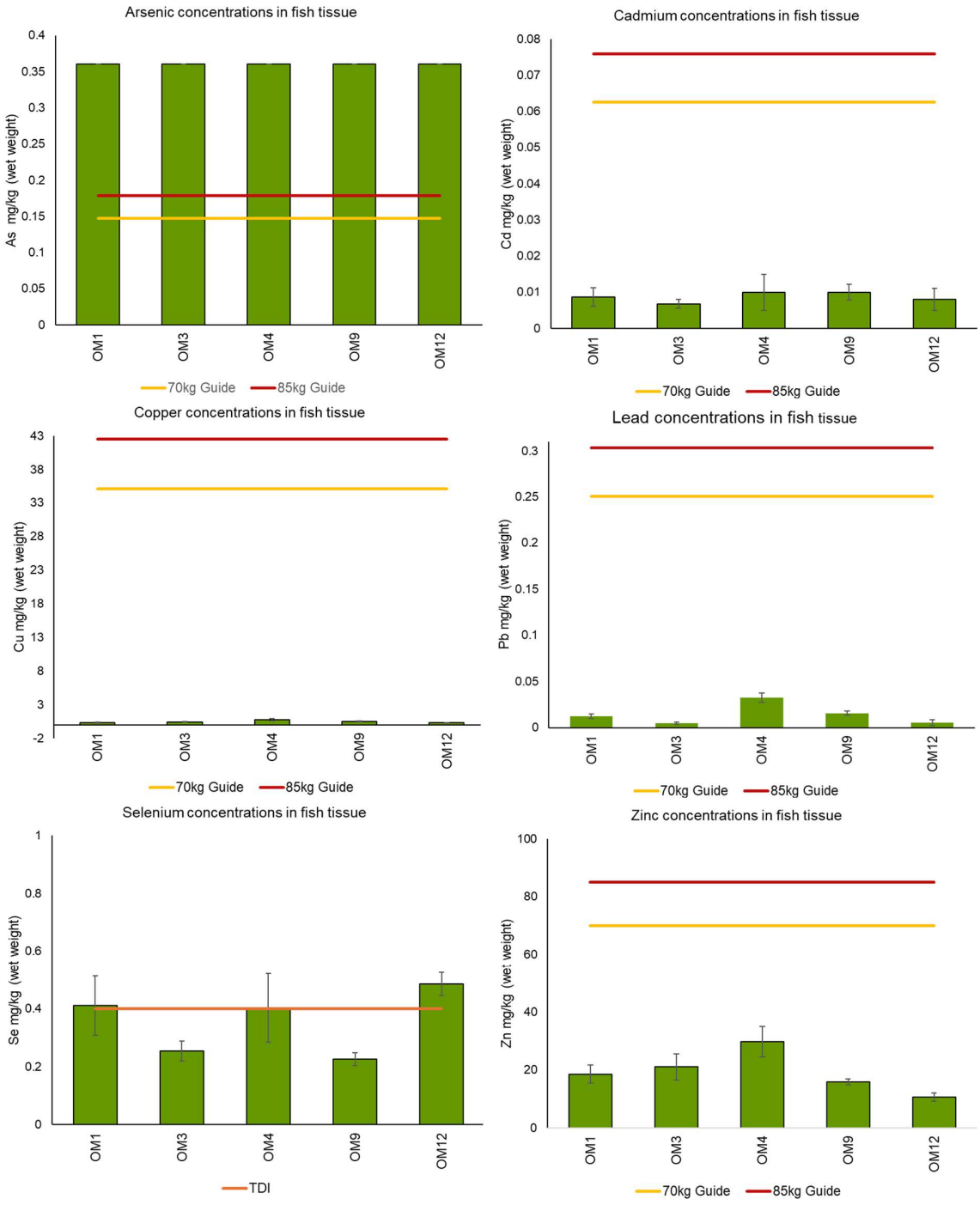

Figure 35: Concentrations of selected metals in fish tissue from whole fish specimens. All fish species are grouped per site sampled in Ok Ma.

3.2.9.2 Species differences in metal concentrations

This section characterises the metal accumulation across the different species sampled across sites in Ok Ma. Figure 36 and Figure 37 present the average (± 1 SE) concentrations for each species across sites sampled on the Ok Ma. As was below detection for all specimens and therefore was invariate and not analysed further. All other metals (Cd, Cu, Pb, Se, Zn) varied among species but did not display distinct cross-species patterns, and for no species sampled from sites on the Ok Ma did concentrations of Cd, Cu, Pb or Zn exceed the human-health risk guideline values (as indicated in Table 3). Copper concentrations were low to moderate across species, and for none of the fish species did Cu exceed the relevant guideline values. Copper concentrations in crayfish (*Cherax sp.*), were high as would be expected for crustaceans, using copper instead of iron in their blood, and levels were not considered a risk to human health as these concentrations were all lower than the PMTDI guideline values. Lead concentrations were similarly low, remaining below guideline thresholds for all species, also within crayfish.

Cadmium concentrations were low across all species (means generally < 0.05 mg/kg wet weight), guideline values for Cd were not surpassed by any individuals either, indicating limited bioaccumulation in most of the sampled taxa. Overall, cadmium does not appear to be a major element of concern in this dataset. Similarly zinc concentrations varied considerably across most species, but no individuals or fish species had concentrations higher than the 85kg or 70kg guideline values. Selenium concentrations did show considerable variability among species, with three of the 12 fish species exhibiting concentrations higher than the Tolerable Daily Intake (TDI) based guideline (0.4 mg/kg/day), indicating that selenium is one of the more consistently elevated metals in the dataset. These three species in descending order were *Glossomia trifasciatica*, *Glossogobius concavifrons, and Neosilurus brevidorsalis.* While selenium is an essential micronutrient, the exceedances observed here suggest that targeted consumption of select species would surpass recommended intake thresholds, particularly for high consumers. However, as noted above, dietary intake from other sources is deficient in Se, and guidelines assume a balanced diet, with average intake of metals from other sources as well as from the target food item. Therefore, relatively high levels of Se in fish, especially whole fish will likely compensate for Se deficiency in other food items.

As mentioned in the previous section when interpreting these results, it is important to recognise that the guideline values shown in the figures are expressed on a per-kilogram consumption basis, whereas typical fish consumption by local villagers, based on OTML Community Health surveys is closer to a 80 g portion, indicating that actual daily intakes would be approximately one-twelfth of the concentrations plotted. Applying this adjustment eliminates all exceedances for all relevant metals relative to the standard comparisons.

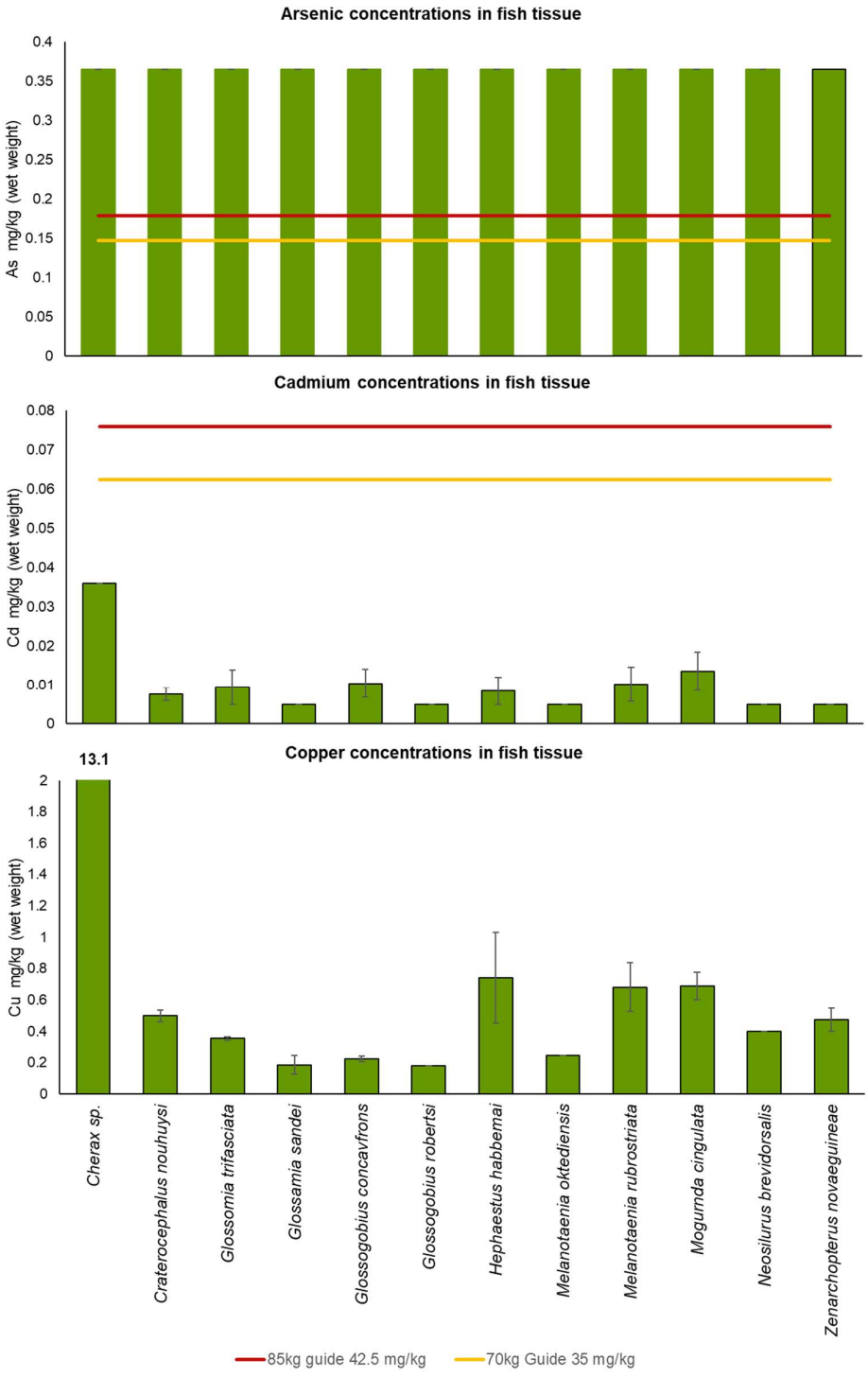

Figure 36: Arsenic, cadmium, and copper concentrations in fish and crayfish tissues across species collected from sites on Ok Ma, with mean values (± SE) shown for each species and guideline thresholds indicated for 70 kg and 85 kg consumers.

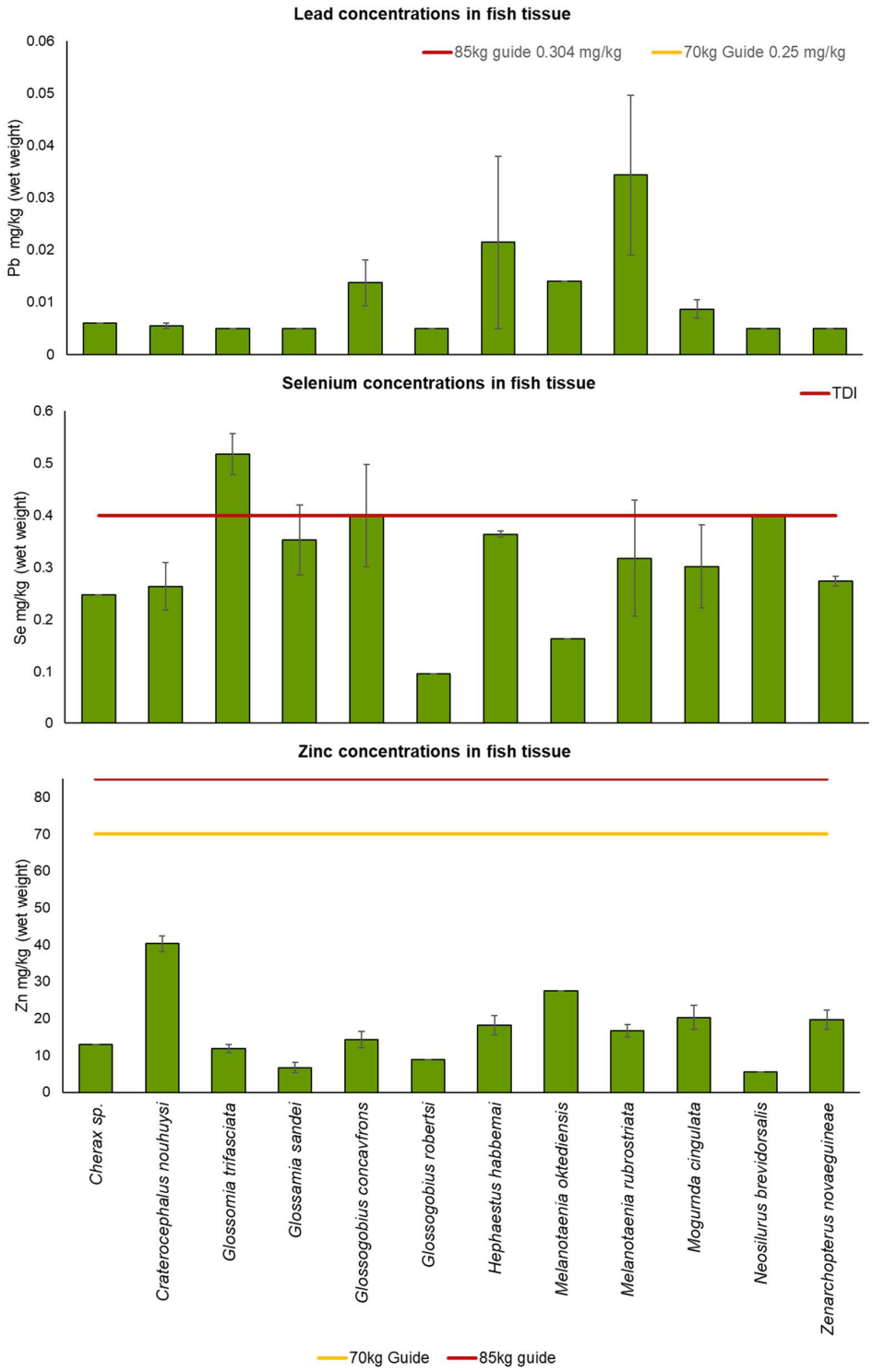

Figure 37: Lead, selenium, and zinc concentrations in fish and crayfish tissues across species collected from sites on Ok Ma, with mean values (± SE) shown for each species and guideline thresholds indicated for 70 kg and 85 kg consumers.

3.2.9.3 Metal Concentrations – Effect of Trophic Position

Relationships between trophic position and metal concentrations in fish tissue were evaluated using Spearman rank correlation analyses across all sampled sites on Ok Ma (see Table 7). Arsenic was excluded from this analysis as concentrations in all samples were below analytical detection limits.

Positive correlations were observed between trophic position and concentrations of cadmium (Spearman ρ = 0.148, p = 0.683, n = 10) and selenium (Spearman ρ = 0.245, p = 0.193, n = 30), as opposed to the results from Ok Birim where these data were not significant. Scatter plots illustrating the relationships between trophic position and cadmium and selenium concentrations are presented in Figure 21. In contrast, lead (Spearman ρ = -0.516, p = 0.059, n = 14), copper (Spearman ρ = -0.379, p = 0.03, n = 33) and zinc (Spearman ρ = -0.42, p = 0.015, n = 33) concentrations demonstrated a negative relationships with trophic position, indicating that fish occupying lower trophic positions generally exhibited higher concentrations of these metals than higher trophic/predatory species. These patterns differ from those found in the Ok Birim and can likely be attributed to differences in species in which concentrations were measured or a sampling artefact of lower numbers of individuals analysed from the Ok Ma compared to the Ok Birim.

Table 7: Spearman rank correlations between Trophic position and Metal concentrations for fish species collected from Ok Ma.

Spearman Rank Correlations – Trophic Position vs. Metal concentration					
	Cadmium	Copper	Lead	Selenium	Zinc
Spearman's rho	0.148	**-0.379**	-0.516	0.245	**-0.42**
p-value	0.683	0.03	0.059	0.193	0.015
N	10	33	14	30	33

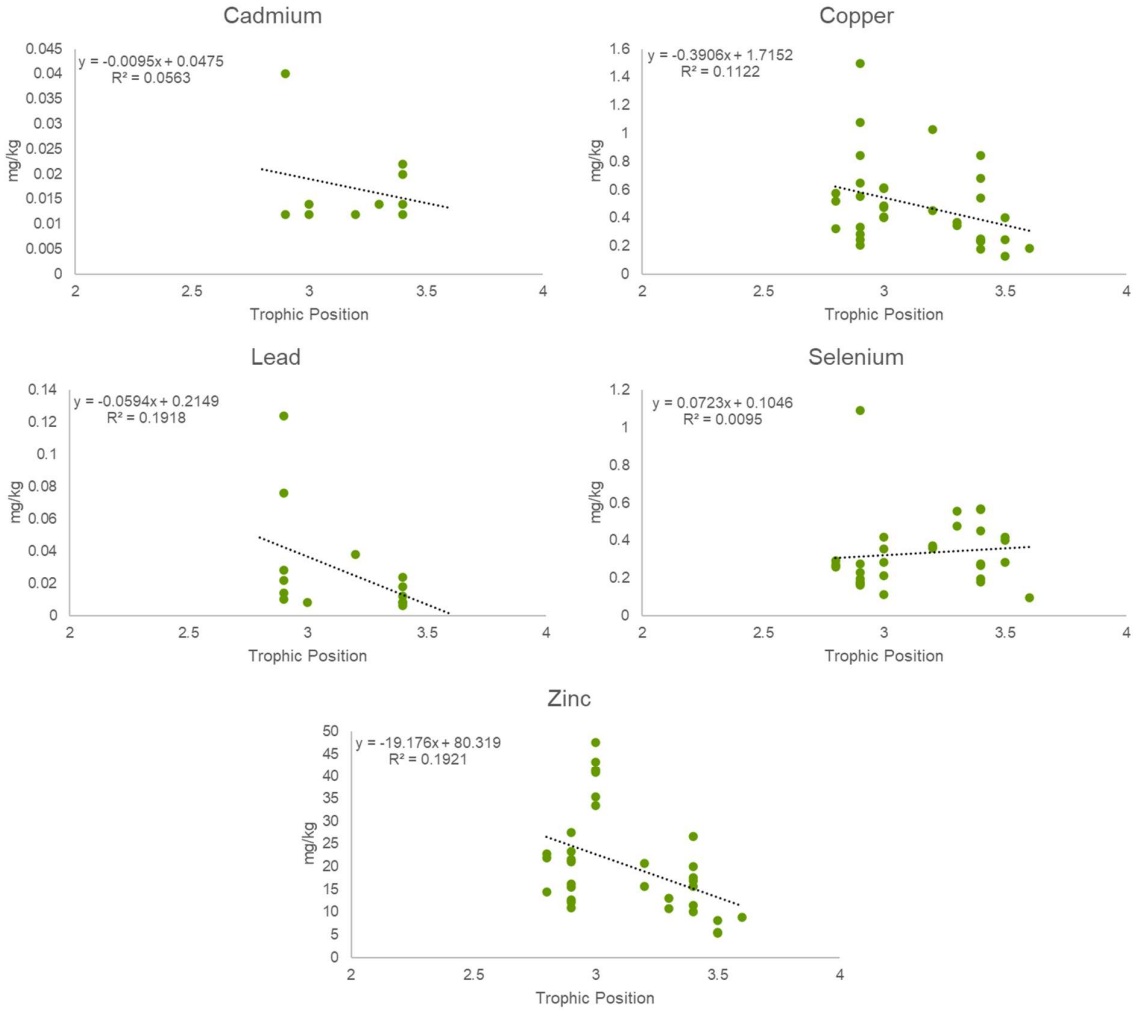

Figure 38: Scatter plots indicating linear relationships between trophic position and metal concentrations (cadmium, copper, lead, selenium, and zinc) of individuals fish sampled from selected sites across Ok Ma. Each panel shows observed values with a fitted regression line, corresponding equation, and R^2 value.

3.2.10 Social Use Observations

When sampling sites along the Ok Ma general discussions were had with villagers assisting the survey team, on their everyday use of the river and tributary creeks. The Ok Ma is less accessible by locals due to the rapid change in water levels within the creek in response to local rainfall, making travel by dinghy difficult, and the absence of large villages located along the Ok Ma, negating the need to travel along the river. Smaller villages consisting of a few huts, likely gardening camps, were observed with various isolated huts along the Ok Ma utilising the creek for fishing and agricultural activities.

3.2.10.1 Freshwater Use

Discussions with villagers along the Ok Ma during the survey confirmed that, although rainwater is harvested, the river is also used as a source of drinking water. The upper reaches of the Ok Ma are more turbid, and residents of Ok Ma village advised that this section is not used for drinking purposes. The mid-reach of the Ok Ma provides the sole drinking water source for villages near site OM3, as confirmed by a local fisherman. The lower Ok Ma is used as a freshwater source by villages such as Digam and others, in conjunction with rainwater harvesting. Smaller tributaries, including Ok Tara which was specifically noted by villagers at Digam, are also used by village for washing, bathing, and drinking water.

3.2.10.2 Food

The Ok Ma is used by local villagers for fishing with people from Ningerum and larger villages travelling up the Ok Ma for fishing. Various fishing huts were noticed while travelling up the Ok Ma with local fishermen confirming the presence of prawns, crayfish, turtles and various other small and larger fish species being caught in the Ok Ma system.

Fishing methods such as hook and line, and gill netting is used in the lower Ok Ma and smaller tributaries where water is clear. Methods for smaller fish are similar to methods mentioned in section 3.1.10. Fishing within the upper Ok Ma (OM1) is limited due to the turbid waters and most local villagers move further downstream to fish.

The locals from Digam village (OM12) confirmed that turtles were reported within the Ok Tara and caught to eat, as well as various other fish species. Locals from Ok Ma village located close to OM1 also confirmed that fishing is the main activity within the upper Ok Ma. One of the local fishermen that reside close to OM3 said that he catches larger fish within the middle Ok Ma (deep gorge area, OM2) and sells them at the fish markets in Kiunga and Ningerum. It was mentioned that crocodiles within the Ok Ma are not hunted for cultural reasons.

3.2.10.3 Transportation

Generally, the lower Ok Ma is used for transportation to and from Ningerum by locals in the lower Ok Ma. Due to nature (rapids, flow etc) of the Ok Ma channel in the upper reaches it is not used for transport.

4.0 Potential Impacts of the TSF and Infrastructure Corridor

4.1 Project Design and modelled sediment/water quality impacts

Tetra Tech Coffey has provided SLR a short project description for technical studies document (754-POMEN374244C_R12 February 2026) highlighting the key project components and a description of proposed project activities and will be referred to as the "project description" (TTC, 2026) in this chapter.

Project activities will primarily occur in the TSF development area and the infrastructure corridor development area. The TSF development area is approximately 1,500 ha and the infrastructure corridor development area is approximately 400 ha. Based on the proposed layout, the total disturbance footprint is approximately 1,900 ha. An overview of the proposed project is provided in Table 8.

Table 8. Overview of project as per TTC short project description document.

ASPECT	DESCRIPTION
TSF	
Tailings volume	Current TSF design provides storage for approximately 368 Mt of tailings material, with a maximum design storage capacity allowance of 263 million cubic meters (Mm^3).
TSF design and staging	• TSF to be developed in stages, with two conceptually defined storage cells to be constructed, operated and closed consecutively. Embankments will be primarily constructed using tailings cyclone underflow sand. • TSF starter embankment to use borrow material sourced from the Ok Tedi or from within the TSF footprint. • Centreline-raised embankments of cyclone underflow primarily via hydraulic cell construction, compacted to the density specified in the design to retain cyclone overflow and uncycloned tailings. • No permanent water cover is expected to be required for tailings in the TSF impoundment area as the tailings are NAF based on geochemical characterisation results. • TSF ultimate embankments will reach a maximum height of 30 m with a final crest elevation of 80 m RL.
TSF water management	• TSF lies entirely within the Ok Tedi catchment to minimise introducing new impacts to other catchments such as the Ok Birim, which remains unaffected by current mining activities. • TSF has been positioned above the high banks of the Ok Birim and Ok Tedi to minimise flood interaction. Pending ongoing design work, some flood protection controls such as small levees may be required in the southeast corner of the TSF to meet the 1:2,000 annual exceedance probability (AEP) flood event. • Planned discharge of excess TSF decant water will flow to the Ok Tedi after reduction of suspended solids. • Surface water diversions will be established to divert existing streams, and clean surface water flows away from the TSF during all phases of the

ASPECT	DESCRIPTION
	project. Sedimentation ponds will be constructed strategically to reduce fugitive sediment. • TSF and emergency spillways have been designed to accommodate the probable maximum flood (PMF) of 1:100,000 AEP storm event with minimum 3 m operational freeboard. • During operations, the TSF will operate as a flow-through system with excess decant water reporting to the Ok Tedi in a controlled manner via a siphon system and diversion channel to be constructed. Each TSF cell will incorporate a siphon system, associated pipelines and outlet, and emergency spillway to enable planned and emergency release of excess TSF decant water. • TSF seepage flow is expected to be within the shallow weathered profile and in any structures acting as preferential flow paths. Seepage collection at the south (downstream) of the TSF will be transferred to a sedimentation pond, while un-intercepted seepage is expected to report to the Ok Tedi. Based on current studies, groundwater seepage flows toward the Ok Birim are unlikely. • Sedimentation pond volumes will vary by cell but will be designed as wet (constant flow) systems with flow capacity based on exceeding a 1:10 AEP event. • During post-closure, the TSF will be configured as a stable, water-shedding and erosion-resistant landform that comprises benched embankment slopes and designed to safely convey PMF flows away from rehabilitated surfaces to the receiving environment via appropriately sized closure spillways and channels.
Hydro-cyclone and recycling of TSF decant water	• Construction of the hydro-cyclone house is planned to separate the following streams: o Underflow – to be used for embankment construction. o Overflow – to be deposited into the TSF impoundment. o Decant water from the TSF will be re-used as process water via dedicated pumping and piping distribution infrastructure.
Ancillary infrastructure	• Other supporting facilities required for the TSF include laydown areas, site office, workshops, maintenance stations, waste and sewage management facilities, fuel storage, borrow and gravel pits, and accommodation camps (as required).
Power supply	• On-site diesel generators with up to 11 MW installed capacity for operations. Additional power supply for tailings pipeline infrastructure will be drawn from the existing TPP power supply.
Water supply	• Temporary construction water supply: approximately 2 ML/year to provide initial water supply for construction activities for the TSF and infrastructure corridor. Raw water may be sourced from construction sediment ponds (after decanting), existing water supply or nearby watercourses, subject to confirmation by ongoing studies. • Process water for hydro-cyclone and associated flush water systems: estimated to be approximately 32,000 ML/year and 34 ML/year respectively; initially sourced from mine site water supply then from TSF decant water and rainfall. Water required for the tailings pipeline flush water system is expected to be approximately 23 ML per flush. • Raw water for dust suppression, vehicle washdown and progressive rehabilitation: approximately 1 ML/year, planned to be sourced from

ASPECT	DESCRIPTION
	suitable clean water such as from TSF decant water (if deemed adequate) or on-site rainfall collected within the TSF footprint. • Potable water for the workforce, camp, kitchens and ablutions: estimated to be approximately 1.3 ML/year, to be trucked daily from Kiunga or mine supply, extracted from groundwater boreholes or nearby upstream watercourse after adequate treatment to meet drinking water quality standards.
Infrastructure corridor	
Access road	Construction and upgrade of access roads/tracks, including an 87-km-long pipeline access road from the Ok Tedi Mine to the proposed TSF (comprising 22 km along the existing highway from the mine to Tabubil and 65 km of new road); three permanent bridges over the Ok Tedi, Ok Taub and Ok Birim; and several minor water/ravine crossings. Generally two-lane, unsealed roads with an all-weather road base, with single lane sections and passing bay areas where required. Gravel will be applied as needed for dust suppression, such as near villages. Single or two-lane bridges will be provided with dedicated pedestrian footpaths. A speed limit of 40 km/hr for internal roads/tracks and 65 km/hr for roads shared with the community with appropriate road safety signage where needed.
Tailings pipeline	Construction of an 87-km-long pipeline to transport final tailings from the TPP at the Ok Tedi Mine to the proposed TSF. Approximately 80% buried and 20% above ground. Pipeline is expected to be constructed along the pipeline access road for the entire route with minor deviations as required.

The aim of the impact assessment chapter is to assess the extent to which the proposed project components will impact (both positive and negative) the aquatic ecology of waterbodies within and downstream of the project area. The impact assessment is based on the information provided by TTC (TTC, 2025), and modelling of effects on sediment/geomorphology (Pickup, 2025) and water quality (EGi, 2026). Studies undertaken by Dr Geoffrey Pickup (Pickup, 2025) and Environmental Geochemistry International (EGI, 2026) assessed the potential changes the Ok Birim TSF would have on the hydrology, sediment transport, particulate geochemistry and water chemistry across the Ok Tedi-Fly River system, as well as the Ok Yep receiving environment immediately downstream of the TSF.

Modelling, particularly for water chemistry, developed a TSF module for the established OkChem model, here named OkChem-TSF, based on a rudimentary concept design as outlined in the Project Conventions document provided by Tetra Tech (2025) but also draws on design elements included in Ok Birim TSF Pre-Feasibility Study Design Update (KCB 2024) and technical memoranda prepared by (KCB (2025a, 2025b) pertaining to TSF Concept Design C5. Key elements of the rudimentary concept design were:

- TSF constructed as a ring-dyke structure with two conceptually defined storage cells to be constructed and closed consecutively
- A total TSF footprint of approximately 1,431 ha, comprising 921 ha for Cell 1 and 510 ha for Cell 2
- Outer and centreline-raised embankments constructed using cyclone underflow sand
- No permanent water cover for tailings in the TSF impoundment areas
- Tailings expected to be NAF based on current geochemical characterisation results.

- TSF positioned above the high banks of the Ok Birim and Ok Tedi and located entirely within the Ok Yep sub catchment of the Ok Tedi catchment to avoid introducing any impacts to the Ok Birim, which will remain unaffected by current mining activities
- During operations and closure, the TSF spillways will operate as a flow-through system that channels excess water from each storage cell to downstream sedimentation ponds to manage and reduce suspended solids from decant water, before controlled discharge into the receiving environment
- Planned discharge of surplus TSF decant water will flow to the Ok Tedi after reduction of suspended solids to meet applicable water quality criteria[5]
- Ditches and clean water diversions will be established to divert existing streams, and clean surface water flows away from the TSF impoundment during all phases of the project

It was assumed that the water discharged from the TSF would be a mixture of the following water types:

- Bleed water from discharged tailings
- Runoff/seepage from the exposed tailings beach area associated with rainfall
- Runoff/seepage from embankments
- Runoff/seepage from natural ground (area that hasn't yet been covered with tailings); and
- Direct rain into the pond.

This understanding and range of parameters underpinned the current modelling.

4.1.1 Sediment and Geomorphology

The proposed TSF represents a major structural change to sediment and material fluxes within the Ok Tedi-Fly River system, with implications extending from the local Ok Birim sub-catchment to the Lower Ok Tedi and Middle Fly River floodplains. By diverting most tailings away from direct riverine discharge, the TSF will remove a substantial proportion of fine and coarse tailings material from the active river system, fundamentally altering sediment transport, particulate geochemistry, and associated water quality processes (Pickup, 2025).

Pickup (2025) notes that while TSF implementation will significantly reduce sand and silt inputs, it does not operate in isolation. Downstream transport of historically deposited sediments, ongoing waste rock inputs, and episodic natural landslides will continue to contribute material to the river system regardless of TSF construction. These factors underpin a system that remains dynamic, with multiple interacting sediment sources and sinks.

When evaluating hydrology, sediment transport, and particulate geochemistry, focusing on impacts with and without a TSF, Pickup (2025) notes there are a range of inputs and losses to the system. Waste rock inputs have involved peaks of up to 80 Mt/year with recent averages of around 55 Mt/year. These have entered the system mostly via the Southern Dumps. Recent inputs via the Northern Dumps have averaged around 30 Mt/year. Future reductions of inputs to the river system are anticipated via engineered waste rock dumps (EWRDs) and a mine plan which sees total waste rock production reducing from around 2030 onwards. Tailings production has declined historically from an average of about 26 Mt/year to 17 Mt/year since

[5] In the absence of specified water quality criteria SLR have applied ecosystem protection GVs

2013; diversion to a TSF would cut tailings inputs to the river system by a further ~85–95%. Landslides are common throughout the mountain areas of the Ok Tedi drainage basin and are a major, though intermittent, source of sediment delivery to the river system. Major natural and mine-triggered slides include the Vancouver Avalanche which delivered an estimated 115 Mt between 1989 and 1991, and the Harvey Creek landslides which added 19-28 Mt/year to the river system between 1991 and 1996. The major outputs or sediment losses from the river system are dredge offtake, storage in very long-term depositional areas, notably on the floodplains, and discharge of sediment to the Lower Fly and the Fly Delta. The latter was not part of this study but is estimated at about 15 Mt/year when averaged over the whole of mine life so far (Pickup, 2025). Since 1998, dredging at Bige at the head of the Lower Ok Tedi has removed about 17 Mt/year of sand from the river. This has halted or reversed pre-dredging bed level rise on the Lower Ok Tedi and on the upper and central Middle Fly but there continues to be very slow bed level rise further downstream as progression of material already in the river system downstream from the dredge site occurs. Dredging does not capture the silt component of either tailings or waste rock inputs. Diversion to a TSF will capture both the sand and silt component of tailings but not the sand and silt of waste rock inputs. Waste rock has a large component of siltstone and limestone, both of which abrade to mostly silt. This means that the sand: silt ratio of the river sediment load will reduce by about 40% and change to reflect a finer sediment load. Diversion of tailings to a TSF will further reduce bed level rise in the lower and central Middle Fly and eliminate it in the lower Ok Tedi and upper Middle Fly. The Lower Ok Tedi and Middle Fly floodplains have developed over millennia as the river has meandered across its containing valley. As such, the floodplains are zones of long-term sediment storage and loss of material from the sediment load of the river. Sediment is added to the floodplain both by channel migration and as overbank floods deposit material on the floodplain surface. As such, the floodplain becomes an area of long-term sediment storage. Sediment is only released by floodplain destruction as the river channel migrates laterally which, on the Lower Ok Tedi and Middle Fly, is a very slow process occurring over many centuries. Pickup (2025) estimates a long-term average sediment loss rate of about 5 Mt/year.

Diversion of tailings to the TSF is expected to deliver a pronounced reduction in sediment loading, particularly of sand-sized material. Combined with long-standing dredging at Bige, this reduction will eliminate bed level rise in the lower Ok Tedi and upper Middle Fly reaches. Importantly, removal of tailings will reduce both sand and silt loads, with a shift in the overall sediment regime toward a finer load, with an estimated ~40% reduction in the sand-to-silt ratio. This will reduce sand bed load in the Ok Tedi and Middle Fly, and to a lesser extent reduce TSS levels.

Floodplains of the Lower Ok Tedi and Middle Fly function as long-term sediment sinks developed over millennial timeframes. Reduced sediment delivery under TSF operations will therefore translate to reduced rates of overbank deposition and long-term storage, with sediment release to the channel remaining a slow, geomorphically controlled process operating over centuries.

A key ecological benefit associated with these physical changes is a substantial reduction in total suspended solids (TSS). Median TSS concentrations upstream of Ningerum are predicted to decline from current levels of ~2,500 mg/L to approximately 1,000–1,500 mg/L following cessation of riverine tailings discharge, with further reductions downstream and variability driven primarily by flow conditions. Pickup (2025) suggests this reduction in suspended sediment is expected to lessen turbidity stress and improve habitat conditions for aquatic biota across much of the system.

With respect to the immediate receiving environment of the Ok Yep, Pickup (2025) reports that the effect of the TSF on sediment load and geochemistry in the lower Ok Yep is unknown. However, the impact on sediment load is likely to be greatest in the construction period. At

present, these lowland watercourses carry little sediment load and occupy shallow, well-vegetated valleys. Clearing of the TSF area and that of associated infrastructure during construction is likely to produce an ongoing pulse of sediment load to the Ok Yep, mostly from local sources containing minimal copper and sulphur, especially before the ring dyke dams are completed (Pickup, 2025). This is likely to result in Ok Yep stream bed aggradation which may subsequently flush out to some degree in the post construction period. However, some deposited sediment may remain given the reduction in the post-construction Ok Yep catchment area and reduced streamflow. There may also be continuing sediment delivery to the lower Ok Yep from the constructed flow diversion channels that border the ring dyke and other cleared areas, especially if blocking due to sediment build-up occurs (Pickup, 2025).

4.1.2 Water quality

EGi (2026) modelled the effects of the TSF on water quality of the immediate receiving environment, as well as the Ok Tedi and Middle Fly. The assumptions and parameters on which modelling was based were summarised by EGi (2026). When commissioned, the Ok Birim TSF will replace most riverine discharge of tailings. Instead, tailings slurry discharge from the TPP will be piped directly to the TSF which will be developed as a ring-dyke structure comprising internal storage cells developed progressively, with embankments constructed using a coarse-grained fraction separated from tailings. An on-site cyclone house will separate piped tailings into fines and coarse sands prior to TSF disposal, with coarse sands used for embankment construction, and fines deposited in the TSF cells. The current design also includes drainage of tailings decant water from the TSF with transfer to sediment ponds and discharge of supernatant to the Ok Tedi (via the Ok Yep). The release of excess water from the TSF to the Ok Tedi may have implications for water quality, in the Ok Yep, the Ok Tedi and downstream in the Fly River.

EGi (2026) note that the objective of the hydrogeochemical assessment was to provide a basis for impact assessment of the TSF to support the ESIA for the Project, and in particular the potential for the TSF to impact water quality along the Ok Tedi and Fly River. The assessment included review of available data sets for riverine sediments and water quality along the Ok Tedi and Fly River, and the development of a hydrogeochemical model, OkChem-TSF, to predict the chemistry of water discharge from the TSF as well as potential changes the discharge may have on river water quality.

EGi (2026) assumptions for the Ok Birim TSF assessment is that tailings deposited in the TSF beach, and river deposited sediment, will be non-acid forming (NAF) and have ANC/MPA ratios that are of such magnitude that there is zero risk of acid generation. Hence it is assumed that runoff/leachates from these materials will be alkaline. However, the NAF tailings that will be placed in the Ok Birim TSF, as well as riverine sediments, will still have a significant sulphide content, most likely in the range 0.5 to 1 %S. This sulphide will be susceptible to oxidation in situations where the tailings/sediment are exposed to atmospheric conditions and there is capacity for ingress of oxygen into the pore space of the tailings/sediment.

The TSF embankments constructed with the coarse-grained cyclone underflow will be particularly susceptible to oxidation processes, as they will be free-draining and dewater readily, thereby allowing for ingress of oxygen. The tailings deposited within cells will comprise both uncycloned final tailings and cyclone overflow (fine grained fraction), which will be spigotted from embankment crests to develop an upstream beach which drains to the TSF pond. During operations, the nominal volumetric flow rate of the tailings pipeline system is expected to range between 1,929 and 2,978 m³/hr. The moisture content of tailings deposition will likely remain high, thereby limiting the potential for oxygen ingress, however, some drying of near surface material may be a possibility where active deposition is not occurring. EGi

(2026) predicted water quality seepage direct from the TSF and into Ok Yep on completion of Cell 1 (with water quality on completion of Cell 2 being essentially the same) (Table 9):

Table 9. Predicted Chemistry of Discharge from the TSF into the Ok Yep for Stage 1 (completion of Cell 1) all parameters except pH are mg/L (after Table 7 of EGi (2026)).

pH	TDS (mg/L)	SO_4 (mg/L)	Ca (mg/L)	K (mg/L)	Mg (mg/L)
6.3	1318	925	343	22	11
Al	Cd	Cu	Fe	Mn	Zn
0.001	0.0002	0.049	0.05	0.11	0.014

EGi (2026) predict elevated dCu levels in their modelling (Table 9) but note that DOC is known to moderate toxicity of dCu. Measured DOC typically range from 0.5 to 1 mg/L for mountain streams through to 2 to 3 mg/L for the major lowland rivers (i.e. Fly) (WRM, 2012). It is expected that some drainage within the floodplain may have even higher DOC. For preliminary modelling, the major river inputs (i.e. Upper Fly River above Ok Tedi, and the Strickland River above the Fly River) were assigned mid-range DOCs of 1 mg/L. For smaller, unnamed rivers and streams entering the middle and lower Fly River a DOC of 2 mg/L was assumed. This conversion means that a DOC of 1.0 mg/L corresponds to 5x10-7 M humic. Assuming 1:1 molar humic – copper complexation, it would correspond to a copper complexing capacity (CuCC) of approximately 32 µg/L. A complexing capacity of this magnitude is consistent with measurements of CuCC made by CSIRO (2005) and Apte (2008) as part of OTML's water quality monitoring program for the Middle Fly, indicating CuCC values for the river system range from 9 to 38 µg/L. Modelled water quality for the Ok Yep has a dCu of 49 ug/L which exceeds this CuCC, with dCu >~30 ug/L potentially labile/ bioavailable and toxic.

Although modelled water quality for the Ok Yep shows elevated dCu, dZn, TDS and SO_4, modelling by EGi (2026) for further downstream in the system shows that changes in water quality of the Ok Tedi are minor (increases of 5 mg/L sulphate and <1 ug/L of dCu, with most Cu re-absorbed onto particulates), and effects then get progressively diluted with distance downstream as the Ok Tedi meets the Upper Fly, and then further progressive dilution through the Middle Fly.

Predicted modelling indicates that TSF discharge will have no material impact on river pH. In the Ok Tedi immediately downstream of the TSF, pH remains essentially unchanged from upstream conditions at Ningerum (around pH 8.1) under high and median flows, with only a very slight reduction under low-flow and El Niño conditions. A minor downstream decrease in pH is predicted across all flow conditions, followed by a recovery after the Fly–Strickland River confluence. All predicted changes are within 0.1 pH units and are therefore rated as a very low significance. EGi (2026) do not discuss pH of the Ok Yep, but TSF discharge is modelled to be pH 6.3 (Table 9), compared to the pH of the Ok Yep of pH 5.5 – 6.0, and therefore it is assumed the pH of the Ok Yep will remain acidic, at around pH 5.5 - 6.0.

TSF discharge is predicted to cause a minor increase in sulphate concentrations in the Ok Tedi immediately downstream of the discharge entry. Increases range from 3 - 17 mg/L during completion of cell 1 and 4 - 25 mg/L during completion of cell 1 and 2, with higher increases occurring under lower flow conditions. Further downstream, sulphate concentrations generally decrease due to dilution from tributary inflows. However, under El Niño low-flow conditions, sulphate levels at Atkamba (located South of the project area) are predicted to be temporarily elevated (up to ~60 mg/L), primarily due to sulphate release from exposed mine-derived sediments rather than TSF discharge. Downstream of the Ok Tedi - Fly River confluence,

sulphate concentrations reduce to 15 - 20 mg/L under normal flows and 20 - 30 mg/L during El Niño, indicating a dilution-dominated system at regional scale. The change in sulphate is predicted to have a low negative significance on the Ok Tedi and Lower Fly River. Baseline sulphate levels in the Ok Yep were not measured, but based on modelled sulphate of TSF discharge of 925 mg/L (Table 9), and allowing for a degree of dilution, it is expected sulphate of the Ok Yep will remain around 500 mg/L.

Model results show no measurable impact of TSF discharge on copper concentrations in the Ok Tedi River. Predicted copper levels immediately downstream of the TSF remain consistent with existing conditions, at approximately 6 - 7 µg/L, regardless of whether a TSF is present. This indicates that TSF operations do not contribute to an increase in copper concentrations in the receiving environment. Impact is rated as having a very low significance. However, dCu in the Ok Yep will be elevated, and likely exceed the CuCC by 10 – 20 ug/L, dependent on the DOC of the Ok Yep.

KCB (2026) evaluated the groundwater and surface water quality within the project area. Water quality across the Ok Birim TSF area is generally good, with both surface water and groundwater characterised by fresh conditions, low salinity, and minimal dissolved constituents. Groundwater is typically near neutral in pH and low in electrical conductivity, indicating fresh, uncontaminated conditions, and evolves from calcium-bicarbonate type in shallow zones to sodium-bicarbonate type at depth due to longer residence time and water–rock interaction. Dissolved metals are largely absent or below detection limits, with only minor naturally occurring iron and manganese present. Surface water shows similar overall quality, with mostly neutral to slightly alkaline pH and low conductivity, although some localised acidic streams occur in the western area[6]. Chemically, surface waters also range between calcium- and sodium-bicarbonate types, reflecting varying degrees of interaction with groundwater and different source contributions. Smaller streams tend to resemble groundwater chemistry, suggesting they are sustained by baseflow, while larger systems like the Ok Tedi are more influenced by rainfall runoff. Springs show intermediate chemistry, supporting mixing between shallow and deeper groundwater sources. In contrast, process (tailings) water is distinctly different, dominated by calcium-sulphate, indicating a clear separation from the natural water quality regime (KCB, 2026).

KCB (2026) use modelling of TSF and bund seepage by EGi (2026) as inputs to their TSF groundwater seepage, with bund seepage, due to larger particle sand composition, shown to generate elevated metal levels, as well as high SO4 and EC. Groundwater seepage from the TSF represents the main pathway by which impacts could reach surface water, as it contains elevated concentrations of dissolved solids, sulphate, and trace metals; TSF surface seepage and runoff will be diverted directly to the Ok Tedi via a diversion channel, and this should mitigate surface water creekline contamination. Modelling indicates that these contaminants will predominantly migrate within deeper groundwater (generally below 10 m), where they are substantially diluted by the very high recharge rates. In addition, the extent of the contaminant plume is expected to remain limited, typically within about 300 to 500 m of the TSF and extending to around 1 km only for more mobile constituents such as sulphate at low concentrations. KCG (2026) note that this groundwater will discharge to creeklines adjacent to the TSF due to the creeklines siting lower in the landscape and currently being gaining reaches from groundwater discharge.

[6] Data for creeklines in and adjacent to the TSF tabulated in KCB (2026), but also data collected by SLR (2025) and WRM (2014) for the TSF assessment, and for other lowland/foothill pipeline bursts (WRM 2011, 2012) show all forested foothill creeklines to be acidic, with pH from 5 to 7, and therefore all TSF creeklines are considered neutral to acidic. Only the Ok Birim and Ok Tedi main channels are alkaline, due to different catchment sources.

4.2 Impact to TSF Project Area and Receiving Creeks

4.2.1 Construction Phase

4.2.1.1 Loss of Aquatic Fauna Habitat

The construction phase will require clearing of the proposed TSF footprint area. Exact details of the construction process are unknown, but construction will be staged, with Cell 1 constructed first, followed by Cell 2. It is not yet known if the whole of Cell 1 will be cleared, or if the boundary will be cleared and the bunding constructed before the interior of the cell is then cleared. The sequence of ground disturbance will affect sediment and erosion of the TSF area, affecting TSS and siltation of creeks. Survey results confirm that this area contains numerous small creeklines that traverse the footprint and drain southward to form the Ok Yep, before discharging into the Ok Tedi (Figure 39). The area also supports natural springs that provide important ecological functions and villagers note they serve as valuable water sources for local communities. Clearing of vegetation and ground disturbance within the TSF footprint will result in the permanent loss of these creeklines and springs, with the potential for cumulative downstream impacts. In particular, creeklines sustained by springs may experience reduced discharge, altered flow regimes, or complete drying as a consequence of removing spring-fed inputs. The loss of natural undisturbed habitat will be permanent and irreversible with no mitigation possible thus rating the magnitude as major. The sensitivity value is rated as very high as these undisturbed creeklines provide high ecological values to the ecosystem. The residual impact significance is rated as a major negative impact. (Table 10).

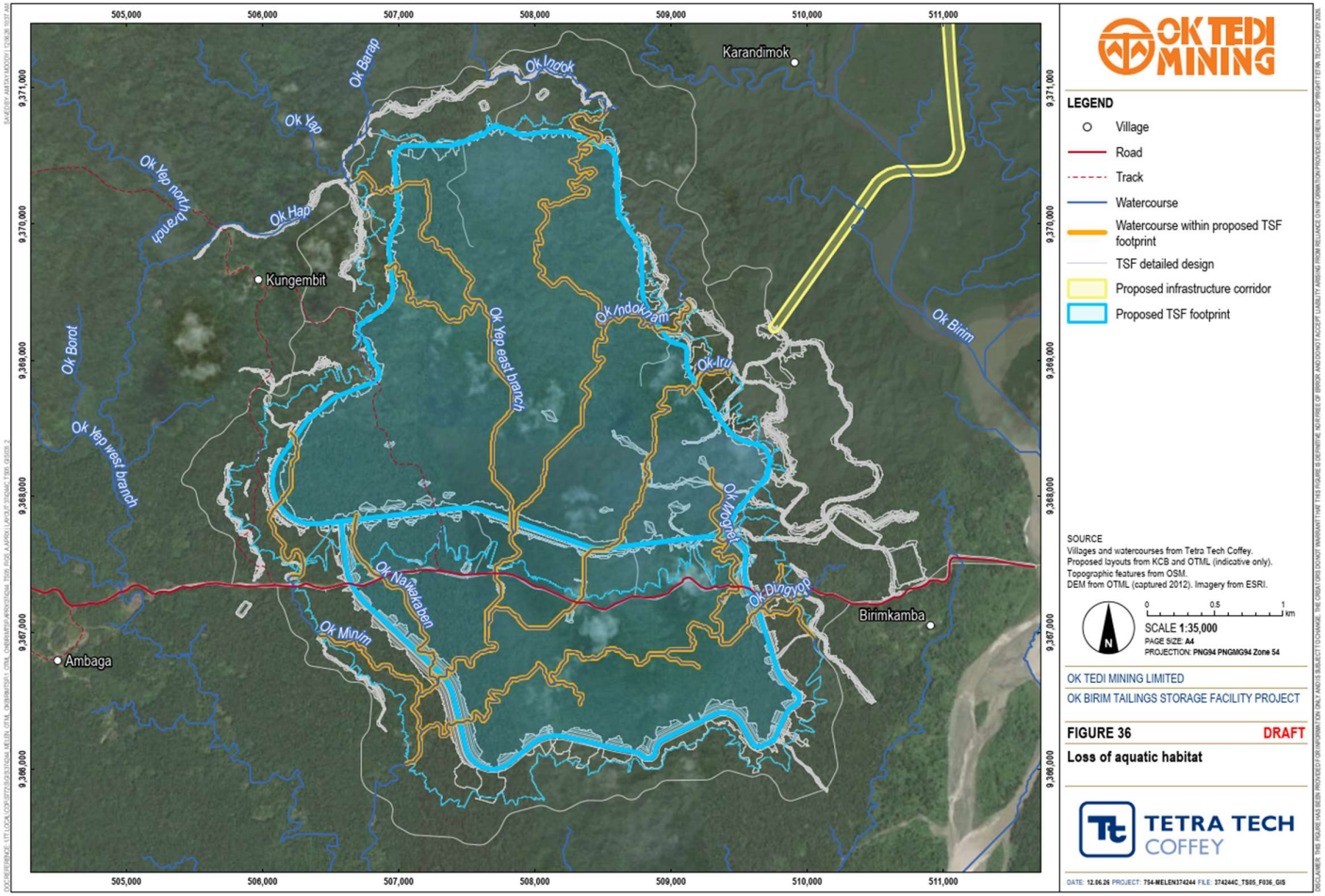

Figure 39. Loss of Aquatic Habitat

4.2.1.2 Environmental Quality

Clearing of rainforest within the proposed TSF footprint will be progressive, but will expose underlying clay and mudstone soils, substantially increasing the potential for sediment mobilisation during rainfall. Given the high-rainfall environment, surface water runoff from these disturbed areas will transport elevated sediment loads downslope into adjacent creeklines and drainage channels. Resultant increases in TSS in the Ok Yep will degrade water quality, and result in bed aggradation which will smother benthic habitats, disrupt ecological functioning, and adversely affect sensitive aquatic biota. The impact on sediment load is likely to be the greatest in the construction period (Pickup, 2025).

The footprint covers much of the east branch of the Ok Yep, a small 66.6 km^2 catchment that drains south and joins the Ok Tedi about 4 km south of the TSF. The TSF cuts off some of the upper tributaries of the Ok Yep in the north and east, but the design redirects flow back into the western arm of the Ok Yep further south. Pickup (2025) states that at present, these lowland watercourses carry little sediment load and occupy shallow, well-vegetated valleys. Clearing of the TSF area and that of associated infrastructure during construction is likely to produce an ongoing pulse of sediment load to the Ok Yep, mostly from local sources containing minimal copper and sulphur, especially before the ring dyke dams are completed. This is likely to result in Ok Yep stream bed aggradation which may subsequently flush out to some degree in the post construction period. Change in the environmental quality will be most significant in the 5km stretch of the Ok Yep south of the TSF with the magnitude rated as high. The change in environmental quality will impact on a close to pristine, natural, undisturbed system that provides refuge for various aquatic fauna, this change is rated as a high impact on the environmental sensitivity. The impact significance is rated as a major negative impact before and after mitigation (Table 10).

4.2.1.3 Aquatic Fauna

During construction, when vegetation is being cleared, elevated TSS levels will affect aquatic fauna that are sensitive to changes in water quality. All aquatic fauna inhabiting the small creeklines and the reaches of the Ok Yep within the TSF footprint will be permanently lost once construction begins. Increased sediment mobilisation from clearing activities will also elevate TSS and result in bed aggradation within the lower Ok Yep, as this system drains the TSF footprint and conveys runoff toward the Ok Tedi

Aquatic fauna from these creeklines would move upstream to find refuge if possible as there is limited connectivity within the smaller creeklines and springs. Aquatic fauna within the two larger tributaries of the Ok Yep (OB27 and OB10) would be able to move upstream above the TSF but will likely become isolated in the upper reaches with the TSF cutting off all connectivity. Bypass channels may be constructed around the TSF to redirect this flow back to the Ok Yep, but the channels are unlikely to be habitable by native fauna sensitive to the modelled changes in water quality. These upstream reaches could potentially also dry out due to change in hydrology within the catchment. Aquatic fauna moving downstream within the main Ok Yep channel could find refuge although some species of fish would not survive in the larger system with the possibility of increased sediment levels within this reach. Native species, such as Kiunga blue-eye (*K. leucozona*), Paskai's blue eye (*P. paskai*, and the restricted Fly River rainbow (*M. sexlineata)* are known to be very sensitive to elevated TSS and siltation.

As discussed above, *K. leucozona* appears to be isolated to the Ok Yep sub catchment and, as such, will likely be impacted by the development. At present *K. leucozona* is known from reference sites and from exposed sites within the TSF footprint and downstream potential exposed sites which will be affected by seepage/overflow. While populations have been

recorded outside areas of impact (i.e. reference sites OB10, OB16, OB17, OB20, OB21, OB24 & OB25), it is currently known only from a small geographic area, increasing its conservation status. Based on current surveys of the study area, but also adjacent areas towards Kiunga and Ningerum, *K. leucozona* is restricted to the Ok Yep sub catchment. Other species of Kiunga found to the east have similarly limited distributions (Allen et al., 2024). Based on current known occurrences, approximately 40% of the known occurrences of this species will be lost to the footprint of the TSF and associated impacts to creeks by seepage/TSS. Kiunga species appear to be very sensitive to changes in habitat and water quality, based on loss of *K. ballochi* from its historic distribution. Such a high population/distributional loss to *K. leucozona* would result in an IUCN Redbook listing as Critically Endangered if assessed. Table 11 provides an overview of restricted, or potentially restricted, species that will be impacted by the proposed development.

M. sexlineata is listed as Endangered and has also been recorded from reference and potentially exposed site (OB36 & OB37). The species has specific habitat preferences found in shallow, low EC spring fed creeklines. Due to their specific habitat preferences this species will not move into the main creeks of the Ok Yep. From known occurrences, approximately 17% of the known occurrences of this species in the Ok Yep sub catchment will be lost to seepage and water quality changes downstream of the TSF. However, *M. sexlineata* occurs more widely, and to the east of the Ok Tedi and of the upper Fly River main channel, and so impacts at a population level are less than for *K. leucozona*.

P. paskai is currently listed globally as Critically Endangered and has been recorded at site OB20 (reference site). The species is habitat specific and has a highly restricted distribution, often co-occurring with *M. sexlineata*. Although it was recorded outside the proposed TSF area, its known habitat preferences indicate that it may occur within the TSF footprint. More survey effort targeting the specific habitat where this species occurs is required, within and adjacent to the TSF to better understands in occurrences with the greater TSF project area.

The sensitivity of value of the aquatic fauna affected is considered very high due to the presence of IUCN-listed species, species with restricted distributions, and taxa potentially new to science that would be lost. While additional surveys beyond the project area could help delineate, and potentially extend the currently known species distributions and slightly reduce the perceived magnitude of impact, the impact would still be classified as major. The loss of aquatic fauna (particularly species with limited distributions and high ecological significance) represents a major negative impact, as it would be permanent and irreversible (Table 10).

4.2.2 Operational Phase

4.2.2.1 Environmental Quality

Pickup (2025) notes the risk of sedimentation and bed aggradation is predominantly during construction, but aggradation may persist after construction due to the low energy nature of these lowland creeks. Therefore, habitat alteration due to sedimentation may persist into operational phase. There is also risk of further sedimentation during operations, dependent on the effectiveness of settlement ponds capturing silt from TSF run-off. This continued siltation and elevated TSS will adversely affect the fauna of Ok Yep as the resident fauna is not adapted to elevated TSS.

In addition to TSS and sedimentation, EGi (2026) modelled effects of TSF seepage and overflow on water quality of the creeks in the immediate receiving environment, principally the Ok Yep. Predicted discharge water chemistry (Table 9) indicates that dissolved copper (dCu) and zinc (dZn) concentrations will exceed default guideline values (DGVs, 95% species protection), and will be higher than baseline concentrations currently measured at sites OY1 (already affected by backwater effects from the Ok Tedi) and OY2 on the Ok Yep. DOC (in

combination with pH) is known to reduce toxicity of dCu and dZn (ANZG, 2025) by complexing the metals into large molecule colloidals. DOC concentrations of receiving creeks are not known, but even allowing for complexing by conservative DOC concentration, dCu would remain at levels known to be acutely toxic to aquatic biota, exceeding the 80% species protection GV, and by inference, 80% of biota would be affected by adverse water quality. Similarly modelling indicated sulphate and TDS would be elevated in comparison with baseline conditions, and given the very low baseline levels in these creeks, particularly of conductivity/salinity (TDS), modelled levels would likely result in severe impact through osmotic shock to resident biota. Seepage would result in a measurable change in water quality within the Ok Yep relative to present baseline conditions.

Seepage from the TSF will impact on surface water quality with the KCB GWIA, (2026) predicting that elevated concentrations of dissolved solids, sulphate and trace metals will seep into the groundwater. As various smaller creeks to the west of the project area are groundwater fed, the environmental quality within these creeks will be impacted. Modelling indicated that the elevated concentrations would migrate within deeper groundwater and will remain limited, typically about 300 to 500m of the TSF and extending around 1 km for constituents such as sulphate.

The impact is assessed as high in magnitude due to its extent, occurring in an environment with high sensitivity. As a result, the overall significance is considered a major negative and permanent impact. Even after the implementation of mitigation measures, the residual impact is expected to remain major and adverse (Table 10).

4.2.2.2 Aquatic Fauna

Seepage and change in water quality within the Ok Yep will impact on biota sensitive to change in water quality. During operations, the TSF spillways will operate as a flow-through system that channels excess water from each storage cell to downstream sedimentation ponds to manage and reduce suspended solids from decant water, before controlled discharge into the receiving environment. Planned discharge of surplus TSF decant water will flow to the Ok Tedi via the Ok Yep after reduction of suspended solids. Seepage collection at the south (downstream) of the TSF will be transferred to a sedimentation pond, while un-intercepted seepage is expected to report to the Ok Yep and then to the Ok Tedi.

Elevated sediment yield and deposition along the Ok Yep will be observed during the construction phase. Post construction, some of the deposits may be eroded but sediment yield from the catchment is likely to remain higher than under pre-construction forested conditions (Pickup, 2025). Pickup (2025) further mentions that there may also be continuing sediment delivery to the lower Ok Yep from the constructed low diversion channels that border the ring dyke and other cleared areas, especially if blocking due to sediment build-up occurs.

The increased sediment levels within the Ok Yep during operational phase will have a major negative impact on the aquatic fauna within the system. Aquatic fauna sensitive to water quality changes might move upstream in the upper reaches (north-western reaches) for the Ok Yep.

The seepage from the TSF will alter the water quality within the lower Ok Yep further with the potential for elevated sulphate, TDS and dCu and dZn as mentioned previously. Levels of metals will be acutely toxic, and concentrations of salts (TDS and sulphate) will expose fauna to high osmotic stress. In combination, aquatic fauna of the Ok Yep downstream of the TSF will likely be severely impacted; dissolved metals will exceed guideline values, and conservative estimates of sulphate concentrations (~ 500 mg/L) will be toxic, with northern Australian studies indicating sulphate at around 70 mg/L adversely affects sensitive species (AW Storey, unpub. dat.). The impact magnitude is considered high due to its extent within

the Ok Yep and adjacent creeklines. Given the limited capacity of the receiving environment to recover, the sensitivity is also rated as very high, resulting in an overall classification of a major negative impact on aquatic fauna. Even with mitigation measures in place, the residual impact on aquatic fauna is expected to remain major and adverse (Table 10).

4.3 Ok Tedi and Fly River

There will be minimal changes to sediment/TSS or water quality of the Ok Tedi and Middle Fly during construction. Increases in TSS and bed aggradation predicted to affect the Ok Yep will be hard to detect in the Ok Tedi. The most significant changes will be during operations.

4.3.1 Operational Phase

4.3.1.1 Environmental quality

The Ok Tedi - Fly River system has been profoundly altered by mine-derived sediment inputs since mining commenced in 1984. Riverine disposal of tailings, erosion of waste rock dumps, and episodic large landslides have increased sediment loads by orders of magnitude above natural levels, fundamentally changing sediment transport, channel morphology, floodplain dynamics and water quality. Large volumes of sand and silt have accumulated in mine area creeks, the Middle Ok Tedi and the Lower Ok Tedi, and have progressively migrated downstream into the Middle Fly. Much of this sediment is now stored long-term on channel beds, levees, floodplains and off-river water bodies, with only slow reworking under contemporary flow conditions.

Sediment transport modelling and field observations indicate that these inputs caused major bed aggradation prior to the introduction of dredging at Bige. In the Lower Ok Tedi, riverbed levels rose by as much as seven metres, while several metres of aggradation occurred through parts of the upper and middle Middle Fly, with aggradation progressing into the lower Middle Fly. Bed aggradation reduced channel capacity and increased river water levels, promoted widespread overbank flooding, drove rapid levee growth, infilled off-river waterbodies (ORWBs) and progressively disconnected the floodplain from the main channel. Since dredging began in 1998, much of the sand delivered to the Lower Ok Tedi has been extracted, reversing or stabilising bed aggradation near the dredge reach. However, downstream reaches have continued to experience slow deposition as sediment already stored within the system continues to move downstream.

The proposed diversion of tailings to the TSF represents a substantial change to the sediment budget of the Ok Tedi - Fly River. Modelling shows that capturing the majority of tailings would reduce sediment inputs to the river system by approximately 85 to 95 percent, resulting in a major reduction in both sand and silt delivery to the Lower Ok Tedi and Middle Fly. Sand supply to the Bige dredging reach is expected to decline by roughly two-thirds, while the overall sediment load exported downstream becomes finer and increasingly dominated by silt derived from waste rock erosion and remobilisation of legacy deposits. Although sediment loads would be greatly reduced relative to current conditions, they would remain elevated above pre-mining levels for decades due to the release of material already stored within the river and floodplain systems. The addition of reduced

In terms of river morphology, the TSF would largely eliminate further bed aggradation in the Lower Ok Tedi and upper Middle Fly. Sediment-starved conditions in these reaches are expected to promote localised bed erosion and partial channel incision, particularly upstream of the dredge reach. Further downstream, especially in the central and lower Middle Fly, deposition is predicted to continue but at much lower rates, controlled primarily by the gradual downstream transfer of legacy sediment rather than new inputs. Levee growth is expected to

slow but largely persist, reflecting the longer response times of floodplain deposition processes compared with channel bed adjustment.

Water quality impacts within the Ok Tedi–Fly River system are closely linked to sediment dynamics, as more than 99 percent of copper and other key contaminants are transported in particulate form rather than dissolved. Existing water quality data and hydrogeochemical modelling indicate that diversion of tailings to a TSF would have minimal effect on river pH, which would remain circum-neutral to mildly alkaline. Small increases in sulphate concentrations are predicted immediately downstream of the TSF discharge under low-flow conditions, but these increases are rapidly diluted downstream and are not expected to materially affect water quality in the Middle Fly.

Dissolved copper concentrations are predicted to change little with TSF operation. Although dCu is released in TSF discharge waters, much of this copper rapidly adsorbs to suspended sediments upon mixing with river water with high TSS, limiting increases in dissolved concentrations. Importantly, overall copper loads transported downstream, predominantly pCu, are expected to decline by approx. 50% (400 mg/L to 200 mg/L) due to removal of tailings and associated reductions in suspended sediment concentrations. This represents an improvement relative to current conditions, where particulate copper stored in channel and floodplain sediments represents the dominant and persistent source.

The risk of acid rock drainage has also declined substantially compared with early mine life. Tailings sulphur contents are now less than one percent as a result of pyrite removal, and the addition of limestone has significantly increased the acid neutralising capacity of tailings and associated sediments. Modelling indicates that acid neutralising capacity to maximum potential acidity ratios would increase from approximately two to three under continued riverine disposal to values of five to six with a TSF in place. These ratios indicate a low likelihood of acid generation from future sediment inputs, representing a major long-term improvement to geochemical stability.

The magnitude of the change in environmental quality is rated as a very high positive, while the sensitivity of the Ok Tedi and fly river is rated as medium. The impact significance on the environmental quality is categorised as a major positive impact that will have long term improvements for the Ok Tedi and Fly River systems (Table 10).

4.3.1.2 Aquatic fauna

The reduction in sand inputs under TSF conditions is expected to substantially reduce mobile sand bed load in the Lower Ok Tedi and upper Middle Fly. This will decrease bed aggradation rates and improve channel stability, enhancing habitat availability for benthic and demersal fauna. Reduced sand movement will also lessen physical disturbance to eggs, larvae, and invertebrates associated with the riverbed, as well as make habitat conditions for bottom-dwelling fish more benign.

Total suspended solids (TSS), dominated by silt, are also predicted to decline markedly following tailings diversion. Median TSS concentrations upstream of Ningerum are expected to fall from around 2,500 mg/L to approximately 1,000 - 1,500 mg/L, with further reductions downstream. Lower TSS will improve water clarity, reduce gill abrasion and clogging in fish, and enhance feeding efficiency, especially for visual predators. The combined reduction in mobile sand and suspended silt will decrease the “sediment snowstorm” effect in the water column and along the bed, representing a High positive impact for fish health and aquatic productivity.

Changes in fish diversity, abundance and biomass in the Ok Tedi and Fly River downstream of the mine have been documented since 1983, with losses in biomass of between 65% and 96% relative to pre-mine levels in the Ok Tedi and middle Fly River channel, with the greatest

reductions recorded from sites closest to the mine. Species diversity in the Ok Tedi and Middle Fly River has also declined, although extensive fish diversity surveys determined that most species still occur in tributaries or other parts of the system.

Initial concerns were that observed effects were due to metal toxicity, given the elevated concentrations of total copper in the Fly River downstream of the mine. However, the majority of metals are particulate-associated, and therefore not readily bioavailable and concentrations of dissolved copper are generally low. Furthermore, the majority of the dissolved copper is non-labile due to the complexing capacity of the receiving waters which are alkaline and high in dissolved organic carbon.

The other major impacts in the river channel were increased total suspended sediments (TSS) and riverbed aggradation. In the apparent absence of any ecotoxicity effect, bed aggradation and associated changes provide a mechanism for reductions in fish catch by impacting on fish habitat in the main channel. Although TSS is elevated and is often reported in the scientific literature as impacting on aquatic fauna, the fish fauna of the Fly River system is considered relatively tolerant of high TSS. Therefore, aggradation and associated changes are thought likely of greatest effect. Storey et al. (2009b) demonstrated a significant inverse relationship between parameters likely to constitute or reflect aspects of fish habitat and bed aggradation in the Lower Ok Tedi and upper Middle Fly, indicating that declines in diversity and biomass of fish in the Fly River channel are most likely related to loss of habitat associated with bed aggradation.

In recent years a slight, but significant recovery in fish assemblages in the upper and middle Middle Fly has been observed (SLR, 2025), correlating to improvements in water quality, and reduced bed aggradation due to a combination of factors including reduced mining rates with reduced volumes of waste material, establishment of the pyrite circuit, dredging at Bige and reduced dissolved metal levels due to higher buffering capacity. As noted by Pickup (2025), the TSF will halt bed aggradation in the lower Ok Tedi and upper Middle Fly, with areas of the channel starting to erode/degrade. The visual effects of bed aggradation on fish habitat include smothering and covering of woody debris/snags, and infilling of ‘backwaters’ along the banks, as well as simplification of the littoral habitat due to forest dieback associated with overbank flooding (i.e. loss of trailing root mats, loss of complex root balls, loss of undercuts etc). If the TSF reverses some of these impacts, the improvement in fish habitat will have a positive effect on main channel fish assemblages and is seen as a High positive impact for fish health and aquatic productivity. Pickup (2025) notes that future reductions of inputs to the river system are anticipated via engineered waste rock dumps (EWRDs) and a mine plan which sees total waste rock production reducing from around 2030 onwards. This will also benefit recovery of river ecology and fish assemblages.

Floodplains of the Lower Ok Tedi and Middle Fly act as long-term sediment sinks, gradually removing sediment from the active river system. This natural storage process further moderates downstream sediment impacts over long timescales, supporting the recovery of aquatic habitats where sediment inputs are reduced. Dissolved organic carbon (DOC) concentrations increase downstream from mountain streams to lowland rivers, providing an important moderating influence on copper toxicity. DOC levels of approximately 1 mg/L correspond to a copper complexing capacity (CuCC) of around 32 µg/L, consistent with measured CuCC values (9–38 µg/L) within the system. This indicates that dissolved copper concentrations below approximately 30 µg/L are likely to be complexed and therefore less bioavailable and less toxic to aquatic fauna. Reductions in sediment-associated copper inputs following tailings diversion, together with natural DOC complexation, are expected to lower the risk of chronic and acute copper toxicity in fish and invertebrates. The significance of the impact is rated as a Major positive impact with a very high positive magnitude (Table 10).

4.4 Ok Birim

The Ok Birim catchment is currently a largely unimpacted, lowland rainforest and river system, with water quality, sediment regimes and aquatic habitats that are representative of natural background conditions in the Western Province of Papua New Guinea. Unlike the Ok Tedi, the Ok Birim has not historically received mine-derived tailings or waste rock and therefore has high environmental value and sensitivity. In acknowledgement of the Ok Birim as an important refuge for a range of fish species that have been heavily impacted in the main Ok Tedi channel, the TSF alignment proposed in 2014/15 was adjusted to avoid any impacts to the Ok Birim. The revised alignment means the TSF construction and operation will have no impact on the Ok Birim. However, the pipeline corridor crosses the Ok Birim, from the Ok Ma to reach the TSF, and potential impact of that alignment are here assessed.

4.4.1 Construction Phase

4.4.1.1 Environmental Quality

During construction, the lower reaches of the Ok Birim may experience localised, short-term reductions in environmental quality, primarily associated with land disturbance, vegetation clearing and infrastructure development near catchment margins. Although the TSF is designed to remain hydrologically separated from the Ok Birim River, construction activities from the associated infrastructure (road and pipeline) introduce several temporary impact pathways.

Disturbance of soils from clearing, bulk earthworks, borrow pits, access roads and drainage installation can increase the generation of fine sediments. In high-rainfall conditions typical of the area, these sediments may be mobilised and transported into small tributaries or drainage lines connected to the Ok Birim catchment. This can cause short-term increases in turbidity and suspended sediment concentrations, reducing water clarity and temporarily affecting benthic habitats and aquatic organisms. Such effects are expected to be episodic and confined to areas immediately downstream of disturbed sites and thus having a low magnitude. The impact is seen as a low negative impact (Table 10).

4.4.1.2 Aquatic Fauna

The main channel of the Ok Birim is one of the remaining, intact major tributaries of the Ok Tedi. Results from this study indicate that the system serves as an important refuge for a number of fish species now essentially lost from the Ok Tedi, or in decline in the Middle Fly, including the duck-billed catfish *(Cochlefelis spatula)*, broad-snouted catfish *(Potamosilurus latirostris)* and fringe-lipped mullet *(Crenimugil heterocheilos)*. The only other major tributary of the Ok Tedi of this size, and in a similar geomorphic setting, is the Ok Mart. The Ok Mart catchment, however, is subject to greater levels of disturbance from roads, villages, population growth and agriculture, as well as oil and gas development. Once the Ok Tedi copper mine closes, and habitat and water quality in the Ok Tedi improve, the Ok Birim will likely provide an important refuge from where fish recolonisation of the Ok Tedi main channel will take place. The TSF design avoids potential impacts on the Ok Birim and allows the Ok Birim to remain a refuge for fish species and categorised as a major positive impact.

The potential increase in TSS, sediment, nutrient loads and potential hydrocarbon spills from the clearing and construction activities associated with the major river crossing will impact on various aquatic fauna species using the Ok Birim as a refuge area (Table 11) that have limited distributions and sensitive to water quality changes (high sensitivity value). The impact of aquatic fauna will be limited to the approximate 1.7 km downstream of the river crossing and is categorised as having a low negative impact on the Ok Birim (Table 10).

4.4.2 Operational Phase

4.4.2.1 Environmental quality

The proposed Ok Birim Tailings Storage Facility has been deliberately positioned outside the Ok Birim drainage network, with the design intent of maintaining hydrological and geochemical isolation between the TSF and the Ok Birim. As a result, no direct operational discharge of tailings or process water to the Ok Birim is proposed, and long-term regional impacts are expected to be limited. However, some localised and indirect impacts on environmental quality may occur, during the operational phase.

The infrastructure associated with the Ok Birim TSF i.e. the tailings pipeline and access road will cross the Ok Birim as probably the largest river crossing along the alignment (Figure 40). The road and tailings pipeline will cross the Ok Birim and depending on the material used for the unsealed road will increase sediment run-off into the Ok Birim. Due to the high rainfall within the project area this impact will increase the TSS levels within the Ok Birim and potentially copper levels if road base material is extracted from the Ok Tedi, as used for the Kiunga/Tabubil Hwy, and the ITCS road. However, the Ok Birim is an alkaline system, and relatively well buffered, and so any dCu in seepage/runoff from road base will likely not be bioavailable. The impact from road crossing on the Ok Birim is categorised as a low negative impact even though the Ok Birim is seen as a refuge area for aquatic fauna especially species sensitive to water quality changes.

As the tailings pipeline will cross the Ok Birim the potential for pipeline bursts exists. Historical performance of the existing CuCon and PCon pipelines demonstrates a recurring risk of pipeline rupture or burst events. Although the geochemical characteristics of the proposed tailings stream differs from CuCon and PCon in previous pipelines bursts, a major rupture would result in the release of substantial volumes of tailings, presenting a significant risk to downstream aquatic ecosystems.

Although tailings differ chemically from PCon and CuCon, tailings are the primary source of particulate copper (pCu) in the Fly River. Pickup (2025) predicts that operation of the TSF would reduce pCu concentrations in the Ok Tedi/Fly River system by approximately 50%, from around 400 mg/kg to 200 mg/kg. Therefore, tailings will contain elevated concentrations of particulate-bound copper (and other metals). Under alkaline, well-buffered conditions (such as those observed in the Ok Tedi and Middle Fly) copper remains strongly associated with particulates, occurring predominantly as pCu within total suspended solids (TSS) at pH values of around 8.0. While the Ok Birim also has a near-neutral to slightly alkaline pH (~8.0), the introduction of tailings material would lead to water-quality deterioration, increased sedimentation, and ecological disturbance, representing a moderate adverse impact on the receiving aquatic environment downstream of the pipeline crossing (Table 10). The magnitude is considered low, as the impact will be confined to the area directly downstream of the pipeline, with aquatic fauna retaining the ability to move both upstream and downstream. The Ok Birim provides important refuge for a range of aquatic species, and the anticipated change in environmental quality results in the impact being classified with high sensitivity.

4.4.2.2 Aquatic Fauna

Operation of the tailings pipeline presents a risk of accidental releases that will affect aquatic fauna, with the magnitude of impact dependent on the scale of any pipeline failure. The magnitude of spills will depend on the size of the pipe, and location of the rupture relative to any pump stations or check valves in the pipeline. If a rupture occurs immediately upstream of such a structure, the total volume contained within the pipeline upstream of that point will

be lost to the environment. For PCon and CuCon pipelines some spills were up to 180-200 m^3 of material.

Minor ruptures of the pipeline (i.e. those downstream, but close to a pumpstation/check valve) may result in localised increases in sediment loads immediately downstream of the release point depending on volume released. These short-range impacts would primarily affect benthic habitats through smothering of substrates, leading to the loss or degradation of habitat for aquatic macroinvertebrates. Such changes may result in adverse effects on macroinvertebrate assemblages, particularly taxa sensitive to increased fine sediment deposition. Impacts from small ruptures are anticipated to be spatially limited and of short to medium duration, with recovery dependent on flow conditions and natural sediment transport processes. The impact is rated as a low negative significance.

Major pipeline failures or bursts would release substantially larger volumes of tailings into the receiving environment and are likely to result in impacts extending further downstream. Evidence from the 2010 tailings pipeline burst impact assessment undertaken by WRM in 2010 and 2011 indicates that while overall macroinvertebrate taxa richness was not significantly reduced at some downstream sites, there were marked changes in community composition. Specifically, taxa sensitive to declines in water quality (such as mayflies and dragonflies) were replaced by more tolerant species (including midge larvae). These shifts indicate a degradation of ecological condition and reflect residual impacts associated with tailings and concentrate spills rather than complete loss of aquatic fauna. The impact of a major pipeline failure is rated as a Major negative significance.

This impact assessment relates specifically to the Ok Birim bridge and pipeline crossing. Once the pipeline design is finalised, it will be possible to assess the potential impact relative to size of pipe, position relative to pumps and check valves, and calculate the volume of tailings that potentially could enter the Ok Birim in event of a major failure, and better estimate the potential impact (Table 10).

Table 10. Summary table of Significance Matrix for impacts associated with the TSF Project. + Denotes positive impact.

Impact	Magnitude of Impact	Sensitivity of Value	Significance
Impact to TSF Project Area and Receiving Creeks			
Construction Phase			
Loss of Aquatic Fauna Habitat	Major	Very High	Major
Environmental Quality	High	Very High	Major
Aquatic Fauna	Major	Very High	Major
Operational Phase			
Environmental Quality	High	Very High	Major
Aquatic Fauna	High	Very High	Major
Ok Tedi and Fly River			
Operational Phase			
Environmental Quality	Very High +	Medium	Major +
Aquatic Fauna	Very High +	Medium	Major +

Impact	Magnitude of Impact	Sensitivity of Value	Significance
Ok Birim			
Construction Phase			
Environmental Quality	Very Low	High	Low
Aquatic Fauna	Very Low	High	Low
Operational Phase			
Environmental Quality	Low	High	Moderate
Aquatic Fauna (Minor pipeline ruptures)	Very Low	High	Low
Aquatic Fauna (Major pipeline ruptures)	High	High	Major

Table 11. Restricted, or potentially restricted, species which may be at risk from the development of the Ok Birim TSF

TYPE	SPECIES	KNOWN DISTRIBUTION	CONSERVATION STATUS	STUDY SITES RECORDED	REASON FOR IMPORTANCE
Rotifer	*Lepadella* n. sp.	First record	No	Reference site OB25	Species potentially new to science; first record; currently only known from potential exposed sites
Crayfish	*Cherax peknyi*	Fly River drainage only	IUCN Data Deficient	OB1 on the Ok Birim main channel, as well as small creeks including both potential exposed (OB28, OB33 & OB34) and reference sites (OB17, OB20 & OB22).	This species is affected by fishing pressure from locals, as well as aquarium trade with Europe and is known from a number of creeks which may be impacted now or in the future by mining. Although it is known from reference sites and areas outside the TSF footprint and potential exposed sites, there is insufficient data on the species to assess the level of threat.
Water scorpion	*Cercotmetus dissidens*	Endemic to the island, previously known only from West Papua; Sabang and Wapoga River area	No	Reference site OB1 on the Ok Birim main channel	Disjunct distribution; first record from PNG; only recorded from one site which is likely to not be impacted by the development. As such the PNG population is at risk.
Naucorid	*Cavocoris minor*	PNG endemic previously known from the Morobe Province	No	Reference sites OB7 and OB15	Appears to have a disjunct distribution, with few occurrences. Not recorded from any reference sites but is also known from the Morobe Province

TYPE	SPECIES	KNOWN DISTRIBUTION	CONSERVATION STATUS	STUDY SITES RECORDED	REASON FOR IMPORTANCE
Damselfly	*Pseudagrion* sp. PNG02	Morphotype not known from elsewhere, no previous records by the authors from any other surveys conducted for OTML	No	OB10 within the TSF footprint	Only known record is from within the TSF footprint. While this may represent a morphological variant of a species with a more broad distribution, current taxonomic knowledge indicates it may be new and may have a restricted distribution.
Mayfly	*Thraulus* sp. PNG03	Morphotype not known from elsewhere, no previous records by the authors from any other surveys conducted for OTML	No	Reference sites (OB5, OB7, OB11, OB12, OB14 & OB15)	All records were from potential exposed sites. Not recorded by the authors previously. Again, while this may represent a morphological variant of a species with a more broad distribution, current taxonomic knowledge indicates it may be new and may have a restricted distribution.
Kiunga Blue-eye	*Kiunga leucozona*	Small tributary creeks of the Ok Birim	Not assessed. Limited distribution.	Potential exposed site OB10, as well as reference sites OB17, OB18, OB20, OB21, OB22, OB23 & OB24.	The specimens from the Ok Birim were sufficiently genetically distinct from other *Kiunga species* known from creeks to the east of the Ok Tedi for this species to be described as a new species. This species has a highly restricted distribution and would be at risk from the TSF development.
Eel-tailed catfish	*Neosilurus Sp. B*	Ok Birim main channel	No	Reference site OB1	Known to be a new species to science

TYPE	SPECIES	KNOWN DISTRIBUTION	CONSERVATION STATUS	STUDY SITES RECORDED	REASON FOR IMPORTANCE
Mountain River Sprat	*Clupeoides ?venulosus*	Fly River, specifically from the upper Ok Tedi main channel around Tabubil	No	OB2 (Ok Birim main channel)	Due the apparent loss of C. venulosus from the main channel of the Ok Tedi it was considered a priority species under the irreversibility studies conducted for OTML. The status of the specimens recorded from the Ok Birim remains unclear. They may be a morphological variant of *C. papuensis*, or it may be *C. venulosus*.
Fly river Rainbowfish	*Fly River Rainbowfish (Melanotaenia sexlineata)*	Known only from Upper Fly system in a few creeks between Kiunga and Rumginae. Full extent of distribution remains undetermined	Endangered	OB5, OB7, OB12, OB13, OB14, OB15, OB16 (recorded in 2014). OB9, OB21, OB20, OB36, OB37 (recorded in 2025)	Recorded from reference site (OB9, OB20 & OB21) and from potentially exposed site (OB36 & OB37). The species has specific habitat preferences found in shallow, low EC spring fed creeklines. The species would be at risk from the TSF.
Few-Pored Gudgeon	*Swamp Gudgeon (Oxyeleotris stagnicola)*	Central-southern New Guinea between Fly River, PNG and the Timka region, Papua Province (Indonesia)	Endangered	OB12, OB13, OB14, OB16, OB17, OB18, OB20, OB21 and OB23 (2014) OB17, OB20, OB25, OB26, OB28, OB29, OB33, OB34 and OB35 (2025)	Recorded at potentially exposed site (OB28, OB29, OB33, OB34, OB35) the development of the TSF will impact on the species distribution and habitat.
Paska's Blue Eye	*Pseudomugil paskai*	Upper Fly River system only from a few small creeks along the Kiunga-Tabubil road.	Critically Endangered	OB20	Recorded at reference site (OB20). Species has specific habitat preferences and limited distribution. Likely habitat within the Ok Birim TSF footprint.

4.5 Ok Ma Infrastructure Corridor

4.5.1 Construction Phase

4.5.1.1 Environmental Quality

The proposed alignment for the pipeline access route provides a more direct connection between the existing Ok Tedi Mine and the proposed TSF site, approaching from the north through undeveloped areas, and including up to four (4) major crossings and nine (9) minor water crossings (Figure 40). The infrastructure corridor for construction of a new access road and laying of the pipeline will require clearing of a road corridor, and significant earthworks which will lead to increased sediment run-off from areas cleared of rain forest and where ridges and hill sides will be cut into or removed. The increased run-off will have elevated sediment load from clearing and disturbed soils along the route. As the water quality within the Ok Ma and particularly associated smaller tributaries is of good quality, even small increases in TSS, EC and nutrients from disturbed soils are known to be detrimental to species adapted to very fresh, low TSS waters. Hortle (1986) reported significant impacts to tributaries and the Ok Tedi from the construction of the access road from Kiunga to Tabubil due to sediment run-off increases and increase in TSS even before the mine commenced operations. The impact that the clearing and construction of the access road is categorised as a major significant impact. The extent of the impact will be dependent on type of river crossing and volume of sediment runoff. As these crossing have not been confirmed it's difficult to determine the exact extent of these impacts. The increase in TSS from surface water runoff and disturbance is rated as a high negative significance.

The use of road base, if extracted from the Ok Tedi poses a risk to aquatic ecosystems. The Kiunga-Tabubil Highway has been constructed using road base dredged from the Ok Tedi. This material is elevated in Cu. Studies of the impact of various pipeline bursts along the highway detected significant impacts downstream of road crossings that was attributed to leaching of metals from the road base material (WRM, 2009, 2012). The use of gravel from the Ok Tedi will increase the mobilisation of various toxicants such as copper due to oxidation of exposed material, and increased surface water runoff from the access road. The impact on water quality directly downstream of the proposed water crossings is rated as medium on smaller, pH < 7.0 creeks, and Low in larger, alkaline and well buffered main channel of the Ok Ma a moderate negative significance (Table 13).

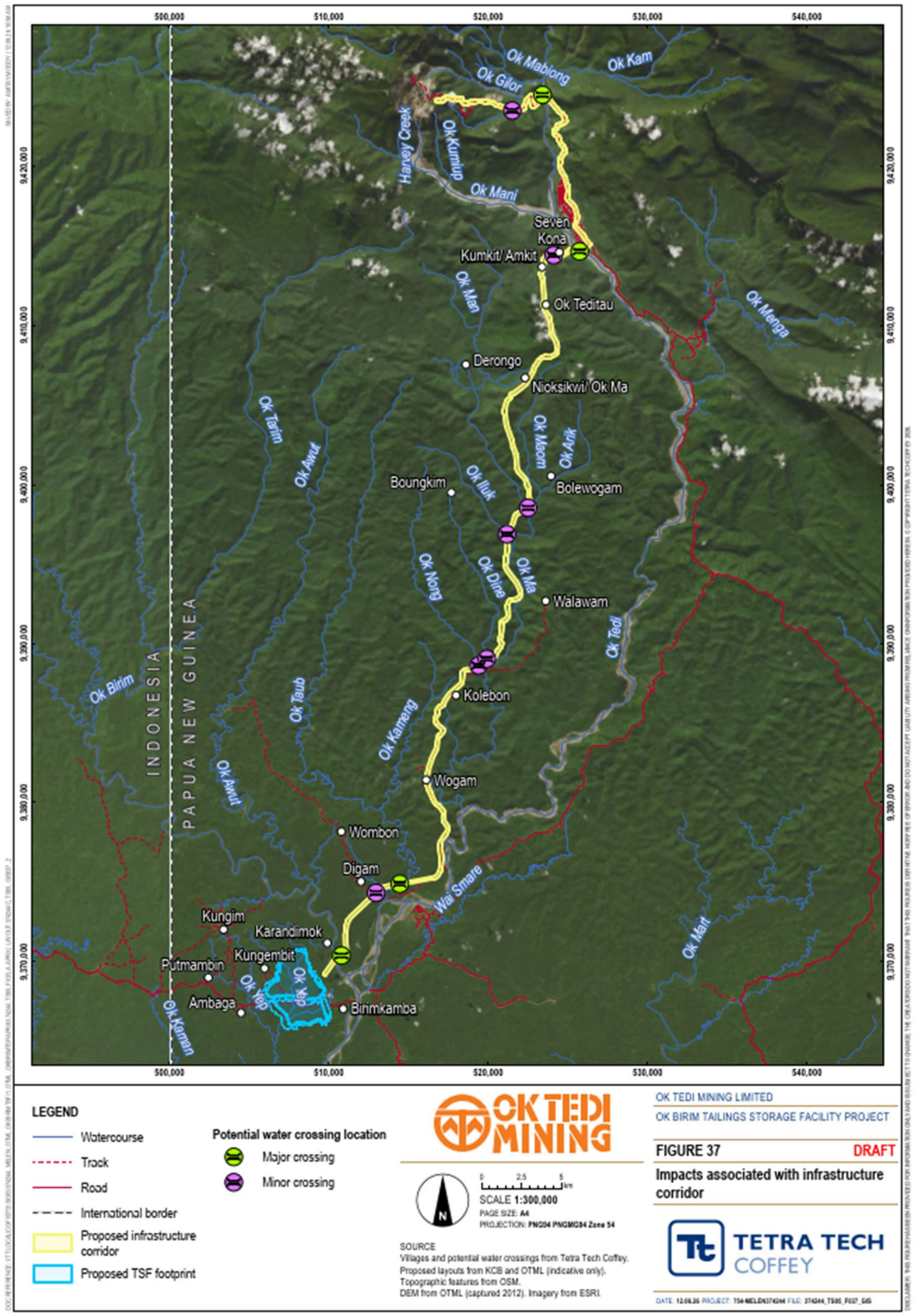

Figure 40. Impacts Associated with Infrastructure Corridor

4.5.1.2 Aquatic Fauna

The Ok Ma is one of the few remaining, intact major tributaries of the middle Ok Tedi. Results from this study indicate that the system is an important refuge for a number of fish species now essentially lost from the Ok Tedi, including Roberts Goby (*Glossogobius robertsi)* and Ok Tedi Rainbowfish (*Melanotaenia oktediensis)*. OTML gill net catch data also indicate the lower Ok Ma is a refuge for several species once common but now in decline in the Ok Tedi and Middle Fly.

The potential increase in TSS, and sediment and nutrient loads associated with clearing, cutting and construction of the additional infrastructure could impact on various aquatic fauna species using the Ok Ma as a refuge area that have limited distributions and are sensitive to water quality changes. These species were found at numerous potentially exposed sites and reference sites along the Ok Ma with the full spatial extent of these species unknown (Table 12). Depending on the magnitude of silt and sediment run-off, the channel TSS will be elevated, bed aggradation may occur in places, and interstices of the bed will be filled, limiting benthic fauna habitat and spawning sites for rheophilic fish species. The direct impact on the Ok Ma of use of Ok Tedi gravel as road base at the river crossings is rated as a moderate negative impact (Table 13) on smaller, less buffered creeks as the change in water quality would impact on aquatic fauna sensitive to water quality changes, and Low in the well buffered, alkaline Ok Ma main channel. The extent of the impact will be dependent on the type of crossing, construction method and material used for the road construction.

Table 12. Restricted, or potentially restricted, species which may be at risk from the development of the Ok Birim TSF and associated infrastructure

TYPE	SPECIES	KNOWN DISTRIBUTION	**CONSERVATION STATUS**	STUDY SITES RECORDED	REASON FOR IMPORTANCE
Roberts Goby	*Glossogobius robertsi*	Upper Fly in the vicinity of Palmer River junction and from mountainous tributaries of the Ok Tedi just south of Tabubil	Near Threatened	OM3, OM7, OM8 and OM9	*G. robertsi* prefer mountainous tributaries such as ok Ma providing unimpacted refuge areas for the species. All records were from potentially exposed sites and at risk from the associated infrastructure.
Ok Tedi Rainbowfish	*Ok Tedi Rainbowfish (Melanotaenia oktediensis)*	Known only from the Ok Tedi and its tributaries	Critically endangered	OM1, OM5 and OM6	Recorded at reference site (OM1 & OM6) and potentially exposed site (OM5). The species has a highly restricted distribution and would be at risk from the associated infrastructure.

4.5.2 Operational Phase

4.5.2.1 Environmental Quality

The operation of the unsealed access road from Tabubil involves multiple crossings of major and minor waterways and tributaries. The alignment crosses the Ok Tedi and follows the Ok Hwie southward past Kumkit/Amkit village for approximately 8 km toward Ok Ma village. From this point, the road alignment continues along the Ok Ma corridor, intersecting numerous creeklines as it extends south toward the proposed Tailings Storage Facility (TSF).

At the time of reporting, the detailed design of individual watercourse crossings has not been confirmed. It is assumed that smaller creek crossings will be constructed using culverts, while larger watercourses will require bridge structures. Both construction and ongoing operation of the unsealed road are expected to alter surface hydrology by increasing surface runoff due to compacted and hardened road surfaces. This will result in increased delivery of sediment-laden runoff to adjacent waterways, leading to elevated total suspended solids (TSS) in the receiving aquatic environment.

Road construction and maintenance activities have the potential to further exacerbate water quality impacts if construction materials are sourced from the Ok Tedi. Such material has been observed to contain elevated concentrations of metals, including lead (Pb), cadmium (Cd), copper (Cu), and zinc (Zn), as identified at monitoring site OY1. Where this material is used—assumed to be limited to the northern and southern sections of the road—there is a clear potential for mobilisation of metals into the Ok Ma and its tributaries at creek crossings through erosion, runoff, and sediment transport processes.

Over the long term, the sustained increase in sediment input from road runoff and disturbed surfaces is expected to degrade water quality in the Ok Ma system. Elevated TSS levels may reduce water clarity, alter streambed habitats, and adversely affect aquatic biota, particularly in smaller tributaries with limited dilution capacity. In the absence of effective erosion and sediment control measures, the increase in TSS associated with road operation is assessed as having a high negative impact on the water quality of the Ok Ma and connected waterways.

The purpose of the Ok Ma road and alignment is to provide a corridor for placement of the tailings pipeline. Historical performance of the existing CuCon and PCon pipelines demonstrates a recurring risk of pipeline rupture or burst events. Although the geochemical characteristics of the tailings stream may differ from CuCon and PCon in previous pipelines, depending on its location, a rupture could result in the release of substantial volumes of tailings, presenting a significant risk to downstream aquatic ecosystems.

Previous assessments by WRM provide relevant context for evaluating potential impacts. In 2010, WRM assessed the environmental consequences of CuCon pipeline burst volumes ranging from approximately 18 to 20 cubic metres of concentrate. In 2011, WRM assessed the impacts associated with pyrite discharges of approximately 60 and 100 cubic metres. These studies determined that released material rapidly filled creeklines to bank full, with particularly severe effects observed in smaller tributaries. The material was either recovered manually over following months (villagers employed to manual dig the material from the creek into ~20 kg bags, return the bags to a collection point, with bags transported to the mine for re-processing), or spills were allowed to erode downstream.

The magnitude of these impacts was substantial, with physical smothering of streambeds, degradation of water quality, and disruption to aquatic habitats. Spill material coated Creekside/banks and was regularly dried and wetted due to fluctuating water levels, with contaminants leached after oxidation. Notably, residual impacts from these spill events remain evident up to 18 years after the incidents, indicating long-term ecological consequences and limited natural recovery in some affected catchments.

Based on these precedents, a pipeline rupture associated with the proposed infrastructure corridor would likely result in significant loading of tailings material into creeklines and downstream waterways. Although tailings are different in chemical composition to PCon and CuCon, they are the main source of pCu in the Fly River. Pickup (2025) predicts a 50% reduction in pCu in the Ok Tedi/Fly River under TSF (from 400 mg/kg to 200 mg/kg). Tailings therefore contain a high concentration of particulate-bound Cu (& other metals). Under alkaline/well buffered conditions, as seen in the Ok Tedi and Middle Fly the Cu remains bound to particulates (viz. as pCu in the TSS in the Ok Tedi and Fly, with pH around 8.0). However, in the event of a pipeline rupture/spill into naturally acidic lowland/foothill creeks (pH < 7.0), tailings will start to produce dCu. EGi predict levels of dCu (& Zn, TDS and SO4) above toxicity GVs seeping/leaching from the TSF, notable the embankments made from sand, which will oxidise. This same material if lost into small creeks that are naturally acidic, with fluctuating water levels will oxidise and leach metals. The resulting water quality degradation, sedimentation, and ecological disturbance would constitute a major negative impact on the receiving aquatic environment (Table 13).

4.5.2.2 Aquatic Fauna

Operation of the tailings pipeline presents a risk of accidental releases that will affect aquatic fauna, with the magnitude of impact dependent on the size of any pipeline failure. The magnitude of spills will depend on the size of the pipe, and location of the rupture relative to any pump stations or check valves in the pipeline, and severity of the rupture. If a rupture occurs immediately upstream of such a structure, the total volume contained within the pipeline upstream of that point will be lost to the environment. For PCon and CuCon pipelines some spills were up to 180-200 m^3 of material. Ruptures are under high pressure, and spills happen very quickly, with material spraying 10s-100s of meters into the bush. If adjacent to a creek, the volume of the material can fill smaller creeks to bank full and erode downstream into larger water courses.

Minor ruptures of the pipeline (i.e. those downstream, but close to a pumpstation/check valve; < 10 m^3 of material) may result in localised increases in sediment loads within small creeks immediately downstream of the release point depending on volume released and size of the creek. These short-range impacts would primarily affect benthic habitats through smothering of substrates, leading to the loss or degradation of habitat for aquatic macroinvertebrates. Such changes may result in adverse effects on macroinvertebrate assemblages, particularly taxa sensitive to increased fine sediment deposition. Impacts from small ruptures are anticipated to be spatially limited and of short to medium duration, with recovery dependent on flow conditions and natural sediment transport processes. The impact is rated as a low negative significance.

Major pipeline failures or bursts would release substantially larger volumes of tailings into the receiving environment and are likely to result in impacts extending further downstream. Evidence from the pipeline burst impact assessment undertaken by WRM in 2010 and 2011 indicates that while overall macroinvertebrate taxa richness was not significantly reduced at some downstream sites, there were marked changes in community composition. Specifically, taxa sensitive to declines in water quality (such as mayflies and dragonflies) were replaced by more tolerant species (including midge larvae). These shifts indicate a degradation of ecological condition and reflect residual impacts associated with pyrite and copper concentrate spills rather than complete loss of aquatic fauna. The impact of a major pipeline rupture into a lowland/foothill, naturally acidic tributary creek along the Ok Ma is rated as a Major negative significance (Table 13), with this impact reducing to Medium to Low, depending on magnitude, once this material reaches the alkaline, well buffered Ok Ma main channel.

Table 13. Summary table of Significance Matrix for impacts associated with the Ok Ma Infrastructure Corridor

Impact	Magnitude of Impact	Sensitivity of Value	Impact Significance
Ok Ma Infrastructure Corridor			
Construction Phase			
Environmental Quality - Increase TSS from clearance	Moderate	High	High
Environmental Quality - Runoff from road	Low	High	Moderate
Aquatic Fauna	Low	High	Moderate
Operational Phase			
Environmental Quality	High	High	Major
Aquatic Fauna	High	High	Major

5.0 Conclusions

This report provides results for the 2025 aquatic fauna baseline survey and impact assessment for the proposed Ok Birim TSF and Ok Ma infrastructure corridor. The survey was undertaken in two phases, the first phase in August 2025 and the second in November 2025. The initial survey focussed on the northern TSF area due to logistical and community issues preventing access to the TSF south of the Infrastructure Tax Credit Scheme Road. Prior to the second survey, a decision was made to construct a road and pipeline infrastructure alignment along the Ok Ma creekline, from the mine to the TSF. Once community access had been resolved, a second survey was conducted which focussed on the southern TSF area, and included the proposed associated infrastructure corridor along the Ok Ma.

In total, 37 sites were sampled across the two surveys, with 14 reference (R) sites and 23 potentially exposed (PE) sites. 11 of the sites were previously also sampled in the 2014/15 baseline surveys and were resampled in 2025. Each site was surveyed for water quality, sediment quality, habitat assessment, macroinvertebrate and fish fauna.

5.1 Ok Birim TSF

The Ok Birim TSF project area and reference tributaries varied in morphology and substrate and habitat composition. The main Ok Birim channel sites had lower habitat diversity than the smaller creekline sites, dominated by medium size inorganic substrate, whereas smaller creeks were dominated by small-sized inorganic substrates, detritus, macrophytes and LWD. Only two types of macrophytes were recorded within the smaller creekline sites, and no macrophytes were recorded within the main Ok Birim channel.

Water quality ranged from acidic (smaller creeks) to alkaline (main Ok Birim channel) across sites (pH 5.5 - 7.94). EC was extremely low across sites with majority of the smaller creeklines having an EC <10 µS/cm, while DO saturation levels were within the guideline values with some sites having saturation levels below the lower DGV. The concentrations of dissolved metals (dCu, dPb, dZn, dCd and dAs) were occasionally higher than the DGVs at some sites.

Metals in sediments were generally low, but site OY01 exceeded DGVs for Cd, Cu, Pb, and Zn, indicating a localised increase in concentrations. Site OY1 is located upstream of the confluence of the Ok Yep with a branch of the Ok Tedi and localised increased concentrations is likely due to the backwater effect of sediments being deposited during high flow events within the Ok Tedi. ANC was low across many sites; several locations showed positive NAPP, indicating sediments are potentially acid-generating.

The fish fauna of the Ok Birim TSF project area is diverse and ecologically significant, with 44 freshwater species recorded across the combined 2014/15 and 2025 surveys, the majority of which are native to the region. Site species richness was highest in the main Ok Birim channel, where up to 21 species were recorded at individual sites, reflecting the broader habitat diversity and the effectiveness of sampling methods in these larger waterways. In contrast, fish assemblages in the smaller tributaries exhibited lower richness, partly due to naturally complex habitats and very low conductivity, which limited electrofishing efficiency.

The mainstream of the lower Ok Birim system functions as a critical refuge for several species of fish previously diminished or lost from the Ok Tedi, including fork-tailed catfish (Ariidae) and the giant glassfish (*Parambassis gulliveri)*. These species were recorded only within the main channel of the Ok Birim, highlighting its importance as a stable habitat capable of supporting sensitive and larger-bodied species historically affected by mining impacts along the length of the Ok Tedi and Middle Fly.

The smaller creeks in the TSF footprint area supports a suite of fish species of high conservation significance, including several listed as Endangered and a number of

geographically restricted or potentially undescribed taxa. These species occur predominantly within small tributary creeks, habitats that are highly sensitive to changes in water quality, hydrology, and physical disturbance.

Species such as the Fly River Rainbowfish (*Melanotaenia sexlineata*), Swamp Gudgeon (*Oxyeleotris stagnicola*), Paska blue eye (*Pseudomugil paskai*) and the newly described *Kiunga leucozona* have limited distributions, and occur within the study area, making their populations particularly vulnerable to habitat loss and water-quality changes associated with TSF development.

Ok Birim system currently provides an ecologically important and culturally significant subsistence fishery for local communities. While catch rates during the 2025 survey were lower than expected due to high flows, historical data and local knowledge confirm that the lower Ok Birim remains an important subsistence, artisanal source of fish and other aquatic foods.

Metal concentrations in fish and crayfish tissue were generally low to moderate across sites, with exceedances limited to selenium and zinc at select locations; however, when adjusted for realistic portion sizes, based on documented local intake, exceedances were substantially reduced. These results suggest that, under current conditions, human health risks from fish consumption are low, though continued monitoring is warranted given the reliance of communities on whole-fish consumption.

Community observations highlight that creeks and springs across the TSF area are used daily for drinking, washing, sago processing, and fishing. The Ok Birim and lower reach of the Ok Yep also serve as key transport routes. These findings underline the dependence of local communities on healthy aquatic environments and reinforce the importance of maintaining water quality and aquatic habitat integrity downstream of the TSF footprint.

5.2 Ok Ma Associated Infrastructure Corridor

The Ok Ma habitat assessments show that reference and potentially exposed sites vary in substrate composition, with most sites dominated by inorganic mineral substrates and moderate habitat diversity, while submerged macrophytes were present only at two sites (OM3 and OM12).

Sediment quality within the Ok Ma was typically low in metals, with no values higher than the sediment guideline values for Cu, Pb or Zn. Acid neutralising capacity data indicate that while most sites have sufficient buffering capacity, site OM12 shows limited resilience, reflected by a positive NAPP value suggesting natural acid-generation potential.

Water quality within the Ok Ma survey sites were within slightly acidic to alkaline pH ranges (6.7–8.1) and while very low EC (20–100 µS/cm) was recorded, aligning with conditions expected in undisturbed lowland PNG rivers. Isolated elevated levels were noted for dissolved copper at both reference and potentially exposed sites, particularly OM5 (10 µg/L; 7× DGV), although most metals remained below detection limits or well below guideline thresholds. Dissolved oxygen was often above the upper DGV, likely due to natural site conditions (i.e. fast and turbulent flow) and was not considered ecologically concerning.

The fish fauna of the Ok Ma channel comprised 16 native species, with species richness influenced by the fast-flowing, deeper channel habitats that limited some sampling methods. Several species of conservation significance were recorded, including the Near Threatened *Glossogobius robertsi* and the Critically Endangered Ok Tedi Rainbowfish *(Melanotaenia oktediensis)*, both of which rely on the Ok Ma as a refuge from broader catchment disturbances. Their restricted distributions highlight the ecological value of this system.

Metal concentrations in fish tissue from Ok Ma were generally low, with most analytes well below human-health guideline values. Selenium was the only element that exceeded the TDI-based threshold in several whole-fish specimens; however, when assessed using realistic portion-based exposure scenarios, and considering limited exposure to Se in other dietary sources (i.e. sago), exceedances were removed. These results indicate that, under present conditions, fish consumption from the Ok Ma does not pose a substantive human-health risk, though continued monitoring remains appropriate given community reliance on whole-fish consumption and the potential for future disturbance.

Social-use observations confirm that the Ok Ma continues to support local livelihoods through fishing, collection of prawns and crayfish, and opportunistic harvest of larger species such as eels and turtles. Although the system is less accessible than the Ok Birim due to variable water levels and limited settlement density, the Ok Ma remains an important cultural and subsistence resource for villages along its middle and upper reaches. Collectively, these findings emphasise the need to maintain the integrity of the Ok Ma's aquatic habitats, water quality, and hydrological function to support both ecological values and community wellbeing.

5.3 Potential Impacts of the TSF and Infrastructure Corridor

5.3.1 TSF Project Area and Receiving Creeks

The assessment of the TSF Project Area and its receiving creeks, particularly the Ok Yep, demonstrates that the proposed development will result in substantial and, in several respects, irreversible local-scale impacts to aquatic habitats and fauna. These impacts are most pronounced within the TSF footprint and the immediate receiving environment downstream (i.e. lower Ok Yep to its confluence with the Ok Tedi), and are attributable to both construction-related disturbance and long-term changes in hydrology, sediment dynamics, and water quality during and post operations.

During construction, clearing of the TSF footprint will lead to the permanent loss of spring-fed creeklines and associated aquatic habitats that currently support a diverse and highly sensitive fauna. These systems are of high ecological value, providing habitat for species with restricted distributions and specialised habitat requirements. Increased sediment mobilisation from exposed clay and mudstone soils will generate sustained pulses of fine sediment to the Ok Yep, resulting in elevated TSS, streambed aggradation, and widespread degradation of benthic habitats. The magnitude of these impacts during construction is assessed as major and negative, with effects concentrated within the Ok Yep catchment and extending the length of the Ok Yep from the TSF outflow to its confluence with the Ok Tedi.

Aquatic fauna impacts during construction are significant and largely irreversible within the footprint, with complete loss of resident communities in small creeklines and springs. Opportunities for refuge are limited due to poor connectivity, altered hydrology, and the sensitivity of key species to increased turbidity and siltation. Species of particular conservation concern (including *Kiunga leucozona*, *Melanotaenia sexlineata*, and *Pseudomugil paskai*) are expected to experience substantial reductions in population size and distribution. For *K. leucozona*, the loss of approximately 40% of known occurrences represents a critical conservation risk and would likely meet criteria for listing as Critically Endangered if formally assessed. *Melanotaenia sexlineata*, and *Pseudomugil paskai* have broader distributions and so impacts at the population level are not so significant. These losses represent major negative impacts that are permanent in nature.

During operations, the Ok Yep will continue to experience degraded environmental conditions as a consequence of persistent sedimentation and elevated metals from TSF seepage. Modelling indicates that seepage and discharge waters will result in elevated concentrations of dissolved copper, zinc, sulphate and total dissolved solids relative to natural baseline conditions. Even allowing for metal complexation by dissolved organic carbon, modelled concentrations are predicted to exceed guideline values for aquatic ecosystem protection and are expected to be acutely toxic to a large proportion of resident biota. In addition to elevated metals, at levels known to be toxic, elevated TDS, TSS and sulphate in systems with naturally low conductivity and very low sediment tolerance of fauna inhabiting the Ok Yep, these changes represent a fundamental shift away from baseline conditions.

Operational impacts to aquatic fauna are therefore assessed as major, negative and permanent. The combined effects of ongoing sediment delivery altered hydrology, and water quality degradation to acutely toxic levels are expected to preclude recovery of sensitive species in the Ok Yep downstream of the TSF. While some mobile fauna may seek refuge upstream, available habitat is limited and may itself be affected by flow reduction and isolation caused by the TSF.

5.3.2 Ok Tedi and Fly River

The assessment of the Ok Tedi and Fly River systems indicates that the proposed diversion of tailings to the TSF will result in a substantial and enduring improvement to environmental quality and aquatic ecological condition at a regional scale. While construction-phase activities are not expected to produce measurable changes in sediment loads or water quality within the Ok Tedi or Middle Fly, the operational phase represents a fundamental shift in the sediment, with minimal change in the contaminant dynamics of the system.

More than four decades of mining have profoundly altered the Ok Tedi - Fly River system through elevated sediment inputs, widespread bed aggradation, floodplain inundation, and the accumulation of copper-bearing sediments. Modelling demonstrates that diverting tailings to a TSF will reduce direct sediment inputs to the river system by approximately 85 - 95%, markedly reducing both sand and silt delivery to the Lower Ok Tedi and Middle Fly. This reduction will effectively eliminate further bed aggradation in the Lower Ok Tedi and upper Middle Fly and promote gradual channel stabilisation or incision, while downstream deposition will continue at lower, legacy-controlled rates. Further reduction is predicted with the mine plan which sees total waste rock production reducing from around 2030 onwards.

Water quality modelling indicates that TSF operations will not materially alter river pH and will result in only very minor, localised increases in sulphate concentrations that rapidly diminish through downstream dilution. Dissolved copper concentrations are predicted to remain similar to current levels, with most copper released from TSF discharges quickly adsorbing to suspended particles in the alkaline and well buffered main channels of the Ok Tedi and Middle Fly. Importantly, the overall downstream transport of copper is expected to decline significantly due to removal of tailings leading to reductions in suspended sediment concentrations and lower (50% decline in) pCu concentrations. Together with improved acid–base balance arising from lower sulphur tailings and increased acid neutralising capacity, this represents a major long-term improvement in the geochemical stability of the river system.

From an ecological perspective, reduced sand bed load and lower total suspended solids will improve channel stability, reduce physical disturbance of benthic habitats, and enhance water clarity. These changes will directly benefit fish and macroinvertebrate communities by improving feeding efficiency, reducing gill abrasion, and lowering habitat stress associated with high turbidity. Stabilised and even reduced bed aggradation predicted under TSF will lead to improvements in fish habitat condition in the lower Ok Tedi and upper and middle Middle Fly. Natural increases in dissolved organic carbon downstream further moderate copper bioavailability, reducing the risk of acute metal toxicity to aquatic fauna. However, chronic toxicity (due to high pCu and elevated dCu) on larval fish still pose a risk. Collectively, these changes are expected to support progressive recovery of aquatic habitats and biological productivity across the Lower Ok Tedi and Middle Fly.

5.3.3 Ok Birim

The Ok Birim catchment is a high-value, largely unmodified river system that supports environmental conditions and aquatic communities' representative of natural background conditions in the Western Province. It functions as a critical ecological refuge within the Upper Fly region, supporting species that have declined or disappeared from the Ok Tedi. Maintaining the integrity of this catchment is therefore of strategic importance both for biodiversity conservation and for the long-term recovery of the Ok Tedi system following mine closure.

The current (2025) TSF alignment has been deliberately located and designed to avoid direct interaction with the Ok Birim main channel drainage network. Provided that design assumptions are met and environmental controls are effectively implemented, long-term

degradation of water quality, sediment regimes or aquatic ecosystem function within the Ok Birim catchment is not predicted. At a catchment scale, the TSF is therefore assessed as having an overall high positive outcome for the protection of the Ok Birim.

Notwithstanding this, the assessment identifies several residual risks that are locally significant. During construction, short-term increases in sediment mobilisation may occur as a result of vegetation clearing and earthworks associated with access roads, bridge construction and pipeline installation, resulting in moderate negative impacts that are expected to be localised and temporary. During operations, the most significant risks arise from infrastructure crossings of the Ok Birim, particularly the unsealed access road leaching metals, if road base material is sourced from the Ok Tedi, and impact from tailings if the tailings pipeline ruptures at the crossing. Increased sediment runoff from the road crossing and the potential for accidental pipeline ruptures represent high to major negative risks given the ecological sensitivity of the Ok Birim and its role as a refuge for aquatic fauna.

Although overall particulate copper loads in the Fly River system are expected to decline under the TSF scenario, tailings remain a concentrated source of particulate-bound copper and other metals. Any release of tailings via the pipeline into the Ok Birim would result in increased suspended solids, sedimentation and associated ecological disturbance under the prevailing alkaline conditions, with the potential to cause significant impacts to sensitive habitats and species with restricted distributions.

5.3.4 Ok Ma Infrastructure Corridor

The assessment of the Ok Ma Infrastructure Corridor indicates that both construction and operation of the access road and tailings pipeline may present significant localised risks to environmental quality and aquatic fauna, particularly within the Ok Ma catchment and its tributaries. These impacts contrast strongly with the corridor's function as a critical connectivity element for the TSF and occur within a river system that currently retains high ecological integrity and refuge value.

During the construction phase, extensive vegetation clearing, earthworks, and multiple watercourse crossings are expected to substantially increase sediment runoff into the Ok Ma and associated tributaries. Even relatively small increases in total suspended solids, electrical conductivity and nutrients are likely to adversely affect aquatic biota that are adapted to very clear, low-TSS waters. Historical evidence from the Kiunga - Tabubil road construction demonstrates that such disturbances can lead to widespread and persistent degradation of tributary systems. The use of road base material sourced from the Ok Tedi, which is elevated in copper and other metals, further increases the risk of contaminant mobilisation at crossings. As a result, construction-related impacts on water quality are assessed as high to major negative, with associated high negative impacts on aquatic fauna downstream of crossings.

The Ok Ma is one of the last relatively intact tributary refuges in the middle Ok Tedi system and supports species that have declined or disappeared elsewhere, including *Glossogobius robertsi* and the Critically Endangered Ok Tedi Rainbowfish (*Melanotaenia oktediensis*). Increased sediment and contaminant inputs associated with corridor construction pose a direct threat to these species and others with restricted distributions and high sensitivity to water quality change. The spatial extent and severity of these impacts will depend on crossing design, construction methods, erosion controls and material sourcing, but the vulnerability of the system indicates a high consequence even under conservative disturbance scenarios.

During the operational phase, ongoing use of an unsealed access road is expected to cause rainfall-related increases in sediment delivery due to altered surface runoff and repeated disturbance from traffic and maintenance activities. Without effective long-term erosion and sediment controls, cumulative degradation of water quality within the Ok Ma system is likely. Elevated TSS, altered streambed habitats, and reduced water clarity would progressively

reduce the refuge function of the Ok Ma for sensitive aquatic fauna. These impacts are assessed as moderate negative in the absence of robust mitigation measures.

The most severe potential consequences arise from the risk of tailings pipeline failure at crossings of the Ok Ma and smaller tributaries. Historical performance of existing copper concentrate and pyrite pipelines demonstrates that ruptures do occur and that their ecological consequences may persist for decades. Although tailings differ in composition from PCon and CuCon, they remain a concentrated source of particulate-bound copper and other metals. In alkaline main-river environments, copper remains largely particulate-bound; however, in the naturally acidic lowland and foothill creeks intersected by the corridor, tailings releases would promote oxidation and leaching of dissolved copper, zinc and sulphate at levels exceeding toxicity guideline values, as modelled by Egi for the TSF bund, where tailings derived sand will oxidise and leach metals. A major pipeline failure in these settings would result in severe water quality deterioration, physical smothering of habitats, and long-term ecological change, and is therefore assessed as a major negative impact.

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Appendix A Habitat Assessment in Percentages

Ok Birim Tailings Storage Facility Project ESIA: Baseline Aquatic Fauna Survey and Impact Assessment

June 2026

Tetra Tech Coffey

SLR Project No.: 675.073208.0001

16 June 2026

Table A.1 Ok Birim Habitat Assessment

Site code		Bedrock	Boulders (>256mm)	Cobbles (64-256mm)	Pebbles (16-64mm)	Gravel (4-16mm)	Sand (1-4mm)	Silt (<1mm)	Clay	Total Inorganic	Mineral substrate	Emergent macrophyte	Submergent macrophyte	Floating macrophye	Algal cover	Detritus / Leaf litter	Trailing vegetation	Other	Large Woody Debris	Total %
Reference	OB1	0.00	0.00	65.00	30.00	0.00	5.00	0.00	0.00	100.00	94.00	0.00	0.00	0.00	2.00	2.00	0.00	0.00	2.00	100.00
	OB2	0.00	0.00	40.00	50.00	10.00	0.00	0.00	0.00	100.00	96.00	0.00	0.00	0.00	2.00	2.00	0.00	0.00	0.00	100.00
	OB3	0.00	0.00	45.00	50.00	5.00	0.00	0.00	0.00	100.00	96.00	0.00	0.00	0.00	2.00	2.00	0.00	0.00	0.00	100.00
	OB16	0.00	0.00	0.00	0.00	50.00	30.00	10.00	10.00	100.00	35.00	0.00	5.00	0.00	0.00	15.00	10.00	5.00	30.00	100.00
	OB17	10.00	0.00	0.00	0.00	50.00	20.00	10.00	10.00	100.00	50.00	0.00	15.00	0.00	0.00	5.00	5.00	5.00	20.00	100.00
	OB20	0.00	0.00	0.00	0.00	0.00	40.00	40.00	20.00	100.00	55.00	0.00	5.00	0.00	0.00	20.00	5.00	5.00	10.00	100.00
	OB21	0.00	0.00	0.00	0.00	0.00	40.00	40.00	20.00	100.00	40.00	0.00	10.00	0.00	0.00	10.00	10.00	10.00	20.00	100.00
	OB22	0.00	0.00	0.00	0.00	10.00	60.00	20.00	10.00	100.00	40.00	0.00	5.00	0.00	0.00	20.00	10.00	10.00	15.00	100.00
	OB24	0.00	0.00	15.00	10.00	50.00	20.00	5.00	0.00	100.00	45.00	0.00	5.00	0.00	0.00	10.00	10.00	5.00	25.00	100.00
	OB25	0.00	0.00	0.00	0.00	20.00	20.00	30.00	30.00	100.00	40.00	0.00	5.00	0.00	0.00	15.00	5.00	5.00	30.00	100.00
	OB26	0.00	0.00	5.00	0.00	0.00	60.00	30.00	5.00	100.00	50.00	0.00	2.00	0.00	0.00	20.00	10.00	8.00	10.00	100.00
Potential Exposed	OB4	0.00	0.00	25.00	65.00	5.00	5.00	0.00	0.00	100.00	95.00	0.00	0.00	0.00	0.00	5.00	0.00	0.00	0.00	100.00
	OB9B	0.00	0.00	0.00	0.00	0.00	40.00	30.00	30.00	100.00	40.00	0.00	15.00	0.00	0.00	20.00	5.00	5.00	15.00	100.00
	OB10	0.00	0.00	0.00	0.00	5.00	50.00	25.00	25.00	105.00	35.00	0.00	8.00	0.00	0.00	17.00	10.00	10.00	20.00	100.00
	OB27	0.00	0.00	0.00	0.00	10.00	65.00	20.00	5.00	100.00	45.00	0.00	5.00	0.00	0.00	15.00	10.00	5.00	20.00	100.00
	OB28	0.00	0.00	0.00	0.00	10.00	60.00	20.00	10.00	100.00	35.00	0.00	5.00	0.00	0.00	15.00	15.00	5.00	25.00	100.00
	OB29	0.00	0.00	0.00	0.00	0.00	30.00	40.00	30.00	100.00	30.00	0.00	10.00	0.00	0.00	15.00	10.00	5.00	30.00	100.00
	OB30	0.00	0.00	0.00	0.00	0.00	30.00	40.00	30.00	100.00	10.00	0.00	40.00	0.00	0.00	10.00	10.00	10.00	20.00	100.00
	OB31	0.00	0.00	0.00	0.00	10.00	70.00	10.00	10.00	100.00	60.00	0.00	0.00	0.00	0.00	10.00	10.00	5.00	15.00	100.00
	OB32	0.00	0.00	0.00	0.00	0.00	20.00	50.00	30.00	100.00	25.00	5.00	5.00	0.00	0.00	20.00	10.00	5.00	30.00	100.00
	OB33	0.00	0.00	0.00	0.00	0.00	30.00	40.00	30.00	100.00	35.00	0.00	20.00	0.00	0.00	15.00	10.00	5.00	15.00	100.00
	OB34	0.00	0.00	0.00	0.00	0.00	20.00	40.00	40.00	100.00	25.00	0.00	10.00	0.00	0.00	25.00	5.00	5.00	30.00	100.00
	OB35	0.00	0.00	0.00	0.00	0.00	30.00	30.00	40.00	100.00	50.00	0.00	10.00	0.00	0.00	10.00	10.00	5.00	15.00	100.00
	OB36	0.00	0.00	0.00	0.00	0.00	20.00	45.00	35.00	100.00	55.00	0.00	15.00	0.00	0.00	10.00	5.00	0.00	15.00	100.00
	OB37	0.00	0.00	0.00	0.00	0.00	30.00	40.00	30.00	100.00	45.00	0.00	15.00	0.00	0.00	25.00	5.00	0.00	10.00	100.00
	OB38	0.00	0.00	0.00	0.00	0.00	40.00	30.00	30.00	100.00	55.00	0.00	15.00	0.00	0.00	20.00	5.00	0.00	5.00	100.00
	OY1	0.00	0.00	25.00	10.00	0.00	30.00	15.00	20.00	100.00	80.00	10.00	0.00	0.00	0.00	5.00	0.00	0.00	5.00	100.00
	OY2	0.00	0.00	0.00	0.00	0.00	35.00	25.00	40.00	100.00	40.00	15.00	0.00	0.00	0.00	0.00	10.00	0.00	35.00	100.00

Table A.2. Ok Ma Habitat Assessment

Site	Site code	Bedrock	Boulders (>256mm)	Cobbles (64-256mm)	Pebbles (16-64mm)	Gravel (4-16mm)	Sand (1-4mm)	Silt (<1mm)	Clay	Total Inorganic	Mineral substrate	Emergent macrophyte	Submergent macrophyte	Floating macrophye	Algal cover	Detritus / Leaf litter	Trailing vegetation	Other	Large Woody Debris	Total %
Reference	OM1	0.00	0.00	40.00	0.00	10.00	20.00	30.00	0.00	100.00	85.00	5.00	0.00	0.00	0.00	5.00	0.00	0.00	5.00	100
	OM3	5.00	0.00	0.00	20.00	35.00	30.00	0.00	10.00	100.00	20.00	5.00	10.00	0.00	25.00	30.00	5.00	0.00	5.00	100
	OM6	5.00	0.00	35.00	15.00	0.00	30.00	15.00	0.00	100.00	70.00	0.00	0.00	0.00	0.00	20.00	5.00	0.00	5.00	100
Potential Exposed	OM4	0.00	40.00	30.00	0.00	0.00	20.00	10.00	0.00	100.00	85.00	5.00	0.00	0.00	0.00	5.00	0.00	0.00	5.00	100
	OM5	0.00	0.00	25.00	15.00	0.00	30.00	30.00	0.00	100.00	90.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	10.00	100
	OM7	0.00	0.00	20.00	20.00	25.00	20.00	15.00	0.00	100.00	75.00	0.00	0.00	0.00	0.00	15.00	0.00	0.00	10.00	100
	OM8	0.00	0.00	40.00	25.00	0.00	20.00	15.00	0.00	100.00	75.00	0.00	0.00	0.00	0.00	10.00	0.00	0.00	15.00	100
	OM9	0.00	0.00	30.00	20.00	0.00	30.00	20.00	0.00	100.00	70.00	0.00	0.00	0.00	0.00	10.00	5.00	0.00	15.00	100
	OM12	0.00	0.00	0.00	15.00	20.00	40.00	15.00	10.00	100.00	55.00	0.00	5.00	0.00	0.00	15.00	5.00	0.00	20.00	100

Appendix B Site Photos

Ok Birim Tailings Storage Facility Project ESIA: Baseline Aquatic Fauna Survey and Impact Assessment

June 2026

Tetra Tech Coffey

SLR Project No.: 675.073208.0001

16 June 2026

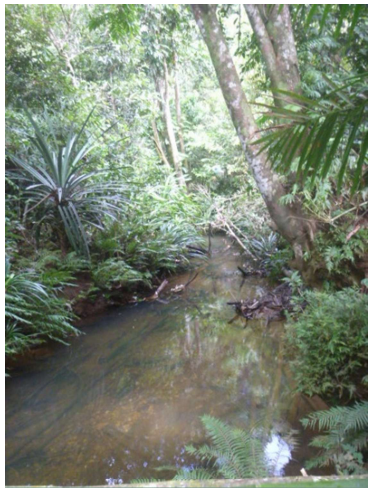
OB1

OB2

OB3

OB9B

OB16



OB25

OY1

OY2

OB36

OB37

OB38

OM1

OM4

OM5

OM6

OM7

OM8

OM9

OM12

Appendix C ANZG (2018) Default Guideline Values

Ok Birim Tailings Storage Facility Project ESIA: Baseline Aquatic Fauna Survey and Impact Assessment

June 2026

Tetra Tech Coffey

SLR Project No.: 675.073208.0001

16 June 2026

Table C2-1. Default guideline values for some physical and chemical stressors for tropical Australia for slightly disturbed ecosystems (TP = total phosphorus; FRP = filterable reactive phosphorus; TN = total nitrogen; NOx = total nitrates/nitrites; NH4+ = ammonium). Data derived from trigger values supplied by Australian states and territories, for the Northern Territory and regions north of Carnarvon in the west and Rockhampton in the east (ANZG 2018).

	TP	***FRP***	***TN***	***NOx***	***NH_4^+***	***DO***	***pH***
	(µg L^{-1})	***(µg L^{-1})***	***(µg L^{-1})***	***(µg L^{-1})***	***(µg L^{-1})***	***% saturation***	
Aquatic Ecosystem							
Upland River[e]	10	5	150	30	6	90-120	6.0-7.5
Lowland River[e]	10	4	200-300[h]	10[b]	10	85-120	6.0-8.0
Lakes & Reservoirs	10	5	350[c]	10[b]	10	90-120	6.0-8.0
Wetlands[3]	10-50[g]	5-25[g]	350-1200[g]	10	10	90[b]-120 [b]	6.0-8.0

b = Northern Territory values are 5µgL^{-1} for NO_x, and <80 (lower limit) and >110% saturation (upper limit) for DO;

c = this value represents turbid lakes only. Clear lakes have much lower values;

e = no data available for tropical WA estuaries or rivers. A precautionary approach should be adopted when applying default trigger values to these systems;

f = dissolved oxygen values were derived from daytime measurements. Dissolved oxygen concentrations may vary diurnally and with depth. Monitoring programs should assess this potential variability;

g = higher values are indicative of tropical WA river pools;

h = lower values from rivers draining rainforest catchments.

Table C2-2. Default guideline values for salinity and turbidity for the protection of aquatic ecosystems, applicable to tropical systems in Australia (ANZG 2018).

Aquatic Ecosystem		***Comments***
Salinity	***(µs/cm)***	
Aquatic Ecosystem		
Upland & lowland rivers	20-250	Conductivity in upland streams will vary depending on catchment geology. The first flush may result in temporarily high values
Lakes, reservoirs & wetlands	90-900	Higher conductivities will occur during summer when water levels are reduced due to evaporation
Turbidity	***(NTU)***	
Aquatic Ecosystem		
Upland & lowland rivers	2-15	Can depend on degree of catchment modification and seasonal rainfall runoff
Lakes, reservoirs & wetlands	2-200	Most deep lakes have low turbidity. However, shallow lakes have higher turbidity naturally due to wind-induced re-suspension of sediments. Wetlands vary greatly in turbidity depending on the general condition of the catchment, recent flow events and the water level in the wetland.

Table C2-3. Guideline values for toxicants at alternative levels of protection (µg/L).

	Trigger values for freshwater			
	Level of protection (% species)			
Compound	***99%***	***95%***	***90%***	***80%***
METALS & METALLOIDS				
Aluminium pH > 6.5	27	55	80	150
Aluminium pH < 6.5	ID	ID	ID	ID
Arsenic (As III)	1	24	94	360
Arsenic (As IV)	0.8	13	42	140
Boron	340	940	1500	2500
Cadmium	0.06	0.2	0.4	0.8
Cobalt	ID	ID	ID	ID
Chromium (Cr III) [R]	0.95	6.7	16	39
Chromium (Cr VI)	0.01	1	6	40
Copper [R]	0.2	0.47	0.73	1.3
Iron [R]	ID	ID	ID	ID
Manganese	1200	1900	2500	3600
Molybdenum	ID	ID	ID	ID
Nickel [R]	0.31	2	4.6	10
Lead	1	3.4	5.6	9.4
Selenium (Se total)	5	11	18	34
Selenium (Se IV)	ID	ID	ID	ID
Uranium	ID	ID	ID	ID
Vanadium	6	ID	ID	ID
Zinc [R]	1.5	4.1	6.8	12
NON-METALLIC INORGANICS				
Ammonia	320	900	1430	2300
Chlorine	0.4	3	6	13
Nitrate [R]	1100	2100	3100	5400

Note: several new (proposed) toxicant default guideline values are soon to be released and are denoted as [R].

Table C2-4. Recommended toxicant default guideline values for sediment quality.

Type of toxicant	Toxicant	DGV	GV-high
Metals (mg/kg dry weight)	Antimony	2.0	25
	Cadmium	1.5	10
	Chromium	80	370
	Copper	65	270
	Lead	50	220
	Mercury (inorganic)	0.15	1.0
	Nickel	21	52
	Silver	1.0	4.0
	Zinc	200	410

Appendix D Sediment Quality

Ok Birim Tailings Storage Facility Project ESIA: Baseline Aquatic Fauna Survey and Impact Assessment

June 2026

Tetra Tech Coffey

SLR Project No.: 675.073208.0001

16 June 2026

Table D-1: Sediment Quality Exceedances Ok Birim

				Reference										
Analyte	Units	LOR	DGV	OB01	OB02	OB03	OB16	OB17	OB20	OB21	OB22	OB24	OB25	OB26
ANC	kg H2SO4/t	-	-	10.99	2.01	11.66	1.03	10.1	-1.52	-0.25	1.38	-1.22	-3.02	-1.96
Carbon	%	<0.005	-	0.131	1.273	1.186	0.801	0.24	2.191	1.246	1.455	1.4	2.796	2.696
Sulphur	%	<0.005	-	0.04	0.1	0.02	0.09	0.02	0.06	0.07	0.09	0.04	0.02	0.09
Cd	mg/kg	0.01	1.5	0.5	<0.01	<0.01	<0.01	0.2	0.2	<0.01	<0.01	<0.01	<0.01	<0.01
Cu	mg/kg	<2	65	33.5	10.8	35.9	11.6	35.7	7.5	7.5	7.5	17.2	3.6	8.2
Pb	mg/kg	<5	50	6.5	7.7	4.3	6.8	4.8	9.5	5.6	7.3	8.9	3.4	6.3
Zn	mg/kg	<5	200	63.7	107.9	61.4	82.9	75.4	97.8	64	58.7	85	22.5	62.7
NAPP (Calculated)	kg H2SO4/t	-	-	4.714	-9.766	1.05	-11.048	1.724	-9.488	3.356	2.392	1.374	2.444	3.632

				Potentially Exposed															
Analyte	Units	LOR	DGV	OB04	OB09B	OB10	OB27	OB28	OB29	OB30	OB31	OB32	OB33	OB34	OB35	OB36	OB37	OB38	OY1	OY2
ANC	kg H2SO4/t	-	-	14.18	-1.49	0.38	1.08	-0.7	-2.85	-7.19	0.3	1.35	-3.51	-3.85	-7.41	-6.54	-3.49	-0.76	153.33	-3.47
Carbon	%	<0.005	-	0.429	1.133	1.078	0.714	0.861	2.675	7.812	1.356	6.397	3.607	3.856	9.824	6.12	3.83	1.5	3.02	3.53
Sulphur	%	<0.005	-	0.04	0.02	0.03	0.05	0.14	0.06	0.05	0.07	0.02	0.005	0.01	0.04	0.12	0.06	0.06	1.19	0.1
Cd	mg/kg	0.01	1.5	<0.01	0.2	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	0.2	<0.01	<0.01	<0.01	<0.01	2.4	<0.01
Cu	mg/kg	<2	65	39.7	11	7.7	9.8	15.4	27.3	8.7	20	12.2	11.7	10.1	<2	21.8	4.8	4.8	473.8	9.7
Pb	mg/kg	<5	50	4.1	7.7	7	7.4	8.6	8.2	7	8.3	7.1	7.6	7.7	<5	9.7	4.8	7.2	97.6	9.7
Zn	mg/kg	<5	200	54.3	117.1	77.8	48.6	75.7	52.3	57.1	49.3	60.9	56.7	73.6	<5	26.6	19.2	24.1	466.7	45.9
NAPP (Calculated)	kg H2SO4/t	-	-	-12.956	2.102	0.538	0.45	4.984	4.686	8.72	1.842	-0.738	3.663	4.156	8.634	10.212	5.326	2.596	-116.92	6.53

Table D-2: Sediment Quality Exceedances Ok Ma

				Reference			Potentially Exposed					
Analyte	Units	LOR	DGV	OM1	OM3	OM6	OM4	OM5	OM7	OM8	OM9	OM12
ANC	kg H2SO4/t	-	-	55.38	25.14	12.19	45.45	45.72	36.9	48.91	24.64	-1.88
Carbon	%	<0.005	-	1.62	0.69	1.78	1.21	0.84	1.23	1.88	0.69	2.53
Sulphur	%	<0.005	-	0.21	0.06	0.05	0.15	0.08	0.14	0.23	0.05	0.07
Cd	mg/kg	0.01	1.5	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Cu	mg/kg	<2	65	4.8	50.6	45.6	16.7	26.4	19.4	12.1	17	12.1
Pb	mg/kg	<5	50	7.2	0.5	4.8	4.8	4.8	7.3	7.3	4.9	9.7
Zn	mg/kg	<5	200	47.8	60.3	62.4	59.5	45.6	50.9	60.5	77.7	104
NAPP (Calculated)	kg H2SO4/t	-	-	-48.954	-23.304	-10.66	-40.86	-43.272	-32.616	-41.872	-23.11	4.022

Appendix E Water Quality Exceedance Table

Ok Birim Tailings Storage Facility Project ESIA: Baseline Aquatic Fauna Survey and Impact Assessment

June 2026

Tetra Tech Coffey

SLR Project No.: 675.073208.0001

16 June 2026

Table E-2: Water Quality Exceedances Ok Birim

Analyte	Units	LOR	ANZG DGV 95%	WQC (2002)	Reference											Potentially Exposed																	
					OB01	OB02	OB03	OB16	OB17	OB20	OB21	OB22	OB24	OB25	OB26	OB04	OB09B	OB10	OB27	OB28	OB29	OB30	OB31	OB32	OB33	OB34	OB35	OB36	OB37	OB38	OY1	OY2
Fe	µg/L	<5	700	1000	<10	15	19	41	37	68	42	58	44	81	48	17	34	43	67	49	88	288	72	41	61	58	133	46	21	49	66	90
Na	mg/L	<0.1	-	-	1	2	3	1	1	1	1	1	2	1	1	1	1	1	1	1	1	1	1	1	1	1	1	<0.1	<0.1	<0.1	<0.1	<0.1
Mg	mg/L	<0.1	-	-	2	2	1	1	<1	1	<1	<1	1	<1	<1	1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<0.1	<0.1	<0.1	<0.1	<0.1
Al	µg/L	<5	55	-	19	24	30	<10	<10	<10	<10	<10	<10	14	<10	33	<10	<10	12	<10	10	14	<10	16	12	<10	12	53	14	30	43	89
K	mg/L	<0.1	-	5000	<1	<1	1	<1	<1	<1	<1	<1	1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<0.1	<0.1	<0.1	<0.1	<0.1
Ca	mg/L	<0.1	-	-	13	17	21	2	2	1	1	1	4	1	<1	13	<1	1	1	1	1	1	1	<1	1	1	2	<0.2	<0.2	<0.2	1	<0.2
Cr	µg/L	<0.5	1	50	1	4	5	4	1	2	4	2	3	4	2	4	5	2	1	2	4	3	4	5	2	<1	<1	<0.9	<0.9	<0.9	<0.9	<0.9
Mn	µg/L	<0.1	1900	500	5	5	10	15	7	12	17	6	14	66	8	4	48	7	9	12	39	41	11	21	13	14	33	14	31	19	12	18
Co	µg/L	<0.5	-	-	3	13	22	9	<1	6	5	9	8	25	3	5	16	2	3	5	14	14	10	10	4	<1	4	<0.7	<0.7	<0.7	<0.7	<0.7
Ni	µg/L	<0.5	11	1000	<1	2	6	<1	<1	1	3	1	<1	5	3	3	<1	<1	<1	<1	<1	3	<1	<1	<1	<1	<1	<0.7	<0.7	<0.7	<0.7	<0.7
Cu	µg/L	<0.5	1.4	1000	65	2	5	3	1	2	4	<1	2	6	1	2	3	<1	3	<1	1	2	4	6	1	<1	<1	7	8	7	6	6
Zn	µg/L	<0.5	8	5000	69	<3	<3	<3	<3	<3	<3	<3	<3	<3	<3	<3	<3	<3	4	<3	<3	4	<3	<3	<3	<3	<3	2	2	5	1	1
As	µg/L	<1	2.4	50	<1	2	3	1	<1	6	4	2	2	1	<1	3	<1	1	3	3	<1	4	<1	<1	<1	2	5	<0.4	<0.4	<0.4	<0.4	<0.4
Se	µg/L	<0.5	-	10	5	16	20	12	<4	<4	17	<4	9	7	<4	<4	9	13	<4	10	7	16	10	19	<4	7	4	<0.5	<0.5	<0.5	<0.5	<0.5
Mo	µg/L	<1	-	-	<2	<2	4	2	<2	<2	2	3	<2	4	<2	<2	2	<2	<2	<2	2	<2	2	<2	<2	<2	2	<0.6	<0.6	<0.6	<0.6	<0.6
Ag	µg/L	<0.5	-	50	<1	<1	1	<1	<1	1	<1	<1	<1	1	1	<1	1	<1	1	<1	1	<1	1	<1	<1	<1	<1	<0.4	<0.4	<0.4	<0.4	<0.4
Cd	µg/L	<0.1	0.2	10	<1	1	<1	<1	<1	<1	<1	<1	<1	1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<0.6	<0.6	<0.6	<0.6	<0.6
Sb	µg/L	<1	-	-	3	15	18	6	4	9	6	<2	5	17	8	15	10	5	<2	9	10	6	5	8	<2	3	<2	<0.4	<0.4	<0.4	<0.4	<0.4
Pb	µg/L	<0.5	3.4	5	6	11	12	8	<1	1	8	7	13	21	6	<1	17	5	1	7	14	3	2	6	<1	2	4	<0.7	<0.7	<0.7	<0.7	<0.7
pH	-	<0.01	6.0-7.5	-	7.8	7.7	7.4	6.2	6.5	6.4	6.1	6.2	6.5	6.1	6	7.8	5.5	6	6.2	6.2	6.2	5.7	6.3	5.5	5.9	6	6.2	5.1	5.2	5.4	5.9	5.1
Alkalinity	mg CaCO3 / L	-	-	-	60	20	40	10	8	8	8	10	20	5	5	40	5	5	5	8	8	5	5	3	5	8	5	10	6	6	6	6
TSS	mg/L	-	-	-	195.8	234.6	235	1.9	2.8	11.2	14.9	24	6.1	133.8	1.9	160.8	2.2	2.9	30.6	2.6	1.7	75.9	3.5	6.4	4.4	14.9	20.3	7.3	2.1	5.4	13.3	7.1
Electrical Conductivity	µS/cm	<1	250	-	80	90	70	20	20	10	10	10	30	10	6	80	5	8	9	10	10	10	10	5	8	10	20	6	5	6	7	6
Sulphate	mg/L	<1	-	400	48	29	32	<1	<1	5	4	13	<1	2	<1	20	20	10	12	25	14	4	28	24	79	77	72	267	173	61	95	409
DO% (in-situ)	%	-	85-120	-	104.1	103.3	97.1	111.0	80	83.2	89.9	92.8	92.9	90.8	78.1	86.4	90.2	87.5	99.0	77.5	81.4	58.5	93.1	64.9	81.4	74.3	94.5	70.4	61.8	68.5	78	72.7

Table E-3: Water Quality Exceedances Ok Ma

Analyte	Units	LOR	ANZG DGV 95%	WQC (2002)	Reference			Potentially Exposed					
					OM1	OM3	OM6	OM4	OM5	OM7	OM8	OM9	OM12
Fe	µg/L	<1	700	1000	52	12	9	9	20	20	19	6	37
Na	mg/L	<0.1	-	-	1	1	2	2	1	1	1	2	1
Mg	mg/L	<0.1	-	-	1	1	<0.1	2	1	1	1	1	<0.1
Al	µg/L	<0.6	55	-	20	3	6	11	19	18	16	8	5
K	mg/L	<0.1	-	5000	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
Ca	mg/L	<0.2	-	-	21	6	4	21	17	15	14	13	2
Cr	µg/L	<0.9	1	50	<0.9	1	<0.9	<0.9	<0.9	<0.9	<0.9	<0.9	<0.9
Mn	µg/L	<0.7	1900	500	1	1	2	<0.7	<0.7	<0.7	<0.7	<0.7	6
Co	µg/L	<0.7	-	-	<0.7	<0.7	<0.7	<0.7	<0.7	<0.7	<0.7	<0.7	<0.7
Ni	µg/L	<0.7	11	1000	1	<0.7	<0.7	<0.7	<0.7	<0.7	<0.7	<0.7	<0.7
Cu	µg/L	<0.6	1.4	1000	8	1	7	6	10	4	8	8	7
Zn	µg/L	<0.7	8	5000	<0.7	<0.7	1	<0.7	<0.7	<0.7	2	<0.7	1
As	µg/L	<0.4	2.4	50	1	<0.4	<0.4	<0.4	1	1	<0.4	<0.4	<0.4
Se	µg/L	<0.5	-	10	<0.5	4	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
Mo	µg/L	<0.6	-	-	<0.6	<0.6	<0.6	<0.6	<0.6	<0.6	<0.6	<0.6	<0.6
Ag	µg/L	<0.4	-	50	<0.4	<0.4	<0.4	<0.4	<0.4	<0.4	<0.4	<0.4	<0.4
Cd	µg/L	<0.6	0.2	10	<0.6	<0.6	<0.6	<0.6	<0.6	<0.6	<0.6	<0.6	<0.6
Sb	µg/L	<0.4	-	-	<0.4	<0.4	<0.4	<0.4	<0.4	<0.4	<0.4	<0.4	<0.4
Pb	µg/L	<0.7	3.4	5	<0.7	<0.7	<0.7	<0.7	<0.7	<0.7	<0.7	<0.7	<0.7
pH	-	<0.01	6.0-7.5	-	7.8	7.5	7.4	7.9	8.1	8	8.1	7.8	6.7
Alkalinity	mg CaCO3 / L	-	-	-	61	39	17	67	61	50	50	50	17
TSS	mg/L	-	-	-	344.9	16.3	7.8	228	482.6	338.6	268.1	46.3	0.9
Electrical Conductivity	µS/cm	<1	250	-	100	70	30	100	100	90	90	90	20
Sulphate	mg/L	<1	-	400	89	35	86	164	88	30	26	52	23
DO% (in-situ)	%	-	85-120	-	96.9	-	138.0	168.1	115.8	131.2	72.5	85.5	114.4

Appendix F Fish data

Ok Birim Tailings Storage Facility Project ESIA: Baseline Aquatic Fauna Survey and Impact Assessment

June 2026

Tetra Tech Coffey

SLR Project No.: 675.073208.0001

16 June 2026

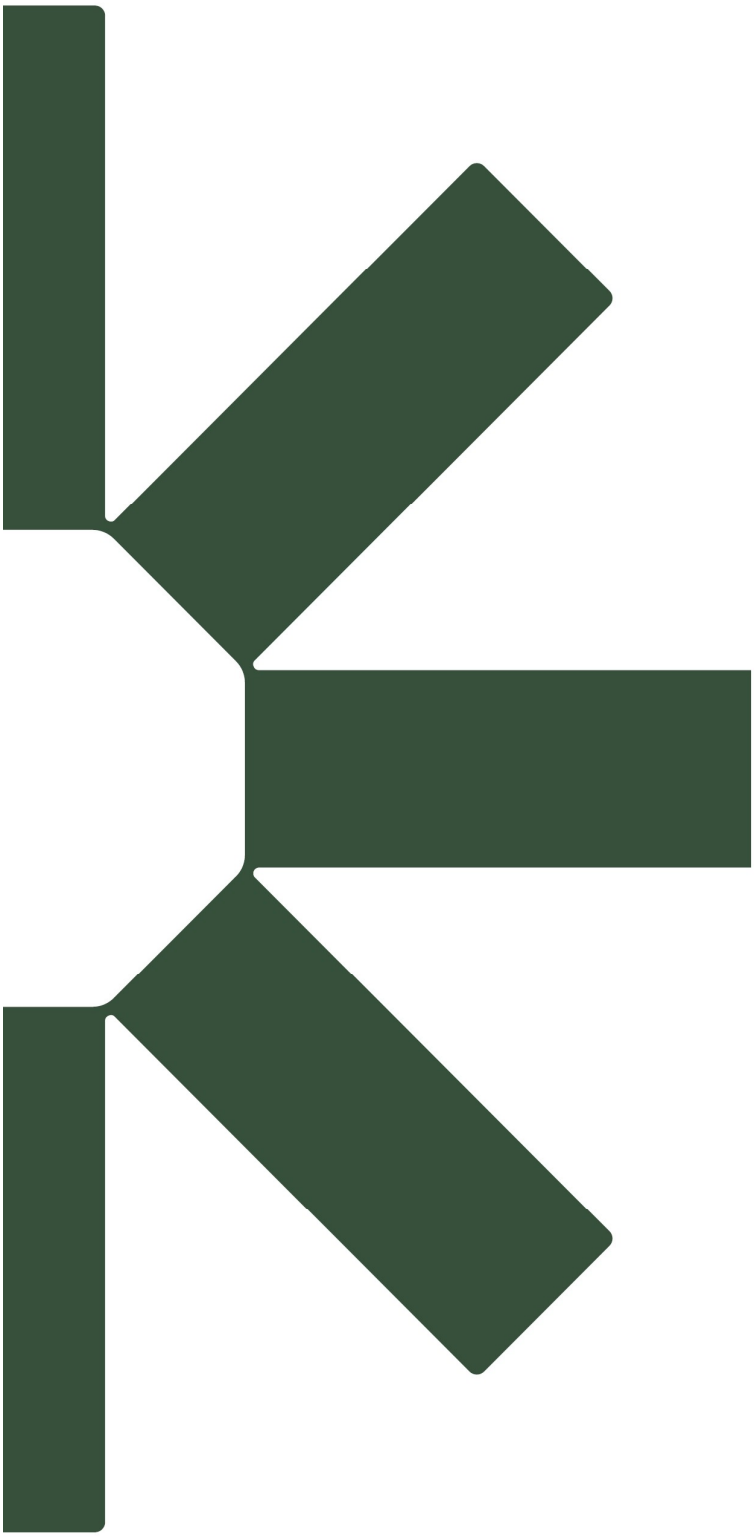
Table F.1 Ok Birim Fish Data

Species	Reference												Potential Exposed																																			
	Ok Birim 1	Ok Birim 2	Ok Birim 3	Ok Birim 16	Ok Birim 17	Ok Birim 18	Ok Birim 20	Ok Birim 21	Ok Birim 22	OK Birim 24	OK Birim 25	Ok Birim 26	Ok Birim 4	Ok Birim 5	Ok Birim 6	Ok Birim 7	Ok Birim 9B	Ok Birim 10	Ok Birim 11	Ok Birim 12	Ok Birim 13	Ok Birim 14	Ok Birim 15	Ok Birim 19	OK Birim 23	Ok Birim 27	Ok Birim 28	Ok Birim 29	Ok Birim 30	Ok Birim 31	Ok Birim 32	Ok Birim 33	Ok Birim 34	Ok Birim 35	Ok Birim 36	Ok Birim 37	Ok Birim 38	Ok Yep 1	Ok Yep 2
Ambassis agrammus	36												31																																			
Bostrychus strigogenys	1																																														
Channa Striata								1					1																																			
Chelon (Liza) subviridis													1																																			
Clupeoides papuensis	5	4											2																																			
Clupeoides venulosus?		2																																													
Cochlefelis spatula													6																																			
Craterocephalus nouhuysi	28	37	14		1		5	7	1		1		45		1			1						1		1	5		4	13	4	5		4				1	18							
Craterocephalus randi	1																																														
Crenimugil heterocheilos	7												5																																			
Cynoglossus heterolepis	1																																														
Glossamia aprion	1	2											4																																			
Glossamia sandei		2					1			1					1																																	
Glossamia sp.				2		1		1	2				1					3						1																							
Glossamia trifasciata		2		1					1	1					1																		1	1											
Glossogobius concavifrons		1		1	1	2	7	3	3	5	4		8					9	1							1	4			1				1				2	2						
Glossogobius muscorum				3	9	10	13	6	4	10	1		3		1			9	2				4		4												1								
Glossogobius pumilus					2				2	2																	3	1		1		2	10	10											
Glossogobius sp										1																																				
Hephaestus fuliginosis																																														
Hephaestus habbemai	1																																														
Kiunga leucozona		2					40	20	16	5	13	2						46							4	14	12			1	5															
Melanotaenia novaeguineae					1		13	36	18	9	16	12	7		29	17	12	36	19	6	1	24	49	40	1	20	4	20	20	15	15	25	10	25			12	8	5
Melanotaenia rubrostriata	31			1	34	8							105																										2	4						
Melanotaenia sexlineata							5	20						64		52	10			10	11	4	5												20	18									
Mogurnda cingulata							3		3	1		1		2			5			5	2	1	2	4	2		1		3						4	7	1						
Neosilurus ater		77	6										1																																	
Neosilurus brevidorsalis				1																												1												
Neosilurus brevidorsalis				2	1	3																																							
Neosilurus sp.	1																																													
Ophisternon guttarale							1																																							
Oreochromis mossambicus	1					1							2																																	
Oxyeleotris aruensis									1	13	2	2					2	1									1							1	4	7								
Oxyeleotris fimbriata							4	2	3			1								2		2		3				1			2		1			2							
Oxyeleotris paucipora/stagnicola							6	3	1		1	1				3	1			4	1	3	1		3		1	3			1	1	1	5								
Oxyeleotris sp.					2					1																																			
Pachyula conorhynchus				1		1							1																																	
Pachyula crassilabris				4	6	6							2																																	
Parambassis gulliveri	17												26																																	
Potamosilurus latirostris	7												4																																	
Pseudomugil novaeguineae							13	22	65	14	19	3					3	20	2						12	20	4	5	4		5	5	10	3			11						
Pseudomugil paskai							1																																						

Species	Reference												Potential Exposed																															
	Ok Birim 1	Ok Birim 2	Ok Birim 3	Ok Birim 16	Ok Birim 17	Ok Birim 18	Ok Birim 20	Ok Birim 21	Ok Birim 22	OK Birim 24	OK Birim 25	Ok Birim 26	Ok Birim 4	Ok Birim 5	Ok Birim 6	Ok Birim 7	Ok Birim 9B	Ok Birim 10	Ok Birim 11	Ok Birim 12	Ok Birim 13	Ok Birim 14	Ok Birim 15	Ok Birim 19	OK Birim 23	Ok Birim 27	Ok Birim 28	Ok Birim 29	Ok Birim 30	Ok Birim 31	Ok Birim 32	Ok Birim 33	Ok Birim 34	Ok Birim 35	Ok Birim 36	Ok Birim 37	Ok Birim 38	Ok Yep 1	Ok Yep 2
Sciades leptaspis													1																											
Strongylura krefftii	3												2																											
Zenarchopterus novaeguineae	3			19	20	2		5					12																											
Grand Total	**144**	**129**	**20**	**35**	**77**	**34**	**112**	**126**	**120**	**63**	**57**	**22**	**270**	**66**	**33**	**72**	**33**	**125**	**24**	**27**	**15**	**34**	**61**	**49**	**26**	**56**	**35**	**30**	**31**	**31**	**31**	**40**	**33**	**45**	**33**	**34**	**25**	**13**	**29**

Table F.2. Ok Ma Fish Data

Species	Reference			Potential Exposed					
	Ok Ma 1	Ok Ma 3	Ok Ma 6	Ok Ma 4	Ok Ma 5	Ok Ma 7	Ok Ma 8	Ok Ma 9	Ok Ma 12
Bostrychus strigogenys				1					
Clupeoides papuensis						1			
Craterocephalus nouhuysi		25	20	11	3			2	7
Glossamia sandei			8	1		4		4	1
Glossamia trifasciata									2
Glossogobius concavifrons	6		2	1		1	1	3	5
Glossogobius muscorum		3							
Glossogobius sp		3				1	1	3	
Hephaestus habbemai		4							
Melanotaenia novaeguineae		2	2					1	
Melanotaenia sexlineata		8						3	20
Mogurnda cingulata	3		7		1				
Neosilurus ater			16		3		7	6	
Neosilurus brevidorsalis	2						3	3	
Ophisternon guttarale		3	3					1	
Grand Total	**11**	**48**	**58**	**14**	**7**	**7**	**12**	**26**	**35**



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