

Ok Birim Tailings Storage Facility Project

Environmental and Social Impact Assessment

Chapter 8

Description of existing biophysical environment



8. DESCRIPTION OF EXISTING BIOPHYSICAL ENVIRONMENT

This chapter describes the existing biological and physical environment of the proposed Ok Birim Tailings Storage Facility (TSF) Project (the project). Each section presents an overview of a different aspect of the environment, including the regional and local context.

8.1 CLIMATE

This section summarises the regional and local climate relevant to the project area, including key parameters such as rainfall, temperature, relative humidity, wind speed and direction, and seasonal variations.

8.1.1 Regional context

Papua New Guinea (PNG) experiences a monsoonal tropical climate which is hot and humid throughout the year. Conditions vary significantly across the country's mountainous terrain and the influence of two major air streams: the Southeast Trade Winds and Northwest Monsoon. The country's rainfall is among the highest in the world, exceeding 2,500 mm annually in most regions, with the heaviest precipitation in the Highlands (WBG 2021).

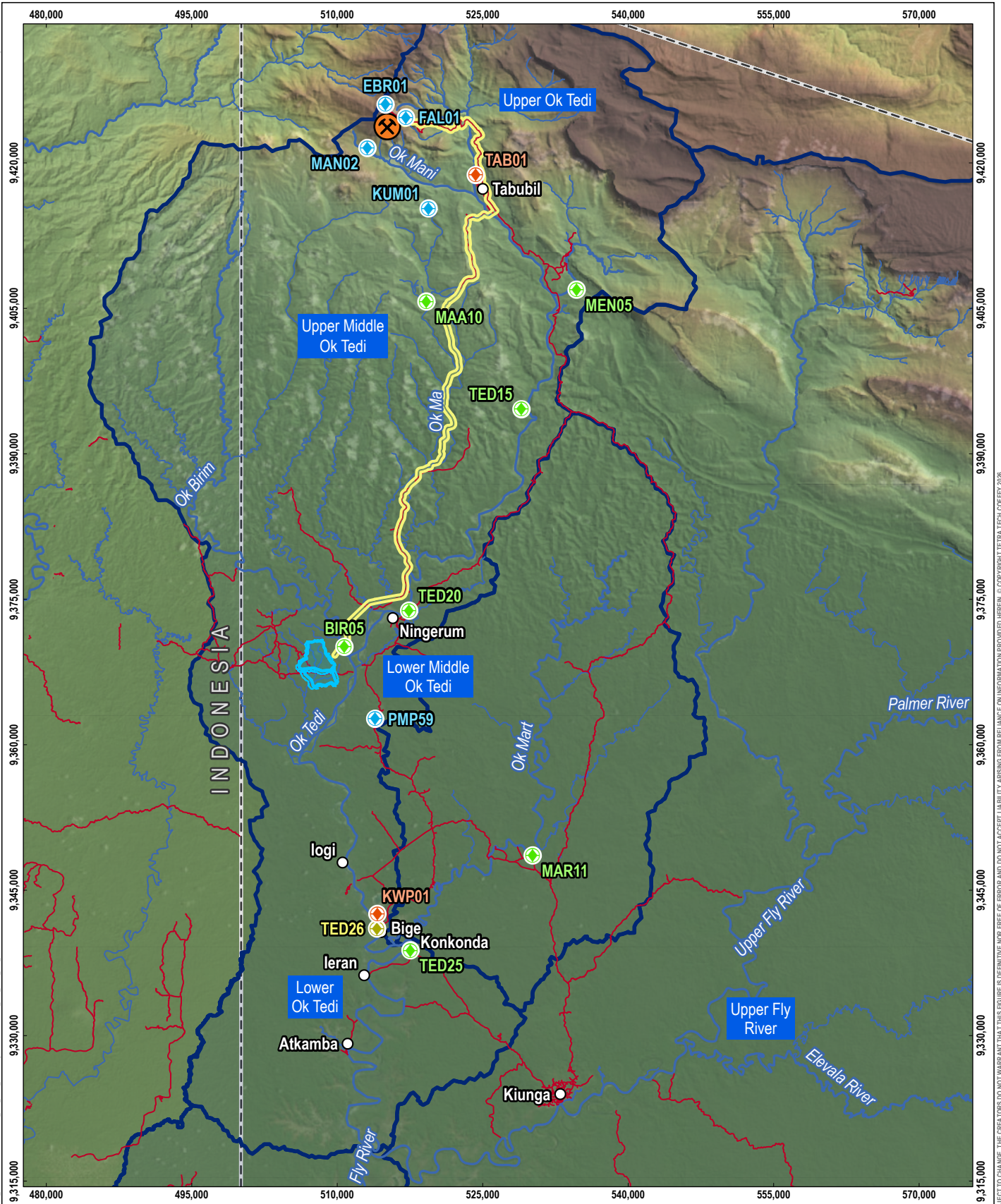
PNG's wet season typically occurs between December and April, while the dry season typically occurs from May to October. Even during the drier months between June and September, rainfall occurs with average monthly precipitation typically in the range of 200 to 400 mm (WBG 2021).

Weather patterns in the country are influenced by the interaction of the Southeast Trade Winds, Northwest Monsoon and the South Pacific Convergence Zone, a zone of high pressure and rainfall that migrates across the Pacific south of the equator. Inter-annual climate variability is strongly linked to the El Niño Southern Oscillation in the southeast Pacific, which usually delays the start of the monsoon season and brings drought conditions to PNG, especially in the southern areas of the main island (WBG 2021). Conversely, the cool phase of the El Niño Southern Oscillation (La Niña) is typically associated with extreme precipitation (Kuleshov et al. 2019, as cited in CCDA 2023).

8.1.2 Project area

The project area lies on the southern slopes of the Central Cordillera in the North Fly region of Western Province, approximately between 5°S and 6°S latitude, and 141°E and 141.5°E longitude. The Ok Tedi Mine is located at about 1,750 m above sea level on Mount Fubilan, with associated infrastructure extending down the slopes and foothills. According to the Köppen-Geiger Climate Classification, the North Fly region sits in the Af Zone, indicating an equatorial, fully humid climate. The Af Zone is characterised by consistently warm temperatures averaging at least 18°C year-round, and the presence of rainfall, with each month receiving a minimum rainfall of 60 mm (KCB 2024a). Due to the proximity of PNG to the equator, there is limited seasonal variation between the wet and dry seasons.

Ok Tedi Mining Ltd (OTML) has established a network of 24 automated hydrometeorology monitoring stations throughout the Ok Tedi and Fly River catchments (Figure 8.1) (KCB 2024a). Table 8.1 lists the name, location and site of hydrometeorological parameters collected at stations located within the Upper Ok Tedi Catchment, which covers the project area. Historical data are stored in OTML's long-term hydrometeorological database (OTML 2020a). The Karandimok Village, PMP59 and Bige stations are the nearest stations to the tailing storage facility (TSF) development area, located approximately 1.6 km northeast, 5 km and 23 km southeast of the site respectively. The Edinburgh station (EBR01) is the closest to the existing Ok Tedi Mine site.



LEGEND

- Ok Tedi Mine
- Community
- Road/track
- Watercourse
- Province boundary
- Catchment

- Proposed TSF footprint
- Proposed infrastructure corridor
- Monitoring station**
 - Rainfall
 - Water level
 - Water level & rainfall
 - Weather



0 5 10 km
SCALE 1:550,000
PAGE SIZE: A4
PROJECTION: PNG94 PNGMG94 Zone 54

SOURCE
Villages from Tetra Tech Coffey. Proposed infrastructure from KCB and OTML. Catchments and monitoring sites from OTML. Topographic features from OSM. Admin boundary from NSO. DEM from SRTM. Imagery from ESRI.

OK TEDI MINING LIMITED

OK BIRIM TAILINGS STORAGE FACILITY PROJECT

FIGURE 8.1

Regional hydrometeorology monitoring stations in the Ok Tedi and Fly River catchments



Table 8.1 Relevant hydrometeorology stations for the Ok Tedi Catchment

Site ID	Site Name	Location	Parameters measured at site		
			Water level	Discharge	Rainfall
EBR01	Edinburgh (near Ok Tedi Mine)	Upper Ok Tedi	-	-	✓
FAL01	Falomian	Upper Ok Tedi	-	-	✓
TAR02	Tanaki Weather Station	Upper Ok Tedi	-	-	✓
TED15	Haidauwogam	Upper Ok Tedi	✓	✓	✓
KUM01	Kumkit	Upper Ok Tedi	-	-	✓
MAA10	Lukwi	Upper Ok Tedi	✓	✓	✓
TAB01	Tabubil Weather Station	Upper Ok Tedi	-	-	✓
MEN05	Ok Menga	Upper Ok Tedi	✓	✓	✓
MAN02	Ok Mani	Upper Ok Tedi	-	-	✓
TED20	Ningerum	Upper Ok Tedi	✓	✓	-
MAR11	Rumginae	Lower Ok Tedi	✓	✓	-
BIR05	Karandimok Village (approximately 1.6 km east of the TSF development area across the Ok Birim)	Lower Ok Tedi	✓	-	✓
PMP59	KM 59 Pump Station (approximately 5 km southeast of the TSF development area across the Ok Tedi)	Lower Ok Tedi	-	-	✓
TED25	Konkonda	Lower Ok Tedi	✓	✓	✓
TED26	Bige Weather Station (approximately 23 km southeast of the TSF development area across the Ok Tedi)	Lower Ok Tedi	✓	-	-
KWP01	Bige Weather Station	Lower Ok Tedi	-	-	✓

Source: Adapted from OTML Tailings Storage Facility Project - Pre-Feasibility Study Summary Report, Appendix VII Surface Water Management Report (KCB 2015a; KCB 2015b).

The project area extends from the highlands within the Ok Tedi Region down to the lower elevations near Ningerum within the upper middle Ok Tedi region. Annual rainfall ranges from 4,000 mm to more than 10,000 mm, with the highest rainfall occurring on the southern slopes of the mountain range from May to October.

The regional climate is influenced by the Southeast Trade Winds and the Northwest Monsoon, separated by the shifting Inter-Tropical Convergence Zone. The Southeast Trade Winds prevail from May to October and produce very heavy rainfall on the southern windward slopes of the Central Cordillera. The Northwest Monsoon westerly winds to the north of the Inter-Tropical Convergence Zone are dominant from December to March and bring heavy rain interspersed with dry conditions. The air is generally moist and unstable, producing deep convection activity and highly localised heavy rainfall. The transitional months of April and November mark the seasonal shift between these systems. The general wind pattern shifts during late March through April, as the Inter-Tropical Convergence Zone shifts north of the equator. Topography plays a major role in the local precipitation. Due to the influence of orographic lift, the Ok Tedi Mine and surrounding mountainous areas receive substantially higher rainfall than the lowlands where the TSF development area is proposed (KCB 2024a).

Table 8.2 summarises the key climate parameters for the project area around the TSF development area, which can be described as follows:

- **Air temperature:** Based on historical records from 2019 to 2023 at Bige, the average annual temperature was approximately 27.8°C, with a minimum temperature of 24.8°C recorded in August 2019 and a maximum temperature of 31.1°C recorded in November 2020.
- **Rainfall:** The nearest rainfall monitoring point at Karandimok Village (about 1.6 km northeast of the TSF development area) recorded an average of 20 mm/day and 7,434 mm/year based on data from May 2018 to January 2024 (OTML 2025d). For comparison, the average annual rainfall at the PMP59 and Bige stations is approximately 6,650 mm and 5,500 mm, respectively; and 9,800 mm at the Edinburgh station near the Ok Tedi Mine (KCB 2024a). The TSF development area has an annual average rainfall slightly above those measured at PMP59 and Bige but much lower than in the highlands around Ok Tedi Mine (KCB 2024a). Mean monthly precipitation recorded at Bige ranges from 490 mm in January to 682 mm in June.
- **Evaporation:** The nearest evaporation station located at Bige recorded an annual evaporation (US Class A evaporation pan) of approximately 770 mm between 2006 and 2008. Based on these measurements, the annual evapotranspiration at the TSF development area is estimated at ~535 mm (KCB 2024a). Therefore, rainfall exceeds evaporation by an order of magnitude.
- **Wind speed and direction:** Figure 8.2 provides seasonal wind roses from OTML's Bige weather station, showing the frequency of occurrence of wind speed and direction using data collected from 1994 to 2013. From January to March, relatively calm conditions at 9 am are typical, with mild breezes from the northwest (morning winds being a downslope wind from the mountains). By 3 pm, the winds generally strengthen from the west, consistent with the Northwest Monsoon westerly winds. From July to September, winds are predominantly southeasterly throughout the day, reflecting the prevailing seasonal Southeast Trade Winds that dominate during this period (KCB 2024a).

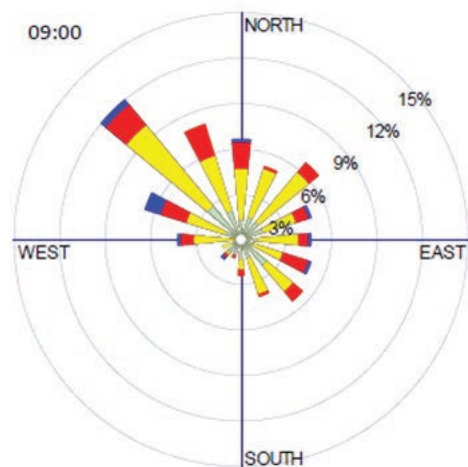
Table 8.2 Climate parameters for the project area from PMP59 (1994-2024) and Bige stations (2019-2023)

Month	Total precipitation (mm) [*]	Average pan evaporation (mm) [†]	Minimum air temperature (°C) [‡]	Maximum air temperature (°C) [‡]	Average wind speed (m/s) [‡]	Average humidity (%) [‡]
Jan	490	85.8	25.8	30.9	1.8	87
Feb	507	77.3	25.4	30.9	1.8	87
Mar	584	77.3	25.5	30.7	1.8	87
Apr	560	63.0	26.2	30.4	1.5	89
May	630	57.3	25.5	29.9	1.6	91
June	682	43.3	25.0	28.5	1.5	92
Jul	587	40.7	24.9	28.3	1.7	92
Aug	530	46.2	24.8	28.4	1.7	90
Sept	580	53.1	25.0	29.6	1.7	90
Oct	501	65.6	25.1	30.5	1.6	88
Nov	509	78.5	25.5	31.1	1.6	87
Dec	497	76.6	26.0	30.8	1.6	88
Annual Total	6,657	764.6	-	-	-	-

^{*} Based on OTML's PMP59 monitoring station data from 1994 to 2024. Months with more than three days missing were excluded (KCB 2024a).

[†] Based on OTML's Bige weather station data from 2006 to 2008 (KCB 2015a).

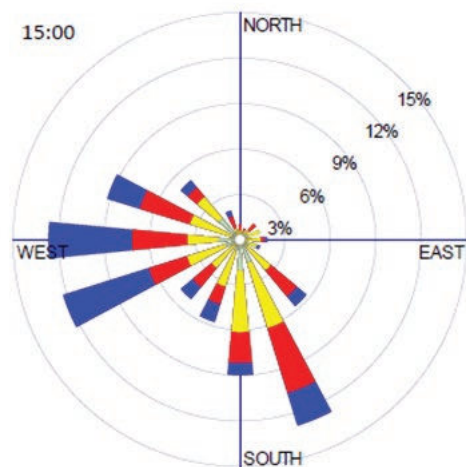
[‡] Based on OTML's Bige weather station data from 2019 to 2023. June to July 2022 contained some missing data (OTML 2024c).



WIND SPEED
(m/s)

- ≥ 3.0
- 2.0 - 3.0
- 1.0 - 2.0
- 0.5 - 1.0

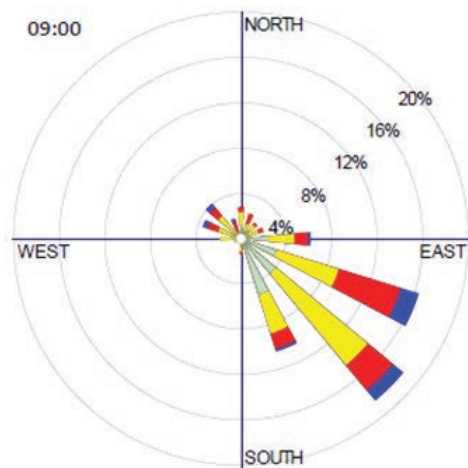
Calms: 1.19%



WIND SPEED
(m/s)

- ≥ 3.0
- 2.0 - 3.0
- 1.0 - 2.0
- 0.5 - 1.0

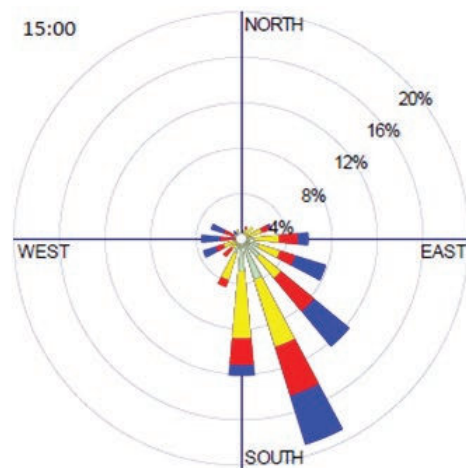
Calms: 0.81%



WIND SPEED
(m/s)

- ≥ 3.0
- 2.0 - 3.0
- 1.0 - 2.0
- 0.5 - 1.0

Calms: 1.44%



WIND SPEED
(m/s)

- ≥ 3.0
- 2.0 - 3.0
- 1.0 - 2.0
- 0.5 - 1.0

Calms: 1.03%

SOURCE
KCB, 2024



OK TEDI MINING LIMITED
OK BIRIM TAILINGS STORAGE FACILITY PROJECT

FIGURE 8.2
Seasonal wind roses from Bige weather
station (from 1994 to 2013)



DATE: 21.06.26 PROJECT: 754-MELEN374244 FILE: 374244C_R08_F08.02_GRA

8.1.1 Climate-related natural hazards

PNG is exposed to a wide range of natural hazards including earthquakes, landslides, floods, droughts, volcanic eruptions, tsunamis, tropical cyclones and the effects of climate change. Over the last two decades, studies also indicate trends of increasing occurrence of wildfires, heatwaves and droughts, and tropical cyclone related damage during El Niño events (Kumar et al. 2006; Salinger 2001; cited in Howes et al. 2018).

The project is in a region that is periodically affected by natural hazards such as earthquakes, landslides, extreme rainfall during storms, seasonal floods, drought and bushfires. Although infrequent, these events have the potential to cause significant disruption, damage to project infrastructure and serious social and environmental impacts. Earthquakes, landslides and volcanic activity are discussed further in Section 8.2.2.

8.1.1.1 Tropical cyclones and severe storms

Tropical cyclones can cause intense rainfall, strong winds, flooding and widespread damage, with potential impacts on water quality, infrastructure and public health. PNG is classified as at high risk of tropical cyclones and severe storms with potentially damaging wind speeds. Between 1970 and 2010, an average of 15 cyclones per decade passed through PNG's exclusive economic zone, mostly between November and April (WBG 2021). These events can result in widespread flooding and inundation of low-lying islands due to elevated sea levels and storm surges.

Most cyclones track south of PNG's mainland due to its proximity to the equator, where the Coriolis effect is too weak to sustain cyclone rotation (approximately from 4°S to 4°N) (WBG 2021). El Niño conditions can increase cyclone activity in the eastern Pacific while suppress activity in the north Atlantic, northwest Pacific and Australian regions (WBG 2025).

The project area, located approximately 600 km inland, is not directly exposed to tropical cyclones with the nearest cyclone path recorded in 2017 over 250 km south (BOM 2023). Consistent with this, the cyclone hazard for the project area is classified as low (GFDRR 2020), indicating a 1% chance of potentially damaging winds in the next 10 years. However, severe storms bringing damaging winds, heavy rainfall and flooding may still occur and cause impacts on infrastructure, settlements, public health and the environment (CFE-DM 2025a).

8.1.1.2 Floods

Flooding represents a major risk with most of PNG experiencing flooding during the monsoons (WBG 2011). The country is affected by coastal, riverine (fluvial), and surface (pluvial) flooding, with approximately 18% of PNG's landmass either permanently or seasonally inundated (WBG 2021). Major flood events in recent years include:

- 2025 and 2021: Large-scale River flooding along the Fly and Strickland rivers from continuous rainfall, which led to widespread impacts on access to drinking water and an increase in waterborne diseases (PNG Red Cross 2024; PNG National Broadcasting Corporation News press release, 19 May 2025).
- 2020: In early April, nearly 500 homes were damaged or destroyed by flooding from the Zokozoi River in Eastern Highlands Province (CFE-DM 2025a).
- 2012: In September, heavy rains in Southern Highlands province triggered flooding and landslides that affected as many as 200,000 and left at least three dead (CFE-DM 2025a).

In particular, PNG faces high riverine flood risks due to its steep terrain, low-lying floodplains and heavy rainfall (CFE-DM 2025b). Historical data suggests that inland floods affect 22,000 to 26,000 people annually (including deaths), displacing 6,000 to 8,000 people, and causing estimated annual damages of over PGK 33,600,000 (US\$8 million) (PNG Government 2014; cited in CCDA 2023).

Floods can cause significant erosion and heavy sedimentation that impact settlements, infrastructure, ecosystems and agricultural productivity. In the lowlands, heavy silt loads and debris brought by flood events may also cause damage to coastal ecosystems such as mangroves, estuaries and coral reefs (WBG 2021).

The project area is not exposed to coastal flooding. However, the river flood hazard is high in the lowlands surrounding the TSF site (GFDRR 2020). The Fly-Strickland River watershed in Western Province, which the Ok Tedi catchment is part of, is particularly prone to frequent seasonal riverine flooding including because of the historical impacts of the Ok Tedi Mine. The Kiunga–Tabubil Highway, a critical link for OTML operations and local communities, is frequently affected by riverbank erosion and seasonal flooding associated with this watershed (CFE-DM 2025b).

8.1.1.3 Prolonged droughts

Droughts are common in PNG, often coinciding with dry spells and heat linked to El Niño, and can lead to wildfires and reduced crop yields. Two main drought types occur: meteorological (precipitation deficit) and hydrological (deficit in water flow) (CFE-DM 2025a). Most affected areas include Southwestern Plains, Central Province Plains, Cape Vogel area, Markham Valley, Bulolo Valley, Maprik–Angoram area as well as parts of Eastern Highlands and Madang provinces (CCDA 2023).

As most rural communities rely on subsistence agriculture, droughts can cause severe impacts. Notable droughts include (CFE-DM 2025a):

- 2024: La Niña event caused critical drought conditions in South Bougainville, East New Britain, and parts of New Ireland province.
- 2022: PNG relies on hydropower for 40% of its power supply. In September, water levels at three of the country's six dams dropped to critical levels from drought, affecting power to around 1 million residents.
- 2015–2016: El Niño drought affected around 40% of the population and about half a million people were affected.
- 1997–1998: Worst drought in PNG history. El Niño event impacted over 1 million people due to food and water shortages, particularly in rural populations (Chua et al. 2019 cited in CCDA 2023).

While the project area's water scarcity hazard is classified as very low (GFDRR 2020), extended droughts can lower river levels along the main Fly River and Ok Tedi channels and restrict shipping critical to OTML operations and local communities. Shipping interruptions most commonly occur during El Niño droughts. OTML continuously monitors river conditions along the main Fly River and Ok Tedi channels to manage such risks. In 2023, drought-induced low water levels severely restricted the transport of fuel and supplies up the Fly River, interrupting Ok Tedi Mine production (OTML 2024d).

Historical droughts recorded by OTML in 1965, 1972, 1982, 1997, 2002 and 2004 also demonstrated that prolonged dry periods can severely affect hydropower, local communities and food security through crop failures, migration, increased hardship and health risks. OTML has established a response strategy to mitigate operational and community impacts in coordination with government agencies and affected communities (OTML 2016).

8.1.1.4 Bushfires

While bushfire likelihood in PNG is considered high (Australian Aid 2021), the project area is classified as medium, indicating a 10% to 50% annual chance of weather conditions suitable for hazardous wildfire (GFDRR 2020).

Lightning strikes can naturally ignite fires. However, most fires are human-induced through seasonal burning for traditional shifting cultivation and hunting. The slash-and-burn method used to clear land for farming can cause uncontrolled or high intensity fires (NASA 2018). Fire is also used traditionally to protect natural

resources and maintain grassland and woodland ecosystems (Stronach 2000), while commercial logging and agricultural expansion have increased the incidences of forest fires (Butler 2015).

Between 2001 and 2024, Western Province recorded the highest rate of tree cover loss due to fires in PNG, with an estimated 59,000 ha lost, mostly in South and Middle Fly. Fires accounted for roughly 27% of total tree cover loss during this period, with the 2016 El Niño drought being the most severe year recorded. Peak fire season in the province typically begins in mid-September and lasts about 11 weeks, with drought and prolonged dry periods contributing to the intensity and spread of fires (Global Forest Watch 2025).

Although the project area is less affected than other parts of Western Province (forest fire loss in the North Fly was only 73 ha between 2001 and 2024), prolonged dry conditions and local traditional burning practices can still increase localised bushfire risk. Nonetheless, consistently high rainfall throughout the year naturally suppresses the likelihood and spread of bushfires in the area.

8.2 TOPOGRAPHY, GEOLOGY AND SOILS

This section outlines the topography, geology and soils of the project area, which are heavily influenced by the tectonic setting of the region.

8.2.1 Tectonic setting

The New Guinea region, comprising the Independent State of Papua New Guinea in the east and the Republic of Indonesia in the west, lies within one of the most tectonically complex regions in the world (Baldwin et al. 2012). Geological processes have formed PNG's distinctive mountainous topography, mineral wealth and seismic activity.

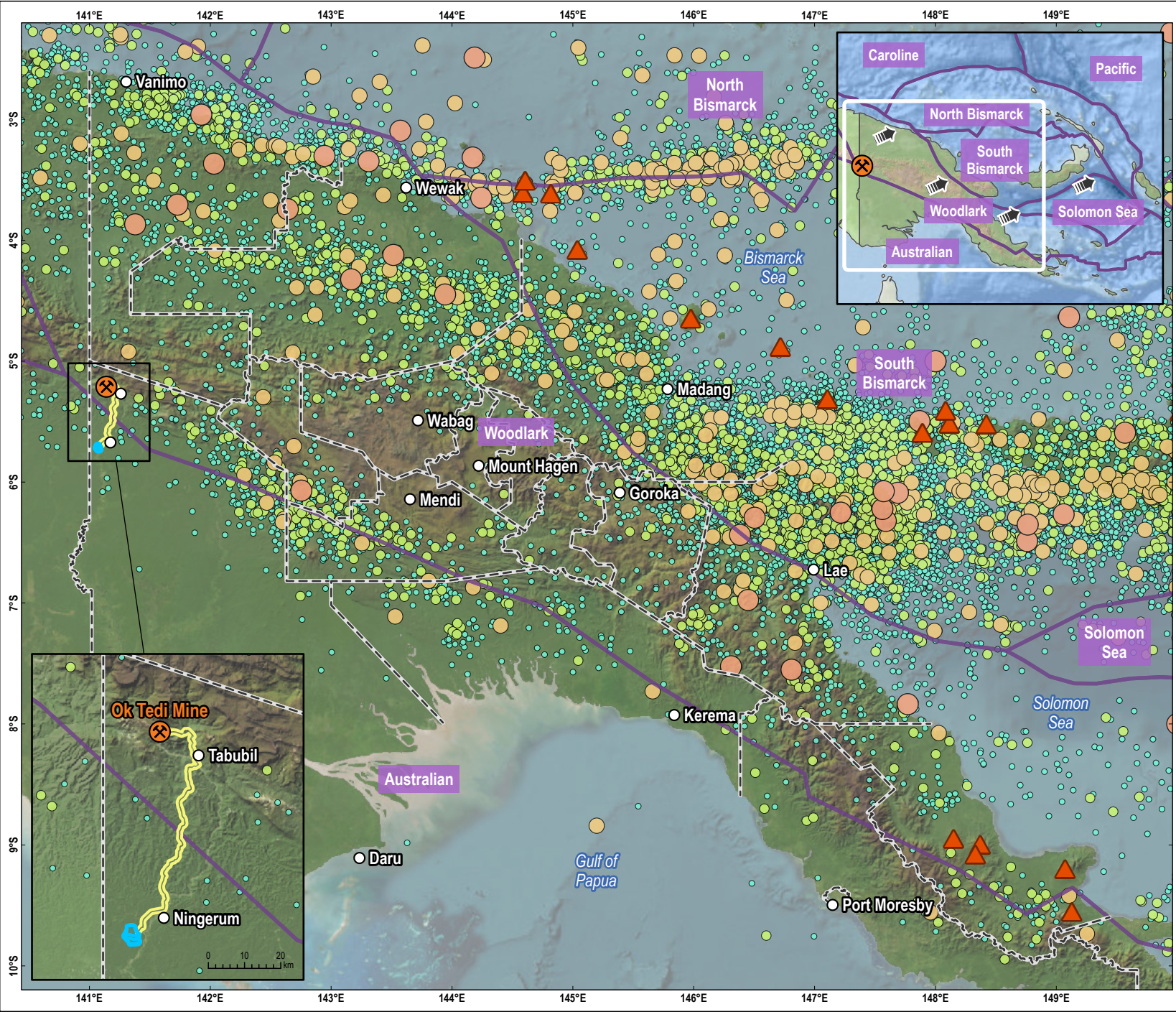
The island of New Guinea is composed of several major tectonic elements. PNG is situated at the boundary between two major tectonic plates, the relatively stable, continental Australian Plate and the Pacific Plate (Figure 8.3), with a movement of around 70 mm per year across the New Guinea region (Baldwin et al. 2012).

The region experiences rapid movement between the Australian and Pacific plates. This tectonic interaction drives a variety of geological processes that continue to shape the region's geology, including magmatic arcs, subduction zones, and contributing to region's high seismicity and volcanism (Baldwin et al. 2012).

The collision zone between the Australian and Pacific plates is expressed on the surface off PNG's northern coast. This surface expression is complex due to the further interactions between the Woodlark, Solomon, and North and South Bismarck microplates (see Figure 8.3). The boundaries of these microplates outline the volcanic and seismically active island arc regions of New Guinea. Plate interactions and movements generate faulting and seismic events extending up to 300 km inland from the coast (KCB 2015a).

The Ok Tedi Mine is located on the southern flanks of the Central Cordillera mountain range which extends east-west across the island of New Guinea (KCB 2024a). The tectonic forces responsible for building the Central Cordillera have also contributed to the formation of the large porphyry copper-gold deposits such as Mt Fubilan. Baldwin et al. (2012) describe several major fault zones that play a critical role in accommodating the complex interactions between tectonic plates in the New Guinea region.

Notable fault zones are the Ramu-Markham Fault, the Papuan Peninsula shear zone, and the Southern Highlands Thrust Fault and Aure Fold and Thrust Belt. These fault systems contribute to the region's high seismicity and influence the structural evolution of the landscape.



LEGEND

- Ok Tedi Mine
- Town
- Province boundary
- Proposed TSF footprint
- Proposed infrastructure corridor

Seismic activity

- Volcano
- Plate motion
- Tectonic plate

Earthquake by magnitude

- <5
- 5 - 5.9
- 6 - 6.9
- >7

SOURCE

Earthquake data (1900-2026) and plates from USGS.
Volcanoes from Smithsonian Institution (2026).
Proposed infrastructure from KCB and OTML.
Place names from NGIA.
Provinces from NSO.
Imagery from ArcGIS Online.



0 50 100 km
SCALE 1:5,000,000
PAGE SIZE: A4
PROJECTION: GCS PNG94

OK TEDI MINING LIMITED

OK BIRIM TAILINGS STORAGE FACILITY PROJECT

FIGURE 8.3

Simplified tectonic plate boundaries,
earthquakes and volcanoes



TETRA TECH
COFFEY

DATE: 21.06.26 PROJECT: 754-MELN374244 FILE: 374244C_R08_F08.03_GIS

8.2.2 Natural hazards

PNG is at risk of seismic, volcanic and landslide hazards due to its location within the Pacific Ring of Fire, steep mountainous terrain and high rainfall (CFE-DM 2025a). Each of these hazards are discussed in this section.

8.2.2.1 Earthquakes

PNG lies on one of the world's most tectonically active regions in the collision zone of the Australian and Pacific plates (PSM 2024) and ranks among the top six countries globally in terms of population exposure to earthquakes (CFE-DM 2025b). Small earthquakes occur daily, large earthquakes frequently and severely damaging earthquakes every few years (CFE-DM 2025a). The dominant mechanisms are thrust and strike slip movements associated with arc-continent collision and local microplates. Project design has considered site-specific seismic hazard studies.

8.2.2.2 Regional seismicity

From 1900 to 2010, 22 earthquakes over magnitude 7.5 occurred in the New Guinea region (Benz et al. 2011). Between 2014 and 2018, at least 10 earthquakes greater than magnitude 7.0 (considered a major earthquake with serious damage) were recorded (CFE-DM 2025a). Recent major earthquakes include (CFE-DM 2025a):

- 1996: An 8.2 magnitude shallow thrust fault earthquake in the northern Papua province of Indonesia, which resulted in 166 deaths (Benz et al. 2011).
- 2018: A 7.5 magnitude earthquake in Hela Province causing 160 deaths, major disruption to the Highlands Highway (a critical transportation corridor for PNG) and US\$140 million in damages. Western, Enga, Southern Highland and Hela provinces were declared a state of emergency (WHO 2018). The event was reported to have triggered over 10,000 landslides across 145 km² (CFE-DM 2025a). This earthquake damaged pipelines and roads in the Ok Tedi area, resulting in a three-week production outage at the mine (OTML 2018).
- 2022: A 7.6 magnitude earthquake in Markham Valley affected Morobe, Madang, and the Eastern Highlands provinces, causing 21 deaths, affecting 3,211 people and causing major disruption to the Highlands Highway.
- 2024: A 6.9 magnitude earthquake in northern PNG region, killing five people and destroying more than a thousand homes across villages already affected by severe flooding along the Sepik River.

The earthquake hazard for the project area is classified as medium (GFDRR 2020). Seismic hazard across Western Province generally increases from the lowland areas of the Ok Tedi towards the central mountain range. The closest major fault to the TSF development area is the Southern Highlands Thrust Fault, located approximately 75 km from the site with a calculated maximum magnitude of 8.5 (KCB 2024a). Chapter 13 provides further information regarding seismic hazards.

8.2.2.3 Volcanic activity

PNG contains the most active volcanoes in the southwest Pacific, with 14 active volcanoes (see Figure 8.3). Volcanic eruptions can affect large areas from powerful explosive blasts of rock and lava, ashfall, and release of volcanic gases (CFE-DM 2025a). None are situated near the project area and the volcanic hazard for this area is classified as very low (GFDRR 2020).

8.2.2.4 Landslides

Steep terrain, high rainfall, geology and elevated seismic activity combine to create a very high landslide risk across PNG. Landslides are commonly triggered by intense rainfall, seismic activity and deforestation (PSM 2024)), particularly in mountainous rural areas where they frequently damage vital infrastructure, homes and gardens, and upland forests (PNG Government 2020; cited in CCDA 2023).

Landslides are known to take place annually in PNG, with multiple medium- to high-impact events reported most years involving fatalities and infrastructure damage. Between 1997 and 2002, landslides affected 19,707 people, killed 128 people and cost the PNG Government an estimated PGK 1,090,000 (approximately US\$420,200) (WBG 2011).

Around 60% of landslides are reportedly rainfall-induced while the most catastrophic landslides are triggered by earthquakes, particularly combined with heavy rainfall that saturates the soil and weakens slope stability. Landslides can also occur from flash flooding, particularly in degraded ecosystems and soils (WBG 2021).

The Blucher Range (on the border between Western and Sandaun provinces) is generally considered a quiet seismic region relative to other parts of PNG, though earthquakes significantly contribute to slope instability and the occurrence of landslides. According to Byrne et al. (1978) as cited in KCB (2015a), the locations most susceptible to earthquake-triggered movements are the steep, high ridge tops, particularly those with deep weathering on the surface.

The potential for landslides varies across the project area with the landslide hazard classified as high in the mountainous area around Ok Tedi Mine and the infrastructure development corridor and low in the lowlands where the TSF site is located (GFDRR 2020). Heavy rainfall is the dominant trigger for landslides around the Ok Tedi Mine site. Mining-related disturbance to vegetation and terrain further destabilise the landscape and exacerbate slope instability by increasing water infiltration, pore water pressure and erosion. The landslide risk decreases towards the proposed TSF site where the landscape is flatter and more geomorphologically stable (PSM 2024).

Landslides often occur in the hilly mountainous terrain around the Ok Tedi Mine. Notable landslide events include a 7 km³ landslide about 8,800 years before present (BP) and a recent landslide in 1977, both from the Hindenburg Wall. Additionally, the Vancouver Landslide between 1989 and 1991 and landslides in Harvey Creek between 1991 and 1996 resulted in large amounts of sediment entering the Ok Tedi system.

Chapter 13 provides additional information on landslide risk, potential impacts and controls for the project.

8.2.3 Landforms

Landforms are the recurring topographic patterns in a landscape. A landform unit is defined by a distinct combination of landform elements. Landform units are primarily determined by elevation and relief, which influence environmental characteristics of the landscape and processes such as erosion, water retention, and ecosystem function.

The project area extends from the hilly mountainous terrain near the Ok Tedi Mine, through undulating hilly terrain south of the mine to the TSF development area, located on relatively flat terrain. The Papua New Guinea Resource Information System (PNGRIS) provides environmental mapping across PNG, including detailed soil, geology and landform mapping (Bryan and Shearman 2008). The project intersects the following landform units defined by PNGRIS (Bryan and Shearman 2008) (Figure 8.4):

- Mountains and hills with weak or no structural control.
- Polygonal karst: plateaux or broad ridges on limestone covered with numerous rugged hills.
- Homoclinal ridges and cuestas: inclined asymmetrical structurally controlled ridges.
- Dissected relict alluvial, colluvial mudflow and fans.

- Hilly terrain with weak or no structural control.
- Intricately dissected relict alluvial plains: low closely spaced ridges and narrow swampy valleys.
- Meander floodplains: unstable alluvial floodplain.

8.2.3.1 TSF development area

The TSF development area is situated primarily within a lowland setting characterised by relatively flat terrain interspersed with shallow undulating valleys. Elevations across the site range from approximately 40 to 80 m above mean sea level, with regional topography gently sloping southward (KCB 2024d). The TSF development area landform reflects a combination of gently sloping valley floors and low ridges with drainage channels contributing to local geomorphology. The presence of such features influences surface water flow and natural drainage patterns relevant to the design and management of the TSF.

The TSF is situated predominantly within the intricately dissected relict alluvial plains: low closely spaced ridges and narrow swampy valleys landform unit, with the eastern extent of the TSF near the Ok Tedi intersecting the meander floodplains: unstable alluvial floodplain unit.

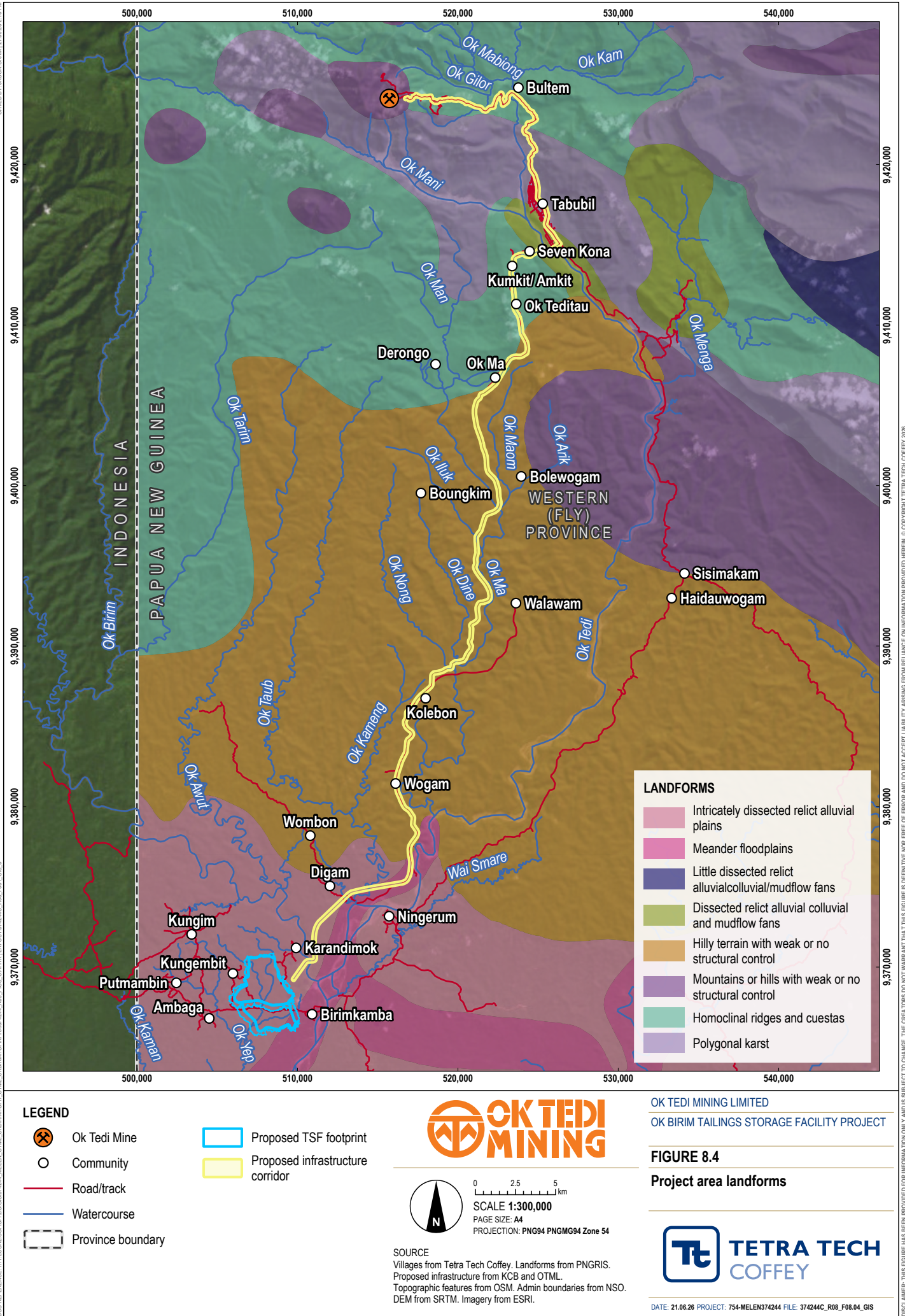
8.2.3.2 Infrastructure development corridor

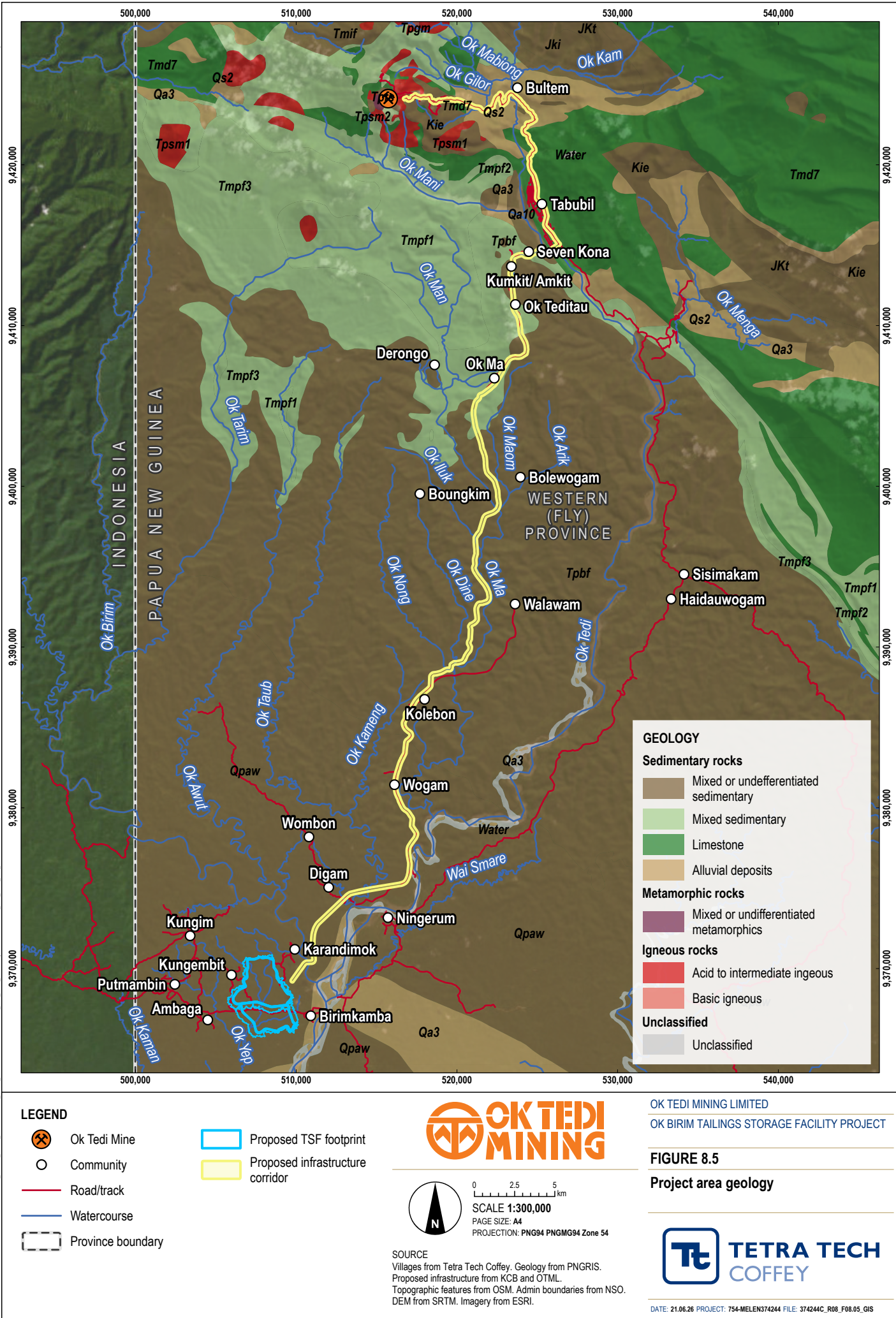
The infrastructure development corridor intersects several landform units as it extends south from the mine to the TSF. The northern end of the corridor commences in the mountains and hills weak or no structural control near the mine. The corridor intersects the homoclinal ridges and cuestas: inclined asymmetrical structurally controlled ridges landform unit south from the mine towards Bounkim and east towards Tabubil, as well as southwest of Tabubil from Kumkit towards Dorongo and the Ok Ma. The corridor intersects the dissected relict alluvial, colluvial mudflow and fans landform unit near Tabubil, and the hilly terrain with weak or no structural control south of Tabubil. Further south near Ningerum, it predominantly intersects the intricately dissected relict alluvial plains: low closely spaced ridges and narrow swampy valleys unit, with the meander floodplains: unstable alluvial floodplain unit present near major watercourses, such as the Ok Tedi.

8.2.4 Geology

PNGRIS mapping of the project area (Figure 8.5) shows the TSF development area and most of the pipeline development corridor (particularly between Tabubil and the TSF) predominantly traverses consolidated non-calcareous mixed or undifferentiated sedimentary rock. Other rock types present along the infrastructure development corridor include:

- Consolidated extrusive acid to intermediate igneous.
- Unconsolidated alluvial deposits.
- Consolidated calcareous limestone.
- Consolidated calcareous mixed sedimentary and limestone.





8.2.4.1 TSF development area

Lithostratigraphic units in the TSF development area are summarised in chronological order as follows:

- Transported Deposits (Quaternary-age; mainly Holocene) – thin, discontinuous surface layers comprising talus, alluvium and colluvium. These deposits generally comprise soft to firm residual soil mainly composed of clay and silt.
- Awin Formation (Pliocene-age) – roughly 500 m thick, comprising clean quartz sandstone and conglomerate, volcanoclastic arenite, siltstone, mudstone, thin lignite seams and sandy clay. Primary structures include current bedding and cut-and-fill structures.
- Birim Formation (Middle Pliocene to Pliocene) – between 1,000 m and 1,500 m thick, comprising mainly volcanoclastic sediments divided into lower and upper units. Both units generally consist of bedded calcareous shale and mudstone, volcanoclastic calcareous mudstone, limestone and volcanoclastic siltstone and conglomerate. The upper unit is generally finer-grained than the lower unit. The Birim Formation overlies the Warre Limestone Member of the Pnyang Formation with a transitional contact.

Warre Limestone Member (Pnyang Formation) (Middle to Late Pliocene-age) – typically 40 m to 100 m thick, comprising massive, medium to fine-grained detrital limestone and extensively karstified in areas. The Warre Limestone Member is the uppermost lithostratigraphic unit of the Pnyang Formation. At the TSF development area, the Awin Formation unconformably overlies the Birim Formation, indicating a gap in the geological record typically caused by a period of erosion or non-deposition before the younger layer was deposited. Field investigations identified interbedded mudstone, siltstone, sandstone, conglomerate and minor lignite. The Awin Formation at Ok Birim typically consists of moderately to highly weathered sandstone and siltstone with low rock strength, observed in outcrops along drainage channels (KCB 2024a). Quaternary alluvium and colluvium overlying the Awin Formation are in thin, discontinuous layers along drainage lines, indicating continuous deposition and no significant interruption in sedimentation.

Outcrops were not observed by Klobn Crippen Berger (KCB) during the 2014 site investigation outside of drainage channels due to residual soil and tropical forest cover. Weathering intensity decreased and rock strength generally increased with depth, from extremely weathered rock underlying the residual soil, to less weathered rock at depth.

The TSF development area is characterised by several low-angle fold and fault structures (Arnold et al. 1979, as cited in KCB 2015a). The geological units in the study area typically slope gently toward the south, with broad, low-angle folds. The timescale of the folding and thrusting has not been accurately defined but possibly occurred during the Middle to Late Pliocene and may still be active today (Arnold et al. 1979, as cited in KCB 2015).

8.2.4.2 Infrastructure development corridor

East of the Ok Tedi Mine and from Tabubil south to the TSF, the pipeline development corridor primarily traverses consolidated non-calcareous mixed or undifferentiated sedimentary rocks with the following lithologies, as well as some consolidated extrusive acid to intermediate igneous rock:

- **Kie:** Silty polymict blue and greenish grey fine glauconitic quartzose sandstone and siltstone, recessive grey glauconitic mudstone and siltstone.
- **Tpbf:** Sandstone, conglomerate, tuff, agglomerate, marl near base; minor lignite near top: mostly former alluvium.
- **Qa10:** Weakly or moderately lithified conglomerate, sandstone, siltstone, mudstone: older alluvium, lake deposits, includes some Qs2.

East of the mine and along the Kiunga-Tabubil Highway to Tabubil the pipeline development corridor crosses unconsolidated alluvial deposits and consolidated non-calcareous limestone. Near Kumkit/Amkit and south of Nioksikwi/Ok Ma the pipeline development corridor also crosses areas of consolidated calcareous mixed sedimentary and limestone, with the following lithology:

- **Tmpf3:** White fossiliferous limestone, partly tuffaceous with marl interbeds.

This limestone unit is associated with mapped Lukwi karst features near the Ok Ma, approximately 1 km from the pipeline alignment (see Section 8.4.7). This generally corresponds to the Warre Limestone Member, which is extensively karstified in some areas (KCB 2015a).

8.2.5 Soils

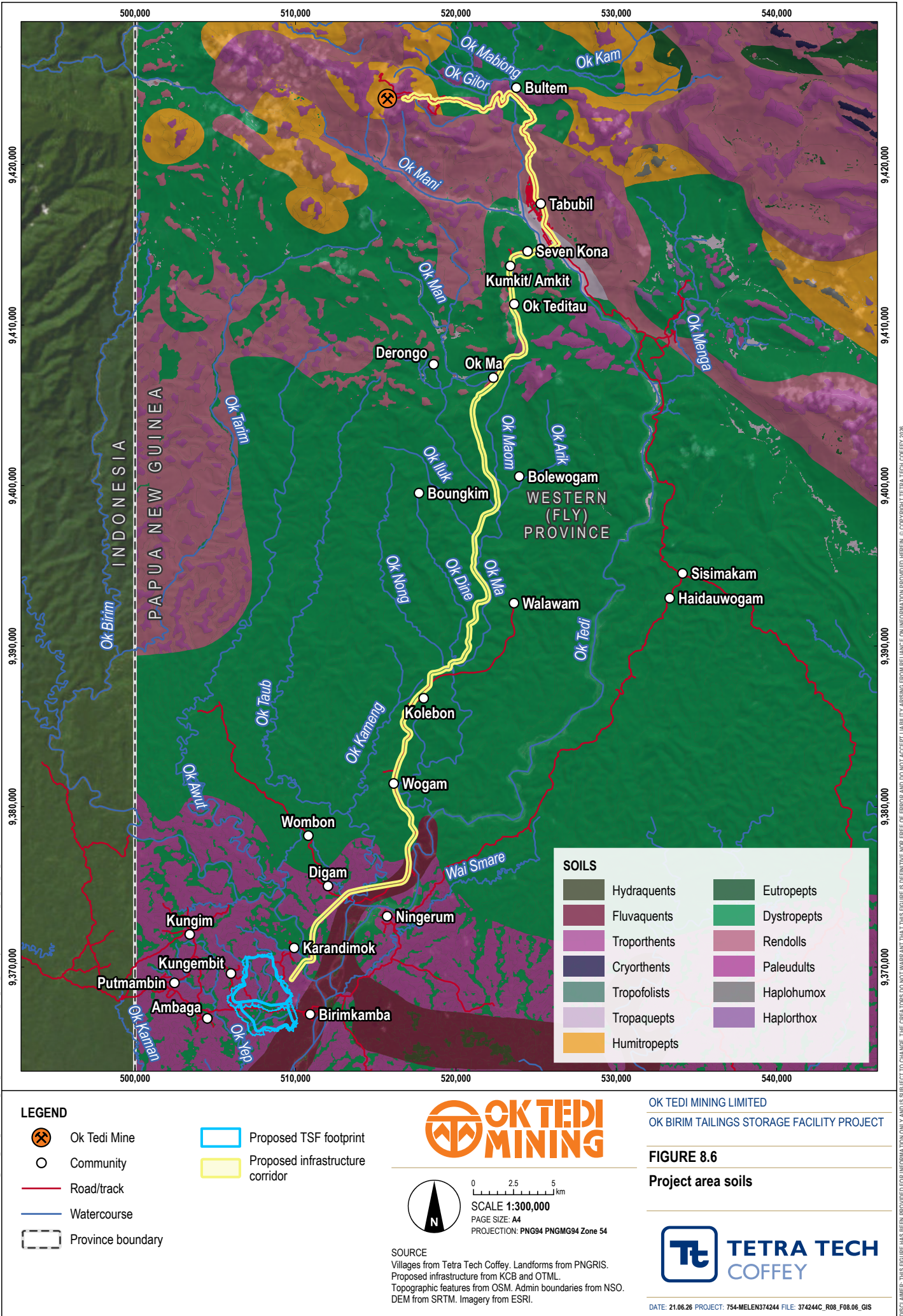
PNGRIS soil mapping of great soil groups shows soils in the area around Ok Tedi Mine and Tabubil vary between humitropepts, troprothents, rendolls, and dystropepts (Figure 8.6). The infrastructure corridor primarily intersects dystropepts between Tabubil and just north of Ningerum. The area around Ningerum is a combination of dystropepts and paleudults, with fluvaquents surrounding the Ok Tedi. These soil types are characterised below (Bryan and Shearman 2008):

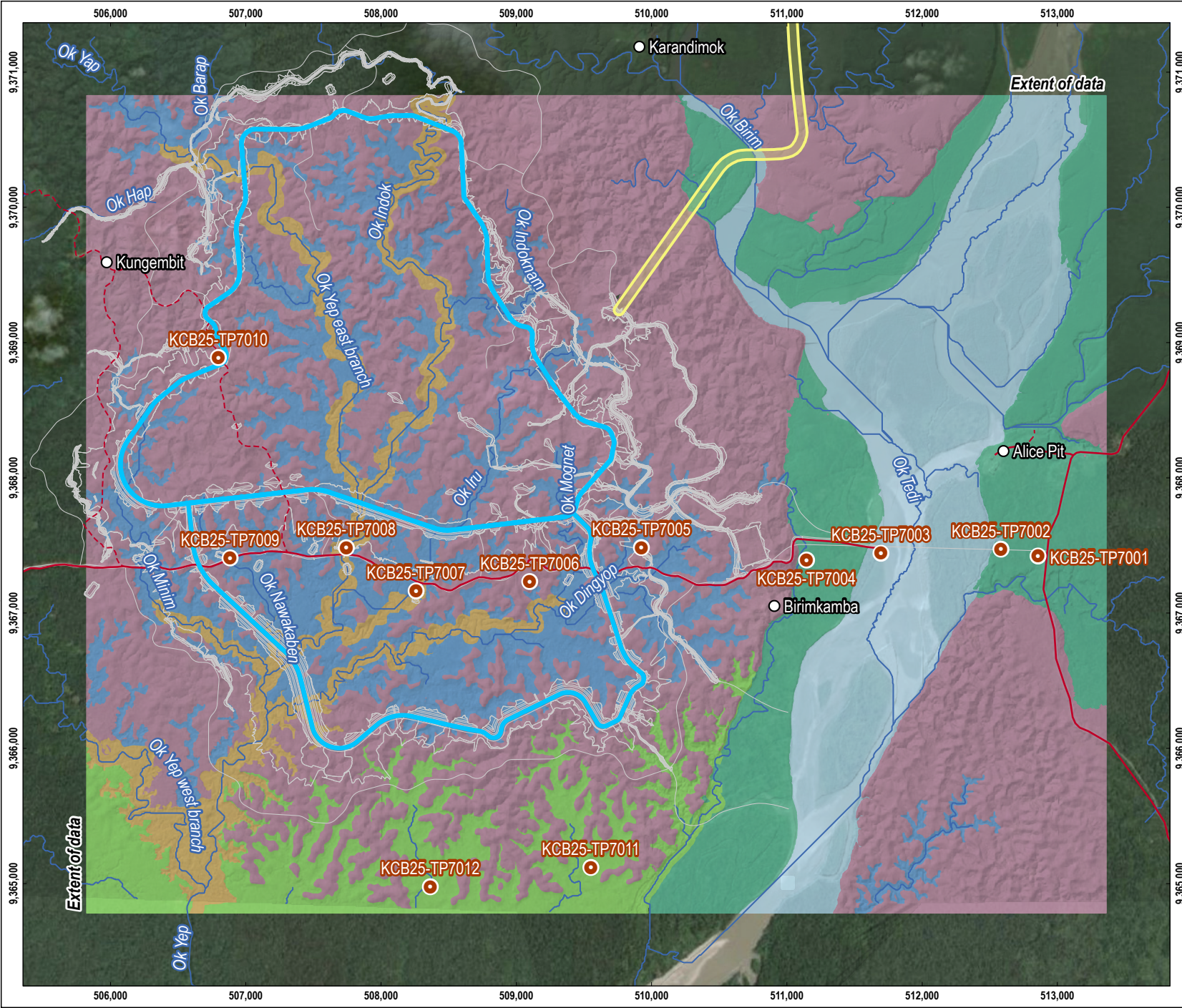
- Tropetps, including humitropepts and dystropepts are moderately well drained soils with relatively high bulk densities and low proportions of clay minerals. The key difference between humitropepts and dystropepts is the organic carbon content. Humitropepts have over 12 kg/m of organic carbon up to 1 m depth and dystropepts have less than 12 kg/m of organic carbon up to 1 m depth.
- Troprothernts are young, shallow soils found on steep or rocky slopes in warm, humid areas. They stay moist most of the year and lack distinct soil layers.
- Rendolls are shallow, dark-coloured soils formed from calcareous parent material in humid regions. They have a thin surface later that lies directly on overlying rock or partly decomposed, disintegrating material.
- Fluvaquents are poorly to very poorly drained alluvial soils with relatively high organic carbon content, mostly found on river floodplains.
- Paleudults are moderately well-drained soils found in humid climates with warm temperatures. They have fairly uniform subsoils where the clay content changes very little with depth.

8.2.5.1 TSF development area

Geology and soil investigations (Appendix K), including soil sampling and testing, were used to identify land facets the TSF is located within. Land facet groups are a series of individual land facets with common regional landforms, bedrock geology, soil profile, or engineering behaviours (van Schalkwyk and Price 1990 as cited in Appendix K). The individual land facets are areas defined by the landscape's geomorphology, linking particular rock and surficial deposits with expected uniform soil and water profiles, including, ridge crests, free faces, pediments, and gullies (van Schalkwyk and Price 1990, as cited in Appendix K).

The TSF development area is characterised by ridgelines dissected by perennial tributaries and seasonal tributaries (Plate 8.1 to Plate 8.3). Based on 2025 investigations in the TSF development area presented in Appendix K, the TSF development area intersects the ridgeline, perennial tributaries and seasonal tributaries land facet groups (Figure 8.7).





LEGEND

- Soil sampling location
- Community
- Road
- - - Track
- Watercourse

Proposed layout

- TSF detailed design
- TSF footprint
- Infrastructure corridor

Land facet group

- Braidplain
- Floodplain
- Marshland
- Ridgeline
- Perennial tributary
- Seasonal tributary

SOURCE

Villages and watercourses from Tetra Tech Coffey.
Land facets and sampling locations from KCB.
Proposed infrastructure from KCB and OTML.
Roads from OSM.
Imagery from ESRI and Google Earth.



0 0.5 1 km
SCALE 1:40,000
PAGE SIZE: A4
PROJECTION: PNG94 PNGMG94 Zone 54

OK TEDI MINING LIMITED

OK BIRIM TAILINGS STORAGE FACILITY PROJECT

FIGURE 8.7

Land facet groups within and around the TSF development area



TETRA TECH
COFFEY

DATE: 21.06.26 PROJECT: 754-MELN374244 FILE: 374244C_R08_F08.07_GIS

These are described as:

- **Ridgelines:** The ridgeline facet group is dominated by residual soils derived from the Awin Formation. These soils are red, clay-rich, and exhibit medium to high plasticity. Profiles are relatively uniform and become stiffer with depth, contrasting with the more variable alluvial soils in adjacent land facets. The high moisture content and moderate to very high plasticity indicate soils that are cohesive, low permeability, and moisture-sensitive.
- **Perennial tributaries:** The perennial tributary facet group is characterised by predominantly grey, brown and red moderate to high plasticity clay, with greater proportions of sand and gravels and higher moisture contents than the ridgelines and seasonal tributaries due to the consistent flow throughout the year. The red material is likely eroded from the surrounding ridgelines and deposited in the tributaries.
- **Seasonal tributaries:** Predominantly grey and brown medium or medium to high plasticity clays. Soils are clay-dominated with less gravels than the perennial tributaries facet group, and exhibiting high moisture levels, slightly lower than the perennial tributaries facet group.

Adjacent to the TSF development area, the Ok Birim and Ok Tedi are characterised as braidplains (Plate 8.4) with adjoining floodplains (Plate 8.5). Marshlands are located on the periphery of the floodplain land facet group (Plate 8.6). The braidplain facet group is characterised by greater variability in grain size distribution due to the higher-energy depositional environment. Although still predominantly fine-grained, these soils commonly include sand and gravel, resulting in lower plasticity than other facets. The floodplain facet group is located in a lower-energy environment than the braidplain facet group, resulting in finer, more cohesive deposits, although still with some variability. Soils remain dominated by clay and silt but can include gravel.

The marshland facet group represents the lowest energy depositional environment, located within vegetation and standing water. Soils are primarily mostly clays with minimal gravels and sand. These soils have lower plasticity than the perennial and seasonal tributaries facet groups. As distance from active channels increases, there is a gradual transition toward more residual soil input, eroded from ridgelines, reflected in redder soil coloration within the profile.

While the pH of soil samples within the TSF development area indicate soils in some low-lying areas may exhibit potential acid sulfate soils (PASS) characteristics, the measured sulfur concentrations and acidity parameters are insufficient to classify the tested soils as ASS. On this basis, no PASS or ASS are assumed to occur in the TSF development area.

8.2.5.1 Infrastructure development corridor

Soil samples were collected from selected locations across the proposed pipeline route to characterise surficial and shallow soils from the soil types across the route and assess the suitability of the soils for reuse. The soil survey covered 18 sites (SS01 to SS18) shown in Figure 8.8. At each location, a hand auger was used to dig to a depth of approximately 0.2 m to 0.4 m below ground level, and four soil subsamples per site were collected for laboratory analysis. Duplicate quality assurance samples were also collected at SS10 and SS15. The laboratory parameters included:

- Electrical conductivity.
- pH and oxidation pH measurements.
- Acidity and sulfur parameters.
- Calcium and magnesium parameters.
- Moisture content.
- Emerson aggregate/stability testing.

- Exchange acidity and exchangeable aluminium.
- Exchangeable cations.
- Chloride.
- Extractable metals.
- Total metals.
- Nitrogen and phosphorus parameters.
- Organic matter.
- Total organic carbon.

Table 8.3 shows a summary of the maximum survey results for the main parameters tested.

Metal results

In absence of PNG-specific criteria, screening criteria were selected for metals and nutrient analytes for the protection of human health for commercial / industrial land use from the Australian *Schedule B1, Guideline on Investigation Levels For Soil and Groundwater, National Environment Protection (Assessment of Site Contamination)*, 2013 (NEPC, 2013). The criteria in Schedule B1, Table 1A (1) is applied to this assessment, as it is relevant to commercial / industrial premises. Screening criteria for protection of the environment were selected for limited metal analytes for commercial/industrial land use from the NEPC guidelines (NEPC 2013). The criteria selected include:

- Environmental investigation level (EIL) for arsenic.
- Added contaminant limit (ACL) for chromium (for samples with 2.5% clay content), copper, lead, nickel and zinc with 20 meq/100g (sample average is 22 meq/100g) and average pH of 6.5 across all samples

Lead was detected above the criteria for protection of human health and the environment in an industrial setting in sample SS01d. Elevated concentrations were also detected at the other subsamples at SS01 (ranging from 168 mg/kg to 258 mg/kg) and SS02 (ranging from 195 mg/kg to 288 mg/kg), however still below criteria.

Elevated concentrations of copper, nickel and zinc were also detected at location SS02 in relation to other sample locations but were below the relevant criteria. Both SS01 and SS02 are close to the Ok Tedi Mine.

Acidity, pH, and other non-metal parameters

Net acidity and field pH results indicate the presence of acidity; however, the detected presence of reduced inorganic sulfur above the LOR indicate that the acidity is likely to be from oxidation of sulfides and not from high organic matter content. Electrical conductivity indicated salinity from 423 to 7,368 $\mu\text{S}/\text{cm}$, with generally higher values in loamy materials and lower values in clay or loamy clay samples. The nutrient suite was dominated by total Kjeldahl nitrogen, with total nitrogen ranging from 410 to 4,020 mg/kg, ammonia detected at 20 to 160 mg/kg, nitrite and nitrate present at comparatively low concentrations, and total phosphorus ranging from 155 to 1,030 mg/kg.

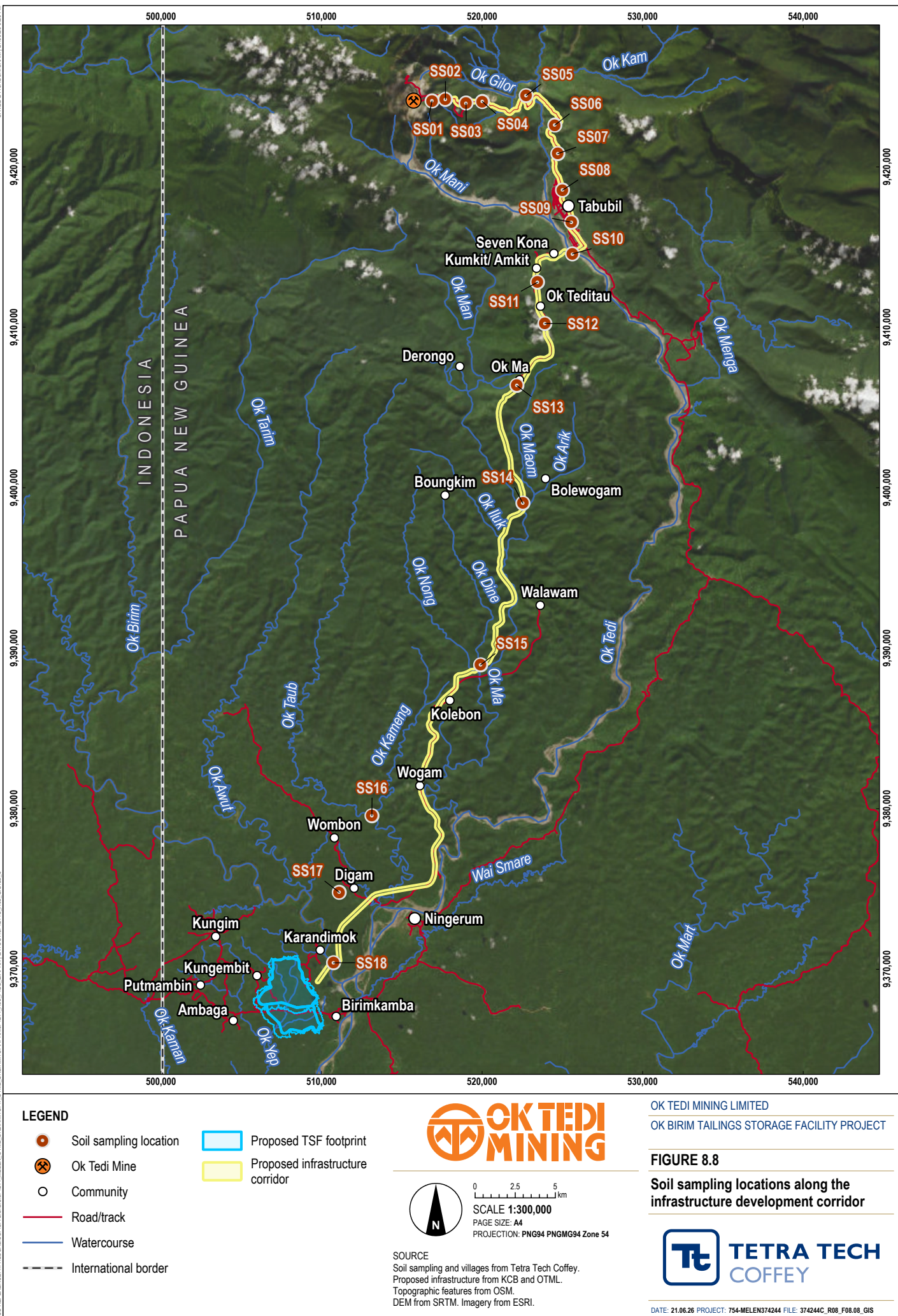


Table 8.3 Summary of maximum soil survey results

Site	Arsenic mg/kg	Acid Neutralising Capacity % CaCO ₃	Total Phosphorus as P mg/kg	Total Organic Carbon %	Organic Matter %	Zinc mg/kg	Total Nitrogen as N mg/kg	Cadmium mg/kg	Chromium mg/kg	Copper mg/kg	Lead mg/kg	Nickel mg/kg
SS01	185	-	864	2.2	3.7	304	1,250	1	<2	85	3,240	<2
SS02	65	24.8	1,010	1.2	2	541	710	4	23	5,590	288	33
SS03	9	1.05	303	1.5	2.6	59	1,360	<1	16	5	29	7
SS04	<5	83.5	417	4	6.8	36	2,880	<1	13	16	9	6
SS05	<5	41.5	428	2.7	4.7	37	2,160	<1	14	47	12	14
SS06	<5	64	361	4.1	7	36	2,500	<1	11	12	<5	16
SS07	<5	91.4	365	4.3	7.4	62	1,490	<1	9	58	9	6
SS08	12	52.8	948	4.6	8	24	4,020	3	131	6	9	26
SS09	6	3.58	663	3.8	6.6	12	1,960	1	65	<5	<5	16
SS10	6	2.07	558	2.1	3.6	45	1,900	<1	13	38	8	14
SS10A	6	-	603	2	3.4	54	1,390	<1	12	60	7	14
SS11	13	11.5	413	1.5	2.6	73	700	<1	4	86	18	4
SS12	27	-	299	1.2	2	39	1,550	<1	26	<5	18	15
SS13	<5	-	1,030	1.1	1.9	36	680	<1	10	141	7	5
SS14	<5	-	1,020	4.1	7	85	3,850	<2	<5	193	8	7
SS15	5	-	700	5.4	9.3	65	1,510	<2	6	66	7	7
SS15A	<5	-	637	2.4	4.2	62	1,460	<1	6	63	6	7
SS16	<5	-	636	1.9	3.3	72	1,250	<1	7	49	6	7
SS17	<5	-	618	1.6	2.7	36	1,520	<1	4	13	9	<2
SS18	<5	-	638	1.3	2.2	85	1,110	<1	9	43	7	7

Potential acid sulfate soils

The acid sulfate soil assessment is based primarily on pH_F and pH_{Fox} screening, supported by laboratory net acidity and acid neutralising capacity (ANC). Table 8.4 presents these results.

Table 8.4 Assessment of potential acid sulfate soils along the infrastructure development corridor

Site	pH _F	pH _{Fox}	Net Acidity (excluding ANC) (%S) (mole H+/t)		Excess ANC (%S) (mole H+/t)		Net acidity (including ANC) (%S) (mole H+/t)	
SS01a	5.7	2.6	0.32	202	NA ¹	NA	-	-
SS01b	4.4	1.4	0.83	519	NA	NA	-	-
SS01c	4.5	2.0	1.06	661	NA	NA	-	-
SS01d	4.7	1.7	0.71	445	NA	NA	-	-
SS02a	6.4	6.8	0.52	325	0.463	289	<0.02	<10
SS02b	7.0	7.5	0.19	118	3.45	2150	<0.02	<10
SS02c	6.4	6.9	0.68	423	7.51	4690	<0.02	<10
SS02d	6.9	7.0	0.46	285	0.352	219	<0.02	<10
SS03a	6.9	5.8	<0.02	<10	NA	NA	-	-
SS03b	6.7	4.5	<0.02	<10	0.121	75	<0.02	<10
SS03c	6.6	4.6	<0.02	10	NA	NA	-	-
SS03d	6.5	5.3	0.02	13	NA	NA	<0.02	<10
SS04a	7.3	6.4	0.04	27	23.9	14900	<0.02	<10
SS04b	7.8	6.5	0.03	21	24.5	15300	<0.02	<10
SS04c	7.9	7.0	0.04	24	24.8	15500	<0.02	<10
SS04d	8.1	6.6	0.03	20	24.1	15000	<0.02	<10
SS05a	8.0	6.6	0.03	21	9.3	5810	<0.02	<10
SS05b	8.1	6.8	0.04	23	11.6	7260	<0.02	<10
SS05c	8.2	6.6	0.03	20	12.7	7930	<0.02	<10
SS05d	8.2	6.7	0.03	22	12.6	7890	<0.02	<10
SS06a	8.4	6.6	0.07	43	19.7	12300	<0.02	<10
SS06b	8.4	6.4	0.13	79	13.7	8530	<0.02	<10
SS06c	8.4	6.5	0.07	46	19.2	12000	<0.02	<10
SS06d	8.3	6.2	0.08	48	14.4	8980	<0.02	<10
SS07a	8.5	6.6	0.02	14	25.4	15900	<0.02	<10
SS07b	8.5	6.7	0.04	22	26.6	16600	<0.02	<10
SS07c	8.6	6.7	0.03	17	22.4	14000	<0.02	<10
SS07d	8.5	6.9	0.03	20	24.3	15100	<0.02	<10
SS08a	8.5	6.5	0.03	18	12.3	7670	<0.02	<10
SS08b	8.3	6.6	0.04	25	7.92	4950	<0.02	<10
SS08c	8.2	6.4	0.04	24	6.25	3910	<0.02	<10
SS08d	8.3	6.4	0.05	28	7.8	4870	<0.02	<10

Site	pH _F	pH _{FOX}	Net Acidity (excluding ANC) (%S) (mole H+/t)		Excess ANC (%S) (mole H+/t)		Net acidity (including ANC) (%S) (mole H+/t)	
SS09a	8.2	6.4	0.04	23	0.388	242	<0.02	<10
SS09b	7.6	5.8	0.03	20	NA	NA	-	-
SS09c	7.8	6.6	0.03	20	0.672	420	<0.02	<10
SS09d	7.8	5.3	0.04	22	NA	NA	-	-
SS10a	7.8	5.8	0.02	13	NA	NA	-	-
SS10b	7.6	5.1	<0.02	<10	NA	NA	-	-
SS10c	7.5	5.1	<0.02	<10	NA	NA	-	-
SS10d	7.6	5.1	<0.02	<10	NA	NA	-	-
SS10Aa	7.6	5.0	0.02	15	NA	NA	-	-
SS10Ab	7.8	5.2	<0.02	<10	NA	NA	-	-
SS10Ac	7.7	5.2	0.03	20	NA	NA	-	-
SS10Ad	7.7	5.0	0.03	19	NA	NA	-	-
SS11a	7.5	7.7	0.06	36	3.38	2110	<0.02	<10
SS11b	7.5	7.6	0.08	47	0.659	411	<0.02	<10
SS11c	7.6	7.9	0.06	40	1.11	691	<0.02	<10
SS11d	7.6	7.9	0.03	21	1.56	977	<0.02	<10
SS12a	5.2	3.6	0.26	162	NA	NA	-	-
SS12b	5.2	3.7	0.23	143	NA	NA	-	-
SS12c	5.1	3.6	0.2	128	NA	NA	-	-
SS12d	5.0	3.5	0.3	188	NA	NA	-	-
SS13a	4.8	3.4	0.32	197	NA	NA	-	-
SS13b	4.8	3.5	0.29	183	NA	NA	-	-
SS13c	4.8	3.6	0.34	215	NA	NA	-	-
SS13d	4.8	3.4	0.31	192	NA	NA	-	-
SS14a	4.5	3.1	0.65	404	NA	NA	-	-
SS14b	4.5	3.3	0.65	404	NA	NA	-	-
SS14c	4.5	3.7	0.67	415	NA	NA	-	-
SS14d	4.5	3.7	0.71	442	NA	NA	-	-
SS15a	6.1	4.2	0.06	39	NA	NA	-	-
SS15b	6.1	4.0	0.06	40	NA	NA	-	-
SS15c	6.0	4.1	0.07	43	NA	NA	-	-
SS15d	6.1	4.0	0.07	42	NA	NA	-	-
SS15Aa	5.6	4.1	0.08	48	NA	NA	-	-
SS15Ab	5.6	4.1	0.08	51	NA	NA	-	-
SS15Ac	6.0	4.0	0.07	43	NA	NA	-	-
SS15Ad	5.9	4.1	0.07	47	NA	NA	-	-
SS16a	6.1	3.8	0.04	23	NA	NA	-	-

Site	pH _F	pH _{FOX}	Net Acidity (excluding ANC) (%S) (mole H+/t)		Excess ANC (%S) (mole H+/t)		Net acidity (including ANC) (%S) (mole H+/t)	
SS16b	6.1	3.9	0.04	22	NA	NA	-	-
SS16c	6.1	3.8	0.03	22	NA	NA	-	-
SS16d	6.2	3.9	0.04	22	NA	NA	-	-
SS17a	4.9	3.5	0.09	54	NA	NA	-	-
SS17b	4.8	3.4	0.09	55	NA	NA	-	-
SS17c	4.8	3.5	0.11	67	NA	NA	-	-
SS17d	4.7	3.4	0.1	64	NA	NA	-	-
SS18a	5.5	3.9	0.09	54	NA	NA	-	-
SS18b	5.4	3.8	0.09	56	NA	NA	-	-
SS18c	5.4	3.7	0.09	58	NA	NA	-	-
SS18d	5.4	3.8	0.09	56	NA	NA	-	-

NA – Not analysed. Blank cells were below the limit of reporting (LOR). Red numbers indicate high trigger level for PASS, and orange numbers indicate moderate exceedance triggered.

Net acidity (excluding ANC) results indicated that PASS may be present in soils along the alignment. However, where ANC testing was undertaken, results showed that there was sufficient excess neutralising capacity for disturbed soils to self-neutralise, indicating PASS is unlikely. ANC testing was not undertaken on all samples, and there is some uncertainty in the ability of some of the locations to self-neutralise.

The results of the field ASS testing (pH_F and pH_{FOX}) generally indicated that there was a low potential for significant acid generation across the infrastructure development corridor.

Whilst the ANC of many of the soil samples has not been assessed, given the similarity of the pH_F/pH_{FOX} results between those with and without ANC testing undertaken, it is likely that the majority of soils along the alignment have excess capacity to neutralise any acid generated during construction activities.

ANC testing was not undertaken from samples collected from location SS01, and this reported the highest pH_F/pH_{FOX} change, as well as the highest net acidity (excluding ANC) results across the alignment. This location is closest to the mine site and may be impacted by mining derived sulfides.

Erosion and stability

Laboratory soil structure and erosion testing indicated that SS01, SS04 to SS08, SS10, SS13 to SS14 and SS17 to SS18 reported an Emerson class of around 7, indicating water-stable soils with very low dispersion risk. SS02 to SS03, SS11 and SS15 to SS16 recorded more moderate erosion susceptibility, with Emerson class results indicating lower stability than the Class 7 sites. The results show that soil stability varies across the sampled locations, with most sites exhibiting strong aggregate stability and a smaller number showing moderate susceptibility to erosion.

Plate 8.1
Ridgeline soil profile exposure through road cutting

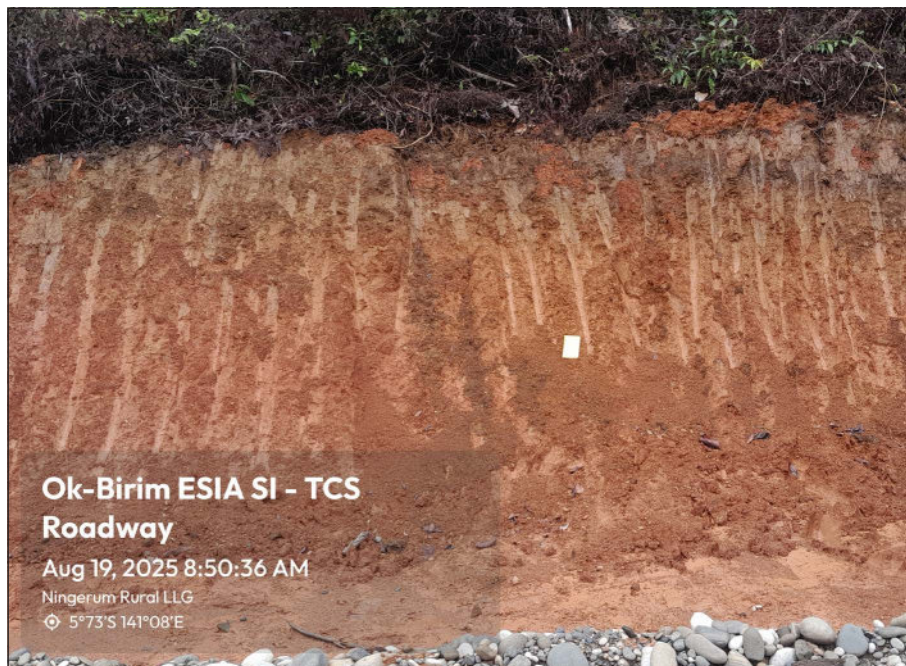


Photo credit: KCB, 2026

Plate 8.2
Roadway crossing over a perennial tributary



Photo credit: KCB, 2026

Plate 8.3
Seasonal tributary

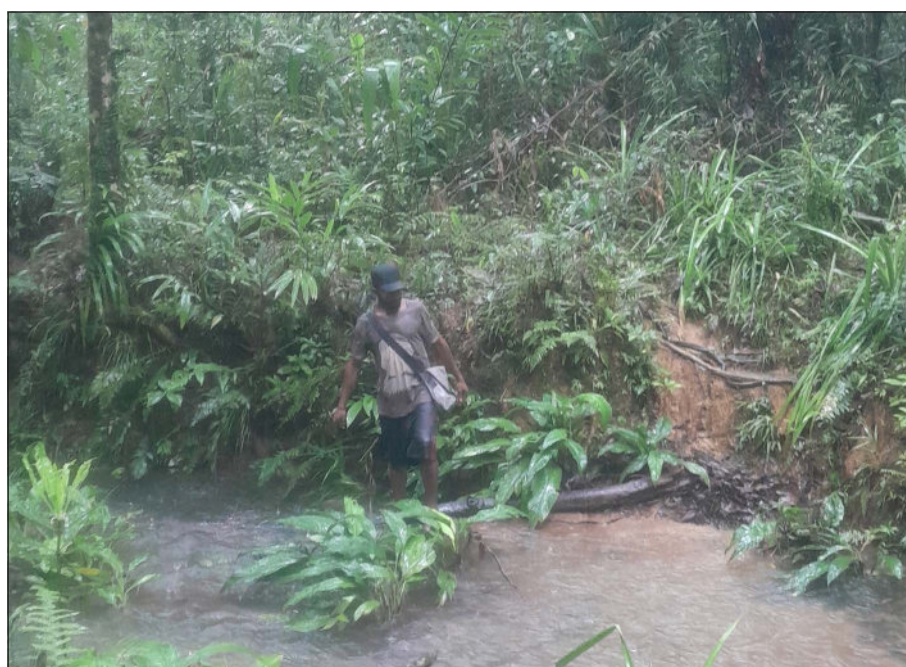


Photo credit: KCB, 2026

Plate 8.4
The Ok Tedi captured from the eastern bank
within the area



Photo credit: KCB, 2026

Plate 8.5
Pooling water within the floodplain facet group



Photo credit: KCB, 2026

Plate 8.6
Marshland facet group



Photo credit: KCB, 2026

8.3 PHYSICAL RIVERINE ENVIRONMENT

This section describes the physical riverine environment across the project area, focussing on drainage systems within the mine area, along the infrastructure corridor and surrounding and downstream of the TSF (Figure 8.9). The current geomorphic, hydrological and surface water quality conditions of both ephemeral and permanent watercourses and waterbodies within the drainage systems have been summarised. Major sediment inputs, quality and transport pattern from natural and anthropogenic sources have also been considered, including ongoing inputs and removal associated with OTML mining and dredging activities.

8.3.1 Study area and method

At present, OTML measures the effectiveness of its environmental controls through compliance monitoring against the following key environmental values across the Ok Tedi and Fly River system:

- Downstream drinking water quality following settlement of total suspended solids.
- Availability of aquatic resources including fish and edible aquatic plants to meet community requirements.
- Safe edibility of these aquatic resources.
- Navigability of the main Ok Tedi and Fly River channels by commercial and village craft.
- Diverse and productive ecology of the river and floodplain system downstream of the mining operation.

Building on more than 20 years of extensive monitoring data collected since the 1980s, the study area focuses on key watercourses around the project and downstream, grouped according to proximity to the mine and position in the river system, as follows:

- Mine area creeks (Ok Mani, Harvey Creek, Sulphide Creek, which are tributaries of the Ok Tedi).
- Ok Tedi (Upper, Middle, and Lower reaches).

Watercourses relevant to the following project areas within the Ok Tedi system are discussed separately:

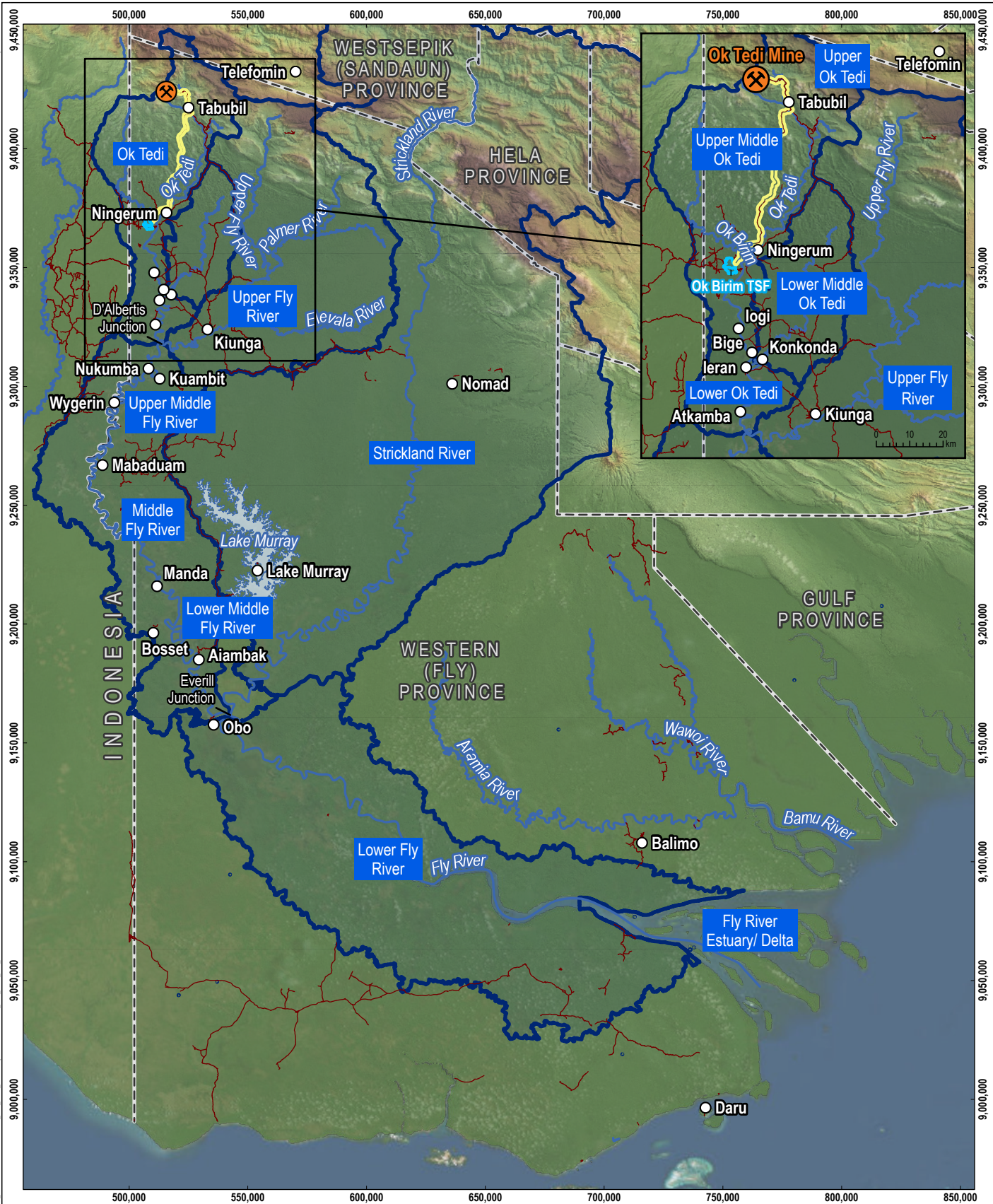
- Infrastructure development corridor (Ok Hwie, Ok Ma, and Ok Birim and their tributaries).
- TSF development area (Ok Yep and its tributaries).
- Fly River (Upper, Middle, and Lower reaches).

The characterisation of the existing physical riverine environment relevant to the project is based on information from OTML's annual environmental performance reports, previous PFS investigations (including a 2014 field program in the Ok Birim area), hydrological datasets and sediment deposition surveys, and the following technical studies prepared for this environmental and social impact assessment (ESIA):

- Appendix B, Hydrology, Sediment Transport and Riverine Particulate Geochemistry.
- Appendix C, Surface Water Quality.
- Appendix E, Aquatic Ecology.

The aquatic ecology surveys included sampling of riverine sediment and surface water for analysis with relevant results discussed in this section. Surface water monitoring has been undertaken across the system in accordance with permit requirements, with results reported in OTML's annual environmental reports. Surface water is monitored by OTML at the following sites:

- Ok Tedi River: Ok Tedi Bridge, Ningerum, Atkamba and at least one off-river waterbody (ORWB).
- Middle Fly River: Nukumba, Obo and at least one ORWB in the Upper and Lower Middle Fly.
- Lower Fly River: Ogwa and Lewada.



LEGEND

- Ok Tedi Mine
- Town
- Road
- Province boundary
- Major watercourse
- Waterbody
- Catchment
- Proposed TSF footprint
- Proposed infrastructure corridor



0 25 50 km
SCALE 1:2,250,000
PAGE SIZE: A4
PROJECTION: PNG94 PNGMG94 Zone 54

SOURCE
Villages from Tetra Tech Coffey. Proposed infrastructure from KCB and OTML. Catchments from OTML. Topographic features from OSM. Admin boundary from NSO. DEM from SRTM. Imagery from ESRI.

OK TEDI MINING LIMITED

OK BIRIM TAILINGS STORAGE FACILITY PROJECT

FIGURE 8.9

River system overview



TETRA TECH
COFFEY

8.3.2 Hydrology, geomorphology and sediment processes

The project area experiences very high annual rainfall, with a significant surplus of rainfall over evaporation (see Section 8.1). This surplus water supports perennial streams with substantial discharges. Over areas where vegetation has been cleared, such as the Ok Tedi Mine site, drainage channels have been established and maintained to manage runoff. Infiltration is managed to prevent excess pore water pressures in batters and associated mining facilities, such as waste rock dumps. Rainfall distribution over the ground is a key factor for hydrological and hydrogeological assessments (PSM 2024).

In the natural vegetated catchments of the Ok Tedi region, evapotranspiration is low, direct runoff is minimal due to rapid infiltration into the forest floor, and there is significant interflow as water moves quickly through soil and root layers. In contrast, catchments where vegetation has been cleared (such as the mine site) exhibit very low evapotranspiration and high direct runoff. There is potential for high infiltration in zones of loose, coarse material (such as waste rock dumps), with water likely reemerging downslope. Previous studies show varied runoff and baseflow estimates partly because interflow is inconsistently classified between these components (PSM 2024).

Tailings and waste rock generated from mining operations have been discharged directly into the Ok Tedi and Fly River systems since 1984. Up to the end of total of 2024, this includes a total of 1,602 Mt of waste rock and 832 Mt of tailings. The annual amount has varied over the mine life, with 83 Mt of waste rock and 18 Mt of tailings discharged in 2024. Since 2009, tailings discharge volumes have generally been around 20 Mt per year (OTML 2025e).

Sediment entering the river systems comprise:

- Tailings deposited into Ok Kumiup, a tributary of Ok Mani.
- Eroded material from waste rock dumps.
- Abraded material from the watercourses near the Ok Tedi Mine and Middle Ok Tedi.
- Natural sediment loads.
- Contributions from landslides in the upper catchments.

Mine-derived sediment has vastly exceeded the sediment transport capacity of creeks near the mine where deposition has caused riverbed levels to rise (aggradation). Deposition of mine-derived sediment in downstream channels has also caused aggradation and increased the frequency and duration of flooding.

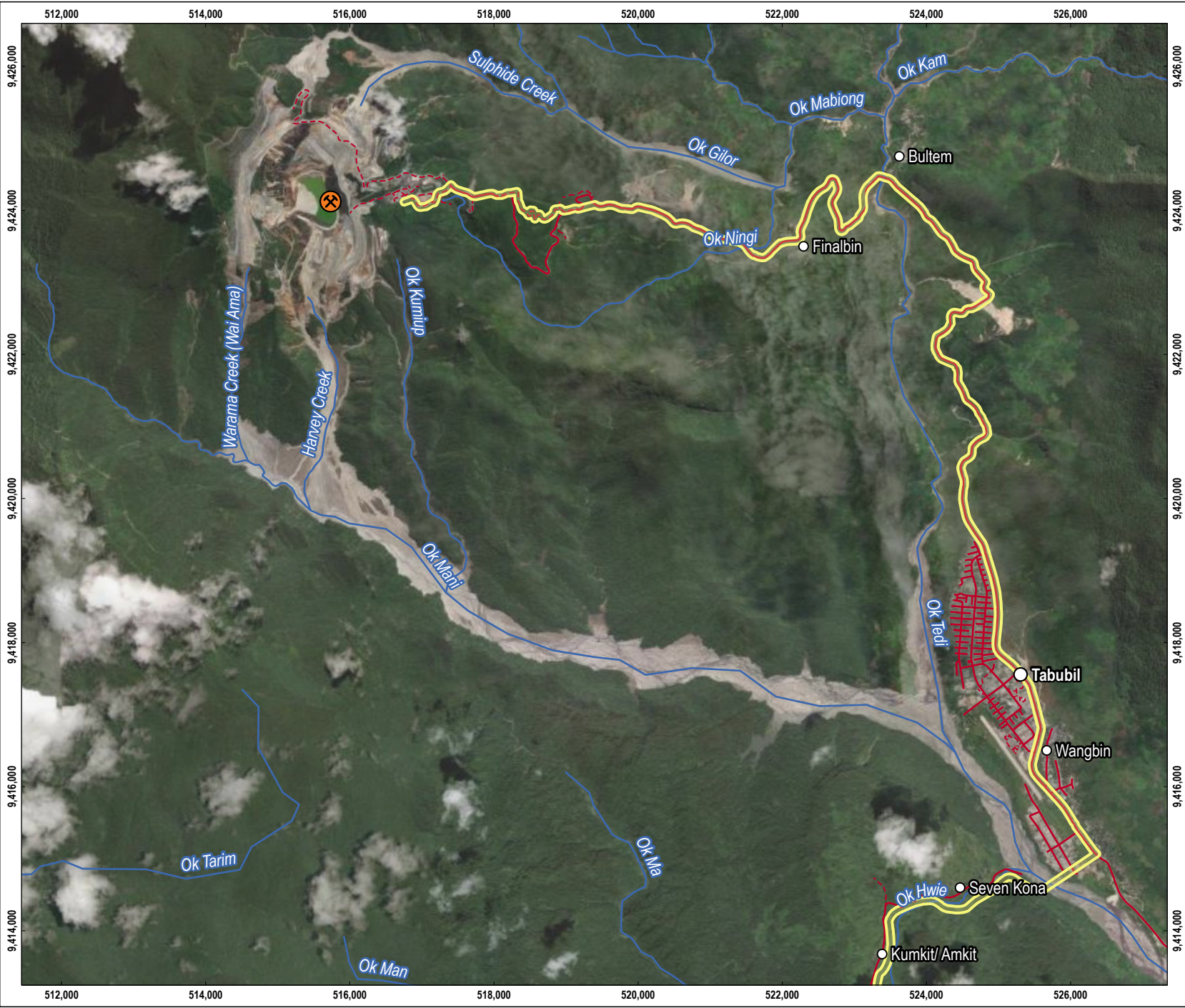
This section includes a summary of sediment load generation, sediment transport dynamics, and observed trends in total suspended solids (TSS) within the river systems, focusing on the sediment loads associated with the riverine disposal of tailings and waste rock from the Ok Tedi Mine.

Information is taken from Appendix B unless otherwise referenced.

8.3.2.1 Mine area creeks

Three creeks extend from the Ok Tedi Mine area: Harvey Creek, Ok Mani, and Sulphide Creek (Figure 8.10). These creeks join the Ok Tedi downstream of the mine.

In addition to tailings discharged directly into Ok Kumiup, a tributary of Ok Mani, sediment enters the river system via the mine's waste dumps via Harvey Creek and Sulphide Creek. OTML's waste dumps fail gradually, allowing waste rock to erode into adjacent creeks. Material from northern dumps enters Sulphide Creek, while material from southern dumps is routed via Harvey and Warama creeks (OTML 2023b).



LEGEND

- Ok Tedi Mine
- Community
- Road
- Track
- Watercourse
- Proposed infrastructure corridor

SOURCE

Villages from Tetra Tech Coffey.
Topographic features from OSM.
Proposed infrastructure from KCB and OTML.
DEM from SRTM. Imagery from ESRI.



0 1 2 km
SCALE 1:75,000
PAGE SIZE: A4
PROJECTION: PNG94 PNGMG94 Zone 54

OK TEDI MINING LIMITED

OK BIRIM TAILINGS STORAGE FACILITY PROJECT

FIGURE 8.10

Mine area creeks



TETRA TECH
COFFEY

DATE: 21.06.2015 PROJECT: 754-MELEN374244 FILE: 374244C_R08_F08.10_GIS

Waste material is mobilised and transported downstream through natural erosion processes, contributing to significant increases in sediment load across the system. Ongoing physical abrasion breaks down larger rock particles, increasing the fine sediment fraction. Increased sediment loads entering the river system leads to increased transport of sediment and subsequent aggradation of the riverbeds and increased total suspended sediment. Erosion and sediment transport dynamics within mine area creeks near the Ok Tedi Mine are influenced by ongoing waste rock and tailings disposal activity. As these activities continue, sediment volumes in the creeks increase. Material is progressively lost from the dump sites due to erosion, with sediment transported downstream to the Ok Tedi (Pickup & Ridd 2024).

Figure 8.11 presents longitudinal profiles of the mine area creeks and the Ok Tedi, where they join. These profiles highlight the steepness of the mine area creeks compared to the Ok Tedi.

Sulphide Creek

Sulphide Creek (see Figure 8.10; Plate 8.7) is located downstream from the northern waste dump, with a waterfall dividing two main reaches. It flows downstream into Ok Gilmor and Ok Mabiong, before reaching the Ok Tedi. The sections of these creeks downstream from the mine to the confluence with Ok Tedi are collectively referred to as Sulphide Creek. The upper reach primarily acts as a dump runout zone that has experienced both deposition and erosion over time; it is currently predominantly eroding.

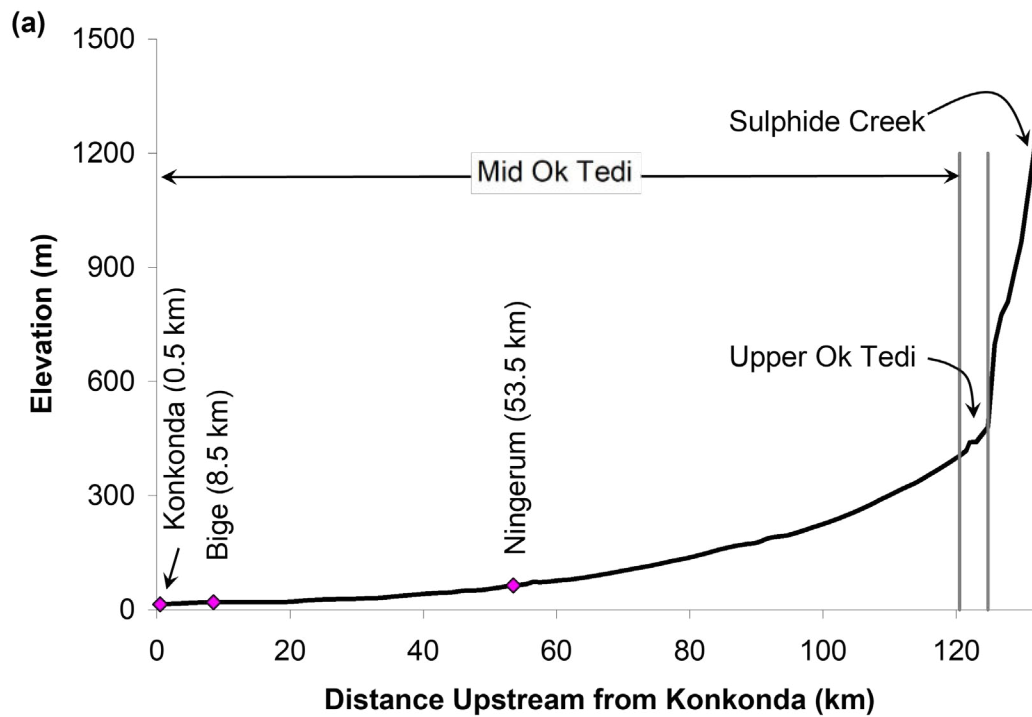
Two failing waste rock dumps are located on the headwaters of Sulphide Creek: the Taranaki Dump and the Vancouver Dump. Commencing in 1985, up to 30 Mt mine waste rock was disposed into these dumps per year with sediment loss from the dumps entering Sulphide Creek. Between 1989 and 1992, the Vancouver Landslide resulted in about 120 Mt of sediment being added to the Sulphide Creek system and led to the decline of waste rock disposal in this catchment.

Waste rock and erosion of valley walls recorded between March 1996 and November 2000 resulted in 44.4 Mt of sediment being transported through Sulphide Creek, with 48.7 Mt then entering the Ok Tedi. This indicates the creek is eroding, with transport capacity greater than delivered load. Considering the estimated storage capacity of 2.4 Mt and estimated transport rate of 15 Mt per year, Sulphide Creek is expected to continue transporting sediment entering the system from the failed dumps to the Ok Tedi.

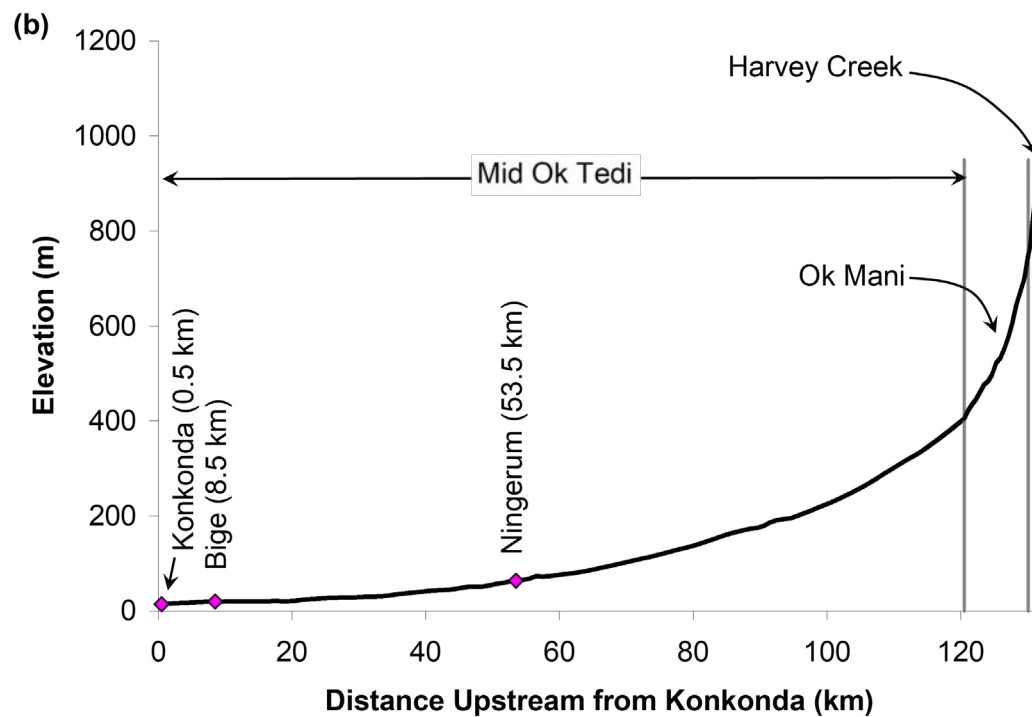
Harvey Creek

Harvey Creek (see Figure 8.10; Plate 8.8) is located south of the mine pit, downstream from the southern waste dumps. Harvey Creek is located in a steep mountainous setting, and flows south, joining the Ok Mani approximately 2 km south of the mine. Since mining began, the creek's hydrology and form have been heavily altered by large volumes of waste rock and debris flows originating from the Harvey Creek and Moscow waste dumps. This material has covered the steep terrain, with up to 80 to 100 m of sediment accumulation in the lower reaches and formation of an alluvial fan at the confluence with Ok Mani.

Sediment deposition in the Ok Mani predominately occurs in the upper reaches due to input from Harvey Creek. Following the Vancouver Landslide, deposition on the southern side of the mine commenced, resulting in large amounts of sediment entering Harvey Creek. Erosion due to lateral channel migration also resulted in input of sediment to the creek. Landslides in the Harvey Creek catchment between 1991 and 1996 added a further 19 to 28 Mt of sediment per year to the river system.



(a) Sulphide Creek, the Upper and Middle Ok Tedi



(b) Harvey Creek, Ok Mani, and Middle Ok Tedi

SOURCE
Appendix B



OK TEDI MINING LIMITED
OK BIRIM TAILINGS STORAGE FACILITY PROJECT

FIGURE 8.11
Longitudinal profiles of the mine area
creeks and Middle Ok Tedi



DATE: 21.06.26 PROJECT: 754-MELEN374244 FILE: 374244C_R08_F08.11_GRA

DISCLAIMER: THIS FIGURE HAS BEEN PROVIDED FOR INFORMATION ONLY AND IS SUBJECT TO CHANGE. THE CREATORS DO NOT WARRANT THAT THIS FIGURE IS DEFINITIVE NOR FREE OF ERROR AND DO NOT ACCEPT LIABILITY ARISING FROM RELIANCE ON INFORMATION PROVIDED HEREIN. © COPYRIGHT TETRA TECH COFFEY 2026.
DOC REFERENCE: \\T:\LOCAL\CP\ST72\GIS\374244_MELEN_OTML_OKBIRIM\SP2_GRAPHICS\R08_ESA\374244C_R08_GRA081.A1_1 | SAVED BY: JO 21.06.26

Ok Mani

Ok Mani is a larger stream with active braided channels, located south of the mine (see Figure 8.10; Plate 8.9). It flows southeast, joining the Ok Tedi approximately 10 km downstream of the confluence with Harvey Creek. Ok Mani has undergone major geomorphic and hydrological changes in response to mine waste inputs.

Tailings are discharged directly into Ok Kumiup in the Ok Mani catchment, downstream of the waste rock dump. Ok Mani is less steep than Sulphide Creek but is increasing in steepness over time in response to increased sediment load from Harvey Creek. Its naturally concave profile has progressively steepened as it accommodates the sediment load from Harvey Creek. Significant deposition occurs in the upper reaches, with sediment thickness decreasing downstream toward the Ok Tedi confluence, where the river has sufficient transport capacity to carry greater sediment load.

Tailings entering the system contain relatively coarse sediment. Based on investigations into particle size distribution of tailings and deposits of mine-derived sediment downstream, the coarse fraction of tailings appears to be deposited in the Ok Mani but may be remobilised in subsequent flood events. The tailings and waste rock characteristics in this system result in a significant coarse sediment component.

Significant aggradation has occurred in the Ok Mani system, driven by tailings input into Ok Kumiup and waste rock erosion from Harvey Creek. Ok Mani and Harvey Creek have received approximately 1.3 billion tonnes of waste rock and 220 Mt of landslide material since 1991.

Since mining commenced, an alluvial fan has developed at the confluence of Harvey Creek and Ok Mani with sediment accumulation up to 100 m deep. There has been up to 145 m of vertical aggradation in the upper Ok Mani and up to 9 m of aggradation at the confluence with Ok Tedi. Typically, the Ok Mani retains 30 to 60% of delivered material, with throughflow increasing during years with greater dumping and sediment input to the system.

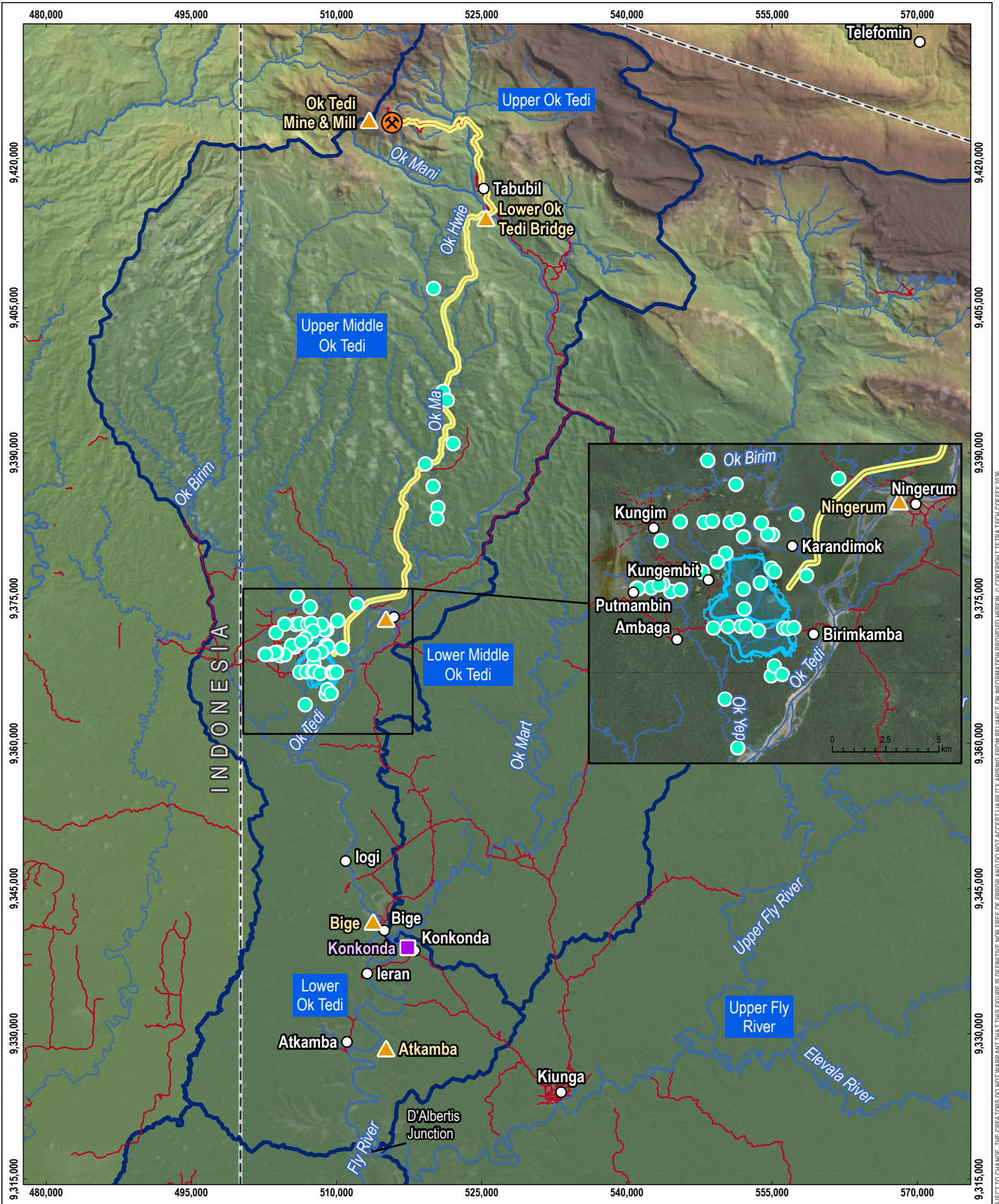
8.3.2.2 Ok Tedi

The Ok Tedi Mine is situated at the headwaters of the Ok Tedi, draining the mountainous Bismarck Range terrain in the north, flowing past the TSF development area to the south, and connecting to the Fly River system at D'Albertis Junction. The Ok Tedi system has experienced significant hydrological changes due to long-term mining activities such as riverine tailings and waste rock disposal.

The Ok Tedi is a permanent watercourse where discharge persists during both high rainfall (typically in the wet season from November to April) and low rainfall (typically in the dry season from May to October) periods. While flooding has always occurred along the floodplains of the Ok Tedi and the Fly River through natural processes, an increased frequency and duration of inundation has arisen from the aggradation of mine-derived sediment in the main river channels, and blockage of tie-channels and perching of levees as a result of silt deposition which prevents effective drainage of the floodplain water during low river level (OTML 2023a).

The Ok Tedi river system is divided into Upper, Middle, and Lower Ok Tedi (Figure 8.12). Watercourses within the infrastructure development corridor and TSF development area include tributaries of the Ok Tedi and are located within the Ok Tedi catchment.

Since commencement of mining in 1985, sediment loads within the Ok Tedi have increased by a factor of 8 to 10, due to the input of mine-derived materials. The increased sediment load has resulted in increased suspended solids and deposition throughout the river. This section describes sediment transport and deposition in each section of the Ok Tedi, including consideration of the measures OTML has taken to manage this.



LEGEND

- Ok Tedi Mine
- Community
- Aquatic survey site
- Environment permit monitoring site
- Additional monitoring site
- Road/track
- Province boundary
- Watercourse
- Catchment
- Proposed TSF footprint
- Proposed infrastructure corridor



0 5 10 km
SCALE 1:550,000
PAGE SIZE: A4
PROJECTION: PNG94 PNGMG94 Zone 54

SOURCE
Villages from Tetra Tech Coffey. Proposed infrastructure from KCB and OTML. Catchments and sampling sites from OTML and SLR. Topographic features from OSM. Admin boundary from NSO. DEM from SRTM. Imagery from ESRI.

OK TEDI MINING LIMITED

OK BIRIM TAILINGS STORAGE FACILITY PROJECT

FIGURE 8.12

Ok Tedi system



TETRA TECH
COFFEY

DATE: 21.06.26 PROJECT: 754-MELN374244 FILE: 374244C_R08_F08.12_GIS

Plate 8.7
Sulphide Creek



Photo credit: Tetra Tech Coffey, 2025

Plate 8.8
Harvey Creek



Photo credit: Tetra Tech Coffey, 2025

Plate 8.9
Ok Mani



Photo credit: Tetra Tech Coffey, 2025

Upper Ok Tedi

The Upper Ok Tedi, upstream of the confluence with the Ok Mani, exhibits steep gradients and high-energy flow conditions. It flows through a narrow gorge, which widens 3 km upstream of the junction with Ok Mani (Plate 8.10).

Sediment loads in the Upper Ok Tedi are influenced by landslides in the upper catchment and input from Sulphide Creek. Generally, there is little deposition of mine-derived sediment input from Sulphide Creek, with this being transported to the Middle Ok Tedi. Landslides in the upper catchment may result in large amounts of sediment entering the system and subsequent deposition. Notable landslide events include a 7 km³ landslide about 8,800 BP and a recent landslide in 1977, both from the Hindenburg Wall.

Middle Ok Tedi

The Middle Ok Tedi extends from the confluence with Ok Mani downstream to Konkonda. The Middle Ok Tedi is a predominantly a braided river system with occasional narrow single-channel sections.

The median flow rates in the Middle Ok Tedi near Ningerum is 220 m³/s, based on historical flow records from 1984 to 2023. Downstream near Bige, flow rates range from 400 m³/s to 2,800 m³/s, based on historical flow records from 2018 to 2023 (KCB 2024a).

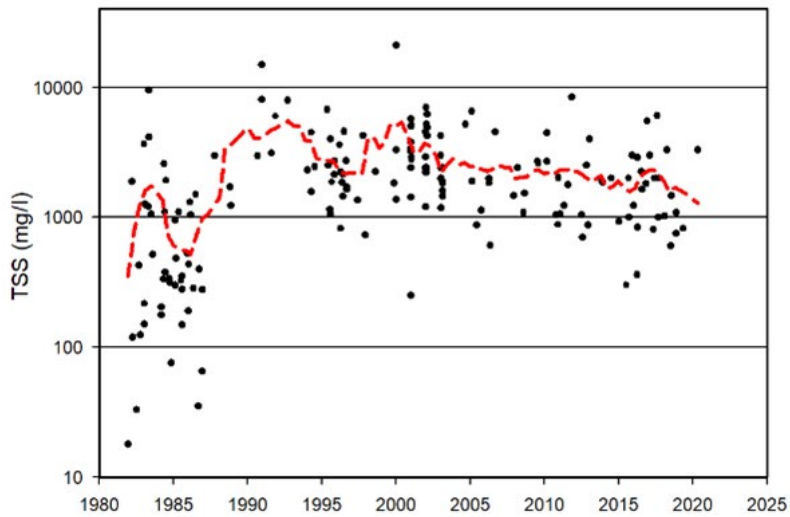
Monitoring indicates that sediment deposition is ongoing and remains a dominant geomorphic process in the Middle Ok Tedi (Plate 8.11), as eroded material from the upper system moves downstream.

The Upper Ok Tedi and mine area creeks contribute mine-derived sediment to the Middle Ok Tedi. Since mining began, the Middle Ok Tedi has experienced widespread aggradation, with a wedge of mine-derived sediments up to 8 m thick accumulating in the 30 km downstream of the Ok Mani confluence. The thickness of deposited sediment thins further downstream. Water levels of the Middle Ok Tedi have changed in response to this deposition.

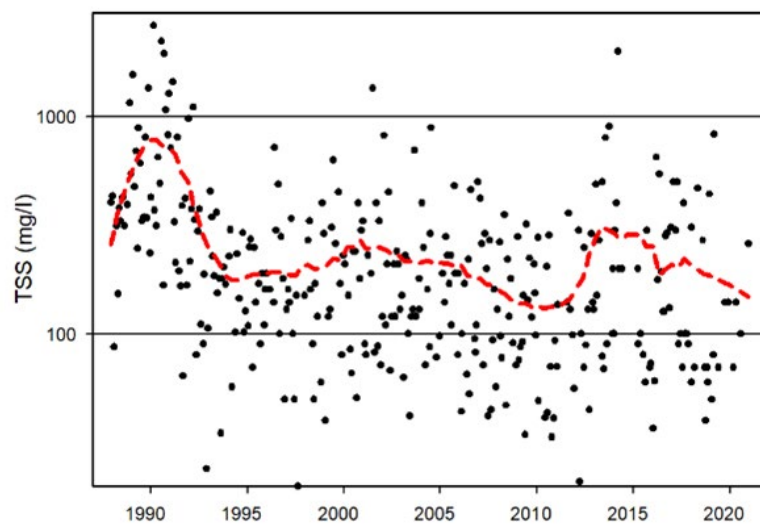
The wedge decreases in thickness downstream, from 8 m in the upper reach to 1 to 2 m toward the confluence with Ok Taub. This coarse sediment deposition reflects both a reduction in the river's capacity to transport large particles as slope decreases and the progressive breakdown of coarse material into finer fractions during transport. Downstream of the Ok Mani, sediment from tailings combines with natural sediment and waste rock. Abrasion during transport breaks down particles, increasing the proportion of finer material. The sand-to-silt ratio decreases downstream, with noticeable dilution of the coarser fraction.

Although gravel dominates deposition in the Middle Ok Tedi upstream of the confluence with Ok Birim, there are also localised and temporary sand deposits on gravel bars. Near the confluence with Ok Birim, deposition is predominantly sand, which reflects these processes. Consequently, riverbed and water levels in the Middle Ok Tedi have increased over time as sediment is deposited. Approximately 100 to 110 km downstream of the confluence with Ok Mani, riverbed levels have begun to decrease over time in response to dredging at Bige.

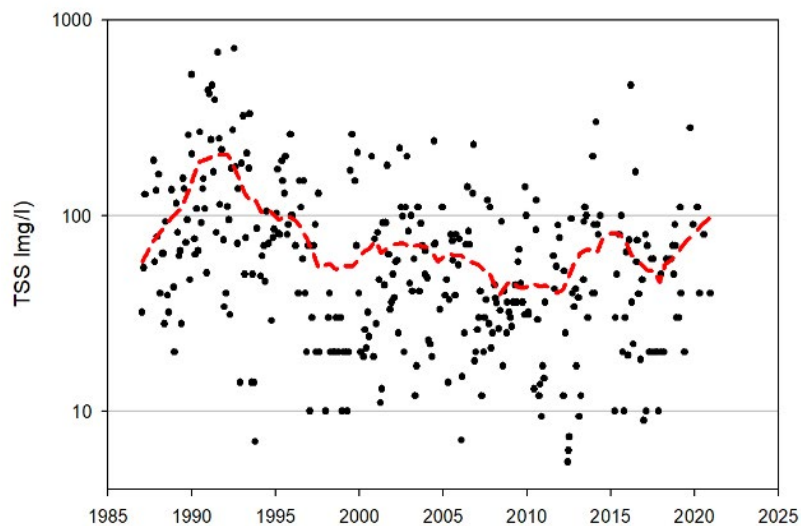
Total suspended solids in the Middle Ok Tedi is typically highest where the sediment originates, and remains high in the upper, high-energy reaches of the Ok Tedi and decreases downstream due to settling and dilution. TSS in water quality samples at Ningerum and Nukumba between 1980 and 2020 show peaks associated with active landslides upstream. Generally, TSS in the Ok Tedi has been variable but overall declined in recent decades (Figure 8.13), with values between 1,000 and 10,000 mg/L at Ningerum and values between 100 and 1,000 mg/L at Nukumba. Total TSS concentrations in the Lower Middle Ok Tedi are an order of magnitude greater than at Obo, along the Middle Fly River. TSS at Obo along the Lower Middle Fly is generally less than 100 mg/L but trended upwards closer to 100 mg/L between the late 2010s and early 2020s. OTML's 2024 Annual Environmental Report notes TSS was 816 mg/L in the Ok Tedi upstream of Bige and 689 mg/L downstream of Bige (OTML 2025e).



(a) Total suspended solids in water quality samples at Ningerum on the Middle Ok Tedi



(b) Total suspended solids in water quality samples at Nukumba on the Upper Middle Fly



(c) Total suspended solids in water quality samples at Obo on the Lower Middle Fly

SOURCE
Appendix B



OK TEDI MINING LIMITED
OK BIRIM TAILINGS STORAGE FACILITY PROJECT

FIGURE 8.13
TSS in the Middle Ok Tedi and
Middle Fly River



DATE: 21.06.26 PROJECT: 754-MELEN374244 FILE: 374244C_R08_F08.13_GRA

DISCLAIMER: THIS FIGURE HAS BEEN PROVIDED FOR INFORMATION ONLY AND IS SUBJECT TO CHANGE. THE CREATORS DO NOT WARRANT THAT THIS FIGURE IS DEFINITIVE NOR FREE OF ERROR AND DO NOT ACCEPT LIABILITY ARISING FROM RELIANCE ON INFORMATION PROVIDED HEREIN. © COPYRIGHT TETRA TECH COFFEY 2026.
DOC REFERENCE: \\T:\LOCAL\CP\72\SIG\374244_MELEN_OTML_OKBIRIM\TSP2_GRAPHICS\R08_ESA\374244C_R08_GRA082.A1_3 | SAVED BY: JO 21.06.26

Lower Ok Tedi

The Lower Ok Tedi extends from Konkonda to D'Albertis Junction, where it joins the Fly River. The Lower Ok Tedi (Plate 8.12) has undergone significant morphological and hydrological changes in response to mining and subsequent dredging at Bige.

Rainfall in 2024 was above average in the upper Ok Tedi catchment, with rainfall distributed relatively evenly throughout the year. River levels in 2024 in the Lower Ok Tedi at Konkonda reflected upstream rainfall distribution, with river levels below the long-term average during the first quarter of 2024, before increasing to above-average levels through the middle of the year and then returning to near-average conditions (OTML 2025e).

Sediment loads in the Lower Ok Tedi are influenced by OTML's dredging operations at Bige, a key sediment management measure that commenced in 1998. Dredging activities aim to capture most of the sand-size particles, removing it from the river system and stockpiling it on the riverbanks. Dredging usually removes around 10 mm³ (17 Mt) of sediment per year, except in exceptional events such as the El Niño temporary shutdown in 2015/16; unplanned breakdowns; and short dry spells in 2019. In 2023, 10.31 mm³ of sediment was removed (OTML 2024d). About 85% of sediment is estimated to be captured by dredging, noting dredging does not remove silt and fine sediment (Appendix B). Fine sediment constitutes most suspended sediment downstream of Bige (Pickup & Ridd 2024).

Before dredging, the Lower Ok Tedi experienced extensive aggradation, with up to 7 m of bed level rise in the gravel–sand transition zone between Konkonda and Atkamba. Channel confinement by sediment deposits created sediment 'choke zones', promoting areas of deposition. Since dredging began, riverbed levels have declined by several metres, with the riverbed in the Konkonda area reaching 3.7 m below 1998 levels by 2016. Since 2016, riverbed levels have generally stabilised, fluctuating by ±1 m. There are local increases in riverbed levels in some locations due to channel adjustments such as meander cutoffs.

Since dredging began, there has been a general trend of bed lowering, with reductions of several metres observed along much of the reach, although some local increases have occurred. Bed level lowering at Konkonda has increased channel capacity by over 60%, reducing flood frequency and slowing levee growth (OTML 2025e). Channel capacity changes in the Lower Ok Tedi between December 2022 and January 2024 were variable, with an average increase of 1.2%. Since dredging began, capacity gains of approximately 40% at D'Albertis Junction and 60% immediately downstream of Bige have been recorded (OTML 2024d).

Levees that formed during the pre-dredging period due to deposition of mine-derived sediment have largely been maintained or continued to grow, contributing to the isolation of floodplain channels and water bodies. Similar trends are observed across the Lower Ok Tedi. As average bed levels have decreased and channel capacity increased, overbank flooding frequency has reduced, slowing the rate of levee formation (OTML 2024d).

Sediment delivered to the system is a mixture of sand and silt, with proportions shifting over time from slightly sand-dominated prior to 2013 to more silt-dominated as tailings inputs declined. Material that is not deposited in the Middle Ok Tedi, and sediment derived from ongoing abrasion of deposited material contribute to the silt and sand load entering the Ok Tedi. The coarse tailings fraction is increasingly diluted, and silt content rises due to ongoing abrasion and inputs from fine-grained waste rock.

Plate 8.10
Upper Ok Tedi



Photo credit: Tetra Tech Coffey, 2025

Plate 8.11
Middle Ok Tedi



Photo credit: Pickup, 2025

Plate 8.12
Lower Ok Tedi



Photo credit: Tetra Tech Coffey, 2025

Infrastructure development corridor watercourses

The key tributaries of the Ok Tedi within the infrastructure development corridor are the Ok Hwie, Ok Ma and Ok Birim. These watercourses have largely not been influenced by mining activities.

Sediment transport and deposition in these watercourses is determined by natural erosion and sedimentation processes, influenced by flow rates and the morphology of the watercourses. Backwater effects from the Ok Tedi has resulted in the deposition of contaminated sediment into the lower Ok Yep during high flows (Appendix E).

Aquatic ecology surveys of the infrastructure development corridor creeks recorded substrates across several sites along the Ok Ma and tributaries. The main channel of the Ok Ma is fast flowing, which is reflected in the substrates and morphology. Substrate across the Ok Ma sites was characterised by a mix of coarse and fine materials, with cobbles and sand dominant at many sites. Bedrock was present at two locations, while boulders were only observed at one site. Most sites contained larger substrates interspersed with sand and silt (Appendix E).

The Ok Birim is a perennial river that flows southeasterly, joining the Ok Tedi approximately 1 km northeast and upstream of the TSF development area. Based on historical flow records from 1997 to 2003 and 2018 to 2023, median flow rates in the Ok Birim near Karandimok are 170 m³/s with flows increasing during heavy rain (KCB 2024a).

TSF development area watercourses

The key tributary of the Ok Tedi within TSF development areas is the Ok Yep and its tributaries. The Ok Yep flows through relatively gentle topography and has not been directly influenced by mining activities.

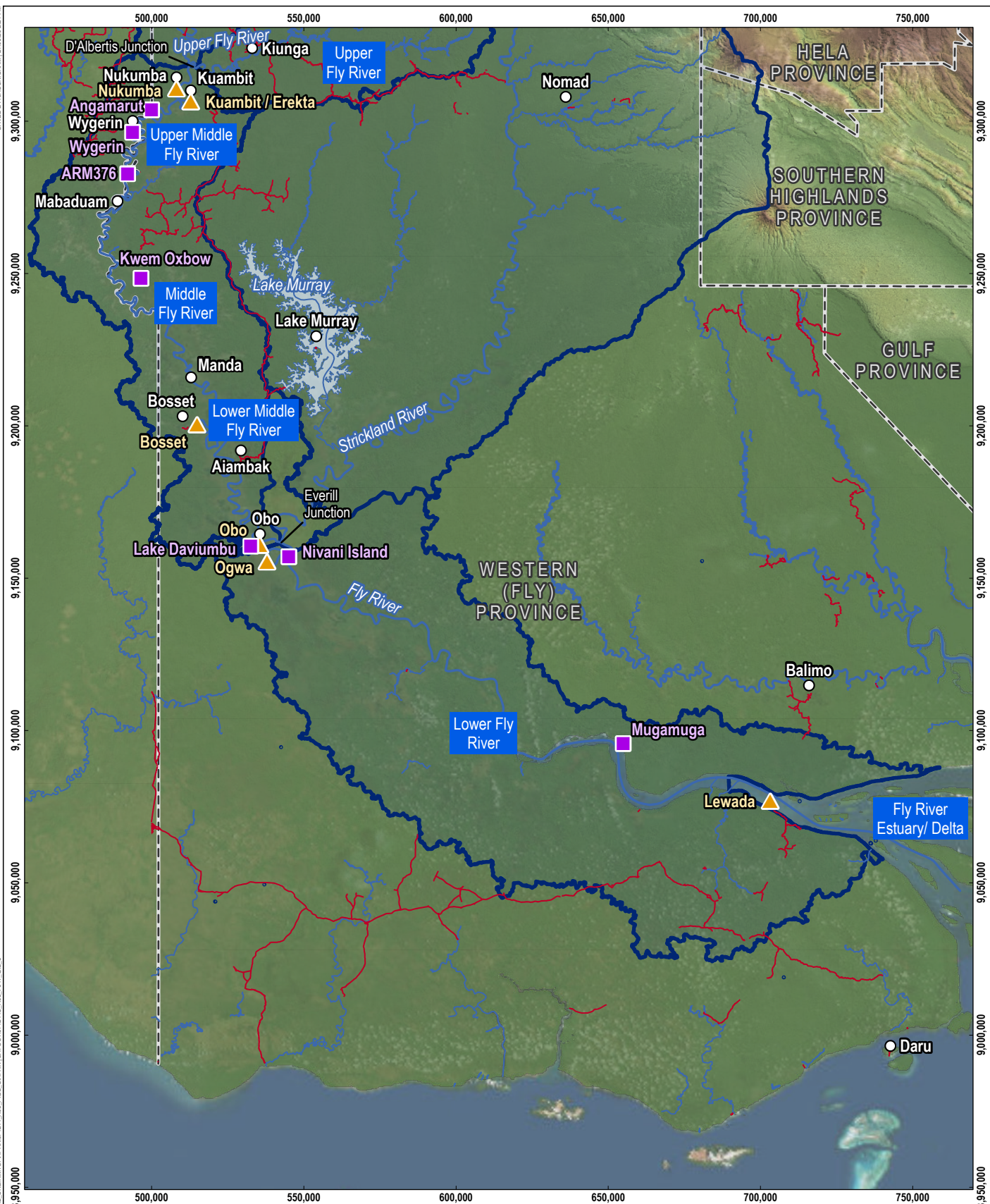
Mine-derived sediment is not transported or deposited in the TSF development area watercourses but there is mine-derived aggradation at the junction where these watercourses meet the Ok Tedi. Sediment transport and deposition in these watercourses is determined by natural erosion and sedimentation processes, influenced by flow rates and the morphology of the watercourses.

The Ok Yep is a lowland watercourse with a 66.6 km² catchment that flows south through the TSF development area and joins the Ok Tedi approximately 4 km south of the TSF development area and upstream of the village of Komopkin. There are no flow estimates available for the Ok Yep.

8.3.2.3 Fly River

The Fly River is the third longest river on the island of New Guinea, with a total length of 1,060 km and catchment of 75,000 km². The Fly River system drains the heavily dissected mountain landscape of the Star Mountains, including the Hindenburg Ranges, the Victor Emanuel Ranges and the Central Ranges. While the headwaters are located over 2,000 m above sea level, most of the Fly River flows through the southwestern lowlands, with a catchment between 200 and 800 m above sea level.

The Fly River system is divided into the Upper Fly River, Middle Fly River and Lower Fly River (Figure 8.14), with key tributaries including the Ok Tedi and Strickland River. The Upper Fly and Ok Tedi join at D'Albertis Junction, approximately 160 km downstream of the mine. The Middle Fly meanders down a 400-km-long floodplain, extending from D'Albertis Junction to Everill Junction. The Middle Fly and the Strickland meet at Everill Junction before entering the Fly Delta. The delta covers about 10,000 km² and extends downstream for another 400 km before entering the ocean in the Gulf of Papua.



LEGEND

-
- Town
 - Environment permit monitoring site
 - Additional monitoring site
 - Road/ track
 - Province boundary
 - Watercourse
 - Waterbody
 - Catchment



0 25 50 km
SCALE 1:1,750,000
PAGE SIZE: A4
PROJECTION: PNG94 PNGMG94 Zone 54

SOURCE
Villages from Tetra Tech Coffey. Proposed infrastructure from KCB and OTML. Catchments and sampling sites from OTML. Topographic features from OSM. Admin boundary from NSO. DEM from SRTM. Imagery from ESRI.

OK TEDI MINING LIMITED

OK BIRIM TAILINGS STORAGE FACILITY PROJECT

FIGURE 8.14

Fly River system



TETRA TECH
COFFEY

DATE: 22.06.26 PROJECT: 754-MELEN374244 FILE: 374244C R08 F08.14 GIS

Upper Fly

The Upper Fly River is subject to significant backwater effects likely caused by influences of mine-derived sediment deposition in the Middle Fly. Backwater effects were greater prior to dredging and then partially declined in the early 2000s as dredging reduced sediment accumulation. Variability in backwater effects has also been driven by changes in the amount of sediment entering the system and channel adjustments, including meander cutoffs that have shortened the river and changed its sediment transport capacity.

Rainfall in 2024 was above average in the Upper Fly River catchment, with rainfall concentrated in half of the year. River levels in the Upper Fly River at Kiunga (Plate 8.13) were generally above the long-term average throughout 2024, due to this higher-than-average rainfall in the first half of the year.

Middle Fly

The Middle Fly River flows through a wide, gently sloping and highly weathered landscape, where resistant bank sediments locally confine the channel and limit lateral migration. The system is strongly connected to a floodplain, which includes complex drainage features such as parallel floodplain channels, blocked valley lakes, and distributary systems like the Agu River that intermittently connects to the main channel depending on water levels. The Middle Fly River receives sediment from low-gradient forested terrain along the Upper Fly River, and more substantial quantities from the Ok Tedi, where it joins the Fly River at D'Albertis Junction.

Input of mine-derived sediment loads have caused widespread in-channel deposition, raised river and floodplain water levels, and enhanced floodplain connectivity, leading to more frequent and prolonged inundation, levee growth, and broader ecological changes such as forest dieback and expansion of aquatic habitats.

The Middle Fly is divided into the Upper Middle Fly and Lower Middle Fly at Manda. Hydrologically, the river transitions from a sand zone with a steeper gradient upstream of Manda to a lower-gradient backwater zone characterised by finer sediments downstream of Manda.

The Upper Middle Fly (Plate 8.14) is characterised as a slowly meandering river with an 8-km-wide floodplain. The main Upper Middle Fly channel is partly confined by discontinuous levees, and the system features numerous point bars and oxbow lakes formed by meander cutoffs. While water levels rose during mine life due to sediment deposition, this has slowed or begun to stabilise following the implementation of dredging at Bige.

The Lower Middle Fly (Plate 8.15) is characterised as a slow-flowing river, with a much lower gradient than the Upper Middle Fly and with a broader, 10- to 15-km-wide floodplain. Because the river has less energy, it meanders less than the Upper Middle Fly, leading to the formation of continuous, narrow, and higher levee banks.

By the time the river reaches Manda, most of the sand load has been deposited, and the Lower Middle Fly primarily transports finer material. Reduced flow energy limits meandering, leading to the development of more continuous, higher levees that restrict lateral connectivity and isolate off-river water bodies, which can retain water for longer periods than the main channel. Water levels in the downstream part of the Lower Middle Fly are influenced by backwater effects from the Strickland River.

The blocking of tie channels and the infilling of levee breaches have reduced floodplain drainage. As a result, floodplains are now more prone to prolonged inundation, with higher water levels and a diminished ability to drain local runoff during periods of low river flow.

Transport and deposition of mine-derived sediments in the Middle Fly River have resulted in increased sediment loads, turbidity, and deposition. Prior to mining the Upper Middle Fly riverbed comprised well-sorted fine to medium sand, and the Lower Middle Fly riverbed comprised fine sand but with an increasing proportion of silt-clay particles further downstream. The input of mine-derived sediment has resulted in increased

deposition of sand-sized particles in the Upper Middle Fly, and the transport and deposition of silt through the Lower Middle Fly.

Figure 8.13 presents TSS in water quality samples taken along the Upper Middle Fly at Nukumba, and along the Lower Middle Fly at Obo. TSS concentrations are considerably lower in the Middle Fly than in the Middle Ok Tedi. In the Middle Fly River, mine-derived TSS remains evident, but decreases downstream, with the Strickland River becoming the dominant source of suspended solids in the Lower Fly, supplying about 85% of delivered sediment. Strickland River is the Fly River's longest tributary, containing significant sediment loads from natural sources and additional inputs from mining operations at Porgera.

Bed level changes in the Upper Middle Fly show a mixed pattern, with recent decreases near D'Albertis Junction but increases at most other sites. Higher flows have enhanced sediment transport, while channel migration and avulsion have added additional sediment from bank erosion. This extra load has largely moved downstream, leading to stabilisation or declining bed levels at some upstream sites, while deposition continues further downstream where sediment is still being redistributed (OTML 2025e).

Levee heights along the Middle Fly have increased by 1 to 2 m since 2003 due to overbank deposition, contributing to increased channel capacity despite some local bed aggradation. Tie channel blockage and levee growth have reduced floodplain connectivity, which further contributes to channel confinement and floodplain inundation and reduced drainage. Improvements in navigability are seen where bed levels have decreased, while areas with stable or rising beds show little change. Localised channel changes, including avulsion and sediment build-up, have created ongoing navigation constraints at sites such as Kuambit and Erehta, although conditions at D'Albertis Junction have stabilised in recent years (OTML 2025e).

8.3.2.4 Floodplains and off-river water bodies

The Fly River floodplain downstream of the Ok Tedi confluence supports a complex network of ORWBs, including oxbow lakes, blocked valley lakes, levee backplain water bodies, and point bar swales. Connectivity with the main river occurs via tie channels, levee breaches, and overbank flooding, with many channels experiencing two-way flow depending on water levels. Increasing sediment loads in the Fly River and Ok Tedi system have enhanced levee growth and tie channel blocking, leading to greater floodplain isolation but longer water retention. Floodplain sedimentation is highest near main and tie channels and decreases with distance across the floodplain. Persistent ORWBs provide critical ecological functions, including aquatic ecosystem habitat. These areas have increased due to the effects of the Ok Tedi Mine.

ORWBs in the Lower Ok Tedi and Middle Fly floodplain include:

- **Oxbow lakes:** Former river meanders that have been cut off from the main channel. These are typically deeper and longer-lasting than other ORWBs, often supporting diverse aquatic biota and providing aquatic habitats during dry periods. Some ORWBs are only seasonally connected to the river during high flow periods, via tie channels or via overbank flow during flood events.
- **Blocked valley lakes:** Formed where sediment accumulation or levee growth has obstructed the natural drainage of tributaries or low-lying areas. These features retain water for extended periods and can persist through moderate droughts.
- **Levee backplain waterbodies:** Isolated waterbodies behind elevated levees, formed through overbank deposition or breaches in a levee caused by a bank collapse. These are commonly shallow margin lakes or small rivers, such as the Agu River floodplain system. The Agu River system is east of the Middle Fly, receiving overflow from the Fly and periodically becoming a lake if the lower reach is blocked during high water levels in the Fly River.
- **Point bar fields:** Shallow, topographically low ridges and swales adjacent to meandering watercourses that gradually become blocked by sediment.

- **Tie channels:** Narrow watercourses that connect ORWBs to the main river or tributary, allowing water to flow to and from the ORWBs. These may become impeded over time, blocking the connection between the ORWB and watercourse. Tie channel blockage is most common in the Lower Ok Tedi and parts of the Lower Middle Fly. Tie channels draining large tributaries generally do not block, while tie channels draining small tributaries are more likely to become blocked.

The Ok Tedi floodplain contains a network of ORWBs, including oxbow lakes, blocked valley lakes, and water bodies associated with levees and backswamps. These features are typically connected to the main river through tie channels, although many have become blocked or impeded since the early 2000s due to high sediment loads. This has reduced connectivity and limited drainage from the floodplain. Sediment deposition is concentrated along main channel and tie channel levees, with much lower accumulation in more distant ORWBs.

The Upper Middle Fly floodplain contains numerous ORWBs, primarily oxbow lakes and blocked valley lakes formed by long-term sediment deposition that has raised the inner floodplain and obstructed tributary valleys. Many of these ORWBs are connected to the main river by tie channels, allowing exchange of water and sediment, although some have become blocked or modified. Oxbow lakes are relatively more active in this reach due to ongoing meander migration, with several cutoffs recorded in recent decades. During droughts, much of the floodplain dries out, leaving only deeper oxbows and connected systems as key water refuges. Some oxbows are beginning to infill, particularly where sediment plugs are advancing into their entrances.

The Lower Middle Fly floodplain is wider, lower-lying, and more persistently inundated, with extensive swamp, shallow lakes, and large blocked valley lakes influenced by backwater from the Strickland River. ORWBs in this reach are more isolated, with fewer active connections to the main channel and many only linked during overbank flooding. Levee growth and tie channel blocking have increasingly isolated the floodplain, reducing drainage and prolonging inundation. As a result, water bodies tend to persist longer during droughts compared to upstream, although even these may dry out under severe conditions.

The Middle Fly floodplain is a key sediment storage zone with levee development from overbank flows and the formation of ORWBs (including blocked valley lakes and oxbow lakes) due to sediment blocking drainage paths.

Table 8.5 presents median thicknesses and vertical accretion rates of mine sediments across a range of different floodplain and ORBW depositional environments in the Fly River system, determined through coring projects by OTML.

Table 8.5 Estimated thicknesses and sedimentation rates of mine sediment in the Fly River system

Depositional environment	Estimated thickness of mine-derived sediments (mm)	Estimated sedimentation rate (mm/yr)	Estimated maximum sedimentation rate (mm/yr)
Fly levee	1,805	69	251
Fly levee backslope	1,340	61	163
Fly point bar	1,570	65	96
Tie channel levee	2,040	59	151
Fly backswamp	270	12	118
Fly scroll bar complex	312	15	20
ORWB	210	11	46

Source: Appendix B

Plate 8.13
Upper Fly River



Photo credit: Tetra Tech Coffey, 2025

Plate 8.14
Upper Middle Fly River



Photo credit: Pickup, 2025

Plate 8.15
Lower Middle Fly River near Everill Junction



Photo credit: Pickup, 2025

Mine-derived sediment deposition is greatest near channels and decreases with distance across the floodplain. The thickest deposits occur on tie channel levees (approximately 2,040 mm), followed by main river levees, point bars, and levee backslopes, while much thinner deposits are found in more distal environments such as scroll bars, backswamps, and ORWBs. Sedimentation rates follow a similar pattern, with the highest rates (up to 69 mm/year) on tie channel levees and other near-channel features, and much lower rates in areas further from the main river, particularly in distal ORWBs

8.3.3 Riverine sediment quality

Riverine sediment in the Ok Tedi and Fly River systems reflects a combination of natural background material and long-term contributions from mine-derived tailings and waste rock, which have elevated copper concentrations. Sediment quality has been characterised through levee core sampling, floodplain geochemical surveys, and particulate mass balance modelling, with a focus on copper, sulfur, and acid neutralising capacity (ANC).

Figure 8.15 shows levee geochemistry trends, which are described further in the following subsections. This data was recorded in 2006, 2012 and 2019 and shows the changes in copper, sulfur and ANC over time to determine the effectiveness of controls implemented to improve riverine sediment quality. The 2019 data is assumed to be representative of current conditions.

8.3.3.1 Copper and other metals

As the Ok Tedi Mine is a copper porphyry system, mineralogy of sediment eroded from the mine and mine waste is dominated by copper-bearing minerals, with low levels of lead, arsenic or cadmium. Copper is the primary metal of interest in tailings and waste rock that enters the Ok Tedi system.

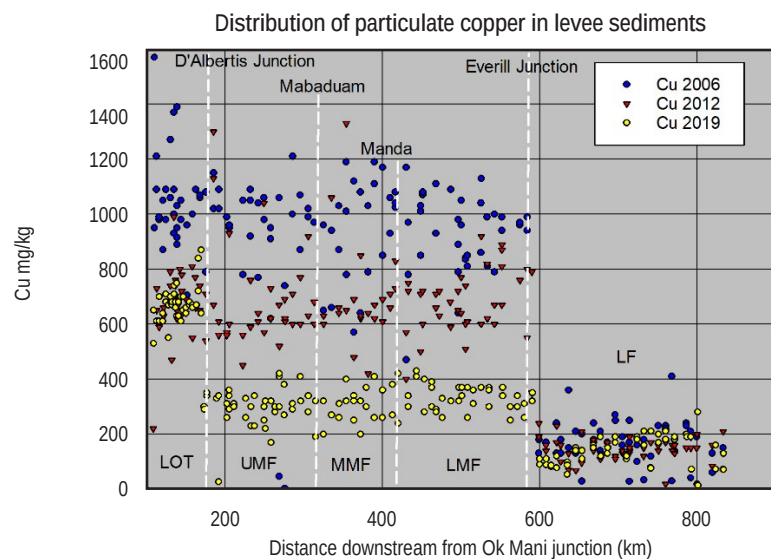
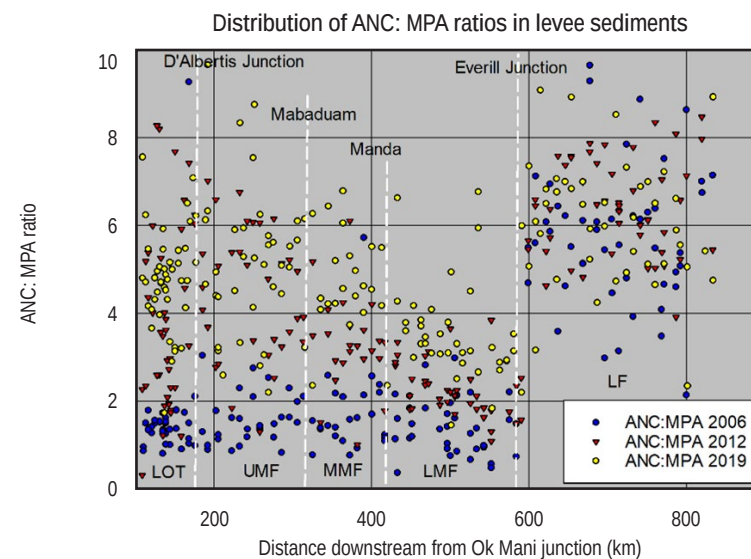
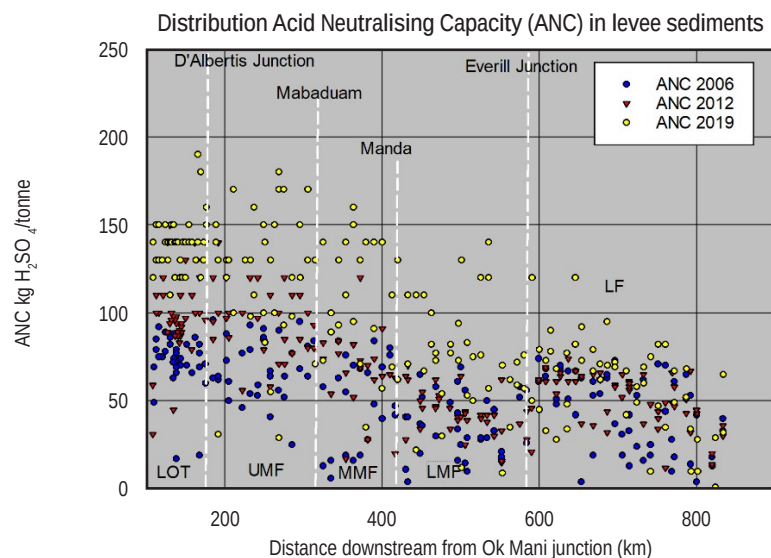
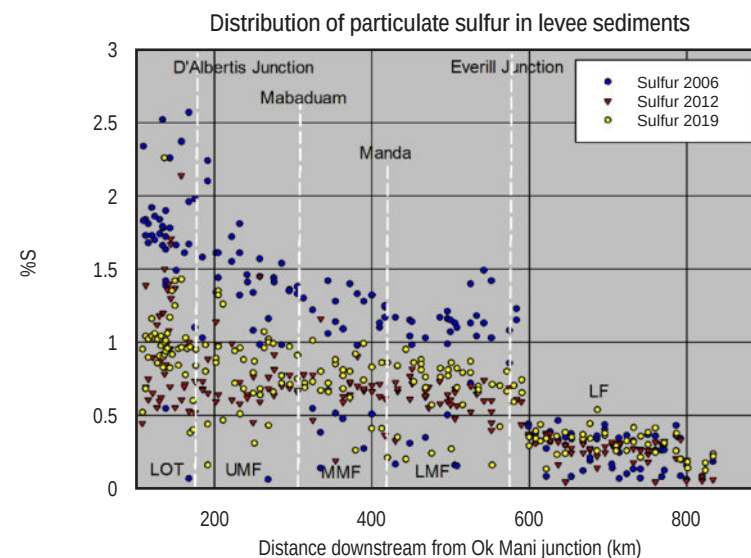
Ok Tedi and Fly River systems

Copper concentrations in riverine sediment have historically been elevated in reaches downstream of the mine. During the early phases of mining, copper was distributed broadly across the Lower Ok Tedi and Middle Fly, as tailings and waste rock were transported and deposited on floodplains and within river systems.

Early studies of floodplain deposition used copper as a tracer because mine-derived sediments contain higher copper levels than natural background concentrations. Analysis of surface samples and shallow cores from floodplain and ORWBs collected between 1989 and 2000 showed that copper-rich sediments were present across the floodplain, with concentrations exceeding background levels at most sites by 1993.

Over time, copper inputs and distribution patterns have changed. The combined copper load from waste rock and tailings decreased significantly from around 125 kt/year in 2004 to 30 to 40 kt/year, before increasing to 127 kt/year in 2024. This is largely driven by variations in waste rock volume and grade, with copper grade in waste rock increasing from 0.08% to 0.14% over this period. While most copper in waste rock is stored in coarse gravel deposits in the Upper Ok Tedi, copper associated with tailings is transported further downstream and has been the primary driver of dissolved copper in the downstream Ok Tedi and Fly River systems (OTML 2025e).

Considering the understanding of copper deposition across floodplains and the high concentrations present in levees, sampling focussed on levee sediments from 2000 onwards. Copper levels in levee sediments generally decreased downstream where tributaries diluted the load, and more recently declined further as copper content in tailings was reduced. Previously, copper was distributed relatively evenly across the Lower Ok Tedi and Middle Fly, demonstrating its high mobility, with significant reduction only occurring where diluted by the Strickland River.



SOURCE
Appendix B



NOTES
LOT: Lower Ok Tedi
UMF: Upper Middle Fly
MMF: Central Middle Fly
LMF: Lower Middle Fly
LF: Lower Fly

OK TEDI MINING LIMITED

OK BIRIM TAILINGS STORAGE FACILITY PROJECT

FIGURE 8.15

Levee sediment geochemistry trends



DATE: 21.06.26 PROJECT: 754-MELEN374244 FILE: 374244C_R08_F08.15_GRA

DISCLAIMER: THIS FIGURE HAS BEEN PROVIDED FOR INFORMATION ONLY AND IS SUBJECT TO CHANGE. THE CREATORS DO NOT WARRANT THAT THIS FIGURE IS DEFINITIVE NOR FREE OF ERROR AND DO NOT ACCEPT LIABILITY ARISING FROM RELIANCE ON INFORMATION PROVIDED HEREIN. © COPYRIGHT TETRA TECH COFFEY 2026.
DOC REFERENCE: \\IT.LOCAL\CP\S\772\SIG\S374244_MELEN_OTML_OKBIRIM\TSF2_GRAPHICS\R08_ES\A374244C_R08_GRA02AI_2 | SAVED BY: JD 21.06.26

OTML conducts annual sampling of the levee and floodplain deposits, which provides insights into the copper content of these sediments. Table 8.6 presents a summary of 2023 and 2024 sampling results. The marked reduction in copper concentrations in the South Fly samples reflects dilution of the mine impacted sediment sourced from the Middle Fly by the greater flux of sediments sourced from the Strickland River as discussed above.

Annual sampling of Upper Ok Tedi gravel and sand bar (GSB) sites typically records particulate copper levels of below 800 mg/kg. Sampling in 2024 showed that particulate copper had increased by 16% (394 mg/kg) compared to 2023 (330 mg/kg) (OTML 2025e). Mean particulate copper concentrations decreased across all Ok Tedi floodplain sites in 2024 compared to 2023, with similar reductions observed in Fly River sediments, indicating a downstream decline across the system (OTML 2025e).

Table 8.6 Particulate copper content of Lower Ok Tedi area and Middle and Lower Fly levees (2023-2024)

Site	Year	Number of samples	Particulate copper content (mg/kg)
Levee	2024	40	537
	2023	40	547
Konkonda	2024	31	438
	2023	30	489
D'Albertis	2024	28	477
	2023	28	506
Upper Middle Fly	2024	69	369
	2023	69	401
Lower Middle Fly	2024	34	384
	2023	34	428
South Fly	2024	47	78
	2023	48	123

Source: Modified from OTML 2024e

Infrastructure corridor watercourses

The aquatic ecology survey for the ESIA collected sediment samples at 13 sites along the infrastructure corridor, including several along the Ok Ma and Ok Birim, to analyse metal concentrations.

Sediment metal concentrations across these sites were generally low, although some variation occurred between locations (Table 8.7). All sites, remained below relevant guideline values. Cadmium was below detection limits at all sites, while copper, lead, and zinc showed some variability but did not exceed threshold levels, indicating no significant contamination concern based on current standards

TSF development area watercourses

The aquatic ecology survey collected sediment samples at 24 sites in the area, including sites along the Ok Yep, to analyse metal concentrations (Table 8.8). Sediment metal concentrations were generally low across sites, with elevated levels at one site (OY01). OY01 is the site located in the Ok Yep slightly upstream of the confluence with the Ok Tedi. Concentrations of cadmium, copper, lead, and zinc were highest at this site, with copper and zinc exceeding both default sediment quality guideline values (DGVs) and guideline value-high (GV-high) thresholds, indicating potential impacts to benthic fauna, while lead and cadmium exceeded the relevant DGVs. These elevated levels may be due to backwater effects from the Ok Tedi depositing contaminated sediment into the lower Ok Yep during high flows.

Table 8.7 Riverine sediment quality table for infrastructure corridor watercourses

Analyte	Units	DGV	OB01	OB02	OB03	OB04	OM1	OM3	OM6	OM4	OM5	OM7	OM8	OM9	OM12
ANC	kg H ₂ SO ₄ /t	-	10.99	2.01	11.66	14.18	55.38	25.14	12.19	45.45	45.72	36.9	48.91	24.64	-1.88
Carbon	%	-	0.131	1.273	1.186	0.429	1.62	0.69	1.78	1.21	0.84	1.23	1.88	0.69	2.53
Sulfur	%	-	0.04	0.1	0.02	0.04	0.21	0.06	0.05	0.15	0.08	0.14	0.23	0.05	0.07
Cd	mg/kg	1.5	0.5	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Cu	mg/kg	65	33.5	10.8	35.9	39.7	4.8	50.6	45.6	16.7	26.4	19.4	12.1	17	12.1
Pb	mg/kg	50	6.5	7.7	4.3	4.1	7.2	0.5	4.8	4.8	4.8	7.3	7.3	4.9	9.7
Zn	mg/kg	200	63.7	107.9	61.4	54.3	47.8	60.3	62.4	59.5	45.6	50.9	60.5	77.7	104
NAPP	kg H ₂ SO ₄ /t	-	4.71	-9.77	1.05	-12.96	-48.95	-23.30	-10.66	-40.86	-43.27	-32.61	-41.87	-23.11	4.022

Table 8.8 Riverine sediment quality table for TSF development area watercourses

Analyte	Units	DGV	OB09B	OB10	OB16	OB17	OB20	OB21	OB22	OB24	OB25	OB26	OB27	OB28
ANC	kg H ₂ SO ₄ /t	-	-1.49	0.38	1.03	10.1	-1.52	-0.25	1.38	-1.22	-3.02	-1.96	1.08	-0.7
Carbon	%	-	1.133	1.078	0.801	0.24	2.191	1.246	1.455	1.4	2.796	2.696	0.714	0.861
Sulfur	%	-	0.02	0.03	0.09	0.02	0.06	0.07	0.09	0.04	0.02	0.09	0.05	0.14
Cd	mg/kg	1.5	0.2	<0.01	<0.01	0.2	0.2	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Cu	mg/kg	65	11	7.7	11.6	35.7	7.5	7.5	7.5	17.2	3.6	8.2	9.8	15.4
Pb	mg/kg	50	7.7	7	6.8	4.8	9.5	5.6	7.3	8.9	3.4	6.3	7.4	8.6
Zn	mg/kg	200	117.1	77.8	82.9	75.4	97.8	64	58.7	85	22.5	62.7	48.6	75.7
NAPP	kg H ₂ SO ₄ /t	-	2.102	0.538	-11.048	1.724	-9.488	3.356	2.392	1.374	2.444	3.632	0.45	4.984

Analyte	Units	DGV	OB29	OB30	OB31	OB32	OB33	OB34	OB35	OB36	OB37	OB38	OY1	OY2
ANC	kg H ₂ SO ₄ /t	-	-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	%	-	2.675	7.812	1.356	6.397	3.607	3.856	9.824	6.12	3.83	1.5	3.02	3.53
Sulfur	%	-	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	1.5	<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	65	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	50	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	200	52.3	57.1	49.3	60.9	56.7	73.6	<5	26.6	19.2	24.1	466.7	45.9
NAPP	kg H ₂ SO ₄ /t	-	4.686	8.72	1.842	-0.738	3.663	4.156	8.634	10.212	5.326	2.596	-116.92	6.53

8.3.3.2 Sulfur

Particulate sulfur content in deposited sediment generally reflects the composition of tailings and waste rock inputs. The balance between sulfur (which contributes to acid formation) and acid-neutralising capacity controls how much acid is generated. This consequently strongly affects metal toxicity and riverine environment health.

Ok Tedi and Fly River systems

Sulfur inputs to the Ok Tedi system are more variable than copper and show a different spatial pattern over time. A strong downstream gradient was present in 2006, with higher concentrations upstream, but this gradually diminished and has largely disappeared since OTML commenced the extraction of sulfide minerals (i.e., pyrite) from tailings in 2009. The tailings processing plant extracts up to 90% of the pyrite from tailings, reducing the overall sulfur concentrations within discharged tailings. Since 2012, sulfur levels in the Lower Ok Tedi have remained relatively stable at about 0.84 to 1.04%. Tailings sulfur concentrations remain low, with a mean value of 0.54% in 2024. These concentrations are continuing a declining trend, and low sulfur levels are observed in dredged material at Bige and in floodplain levee sediments. In the Middle Fly, sulfur concentrations are only slightly reduced by dilution from the Upper Fly and more significantly by the Strickland River, with limited variation along the Lower Ok Tedi.

OTML conducts annual sampling of the levee and floodplain deposits, which provides insights into the sulfur content of these sediments. Table 8.9 presents a summary of 2023 and 2024 sampling results. These results indicate sulfur content has generally decreased between 2023 and 2024 in the Ok Tedi sites and increased in the Fly River levees; however, values in the Fly River system are generally lower than values in the Ok Tedi system (OTML 2025e).

Table 8.9 Sulfur content of Lower Ok Tedi area and Middle and Lower Fly levees (2023-2024)

Location	Year	Number of samples	Sulfur content (%)
Levee	2024	40	0.7
	2023	40	0.9
Konkonda	2024	31	0.3
	2023	30	0.5
D'Albertis	2024	28	0.6
	2023	28	0.9
Upper Middle Fly	2024	69	0.65
	2023	69	0.56
Lower Middle Fly	2024	34	0.50
	2023	34	0.48
South Fly	2024	47	0.21
	2023	48	0.17

Source: Modified from OTML 2025e

Infrastructure corridor watercourses

The aquatic ecology survey for the ESIA collected sediment samples at 13 sites along the infrastructure corridor, including several along the Ok Ma and Ok Birim, to analyse sulfur concentrations. Total sulfur content was low at all sites, ranging from 0.04% to 0.23% (see Table 8.7).

TSF development area watercourses

The aquatic ecology survey collected sediment samples at 24 sites in the area, including sites along the Ok Yep, to analyse sulfur concentrations. Total sulfur content was low at all sites, ranging from 0.01% to 1.19% (see Table 8.8). All sites except OY01 recorded sediment sulfur concentrations below 0.2 %. OY01 recorded a value of 1.19 %, which may be due to backwater influences from the Ok Tedi.

8.3.3.3 ANC

ANC is an indicator of a sediment's ability to buffer acid generation from sulfide oxidation. The ANC:MPA ratio is a key indicator of the acid-forming potential of sediment. It compares a material's ANC to its maximum potential acidity (MPA), which is derived from sulfide content. Ratios above 2.0 are generally considered low risk, indicating sufficient neutralising capacity to buffer against acid generation. Ratios near or below 1.0 suggest a higher likelihood of acid formation, particularly in sediments containing reactive sulfide minerals such as pyrite. Ok Tedi Mine has a net acid producing potential (NAPP) threshold value of -150kg H₂SO₄/tonne. If NAPP is greater than this, measures are taken to increase limestone inputs and reduce the value.

Ok Tedi tailings are potentially acid forming (PAF), while waste rock generally has high acid neutralising capacity due to the added limestone content. Dredged tailings-derived sands at Bige pose a future acid and metalliferous drainage (AMD) risk and PAF sediments have previously been identified in some Middle Fly levee deposits.

Ok Tedi and Fly River systems

Sampling of Upper Ok Tedi gravel and sand bar sites in 2024 showed that, despite minor increases in sulfur and some site variability, all four sampled locations had strong ANC, indicating the system has effective buffering capacity. Only one of the 2024 samples exhibited a positive net acid producing potential (NAPP), potentially to older high-sulfur material being mobilised and redeposited (OTML 2025e).

Although the risk of acid generation along the Lower Ok Tedi and Middle Fly has diminished over time, occasional and localised elevated risk remain in downstream areas, likely due to the gradual movement of older, sulfur-rich sediments through the system. In the Middle Ok Tedi, exposed bank profiles show oxidation and occasional acid staining where mine-derived sediments are exposed, especially when older tailings are reworked by erosion.

ANC in floodplain sediments has increased since the early 2000s, mainly due to the intentional addition of ground limestone to tailings to increase the ANC and minimise downstream impacts. This has led to up to a 50% increase in ANC in the Lower Ok Tedi. As a result, acid generation risk is now minimal in the Lower Ok Tedi and has progressively declined along the Middle Fly. ANC is diluted along the Lower Middle Fly, likely due to dilution from sediment inputs from large tributaries.

With the increase in ANC, ANC:MPA ratios now generally exceed 2.5, compared to less than 1.0 in the early 2000s. Dredged material in 2024 had an ANC:MPA ratio of 3.9. This indicates a shift from potentially acid-generating to net acid-neutralising sediments because of OTML's interventions, notably the operation of the tailings processing plant (removing sulfur) and the addition of limestone to tailings and waste rock.

OTML conducts annual sampling of the levee and floodplain deposits, which provides insights into the ANC of these sediments. Table 8.10 presents a summary of 2023 and 2024 sampling results. Whilst mean ANC slightly decreased at the D'Albertis floodplain sites between 2023 and 2024, it increased at the Konkonda and levee sites. Overall, sampling of Lower Ok Tedi levee and floodplain sites at D'Albertis and Konkonda in 2024 indicated the Lower Ok Tedi floodplain has sufficient ANC buffering capabilities (OTML 2025e). In 2024, ANC increased in the Upper Middle Fly and South Fly but declined slightly in the Lower Middle Fly. Overall, there

has been little change in ANC, and net acid producing potential (NAPP) values in Middle and Lower Fly sediments since 2017 (OTML 2025e).

Table 8.10 ANC of Lower Ok Tedi area and Middle and Lower Fly levees (2023-2024)

Site	Year	Number of samples	ANC	NAPP	ANC:MPA
Levee	2024	40	187	-186	-
	2023	40	157	-129	-
Konkonda	2024	31	157	-147	-
	2023	30	144	-128	-
D'Albertis	2024	28	145	-121	-
	2023	28	146	-117	-
Upper Middle Fly	2024	69	135	-115	6.7
	2023	69	110	-93	6.5
Lower Middle Fly	2024	34	64	-49	4.2
	2023	34	71	-57	4.8
South Fly	2024	47	52	-45	8.1
	2023	48	47	-42	8.9

Source: Modified from OTML 2025e

Infrastructure corridor watercourses

The aquatic ecology survey for the ESIA collected sediment samples at 13 sites along the infrastructure corridor, including several along the Ok Ma and Ok Birim, to analyse ANC and NAPP. ANC ranged from below the detection limit to 55.38 kg H₂SO₄/tonne (see Table 8.7). Results indicate the sediment sampled has a limited capacity to neutralise acid. NAPP ranged from -48.95 to 4.02, with only one site returning a positive value. Negative values indicate the sample may have sufficient ANC to prevent acid generation. As these sampling sites are not influenced by mine waste, the positive value indicates the sample may be naturally acid generating material (Appendix E).

TSF development area watercourses

The aquatic ecology survey collected sediment samples at 24 sites in the area, including sites along the Ok Yep, to analyse ANC and NAPP. ANC ranged from below the detection limit to 14.18 kg H₂SO₄/t (see Table 8.8). Results indicate the sediment sampled at several sites has a limited capacity to neutralise acid. NAPP ranged from -12.96 to 8.72, with several sites returning positive values. As these sampling sites are not influenced by mine waste, the positive value indicates the sample may be naturally acid generating material (Appendix E).

8.3.4 Surface water quality

This section describes the surface water quality of the Ok Tedi and Fly River systems based on long-term monitoring programs and historical datasets presented in OTML's annual reports (OTML 2025e); OTML2024d), Earth Systems (2013), Appendix C, and Appendix E.

Surface water quality parameters are discussed in relation to relevant guideline values, including:

- Australian and New Zealand Environment and Conservation Council / Agriculture and Resource Management Council of Australia and New Zealand (ANZECC/ARMCANZ 2000) water quality guideline values.

- PNG Water Quality Regulation 2002 trigger values.
- Australian and New Zealand Guidelines for Fresh and Marine Water Quality (ANZG 2018) DGVs for aquatic ecosystems in tropical northern Australia (lowland rivers). These are indicative guideline values as recent PNG-specific values are not available.
- Ok Tedi Permit requirements.

Surface water quality is monitored at Ningerum, Atkamba, Nukumba, Obo and Ogwa for drinking water quality, and at Lower Ok Tedi Bridge, Ningerum, Atkamba, Nukumba, Obo, Ogwa, Lewada and ORBWs for aquatic ecosystems. Sampling for the ESIA included nine sites in the infrastructure development corridor and 28 sites in the TSF development area.

8.3.4.1 pH and alkalinity

Low pH levels can increase the mobility and toxicity (bioavailability) of metals.

Ok Tedi and Fly River systems

pH is generally circumneutral to slightly alkaline (7.5 to 8.5) throughout the Ok Tedi and Fly systems. Dissolved alkalinity peaks at the Lower Ok Tedi Bridge and Ningerum (100 to 120 mg/L), likely due to limestone-rich mine inputs, declining downstream (Earth Systems 2013).

Alkalinity in the Ok Tedi reduced since 2023, with total alkalinity of 425.3 mg/L upstream of Bige and 292.0 mg/L downstream of Bige in 2024. The downstream alkalinity may be influenced by runoff from the Bige stockpiles, which recorded alkalinity of 150 to 400 mg/L through 2024 (OTML 2025e).

Infrastructure development corridor watercourses

Water quality results for infrastructure corridor watercourses are presented in Table 8.11. Water quality in the Ok Ma was generally alkaline, with pH ranging from 6.7 to 8.1. Most sites were below the upper DGV, although two sites had a pH of 8.1, slightly exceeding the upper DGV of 8.0. The main Ok Birim channel is characterised by alkaline water, reflecting the underlying geology of the headwaters. pH levels in sites within the Ok Ma channel were generally less acidic than the TSF development area sites. This likely reflects the underlying geology and catchment conditions of the Ok Ma (Appendix E).

TSF development area watercourses

Water quality results for TSF development area watercourses are presented in Table 8.12. Water pH ranged from slightly acidic to neutral, with the pH ranging from 5.1 to 6.5, and all sites measuring below the upper DGV. Some lowland creek sites recorded more acidic pH levels (5.5 to 5.9), likely due natural acidic runoff from organic-rich soils in the surrounding rainforest areas (Appendix E).

Table 8.11 Surface water quality in the infrastructure development corridor watercourses

Analyte	Units	ANZG DGV 95%	WQC (2002)	OB01	OB02	OB03	OB04	OM1	OM3	OM6	OM4	OM5	OM7	OM8	OM9	OM12
Fe	µg/L	700	1,000	<10	15	19	17	52	12	9	9	20	20	19	6	37
Na	mg/L	-	-	1	2	3	1	1	1	2	2	1	1	1	2	1
Mg	mg/L	-	-	2	2	1	1	1	1	<0.1	2	1	1	1	1	<0.1
Al	µg/L	55	-	19	24	30	33	20	3	6	11	19	18	16	8	5
K	mg/L	-	5,000	<1	<1	1	<1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
Ca	mg/L	-	-	13	17	21	13	21	6	4	21	17	15	14	13	2
Cr	µg/L	1	50	1	4	5	4	<0.9	1	<0.9	<0.9	<0.9	<0.9	<0.9	<0.9	<0.9
Mn	µg/L	1,900	500	5	5	10	4	1	1	2	<0.7	<0.7	<0.7	<0.7	<0.7	6
Co	µg/L	-	-	3	13	22	5	<0.7	<0.7	<0.7	<0.7	<0.7	<0.7	<0.7	<0.7	<0.7
Ni	µg/L	11	1,000	<1	2	6	3	1	<0.7	<0.7	<0.7	<0.7	<0.7	<0.7	<0.7	<0.7
Cu	µg/L	1.4	1,000	65	2	5	2	8	1	7	6	10	4	8	8	7
Zn	µg/L	8	5,000	69	<3	<3	<3	<0.7	<0.7	1	<0.7	<0.7	<0.7	2	<0.7	1
As	µg/L	2.4	50	<1	2	3	3	1	<0.4	<0.4	<0.4	1	1	<0.4	<0.4	<0.4
Se	µg/L	-	10	5	16	20	<4	5	4	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
Mo	µg/L	-	-	<2	<2	4	<2	<0.6	<0.6	<0.6	<0.6	<0.6	<0.6	<0.6	<0.6	<0.6
Ag	µg/L	-	50	<1	<1	1	<1	<0.4	<0.4	<0.4	<0.4	<0.4	<0.4	<0.4	<0.4	<0.4
Cd	µg/L	0.2	10	<1	1	<1	<1	<0.6	<0.6	<0.6	<0.6	<0.6	<0.6	<0.6	<0.6	<0.6
Sb	µg/L	-	-	3	15	18	15	<0.4	<0.4	<0.4	<0.4	<0.4	<0.4	<0.4	<0.4	<0.4
Pb	µg/L	3.4	5	6	11	12	<1	<0.7	<0.7	<0.7	<0.7	<0.7	<0.7	<0.7	<0.7	<0.7
pH	-	6.0–7.5	-	7.8	7.7	7.4	7.8	7.8	7.5	7.4	7.9	8.1	8	8.1	7.8	6.7
Alkalinity	Mg CaCO ₃ /L	-	-	60	20	40	40	61	39	17	67	61	50	50	50	17
TSS	mg/L	-	-	195.8	234.6	235	160.8	344.9	16.3	7.8	228	482.6	338.6	268.1	46.3	0.9
Electrical Conductivity	µS/cm	250	-	80	90	70	80	100	70	30	100	100	90	90	90	20
Sulfate	mg/L	-	400	48	29	32	20	89	35	86	164	88	30	26	52	23
DO% (in-situ)	%	85–120	-	104.1	103.3	97.1	86.4	96.9	-	138	168.1	115.8	131.2	72.5	85.5	114.4

Table 8.12 Surface water quality in the TSF development area watercourses

Analyte	Units	ANZG DGV 95%	WQC (2002)	OB16	OB17	OB20	OB21	OB22	OB24	OB25	OB26	OB09B	OB10	OB27	OB28
Fe	µg/L	700	1,000	41	37	68	42	58	44	81	48	34	43	67	49
Na	mg/L	-	-	1	1	1	1	1	2	1	1	1	1	1	1
Mg	mg/L	-	-	1	<1	1	<1	<1	1	<1	<1	<1	<1	<1	<1
Al	µg/L	55	-	<10	<10	<10	<10	<10	<10	14	<10	<10	<10	12	<10
K	mg/L	-	5,000	<1	<1	<1	<1	<1	1	<1	<1	<1	<1	<1	<1
Ca	mg/L	-	-	2	2	1	1	1	4	1	<1	<1	1	1	1
Cr	µg/L	1	50	4	1	2	4	2	3	4	2	5	2	1	2
Mn	µg/L	1,900	500	15	7	12	17	6	14	66	8	48	7	9	12
Co	µg/L	-	-	9	<1	6	5	9	8	25	3	16	2	3	5
Ni	µg/L	11	1,000	<1	<1	1	3	1	<1	5	3	<1	<1	<1	<1
Cu	µg/L	1.4	1,000	3	1	2	4	<1	2	6	1	2	3	<1	3
Zn	µg/L	8	5,000	<3	<3	<3	<3	<3	<3	<3	<3	<3	<3	4	<3
As	µg/L	2.4	50	1	<1	6	4	2	2	1	<1	<1	1	3	3
Se	µg/L	-	10	12	<4	<4	17	<4	9	7	<4	9	13	<4	10
Mo	µg/L	-	-	2	<2	<2	2	3	<2	4	<2	2	<2	<2	<2
Ag	µg/L	-	50	<1	<1	1	<1	<1	<1	1	1	1	<1	1	<1
Cd	µg/L	0.2	10	<1	<1	<1	<1	<1	<1	1	<1	<1	<1	<1	<1
Sb	µg/L	-	-	6	4	9	6	<2	5	17	8	10	5	<2	9
Pb	µg/L	3.4	5	8	<1	1	8	7	13	21	6	17	5	1	7
pH	-	6.0–7.5	-	6.2	6.5	6.4	6.1	6.2	6.5	6.1	6	5.5	6	6.2	6.2
Alkalinity	mg CaCO ₃ /L	-	-	10	8	8	8	10	20	5	5	5	5	5	8
TSS	mg/L	-	-	1.9	2.8	11.2	14.9	24	6.1	133.8	1.9	2.2	2.9	30.6	2.6
Electrical Conductivity	µS/cm	250	-	20	20	10	10	10	30	10	6	5	8	9	10
Sulfate	mg/L	-	400	<1	5	4	13	<1	2	<1	20	20	10	12	25
DO% (in-situ)	%	85–120	-	111	80	83.2	89.9	92.8	92.9	90.8	78.1	90.2	87.5	99	77.5

Table 8.12 Surface water quality in the TSF development area watercourses (continued)

Analyte	Units	ANZG DGV 95%	WQC (2002)	OB29	OB30	OB31	OB32	OB33	OB34	OB35	OB36	OB37	OB38	OY1	OY2
Fe	µg/L	700	1,000	88	288	72	41	61	58	133	46	21	49	66	90
Na	mg/L	-	-	1	1	1	1	1	1	1	<0.1	<0.1	<0.1	<0.1	<0.1
Mg	mg/L	-	-	<1	<1	<1	<1	<1	<1	<1	<0.1	<0.1	<0.1	<0.1	<0.1
Al	µg/L	55	-	10	14	<10	16	12	<10	12	53	14	30	43	89
K	mg/L	-	5,000	<1	<1	<1	<1	<1	<1	<1	<0.1	<0.1	<0.1	<0.1	<0.1
Ca	mg/L	-	-	1	1	1	<1	1	1	2	<0.2	<0.2	<0.2	1	<0.2
Cr	µg/L	1	50	4	3	4	5	2	<1	<1	<0.9	<0.9	<0.9	<0.9	<0.9
Mn	µg/L	1,900	500	39	41	11	21	13	14	33	14	31	19	12	18
Co	µg/L	-	-	14	14	10	10	4	<1	4	<0.7	<0.7	<0.7	<0.7	<0.7
Ni	µg/L	11	1,000	<1	3	<1	<1	<1	<1	<1	<0.7	<0.7	<0.7	<0.7	<0.7
Cu	µg/L	1.4	1,000	1	2	4	6	1	<1	<1	7	8	7	6	6
Zn	µg/L	8	5,000	<3	4	<3	<3	<3	<3	<3	2	2	5	1	1
As	µg/L	2.4	50	<1	4	<1	<1	<1	2	5	<0.4	<0.4	<0.4	<0.4	<0.4
Se	µg/L	-	10	7	16	10	19	<4	7	4	<0.5	<0.5	<0.5	<0.5	<0.5
Mo	µg/L	-	-	2	<2	2	<2	<2	<2	2	<0.6	<0.6	<0.6	<0.6	<0.6
Ag	µg/L	-	50	1	<1	1	<1	<1	<1	<1	<0.4	<0.4	<0.4	<0.4	<0.4
Cd	µg/L	0.2	10	<1	<1	<1	<1	<1	<1	<1	<0.6	<0.6	<0.6	<0.6	<0.6
Sb	µg/L	-	-	10	6	5	8	<2	3	<2	<0.4	<0.4	<0.4	<0.4	<0.4
Pb	µg/L	3.4	5	14	3	2	6	<1	2	4	<0.7	<0.7	<0.7	<0.7	<0.7
pH	-	6.0–7.5	-	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 CaCO ₃ /L	-	-	8	5	5	3	5	8	5	10	6	6	7	6
TSS	mg/L	-	-	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	250	-	10	10	10	5	8	10	20	6	5	6	7	6
Sulfate	mg/L	-	400	14	4	28	24	79	77	72	267	173	61	95	409
DO% (in-situ)	%	85–120	-	81.4	58.5	93.1	64.9	81.4	74.3	94.5	70.4	61.8	68.5	78	72.7

8.3.4.2 Major ions and conductivity

Calcium, sodium, magnesium, and potassium are the main cations in the regional river systems, derived from mine materials and natural geology.

Ok Tedi and Fly River systems

Calcium is the dominant cation, with concentrations at the Lower Ok Tedi Bridge ranging from 28 to 66 mg/L, sourced from limestone and to a lesser extent, process water. Annual median sodium concentrations at Lower Ok Tedi Bridge ranged from 28 to 66 mg/L, and magnesium and potassium concentrations were present at low concentrations throughout the system (Earth Systems 2013). Monitoring of electrical conductivity in 2023 and 2024 indicated median values were below 250 $\mu\text{S}/\text{cm}$ at all sites except the Lower Ok Tedi Bridge, with a median value of 412 $\mu\text{S}/\text{cm}$ in 2023 and 432 $\mu\text{S}/\text{cm}$ in 2024 (OTML 2024d; OTML 2025e).

Sulfate concentrations in the Ok Tedi and Fly River systems dilute downstream, with concentrations decreasing from a median of 94 mg/L in the Upper Ok Tedi to 37 mg/L at Ningerum, 16 mg/L at Atkamba and 12 mg/L at Nukumba as mine-impacted water is diluted by unimpacted tributaries. Sulfate concentrations are relatively stable along the Fly River, with a background concentration of 10 mg/L. This indicates sulfate from mine sediments is not significantly impacting downstream water quality (Appendix C)

Infrastructure development corridor watercourses

Electrical conductivity ranged from 20 to 100 $\mu\text{S}/\text{cm}$ across sites in the infrastructure development corridor, with all values less than half of the ANZG guideline of 250 $\mu\text{S}/\text{cm}$ (Table 8.11). The lowest values in the Ok Ma area of 20 and 30 $\mu\text{S}/\text{cm}$ were recorded at OM6 (just north of Kolebon) and OM12 (just south of Digam), respectively. All other sites recorded between 70 and 100 $\mu\text{S}/\text{cm}$. This indicates that all waters are very fresh with minimal dissolved salts and no evidence of elevated salinity (Appendix E)

TSF development area watercourses

Electrical conductivity was low across all TSF development area sites, with all values well below the ANZG guideline of 250 $\mu\text{S}/\text{cm}$ (Table 8.12). Electrical conductivity ranged from 5 to 30 $\mu\text{S}/\text{cm}$, with most values at or below 10 $\mu\text{S}/\text{cm}$, more than an order of magnitude below the ANZG guideline. This indicates that all waters are very fresh with minimal dissolved salts and no evidence of elevated salinity (Appendix E)

8.3.4.3 Organic materials

High organic content in water contributes to increased complexing capacity of metals.

Ok Tedi and Fly River systems

Organic carbon in the Ok Tedi and Fly River systems occurs primarily as dissolved organic carbon (DOC) and total organic carbon (TOC), both of which influence metal complexation and overall water quality. Elevated DOC contributes to reducing the bioavailability of dissolved metals, particularly copper, by forming stable complexes. This results in lower labile copper concentrations and associated ecological risks. In main river channels, DOC levels are typically lower due to greater dilution and higher flow rates but can still contribute to metal speciation and buffering capacity.

Dissolved carbon dioxide levels in the Fly River system are slightly above atmospheric equilibrium. This is typical of tropical rivers, where high rates of organic matter decomposition in the catchment increase CO_2 production and make these systems a net source of CO_2 to the atmosphere. This process is supported by the presence of DOC, which generally increases from low concentrations in upland streams (0.5 to 1 mg/L) to

higher levels in major lowland rivers such as the Fly River (2 to 3 mg/L), and higher values expected in floodplain drainage areas (Appendix C).

Infrastructure development corridor watercourses

Daytime dissolved oxygen ranged from 72.5% to 168.1% saturation. All values were well above levels known to cause ecological harm (50%), despite some sites being below or above DGV values of 85 to 120% (Appendix E).

TSF development area watercourses

Daytime dissolved oxygen ranged from 58.5% to 111% saturation. All values were well above levels known to cause ecological harm (50%), despite some sites being below DGV values of 85 to 120% (Appendix E).

8.3.4.4 Copper

Most copper discharged from the mine into the river system is in particulate form. However, once in the system, copper can dissolve. Dissolution from the particulate form is influenced by pH, oxidation, DOC, and complexing capacity. Particulate copper is not directly bioavailable but becomes bioavailable through dissolution. Bioavailable copper is toxic and can kill or harm organisms by entering tissue.

Labile copper is the proportion of total dissolved copper that is likely to be toxic, including free ionic copper, inorganic copper complexes, and some weakly organically bound forms. As labile copper is weakly bound, it is readily exchangeable or bioavailable.

Copper complexing capacity, which is a measure of the ability of dissolved organic matter to strongly bind dissolved copper and render it non-bioavailable, is influenced by several water quality parameters, including pH, DOC, conductivity, hardness, concentration of major ions, and temperature. Key parameters are DOC and pH. As DOC can form complexes with dissolved copper, higher DOC concentrations mean there is greater opportunity to form complexes with the dissolved copper, reducing concentrations of dissolved, bioavailable copper. Copper complexing is more likely to occur in higher pH settings. Dissolved copper and DOC are more likely to bind in neutral or alkaline environments.

Ok Tedi and Fly River systems

Copper concentrations are variable and show no clear dilution in the Ok Tedi despite increasing river flow. Median concentrations increase slightly from the Lower Ok Tedi Bridge (5.5 µg/L) to Ningerum (6.3 µg/L) and Atkamba (8.5 µg/L), although this trend may not be statistically significant due to variability. A clear decrease in copper concentrations occurs further downstream in the Lower Fly River, below the Strickland confluence, where values drop to around 2 µg/L at Ogwa and Lewada (Appendix C). This may indicate that copper is input from sources across the system such as mine-derived sediments stored within the river system (e.g., sand bars and levees), which can release copper through weathering, as well as copper transported with suspended sediments (Appendix C).

Compared to 2022 sampling results, 2023 median dissolved copper values decreased at Ogwa (4.7 to 1.3 µg/L), Obo (8.5 to 5.2 µg/L), and Ningerum (7.5 to 6.3 µg/L) and remained steady at Nukamba (6.0 µg/L) and Atkamba (9.5 to 9.6 µg/L). Similarly, at the ORWB sites, dissolved copper decreased at Oxbow 4 (2.0 to 0.8 µg/L) and Oxbow 5 (2.7 to 2.2 µg/L). Lower Ok Tedi Bridge was the only site that had increased dissolved copper levels (4.5 to 8.0 µg/L) compared to 2022. Overall, the 2023 median dissolved copper values are within long term trends, which typically exceed the 95% species trigger level of 1.4 µg/L (OTML 2024d).

Generally, ORWBs exhibited lower dissolved metal concentrations than main river bodies; however, many metals showed no temporal changes. ORWBs have lower copper concentrations than the main river but

follow similar declining trends over time. Dissolved copper concentrations declined from 10 to 12 µg/L in 2000 to 2 µg/L by 2013 (Earth Systems 2013).

Infrastructure development corridor watercourses

Dissolved copper concentrations exceeded DGVs at 12 sites within the infrastructure development corridor watercourses, with values ranging from 4 to 65 µg/L. Only one site (OM3) had a value below the DGV, at 1 µg/L. One site (OB01) recorded an anomalously high concentration of 65 µg/L, well above the guideline value, with all other results less than 10 µg/L.

The elevated levels are likely due to the Ok Ma's proximity to the naturally mineralised Mt Fubilan and the Ok Tedi Mine (Appendix E), rather than due to effects of mining activities.

TSF development area watercourses

Dissolved copper exceeded DGVs for 95% species protection at 16 sites, with values ranging between less than detection limit (0.01 µg/L) to 8 µg/L. Despite exceedances, toxicity risk is likely reduced due to high dissolved organic carbon, which as per above can bind copper and limit its bioavailability (Appendix E).

8.3.4.5 Other metals

Dissolved metal concentrations in river systems are influenced by sediment load, as these concentrations may be controlled by interactions with sediments rather than mineral precipitation.

Iron hydroxyoxides (e.g., ferrihydrite) can form a coating on suspended sediments. Copper in the system is commonly associated with iron hydroxyoxides present in ore and tailings, and iron hydroxyoxides can also form when acidic drainage is neutralised by alkaline water. Iron hydroxyoxides have a high capacity to adsorb metals like copper, cadmium, and zinc, reducing their dissolved concentrations in the water. Under certain conditions, these metals can also desorb from sediment particles, contributing back to the dissolved metal load (Appendix C).

Ok Tedi and Fly River systems

While there is no data available on the presence of iron hydroxyoxides on suspended solids in the Ok Tedi and Fly River systems, dissolved metal concentrations are regularly monitored by OTML and reported in annual environmental reports.

Apart from copper, dissolved metal concentrations (Ag, Al, As, Ca, Cd, Co, Cr, Cu, Fe, Hg, K, mg, Mn, Mo, Na, Ni, Pb, Sb, Se and Zn) did not exceed the ANZECC/ARMANZ and PNG *Water Quality Regulation 2002* trigger values at all sites in 2023 (OTML 2024d).

Infrastructure development corridor watercourses

Most dissolved metal concentrations (Cr, Pb, Zn, Cd, and As) were below detection limits or below ANZG (2018) DGVs for protection of 95% of freshwater species across all sites. A summary of these values is:

- Dissolved chromium was below detection at all sites except one, where it equalled the guideline value of 1 µg/L.
- Dissolved lead was consistently below the detection limit of 0.7 µg/L, remaining well below the DGVs.
- Dissolved zinc concentrations were low across all sites, ranging from below the detection limit of 0.7 µg/L to a maximum of 2 µg/L. These values are below the DGV of 8 µg/L.

- Dissolved cadmium was below the detection limit of 0.6 µg/L at all sites; however, the laboratory detection limit is between the 90% (0.4 µg/L) and 80% (0.8 µg/L) DGV for species protection, so potential exceedances could not be confirmed.
- Dissolved arsenic concentrations were generally very low or below the detection limit of 0.4 µg/L. Concentrations were a maximum of 1 µg/L, with all sites below guideline values.

TSF development area watercourses

Most dissolved metal concentrations showed variable exceedances of ANZG DGVs across sites, although many remained within higher protection thresholds or were influenced by detection limits. A summary of these values is:

- Dissolved chromium was equal to or above the 95% DGV at most sites, although concentrations remained below the 90% species protection level and are likely naturally elevated.
- Dissolved lead exceeded the 95% DGV at 15 sites, with concentrations ranging from below detection to a maximum of 21 µg/L.
- Dissolved zinc was below the detection limit of 3 µg/L at all sites except one (OB01), which exceeded the DGV with a concentration of 69 µg/L.
- Dissolved cadmium was mostly below the detection limit of 10 µg/L; however, the laboratory detection limit exceeds the 95% DGV for species protection, so potential exceedances could not be confirmed.
- Dissolved arsenic was generally low, with most sites below the DGV, although eight sites exceeded the DGV, with a maximum concentration of 6 µg/L.

8.4 GROUNDWATER

This section provides a description of groundwater in the project area, primarily based on:

- Appendix D, Ok Birim TSF Groundwater Impact Assessment.
- Hydrogeological Conceptualisation and TSF Seepage Assessment (KCB 2014), prepared during pre-feasibility studies.

8.4.1 Study area

The groundwater study area extends from 12 km north of the Ok Tedi Mine, to 10 km south of the TSF development area. It encompasses the infrastructure corridor, TSF development area, nearby villages that may depend on groundwater resources and watercourses that are hydraulically down-gradient of proposed infrastructure that may be a source of impact to groundwater. Groundwater characterisation focuses primarily on the TSF development area as this is where the greatest potential for groundwater interaction and groundwater-related impacts is anticipated. In comparison, less is currently known about the infrastructure development corridor, and the lower risk of groundwater impacts means that a less detailed understanding of groundwater conditions is sufficient for subsequent impact assessment purposes.

The Groundwater Impact Assessment (Appendix D) used desktop and field studies to characterise the existing groundwater environment and identify groundwater values and potential receptors. The desktop study considered contextual information inferred from topography, climate, surface water features, geological mapping and observations made in similar hydrogeological environments. Groundwater samples were taken from 15 bores near the TSF site and analysed for physical and chemical parameters. This assessment considered results of a 2014 field investigation undertaken as part of the Phase II TSF site selection study. The 2014 investigation included field investigations focussed on the Ok Birim TSF site identified in the 2013 TSF Options Scoping Study (see Chapter 7) and included geological mapping and geotechnical and hydrogeological testing at four locations in the Ok Birim area.

8.4.2 Groundwater units and geological features

The TSF sits on the geological Awin Formation, which is at least 80 m thick (as confirmed by site drill core data) and potentially up to 500 m thick as identified in the broader region. This formation consists of sandstone, conglomerate, siltstone, mudstone and thin lignite seams. The Awin Formation is fluvial in nature, i.e., it was produced by depositional processes relating to rivers and streams. This gives rise to highly variable hydraulic properties.

8.4.2.1 Hydrostratigraphic units

The key hydrogeological units most relevant to the TSF development area include the residual soil and highly weathered zone, the alluvium near the Ok Tedi, and sandstone / conglomerate units, which are expected to represent the most productive and extensive aquifers. The hydrostratigraphic units include:

- **Residual soil and highly weathered rock (Awin Formation):** In-situ weathering of the rock has led to increased porosity compared to un-weathered rock, and residual soils are expected to facilitate direct infiltration of rainfall. Residual soil and highly weathered rock are expected to behave hydrogeologically similar and are grouped as one unit. This unit is up to 30 m thick.
- **Unconsolidated alluvium:** Typically found near the Ok Tedi, the alluvium is uncompacted and inferred to store and transmit larger quantities of groundwater, particularly where alluvium consists of gravelly and sandy deposits. The alluvium is expected to be in direct hydraulic contact with the river and may respond to changes in river flow.

- **Sandstone/conglomerate (Awin Formation):** Expected to form good aquifers, this unit has thick sandstone deposits which are likely to promote the storage and movement of groundwater. The sandstone and conglomerates can occur together and interbed with siltstone and mudstone layers which can cause local hydraulic separation.
- **Siltstone and mudstone (Awin Formation):** Fine-grained, low-permeability units that act as aquitards and locally create semi-confined groundwater conditions by restricting vertical groundwater movement.

Collectively, these units form a layered hydrogeological system comprising a shallow weathered-rock aquifer, sandstone aquifers, and intervening siltstone and mudstone aquitards. This system exerts a primary control on groundwater recharge, groundwater flow pathways and hydraulic connectivity between groundwater units.

The uppermost residual soil and weathered rock unit forms the principal shallow aquifer and recharge zone. This is underlain by sandstone aquifers separated by lower-permeability siltstone and mudstone aquitards, which locally create semi-confined to confined groundwater conditions. The resulting layered hydrostratigraphic framework controls groundwater occurrence, recharge, flow pathways and groundwater–surface water interactions across the study area.

8.4.2.2 Hydraulic conductivity and porosity

Hydraulic conductivity is a measure of the rate of flow of water through an aquifer or aquitard. Hydraulic conductivity was tested in both the 2014 and 2025 field campaigns. While KCB's 2014 field investigation assessed the area north of the current TSF development area, it was focussed on the Awin Formation and is expected to be representative of the TSF development area.

Complete results are presented in Appendix D. Geometric mean hydraulic conductivity represents the typical permeability of a geological unit while accounting for the large natural variability in measured values. Results are summarised as:

- **Residual soil and weathered rock** – Hydraulic conductivity (K) ranges from 0.0002–2.290 m/day (geometric mean 0.123 m/day), reflecting highly variable shallow subsurface conditions influenced by lithology, degree of weathering, and the presence of macropores, which are relatively large openings, channels, or voids in soil and weathered rock that allow water to move much more rapidly than through the surrounding soil matrix. Higher hydraulic conductivity values generally occur on sandy/gravelly ridges and lower values in clay-rich valleys.
- **Alluvium** – Hydraulic conductivity ranges from 0.049–0.397 m/day (geometric mean 0.109 m/day), with variability attributed to differences in clay versus gravel content within the Ok Tedi floodplain deposits.
- **Sandstone** – Hydraulic conductivity ranges from 0.005–0.864 m/day (geometric mean 0.055 m/day), reflecting the heterogeneous nature of sandstone units, which occur as thick beds or are interbedded with mudstone, conglomerate, or carbonaceous layers; shallower sandstone units generally exhibit slightly higher conductivity than deeper units.
- **Conglomerate** – Hydraulic conductivity was not directly tested, but is expected to be broadly similar to that of the deeper sandstone units based on lithological characteristics.
- **Siltstone and mudstone** – Hydraulic conductivity ranges from 0.001–0.075 m/day (geometric mean 0.021 m/day), reflecting their finer-grained nature; these lower-permeability units commonly act as aquitards and contribute to semi-confined groundwater conditions.

8.4.2.3 Structural features and potential groundwater controls

Three interpreted structural lineaments (faults) have been identified from geological mapping, aerial imagery and geophysical investigations. Their presence and hydraulic significance remain unconfirmed but they may influence groundwater flow and spring occurrence. These features are (Figure 8.16):

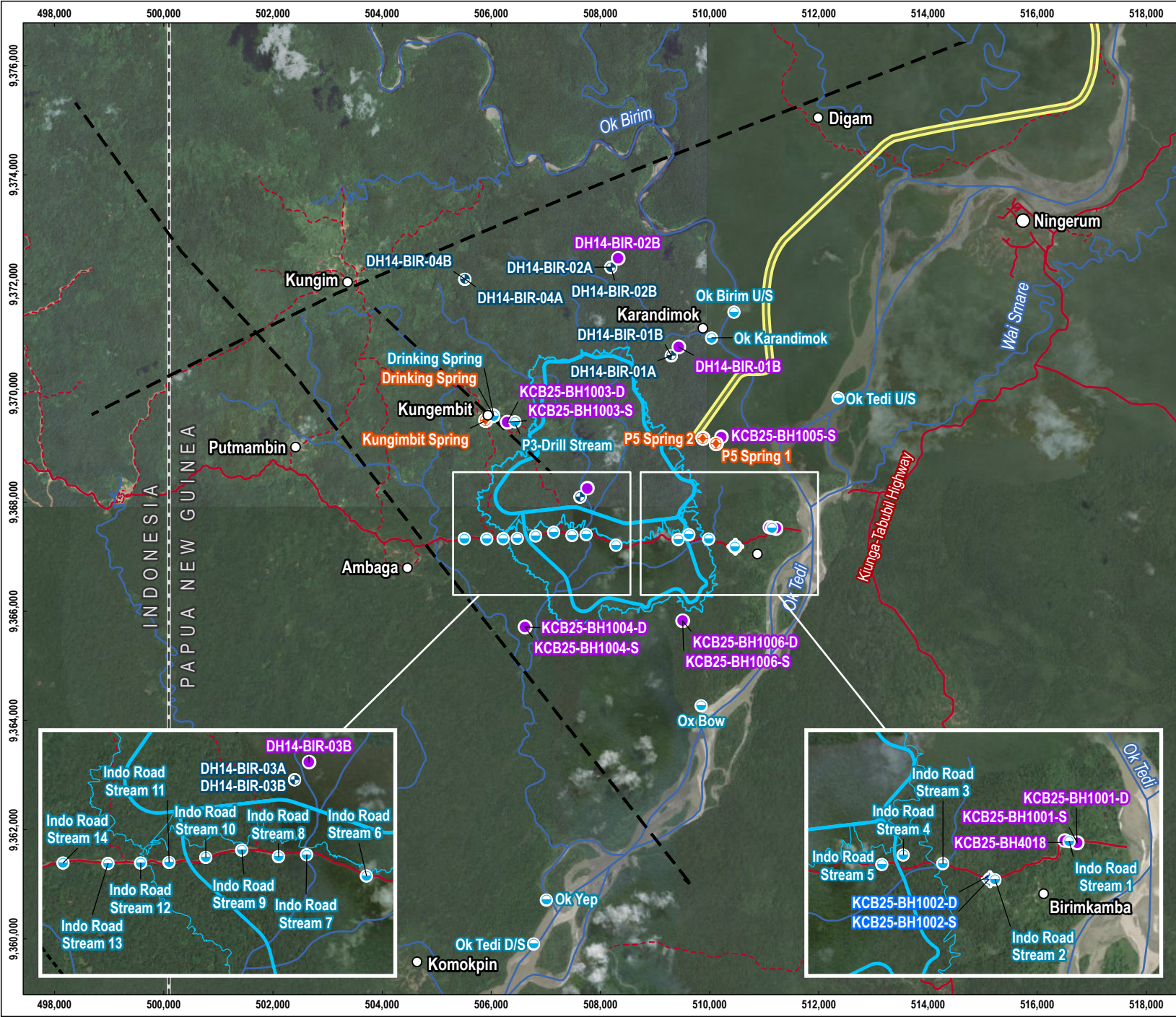
1. Running northwest-southeast through Kungembit into the TSF development area.
2. Running northwest-southeast from the northwest of Ambaga into the TSF development area.
3. Running northeast-southwest from the northwest of Ambaga, north of the TSF development area and past the confluence between Ok Birim and Ok Awut towards Ok Taub.

The features collectively form a cross-cutting structural framework across the area and may play an important role in controlling groundwater flow in the subsurface, and may be related to the springs observed at Kungembit.

8.4.3 Groundwater recharge and discharge

Groundwater recharge and discharge processes within the study area are strongly influenced by the region's high rainfall, topography, hydrostratigraphy, soil characteristics, and vegetation cover. The hydrogeological system is characterised by dynamic interactions between rainfall, surface water, shallow groundwater, and deeper aquifer units, resulting in both localised and regional groundwater flow pathways. Key recharge mechanisms include:

- **Rainfall infiltration:** This represents the dominant source of recharge across the study area. The high annual rainfall promotes infiltration into residual soils and weathered rock, particularly on sandy and gravelly ridge crests where permeability is relatively high. Measured groundwater levels indicate predominantly downward vertical hydraulic gradients in these upland areas, confirming that recharge occurs through the movement of water from the shallow groundwater system into deeper aquifer units. Recharge rates are spatially variable and are influenced by topography and lithology, with lower recharge expected in areas underlain by low-permeability mudstone and shale units, where increased surface runoff limits infiltration.
- **Groundwater-surface water interactions:** Most streams and rivers within the study area are interpreted to be gaining systems, meaning that groundwater discharges into surface water channels and sustains streamflow through baseflow. However, during periods of high flow or flooding, and within some ephemeral headwater streams, surface water levels may exceed groundwater levels, resulting in temporary losing conditions where water infiltrates through streambeds and recharges the underlying groundwater system. These exchanges occur within the hyporheic zone, the area beneath and adjacent to stream channels where groundwater and surface water mix and interact.
- **Interflow and throughflow:** These processes involve the lateral movement of infiltrated rainfall through shallow soils and highly weathered materials above the regional water table. Driven by gravity, this water moves downslope through permeable near-surface layers and may either infiltrate further to recharge groundwater or emerge as seepage and springs along hillslopes and valley margins. Interflow is particularly important where less permeable subsurface layers impede vertical drainage and promote lateral movement of water.
- **Vertical leakage:** This may occur between units across semi-confined geological layers. Where low-permeability siltstone and mudstone units occur, groundwater can move between aquifers through the confining layer in response to differences in groundwater pressure (hydraulic head). Depending on local hydraulic gradients, this leakage may occur either upward or downward, facilitating hydraulic connection between shallow and deeper groundwater systems. Evidence for this connectivity is provided by groundwater chemistry, which indicates mixing between younger shallow groundwater and older deeper groundwater in intermediate-depth monitoring bores.



LEGEND

- Community
- Road
- - - Track
- Watercourse
- - - Fault
- - - International border
- Proposed TSF footprint
- ▭ Proposed infrastructure corridor

Water sample location (2014)

- Borehole

Water sample location (2026)

- Bore
- Groundwater
- Spring
- Surface water

SOURCE

Villages from Tetra Tech Coffey.
Borehole locations & proposed infrastructure from KCB & OTML.
Faults from KCB.
Topographic features from OSM.
DEM from SRTM. Imagery from Google Earth and ESRI.



0 1 2 km
SCALE 1:100,000
PAGE SIZE: A4
PROJECTION: PNG94 PNGMG94 Zone 54

OK TEDI MINING LIMITED

OK BIRIM TAILINGS STORAGE FACILITY PROJECT

FIGURE 8.16

Boreholes and key features in the TSF development area



DATE: 21.06.26 PROJECT: 754-MELN374244 FILE: 374244C_R08_F08.16 GIS

Although groundwater recharge is difficult to quantify precisely in this environment, infiltration testing demonstrates spatial variability. Higher infiltration rates were recorded on ridge crests where soils are generally sandier and better drained, whereas substantially lower rates were measured in valley-floor settings where clay-rich soils remain saturated for extended periods. This is consistent with observed groundwater conditions and the conceptual model of recharge occurring primarily in elevated upland areas.

Groundwater discharge occurs where groundwater emerges at the land surface or enters surface water systems. Key discharge mechanisms include:

- **Baseflow:** The dominant discharge mechanism within the study area is discharge to streams and rivers as baseflow, particularly along valley floors where groundwater levels are typically shallow and often occur within one metre of the ground surface. This groundwater contribution maintains perennial streamflow and supports the extensive drainage network that traverses the study area.
- **Springs and seepage zones:** This occurs where groundwater flow intersects the ground surface along hillslopes, valley margins, and structural features. Springs provide an important water resource for local communities, including those at Kungembit, where spring water is harvested for domestic use. The occurrence of springs reflects the shallow nature of the groundwater system and the strong interaction between groundwater and surface water within the catchment.
- **Evapotranspiration:** Groundwater can be removed from the subsurface through evaporation and uptake by vegetation. This process typically occurs where groundwater levels are shallow and accessible to plant root systems.

8.4.4 Groundwater systems

8.4.4.1 Regional groundwater

Regional groundwater flow is interpreted to broadly follow topography from the northern highlands toward the southern floodplains. Locally, groundwater flow is strongly influenced by ridge-valley topography, lithological heterogeneity and interactions with surface water features.

The regional flow system is recharged in mountainous areas and low-lying areas with permeable rock units. Groundwater flows through deep bedrock and discharges in major drainage features in the plains south of the study area. Movement in deep bedrock occurs through faults, fractures (secondary porosity), and permeable rocks like sandstone and conglomerate.

8.4.4.2 Shallow groundwater system

The shallow groundwater system is strongly influenced by the region's exceptionally high rainfall and responds rapidly to precipitation events. Following rainfall, water infiltrates through the soil and weathered rock, causing groundwater levels to rise quickly before gradually declining over the following hours to days as water drains toward streams, rivers, and deeper groundwater zones. This rapid rise and fall in groundwater levels demonstrates a highly dynamic groundwater system with a close connection to surface recharge processes. The extent and timing of groundwater level fluctuations vary across the site depending on local physical conditions, including topography, weathering profile and lithology.

The shallow groundwater system is hosted within residual soils and weathered rock and forms the principal groundwater recharge zone. Groundwater movement generally follows topography, with groundwater levels commonly occurring within 1 to 4 m of ground surface and discharging to streams, springs and seepage zones along valley floors.

Monitoring data indicate that groundwater behaviour differs significantly between ridges and valleys. At ridge-top locations, groundwater levels show rapid and high-magnitude fluctuations following rainfall events.

These areas typically act as recharge zones where rainfall readily infiltrates into the subsurface and moves downward into the groundwater system. In contrast, locations underlain by lower-permeability materials exhibit slower and more subdued responses as these materials restrict the movement of water.

Groundwater behaviour in valley settings differs from that observed on ridges. Valley-floor areas generally experience smaller groundwater level fluctuations despite receiving substantial recharge. This is attributed to higher hydraulic conductivity, deeper weathering, and stronger hydraulic connectivity with nearby streams. Where hydraulic conductivity is relatively high, groundwater can move more freely through the subsurface, allowing rainfall-derived recharge to be rapidly transmitted to adjacent drainage features. As a result, groundwater levels tend to remain relatively stable because excess recharge is efficiently discharged to nearby streams. Weathered materials in valley areas are often more deeply developed and may contain sandy horizons that further enhance groundwater movement.

In some locations, groundwater levels periodically rise to the ground surface during prolonged or intense rainfall events. This occurs when the residual soil and weathered rock zone becomes fully saturated. Once saturation is reached, additional rainfall cannot be stored within the subsurface and groundwater levels rise to, or very close to, the land surface. This saturation-and-drainage cycle is characteristic of the high-rainfall environment at the site and contributes to the generation of seepage, springs, and stream baseflow.

Along the Ok Tedi floodplain, groundwater occurs within an alluvial aquifer. The silt, sand and gravel materials that form the alluvial aquifer generally possess relatively high permeability and hydraulic conductivity, allowing them to store and transmit significant quantities of groundwater. The alluvial aquifer is hydraulically connected to the Ok Tedi River, indicating that groundwater and river water can readily interact and exchange water. Consequently, groundwater levels within the floodplain aquifer are strongly influenced by the water level of the river. When river levels rise during periods of high flow, groundwater levels in the adjacent alluvial deposits may also rise; similarly, when river levels fall, groundwater levels in the aquifer may decline. This close relationship reflects the strong interaction between surface water and groundwater systems within the floodplain environment.

8.4.4.3 Deep groundwater system

The deeper groundwater system is primarily replenished through recharge. In the TSF development area, recharge occurs within the shallow groundwater system hosted in residual soils and weathered rock. A portion of this groundwater then migrates downward into deeper geological units through downward leakage or vertical recharge. This indicates that the deeper groundwater system is largely dependent on water entering from above, rather than being supplied by regional upward flow, where groundwater moves upward from deeper formations under pressure.

Measurements from paired shallow and deep monitoring bores demonstrate hydraulic connectivity between the shallow and deeper groundwater systems, suggesting water can move between geological units and that the two systems are not completely separated. Groundwater levels in these bore pairs consistently show a downward vertical hydraulic gradient, meaning that groundwater pressure or water levels are generally higher in the shallow system than in the deeper system.

The deeper groundwater system is generally described as unconfined to semi-confined. An unconfined aquifer is one where groundwater is directly connected to the surface through permeable soils or rocks, allowing water levels to respond relatively quickly to rainfall. A semi-confined aquifer is partially separated from overlying groundwater by layers of lower permeability that slow groundwater movement but do not completely prevent it. Locally confined conditions occur where low-permeability siltstone and mudstone layers form barriers to groundwater flow. These low-permeability layers act as aquitards, which are geological units that restrict the movement of groundwater and can partially separate aquifers from one another.

Where aquitards are present, groundwater can become pressurised beneath the confining layers, resulting in artesian conditions. Artesian pressure occurs when groundwater in a confined aquifer is under sufficient

pressure that water levels in a bore rise above the depth at which the groundwater-bearing unit is encountered. In some cases, the water level may rise close to, or even above, ground surface. Artesian pressures were observed in several deeper groundwater monitoring locations and are interpreted to result from recharge occurring at higher elevations, particularly along surrounding ridges. Water infiltrating at these elevated recharge areas moves downgradient beneath confining layers, generating pressure within the deeper aquifer system. Although local recharge from adjacent ridges appears to be the primary cause of these artesian conditions, deeper groundwater pressures may be influenced by broader regional groundwater flow patterns.

Groundwater quality data indicate that deeper groundwater has a longer residence time and greater interaction with geological materials than shallow groundwater. This is reflected by the transition from calcium-bicarbonate water types in shallow groundwater to sodium-bicarbonate water types at depth.

8.4.4.4 Groundwater–Surface Water Interaction

Groundwater and surface water are closely interconnected throughout the study area. Groundwater discharge contributes baseflow to streams and rivers, sustaining perennial flow conditions during periods of reduced rainfall. Springs and seepage zones occur where groundwater flow intersects the land surface, particularly along valley margins and structural features. Groundwater levels are generally shallow near drainage lines and many smaller streams exhibit water quality characteristics similar to groundwater, indicating that they are sustained by groundwater discharge. In contrast, the Ok Tedi appears to be more strongly influenced by rainfall runoff and upstream inflows. The strong hydraulic connection between groundwater and surface water systems is an important consideration for local water resources and environmental values.

8.4.5 Groundwater quality

Ongoing mining activities and non-mining land uses, such as agriculture, waste disposal and villages, have the potential to influence groundwater quality. Contaminants may enter the groundwater system through infiltration to underlying aquifers, or as runoff to surfaces or waterways that interact with groundwater systems.

Most of the groundwater study area is isolated from OTML mining activities and other potentially contaminating land uses. Known and potential sources of groundwater contamination in the study area include:

- Seepage and infiltration of contaminated runoff from hardstand areas and roads.
- Seepage and infiltration from the open pit, waste rock and tailings.
- Accidental or unplanned spills or leaks of hazardous materials.
- Small-scale or informal land use activities in and around villages, such as local waste disposal or fuel storage.
- Alluvial mining, particularly near the confluence of Ok Birim and Ok Tedi (northwest of Birimkamba) and the confluence of Ok Ma and Ok Tedi.

Groundwater quality monitoring has been undertaken at monitoring bores within the proposed TSF development area. The following subsections summarise the baseline groundwater quality results, with the full dataset provided in Appendix D.

8.4.5.1 pH and EC

Groundwater quality is generally good and characterised by near-neutral pH and low salinity. Measured pH values typically range from slightly acidic to neutral (approximately pH 6.0–7.7), indicating natural groundwater conditions with limited evidence of acidification. Electrical conductivity (EC), an indicator of

dissolved salts in water, is generally low, ranging from approximately 40 to 407 $\mu\text{S}/\text{cm}$, reflecting fresh groundwater with relatively low concentrations of dissolved constituents. Isolated anomalous results were recorded at one monitoring bore (KCB25-BH1003-D), where elevated pH and EC values were likely to be influenced by drilling materials rather than representative of ambient groundwater conditions.

8.4.5.2 Major ions

Groundwater is dominated by calcium-bicarbonate and sodium-bicarbonate water types, with generally low concentrations of chloride and sulfate. Chemical composition varies with depth, reflecting the evolution of groundwater as it moves through the subsurface. Shallow groundwater is typically calcium-bicarbonate in character, which is indicative of relatively young groundwater that has undergone limited interaction with geological materials. In contrast, deeper groundwater tends to be sodium-bicarbonate in composition, reflecting longer residence times and increased interaction between groundwater and the surrounding rock. Spring water sampled in the study area exhibits an intermediate composition between these two groundwater types, suggesting mixing between shallow and deeper groundwater systems.

8.4.5.3 Metals

Groundwater contains very low concentrations of dissolved metals, with most analytes below laboratory detection limits, indicating largely natural groundwater conditions with minimal anthropogenic influence. Iron and manganese were the most commonly detected metals and are consistent with natural groundwater interacting with local soils and rock formations. Trace concentrations of barium and strontium are also present and are interpreted to reflect groundwater interaction with clay-rich and carbonate-bearing lithologies that occur within the Awin Formation and associated weathered materials.

8.4.5.4 Comparison with surface water and spring water quality

Surface water and spring water quality is generally consistent with natural conditions and exhibits many similarities to the groundwater system. Surface waters are typically neutral to slightly alkaline, although some small streams within the proposed TSF area display mildly acidic conditions. Electrical conductivity values are generally low, indicating fresh water with low concentrations of dissolved constituents, although the larger Ok Tedi and Ok Birim watercourses exhibit higher conductivity than smaller tributaries, reflecting differences in source areas and catchment characteristics.

Results indicate that surface waters range from calcium-bicarbonate to sodium-bicarbonate types, similar to the groundwater system. The geochemical similarity between many streams, springs, and groundwater samples suggests strong hydraulic connectivity and supports the interpretation that smaller streams are sustained by groundwater discharge (baseflow). Springs and streams in the Kungembit area display geochemical signatures that indicate a potential vertical connection between shallow and deeper groundwater systems. In contrast, the Ok Tedi exhibits a geochemical signature more closely aligned with rainfall-derived runoff and upstream inflows than with local groundwater. Groundwater, surface water, and spring water analytical results are provided in the Appendix D.

8.4.6 Groundwater uses

Communities in the project area, including Kungembit, Birimkamba, Ambaga, and Karandimok rely on springs, streams, and shallow groundwater for water supply, with these sources being sustained by baseflow from and hydraulically connected to the shallow groundwater system. Groundwater is abstracted from dug wells and springs, and a limited number of supply bores for drinking, cooking, washing, gardening, livestock and other domestic needs.

Shallow aquifers in the study area contribute baseflow to the Ok Birim and Ok Tedi and to local springs and seeps, sustaining streamflow and aquatic habitats during dry periods. This groundwater contribution maintains streamflow during dry periods and therefore underpins the reliability of surface water sources that communities use.

8.4.7 Groundwater dependent ecosystems

Groundwater dependent ecosystems (GDEs) are receptors that rely wholly or partially on groundwater to provide all or some of their water needs. GDEs are categorised as:

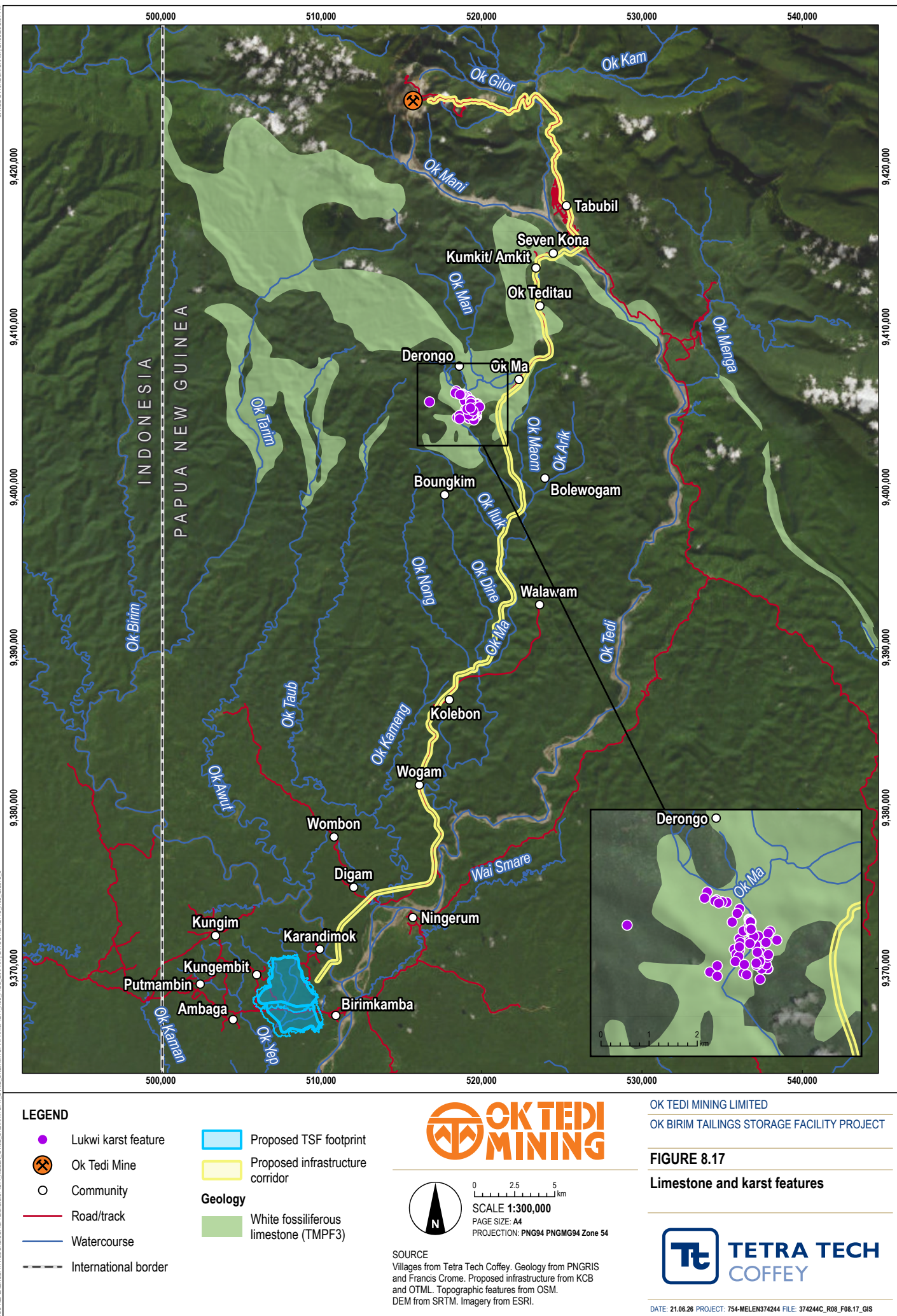
- Terrestrial: Ecosystems reliant on the subsurface presence of groundwater (i.e., vegetation that is accessing the water table and/or capillary fringe). The dependency of terrestrial GDEs ranges from entirely dependent to partially/seasonally dependent.
- Aquatic: Ecosystems reliant on the surface expression of groundwater (i.e., wetlands and baseflow fed watercourses).
- Subterranean: Ecosystems present in caves and aquifers.

Vegetation that accesses the water table and/or capillary fringe typically occurs where groundwater depth is near surface or where the vegetation has sufficient rooting depth to access deeper groundwater. Springs often have terrestrial or aquatic ecosystems that rely on groundwater discharge or near-surface groundwater.

While no dedicated assessment of GDEs has been undertaken for the project area, groundwater-dependent ecosystems may occur within the TSF development area and infrastructure development corridor. The plant-available water capacity of soils is very high, with high and relatively consistent rainfall contribution. Therefore, the water in soils is likely to be sufficient to maintain terrestrial vegetation water requirements, such as for sago, and limited reliance on groundwater as a primary source of water is expected except during periods of drought.

Likewise, while groundwater contributes baseflow to surface flow (see Section 8.4.4.4), sustaining perennial flow conditions during periods of reduced rainfall, the high and relatively consistent rainfall contribution means it is unlikely there are aquatic ecosystems solely dependent on groundwater.

Subterranean GDEs in PNG are typically associated with limestone aquifers and karst features, such as caves or dissolution cavities. The pipeline intersects the PNGRIS geological unit white fossiliferous limestone, partly tuffaceous with marl interbeds south of Tabubil near Kumkit, through Ok Ma, towards Boungkim. This unit is associated with mapped Lukwi karst features near the Ok Ma, approximately 1 km from the pipeline alignment that has been designed to avoid them (Figure 8.17). This unit generally corresponds to Warre Limestone Member, the uppermost unit of the Pnyang Formation. This unit is extensively karstified in some areas (KCB 2015a). Given pipeline trenching will be 1 to 2 metres deep there is no credible subterranean GDEs relevant to the project.



8.5 AQUATIC ECOLOGY

This section provides a description of aquatic ecology within the project area and surrounds, including aquatic habitat conditions, species composition, and ecological functions. The information presented is based on historical data collected in association with the existing OTML operations, the preliminary aquatic ecology characterisation studies undertaken by Wetland Research & Management (WRM) in October 2014 and March 2015 (during pre-feasibility studies for the project), and recent data collected by SLR in 2025-2026 specifically for this EIS (Appendix E).

Fish biomass and diversity are used as an index of the 'health' of the aquatic ecosystem downstream of the Ok Tedi Mine and has implications from a resource use perspective. Declines in fish biomass and diversity (species richness) have been documented by OTML in the main channels and floodplain ORWBs since mining commenced in 1984. Reductions in fish biomass and diversity are due primarily to the loss or degradation of fish habitats as a result of riverbed aggradation and sedimentation. A secondary impact to fish biomass and diversity has been through mine-imposed deteriorations in water quality as a result of sustained high levels of suspended sediment concentrations and, to a lesser extent, AMD and particulate and dissolved copper.

The main Ok Tedi is currently impacted by existing mine operations. The OTML Annual Reports indicate that the ongoing disposal of riverine tailings and waste rock continues to affect the Ok Tedi system, including downstream communities, their livelihoods, and the environment. The impacts associated with riverine disposal include riverbed aggradation, increased sediment loads and elevated TSS, resulting in significant loss of water quality and reductions in aquatic biomass. These impacts have been monitored and managed under the OTML environmental regime and associated compliance conditions. The recent 2025/26 study also observed highly turbid conditions in the Ok Tedi, with impacts observed along the downstream environments.

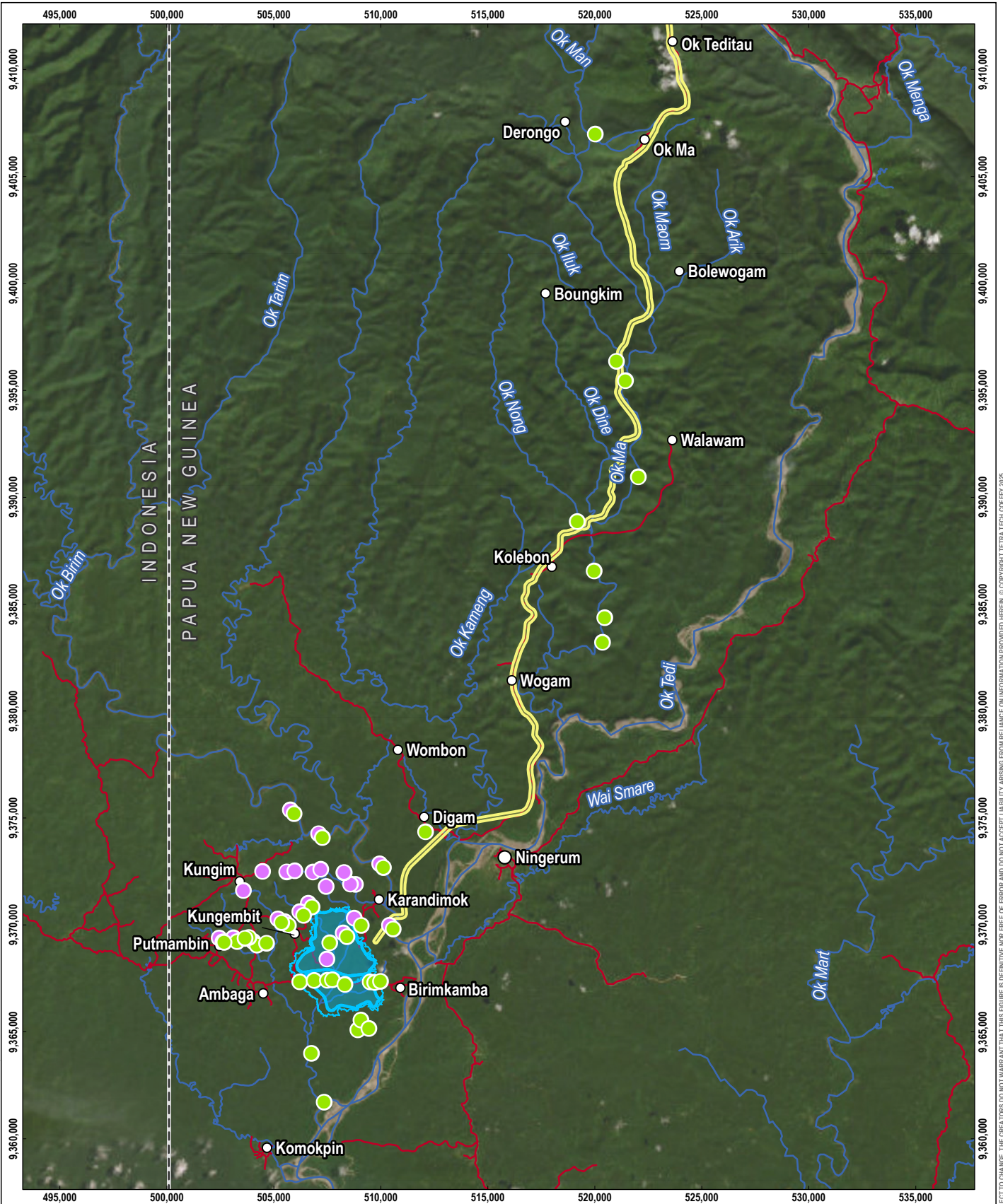
8.5.1 Study area

Figure 8.18 shows the sampling locations in the TSF development area and infrastructure corridor development area. Appendix E separates sites into two categories, Ok Birim TSF and Ok Ma associated infrastructure corridor. This chapter separates sites slightly differently, incorporating sites from the main Ok Birim channel (OB1 to OB4) in the infrastructure development corridor discussion, as the corridor crosses the main channel, while the TSF is located outside the Ok Birim catchment.

8.5.1.1 TSF development area

The TSF development area comprises freshwater systems within and downstream of the proposed TSF footprint and the broader Ok Birim area. Aquatic fauna surveys undertaken in 2025 were designed to characterise aquatic ecosystems both within and outside the area potentially influenced by the proposed TSF, reflecting changes to the TSF general arrangement and the need to update information collected during pre-feasibility studies.

The 24 sampling sites in the TSF development area were distributed across the associated tributary creek systems (see Figure 8.18). Sampling locations were classified as either potentially exposed or reference based on their spatial relationship to the proposed TSF footprint. Sites classified as potentially exposed are located within or downstream of the intended TSF footprint, while reference sites are located outside the area of potential influence.



LEGEND

- Aquatic survey site (SLR, 2026)
- Aquatic survey site (WRM, 2014)
- Community
- Road/track
- Watercourse
- International border
- Proposed TSF footprint
- Proposed infrastructure corridor



0 2.5 5 km
SCALE 1:250,000
PAGE SIZE: A4
PROJECTION: PNG94 PNGMG94 Zone 54

SOURCE
Villages from Tetra Tech Coffey. Survey sites from SLR and WRM.
Proposed infrastructure from KCB and OTML.
Topographic features from OSM.
DEM from SRTM. Imagery from ESRI.

OK TEDI MINING LIMITED

OK BIRIM TAILINGS STORAGE FACILITY PROJECT

FIGURE 8.18

Location of aquatic ecology study area



DATE: 21.06.26 PROJECT: 754-MELN374244 FILE: 374244C_R08_F08.18 GIS

Of the sites sampled in 2025, eight locations were retained from surveys conducted in 2014/15, with an additional 16 new sites added to reflect the revised TSF location and expanded study area coverage. This approach allowed continuity with historical datasets while extending spatial coverage to address changes in project design.

In addition to the primary sampling locations, several opportunistic sites were sampled for fish fauna only to investigate the presence of the cryptic species Fly River rainbowfish (*Melanotaenia sexlineata*). These additional locations are supplementary to the core study area and are described separately in the aquatic fauna results.

8.5.1.2 Infrastructure development corridor

The study area within the infrastructure development corridor focuses on freshwater ecology along the Ok Ma, nearby watercourses, and the section of the main Ok Birim channel intersected by the infrastructure corridor. The watercourses are located near the 85-km-long pipeline that will connect the tailings processing plant at the mine site to the proposed TSF.

A total of 13 sampling locations were surveyed along the infrastructure development corridor, comprising nine Ok Ma sites (OM1 – OM9) and four sites within the main Ok Birim channel (OB1 – OB4). The sampling framework incorporated sites OB1 to OB3 from surveys conducted in 2014/15, while OB4 and all Ok Ma sites were newly established to reflect the infrastructure development corridor alignment. While no previous fish or aquatic surveys have been conducted across the Ok Ma study area, adjacent catchments at Ok Ma have been used as referenced sites in the earlier OTML community health and dietary studies. These studies primarily focused on mine-exposed communities at Ningerum and along the Ok Tedi, with Ok Ma used as a comparative reference for fish consumption due to its relatively low-level of mining impacts.

8.5.2 Aquatic habitats

Aquatic habitat characteristics were assessed at each sampling location to characterise physical and geomorphic conditions across the study area. Habitat assessments were undertaken in accordance with the Australian Monitoring River Health (AusRivAS) protocol, which provides a standardised rapid assessment of geomorphological features, in-stream habitat, and riparian condition. At each site, aquatic substrate composition and in-stream habitat features were recorded. Water and sediment samples were collected at the same time as aquatic ecology surveys with the results of this described in sections 8.3.3 and 8.3.4.

8.5.2.1 TSF development area

Tributary and headwater creek sites within and adjacent to the proposed TSF footprint were generally narrow (<5 m wide), shallow (<1.5 m deep), and slow flowing, with dense overstorey and canopy cover. These smaller creek systems (Plate 8.16 and Plate 8.17) represent forested headwater environments distinct from the larger open-water habitats of the Ok Birim (Plate 8.18).

Most reference sites adjacent to the proposed TSF are dominated by substrate of smaller gravel (4 to 16 mm) and sand (1 to 4 mm), apart from OB17, where bedrock was observed. Most of the potentially exposed creek sites are dominated by finer gravel and sand, with higher clay deposits occurring along the creek lines. Tributary and headwater creek sites at both reference and potentially exposed sites contained variable habitat features, including submerged macrophytes (up to 40% cover) and woody debris (up to 30% cover).

Plate 8.16
Aquatic ecology site OB16 in the
Ok Yep catchment



Photo credit: SLR 2026

Plate 8.17
Aquatic ecology site OB09B in the
Ok Yep catchment



Photo credit: SLR 2026

Plate 8.18
Aquatic ecology site OB1 in the Ok Birim
main channel



Photo credit: SLR 2026

8.5.2.2 Infrastructure development corridor

Sampling sites in the study area along the infrastructure corridor and reference tributaries varied in morphology, substrate and habitat composition.

Sites located along the main Ok Birim channel were characterised by wide (>5 m), deep (>2 m) channels with fast-flowing water and minimal canopy cover. These sites, comprising OB1 to OB4, reflected a greater proportion of coarse substrates, including bedrock, cobbles (64 to 265 mm), and pebbles (16 to 64 mm). Sites OB1 to OB4 were also associated with higher river velocities and predominantly mineral substrates with limited detritus cover, resulting in relatively low habitat diversity. Algal cover was limited, with 6% cover recorded only at reference sites OB2 and OB3.

Ok Ma sites were comparable to Ok Birim, with a high dominance of mineral substrate relative to detritus. Bed structures at the three Ok Ma reference sites are characterised by a mixture of larger substrates, including cobbles (64 to 256 mm) and sand (1 to 4 mm). Bedrock was observed at OM3 and OM6 (Plate 8.19). OM4 is the only potentially exposed site where boulders (>265 mm) were recorded (Plate 8.20). All potentially exposed Ok Ma sites contained larger substrate with interstitial sand and silt elements.

Habitat diversity varied across the Ok Ma sites. OM5 was characterised by the largest proportion of mineral substrate and minimal coverage for large woody debris making it the site with lowest habitat diversity. Reference site OM3 was the only site where algal presence was recorded, covering 25% of habitat composition. Submerge macrophytes accounted for approximately 10% of the habitat cover and were observed only at OM3 and OM12. Large woody debris were observed at all sites, with OM12 representing the highest cover (20%). In addition, the sites (OM3 and OM12) are the only sites with submerged macrophytes, representing the highest habitat diversity across the Ok Ma sites (Plate 8.21).

8.5.3 Aquatic flora

Aquatic macrophytes were assessed qualitatively during habitat surveys, with dominant taxa photographed and identified to the lowest practicable taxonomic level. The distribution of macrophytes was recorded at each site to support comparison across exposed and reference locations.

8.5.3.1 TSF development area

Aquatic flora within the study area was limited in diversity. Two macrophyte taxa were observed at creekline sites. These included a native water lily (*Nymphaea cf. elleniae*) and an unidentified species of *Vallisneria sp.* Submerged macrophyte coverage varied between sites. The limited diversity and distribution of aquatic macrophytes is consistent with shaded headwater creek environments.

8.5.3.2 Infrastructure development corridor

Aquatic flora within the infrastructure development corridor was also limited in diversity.

The macrophyte taxa within infrastructure corridor were the same for those recorded in the TSF development area. Two notable macrophyte observed were the *N.cf. elleniae*. and the *Vallisneria sp.*

At OM3, macrophyte species occurred along the creeklines at equal distribution, collectively representing 10% cover. At OM12, only *Vallisneria sp.* was recorded, with a total cover of 5%. No macrophytes were observed at the remaining sites, including the larger, fast-flowing Ok Birim sites.

Plate 8.19
Aquatic ecology site OM6 in the
Ok Ma catchment



Photo credit: SLR 2026

Plate 8.20
Aquatic ecology site OM4 in the Ok Ma
main channel



Photo credit: SLR 2026

Plate 8.21
Aquatic ecology site OM12 in the
Ok Ma catchment



Photo credit: SLR 2026

8.5.4 Aquatic fauna

Aquatic fauna within the study area comprises macroinvertebrate and fish assemblages associated with both the main Ok Birim channel and its tributary creek systems. Each are discussed in this section.

8.5.4.1 Macroinvertebrates

Sampling for macroinvertebrates was conducted as part of the study to characterise aquatic fauna within the study area. Macroinvertebrate fauna were sampled using a 250 µm mesh Freshwater Biological Association (FBA) pond net, with sampling conducted across all available habitats at each site to maximise taxa representation. Samples were washed through a 250 µm sieve to remove fine sediments, preserved in 70% ethanol, and retained for laboratory processing.

At the time of ESIA preparation, laboratory analysis of samples collected from 2025 survey was still in progress, and the results are not available. A standalone report will be prepared following completion of laboratory analysis.

Macroinvertebrates play an important role as key indicators in the bioassessment of stream and river health. The baseline aquatic fauna survey undertaken in 2014/15 documented macroinvertebrate communities across the Ok Birim study area, including adjacent creeks located within and downstream of the TSF footprint. The Ok Ma study area was not included in the 2014/15 survey. The survey at Ok Birim recorded a total of 226 macroinvertebrate taxa across 25 sampling sites. The taxa recorded are within 11 higher-level groupings listed in Table 8.13. The taxa listed include groups that could not be identified further down to species level, due to unresolved taxonomy (WRM 2016).

Table 8.13 Freshwater macroinvertebrate taxonomy at Ok Birim

Group	Common name
Nematoda	Round worms
Mollusca	Freshwater snails
Oligochaeta	Freshwater segmented worms
Decapoda crustaceans	Freshwater shrimp, prawns and crayfish
Odonata	Dragonflies and damselflies
Ephemeroptera	Mayfly larvae
Hemiptera	Aquatic true bugs
Coleoptera	Freshwater beetles
Diptera	Fly larvae
Trichoptera	Caddisfly larvae
Lepidoptera	Aquatic moth larvae

The macroinvertebrate assemblages of the study area represented a rich taxonomy with spatial variability. The low richness (15 taxa) was recorded at site OB3. Site OB3 is located within the main Ok Birim channel and is characterised by low habitat diversity. The site condition is influenced by factors including high turbidity and elevated TSS, which directly affect the suitability of the freshwater system for macroinvertebrate persistence. Habitat diversity is a critical aspect that supports freshwater invertebrate communities and trophic structure, including greater taxonomic richness (Bis *et al.* 2000; Miserendino 2001, cited in WRM 2016).

In contrast, sites located within smaller tributary creeks recorded high macroinvertebrate richness. Site OB12 recorded the highest richness (77 taxa), followed by OB10 (73 taxa), with OB5 and OB22 each recording 65 taxa. These sites are characterised by greater habitat heterogeneity associated with relatively natural

freshwater systems and low levels of disturbance. The presence of macrophytes and large woody debris provides an important habitat for the aquatic macroinvertebrates and richness.

Most macroinvertebrate taxa recorded were of Australian or Indo-Pacific origin. A total of 11 macroinvertebrate taxa of ecological importance were recorded and are known to occur within Papua New Guinea and the wider New Guinea region, including *Caridina* sp.3, *Caridina* sp.4, *Macrobrachium* sp.1, *Macrobrachium lorentzi*, *Creax peknyi* (freshwater crayfish), *Papuanecta minajerwi* (micronectid water boatman), *Cercotmetus dissidens* (water scorpion), *Idocarus isolatus*, *I. papuus*, *Cavocoris minor*, and *Potamophilinus papuanus* (riffle beetle). Several species of damselflies, dragonflies, mayflies, diving beetle, riffle beetle and net-spinning caddisfly were recorded for the first time in this survey and may represent species of conservation significance.

8.5.4.2 Fish

Fish and decapod fauna were surveyed using OTML's standard sampling methods and equipment, comprising a combination of gill netting, seine netting, backpack electrofishing, and dip netting. The methods and equipment were selected to provide consistency with sampling approach and to allow direct comparison of fish data with the OTML's existing aquatic ecology survey datasets.

Smaller-bodied and juvenile fish were targeted using beach seine nets in shallow areas, while electrofishing was used in headwater and forested creek environments. Gill nets were deployed overnight in the lower Ok Birim channel. All fish were identified in the field, measured, and released alive, with selected specimens retained for tissue metal analysis.

The data collected during the 2025 survey were combined with the 2014/15 baseline results to compare spatial distribution and occurrences of fish across the sites project area.

TSF development area

A total of 27 freshwater fish species and one crayfish species were recorded across the 2014/15 and 2025 surveys, comprising 25 native and two introduced fish species. The species recorded are within 12 families, listed in Table 8.14. Family-level taxonomic classification is used for the purpose of analysis, rather than reflecting the full species richness.

Table 8.14 Freshwater fish taxonomy in the TSF development area

Family	Common name	Native/introduced
Apogonidae	Mouth almighty	Native
Ariidae	Fork-tail catfishes	Native
Atherinidae	Hardyheads	Native
Eleotridae	Gudgeon	Native
Gobiidae	Gobies	Native
Melanotaenidae	Rainbowfish	Native
Plotosidae	Eel-tailed catfishes	Native
Pseudomugilidae	Blue-eyes	Native
Synbranchidae	Swamp eels	Native
Zenarchopteridae	Internally fertilized halfbeaks / viviparous halfbeaks	Native
Cichlidae	Cichlids	Non-native
Channidae	Snakeheads	Non-native

Smaller tributary and headwater creeks have more varied and intact habitats, but their small size and shallow, low-flow conditions naturally support fewer fish and lower species diversity. Smaller-bodied rainbowfish, blue-eyes, gudgeons, and hardyheads are the dominated species within the tributary and headwater creeks.

The most frequently recorded species occurring across Ok Birim sites were the New Guinea blue-eye (*Pseudomugil novaeguineae*) and the New Guinea rainbowfish (*Melanotaenia novaeguineae*). Notable species of conservation significance were also recorded. The species include endangered Fly River rainbowfish (*Melanotaenia sexlineata*) (Plate 8.22), the endangered swamp gudgeon (*Oxyeleotris stagnicola*) (Plate 8.23) and Paska's blue-eye (Plate 8.24). The recently described Kiunga blue-eye (*Kiunga leucozona*) (Plate 8.25Plate 8.26), was also considered for high conservation importance due to its restricted distribution and was recorded at multiple creekline sites.

Considering abundance, the fish sampling campaigns conducted during the 2014/15 and 2025 surveys recorded a total of 1,677 individual fish for the TSF development area. The lowest abundance was recorded at OY1, with 13 individuals.

Introduced fish species

Tilapia (*Oreochromis* spp.) is an introduced fish species recorded at one site in the TSF development area (OB18). Specimens were provisionally identified as *O. mossambicus*; however, species-level identity remains uncertain due to potential presence of *O. niloticus*, including farmed strains such as the genetically improved farmed tilapia. With an unknown origin, *Oreochromis* spp. are considered highly invasive and capable of rapidly adapting to and colonising disturbed freshwater systems and tributaries.

Striped snakehead (*Channa striata*) is another non-native freshwater fish recorded at the TSF development area (OB21), where it is considered an introduced species with established wild populations in parts of the Western Province. The species is believed to have been introduced from Indonesia and is highly adaptable to turbid, low-oxygen freshwater environments. As a voracious predator, *C. striata* is capable of rapidly colonising disturbed aquatic habitats and may pose a risk to native fish and other freshwater fauna through predation and competition (Papua New Guinea Department of Conservation, 2017).

Infrastructure development corridor

The Ok Birim main channel is characterised by its wider channel size and permanent flow, and is well connected with its tributaries, making it an important refugia and foraging habitat for many fish species. Despite having less habitat complexity than the smaller tributaries, it supports the highest fish abundance and species diversity recorded during the surveys, including identification of species that are depleted in the Ok Tedi system.

Collectively, a total of 563 individual fish comprising 31 fish species were recorded in the main Ok Birim channel. Larger-bodied species such as fork-tailed catfish and glassfish were confined to the main Ok Birim channel. Site OB4 had the highest abundance, with 270 individuals recorded. The species recorded fall within the taxonomic classifications outlined in Table 8.15.

Table 8.15 Freshwater fish taxonomy in the main Ok Birim channels (OB1 – OB4)

Family	Common name	Native/introduced
Ambassidae	Glassfishes	Native
Apogonidae	Mouth almighty	Native
Ariidae	Fork-tail catfishes	Native
Atherinidae	Hardyheads	Native
Belonidae	Longtoms	Native
Butidae	Gudgeon gobies	Native

Family	Common name	Native/introduced
Channidae	Snakeheads	Non-native
Cichlidae	Cichlids	Non-native
Cynoglossidae	Tonguefishes	Native
Ehiravidae	River sprats	Native
Gobiidae	Gobies	Native
Melanotaeniidae	Rainbowfish	Native
Mugilidae	Mulletts	Native
Plotosidae	Eel-tailed catfishes	Native
Pseudomugilidae	Blue-eyes	Native
Terapontidae	Grunters	Native
Zenarchopteridae	Viviparous halfbeaks	Native

Sampling in Ok Ma study area occurred only during a single 2025 survey. The survey recorded a total of 16 species in eight families distributed across both reference and potentially exposed sites within the infrastructure development corridor. No introduced species were observed. All fish sampled comprised native species that were also recorded across Ok Birim sites. The species recorded fall within the taxonomic classifications outlined in Table 8.16.

Table 8.16 Freshwater fish taxonomy in the Ok Ma study area

Family	Common name	Native/introduced
Apogonidae	Mouth almighty	Native
Atherinidae	Hardyheads	Native
Clupeidae	Herring	Native
Eleotridae	Gudgeon	Native
Hemiramphidae	Garfishes	Native
Melanotaenidae	Rainbowfish	Native
Plotosidae	Eel-tailed catfishes	Native
Terapontidae	Grunters	Native

Ok Ma is characterised by an open channel with deeper, fast flowing water. The species associated with this habitat and recorded during the survey campaign included the Ok Tedi Rainbowfish (*Melanotaenia oktediensis*) (Plate 8.26), toothed river herring (*Clupeoides papuensis*), and striped cheek gudgeon (*Bostrychus strigogenys*) (Plate 8.27). All other species thrived at the tributary creek habitats.

Species richness at individual sites ranged from three to nine species, with the lowest richness recorded at sites OM1 and OM5, and the highest richness recorded at site OM9. A total of 238 individual fish were recorded across all Ok Ma sites. Abundance varied among sites, with the highest abundance recorded at reference site OM6 (58 individuals) and the lowest abundance recorded at exposed site OM5 (seven individuals). Catch rates were influenced by weather conditions, particularly flooding, and site conditions limiting sampling techniques, including the use of gill nets and electrofishing.

The Ok Ma channel represents a refugia habitat for fish species that have migrated from the main Ok Tedi. These species may potentially return to the OK Tedi when the system is improved post-mine closure.

Introduced species

Tilapia (*Oreochromis* spp.) was recorded at two sites in the Ok Birim main channel (OB1 and OB4). Specimens were provisionally identified as *O. mossambicus*; however, species-level identity remains uncertain due to potential presence of *O. niloticus*, including farmed strains such as the genetically improved farmed tilapia. With an unknown origin, *Oreochromis* spp. are considered highly invasive and capable of rapidly adapting to and colonising disturbed freshwater systems and tributaries. *Channa striata* was also identified in the infrastructure development corridor at site OB4.

8.5.4.3 Metal concentrations in fish

Individual fish and crayfish collected from sampled sites were measured infield for length and weight. Larger fish were dissected for liver and muscle tissues. Where dissection was not possible for smaller fish, whole specimens were used. All dissected tissues and whole specimens were analysed at the OK Tedi Mine laboratory.

Samples were freeze-dried and processed using microwave-assisted nitric acid digestion, and analysed for arsenic (As), cadmium (Cd), copper (Cu), lead (Pb), selenium (Se), and zinc (Zn). Metal concentrations were reported on a dry-weight basis (mg/kg) and converted to wet-weight equivalents using a 5:1 ratio to allow comparison with human-health guideline values established by the World Health Organization (WHO) and the Food and Agriculture Organization of the United Nations Joint Expert Committee on Food Additives (WHO JECFA). The guideline assessed values from provisional maximum tolerable daily intake (PMTDI), provisional tolerable weekly intake (PTWI) and provisional tolerable monthly intake (PTMI). The cutoff for human intake is calculated by multiplying PMTDI/PTWI/PTMI by weight in kilograms. This follows the standard method used by OTML for broader aquatic ecology survey work, allowing comparison of results where required.

Table 8.17 outlines the recommended WHO JECFA guideline values for metal concentrations in fish.

Table 8.17 WHO JECFA guideline values for metal concentrations in fish

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				

TSF development area

The analysis was conducted to assess spatial differences in metal concentrations, including species difference in metal concentration and evaluation of the effect of trophic position from fish liver and muscle tissues. The analysis of trophic position was to understand the relationship between trophic level and metal accumulation in fish.

The spatial variation was assessed using mean concentration (± 1 standard error), whereas trophic position and metal concentration used Spearman rank correlation.

The Ok Tedi has been significantly impacted by historical disposal of tailings and waste rock, with impacts extending into downstream sites and tributaries. Site OY01, located in the lower Ok Yep, shows elevated sediment concentrations of copper, zinc, cadmium and lead due to backwater deposition from the Ok Tedi, resulting in poor fish habitat and insufficient fish catch for ecological assessments and tissue analysis.

Plate 8.22
Fly River rainbowfish (*Melanotaenia sexlineata*)



Photo credit: SLR 2026

Plate 8.23
Swamp gudgeon (*Oxyeleotris stagnicola*)



Photo credit: Gerry & Mark Allen

Plate 8.24
Paska's blue Eye (*Pseudomugil paskai*)



Photo credit: Michael Hammer



Photo credit: SLR 2026

Plate 8.25
Kiunga blue-eye (*Kiunga leucozona*)



Photo credit: SLR 2026

Plate 8.26
Ok Tedi rainbowfish (*Melanotaenia oktediensis*)



Photo credit: SLR 2026

Plate 8.27
Striped cheek gudgeon (*Bostrychus strigogenys*)

Cadmium

Cadmium concentrations in fish samples varied across the sites. The highest mean concentrations of cadmium were observed at OB9B, OB28 and OB30; the lowest mean concentrations of cadmium were at OB10 and OB27. Although OB9B had the highest concentration of cadmium, it is below the provisional maximum tolerable daily threshold for 70 kg. All sites have cadmium concentrations below 0.025 mg/kg.

One crayfish (*Cherax* sp.) and one fish species (*Mogurnda cingulata*) had results exceeding the guideline value. The majority of fish species analysed had cadmium concentrations below the mean of 0.05 mg/kg. While higher cadmium concentrations are not common across the sites, follow-up sampling would be required to determine if the high concentration is associated with species biology, feeding behaviour, or limited sample numbers.

The analysis of cadmium reflected a positive correlation with the trophic position. Species at higher trophic levels had greater cadmium concentrations, reflecting the transfer and accumulation of cadmium within the food web.

Copper

Copper concentrations in fish samples varied across the sites. The highest concentrations of copper were recorded at sites OB31 and OB29; the lowest were recorded at OB10, OB27 and OB33. Copper concentrations in all fish species were below the guideline value. Elevated results were observed for *Cherax* sp. but this can occur naturally in crayfish.

Copper concentrations demonstrated a weak but significant positive relationship with trophic position. Although copper concentrations slightly increase in higher-trophic-level species, the weak correlation indicates that the relationship is inconsistent. It is suggested that trophic position plays a secondary role with copper concentration predominantly reflective of background levels.

Lead

Lead concentrations in fish samples varied across the sites. The highest lead concentrations recorded were at sites OB31 and OB34 with the lowest concentrations at OB27 and OB33. The concentrations of lead remained uniformly low with no exceedances of lead guidelines.

There was a moderate positive correlation of lead concentrations with trophic position, suggesting greater accumulation of lead in higher-trophic-level species. This relationship is based on dietary uptake and trophic transfer of lead concentrations between trophic levels.

Selenium

Selenium concentrations in fish samples varied across the sites. OB28 recorded the highest selenium concentrations, with elevated concentrations also observed at OB9B. The lowest selenium concentrations were recorded at OB10 and OB32. Four fish species recorded in this area exceeded the guideline values for selenium: *Oxyeleotris stagnicola*, *Glossogobius concavifrons*, *Mogurnda cingulata* and *Oxyeleotris aruensis*. Selenium was consistently elevated across several fish species; however, elevated selenium concentrations in fish is common in tropical river systems.

Selenium is an essential micronutrient with a tolerable daily intake value of 0.4 mg/day for humans. Selenium concentrations in fish at OB28 exceeded 0.4 mg per kg of fish; however, this does not necessarily mean the daily intake guideline for consumption is exceeded. The daily intake guideline is based on whole-diet consumption of selenium.

When considering typical fish consumption rates of 80 g per meal, selenium intake falls within the tolerable limit and does not impose risks to human health. OTML's long-term monitoring and community health surveys have consistently demonstrated the low dietary intake of selenium, with fish consumption representing an important source of nutrients rather than contaminant pathway. Consequently, the observed selenium exceedances are not considered indicative of adverse ecological or human-health impacts.

The effect of trophic position for selenium shows the strongest positive trophic relationship relative to all other metals. This indicated the strong increase in selenium concentration up the food web consistent with biomagnification.

Zinc

Zinc concentrations in fish samples varied across the sites. The concentration of zinc was elevated at sites OB29, OB30 and OB31. In addition, the analysis shows variability in zinc concentrations among fish species. *Craterocephalus* sp. recorded the highest zinc concentration, with values exceeding 70 mg/kg of fish; however, this does not necessarily mean the provisional maximum tolerable daily intake guideline for consumption is exceeded. The provisional maximum tolerable daily intake guideline range for zinc is 0.3 to 1.0 mg/kg with the reference value of 70 mg/day for a 70 kg adult.

When the typical fish portion size of 80g per meal is considered, zinc intake falls below the provisional maximum tolerable daily intake thresholds. Consistent with OTML's long-term studies, the zinc concentrations do not indicate a human-health risk under realistic dietary conditions.

The analysis of trophic position showed a very strong negative correlation. Zinc concentrations were highest in lower trophic level species and decreased at higher trophic levels. This pattern reflects dietary uptake from lower trophic levels rather than biomagnification.

Arsenic

All arsenic concentrations were below the laboratory detection limit. Therefore, spatial analyses, including assessments by fish species and trophic position, were not performed.

Infrastructure development corridor

Metal concentration analysis was also undertaken in fish from the infrastructure development corridor watercourses.

Cadmium

Cadmium concentrations in fish samples varied across the sites. The highest concentrations were recorded at sites OM3 and OM9 with lowest observed at OM3 and OM12. Cadmium concentration in fish sampled were all below 0.05 mg/kg. This is reflective of a non-disturbed environment.

Unlike at TSF sites, cadmium concentrations have a weak positive correlation with trophic position. Analytical results show the slight increase in concentration at trophic level; however, there are no clear indications of biomagnification. The result could be reflective of background values.

Copper

Copper concentrations in fish samples varied across the sites. Copper concentrations of copper did not exceed the human health risk guideline values for the main Ok Birim channel at any site sampled. Sites OM4 and OM9 recorded highest concentration values in fish followed by the lowest at OM1 and OM3.

Copper concentrations demonstrated negative relationship with trophic position. This indicates higher concentrations of copper at lower-trophic level species and lower concentrations at higher-trophic level species. This is reflective of background values where concentration in species is driven by dietary exposure and physiology as opposed to bioaccumulation.

Lead

Lead concentrations in fish samples varied across the sites. Lead concentrations at all sites, including the main OK Birim and Ok Ma channels, had results below guideline values. The highest concentrations were observed at sites OM4 and OM9 with lowest concentrations recorded at OM3 and OM12. Lead levels were uniformly low and below the guideline threshold for both fish species and crayfish across the sites. The *Melanotaenia rubrostrita* recorded the highest mean concentration of the fish species.

Lead concentrations demonstrated a negative relationship with trophic position. Higher concentrations were recorded below the lower-trophic level species and decreased at higher-trophic level species. There are no indications of biomagnification.

Selenium

Selenium concentrations in fish samples varied across the sites. Analysis of whole fish specimens indicated selenium concentrations exceeded 0.4 mg/kg at sites OM1, OM4, and OM12. Three fish species recorded in the study exceeded the guideline values for selenium: *Glossogobius concavifrons*, *Neosilurus ater*, and *Parambassis gulliveri*. Selenium was consistently elevated across several fish species; however, elevated selenium concentrations in fish is common in tropical river systems.

As for the TSF development area, when considering typical fish consumption rates of 80 g per meal, selenium intake falls within the tolerable limit and do not impose risks to human health.

Consistent elevation of selenium concentrations was observed across species, represented a positive relationship with trophic level. With limited evidence of biomagnification, the spatial difference in higher concentrations may be associated with dietary and physiological uptake within the food web rather than point-source contamination.

Zinc

Zinc concentrations in fish samples varied across the sites. Zinc concentrations were highest at sites OM3 and OM4, and lowest at OM12 and OB4. The concentration per kg of fish at all sites was below the reference value of 70 mg/day for a 70 kg adult. No species had zinc concentrations exceeding guideline threshold values. Consistent with OTML's long-term studies, the recorded zinc concentrations do not indicate a human-health risk under realistic dietary conditions.

In addition, the effect of trophic level showed a significant negative correlation, indicating limited or no accumulation of zinc within the food web, as higher-trophic level species reflected lower concentrations. This relationship is likely due to dietary uptake from basal food consumers.

Arsenic

All arsenic concentrations were observed below the laboratory detection limit. Therefore, spatial analyses, including assessments by fish species and trophic position, were not performed

8.5.4.4 Conservation significance

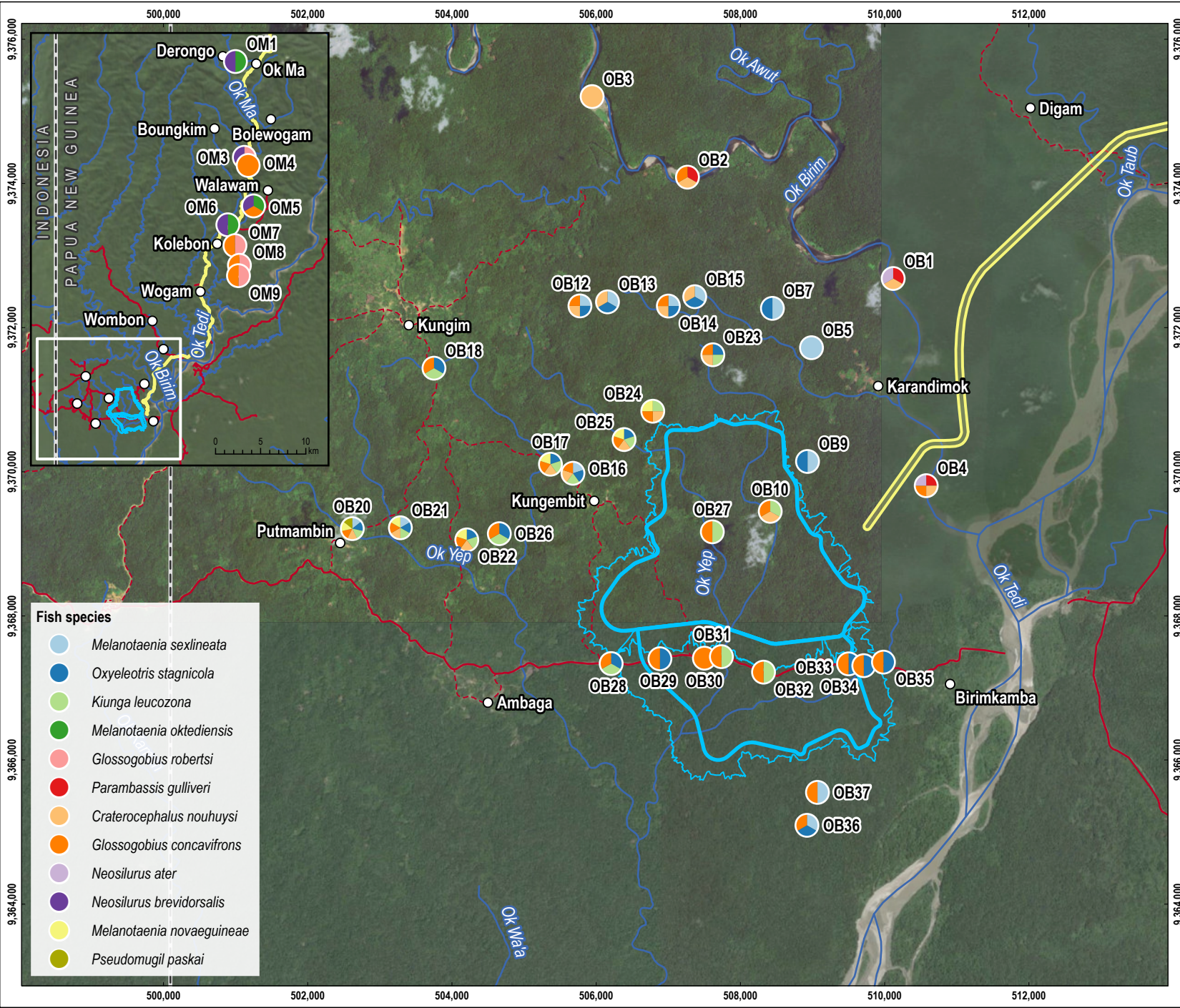
This section describes the conservation significance of aquatic fauna recorded. The conservation significance was assessed in accordance with the criteria for International Union for Conservation of Nature (IUCN).

Native fish species, including those of IUCN conservation concern, were observed and recorded throughout the study area. Figure 8.19 shows the occurrences of these species in assessed watercourses.

TSF development area

Native fish species

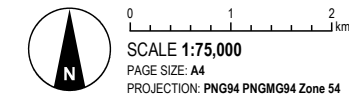
Fish species of conservation concern and IUCN listed were observed and recorded across the sampled sites (see Table 8.19). The species included unknown taxa considered for conservation importance. The *Melanotaenia sexlineata* currently listed as Endangered was recorded at 11 sites across the TSF development area with local distribution across the project area.



LEGEND

- Community
- Road
- - - Track
- Watercourse
- - - International border
- Proposed TSF footprint
- Proposed infrastructure corridor

SOURCE
 Villages from Tetra Tech Coffey.
 Fish species occurrence from SLR.
 Proposed infrastructure from KCB and OTML.
 Topographic features from OSM. Vegetation from FIMs.
 DEM from SRTM. Imagery from ESRI and Google Earth.



OK TEDI MINING LIMITED
 OK BIRIM TAILINGS STORAGE FACILITY PROJECT

FIGURE 8.19
 Fish species and occurrences recorded in the aquatic ecology assessment



The Kiunga blue-eye (*K. leucozona*) not assessed by the IUCN was recently described by Allen et al. (2024) of high conservation significance due to its limited distribution. The species was recorded at 14 sites, comprising eight reference sites and six potentially exposed sites. These sites within creek channels and provide suitable habitat for *K. leucozona*. The species was not observed in larger, open-water bodies and indicate that *K. leucozona* is restricted within the creek system.

The swamp gudgeon (*Oxyeleotris stagnicola*) was recorded at 20 sites spanning between eight reference and 12 potentially exposed sites. *O. stagnicola* is regarded as Endangered while the genetic analysis of taxonomic classification for *O. paucipora* (including *O. stagnicola*) is under review. The study may trigger changes to future classification and conservation assessment and needs for *O. paucipora*.

Multiple species of gudgeons (*Oxyeleotris* spp.) were recorded. Species-level identification remains uncertain and would require further taxonomic assessment before conservation significance and value can be determined.

Other freshwater fauna

The survey also recorded other freshwater fauna from the study area. Crayfish (*Cherax* sp.) was observed and recorded, with specimen collected as macroinvertebrate for further laboratory analysis. The analysis will identify species level followed by determining the conservation value.

The opportunistic interviews with locals also discussed that freshwater crocodiles (*Crocodylus novaeguineae*) and turtles are also present at Ok Birim.

Infrastructure development corridor

Native fish species

An unidentified eel-tailed catfish (*Neosilurus* sp.) was recorded from the main Ok Birim channel at site OB4. Based on deoxyribonucleic acid (DNA) sequencing of specimens collected from the Ok Birim, Ok Mart and Upper Fly River catchments, this taxon is considered to represent a species new to science. The species is currently undergoing formal taxonomic description. The study recorded two fish species of conservation significance: Ok Tedi rainbowfish (*M. oktediensis*) and Robert's goby (*Glossogobius robertsi*). *M. oktediensis*, listed as Critically Endangered by the IUCN, was recorded at sites OM1, OM5 and OM6, where the Ok Ma provides refuge habitat away from the heavily impacted Ok Tedi affected by the mine's discharge. *G. robertsi* is listed as Near Threatened by the IUCN and was recorded at four sites (OM3, OM7, OM8 and OM9), consistent with its preference for upland and mountainous stream habitats.

Other freshwater fauna

The survey recorded sightings of *C. novaeguineae* downstream of the Ok Ma channel. The species is listed by the IUCN as Least Concern and persists within the range of freshwater habitats, including rivers, swamps and marshes. Observations indicate that populations in the Ok Tedi have declined, with crocodiles seeking refuge in less disturbed tributary systems within Ok Birim and Ok Ma.

8.5.5 Aquatic resource use

This section describes aquatic resource use within the TSF and infrastructure corridor. The resource use includes freshwater sources, subsistence food resources, and the role of aquatic systems in supporting community needs and livelihoods. Chapter 9 provides greater detail regarding resource use and ecosystem services for local communities.

TSF development area

Aquatic resource use within the study area was documented through local knowledge surveys undertaken concurrently with aquatic fauna sampling. These surveys were conducted through informal discussions with

local villagers who assisted the field team during sampling activities. Information was recorded at each site regarding the use of creeks and rivers for water supply, food collection, and transportation. The resource use locations were mapped during the separate resource use survey undertaken by the social team.

Local communities use creeks and rivers across the study area for a range of purposes. Despite the presence of rainwater tanks at villages, surface waters including creeks and springs were commonly used for drinking water, washing, and food preparation, including the washing of sago during processing. Springs and small groundwater-fed sources were noted at some locations, although these were not systematically mapped as part of the survey.

Aquatic fauna was an important food resource. Villagers reported harvesting fish, freshwater prawns (*Macrobrachium sp.*), crayfish (*Cherax sp.*), and eels from waterways within the study area. Larger watercourses, were used to collect larger fish, while smaller creeks supported the capture of small-bodied species. Fishing methods included hook and line, gill netting, spearing, diving, and the use of traditional bush nets. Locally grown derris root was also used as a natural fish toxicant in some creeks to facilitate fish capture.

Eels were identified as a particularly valued food resource due to their size and relative rarity. No aquatic plants or freshwater mussels were reported as being collected for consumption.

Smaller creeks within the study area were generally not used for transport due to their size, while larger rivers, including the Ok Yep, were used for canoe and dinghy transport, subject to water levels.

Infrastructure development corridor

Knowledge of aquatic resources and usage was documented through informal discussions and observations, consistent with interviews conducted in the TSF development area. Interviews on resource use were undertaken concurrently with aquatic fauna sampling.

The communities used rainwater and natural watercourses such as creeks, springs and rivers to collect water. Rainwater is collected and stored in tanks during raining seasons. The water from natural sources were mapped out in the resource use surveys.

Aquatic fauna within creeks and Ok Ma provide a food source for local communities. Common freshwater fauna caught at Ok Ma include prawns (*Macrobrachium sp.*), crayfish (*Cherax sp.*), fish and eels such as the shortfin eel (*Anguilla bicolor*), and giant mottled eel (*Anguilla marmorata*). Crocodiles and turtles were also reported as being harvested in the lower Ok Birim, particularly during the dry season when water levels are low and visibility is high.

Fishing methods varied between creeks and large-bodied rivers. Larger fish dwell in rivers and therefore hook and line, gill netting and spearfishing are commonly used to catch fish such as grunTERS. Rainbowfish, gudgeons, and hardyheads are caught using hoop nets made of cane / sapling and bush rope / twine. Gobies are difficult to catch due to its preference living below the bottom of riverbed. Prawns and crayfish are also harvested and, despite being present in OK Ma, crocodiles are reportedly not hunted. In addition, it was reported that turtles also persist within Ok Tara and are caught. The aquatic fauna caught at Ok Ma and tributaries are both used for consumptions and sales at the market for income opportunities.

In addition, local communities use the lower Ok Ma as a transport route to Ningerum. The Ok Birim is also used for canoe and dinghy transport, subject to water levels.

8.5.6 Critical habitat

Under the International Finance Corporation Performance Standard 6 (IFC PS6), critical habitat is an area deemed to be of high biodiversity value, meeting a single or multiple of the following criteria:

1. Habitat of significant importance to Critically Endangered and/or Endangered species.
2. Habitat of significant importance to endemic and/or restricted-range species.
3. Habitat supporting globally significant concentrations of migratory species and/or congregatory species.
4. Highly threatened and/or unique ecosystems.
5. Areas associated with key evolutionary processes.

Aquatic surveys identified the presence of multiple threatened, endemic and restricted-range fish species. The catchments are largely intact, with minimal human disturbance, natural ecological functioning, and high-quality aquatic habitats that support species of conservation significance.

Within the Ok Yep and Ok Birim catchments there are:

- Paska's blue-eye (*Pseudomugil paskai*) – Critically Endangered.
- Fly River rainbowfish (*Melanotaenia sexlineata*) – Endangered.
- Swamp gudgeon (*Oxyeleotris stagnicola*) – Endangered.
- Kiunga blue-eye (*Kiunga leucozona*) – a recently described species with a highly restricted known distribution centred on the Ok Yep/Ok Birim area.

The Ok Birim main channel is also a regionally important aquatic refuge, supporting species that have declined from the Ok Tedi system and potentially serving as a source for future recolonisation following mine closure.

Within the Ok Ma catchment there is the Ok Tedi rainbowfish (*Melanotaenia oktediensis*), listed as Critically Endangered. The Ok Ma is recognised as a relatively undisturbed tributary system that provides important refuge habitat for aquatic fauna that have declined elsewhere in the Ok Tedi catchment.

Given the above, it is likely that at least the following critical habitat criteria are triggered:

- For criteria 1 (a), areas that support globally important concentrations of an IUCN Red-listed EN or CR species ($\geq 0.5\%$ of the global population AND ≥ 5 reproductive units of a CR or EN species) – i.e., the habitat is of significant importance to Critically Endangered and/or Endangered species.
- For criteria 2 (a), areas that regularly hold $\geq 10\%$ of the global population size AND ≥ 10 reproductive units of a species. For terrestrial vertebrates and plants this is any species with an extent of occurrence of 50,000 km² – i.e., the habitat is of significant importance to endemic and/or restricted-range species.

The combination of listed threatened species, restricted-range species and the refuge function of the catchment contributes to critical habitat designation for the catchments of the Ok Yep, Ok Birim and Ok Ma.

8.6 TERRESTRIAL ECOLOGY

Mining at Ok Tedi has had substantial, long-term impacts on downstream floodplain vegetation, resulting in dieback and vegetation community changes. Prior to mining, the Lower Ok Tedi and Middle Fly floodplains were dominated by lowland tropical rainforest and alluvial floodplain forest. Since the commencement of riverine disposal of waste rock and tailings in 1984, large volumes of sediment have been introduced into the river system. This has caused riverbed aggradation, increased overbank deposition, and more frequent and prolonged flooding across the floodplain. These altered hydrological conditions reduce oxygen availability in soils, limiting root respiration and leading to tree stress, decline, and eventual death.

OTML monitors dieback in the Lower Ok Tedi and Middle Fly floodplains annually. Approximately 1,875.4 km² (or 187,540 ha) of forest dieback was recorded between 1992 and 2013, increasing to 2,099 km² in 2023. While the rate of dieback is declining, vegetation change is still occurring, with affected areas progressively transitioning from lowland rainforest to more flood-tolerant plant communities.

The 2023 assessment shows a continued but much slower increase in vegetation impact across the Lower Ok Tedi, Upper Fly, and Middle Fly, with total affected area (2,099 km²) rising by only 0.5% (10.5 km²), compared to a larger increase in 2022. This decreased rate is likely due to lower rainfall and reduced floodplain inundation. Vegetation recovery increased to 271 km², a 12.2% increase from 2022. There was some minor lateral expansion of existing dieback in persistently inundated central floodplain areas; however, recovery is now offsetting some previously stressed and dieback-affected vegetation (Marshall 2024).

This section describes the terrestrial ecology in the project area, including vegetation, flora and fauna. The characterisation is based on information from Appendix F, Terrestrial biodiversity characterisation.

This chapter characterises the existing terrestrial ecology to inform the biodiversity impact assessment of the project.

8.6.1 Study method

The terrestrial ecology characterisation draws on information from a combination of sources, including existing literature, previous studies and field investigation, in addition to Appendix F.

8.6.1.1 Literature review

There has been limited flora and fauna data collection by OTML since the 1980s. Prior studies used for this characterisation include:

- Pre-feasibility study of Ok Birim TSF (BMT WBM 2015).
- Bige tailings storage facilities (BMT WBM 2016).

A broader review of relevant literature included listings of conservation significant species, other published data and scientific papers and a review of satellite imagery data, with an overlay of the project footprint. Appendix F provides further detail about this review and relevant characterisation information.

8.6.1.2 Field surveys

Flora and fauna surveys were undertaken in 2025 at five key sites:

- Three sites within and nearby the TSF development area:
 - o Site 1 (Moketbit) – comprising small ridges and undulating lower slopes traversed by the local track between Kungembit and Birimkamba, including riparian corridors and sago patches.
 - o Site 2 (Okyepbangarat) – comprising riverine and gully habitats on undulating foothill terrain with associated riparian zones.

- o Site 3 – located south of the TSF development area. Camera traps were deployed at Site 3 for 37 days to provide comparative data on mammal presence and relative activity levels outside the TSF development area.
- Two sites along the infrastructure corridor:
 - o Site 4 – comprising tall and well-developed forest, north of the TSF, between 120 and 200 m above mean sea level (AMSL) on the west side of Ok Tedi, along the Ok Ma. This site is expected to be representative of the biodiversity between the TSF development area and Site 4.
 - o Site 5 – comprising small ridges with vertically stratified forest, north of the TSF, with an altitudinal range of 550 to 600 m AMSL on the west side of Ok Tedi, along the Ok Ma.

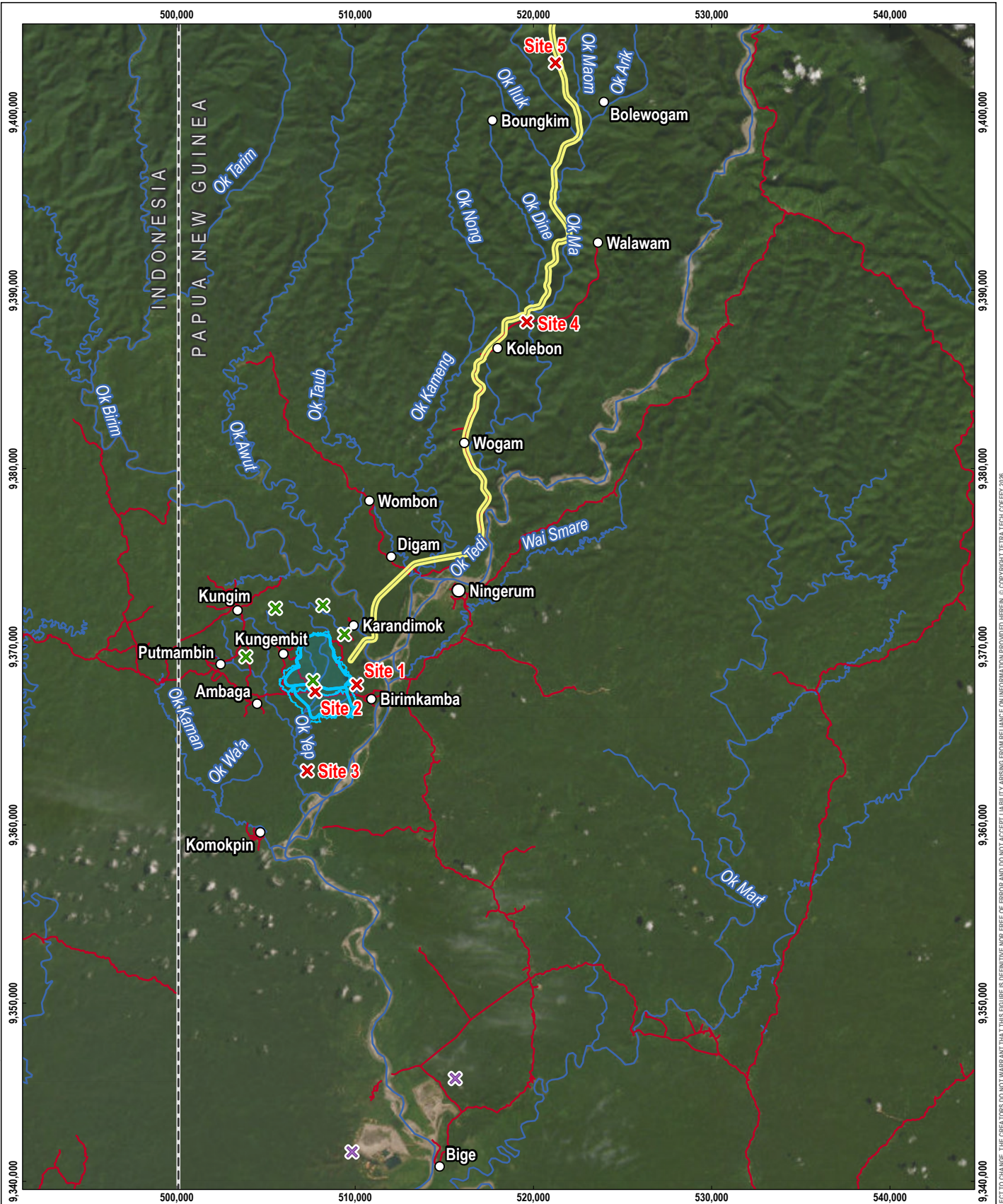
Survey teams also recorded roadside vegetation observations along the ITCS road. Figure 8.20 presents the survey site locations, as well as the locations of previous surveys at Ok Birim and Bige in 2014 and 2015 respectively.

Existing conditions were assessed for a range of biodiversity aspects including habitat types, presence and distribution of vegetation and floral species and presence and distribution of fauna species, including mammals, birds, frogs, reptiles, and odonates (dragonflies and damselflies).

The field surveys followed a rapid assessment protocol. Table 8.18 provides detail on survey methods for each taxonomic group. The surveys combined multiple techniques to maximise species detection and the likelihood of locating ecologically sensitive features within the limited time available at each site. Limitations of the surveys included the short, seasonally constrained field window and periods of heavy rain that reduced detectability for some taxa. Despite these constraints, the 2025 survey results combined with previous regional studies provide reasonable characterisation of the study area.

Table 8.18 Terrestrial ecology survey methods

Type	Method
Terrestrial vegetation and flora	The survey team conducted 10 m × 10 m plot surveys and systematic walk-throughs to record vegetation structure and species composition. Observers logged GPS locations, canopy and understorey measurements, DBH and stem counts, and disturbance indicators. Unknown or notable plants were photographed and collected as voucher specimens, dried in the field and submitted for herbarium verification, and local assistants provided information on culturally important species.
Volant (bats) mammals	Bat surveys used mist nets and harp traps at selected sites and passive acoustic detectors to record echolocation calls. Nets and traps provided specimens for identification and detectors provided call files for specialist analysis. Roost searches were conducted opportunistically, and all records were verified by taxonomic specialists.
Non-volant (non-flying) mammals	Survey methods combined camera trapping, targeted trapping where appropriate, opportunistic observations and structured interviews with local informants. Camera traps were left in place at multiple locations to capture medium and large mammals, small mammal traps and active searches were used where feasible, and interview data supplemented field records to broaden the occurrence dataset.
Birds	Birds were surveyed by timed point counts and walk-through observations with a strong emphasis on call detection. Observers recorded vocalisations using field recorders and made visual identifications where possible. Camera trap images and local informant reports supplemented direct survey records to complete the species list.
Reptiles and amphibians	Surveys combined diurnal and nocturnal visual searches along transects, targeted searches of stream and leaf litter habitats, call recording for frogs and opportunistic trapping where appropriate. Night searches used head torches to detect calling frogs and active reptiles, and voucher specimens or audio recordings were collected for specialist identification.
Odonates (dragonflies and damselflies)	The survey team conducted active searches along waterways and riparian zones using insect nets and photographic records to capture and document odonate species. Collected specimens were preserved or photographed for later identification and special attention was given to clear-flowing streams where stream-specialist damselflies were expected.



LEGEND

- ✕ Terrestrial ecology survey site
- ✕ 2014 terrestrial ecology survey site (BMT 2015)
- ✕ 2015 terrestrial ecology survey site (BMT 2016)
- Community
- Road/track
- Watercourse
- International border
- Proposed TSF footprint
- Proposed infrastructure corridor



0 2.5 5 km
SCALE 1:300,000
PAGE SIZE: A4
PROJECTION: PNG94 PNGMG94 Zone 54

SOURCE
Villages from Tetra Tech Coffey. Survey sites from Ecomate and BMT. Proposed infrastructure from KCB and OTML. Topographic features from OSM. DEM from SRTM. Imagery from ESRI.

OK TEDI MINING LIMITED

OK BIRIM TAILINGS STORAGE FACILITY PROJECT

FIGURE 8.20

Terrestrial ecology survey sites



TETRA TECH
COFFEY

DATE: 21.06.26 PROJECT: 754-MELEN374244 FILE: 374244C_R08_F08.20_GIS

8.6.2 Vegetation communities and habitats

Vegetation in the project area is dominated by three forest inventory management system (FIMS) communities: Medium Crowned Forest and Small Crowned Forest (FIMS code: Hm/Hs), Mixed Medium and Small Crowned Forest (FIMS code: Hm9/Hs9), and Large/Medium Crowned Forest (FIMS code: Hm5). Table 8.19 summarises these communities and Figure 8.21 shows the FIMS vegetation mapping. Site 3 was not characterised because it was not visited by the botany team; only camera traps were employed.

The PNG Forest Resource Information System (FRIMS) was introduced to replace FIMS and is now the mapping system used for forest management in PNG. It was developed from multiple mapping exercises, firstly, the Forest Base Map of 2012, and most recently revised using a land use change study from 2000-2019. PNG-FRIMS uses 21 higher level categories of vegetation, whereas FIMS has 62 types and does not use species to characterise types.

The TSF and the Infrastructure corridor development areas are within low altitude forest on uplands vegetation type, and this is the most common vegetation type in PNG. Three categories were used for vegetation analysis;

- Intact forest, which is low altitude forest on uplands with no obvious signs of human activity and is a conservation relevant habitat, providing all resources that maintain biodiversity. Intact forest classifies as Natural Habitat under IFC PS6.
- Agricultural land, which includes both subsistence and commercial activities. Agricultural land is considered to be of medium biodiversity value and would still be considered as Natural Habitat under IFC PS6 because the primary ecological functions and species composition have not been essentially modified.
- Roads and tracks, which are areas devoid of vegetation and have edge effects which penetrate into the adjoining forest. These areas have minimal to no conservation relevance and hence are considered Modified Habitat under IFC PS6.

Streams and adjacent riparian vegetation provide habitat for stream-breeding odonates. Forests along these stream and riverbanks provide specialised habitats for many vertebrates including kingfishers and flycatchers. Although no species are restricted to this habitat, many birds will utilise these areas, particularly during dry or hot periods. Therefore, these riverine forests are of high conservation relevance and classify as Natural Habitat.

Table 8.19 Vegetation communities in the TSF development area

Vegetation community	Description of community	Relevant site
Medium Crowned Forest / Small Crowned Forest (FIMS code: Hm/Hs)	This forest type is widespread on the eastern portion of the TSF development area and occurs on gentle slopes, foothills and lower ridgelines. The canopy is moderately closed (60–80%) reaching heights of 25 to 30 m. The forest is structurally uniform with limited emergents. Canopy dominants include <i>Vatica</i> , <i>Lithocarpus</i> , <i>Elaeocarpus</i> , <i>Cryptocarya</i> and <i>Syzygium</i> . Ridgelines feature <i>Hopea</i> and <i>Anisoptera</i> as emergents on thinner soils.	Site 1 Site 5
Mixed Medium and Small Crowned Forest (FIMS code: Hm9/Hs9)	This forest type dominates the central and southern portions of the TSF development area, occurring primarily between 70 and 100 m ASL. The canopy density and crown width vary with microtopography. Dominant species include <i>Elaeocarpus</i> , <i>Pometia</i> , <i>Sloanea</i> , <i>Lithocarpus</i> and <i>Weinmannia</i> with occasional montane elements (<i>Magnolia</i> , <i>Platanus</i>).	Site 1 Site 2

Vegetation community	Description of community	Relevant site
Large/Medium Crowned Forest type (FIMS code: Hm5)	This forest is found along the infrastructure development corridor. The canopy is moderately closed (60 to 80%) reaching heights of 25 to 30 m (medium crowned forest) and 30 to 35 m (large crowned forest). This community is found in a wide range of areas up to 1,000 m in altitude. Taller canopies and species assemblages similar to the forests of the low altitude plains and fans are found at altitudes below 500 m. Hm5 is considered heavily disturbed compared to FIMS codes Hm9 (slightly disturbed) and Hm (no disturbance) (Hammermaster and Saunders 1995)	Site 4

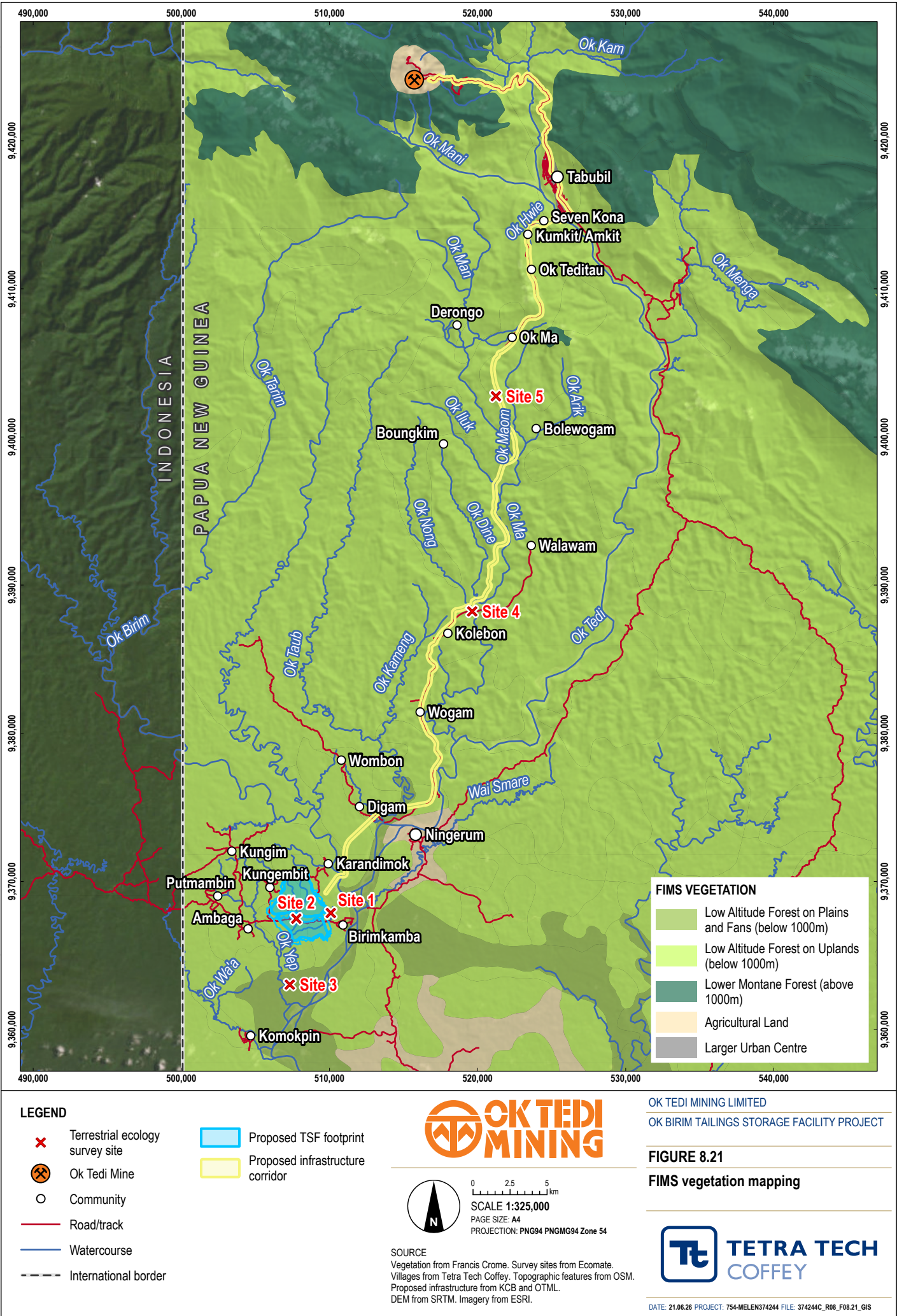
8.6.2.1 TSF development area

The TSF development area is located within approximately 1,556 ha of vegetation, constituting 18 to 19% of the area of the Ok Yep catchment. Approximately 86 % of this vegetation is intact forest, followed by agricultural land. As agricultural land in this landscape is considered IFC PS6 natural habitat, overall, the project overlays approximately 1,838 ha of natural habitat and 118 ha of modified habitat, i.e., roads and tracks.

Site 1 comprises small ridges, undulating lower slopes and adjacent low-lying plains with riverine corridors. The forest at Site 1 is vertically stratified into four layers: canopy, understory, shrub layers and ground floor (Plate 8.28). The canopy layer is moderately closed and reaches heights of 25 to 30 m. Beneath the canopy is the understory layer, comprising an assemblage of mid-storey trees and saplings. Occupying the lower vertical strata is the shrub layer of shade-tolerant and gap-adapted species that are abundant along slope bases and transitional microhabitats. At the ground floor is a rich herbaceous layer that thrives in filtered light and moist conditions and contributes to soil stabilisation and nutrient cycling.

Within Site 1, the canopy in the plains and in riverine corridors is lower and more open (15 to 20 m). Small sago swamp pockets occur in drainage depressions and support specialised ferns (Plate 8.29). River margins are seasonally flooded, which limits sapling densities but maintains a rich herbaceous assemblage. Overall condition ranges from relatively intact forest on ridges to more open, hydrologically influenced vegetation on plains and stream margins.

Site 2 is dominated by Hm9/Hs9 forest, a transitional assemblage of Medium and Small Crowned Forest occurring on undulating terrain. The canopy is generally continuous and reaches about 25 to 30 m. The understorey contains a diverse mix of species reflecting mature lowland rainforest structure. A well-developed shrub layer is abundant in moist depressions and along drainage lines (Plate 8.30 to Plate 8.32), and the herb layer is rich with a locally restricted *Begonia* sp. recorded on shaded riparian banks (Plate 8.33). Overall, the site shows pronounced vertical layering and floristic mixing driven by topography and canopy openness, producing a species-rich forest with strong riparian and gully-associated components.



8.6.2.2 Infrastructure corridor

The forest at Site 4 is tall and well developed covering an altitude of 120 to 200 m AMSL across the four surveyed locations. The estimated canopy height is about 25 m with emergent trees rising above 30 m. The vegetation forms a vertical structure with shaded ground layer. General observations confirm the presence of buttress trees, with moss cover between 50 and 70 percent of tree bark. Large lianas such as *Uncaria lanosa* are absent, leaving the canopy uncluttered. The overall impression is of an old, undisturbed forest with strong vertical layering and intact structure. The combination of tall crowns, emergent trees, dense undergrowth, broad crowned canopy species, and abundant epiphytes confirms that Site 4 corresponds to the Large/Medium Crowned Forest type (Hm5).

The topography of Site 5 is characterised by small ridges with forest vertically stratified into canopy, mid storey, shrub, and ground layers. The survey covered four locations across an altitudinal range of 550 to 600 m AMSL. These features of tall crowns, emergent, dense mid storey, varied shrub layer, and rich ground cover confirm Site 5 as representative of the Large/Medium Crowned Forest type (Hm). The canopy reaches 30 to 35 m and is moderately closed, with a dense mid storey, species-rich shrub layer and a shaded, moist forest floor which supports a dense herbaceous layer.

The infrastructure corridor is 84 km long of which approximately 53 km is along existing roads and tracks. From the Ok Tedi Mine site to the Ok Tedi at Tabubil, the corridor is entirely within Modified Habitat. The corridor then passes through a combination of agricultural land, intact forest and forest edging the road which is in good condition.

The Lukwi caves are key roosting and breeding habitat for swiftlets and bat colonies, including flying foxes. Due to being a key habitat for these species, caves have high conservation relevance and classify as Natural Habitat under IFC PS6.

8.6.2.3 Roadside vegetation

The ITCS Road corridor is gravelled and bordered by narrow strips of regenerating secondary vegetation where disturbance is largely confined to the immediate road formation (Plate 8.34). Fast-growing pioneer trees such as *Macaranga* and *Mallotus* form a loosely structured canopy 10 to 15 m high, and a sparse understorey with limited shrub development. The dominant weed species is *Decalobanthus peltatus*, which climbs and mats over pioneer growth in sunlit sections. Two isolated occurrences of the weed, spiked pepper (*Piper aduncum*), were recorded but show no evidence of active spread into adjacent forest. Primary Hm9/Hs9 forest immediately beyond the roadside retains layered structure and currently limits weed encroachment.

8.6.3 Terrestrial flora

Overall, 638 plant species in 113 families were recorded across the TSF and infrastructure corridor study areas.

8.6.3.1 TSF development area

The botanical survey recorded 477 vascular plant species from 97 families within the TSF development area. The most speciose families were *Lauraceae* (27 species) and *Myrtaceae* (26 species), which contribute to canopy stratification, successional dynamics and trophic interactions.

The survey identified 39 flora species of conservation significance within the TSF development area, including IUCN listed Endangered and Vulnerable species and several Data Deficient species. Four flora species recorded in the 2025 surveys are likely new to science and are associated with riparian microhabitats, saturated sago swamps and ridge slopes (Plate 8.35 to Plate 8.38). Twenty culturally important plant species were also recorded, which are known to provide food, building material and marketable products for local communities.

Plate 8.28
Vegetation on low ridges and undulating slopes
at Site 1



Photo credit: Ecomate, 2025

Plate 8.29
Inundated forest floor in the riverine zone
at Site 1



Photo credit: Ecomate, 2025

Plate 8.30
Riverine vegetation near Site 2



Ecomate, 2025

Plate 8.31
Vegetation along flooded riverine plain



Ecomate, 2025



Plate 8.32
Dense shrub layer and herbaceous community



Plate 8.33
Streamside (riverine) vegetation near Site 2



Plate 8.34
Vegetation adjacent to the ITCS Road

Plate 8.35
Begonia sp.1 found at Site 1, likely new
to science



Photo credit: Ecomate, 2025

Plate 8.36
Begonia sp.2 found at Site 1, likely new
to science



Photo credit: Ecomate, 2025

Plate 8.37
Juvenile *Dillenia* sp.1 found at Site 1, likely
new to science



Photo credit: Ecomate, 2025

Plate 8.38
Glochidion sp.1 found at Site 1, likely new
to science



Photo credit: Ecomate, 2025

The 2014 survey found a total of 233 vascular plant taxa, identified from 98 families. The most species rich families were *Rubiaceae* (trees and shrubs, 18 species), *Arecaceae* (palms, 16 species), followed by *Araceae* (herbs, eight species) and *Euphorbiaceae* (trees, eight species) (BMT WBM 2015). Twelve species/groups of species of conservation significance have been identified as occurring or potentially occurring within the study area based on the desktop review and field survey. However, all but one were listed as Least Concern on the IUCN Red List, with *Myristica buchneriana* being listed as Vulnerable.

Invasive flora species

Two invasive flora species were recorded along the ITCS Road: *Decalobanthus peltatus* (Plate 8.39) and *Piper aduncum* (Plate 8.40). *Decalobanthus peltatus* is a vine that rapidly colonises sunny, disturbed ground, climbs pioneer trees and in places forms dense mats that suppress vertical growth and delay canopy closure. Recordings of this species during the botanical survey found them largely confined to the road edge but could spread into regenerating edge vegetation after clearing. *Piper aduncum*, a highly invasive species in PNG, occurs in roadside clearings and rarely establishes in primary forest.

8.6.3.2 Infrastructure corridor

The botanical survey identified 195 species at Site 4 and 138 species Site 5. Of these, 78 were only found at Site 4 and 59 were only found at Site 5. Two species listed as Endangered on the IUCN Red list were recorded: *Cryptocarya albifrons* at Site 4 and *Timonius argenteus* at Site 5. Similarly, two species listed as Vulnerable on the IUCN Red list were recorded: PNG Basswood (*Endospermum medullosum*) at Site 4 and Amberoi (*Pterocymbium beccarii*) at Site 5.

Data Deficient *Goniothalamus imbricatus* was detected in all survey locations at Site 5. A single genus, *Syzygium* in Myrtaceae, contributed the most species across all five of the study areas, with 14 species identified at both Sites 4 and 5. The family Moraceae was not speciose in comparison; however, the genus *Ficus* contributed 26 species across all five of the sites, with 14 species in Site 4 and six species in Site 5.

As outlined in Appendix G, the flora shows minimal evidence of lower montane species occurring along the infrastructure corridor, where only one *Fagacea* species was recorded. With the current information available there does not appear to be any plant species that are restricted to higher elevations of the corridor.

8.6.4 Terrestrial fauna

The Ok Tedi region and nearby areas are home to a wide variety of terrestrial fauna, including mammals, birds, frogs, reptiles, dragonflies and damselflies. Many of these species are important for conservation, with some found only in this region or yet to be fully studied. The diversity has been highlighted in previous studies such as the 2014 and 2015 surveys (BMT WBM 2015; BMT WBM 2016) and depicts the rich natural environment of this region.

This section describes the terrestrial fauna species recorded within the project area and surrounds.

8.6.4.1 Mammals

Mammals recorded in the surveys are described as two groups: volant mammals (bats) and non-volant mammals (non-flying). Across all the survey sites, 50 native mammal species were recorded: 24 bats and 26 non-volant mammals. Bat species (Plate 8.41 and Plate 8.42) typically roost in trees or caves and forage widely at night and were detected primarily by acoustic recording and mist-netting. Non-volant species comprise marsupials, rodents (Plate 8.43) and introduced taxa (dogs, pigs, rats) and were recorded by camera trapping, opportunistic observations and local informant interviews.

TSF development area

Bats

Bats typically roost in trees and caves and forage from fruiting trees. No caves or sinkholes were observed during the survey of the TSF development area. Karst features, including caves sinkholes are present further north near Ok Ma, and may provide habitat for bats. The TSF development area may provide roosting trees and be a foraging area for bats. Twelve species of bats were identified during field surveys. All species were identified at both sites 1 and 2, except for the great bent-winged bat, which was only identified at Site 2.

No species of conservation significance were recorded during the surveys despite being specifically targeted for detection; however, Bulmer's fruit bat and the lesser tube-nosed bat may occur in the area based on their known distribution and habitats. These are respectively listed as Critically Endangered and Data Deficient on the IUCN Red List. The 2014 survey determined that the Critically Endangered Bulmer's fruit bat (*Aproteles bulmerae*) possibly occurs in the Ok Birim catchment area based on its occurrence in the headwaters of the Fly River catchment. Bulmer's fruit bat is known to roost at higher elevations in caves near the Hindenburg Wall and may forage at lower elevations such as the TSF development area; it is extremely unlikely to be resident or spend more than the occasional night in the Ok Birim area due to the lack of caves and rock shelters (BMT WBM 2015).

The 2015 surveys recorded at least 19 bat species, two of which are listed as Data Deficient on the IUCN Red List. The study also noted two unidentified species likely to be classified as Data Deficient. The 2014 surveys recorded 20 species including two species listed as Data Deficient on the IUCN Red List, the Dragon tube-nosed bat (*Nyctimene draconilla*) and the New Guinea sheath-tailed bat (*Emballonura furax*) (BMT WBM 2015). There is uncertainty over the precise number of bat species recorded in 2014 due to limitations with interpretation of the acoustic data at that time.

Non-volant mammals

Twenty species of non-volant mammals were identified during field surveys of sites 1, 2 and 3 and local informant interviews. This included 17 native species and three invasive species. All 17 native species were identified at Site 1, while only 12 were identified at Site 2 and five at Site 3. Invasive non-volant mammal species identified in the TSF development area were dogs, pigs, and the Pacific black rat; all identified at Site 2 between Ambaga and Birimkamba. Most species were identified through informant interviews, with only three native species and two invasive species recorded via camera trapping.

The eastern long-beaked echidna (*Zaglossus bartoni*) is listed as Vulnerable on the IUCN list and was identified through informant interviews as occurring at both sites. All the other species were Least Concern, not protected by the PNG government, not locally endemic nor of restricted range.

The 2015 surveys recorded 16 non-volant mammal species in the study area, including two introduced species, with low capture rates typical of lowland rainforest and not necessarily indicative of degradation. Local informants reported the grey dorcopsis (*Dorcopsis luctuosa*) (listed as Vulnerable on the IUCN Red List) as occurring in the region, while the long-beaked echidna and lowland tree kangaroo were considered unlikely to occur within the area.

The 2014 survey recorded a total of 15 native species including oral testimony of the grey dorcopsis (*Dorcopsis luctuosa*) and the Near Threatened New Guinean quoll (*Dasyurus albopunctatus*) (BMT WBM 2015).

The relatively low diversity and abundance of non-volant mammals in the TSF development area may be influenced by its location near roads and villages, hunting activities of locals, and predation by invasive species.



Ecomate, 2025

Plate 8.39
Decalobanthus peltatus



Ecomate, 2025

Plate 8.40
Piper aduncum



Ecomate 2025

Plate 8.41
Doryrhina muscinus



Ecomate 2025

Plate 8.42
Nyctimene albiventer



Ecomate 2025

Plate 8.43
Uromys caudimaculatus

Infrastructure development corridor

Bats

Five species (Large-eared Sheath-tailed Bat (*Emballonura diana*), New Guinea Sheath-tailed Bat (*Emballonura furax*), Raffray's Sheath-tailed Bat (*Emballonura raffrayana*), Bare-backed Fruit Bat (*Dobsonia moluccensis*), Lesser Tube-nosed Bat (*Nyctimene draconilla*) were detected at Site 5 through capture and acoustic detection. While only one species, Dagger-toothed Long-nosed Fruit Bat (*Macroglossus minimus*), was only captured at Site 4. Six species were identified at both Site 4 and 5, which were unique to the infrastructure corridor.

No species listed in an IUCN threatened category were encountered while two Data Deficient species *Nyctimene draconilla* from Site 5 and McIntyre's Horseshoe Bat (*Rhinolophus mcintyre*) were detected from Sites 4 and 5.

Site 5 is near the Lukwi caves (James 1989). According to James (1989), there are 25 caves in an area of 5 km². The Barawokwi sinkhole that was visited is likely one of the Lukwi caves. The local assistants confirmed that there are many caves further away from camp area of Site 5. These caves may house significant populations of different bat species. For example, it was observed that bats are actively roosting in the Barawokwi cave where a single individual of *Dobsonia moluccensis* was caught by the local assistants while flying out in the evening.

Non-volant mammals

The largest number of native non-volant mammal species were recorded from Site 5 followed by Site 1, Site 2 then Site 4 and Site 3. *Paramelomys* sp., which was found only at Site 5 had the most independent camera images (29). A total of 23 native species recorded at Sites 4 and 5 were from local informant interviews. Overall, no traps detected any non-volant mammal species at Site 4 although one Feathered-tailed possum (*Distoechurus pennatus*) was caught.

8.6.4.2 Birds

The Ok Tedi region supports a rich diversity of bird species across a wide range of habitats and elevations. Each location hosts distinct bird communities influenced by habitat type and altitude. Across all five survey sites, 116 species of bird were recorded. Each location hosts distinct bird communities influenced by habitat type and altitude.

TSF development area

A total of 104 bird species were recorded during the 2025 surveys. More species were recorded at Site 1, than Site 2 and followed by Site 3, where camera traps captured images of only five birds (Plate 8.44 and Plate 8.45). The recorded assemblage is typical of lowland rainforest and associated riparian and sago habitats. Five species of conservation significance in the IUCN Red List were recorded or noted as present in the area, including Near Threatened taxa such as Sclater's crowned pigeon (*Goura sclateri*), forest bittern (*Zonerodius heliosylus*) and palm cockatoo (*Probosciger aterrimus*) and the Vulnerable New Guinea harpy eagle (*Harpyopsis novaeguineae*) and Pesquet's parrot (*Psittichas fulgidus*). The survey also confirmed the presence of seven nationally protected species: New Guinea harpy eagle, palm cockatoo, Pesquet's parrot, Blyth's Hornbill (*Rhyticeros plicatus*), King Bird of Paradise (*Cicinnurus regius*) (Plate 8.46), Glossy Manucode (*Manucodia ater*) and Raggiana Bird of Paradise (*Paradisaea raggiana*).

Habitat observations indicate the avifauna is characteristic of lowland rainforest with use of riparian corridors and sago pockets for foraging and breeding. Forest canopy and fruiting trees likely support frugivores and nectivores, while the clear-flowing streams and adjacent riparian vegetation provide habitat for water-associated and stream-specialist species, such as Kingfishers. Overall, the bird community reflects intact lowland forest affinities with some seasonal and survey-effort related variation in species detection.

The 2014 survey recorded 28 species of bird including the Southern cassowary (*Casuarius Casuarius*) and Southern crowned pigeon (*Goura scheepmakeri*) which are IUCN Red List Vulnerable and PNG Fauna Act Restricted (BMT WBM 2015). At least two species of bird of paradise and one species of manucode, all Fauna Act Protected and listed on CITES Appendix II, as well as Blyth's hornbill, Fauna Act Restricted, were recorded during surveys.

An unidentified swiftlet (*Aeroramus* sp.) and an unidentified lorikeet (*Charmosyna* sp.) recorded during the 2014 survey are of uncertain conservation status as both groups contain species listed from Data Deficient to Near Threatened on the IUCN Red List (BMT WBM 2015)

Infrastructure development corridor

Along the tailings pipeline corridor, more species were recorded at Site 5 (65) than Site 4 (53). Twelve species were unique to Sites 4 and 5, all of which are assessed as Least Concern in the IUCN Red List. Two IUCN Red List Vulnerable and nationally protected species were identified at Sites 4 and 5, the Papuan eagle (*Harpyopsis novaeguineae*) and Pesquet's parrot (*Psitttrichas fulgidus*).

8.6.4.3 Herpetofauna (reptiles and amphibians)

The Ok Tedi region and nearby areas support a rich variety of amphibians and reptiles (Plate 8.47 to Plate 8.49), as revealed by this survey and other detailed ecological studies conducted in the Ok Birim and Bige areas (BMT WBM 2015, 2016). Fifty-six species of native herpetofauna were recorded across the five survey sites, 32 frogs and 25 reptiles. These species are typical of the lowland tropical rainforests and contribute greatly to the region's biodiversity.

TSF development area

Amphibians

Seventeen frog species were documented during the 2025 surveys, reflecting a typical lowland forest assemblage dominated by *Microhylidae* (narrow-mouthed frogs) and *Hylidae* (tree frogs). The assemblage includes at least seven taxa that are undescribed or likely new to science and at least five restricted-range species known from southern Papua New Guinea. Most recorded species are assessed as Least Concern in the IUCN Red List, while several records are Data Deficient or require taxonomic confirmation.

Frog species in the TSF development area fall into four broad ecological groups, each with distinct habitat requirements and sensitivities:

- Terrestrial/arboreal direct-developers. Nine *Microhylidae* species that lay large, unpigmented eggs in terrestrial or arboreal nests and hatch as froglets without a free-swimming tadpole stage. These microhylids require permanently moist forest conditions and are most diverse in the wet forest habitats present at Ok Birim.
- Stream breeders. Treefrog species such as the *Spicicalyx eucnemis* that occupy clear, slow-flowing streams and seepages and deposit eggs directly into flowing water. These taxa depend on intact riparian habitat and high water quality.
- Canopy hole breeders. Large canopy treefrogs such as *Sandyrana pallidofemora* that likely breed in tree holes high in the forest canopy. These species rely on structurally complex forest with large trees.
- Generalist pond and ditch breeders. Species such as *Sandyrana infrafronata* and the true frogs *Hylarana daemeli* and *H. novaeguineae* that breed in temporary or permanent ponds and ditches and tolerate a wide range of habitats, including modified or edge environments.



Ecomate 2025

Plate 8.44
Talegalla fuscirostris



Ecomate 2025

Plate 8.45
Trugon terrestris



Ecomate 2025

Plate 8.46
King Bird of Paradise (*Cicinnurus regius*)

Prior surveys in the Ok Birim and Bige area recorded additional amphibian taxa and highlighted range extensions and undescribed species. Those studies documented several *Litoria* frogs including *Litoria amboinensis*, *L. cf. genimaculata*, *L. infrafronata* and *L. nasuta*, the latter representing a notable northern range extension. Microhylid frogs recorded previously include *Callulops marmoratus*, *Copiula* species and *Hylophorbus* species. Earlier work also reported newly discovered and undescribed taxa such as *Xenorhina* sp. A from the Bige East Bank site, underlining the region's high undocumented amphibian diversity.

Reptiles

Ten reptile species were recorded during the 2025 surveys, comprising a suite of common, widespread lowland taxa. None of the reptiles recorded within the TSF development area are IUCN listed. Local informants reported the presence of large river turtles and freshwater crocodile in larger waterbodies nearby, specifically the pig-nose turtle *Carettochelys insculpta* (IUCN Endangered), the Southern New Guinea giant softshell turtle *Pelochelys bibroni* (IUCN Vulnerable) and *Crocodylus novaeguineae*, although these taxa were not observed inside the TSF development area. The documentation of the Digul River rainbow skink *Carlia diguliensis* during the surveys represents only the third record for this species in Papua New Guinea and confirms a wider distribution into the Ok Tedi drainage.

The low observed skink diversity at Ok Birim may reflect the very wet and overcast conditions during sampling rather than true absence. Local informants also reported two varanid lizards, of which the taxonomic classification could not be confirmed.

The 2025 survey results broadly match earlier work at Ok Birim and at the nearby Bige site where reptile species lists were similar and dominated by generalist taxa. The 2014 survey records include geckos such as *Cyrtodactylus papuensis* and a likely undescribed *Gehyra*, the range-restricted skink *Carlia diguliensis*, forest dragons of the *Hypsilurus* group and large monitors including *Varanus indicus* (BMT WBM 2015). Snakes recorded in the broader study area include *Boiga irregularis*, *Tropidonophis multiscutellatus*, *Acanthophis cf. laevis* death adder, pythons such as *Morelia amethistina* and *Morelia viridis*, and a *Candoia aspera* ground boa.

Infrastructure development corridor

Amphibians

The documentation of *Cornufer papuensis* at Site 4 was unexpected. This species is broadly distributed across the lowlands of northern New Guinea but only one population has previously been documented from southern New Guinea west of the Bird's Neck; from the vicinity of Timika, far to the west of Ok Birim (Richards et al. 2015, as cited in Appendix F). It is possible that this species has been introduced, but it has not been documented previously from Tabubil or Kiunga and Site 4 is the location surveyed that is most remote from large human settlements.

Reptiles

Local informants reported that freshwater crocodiles are commonly encountered in waterbodies in the vicinity of Site 4 and that both *Pelochelys bibroni* and the small turtle *Emydura subglobosa* occur within the Ok Ma and adjacent streams. No direct evidence was obtained for the presence of *Pelochelys* but *E. subglobosa* probably occurs there. Further assessment of the likelihood of *Pelochelys* occurring in the vicinity should be undertaken if damage to potential nesting sites in the riparian zones of larger stream channels is likely.

8.6.4.4 Odonates (dragonflies and damselflies)

Odonates (dragonflies and damselflies) are aquatic-linked insects that are reliant on small, clear-flowing forest streams for their reproduction and survival (Plate 8.50 to Plate 8.52). These species are vulnerable to changes to stream and forest quality as they typically have narrow habitat tolerances, limited dispersal and higher levels of regional endemism. For this reason, odonates are widely used to monitor environmental

change and to identify aquatic habitats with high conservation value. Fifty-two species of odonates were recorded across the five survey sites, including 25 species of damselflies and 27 species of dragonflies.

TSF development area

Dragonflies

Eighteen dragonfly species were recorded during the 2025 surveys. The dragonfly fauna is dominated by *Libellulidae* (16 species) and most species breed in standing water such as ponds and ditches. Seventeen of the 18 dragonflies recorded are broadly distributed habitat generalists and are assessed as Least Concern in the IUCN Red List. Only a small number of dragonflies such as *Diplacina sp.* and *Macromia viridescens* are closely associated with forest streams. Overall, the dragonfly assemblage shows lower apparent conservation sensitivity than the damselfly assemblage.

Damselflies

Twelve damselfly species were recorded during the 2025 surveys, predominantly of the families *Platynemididae* and *Coenagrionidae*. Nine of the 12 species breed in small clear-flowing forest streams and these stream specialists include several Data Deficient, undescribed or new to science, or unknown taxa. Two species recorded are listed as Data Deficient on the IUCN Red List. Three taxa from the surveys are undescribed or new to science and in need of formal description. Two further records have uncertain taxonomic affinities.

Infrastructure development corridor

Dragonflies

Nine species of dragonfly were identified at Site 4, whereas 15 were identified at Site 5. Eleven dragonfly species identified at these sites were not identified at the TSF development area sites. Two species assessed as Data Deficient on the IUCN Red List were identified at Site 5, *Podopteryx roseonotata* and *Argiolestes muller*. Across the two sites, five species were new to science or unidentified: *Teinobasis sp.1*, *Teinobasis sp.2*, *Idiocnemis sp.1*, *Nososticta sp.1*, *Palaiargia sp.1* and *Papuargia sp.1*.

Damselflies

Five damselfly species were identified at Site 4, whereas 12 were identified at Site 5. Nine damselfly species identified at these sites were not identified at the TSF development area sites. All but three damselfly species are assessed as Least Concern on the IUCN Red List, with the remaining three Not Evaluated.

8.6.5 Key findings for conservation significant species

Data from literature review and field investigations indicates that the study area is inhabited by a number of flora and fauna species of conservation significance. The conservation status of a species considered the following:

- IUCN Red List of Threatened Species (IUCN 2025) 2021], which categorises species as Near Threatened (NT), Critically Endangered (CR), Endangered (EN) and Vulnerable (VU), Other categories such as Least Concern (LC), Data Deficient (DD) and Not Evaluated (NE) are not considered as species of conservation significance.
- Papua New Guinea Fauna (Protection & Control) Act 1966 – species listed under the act are considered to hold conservation significance.
- International Finance Corporation Performance Standard 6 (IFC PS6).
- New or undescribed species.
- Restricted ranged species.

- Species with taxonomic uncertainty.

This section summarises key findings relating to species of conservation significance, subspecies and taxa new to science, and culturally significant species.

8.6.5.1 Flora species of conservation significance

Of the species identified during the study, 54 flora species of conservation significance were recorded: 41 in the TSF development area and 14 along the infrastructure corridor. Table 8.20 presents the IUCN-listed species confirmed occurring in the project area.

Of the 41 species of conservation significance recorded in the TSF development area, four are classified as Endangered, 10 as Vulnerable, 22 as Near Threatened and five as Data Deficient.

Of the 14 species of conservation significance recorded along the infrastructure corridor, three are classified as Endangered, five as Vulnerable, four as Near Threatened and two as Data Deficient.

Table 8.20 IUCN-listed flora species recorded in the terrestrial biodiversity study area

Scientific name	
Endangered	
<ul style="list-style-type: none"> • <i>Cryptocarya albifrons</i>. • <i>Cryptocarya brevipes</i>. • <i>Cryptocarya fluminensis</i>. 	<ul style="list-style-type: none"> • <i>Cryptocarya sulcata</i>. • <i>Endiandra engleriana</i>. • <i>Timonius argenteus</i>.
Vulnerable	
<ul style="list-style-type: none"> • <i>Anisoptera thurifera</i> (Mersawa). • <i>Calophyllum suberosum</i>. • <i>Elaeocarpus murukakai</i> (Quandong). • <i>Endospermum medullosum</i> (PNG Basswood). • <i>Lithocarpus vinkii</i>. • <i>Gmelina sessilis</i>. 	<ul style="list-style-type: none"> • <i>Cryptocarya caloneura</i>. • <i>Litsea collina</i>. • <i>Litsea globosa</i>. • <i>Syzygium leptoneurum</i>. • <i>Palaquium supfianum</i>. • <i>Pterocymbium beccarii</i> (Amberoi).
Near Threatened	
<ul style="list-style-type: none"> • <i>Goniiothalamus aruensis</i>. • <i>Licuala bakeri</i>. • <i>Licuala bellatula</i>. • <i>Licuala brevicalyx</i>. • <i>Calophyllum laticostatum</i>. • <i>Mammea novoguineensis</i>. • <i>Terminalia impediens</i>. • <i>Alsophila andesina</i>. • <i>Aceratium parvifolium</i>. • <i>Elaeocarpus multisectus</i>. • <i>Fagraea gracilipes</i>. • <i>Myristica hooglandii</i>. • <i>Polyalthia longirostris</i>. 	<ul style="list-style-type: none"> • <i>Cryptocarya massoy</i> (Massoy). • <i>Aglaia lepiorrhachis</i>. • <i>Syzygium coalitum</i>. • <i>Aporosa ledermanniana</i>. • <i>Bridelia macrocarpa</i>. • <i>Discocalyx latepetiolata</i>. • <i>Helicia latifolia</i>. • <i>Madhuca leucodermis</i>. • <i>Palaquium warburgianum</i> (Pencil cedar). • <i>Planchonella thyrsoides</i>. • <i>Pleioluma firma</i>. • <i>Acronychia pullei</i>. • <i>Archidendron ptenopum</i>.
Data Deficient	
<ul style="list-style-type: none"> • <i>Garcinia mangostifera</i> (Mangosteen). • <i>Archidendron megaphyllum</i>. • <i>Magnolia tsiampacca</i> (Wau Beech). • <i>Goniiothalamus imbricatus</i>. 	<ul style="list-style-type: none"> • <i>Aglaia cucullata</i> (Amoora). • <i>Syzygium fibrosum</i>. • <i>Ficus aurantiacifolia</i>.



Ecomate 2025

Plate 8.47
Hylophorbus sp.1



Ecomate 2025

Plate 8.48
Emoia kordoana



Ecomate 2025

Plate 8.49
Ground Boa (*Candoia aspera*)

Plate 8.50
Female *Nososticta ovimacula*



Ecomate 2025

Plate 8.51
Idiocnemis cf. *schorri*



Ecomate 2025

Plate 8.52
Metagrion cf. *annehueberae*



Ecomate 2025

8.6.5.2 Fauna species of conservation significance

Fauna species were assessed to be of conservation significance if they were listed as protected under the PNG *Fauna (Protection and Control) Act 1966*, or listed as Critically Endangered, Endangered, Vulnerable, Near Threatened, or Data Deficient on the IUCN Red List. Table 8.21 lists the species of conservation significance recorded or likely to occur within the terrestrial ecology study area.

Table 8.21 Threatened or Protected fauna recorded or likely to occur in the terrestrial ecology study area

Common name	Species name	IUCN*	PNG Fauna Act**	Detection source	Location within the study area
Mammals					
Eastern long-beaked echidna	<i>Zaglossus bartoni</i>	VU	-	Local informant interviews	Sites 1, 2 and 5
New Guinea quoll	<i>Dasyurus albopunctatus</i>	NT	-	Confirmed present	Site 5
Small dorcopsis	<i>Dorcopsulus vanheurni</i>	NT	-	Local informant interviews	Site 5
Lesser tube-nosed bat	<i>Nyctimene draconilla</i>	DD	-	Confirmed present	Site 5
McIntyre's horseshoe bat	<i>Rhinolophus mcintyre</i>	DD	-	Confirmed present	Site 4 and 5
Herpetofauna					
-	<i>Amnihyala longicrus</i>	DD	-	Confirmed present	Site 5
Birds					
New Guinea harpy-eagle	<i>Harpyopsis novaeguineae</i>	VU	P	Local informant interviews	Site 1, 4 and 5
Forest bittern	<i>Zonerodius heliosylus</i>	NT	-	Local informant interviews	Site 1
Palm cockatoo	<i>Probosciger aterrimus</i>	NT	P	Local informant interviews	Site 1
Sclater's crowned pigeon	<i>Goura sclateri</i>	NT	-	Confirmed present	Sites 1, 2 and 5
King bird of paradise	<i>Cicinnurus regius</i>	LC	P	Local informant interviews	Sites 1, 2, 4 and 5
Glossy manucode	<i>Manucodia ater</i>	LC	P	Local informant interviews	Sites 1 and 2
Raggiana bird of paradise	<i>Paradisaea raggiana</i>	LC	P	Local informant interviews	Sites 1, 2, 4 and 5
Pesquet's parrot	<i>Psittichas fulgidus</i>	VU	P	Local informant interviews	Site 1, 4 and 5
Odonates					
-	<i>Idiocnemis cf. schorri</i>	DD	-	Confirmed present	Sites 1 and 2
-	<i>Nososticta ovimacula</i>	DD	-	Confirmed present	Sites 1 and 2
-	<i>Argiolestes muller</i>	DD	-	Confirmed present	Site 1, 2 and 5
-	<i>Podopteryx roseonotata</i>	DD	-	Confirmed present	Site 2 and 5
-	<i>Nososticta rangifera</i>	DD	-	Confirmed present	Site 1, 2 and 5

* CE = Critically Endangered, EN = Endangered, VU = Vulnerable, NT = Near Threatened, DD = Data Deficient, LC = Least Concern

** P = Protected

8.6.5.3 Subspecies and taxa potentially new to science or with uncertain taxonomy

A total of 18 species potentially new to science or undescribed were recorded in the terrestrial ecology surveys, including 14 in the TSF development area and five along the infrastructure corridor. Table 8.22 describes these species and where they were recorded in the study area.

A further three species documented in the study area have uncertain taxonomy. Table 8.23 provides detail of these species.

Table 8.22 Subspecies and taxa potentially new to science or undescribed recorded in the terrestrial ecology study area

Species name	Location recorded	Description
Flora		
<i>Begonia</i> sp.1	Site 1	Recorded once in riverine primary forest and was not observed again in subsequent surveys. The species is a sprawling to erect herbaceous plant; approximately 20 to 30 cm tall; has green leaves with deeply serrated margins and oblique base; stems hairy. Male flowers with greenish tepals and bright yellow stamens. Does not match Lae Herbarium reference material and treated as likely new to science.
<i>Begonia</i> sp.2	Site 2	Recorded at multiple riverine locations. Sprawling to erect herbaceous plant c. 30 to 40 cm tall; oblanceolate serrated leaves with prominent white spots on the upper surface; stems and veins densely hairy. Male flowers with two white tepals and yellow stamens; female flowers with five white tepals; winged, hairy fruit capsules. Treated as likely new to science.
<i>Dillenia</i> sp.1	Site 1	Juvenile <i>Dillenia</i> observed in wet, saturated sago areas. Occupies saturated macrohabitat. No fertile material obtained. Morphology does not match known <i>Dillenia</i> specimens and it is regarded as likely new to science pending collection of reproductive material.
<i>Glochidon</i> sp.1	Site 1	Shrub to small tree (0.5 to 1 m) in closed-canopy forest on well-drained soils. Leaves lanceolate with a glaucous underside; fruits cauliflorous, red, sessile and pumpkin-like in appearance. No flowers observed. Species does not match Lae Herbarium specimens and is considered a potential new taxon pending collection of fertile material.
Herpetofauna		
<i>Choerophryne</i> cf. <i>gracilirostris</i>	Site 1	Acoustic recordings match no known species and most closely resemble <i>C. gracilirostris</i> . Likely new to science and of restricted range. Voucher specimens required to confirm identity.
<i>Hylophorbus</i> sp.1 (fast call)	Sites 1 and 2	Long-limbed frog with a rapid melodious call. Likely undescribed and may be restricted range or locally endemic. Voucher specimens and tissue were collected for taxonomic work.
<i>Hylophorbus</i> sp.2 (slow call)	Sites 1 and 2	Call matches an undescribed <i>Hylophorbus</i> known from eastern PNG or could be <i>H. rufescens</i> . Identification requires voucher material and comparison with other populations.
<i>Oreophryne</i> sp.1	Sites 1 and 2	Small arboreal frog (17 to 18 mm body length) with high-pitched peeping call. Previously recorded near Tabubil and regarded as undescribed. Likely restricted range. Vouchers collected.
<i>Sphenophryne</i> cf. <i>cornuta</i>	Sites 1 and 2	Scansorial shrub-dwelling frog with pointed snout and supra-ocular spikes. Genetically distinct from widespread <i>S. cornuta</i> and common at Ok Birim. Likely undescribed but widespread and not restricted range.
<i>Xenorhina</i> cf. <i>pohleorum</i>	Site 1	Single call similar to <i>X. pohleorum</i> but with subtle differences. May represent an undescribed taxon. Voucher required for confirmation.
<i>Spicicalyx</i> cf. <i>genimaculata</i>	Site 1	Medium sized treefrog with distinctive eye and limb features. Treated as undescribed pending genetic and acoustic study to confirm status.

Species name	Location recorded	Description
Odonates		
<i>Idiocnemis</i> cf. <i>schorri</i>	Sites 1, 2 and 5	Small, slender stream-dwelling damselfly with pale abdominal rings and a blue tail tip. Common along small forest streams. Thorax pattern differs from known regional species and it is likely undescribed.
<i>Nososticta</i> sp.1	Site 2	Small black stream damselfly with orange-yellow thoracic markings. Known from a single specimen at Site 2 and likely undescribed.
<i>Metagrion</i> cf. <i>annehueberae</i>	Site 1	Large, robust flatwing damselfly with blue thoracic markings that perches with wings flat. Resembles <i>Metagrion annehueberae</i> from the Muller Range; further specimens required to confirm status.
<i>Palaiargia</i> sp.1	Site 5	A single male of a small but moderately robust damselfly belonging to the genus <i>Palaiargia</i> appears to be new to science. Two unidentified females may also belong to this species. All were collected near clear-flowing forest streams.
<i>Papuargia</i> sp.1	Site 5	A robust, black-and-green damselfly in the genus <i>Papuargia</i> is sufficiently different from the sole representative of this species in southern PNG that it likely represents a species new-to-science. Like other members of the genus, it was found along clear-flowing rocky streams in forest.
<i>Teinobasis</i> sp.1 (long, slender)	Site 1, 4 and 5	An exceptionally long (abdomen ~55 mm) and slender damselfly in the genus <i>Teinobasis</i> represents a species new to science. This distinctive species is unlike any other member of the genus. It was encountered on low vegetation in primary forest.
<i>Teinobasis</i> sp.2 (yellow)	Site 4	A small, slender, yellow-faced damselfly of the coenagrionid genus <i>Teinobasis</i> is new to science. It is known from a single specimen collected on a hillslope far from water in primary forest at Site 4.

Table 8.23 Subspecies and taxa with uncertain taxonomy recorded in the terrestrial ecology study area

Species name	Location recorded	Description
Odonates		
<i>Podopteryx</i> sp.	Site 1	Single female of a large flat-wing damselfly captured. Male specimens are required for confident identification.
<i>Papuagrion</i> sp.	Site 1	Single female recorded. Male specimens are required for confident identification.
<i>Teinobasis</i> cf. <i>scintillans</i>	Site 1	One specimen resembling <i>T. scintillans</i> was obtained but is missing anal appendages needed for confirmation. Additional intact material is required to resolve identity.

8.6.5.4 Culturally significant species

Interviews with local informants identified 20 plant species of cultural significance within the TSF development area used regularly for food, construction, medicine, weapons and craft purposes. These culturally important plants include staples and multi-use species. For example, sago (*Metroxylon sagu*) is used for food and housing materials, *Pometia pinnata* provides edible fruit that is sold locally, and *Terminalia kaernbachii* supplies timber and marketable nuts, as well as species used for leaf-wrapping, thatching, spice, small tools and traditional medicines. No species were reported solely for body adornment, ritual use or specialised tool manufacture. Appendix F provides further detail of culturally significant taxa, uses and categories.

8.6.6 Protected areas

As noted in Appendix G, there are no national protected areas near the project. The northern end of the infrastructure corridor, approximately 158 ha, lies within the Star Mountains Key Biodiversity Area (KBA). As the KBA contains the entire population of at least one IUCN CE species, it triggers the criteria for an Alliance

of Zero Extinction site. The Star Mountains KBA is a 120,000 ha site reporting to hold the sole populations of Critically Endangered (CE) tree species, *Cryptocarya dipterocarpifolia*, *Cyrtostachys bakeri*, and *Eurya ryozoana*.

As detailed in Appendix F, available information suggests that *Cyrtostachys bakeri* and *Cryptocarya dipterocarpifolia* may be more widely distributed than currently documented, potentially extending beyond the Tabubil area, although their full distributions are not fully understood. Review of taxonomic and herbarium information suggests that the IUCN listing of the third species, *Eurya ryozoana* may be based on nomenclatural confusion, with *E. ryozoana* appearing to be synonymous with *Eurya kanaheiri*, a species known from a much broader distribution across New Guinea. On this basis, *E. ryozoana* is not considered further.

8.6.7 Critical habitat assessment

This section is a summary of the full critical habitat assessment, which is included in Appendix G.

Under the IFC PS6, a critical habitat is an area deemed to be of high biodiversity value, meeting a single or multiple of the following criteria:

1. Habitat of significant importance to Critically Endangered and/or Endangered species.
2. Habitat of significant importance to endemic and/or restricted-range species.
3. Habitat supporting globally significant concentrations of migratory species and/or congregatory species.
4. Highly threatened and/or unique ecosystems.
5. Areas associated with key evolutionary processes.

Critical Habitat under IFC PS6 is defined by the presence of areas of high biodiversity value. IFC guidance recognises that Critical Habitat may also include other recognised high biodiversity values. The project area contains extensive intact and largely unfragmented lowland rainforest with high species diversity, high levels of endemism and relatively undisturbed ecosystems, contributing to its high biodiversity value. Critical Habitat classification is based on biodiversity importance rather than the level of existing human disturbance, and both Natural and Modified Habitat may qualify. An area may meet multiple criteria; however, meeting a single criterion or containing another recognised high biodiversity value is sufficient to trigger classification as Critical Habitat.

The first four of the five criteria require quantitative assessment and assessment against defined thresholds. Table 8.24 presents the thresholds for these.

Table 8.24 Quantitative thresholds for critical habitat criteria 1 to 4

Criterion	Threshold
1. Critically Endangered (CR)/ Endangered (EN) Species	(a) Areas that support globally important concentrations of an IUCN Red-listed EN or CR species ($\geq 0.5\%$ of the global population AND ≥ 5 reproductive units of a CR or EN species). (b) Areas that support globally important concentrations of an IUCN Red-listed Vulnerable (VU) species, the loss of which would result in the change of the IUCN Red List status to EN or CR and meet the thresholds in Guidance Note 72(a). (c) As appropriate, areas containing important concentrations of a nationally or regionally listed EN or CR species.
2. Endemic/ Restricted Range Species	(a) Areas that regularly hold $\geq 10\%$ of the global population size AND ≥ 10 reproductive units of a species. For terrestrial vertebrates and plants this is any species with an extent of occurrence of 50,000 km ²
3. Migratory/ Congregatory Species	(a) Areas known to sustain, on a cyclical or otherwise regular basis, ≥ 1 percent of the global population of a migratory or congregatory species at any point of the species' lifecycle. (b) Areas that predictably support ≥ 10 percent of the global population of a species during periods of environmental stress.

Criterion	Threshold
4. Highly Threatened and/or Unique Ecosystems	<p>a) Areas representing $\geq 5\%$ of the global extent of an ecosystem type meeting the criteria for IUCN status of CR or EN.</p> <p>b) Other areas not yet assessed by IUCN but determined to be of high priority for conservation by regional or national systematic conservation planning.</p>

Source: Modified from Appendix G

The Critical Habitat assessment considered an ecologically appropriate area of analysis (AoA) that is broader than the project footprint to determine whether the project, or part thereof, is within a broader area of Critical Habitat. The AoA comprised an 870 km² area encompassing catchments of streams the project traverses, including the Wai Smare, Ok Birim, Ok Ma, Ok Taub, Ok Kameng, Ok Nong, Ok Dine, Ok Iluk, Ok Maon, Ok Arik and Ok Hwie (Figure 8.22). It excludes the catchments of the streams feeding the Upper Ok Tedi as the project will not impact them.

8.6.7.1 Criterion 1 Critically Endangered and/or Endangered species

Two mammals and eight species of plants which are Endangered or Vulnerable occur or could occur in the AoA. However, upon assessment three tree species, *Cryptocarya brevipes*, *Cryptocarya dipterocarpifolia* and *Calophyllum collinum* as well as one palm *Cyrtostachys bakeri*, were found to trigger or tentatively trigger Criterion 1a.

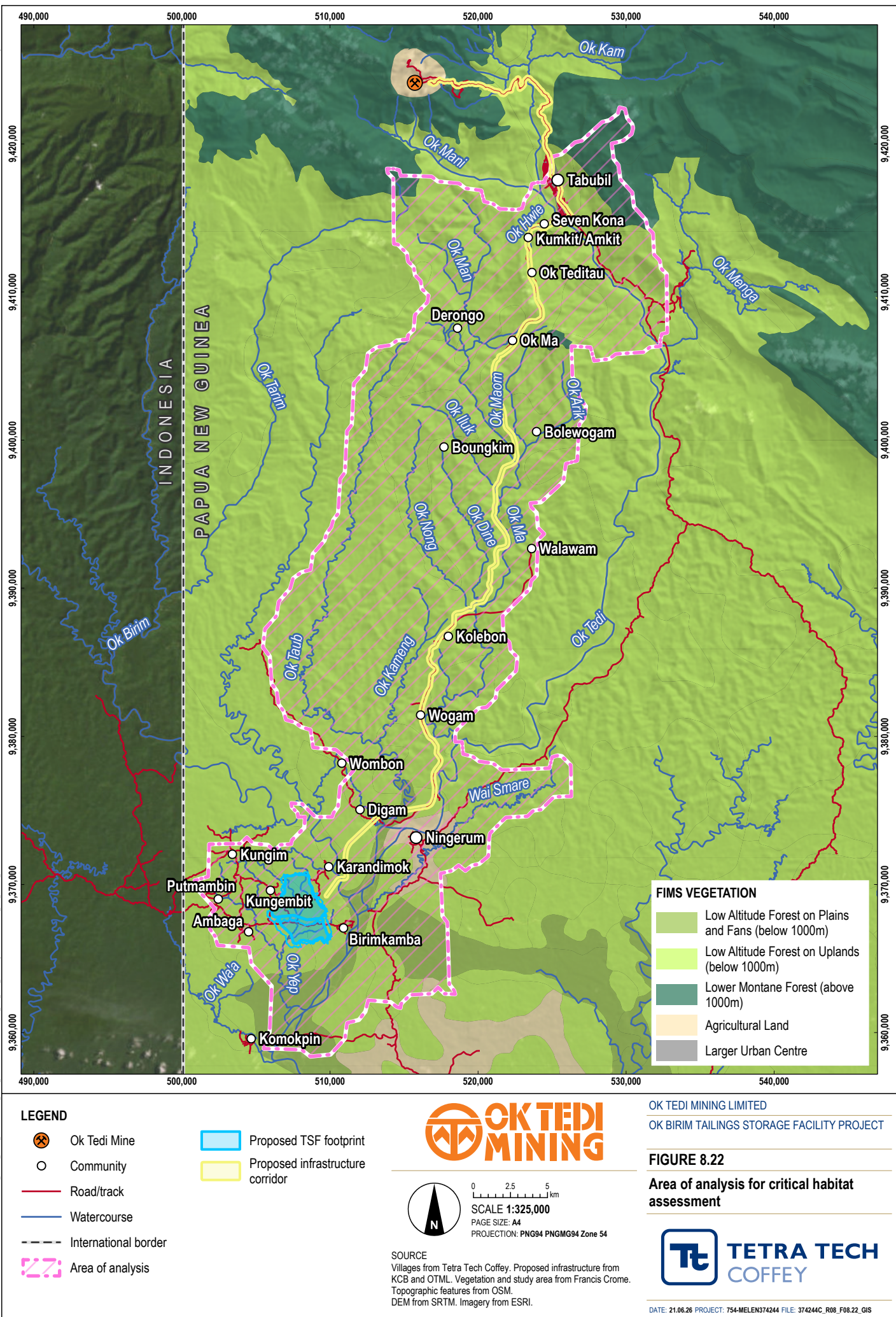
Four mammals, three birds, a reptile and 15 plants are Vulnerable species potentially occurring in the AoA. For three of the mammals it is moot as to whether they occur in the AoA, although the Gray Forest Wallaby (*Dorcopsis luctuosa*) supposedly occurs according to informants. It is predicted that the project will have a largely positive impact on these species.

8.6.7.2 Criterion 2 endemic/restricted range species

Forty restricted range species occur or possibly occur in the AoA. Two amphibians, six damselflies, and eight plants are likely to be species new to science (see Table 8.22) and, although considered unlikely to be restricted to the project development area, could have a large proportion of their distributions centred on the drainages of the Ok Tedi. The AoA might not encompass their entire distributions but, until proved otherwise, it is likely the AoA contains more than 10% and therefore these 16 species would all classify as triggers for Criterion 2.

Ten other restricted range species occur in the AoA but only the frog *Copiula lennarti* may tentatively trigger this criterion.

Fourteen other restricted range species are likely or known to occur in the AoA but not recorded in the project development area. Three damselflies, *Teinobasis cuneata*, *Teinobasis flavolineata*, and *Nososticta oculata* trigger Critical Habitat and Campbell's fairywren and the *Pandanus irwin* tentatively do. The *Echymipera Oriomo* and gecko *Cyrtodactylus derongo* are too poorly known to make an assessment.



8.6.7.3 Criterion 3 habitat supporting globally significant concentrations of a migratory species and/or congregatory species

Migratory species that could occur within the project area are migratory waders from the northern hemisphere and migratory birds from Australia. The project area and AoA do not contain suitable habitat for congregations of migratory waders, with only occasional individuals potentially occurring from time to time on the shores and sandbanks of larger rivers. While important waterbird habitat occurs further south within the Fly River floodplain, migratory bird species occurring within the project area are generally non-congregatory and mostly partial migrants. Accordingly, this criterion is not triggered.

Congregatory species potentially relevant to this criterion are primarily cave-roosting bats and swiftlets. Although 16 species of bats are likely to occur in the project area, including some within the Lukwi Cave system, it is unknown whether any roosts would be large enough to form over 1% of the global population. Appendix G notes this is unlikely, but if further investigations into the Lukwi Cave system identify large enough roosts, this may change. Consequently, no congregatory species currently trigger this criterion.

8.6.7.4 Criterion 4 highly threatened and/or unique ecosystems

No terrestrial ecosystems in PNG are listed on the IUCN Red List as threatened. The AoA is entirely low altitude forest on uplands, which occurs across 11,121,353 ha in PNG. Of this, 77% is still intact, 16% is under shifting cultivation and 7% is cleared. Considering there is likely a similar amount in Indonesian New Guinea and considering how sparsely populated New Guinea is, the AoA does not meet any of the criteria for being a Critically Endangered or Endangered ecosystem and this criterion is not triggered.

8.6.7.5 Criterion 5 areas associated with key evolutionary processes

This criterion is not triggered as the AoA has no relevant geological or geomorphological characteristics.

8.6.7.6 Assessment

The AoA is considered Critical Habitat due to the occurrence of four restricted-range species, and potentially two additional restricted-range species, meeting Criterion 2, together with two Endangered tree species potentially meeting Criterion 1a. In addition, residual impacts on several Vulnerable species (see Chapter 10) are considered sufficient to potentially influence their conservation status, contributing to Criterion 1b. The project area also supports extensive intact and largely unfragmented lowland rainforest with high biodiversity values and high levels of endemism.

8.7 AIR QUALITY

Being near the equator, PNG experiences relatively stable temperatures and minimal seasonality. High rainfall across much of the year helps suppress dust generation. Air quality across the project area is primarily influenced by local and regional climatic factors that affect wind movements and dispersion of airborne particles such as dust and particulate matter.

No air quality monitoring has been undertaken within the project area as ambient conditions are anticipated to be consistent with other rural locations in the region that share similar environmental characteristics. Air quality around the TSF development area is generally high due to the area's remote and relatively undisturbed nature. The ambient air environment is typical of a rural PNG setting with minimal anthropogenic emissions. Local emission sources include:

- Fugitive dust and particulate matter from OTML activities, local village activities (such as shifting cultivation), wind-blown exposed surfaces, and traffic on unsealed roads and tracks.
- Smoke from seasonal fires associated with shifting cultivation and hunting, burning of waste, as well as household cooking fires.
- Exhaust emissions from local vehicles and river boat motors.

Construction activities associated with the ITCS road and site investigations for the project also generate temporary, localised sources of fugitive dust and exhaust emissions in the TSF development area. These emissions contribute to highly localised minor short-term increases in local background air pollution levels.

Beyond the TSF development area, major sources of fugitive dust and air pollutants include the Ok Tedi Mine (approximately 55 km north of the TSF development area) and Bige dredging operations (about 20 km south). The Ok Tedi Mine generates fugitive dust and air pollutants from activities such as blasting, materials handling and processing, ore and waste rock stockpiling, and operation of heavy machinery and vehicles on unsealed surfaces. Similarly, the Bige dredging operations contributes to elevated levels of airborne dust and particulates from dredge material handling and stockpiling, heavy machinery operations and vehicular movements on unsealed surfaces during dry periods.

In 2022, OTML conducted a dust monitoring study along the Tabubil-Kiunga Highway and at Bige stockpiles to assess dust concentrations associated with the highway traffic and OTML's operational activities, and their influence on air quality. Dust monitoring included (OTML 2023c):

- Fine particulates with a diameter of ≤ 2.5 micrometres (μm) referred to as $\text{PM}_{2.5}$, primarily from combustion sources such as vehicle and machinery exhaust. These can penetrate deep into the lungs, posing serious respiratory and cardiovascular health risks.
- Coarse particulates with a diameter of ≤ 10 μm referred to as PM_{10} , commonly generated from non-combustion sources such as road dust and exposed surfaces, with potential to cause upper respiratory irritation.
- Total Suspended Particulate (TSP) which includes $\text{PM}_{2.5}$, PM_{10} and larger particles of sizes $\leq 100\mu\text{m}$. Both PM_{10} and TSP are typically associated with dust nuisance as they settle visibly on surfaces and can smother vegetation and crops.

Monitoring was conducted using a DustTrak™ (Model 8533) for 24-hour sampling periods over 14 consecutive days at three sites: two locations near villages along upper and lower Tabubil-Kiunga Highway and one location adjacent to the Kwiape Village Access Road at Bige. Dust levels were compared against the WHO 2021 Air Quality Guidelines (WHO 2021b), with results summarised as follows:

- DM01 - km17 (Lower Highway): Approximately 40 km southeast of the TSF development area. Dust levels were generally below WHO guideline limits, indicating minor impact from traffic and operational activities.
- DM02 – km84 (Upper Highway): Approximately 17 km northeast of the TSF development area. This site recorded exceedances of PM_{2.5} limits on two days during hot and dry weather, suggesting intermittent short-term localised impacts associated with operational dust sources and traffic along the highway.
- DM03 – Bige (Kwiape village): Approximately 20 km south of the TSF development area. Very low dust levels were recorded and attributed to persistent rainfall that suppressed dust from stockpiling and related activities.

Overall, dust levels across all sites were well below WHO 2021 Air Quality Guidelines for PM except for the two days where km84 dust levels exceeded the PM_{2.5} limit during hot, dry weather.

The study findings indicate that existing regional sources of dust emissions associated with Tabubil-Kiunga Highway traffic and Bige operations are not of significant concern for air quality around the TSF development area. However, short-term elevated dust levels may occur between July and September when prevailing southeasterly winds potentially transport fugitive dust from the Bige stockpiles, particularly during dry weather. These levels are not significant given their short duration and the frequent rainfall that naturally suppresses dust; the Bige stockpiles are approximately 20 km south of the TSF development area.

8.8 GREENHOUSE GAS EMISSIONS

The PNG Climate Change and Development Authority (CCDA) is responsible for monitoring and reporting the country's greenhouse gas (GHG) emissions in accordance with the 2006 International Panel on Climate Change Guidelines for National Greenhouse Gas Inventories. PNG has been a Party to the United Nations Framework Convention on Climate Change since 1993 and ratified the Paris Agreement in 2016. Under Article 4 of the Paris Agreement, PNG is required to submit Nationally Determined Contributions (NDCs) through which it aims to reduce national emissions by 50% by 2030 and achieve carbon neutrality by 2050 (CCDA 2022). PNG submitted its First NDC in 2016, followed by an Enhanced NDC in 2020, and plans to submit the NDC 3.0 in 2026 (CCDA 2025; UNDP 2026).

According to PNG's Second Biennial Update Report to the United Nations Framework Convention on Climate Change, based on the national 2017 GHG inventory, emissions have generally increased over time driven largely by socio-economic growth. Nevertheless, PNG's overall contribution remains a very small share of global emissions. PNG shifted from a net sink of -12,436 kilo-tonnes of carbon dioxide equivalent (kt CO₂e) to a net source in 2016 (6,897 kt CO₂), before returning to a net sink in 2017 (-1,958 kt CO₂e). These variations are primarily driven by the Land use, Land-Use Change and Forestry (LULUCF) sector, which is the largest source of emissions. Historically, the LULUCF sector has acted as a carbon sink. However, over time this has significantly decreased into a smaller sink due to deforestation and forest degradation associated with increased logging and agricultural activities (CCDA 2022).

Excluding the LULUCF sector, in 2024 PNG's annual GHG emissions were 10,761 kt CO₂-e, excluding emissions associated with land-use change and forestry (EDGAR 2025). PNG's total net emissions increased by 34% from 8,052 kt CO₂-equivalent in 2000 to 10,767 kt CO₂-equivalent in 2017, mainly driven by greater fossil fuel consumption in manufacturing, construction and road transportation. In 2017, the energy sector accounted for about 8,673 kt CO₂-equivalent, representing a 28% increase (1,913 kt CO₂ e) from 2000 (CCDA 2022).

For comparison, total emissions from the Industrial Process and Product Use (IPPU) sector, which includes the mineral resource industry, was estimated at 153 kt CO₂e in 2017, which is about 1% of the national total GHG emissions (excluding LULUCF). This represented a slight decrease of approximately 5% from 161 kt CO₂e in 2016. The CCDA notes that the Industrial Process and Product Use IPPU sector inventory remains incomplete and further improvements to the national inventory are ongoing (CCDA 2022).

8.9 NOISE

Ambient noise levels across the project area are anticipated to be typical of background noise levels observed in rural areas of PNG. This reflects the project's location far from major industrial sources and population centres where elevated noise levels typically occur. The Bige dredging operations do not contribute to local background noise given these activities occur approximately 20 km south of the TSF development area.

In these rural settings, background noise predominantly arises from natural sources such as wind and heavy rainfall, flowing water, and wildlife (e.g., insects, bird calls). Local village activities also contribute to ambient noise levels, including small-scale farming, domestic livestock, wood chopping, talking and domestic work, and occasional vehicle movements. Given the dense tropical vegetation across the project area, insect noise is expected to be the most consistent and dominant sound throughout the year.

Current ambient noise levels around the TSF development area are also affected by the temporary, localised noise sources from ongoing construction activities associated with the ITCS road and from site investigations for the project, mostly from heavy machinery operations and vehicular movements on unsealed surfaces. Traffic noise from local roads and tracks in the project area, where present, also contribute to background noise on a regular basis. This includes noise from cars, trucks and river boats used to transport goods and people.

No baseline noise monitoring has been undertaken within the project area as ambient and background conditions are anticipated to be consistent with other rural locations in the region that share similar environmental characteristics. Based on noise monitoring for other developments in PNG, background noise levels (continuous noise in the absence of intermittent noise) (L_{A90}) are typically between 30 dBA and 50 dBA, while average noise levels (all sources of noise) are typically between 40 dBA and 60 dBA. Insect noise is a dominant noise source in rural locations in the region that share similar environmental characteristics to the project. Noise levels in these areas are typically higher in the evening and night when insects are active.