FRIEDA RIVER

Frieda River Limited

Sepik Development Project

Environmental Impact Statement

Appendix 3b – Frieda River Hydroelectric Project Conceptual Closure Plan

SDP-6-G-00-01-T-003-012

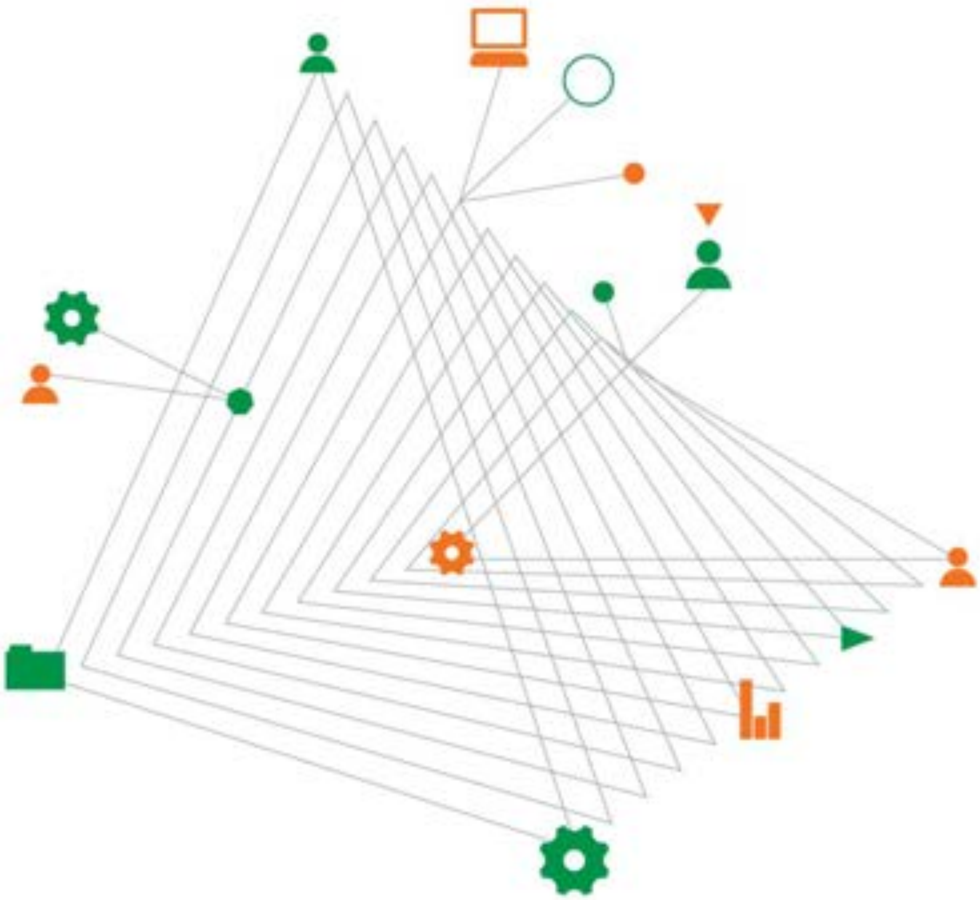
coffey
A TETRA TECH COMPANY

Frieda River Limited

Frieda River Hydroelectric Project

Conceptual Closure Plan

18 September 2018



Experience
comes to life
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Prepared for Frieda River Limited

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Quality Information

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1. INTRODUCTION

1.1 Background

Frieda River Limited (FRL) is assessing the feasibility of the Sepik Development Project in the Sandaun and East Sepik provinces of Papua New Guinea (PNG) (Figure 1.1). The Sepik Development Project is underpinned by the Frieda River Copper-Gold Project (FRCGP), which seeks to develop the Horse-Ivaal-Trukai, Ekwai and Koki (HITEK) porphyry copper-gold deposits.

A key component of the Sepik Development Project is the Frieda River Hydroelectric Project (FRHEP). The 600 megawatt (MW) hydroelectric power facility will provide a renewable energy source to power the FRCGP for the life of the mine. The reservoir will be used as an integrated storage facility (ISF) for the subaqueous storage of the mine's 2.9 billion tonnes of waste rock and tailings produced over the life of the mine (LOM), within the Frieda River catchment (see Figure 1.2). This best practice waste management strategy will limit downstream sedimentation and the potential for the material to generate acid and metalliferous drainage.

The FRCGP's maximum power demand will reach up to 280 MW by Year 8, which provides an opportunity to distribute excess power to other customers including power distributors to purchase and on sell to the PNG grid or export to Indonesia.

It is anticipated that the FRHEP will be owned and operated a by third-party entity with a design life in the order of 100 years. Power supply for the FRCGP will be distributed via a 22-km transmission line for 33-years LOM. There is potential for ongoing power generation by the FRHEP following closure of the FRCGP.

The FRHEP is located in the northern foothills of the Central Range of the New Guinea Highlands in Sandaun Province. It lies in a remote area approximately 200 kilometres (km) from the northern coast and 50 km from the Sepik River. The area is characterised by steep terrain, very high rainfall, low population density and a near-absence of infrastructure such as road, power and communication networks.

The ISF reservoir will be located within the Frieda, Nena and Niar river valleys 16 km downstream of the mine and 35 km (straight line) upstream of its confluence with the Sepik River. The ultimate footprint will be approximately 12,400 hectares (ha).

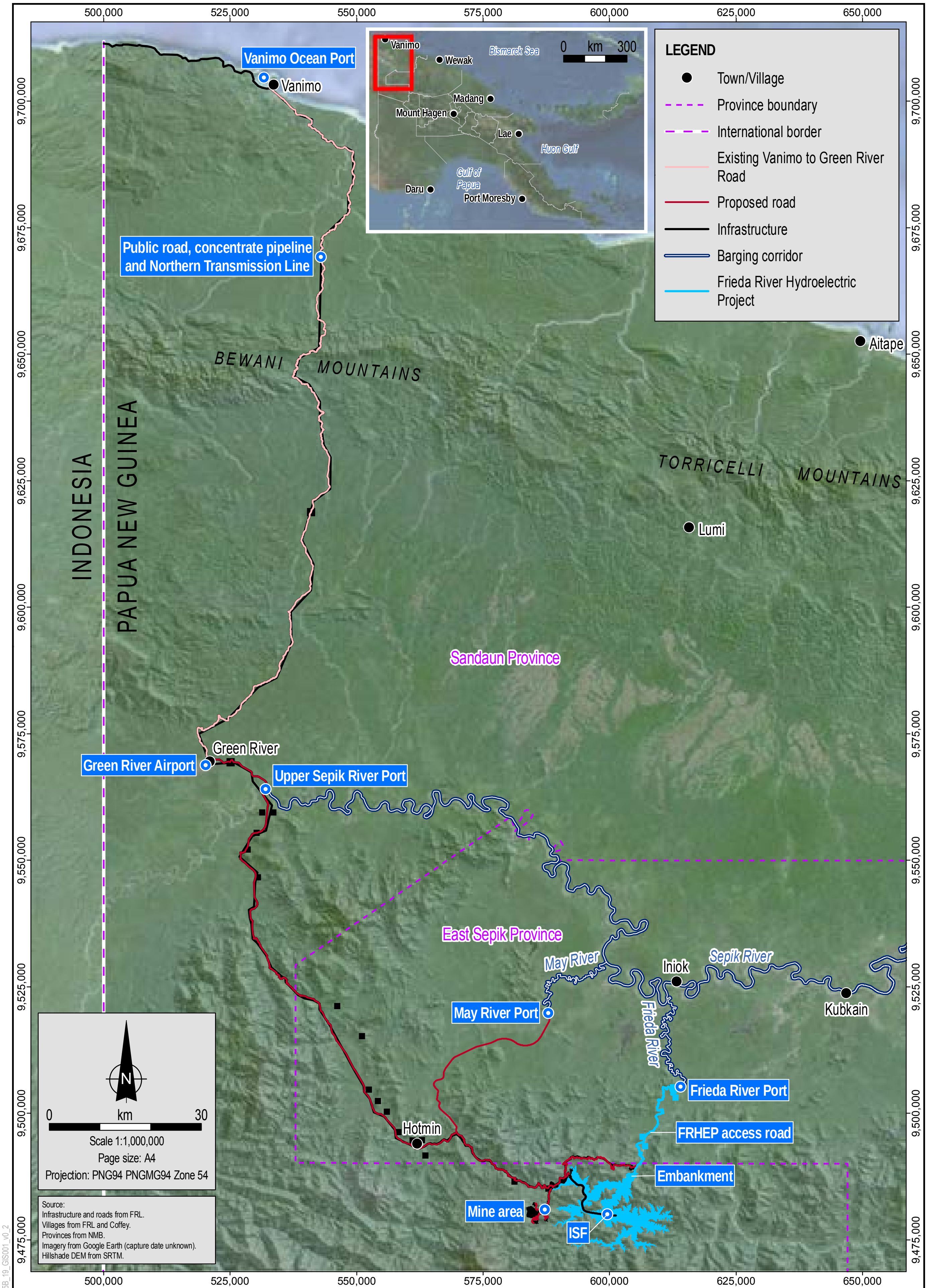
The Frieda River Port will be used to import early works equipment and construction materials for the FRHEP via a barging corridor along the Sepik and Frieda rivers. This 40 km access road will be used for all main construction material movement when completed and will give access to the FRHEP from the Frieda River Port via road transport. A link road connects the FRHEP access road to the mine site accommodation and administration facility.

The main components of the FRHEP are shown in Figure 1.2.

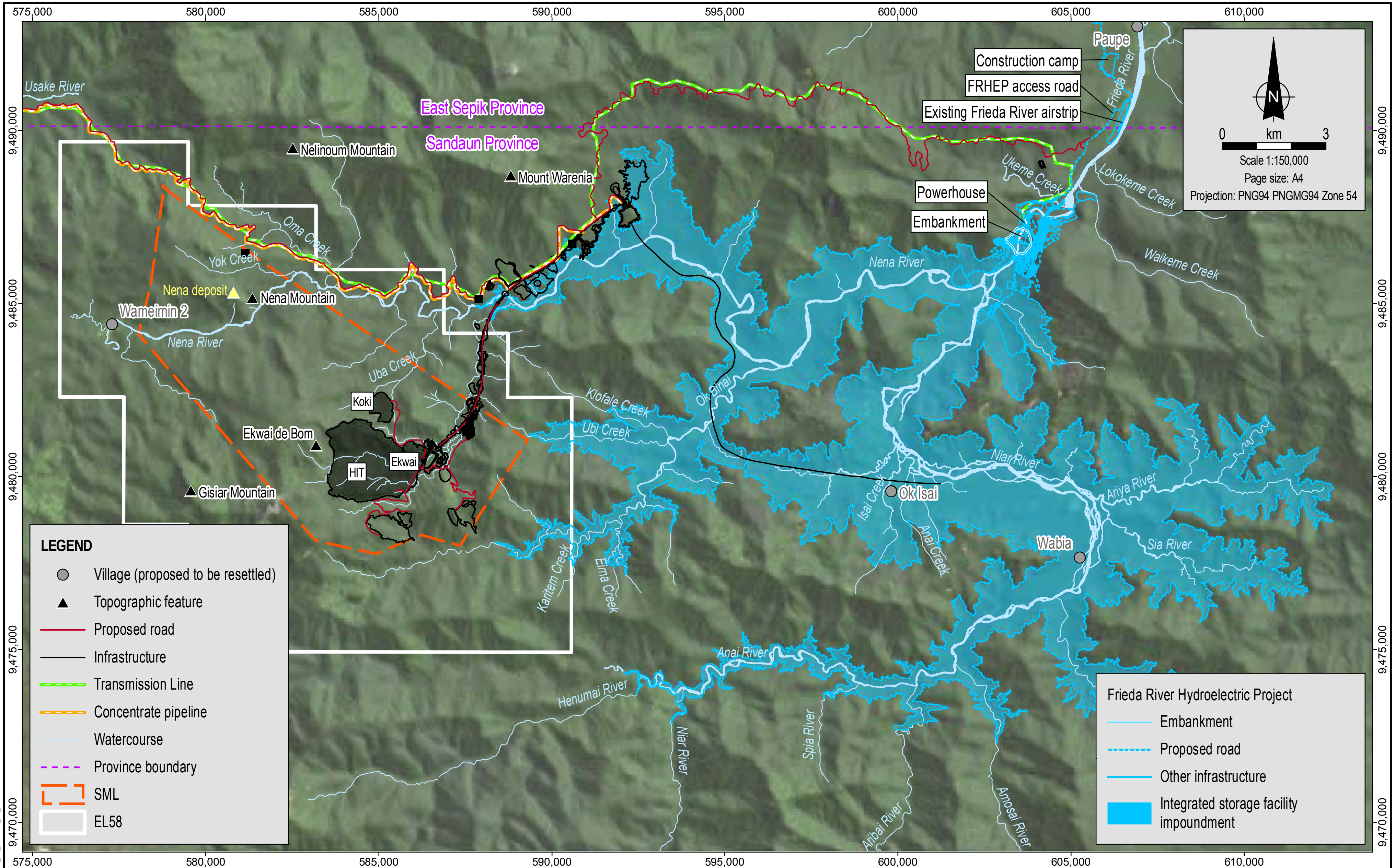
1.2 Scope

The scope of this document covers infrastructure associated with the FRHEP. The proposed layout is shown in Figures 1.1 and 1.2; however, this may change as planning for, and development of, the FRHEP progresses. This plan will be updated to reflect material project changes as required.

Decommissioning and closure of the FRCGP is described in the Frieda River Copper-Gold Project Conceptual Mine Closure Plan (Coffey, 2018).



coffey A TETRA TECH COMPANY	Date: 16.08.2018 Project: 754-ENAUABTF11575B File Name: 11575_19_F01.01_GIS	Frieda River Limited Sepik Development Project	FRIEDA RIVER	Sepik Development Project overview	Figure No: 1.1



Source:
Infrastructure, roads and tenements from FRL.
Villages, topographic features, watercourses and water bodies from FRL and Coffey.
Provinces from NMB.
Landsat satellite imagery from FRL (capture date unknown).
Hillshade DEM from SRTM.

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File Name: 11575_19_F01.02_GIS

Frieda River Limited

Sepik Development Project

FRIEDA RIVER

FRHEP area

Figure No: 1.2

1.3 Purpose of this Document

This Conceptual Closure Plan serves as a planning tool to assist FRL in the eventual closure of the FRHEP. Specifically, the purpose of this plan is to:

- Document the stakeholder consultation plan in relation to closure.
- Define closure objectives in relation to the FRHEP and provide a clear outline of how these will be met.
- Identify the site-specific, key environmental and social issues relevant to closure planning.
- Identify the stewardship program to address the responsibility of hydroelectric dam safety standards and provide a structure for the oversight of mine waste (tailings and waste rock).
- Provide the basis for the ongoing review of closure strategy.

1.4 Definitions

Key definitions in relation to closure are described below and shown in Figure 1.3.

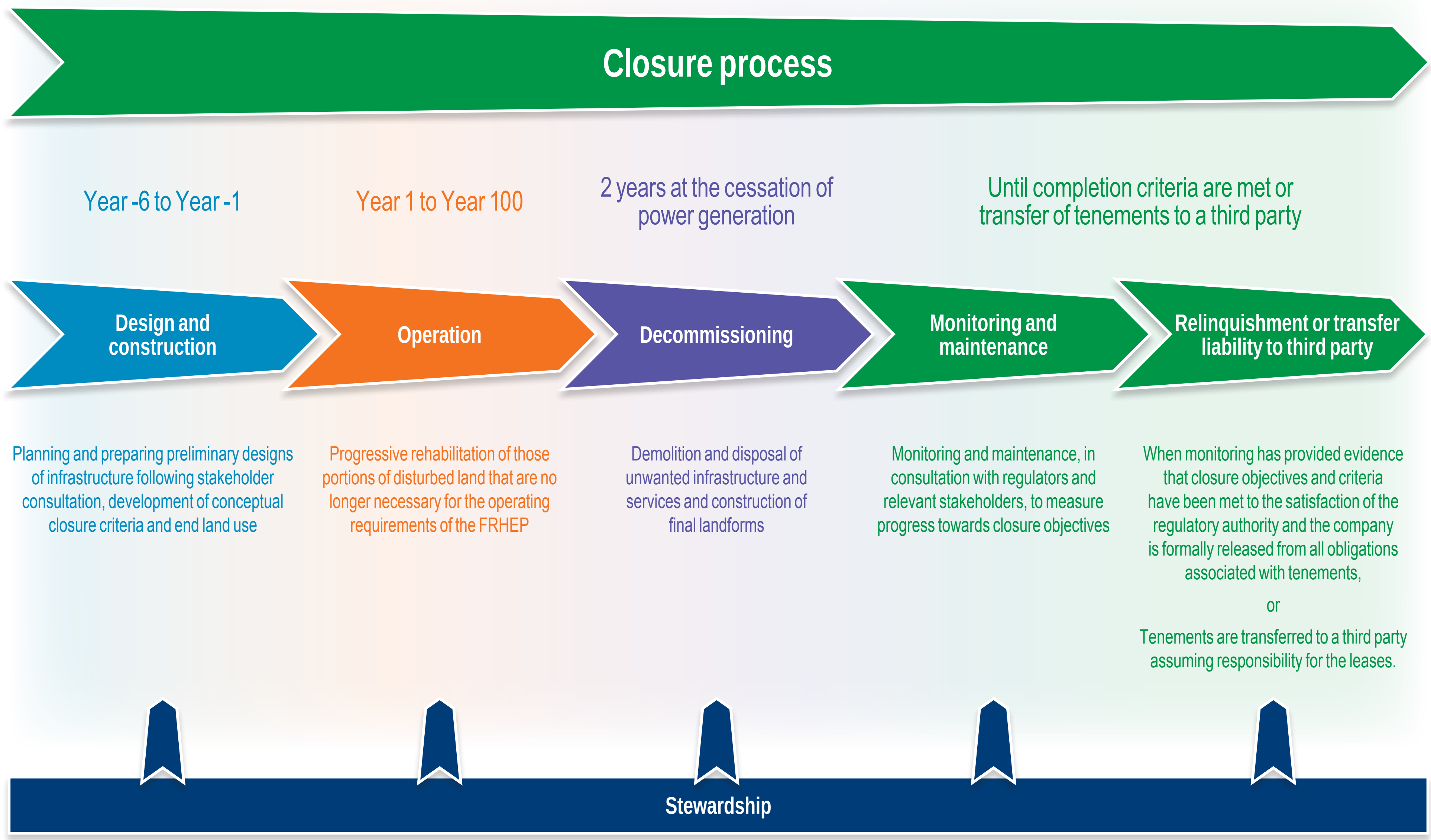
Decommissioning. Decommissioning begins at the cessation of operations and will involve demolition and disposal of all unwanted infrastructure and services. Personnel will comprise a contractor-oriented workforce shutting down the facility.

Post closure monitoring and maintenance. This involves evaluating monitoring data and other evidence, in consultation with regulators and relevant stakeholders, to determine if the objectives and closure criteria have been met. Some ongoing rehabilitation works and maintenance will also occur. Post closure monitoring and maintenance is expected to occur until completion criteria are met.

Relinquishment. When monitoring has provided evidence that the objectives and closure criteria have been met to the satisfaction of the regulatory authority, the company is formally released from all obligations with respect to associated tenements, with the regulators or a third party assuming responsibility for the leases.

Closure. Is the process by which the Project reaches its final state following the cessation of production and refers to the entire process from progressive rehabilitation, decommissioning, post closure monitoring and maintenance, and relinquishment.

Stewardship. The care and management of a facility through its life cycle (from commissioning through to closure) including the infrastructure used during operations and following relinquishment.



coffey A TETRA TECH COMPANY	Date: 16.08.2018 Project: 754-ENAUABTF11575B File Name: 11575_19_F01.03_GRA	Frieda River Limited Sepik Development Project	FRIEDA RIVER	FRHEP closure process	Figure No: 1.3

AI Reference: 11575_19_GRA001.ai_3

2. REGULATORY AND POLICY FRAMEWORK

The following section provides a summary of PNG legislation and policy and other guidelines relevant to rehabilitation and closure planning for the FRHEP.

2.1 Legislation and Policy of PNG

The Independent State of Papua New Guinea promotes the sustainable development of its resources through various policies. This is supported by a legislative and policy framework, which ensures that approved developments assess, reduce and manage residual environmental and social impacts. It is a government priority and constitutional requirement to ensure that the people of PNG benefit from the development of their resources within a sustainable, environmentally responsible and socially acceptable manner.

Key pieces of legislation relevant to the development of the FRHEP are the *Environment Act 2000* (Environment Act) and the *Mining Act 1992* (Mining Act).

The Mining Act is presently the principal regulatory document governing the mining industry and associated infrastructure supporting mine operation such as dams in PNG. The rights to explore for, mine and sell mineral resources are granted in the form of tenements. The FRHEP is likely to operate under a lease for mining purposes (LMP), which is required to construct and operate the ISF. LMP tenements granted under the provisions of the Mining Act will revert back to the State on relinquishment. It is proposed that the FRHEP will be transferred to a state lease on closure of the FRCGP.

The Environment Act provides the administrative mechanism to evaluate impacts on the environment through an environmental approval and permitting system under the Conservation Environment Protection Authority (CEPA). The Sepik Development Project (including the FRHEP) has been deemed a Level 3 activity under the Environment (Prescribed Activities) Regulation 2002, for which an environmental impact statement (EIS) is required for assessment.

In addition to the previously mentioned legislation, the following legislation have legal requirements relevant to closure planning:

- *Land Act 1996*.
- *Mining (Safety) Act 1977.*
- *Industrial Safety, Health and Welfare Act 1961*.
- *Building Act 1971*.
- *Road Maintenance Act 1971*.
- *Physical Planning Act 1989*.
- *National Cultural Property (Preservation) Act 1965*.
- *Water Supply and Sewerage Act 1996*.
- Industrial Safety, Health and Welfare Regulation 1961.
- Public Health (Drinking Water) Regulation 1984.
- Environment (Prescribed Activities) Regulation 2002.
- Environment (Water Quality Guidelines) Regulations 2002.

2.2 PanAust Group Sustainability Framework

The PanAust Group Vision and Values, and Sustainability Policy outline the company’s commitment to preserving and enhancing the environmental, social, technical and financial elements of the business. Fourteen Sustainability Management Standards relating to leadership, risk management, health and safety, training, environment, stakeholder engagement and community have been developed to ensure consistent sustainability-related outcomes across the business.

Sustainability forms part of the Executive Management Team’s five-year plan and their critical tasks. The General Manager Human Resources and Risk Management facilitates annual Risk and Sustainability Workshops with key management and operational and sustainability support staff from across the PanAust Group to drive company-wide alignment with PanAust’s approach to sustainability.

PanAust measures its sustainability performance against international standards and commissions independent audits based on the Equator Principles and the International Finance Corporation's Policy on Social and Environmental Sustainability. PanAust uses an Enterprise Risk Management process to identify all key material risks and audits and/or reviews against those risks are carried out regularly. Through this process gaps are identified and risk management plans are developed and implemented.

2.3 PanAust Group Closure Standard

Key closure risks in relation to mining and supporting infrastructure are identified through PanAust’s Group Closure Standard (PAA, 2012), which establishes guidelines for planning and implementing closure processes while adhering to leading international standards. With respect to the current plan, PanAust’s Group Closure Standard provides guidance relevant to the management of the ISF and supporting infrastructure. The intent of the Standard is to develop and maintain operational activities that have closure outcomes to a leading international standard with the ultimate goal of custodial transfer (i.e., relinquishment) once the site has been reclaimed.

2.4 Guidelines and Performance Standards

2.4.1 International Standards

Projects in the developing world are frequently assessed within the context of the Equator Principles (EPFI, 2006), which were developed in 2003 as an international banking industry framework to determine the environmental and social risks of project financing and are commonly referred to as ‘the guidelines’. The guidelines provide a framework for financial institutions to assess the environmental and social impacts, the management of impacts and the risks associated with the projects that they fund, the underlying premise being that financial institutions will provide loans to projects that have met IFC requirements (i.e., IFC performance standards and environment, health and safety (EHS) guidelines) with respect to environmental and social aspects.

The key IFC guideline with relevance to the FRHEP is the IFC Good Practice Note on Environmental, Health, and Safety Approaches for Hydropower Projects (IFC, 2018). This guideline is a technical reference document with industry-specific examples of Good International Industry Practice.

The Environmental, Health, and Safety General Guidelines (IFC, 2007) also provide specific guidance on prevention and control of community health and safety impacts that may occur at the end of the project life-cycle.

2.4.2 Dam Safety Guidelines

Dam safety programs are described by the International Commission on Large Dams (ICOLD) and most of its associated national organisations, including the Australian National Committee on Large Dams (ANCOLD) and the Canadian Dam Association (CDA).

ICOLD sets guidelines to ensure that dams are built and operated safely, efficiently, economically, and are environmentally sustainable and socially equitable. These documents prescribe closure guidelines to ensure dam structures are continually inspected and supervised throughout their whole life. These guidelines include:

- Bulletin 158 – Dam Surveillance Guide (2015).
- Bulletin 154 – Dam Safety Management: Operational Phases of the Dam Life Cycle.
- Bulletin 139 – Improving Tailings Dam Safety – Critical Aspects of Management, Design, Operations and Closure (2011).
- Bulletin 59 – Dam Safety Guidelines (1987).

Numerous other bulletins have been published by ICOLD relating to specific features for the design of dams.

The Australian National Committee on Large Dams (ANCOLD) guidelines are applicable for tailings dams with the potential to cause loss of life or significant physical damage through operation or failure. These guidelines include:

- Guideline for Design of Dams for Earthquakes (August 1998).
- Guidelines on Tailings Dams - Planning, Design, Construction, Operation and Closure (May 2012).
- Guidelines on Selection of Acceptable Flood Capacity for Dams (March 2000).
- Guidelines on the Consequence Categories for Dams (October 2012).
- Guidelines on the Environmental Management of Dams (January 2001).
- Guidelines on Dam Safety Management (August 2003).
- Guidelines on Risk Assessment (October 2003).

Canadian Dam Association (CDA) serves on the Canadian National Committee of the International Commission on Large Dams (ICOLD) and is a leading organisation in advancing dam expertise and knowledge. These guidelines include:

- Dam Safety Guidelines (2007 and revised in 2013).
- Application of Dam Safety Guidelines to Mining Dams (2014).

FRL has used the performance standards prescribed above to guide the closure planning process for the FRHEP.

3. SETTING

This chapter provides contextual information concerning the physical, biological and social environment of the FRHEP disturbance area and environs. This information establishes the context in which closure issues and plans can be discussed and has been sourced primarily from the following documents:

- Environmental Impact Statement for the Sepik Development Project (Coffey, 2018a).
- Frieda River Copper-Gold Project Feasibility Study Report (FRL, 2018).
- Social Impact Assessment for the Frieda River Project (Coffey, 2018b).

Additional studies and literature were used where required to supplement these reports.

3.1 Geography

The FRHEP area is situated on the northern slopes of the Central Cordillera of PNG, within the watershed of the Sepik River. The FRHEP area is characterised by a dense jungle canopy draped by steep mountains that are incised by rivers and streams.

The reservoir will be located within the Frieda, Nena and Niar river valleys 16 km downstream of the Frieda River Copper-Gold mine and 35 km (straight line) upstream of its confluence with the Sepik River. The ultimate footprint will be approximately 12,400 hectares (ha).

The altitude of the region generally decreases towards the northeast. The FRHEP embankment foundation is situated at roughly at RL 50 m. The Frieda River flows out of the mountainous region into relatively flat terrain, where riverbanks are regularly inundated and poorly drained, and subsequently flows northward to its confluence with the Sepik River, which is approximately RL 30 m.

3.2 Physical Environment

3.2.1 Climate

The region is classified as wet tropical with recorded mean monthly temperatures varying between 21 and 23ºC. Temperatures are generally higher in the floodplains than in the highlands. Relative humidity is consistently high, with maximum monthly humidity in the order of 95 to 100% and minimum monthly humidity between 40 and 55%.

Rainfall on the higher elevations of the FRHEP area (average annual rainfall from 6,900 to 8,200 mm) is greater than the Sepik River floodplain (average annual rainfall from 3,600 to 4,600 mm). Similarly, the mean daily rainfall is considerably higher in the hill zone (23 mm per day) than on the Sepik River floodplain region (11 mm per day) or the northern coast. The Sepik River floodplain region, located at lower elevations, experiences greater rainfall seasonality compared to the FRHEP area with lower rainfall recorded between May and October.

3.2.2 Hydrology

In the higher elevations of the FRHEP area, steep, rapidly flowing mountain streams, including the Ok Binai, Ubi Creek, Aribai River and Dama River, are flanked by dense tropical rainforest. Given the limited storage capacity of their catchments, these watercourses can rise rapidly during rainfall events. Mountain streams and creeks converge to form larger rivers, including the Nena, Niar, Frieda, Wario and Wogamush rivers, all of which are tributaries of the large lowland river, the Sepik River. Levels of suspended solids in the mountain streams and creeks are low, typical of undisturbed forested catchments, unless a recent landslip has occurred.

Features of watercourses within, or adjacent to, the FRHEP area allow them to be categorised into three groups:

- Upland creeks: all creeks above RL 150 m, and those dominated by cascades, rapids, waterfalls or regular riffles.
- Upland rivers: all rivers above RL 150 m.
- Mid-catchment rivers: rivers below RL 150 m and generally still confined by the surrounding geology.
- Large lowland rivers with high, lateral mobility, extensive floodplains and off-river waterbodies (e.g., ox-bows), that have high turbidity with sandy substrates and deep, central channels and outer meander bends. These rivers are located downstream of the ISF embankment.

3.2.3 Seismicity, Geology and Soils

Northern New Guinea is an active tectonic area with a complex geologic history. The Frieda River is dominated by faults that comprise the New Guinea Thrust Fault Zone. These faults include: the Saniap Fault, the Frieda Fault, the Fiak-Leonard Schultz (Fiak) Fault, and the Lagaip Fault (Trangiso, Stolle and Figi faults).

The Northern New Guinea flat plains, which form this ecoregion, have been compressed between the foothills of the Central Cordillera to the south and the Van Rees, Torricelli and Foya mountains to the north. The surface geology consists of clastic sedimentary rocks and recent alluvium. In the highlands, volcanic rocks (mainly basalts) are most common.

The FRHEP lies on the Frieda River Igneous Complex, in the northern foothills of the Central Cordillera, towards the southern margin of the New Guinea Thrust Belt. The igneous complex is approximately 17 km long by 7 km wide and is considered to be the remnants of a large stratavolcano. The area is predominantly made up of mixed or undifferentiated metamorphics including diorites and andesites.

A wide range of soils exists over relatively small areas due to weathering, and colluvial and alluvial soil movements. Generally, soil types show the following pattern:

- Shallow soils over highly weathered rock on the crests/upper slopes.
- Deeper (but variable) colluvial rocky and gravelly soils on the lower slopes.
- Variable alluvial clays, silts, gravels and cobbles within the base of headwater incisions, e.g., Frieda River headwaters.
- Alluvial floodplains and swamps comprise inter-bedded clays, silts, gravels, cobbles and peat.

3.3 Biological Environment

3.3.1 Ecology

The Sepik basin is one of Malesia's most biologically diverse riverine environments and the largest catchment in PNG. The area contains a high diversity of terrestrial fauna, in particular mammals and frogs, in comparison with other remote areas of the PNG highlands. Both flora and fauna tend to have affinities with western New Guinea.

Three major environmental zones within the FRHEP disturbance area can be defined on the basis of unambiguous geomorphic criteria, i.e., the ‘lowland zone’, ‘hill zone’ and ‘montane zone’. The lowland zone comprises depositional landforms that result from past or present overbank flooding of the Sepik River and its major tributaries. These areas are subject to inundation on a seasonal or multiannual basis. The hill zone and montane zone are part of the northern foothills of the Central Cordillera and comprise continuous ranges and isolated hills consisting of primary erosional and colluvial landforms. The topography is generally steep, with significant stretches of cliff line.

The lowland zone supports characteristic vegetation communities that have been described as riverine mixed successions, open low-altitude forest on plains and fans, alluvial swamp, woodland and lowland peat forest. The vegetation of the hill zone shows gradational differences. At low to medium elevations, the vegetation is medium-crowned upland forest, but at higher elevations (typically above 1,000 m), this grades into small-crowned lower montane forest and small-crowned lower montane forest with conifers.

The FRHEP area covers largely intact forest habitats with only small areas of disturbance caused by previous mining exploration activities and by local residents (albeit at low population densities) who carry out traditional subsistence activities, including small-scale gardening, hunting, and artisanal mining.

The biodiversity surveys to support the EIS for the Sepik Development Project recorded a total of 2,220 plants and animal species. These included a range of species new to science or undescribed comprising new species of plants, mammals, frogs, reptiles, dragonflies, damselflies and butterflies, as well as range extensions for several species.

The Sepik River catchment is rich in species endemic to northern New Guinea and mammals, particularly, have high levels of endemism, with over 70% of the species recorded being endemic to mainland New Guinea or smaller areas. A number of individual species and ecosystems of conservation significance were also identified.

3.3.2 Aquatic Flora and Fauna

The upper and mid reaches of the Sepik River catchment are relatively sparsely populated with high habitat integrity, greater diversity of macroinvertebrates and moderate diversity of fish compared with the lower catchment. However, the lower catchment has a higher abundance and diversity of fish and is more influenced by introduced fish species than the upper and mid catchments.

Seventeen species of fish that have been reported in the Sepik River are of conservation significance, due either to their assessment as threatened or potentially threatened species or because of their restricted range (endemism).

In addition to the fish, two New Guinea-endemic species of freshwater turtles are known to occur in the Sepik-Ramu River system: the New Guinea giant softshell turtle (*Pelochelys signifera*), and the spotted or New Guinea snapping turtle (*Elseya schultzei*). The New Guinea giant softshell turtle is listed as vulnerable under IUCN.

3.4 Socio-economic Environment

There are three language groups present in and around the FRHEP area, namely the Paiyamo, Miyan, and Telefol.

Both geographically and culturally, the FRHEP lies in a ‘transition zone’ between the larger populations inhabiting the high peaks of the New Guinea cordillera to the south and those living in the extensive plains of the Sepik basin to the north.

Approximately 97% of land in PNG, including the FRHEP area, remains under customary tenure. The remaining 3% is almost entirely owned by the National Government and is generally referred to as ‘alienated land’. The FRHEP area falls under customary land tenure.

Socio-economic characterisation, undertaken as part of the Sepik Development Project's social impact assessment (SIA) (Coffey, 2018b), recorded the following features:

- **Land Use.** Villagers rely on the surrounding environment to obtain the majority of their food from the land and rivers through harvesting and sago production, gardening, fishing and hunting.
- **Economy.** The economic environment is largely informal due to remoteness and the ensuing lack of access to markets and services or to retail or employment opportunities. Alluvial gold mining is one source of reliable income for a number of communities in the higher reaches of the Frieda River. Other sources of income include the sale of agricultural products, handicrafts, hunted goods and fishing products.
- **Education.** On average across the villages, approximately 47% of the population has received no education, which can largely be correlated with it being difficult to access education services and facilities. Only a very small proportion of the population in the area could be considered employable for occupations in any roles other than unskilled labour.
- **Health**. Infrastructure in communities is, at best, degraded and, at worst, non-existent. Health service delivery is intermittent, with health patrols and extension programs conducted rarely and in few locations.
- **Governance and Law and Order.** Practices and capabilities vary with very little formal law-and-order capability. Generally, village magistrates, village councillors, community leaders and, in some cases, church leaders provide authority and administer law and order.
- **Cultural Heritage.** Villagers have considerable knowledge of places with social and cultural significance, even though they no longer believe in or adhere to the associated practices. Sepik Development Project EIS studies included a detailed assessment of archaeology and cultural heritage with over 250 archaeological and cultural heritage sites recorded.
- **Transport.** Reflecting the lack of road infrastructure, the Frieda and Sepik Rivers provide the most accessible and effective transport corridor for residents living along their banks, with those communities having some access to paddle and motor canoes.

Due to the ISF reservoir and construction activity, three villages will be required to relocate to an area mutually agreed through the resettlement planning process. The land currently inhabited by the villages of Wabia and Ok Isai is within the inundation area of the ISF. Due to the proximity (immediately downstream) of construction areas of the FRHEP, relocation of the village of Paupe is also proposed.

3.4.1 Preferred Points of Hire and Workforce

FRL will recruit the majority of its workforce from within PNG and with a preference to employ people from the Sandaun and East Sepik provinces, particularly those in landowner communities and those affected by the Sepik Development Project.

FRL has designated six employment zones, consisting:

- **Zone 1.** PNG national. Landowning communities in the Special Mining Lease (SML), Mining Lease (ML) and the Lease for Mine Purpose (LMP).
- **Zone 2.** PNG national. Any community within the Telefomin LLG and the western part of the Tunap Hunstein LLG, along the infrastructure corridor, and along the Sepik River downstream of the Frieda River.
- **Zone 3.** PNG national. Sandaun or East Sepik provinces.

- **Zone 4.** PNG national. Anywhere within the Greater PNG.
- **Zone 5.** Expatriate.

Workforce numbers during construction of the FRHEP will peak at approximately 1,780. The operational workforce for the FRHEP will be approximately 100 employees.

FRL will target 95% PNG national labour during the Project life with higher expatriate involvement expected during construction, ramp-up and early operations. Recruitment will be subject to qualifications, skills, experience and budget.

4. PROJECT DESCRIPTION

4.1 Overview

A key component of the Sepik Development Project is the FRHEP. The hydroelectric power facility will provide a renewable energy source to power the FRCGP and surplus power will be made available for export to other customers. The ISF will provide a total storage capacity of 9.6 Bm^3 for approximately 1,450 Mt of waste rock and 1,500 Mt of tailings that will be extracted over the life of the mine (LOM). The ISF waterbody will consist of approximately 7,000 GL at minimum operating level of RL 199 m extending to more than 10,500 GL at probable maximum flood (PMF) level of RL 232 m.

The FRHEP components will include an engineered ISF, hydroelectric power facility (a port (Frieda River Port), FRHEP access road, and quarries to support construction of the FRHEP.

4.2 Organisational Responsibility and Partners

The FRHEP will be developed by FRL (an Australian incorporated company owned by copper and gold producer PanAust Limited (PanAust)) on behalf of the joint venture between FRL (80%) and Highlands Frieda Limited (20%). It is anticipated that a third-party entity may own and operate the FRHEP at some stage during the life of the project.

PanAust is wholly owned by Guangdong Rising Assets Management Co. Ltd (GRAM), which is a Chinese state-owned company regulated under the State-owned Assets Supervision and Administration Commission, the People's Government of the Guangdong Province in China. PanAust has a portfolio of projects in Laos and Chile. PanAust operates to international standards with two producing assets in Laos: the Phu Kham Copper-Gold Operation and the Ban Houayxai Gold-Silver Operation. The Company's corporate office is located in Brisbane, Australia.

Highlands Frieda Limited is a wholly owned subsidiary of Highlands Pacific Limited, which is a PNG incorporated company, listed on the Australian Stock Exchange (ASX) and Port Moresby Stock Exchange (POMSoX). Approximately 30% of Highlands Pacific share register is held by the PNG Government and PNG based funds, with the rest by international investors. Highlands Pacific holds exploration leases in the Star Mountains and on Normanby Island. It also has an investment in the Ramu Nickel-Cobalt Mine near Madang.

4.3 Project Description

The international engineering consultancy, SRK, has designed the FRHEP. This design has been subject to international expert peer review by PanAust's Tailings Independent Review Panel (TIRP), which has been established to assess the adequacy of the design of the FRHEP and the underlying studies informing this design, and to provide recommendations on additional studies or evaluations to address areas of uncertainty.

The principles used for the conceptual design of the FRHEP were a combination of water dams and tailings dams. From a water management perspective (and hydropower generation), the water dam guidelines were the main guiding principles. This design philosophy was adopted by due to the recognition of the risks associated with potential seismic activity in the Project area, the high rainfall, and the necessity for the structure to remain stable under such conditions. For subaqueous deposition of tailings and waste rock including under-water risks, the tailings dam guidelines were the guiding principles.

The consequence of an embankment failure is classified as potentially “Extreme” under guidelines provided by ANCOLD and the International Commission on Large Dams (ICOLD), and as such, appropriate design standards and criteria have been selected.

The hydroelectric power configuration was designed by SRK to provide sufficient power for the FRGCP plus export power capacity that forms the SPGP. The ISF also provides sufficient combined storage capacity for process tailings, mine waste rock, natural sedimentation and surface water from the Frieda River catchment, while keeping the tailings and potentially acid-forming (PAF) waste rock permanently submerged under all foreseeable conditions. This is important because the geochemical characterisation of the waste rock and tailings shows that the material would become acid-forming if exposed to air over short to medium timeframes, with potential impacts to downstream water quality.

Figure 4.1 shows the layout of the hydroelectric power facility, which includes:

- Diversion channel.
- Diversion dam.
- Diversion tunnels and tunnel portals.
- Cofferdams.
- Environmental low flow releases infrastructure.
- Hydroelectric power infrastructure (powerhouse; low and final level power tunnel intakes).
- Operational gated spillway.
- Quarry (for embankment construction material).
- Main embankment and reservoir.
- Spoil dump/s.

In addition to the hydroelectric power facility, other infrastructure that forms the FRHEP includes:

- Frieda River Port.
- Access roads.
- Frieda River Airstrip.
- FRHEP site support facilities including: administration building, emergency response centre, medical centre, control room, workshop, warehouse.

This section describes the construction and operation of the FRHEP in detail.

4.3.1 Embankment

Following the completion of the diversion tunnels and cofferdams, the embankment will be constructed in a single phase and will incorporate the main upstream cofferdam. The embankment will be constructed as a rock fill embankment with a thick central asphalt core. Asphalt has been selected for its viscoelastic-plastic properties and its ability to deform with the slope without significant cracking occurring under the anticipated seismic conditions at Frieda River.

Filter and transition zones will be constructed upstream and downstream of the central asphalt core. The width of the filter and transition zone and the asphalt core was determined based on the predicted deformations that are likely to occur following an earthquake event.

The embankment wall will be constructed with engineered rock fill material with an upstream slope of 2.0H:1.0V and a downstream slope of 1.8H:1.0V below RL 198 m and 2.0H:1.0V above RL 198 m. The foundation for the dam will be excavated to bedrock, typically to a depth of about 2 to 5 m, except in the central portion of the valley. Rock fill will be sourced from the quarry and spillway excavations while filter and drain material will be crushed from quarried material as required. Bitumen for the asphalt liner will be imported to site.

Embankment seepage will be managed through the installation of a plastic cement cutoff wall, to provide a ductile low permeability barrier, and a grout curtain. Where geotechnical structures have been identified beneath and in the abutments of the embankment, fault grouting will be carried out to limit seepage through the plinth and through the abutments.

Construction of the embankment will continue over approximately 3 to 4 years to achieve a final crest elevation of 238.5 m RL with a maximum wall height of 190.5 m. The ISF is designed to provide water storage for an annual maximum energy generation of 2,800 gigawatt hours per year (up to 490 MW) of power and capacity for 1,500 Mt of tailings, 1,500 Mt of waste rock and 44 Mt of sediment over the life of the mine. Post-closure, there will be many hundreds of years of additional storage capacity for sediment based on current loads.

The embankment crest elevation will be high enough to store water from a probable maximum precipitation (PMP) 72-hour rainfall event, which at Frieda River is 1,350 mm. The highest 24-hour rainfall event recorded within the Frieda River catchment is 304 mm at the Upper Nena rainfall gauge.

Intake tunnels will be located at three levels to facilitate environmental release flows during filling (70 m RL), to allow commissioning of turbines and early power generation if required (143.3 m RL) and for normal power generation (185.6 m RL). The lower level intake will be valved and connected to the diversion tunnels, to allow the 50 m^3/s release of environmental low flows, and will be sealed once the powerhouse is built. The two upper intakes will be connected to the powerhouse and will have by-pass valves to allow release of environmental low flows during operation, when no power is being generated. The low-level intake will also be sealed once the dam is in operation.

Early filling of the reservoir will commence approximately 3 months prior to completion of the construction of the embankment. Hydroelectric power generation will commence four months following the commencement of filling once the water level reaches the low-level intake tunnel.

Figure 4.2 shows the embankment in cross section.

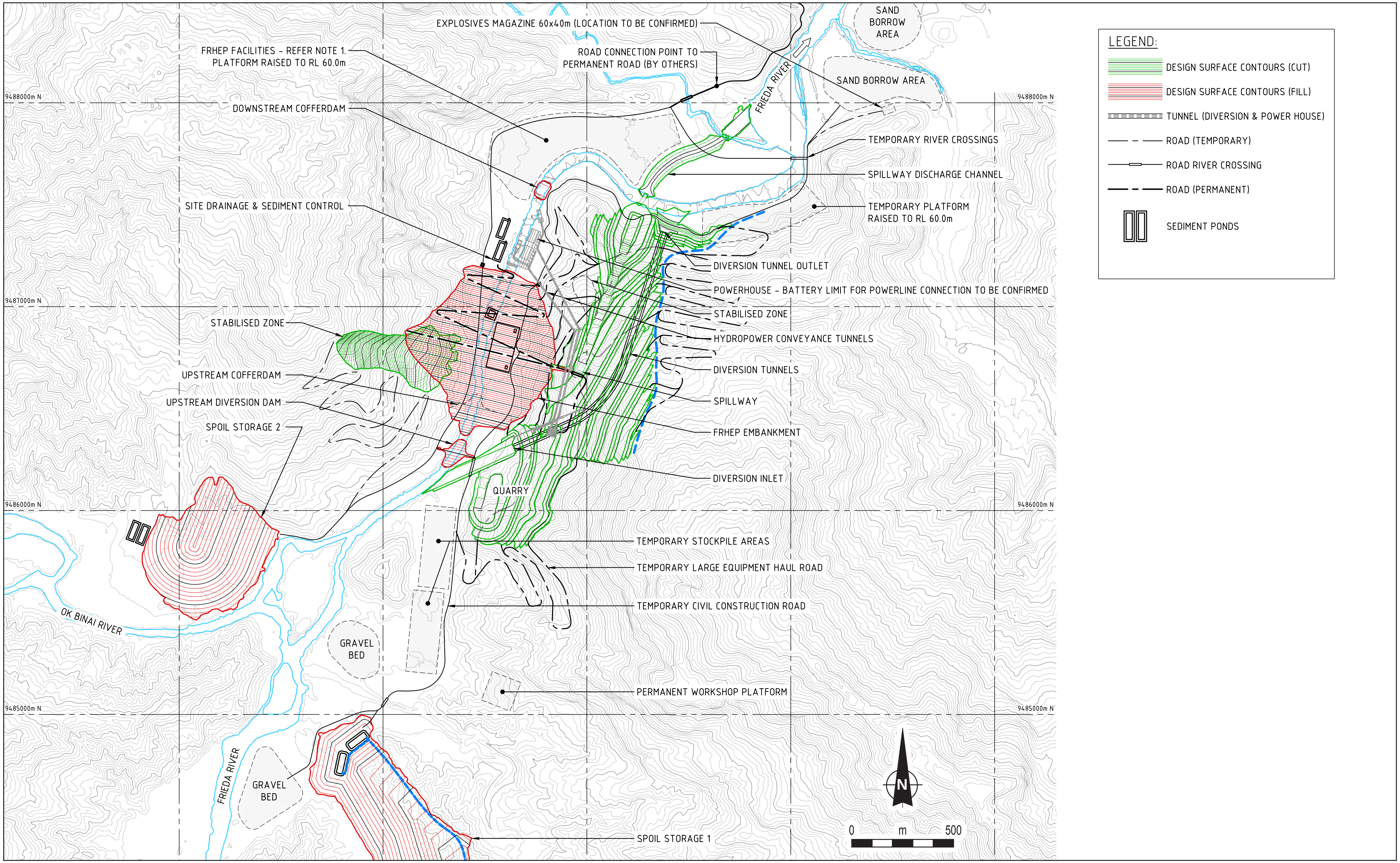
4.3.2 Embankment Stability

PNG lies in an active seismic region, and several large faults are located in the FRHEP area. The potential for seismic activity was a key consideration in the design of the ISF to ensure the embankment is constructed to endure a maximum credible earthquake scenario.

Geotechnical investigation has included geomapping, geotechnical drilling investigations, material sampling and geotechnical laboratory testing activities. This work is subject to expert peer review by the Tailings Independent Review Panel (TIRP).

Site geomapping activities have been performed over many phases of investigation; in 2010 to 2011 and more recently in 2017. The information from mapping has been limited due to the steep terrain and thick forest, so drilling activities have provided the best understanding of ground conditions around the embankment and sources of construction material for the embankment.

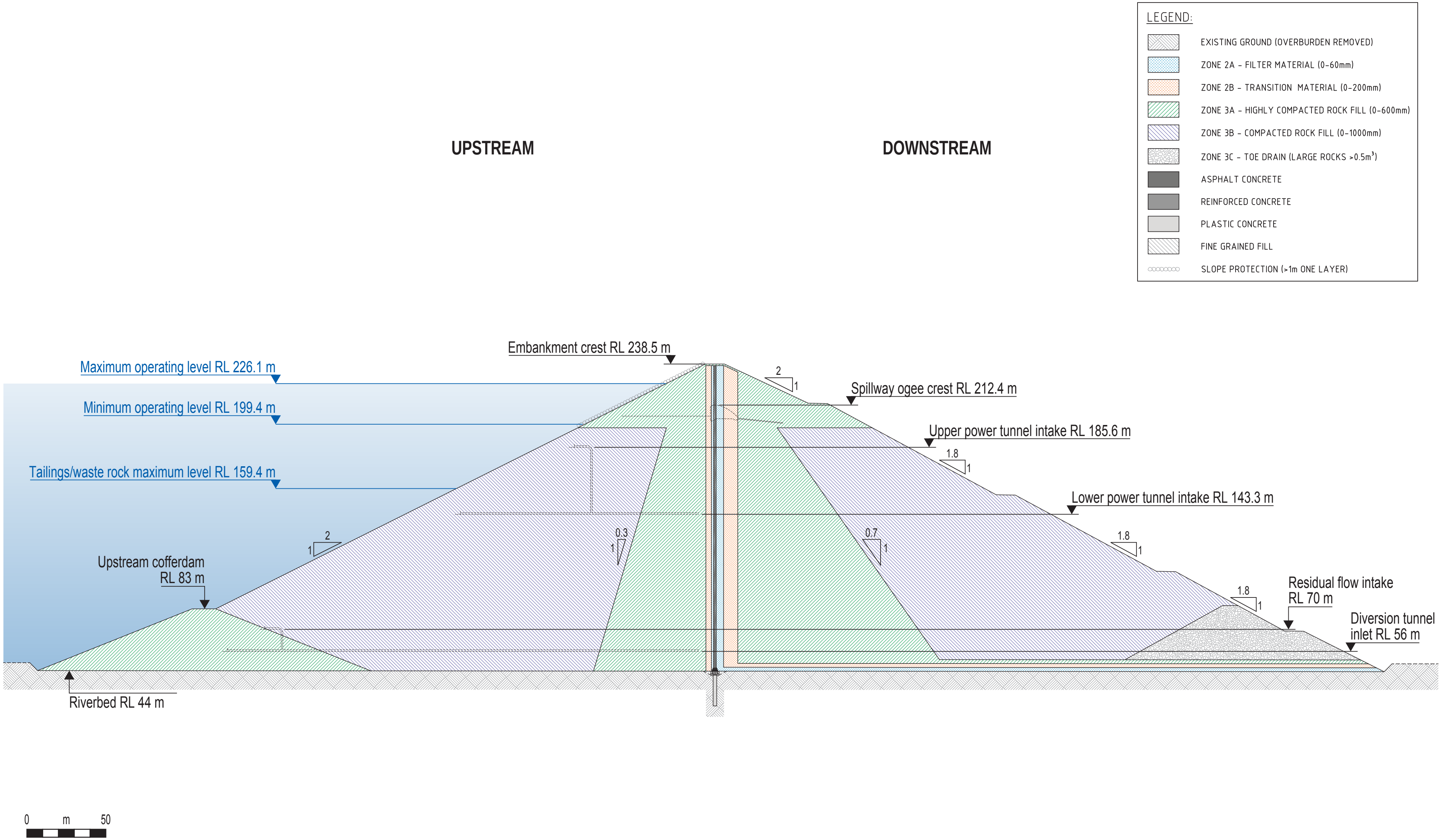
Recent geotechnical drilling investigations in 2017 and 2018 have consisted of 36 drill holes near the embankment, spillway, tunnels and associated infrastructure, and quarry, totalling 4,150 m of drilling. This investigation was in addition to 28 holes drilled as part of an earlier investigation of the site in 2010 to 2011.



Source: PNA009-0020 SITE GENERAL ARRANGEMENT.pdf, SRK	coffey A TETRA TECH COMPANY	Date: 05.10.2018 Project: 754-ENAUABTF11575B File Name: 11575_19_F04.01_GRA	Frieda River Limited Sepik Development Project	FRIEDA RIVER	Preliminary hydroelectric power facility layout

Figure No: 4.1

AI Reference: 11575_19_GRA003.ai_5



Source: Adapted from FRP-2-D-04-01-D-030-003, EMBANKMENT TYPICAL CROSS SECTION & DETAILS and FRP-2-D-00-01-D-030-010, CRITICAL LEVELS SECTION, SRK

coffey A TETRA TECH COMPANY

Date: 24.09.2018	Frieda River Limited	FRIEDA RIVER	ISF embankment cross section schematic	Figure No: 4.2
Project: 754-ENAUABTF11575B	Sepik Development Project			
File Name: 11575_11_F04.02_GRA				

AI Reference: 11575_19_GRA004.ai_5

The findings of the geotechnical studies can be summarised as:

- Bedrock of strong rock dunite is situated at shallow depth below surface (generally less than 10 m, but commonly less than 3 m) within the steep terrain of the embankment abutments. Overlying colluvial materials consist of thin soil cover and sometimes large boulders. Permeability of the dunite bedrock is generally low to moderate (10^{-9} to 10^{-7} m/s), however zones of high permeability are present locally as fault of fracture zones. Curtain grouting has been planned to mitigate zones of high permeability adjacent to the embankment.
- The valley floor has a layer of accumulated alluvial and colluvial materials. The colluvial materials can be very coarse (including very large boulders), mainly clast supported, and with a cemented matrix presenting a weak rock strength of 2 to 10 MPa. The alluvial materials are often similarly cemented, however beneath the main river channel lie uncemented coarse alluvial materials (boulders, gravel and sand). Permeability in these materials is variable locally; generally, it can be considered moderate (10^{-7} m/s), but uncemented zones and zones of deteriorated matrix result in localised higher permeability. Therefore, a cut-off wall will need to be installed below the embankment within these materials.
- There is a zone of highly fractured rock on the left-hand abutment, mostly upstream of the embankment centreline, and extending above the level of the embankment crest. This material is comprised of deteriorated rock mass: rafts of intact fresh or weathered rock and layers of oxidised, deteriorated and possibly sheared soil-like materials. This material may already have undergone shearing and downhill creep, and presents a significant landslide risk. It will be removed prior to embankment construction.
- The investigations were designed to identify significant faults beneath the embankment and within the abutment area. Although several small faults of limited width have been encountered, the investigation has concluded that no large fault structure is present beneath the embankment. Two large regional faults are situated near the embankment site: the Frieda Fault is situated approximately 7 km to the south of the site, while the Saniap Fault is situated a kilometre to the north. Potential movement on these faults has been taken into account in the seismicity assessment for design of the embankment.

4.3.3 Spillway

A gated spillway is included in the design. The spillway will comprise a nominally 30-m-long ogee crest on the east bank of the Frieda River with a reinforced concrete lined chute. A flip bucket and stilling basin at the toe of the chute will dissipate energy to reduce the erosive potential of water flowing down the spillway. A divider wall with four steel spillway radial gates will be installed into the spillway to permit partial and temporary closure of the spillway for maintenance activities.

The need for a spillway discharge channel will be determined during detailed design.

4.3.4 Hydroelectric Power Facility

The hydroelectric power facility will comprise low and high intake structures, pressure tunnel, surge chamber, waterways, powerhouse, and outlet works.

The powerhouse will be located downstream of the embankment adjacent to the Nena River, near its junction with the Frieda River. A powerhouse substation will consist of eight 80 MVA transformers, two 22 MVA transformers, 10 turbine generator units and gas insulated 132 kV switchgear. The powerhouse building dimensions will be 196 m long by 35 m wide. The powerhouse contains concrete lined conveyance tunnels connected via twin 7.1 m diameter epoxy lined penstocks to the powerhouse to provide water to the turbines and bypass valves. A submerged tailrace containing flood and closure protection stoplogs to allow release of discharged water to the river.

The low and high level intake flow structures will feed water to the twin conveyance tunnel arrangement. The bypass valves will mitigate flood flows around the powerhouse during early filling and before the completion of the spillway.

4.3.5 Ancillary Infrastructure

The FRHEP will include development of ancillary infrastructure. This includes

- Accommodation – on-site accommodation will cater for a peak workforce of 2,260 during construction, and permanent accommodation for a total of up to approximately 130 people during operations.
- Frieda River airstrip – the existing Frieda River airstrip will be upgraded to improve safety, reliability, operability and to enable the full 18 passenger capacity. The upgraded airstrip will service Code 1 (18-seat) aircraft and will include a 120 m long by 60 m wide runway strip extension increasing the overall length to 760 m and expansion of the existing aircraft parking apron, airfield lighting, navigational aids and terminal building.
- Roads – 40 km unsealed 7.5-m-wide dual-lane FRHEP access road from the Frieda River Port to the powerhouse will enable passenger and freight access during construction. The access road will also enable movement between the construction camp and ISF. During operation, access will be via the link road that connects to the main access road.
- Frieda River Port – a temporary port will be constructed, approximately 20 km north of the ISF embankment. It will be a concrete structure and used for importing construction materials. It will be a fenced facility that will unload break-bulk and containerised cargoes from landing craft, transfer of heavy equipment from barges onto a low loader, and mooring points for tugboats.
- Quarries – these will be excavated to provide materials for the construction of dams, roads, water diversion bunds, infrastructure pads and the ISF embankment. Quarries will be located within or directly adjacent to proposed infrastructure footprints, where practicable. A quarry immediately northwest of the embankment sources dunite rock that will provide a source material for the embankment’s rock fill.

4.3.6 Water Management

The average river flow for the Frieda River is estimated to be 223 m^3/s. There will be a need to continuously discharge water from the ISF to generate power and because of the significant surplus of rainfall over evaporation, i.e., the volume of water falling as rain in the catchment of the ISF significantly exceeds the amount of water lost as evaporation from the surface of the ISF and infiltration into land. Therefore, the ISF has been designed as a ‘flow-through’ system.

Inflow water will be managed by discharging it to the Frieda River downstream of the ISF embankment. This will take place via a set of hydroelectric power intakes, and through the spillway during storm events. Prior to commissioning of the hydroelectric power facility, the environmental flow intake will allow for water discharge at 50 m3/s. There will be a period of two days when there will be no flow during the transition to the environmental flow intake and the full residual flow of 50 m^3/s will be restored after a total of five days assuming typical river flows.

The hydroelectric power facility will maintain a minimum 50 m^3/s discharge during the operating life of the facility, however, there are expected to be occasions when the natural flow of the Frieda River will fall below 50 m^3/s and under these circumstances the flow from the ISF will match the river flow.

There will be the capacity to increase flows from the ISF during filling using bypass valves if additional flows are required to allow barges to bring heavy construction components up the Frieda River. These valves also have the potential to supplement the spillway capacity.

The ISF will have freeboard to allow PMF events to be discharged safely through the spillway without impinging on the embankment crest. The maximum operating water level will be RL 226 m and the maximum water level rise during PMF conditions will be RL 232 m. The minimum operating water level will be at RL 199 m with no excess power below RL 204 m. A displacement allowance of 3.5 m on the final embankment crest has been incorporated in the design to accommodate a seismic event.

4.3.7 Limnology Investigations

The embankment will impound a waterbody of approximately 7,000 gigalitres (GL) at minimum operating level of RL 199 m extending to more than 10,500 GL at probable maximum flood level of RL 232 m. The reservoir will inundate three major river courses that form the primary branches of the ISF: the Nena which flows from the west of the embankment; the Ok Binai, which flows from the southwest and converges mid way along the Nena branch; and the Niar (Upper Frieda), which carries converged flow from numerous dendritic sub-branches that flow from the south towards the embankment. Waste rock and tailings will be deposited up to RL 159 m in the ISF.

Modelling was undertaken by Hydronumerics (2018) to provide a semi-quantitative assessment of the hydrodynamics, sediment transport and basic water quality aspects of dissolved oxygen, nutrients, primary production and organic matter within the ISF.

The key risks identified included:

- High organic matter and biological oxygen demand, and low oxygen concentrations.
- Potential for generation of hydrogen sulphide in the anoxic hypolimnetic region of the ISF.
- Nutrient enrichment from the decay of flooded vegetation and soils.
- Release of tailings (or fine waste rock) into the water column during the deposition process.
- Scouring of fine tailings from bottom storage during inflows.
- Release of metals from waste rock and tailings.

The current ISF design aims to minimise the risks associated with the release of tailings as suspended solids during deposition by using a tremie diffuser beneath the surface of the deposits.

The modelling demonstrated that the TSS contribution to the powerhouse intake water from barge dumping of soft waste rock (with a 10% size fraction less than 40 µm) was dependent on the distance and frequency of deposition. The larger particles settle to a level below the intake tunnel prior to reaching it whereas the finer particles may be transported to the intake. A deposition distance of greater than 1,000 m from the embankment has been adopted to minimise TSS transport to the hydropower intake. This prolongs the life of the hydropower infrastructure while also having consequential downstream impacts.

Deposited particles may be resuspended if there is sufficient bottom shear to overcome the critical shear required for suspension. This typically takes place during high flow events that scour the bottom of the reservoir near the headwaters. The Project deposition strategy reduces this risk of scouring the tailings by placing them away from the headwaters of the large tributaries.

5. STAKEHOLDER CONSULTATION

Stakeholder consultation regarding closure is required to ensure that interests and concerns of stakeholders, as well as sustainable outcomes, are considered during the closure planning process. Guiding principles of this process are honesty and transparency, providing clear, timely information and giving opportunities for stakeholder input in the closure planning process. Stakeholder identification and consultation avenues for the FRHEP are discussed briefly in the following section.

5.1 Stakeholder Identification

Stakeholder identification is a key step to establishing relationships and to enable tailored stakeholder engagement activities to be developed. Stakeholders were identified through both ‘top down’ and ‘bottom up’ processes drawing upon baseline studies and verified through engagement with stakeholders and host communities to ensure that all key stakeholders have been identified.

Stakeholders were initially characterised and prioritised during a stakeholder engagement workshop in Brisbane in December 2008. The analysis involved identification of the project’s primary stakeholders and consideration of their likely interests and concerns. The stakeholder analysis was reviewed in 2015 and then progressively updated on completion of the various studies and surveys during 2015, 2016 and 2017.

The review of stakeholders was based on the IFC’s Performance Standard 1: Social and Environmental Assessment and Management Systems (IFC, 2012). This process was based on the following steps:

1. *Identify individuals, groups or local communities that may be affected by the project, positively or negatively, and directly or indirectly, making special effort to identify those who are directly affected, including those who are disadvantaged or vulnerable.*

   Stakeholders were initially identified through consideration of the geographic footprint of the ISF. The list was then expanded and updated as findings from specialist studies became available.

2. *Identify broader stakeholders who may be able to influence the outcome of the project because of their knowledge about the affected communities or political influence over them.*

   This involved consideration of the geographic footprint of the project and assessment of government organisations, institutions and non-government organisations that may have an interest in and/or influence over the project.

3. *Identify legitimate stakeholder representatives, including elected officials, non-elected community leaders, leaders of informal or traditional community institutions, and elders within the affected community.*

   Stakeholder representatives were identified through engagement with the communities identified in step 1. Representatives of minority groups have emerged or been sought out during engagement with communities.

4. *Map the impact zones by placing the affected groups and communities within a geographic area to define or refine the project’s area of influence.*

   Stakeholders have been mapped and arranged into groups based on their level of interaction with the project and stakeholder engagement methods.

Steps 1 to 3 have been revisited with material changes to the design to ensure that all affected stakeholders are recognised as the design progressed.

Project stakeholders related to the FRHEP component are summarised according to the following categories:

- Host communities:
  - Landowners and impacted land users of Lease for Mining Purposes.
  - Downstream communities and those in Sandaun and East Sepik Provinces more broadly.
- Government and regulatory stakeholders:
  - PNG national government.
  - CEPA.
  - MRA.
  - Other PNG government departments.
  - Sandaun and East Sepik provincial governments and potentially-impacted local-level governments (LLGs) within these two provinces.
  - Other PNG government stakeholders.
- Internal stakeholders including FRL and PanAust managers, employees, contractors and their families and business functions.
- Customers (national and international).
- Other stakeholders:
  - Owners and investors (owners of the joint venture, Board of Directors and investors).
  - Local suppliers (consisting of key local, regional and national suppliers to the FRHEP).
  - Other suppliers (consisting of key international suppliers).
  - Financiers and insurers.
  - Industry (including other resource sector projects in close proximity to the FRHEP, as well as research and industry associations).
  - Community-based groups (including charitable organisations, environment groups and NGOs).
  - Local services and utilities (hospitals, healthcare, educational facilities, utility providers and emergency services).

This list will continue to evolve throughout the life of the FRHEP.

5.2 Stakeholder Consultation for Closure

A broader stakeholder engagement plan has been developed to guide stakeholder engagement for the Sepik Development Project. The plan identifies who needs to be engaged, why and on what issues, and describes the processes, systems and required resources that will enable FRL to effectively undertake leading practice stakeholder engagement. This plan will be reviewed periodically.

The closure consultation process aims to keep stakeholders informed by developing and agreeing on final closure objectives and criteria, and on a process for the handover and relinquishment of the lease following closure. Specific objectives are to ensure that:

- Stakeholders are included in the closure process, have their interests considered, and have the resources to participate meaningfully in the process.
- All outcomes agreed to are achievable and sustainable, and ensure that the long-term integrity of the site is maintained.
- Requirements of the government and community are met.
- Maximise the potential social opportunities following closure.

The closure consultation process will be part of FRL’s broader stakeholder consultation, involving both formal and informal processes, and will build on that established during pre-feasibility and feasibility stages of the FRHEP, e.g., project briefings, roadshows, project fact sheets and use of local community noticeboards. These mechanisms will be further expanded and refined during operation to ensure their ongoing relevance and effectiveness. Specifically, FRL will:

- Establish a closure steering committee, integrated into an overall stakeholder engagement strategy that can provide a useful forum for discussion and communication on closure issues. This is likely to involve combining members from the government reference group and landowner leaders group, which will exist during construction and operations, and will occur towards the end of operations.
- Identify and engage key stakeholders in a consultation program, where their concerns and interests can be considered during closure planning. Key stakeholders as identified in Section 5.1, are likely to include:
  - FRL: employees, contractors and management.
  - Community: local communities and nearby landowners.
  - Sandaun and East Sepik provincial and local level governments.
  - National government, particularly CEPA, and Treasury.
- Undertake workshops and focus groups to develop specific closure strategies.
- Undertake consultation to identify and address concerns of specific groups.

6. RISKS

6.1 Risk Assessment

Good practice requires closure objectives and impacts to be considered from project inception. The closure of the FRHEP may result in a number of environmental and social risks, each of which requires consideration in accordance with regulations and guidelines, and consultation with stakeholders, to produce a detailed closure plan.

A conceptual closure risk assessment workshop was conducted in November 2015 for an earlier design of the Sepik Development Project (which included a similar ISF with associated infrastructure) to determine key risks and opportunities with regards to closure. Participants were key stakeholders from FRL and consultants with a broad range of skills and experience to assist in outlining the risks associated with closure. The objectives of the risk assessment workshop was to:

- Review risks specific to the rehabilitation and closure.
- Determine and discuss the proposed measures to ameliorate these closure risks and whether the proposed rehabilitation and closure strategies are adequate.
- Identify information gaps and uncertainties regarding closure strategies.
- Consolidate relevant information into this plan.

Following this, SRK, in conjunction with PanAust undertook a risk assessment and Failure Mode Effects Analysis (FMEA) workshop in April 2018. This workshop held during the scope of works phase of the project, considered high level risks. Participants were key stakeholders from FRL and project consultants with a broad range of skills and experience to assist in outlining the risks associated with project closure.

The risk assessment was conducted by examining the potential consequences (i.e., the severity of social and environmental impacts) and the likelihood that those impacts will occur. The assessment of ‘likelihood’ rating applies specifically to the resulting environmental or social impact. In conjunction with the risk assessment, a FMEA is a step-by-step approach to identify all possible failures in design, construction, operation and closure processes. It identifies potential failure modes and their causes, as well as the effects of failure on the systems or end users. The purpose of the FMEA is to take actions to eliminate or reduce failure. The risk assessment method was adapted from, and in accordance with, the following:

- PanAust Group’s Risk Management Framework and assessment tool.
- The Australian standard for risk management and its principles and guidelines (Standards Australia, 2009).
- The Australian standard for environmental risk management and its principles and process (Standards Australia, 2006).
- Dam safety programs based on international and national guidelines including ICOLD, ANCOLD, CDA and the Mining Association of Canada. Specific dam safety guidance documents are included in table 6.1.

Each aspect was assessed for its potential environmental, economic, social and regulatory risk factors. A product of this process was the creation of a risk register that identifies the issues, their risks and their priority.

The FMEA was used to identify and understand potential failure modes and their causes, the subsequent effects and provide adequate mitigations to address the most serious effects. Slope failure of the embankment was considered as the highest rank.

6.2 Conceptual Closure Issues

Preliminary high-level environmental and social issues for relevant to mine closure that have been identified during previous workshops include:

- Spillway becomes blocked by debris or landslide and maintenance cannot clear the blockage, causing the ISF to overtop, eroding the main embankment and potentially resulting in embankment failure and release of mine waste, and subsequent downstream impacts.
- Seismic event causes moving of the upstream and/or downstream crest resulting in a requirement for repair.
- Natural sediment generation after mine closure larger than estimated leading to loss of storage capacity.
- Lack of, or inappropriate maintenance, of the embankment or other infrastructure following transfer of liabilities to a third-party operator.
- Risks associated with failure of diversion.
- Inadequate prediction of ISF water quality causing unexpected downstream impacts.
- Failure to define closure criteria and end land uses to meet community expectations.
- Safety of people due to the failure to maintain safe, stable landforms in the long term.
- Natural overturn of the ISF leads to disturbance of anoxic water, mercury, organics and possible hydrogen sulphide emissions.
- Inadequate prediction of hydrology leading to suboptimal embankment height and causing unexpected downstream impacts (e.g., failure to meet downstream flows).
- Differential settlement leading to cracking of the plinth leading to increased seepage.
- Large landslide into the ISF causing a large overtopping wave and subsequent damage to the embankment.

A large number of risks relating to the feasibility, construction and operation phases are also relevant to the long term performance of the FRHEP and therefore closure.

7. CLOSURE FRAMEWORK

7.1 Approach

Early consideration of closure in project planning is essential to avoid or minimise adverse, long-term environmental and social impacts and reduce the cost of rehabilitation and environmental management at closure. Key principles essential for successful FRHEP closure include development of:

- A closure framework (including design criteria, closure objectives and stewardship).
- Suitable rehabilitation maintenance and decommissioning techniques and plans.
- A strategy for unforeseen circumstances such as unplanned closure (facility closure scenarios include temporary and sudden closure scenarios)

FRL's closure framework establishes its overall objectives, design and operating criteria and stewardship for the closure of the FRHEP.

The closure framework consists of:

- **Objectives.** A clear set of statements relating to environmental and social aspects of closure that describe the intent of the FRHEP.
- **Design criteria.** Design standards of the FRHEP are based on relevant closure legislation, such the *PNG Environment Act*; and national and international guidelines such as ANCOLD and ICOLD. Operational objectives include securing storage of waste rock and tailings and the deposition strategy for waste rock and tailings to minimise sediment release and meet water discharge criteria.
- **Stewardship.** The stewardship program will follow industry practiced hydroelectric dam safety standards whilst also providing a management/ oversight structure for tailings and waste from the mine operations and downstream water quality.

7.2 Objectives

The FRHEP facility is designed primarily as a hydropower generation scheme to supply future power needs associated with the proposed mining activities, with excess power that may be sold. Secondly, to safely store tailings and waste rock produced by the mining and milling operations. Excess power generation also provides an opportunity to supply power for export to Indonesia. The assumed design life of the FRHEP is 100 years The facility will be capable of storing tailings and waste rock forecast to be deposited over the 33-year LOM without jeopardising opportunities for future expansion. The facility is designed to be constructible under local conditions, which include limited access, high seismicity and rainfall, and an eroding environment.

7.2.1 Operational Objectives

Due to the nature of the FRHEP (i.e., designed for as a hydropower facility), operational objectives are relevant to the eventual closure of the facility.

The FRHEP facility is designed primarily as a hydropower generation scheme, built with the intent to supply future proposed mining activities with power and excess power that may be fed to the national power grid in support of PNG's power demand. Secondly, to safely store tailings and mine waste to international standards.

The operating requirements of the facility include the storage of tailings and waste securely within the ISF. This will be achieved by adopting relevant density values for the 'as-placed' tailings and waste to determine the total storage capacity requirements, and ensuring ample storage capacity to attenuate and then discharge storms, while maximising hydroelectric generation potential.

Being a flow-through facility, the discharge water will need to meet end-of-pipe discharge standards. This requires that oxidation of the tailings and waste must be limited prior to disposal. This will be achieved by subaqueous disposal in the ISF. It also requires that contaminated water inputs from sources be controlled or treated. Once inundated, the water cover will provide an oxygen barrier to inhibit further reaction.

To achieve operational objectives, the following will be required:

- The placement of tailings and waste will need to minimise sediment release and the possibility of re-entrainment during high flood inflows. In general, if the water quality meets environmental standards, it should be satisfactory for hydropower generation without causing unreasonable wear to the turbines.
- Extremely large floods may give rise to very high sediment levels. Depending on the particle sizes and the sediment level suspended in the water, hydropower generation may have to shut down until sediment concentrations decrease to acceptable levels.

7.2.2 Closure Objectives

The embankment will be required to be stable in perpetuity. Therefore, the principle is to design a landform rather than a structure.

At closure of the FRHEP, the depth of the ISF will be reduced by removing the spillway gates, while not affecting the oxygen barrier function to prevent the oxidation of tailings and waste, and it is expected that the facility will continuously fill with sediment.

The closure date for the FRHEP could vary, as the potential for continued hydropower demand is yet to be determined. This plan has been prepared on the assumption of a power generation lifespan of more than 100 years. The facility has; however, been designed for closure, irrespective of its succession potential.

FRL has developed a set of closure objectives to achieve acceptable outcomes for closure and rehabilitation of the FRHEP. These objectives are as follows:

- Ensure ongoing geotechnical stability of the ISF, specifically the embankment.
- Provide an agreed process for the planning, validation and reporting of decommissioning and rehabilitation activities.
- Consult with internal and external stakeholders to progressively develop a more detailed closure plan.
- Ensure beneficial use of water resources for downstream existing users and aquatic ecosystems is not compromised.
- Provide long-term surveillance, monitoring and maintenance of the ISF and downstream assessment points.
- Agree to transfer assets (and liabilities) to a third party for sustainable, long-term management including monitoring and maintenance.
- Adhere to key ISF requirements for post-closure including prevention of uncontrolled release of the tailings and waste rock; prevent oxidation and contaminant release from the stored tailings and waste rock; and minimise the risk of failure of the embankment and/ or spillway.

7.3 Design and Operating Criteria

7.3.1 Dam Classification

Dam consequence categories were derived from the potential failure modes of the facility and the resulting consequences to the business, social and natural environment, and the potential for loss of life (based on ANCOLD, 2012). The classification has implications on selection of the design storm storage allowance and water management structures, and types and frequencies of monitoring and inspections required.

A dam break analysis was undertaken by SRK (2018) to inform the design regarding the risks associated with the ISF, develop inundation maps of potential flood extents and estimate flow at critical locations downstream of the ISF in the unlikely event of an embankment failure.

The results of the dam break analysis indicated that the consequences of a dam break are potentially catastrophic including:

- A large population at risk, with more than 30 villages potentially being affected.
- Catastrophic impacts to the dam owner’s business, the environment and infrastructure costs.

As such, the FRHEP is assigned an ‘Extreme’ consequence category.

7.3.2 Embankment and Stability

An asphalt core rockfill dam type was used as the basis for the dam design.

The design seismic event for the embankment was selected as the maximum credible earthquake (MCE) in accordance with (ANCOLD, 2012; CDA, 2013).

A MCE peak ground acceleration of 1.09 g was recommended by SRK to be applied for the embankment dynamic stability analyses. A site-specific seismic hazard assessment is proposed to be completed for the embankment during detailed design of the facility.

The embankment will be designed to provide an acceptable factor of safety (FOS) against instability, in accordance with ANCOLD (2012) guidelines. The minimum factors of safety selected are:

- FOS of 1.5 for long-term drained conditions.
- FOS or 1.2 for post-seismic conditions.

Temporary structures such as spoil dumps will be designed with a minimum FOS of 1.3 under undrained loading conditions.

Large excavations (i.e., for the spillway and quarry) will be designed with a minimum FOS of 1.5 under static conditions, and 1.1 with a pseudo-static seismic loading of 0.4 g.

7.3.3 Seepage

Seepage controls are important to maintain stability and reduce the risk of foundation piping. The energy modelling is based on the total water loss assumed to be 1,100 L/s.

In combination with seepage cut-off infrastructure in the foundation and abutments, an impermeable zone will be designed to prevent water seeping through the embankment. A Multiple Accounts Analysis was undertaken which highlighted the preferred embankment cut-off solution to be an asphalt concrete core, which is located in the centre of the embankment. The asphalt concrete core is a proven technology implemented for dams of similar heights and is overall better suited for this application in comparison with a concrete faced rockfill dam option.

7.3.4 Water Management

Spillway design and sizing was based on inflows for the following flood events:

- Average recurrence interval of 10 to 1,000 years plus the PMP.
- Duration: 6 hrs to 60 days.
- Synthetic long-term flows series, at the location of the embankment for use in the modelling of the hydroelectric scheme and represents the energy source for power generation. Two full record series were generated with a similar methodology: fifty (50) scenarios of 200 years and two hundred (200) scenarios of 38 years.

Based on the potential catastrophic consequences of a embankment failure, the PMF was adopted as the design flood. The embankment will have an open channel side hill spillway to pass the design flood.

The minimum water depths to be maintained above the tailings and waste rock during operations, including other relevant water management parameters, are summarised in Table 7.1.

Table 7.1 Operating water management requirements

Parameter	Value
Minimum operating water depth (barge)	10 m
Absolute minimum water depth	8 m
Minimum pond above waste rock and tailings for hydropower operations (worst case)	18 m
Freeboard	Allowance for wave run-up, earthquake settlement, landslide risk, underwater embankment failure, and n-1 operational gates
Dam and spillway flood capacity	PMF (n-1 gates operational)
Powerhouse and other hydraulic structures	1 in 500 Annual Exceedance Probability (AEP) flood and checked for 1 in 1,000 AEP flood

To inhibit oxidation, tailings and waste rock will remain submerged in the ISF with of a minimum cover of 40 m.

The closure design flood (the PMF) will be attenuated and passed by the spillway. The spillway gates used during operations will be removed for closure to reduce the volume of water stored on the ISF. Stoplogs will be used to block the spillway when conducting any maintenance required or removing the gates.

7.4 Conceptual Completion Criteria

Meeting the completion criteria (as indicated by implementation of an appropriate monitoring program (see Chapter 12)) will demonstrate that the landscape has met the overall objectives and can be handed back to the appropriate stakeholders.

There are two types of completion criteria: design and construction criteria (leading indicators) and outcome or performance criteria (lagging indicators). Both are required for successful closure and relinquishment. The different purposes of these criteria are as follows:

- Design and construction criteria articulate the design intent and the design parameters that should be measured during the construction and quality assurance process respectively.
- Outcome criteria provide measurable indicators of closure success.

Completion criteria will be further developed to be consistent with the SMART (specific, measurable, achievable, relevant and time bound) principles, and to reflect the principle of sustainable development. This will be based on results of further research and ongoing monitoring and in consultation with relevant stakeholders.

The process for developing completion criteria will consist of the following:

- Determine the specific ways in which the land and water will be used in consultation with stakeholders, and define how the rehabilitated area needs to perform to support this use.
- Develop detailed designs that meet the basis of design criteria and land and water use requirements.
- Evaluate the likely outcome of the designs through quantitative assessments (e.g., modelling) and determine whether closure is likely to achieve the required performance standards for the desired end land and water use.
- Revise designs if necessary and identify the criteria that will need to be measured to ensure that construction achieves the design specifications and associated performance objectives.
- Use appropriate assessment techniques and site monitoring data associated with progressive rehabilitation to develop performance criteria for the rehabilitated areas.
- Monitor the performance of the constructed designs and review the performance criteria.
- Develop remedial action plans where monitoring indicates that performance criteria are not being achieved.

Draft conceptual completion criteria that are applicable for the entire site are outlined in Table 7.2. These will be refined based on experience and knowledge gained during construction and operation and through the completion of targeted closure investigations.

Table 7.2 Draft site-wide conceptual completion criteria for the project

Closure Objective	Draft Conceptual Completion Criteria
Embankment is constructed, operated and maintained as per designs.	• Embankment will be designed, constructed and maintained to meet the 24-hour probable maximum flood event and meet hydropower embankment seepage loss criteria. • Embankment will be designed, constructed and maintained to meet a minimum factor of safety of 1.5 based on recommendations of industry guidelines for a range of operating and closure conditions. • Stability analysis including deformation analysis indicates the embankment can tolerate a maximum credible earthquake of 1.09g. • Spillway will be constructed and maintained in accordance with the design, as demonstrated by regular independent engineering assessments during construction and post closure. • Average annual soil loss from the embankment wall does not exceed 10 t/ha. • Maximum depth of rills and gullies on the embankment wall does not exceed 0.3 m.
Provide for safe and non-hazardous final rehabilitated areas	• The final rehabilitated areas meet the agreed end land use. • All infrastructure is removed unless the item is required for an end land use as demonstrated by an audit against the final closure plan.

Closure Objective	Draft Conceptual Completion Criteria
Provide for resilient and self-sustaining ecosystems and landscape function.	• Self-sustaining vegetation is growing on previously disturbed areas, as evidenced by vegetation monitoring. • Vegetative cover is increasing and on a trajectory to achieve in excess of 70% of foliage cover. • Evidence that nutrient cycling is occurring and the presence of leaf litter is assisting in limiting erosion of the soil/spoil surface.
Ensure beneficial use of water resources for existing users and aquatic ecosystems is not compromised.	• Water quality achieves the appropriate water quality criteria as determined by monitoring post closure. • Surface water drainage control measures are installed and meet design criteria. • Prevention of uncontrolled release of the tailings and waste rock. • Prevention of oxidation and contaminant release from the stored tailings and waste rock.
Provide an agreed process for the planning, validation and reporting of decommissioning and rehabilitation activities.	• Closure plan, designs, criteria and monitoring plans meet all regulatory requirements. • Closure plan is reviewed on a three-yearly basis and amended where required.
Consult with internal and external stakeholders to progressively develop a more detailed closure plan, including completion criteria.	• Form and implement a closure steering committee at least 10 years prior to decommissioning with various internal and external stakeholders. • Maintain relationships with the community, landholders and other stakeholders and continue consultation regarding closure planning activities.
Provide the local communities with long-term, sustainable opportunities following closure.	Meet the agreed end land and water use, which provide opportunities for local communities to maintain their sustainable livelihood.

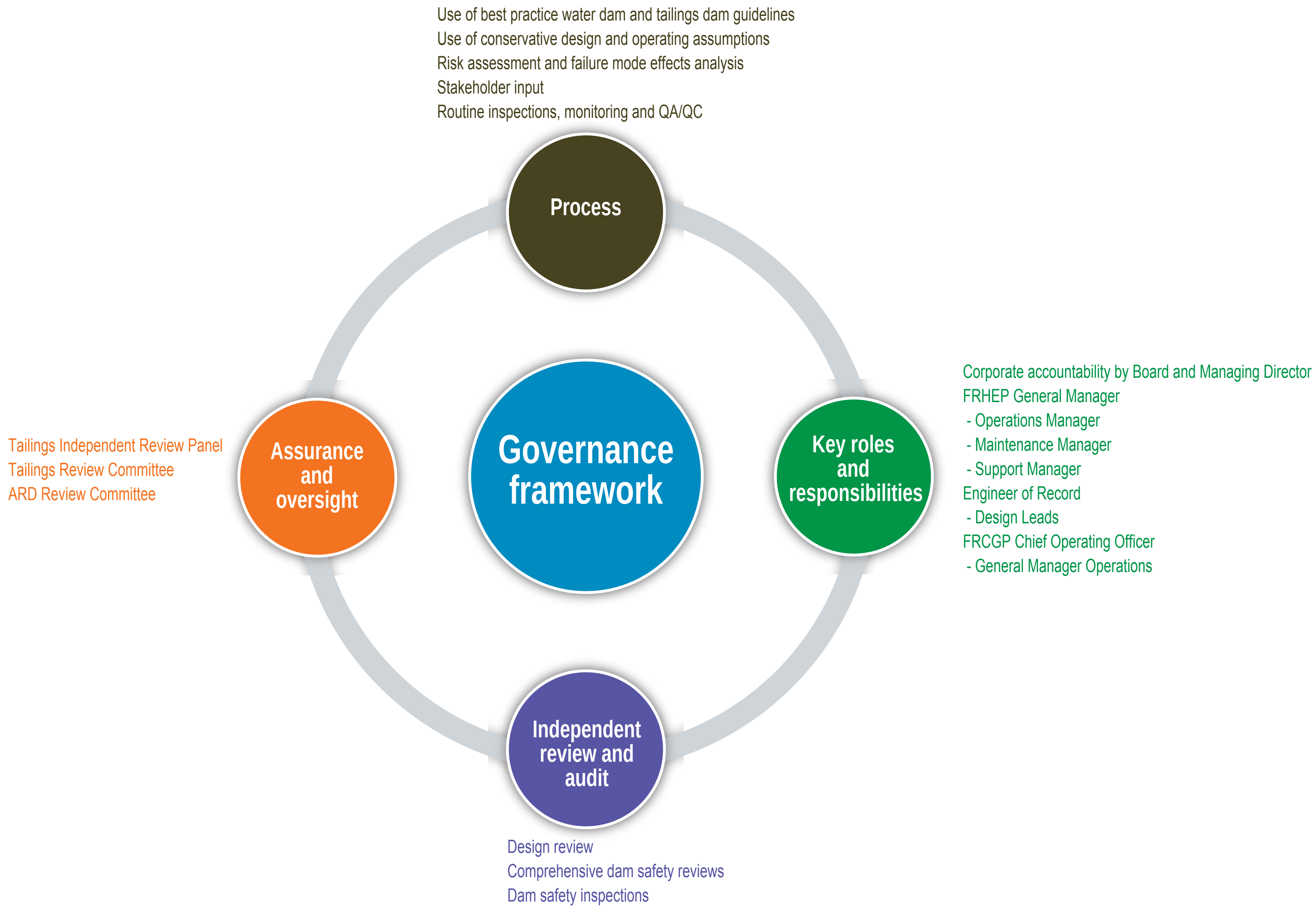
7.5 Governance Framework

FRL recognises the material risk and associated responsibility for managing produced mine waste rock and tailings, and engineered facilities such as dams to contain them. Accordingly, the company and its parent company PanAust has established a comprehensive governance framework that encompasses organisational resourcing, systems and processes to support its sustainable business model. An overview of the governance framework is shown in Figure 7.1.

Considering the responsibility for mine waste will need to be integrated into the FRHEP by closure, aspects relating to waste rock and tailings management are discussed here for completeness.

7.5.1 Tailings Review Committee

PanAust’s Managing Director has instituted a Tailings Review Committee (TRC) whose membership includes the Managing Director, internal experts on tailings engineering and risk management, and executives with organisational accountability for facility planning, design, construction and operation.


Use of best practice water dam and tailings dam guidelines
Use of conservative design and operating assumptions
Risk assessment and failure mode effects analysis
Stakeholder input
Routine inspections, monitoring and QA/QC
Process
Governance framework
Key roles and responsibilities
Corporate accountability by Board and Managing Director
FRHEP General Manager
- Operations Manager
- Maintenance Manager
- Support Manager
Engineer of Record
- Design Leads
FRCGP Chief Operating Officer
- General Manager Operations
Assurance and oversight
Tailings Independent Review Panel
Tailings Review Committee
ARD Review Committee
Independent review and audit
Design review
Comprehensive dam safety reviews
Dam safety inspections

The objectives of the TRC are to:

- Inform the Managing Director of material risks associated with the facilities and the appropriateness and effectiveness of action plans intended to mitigate the identified risks.
- Oversee the implementation of actions related to material risk management and continuous improvement in relation to facility management.
- Ensure that the TIRP completes annual reviews of the design, construction, operation and closure of facilities.
- Provide executive management support and associated resources for identified actions arising from TIRP reviews.
- Evaluate the plans proposed by operational management to act on matters arising from the TIRP reviews to ensure that they are appropriate, practical and make efficient use of resources and funds.
- Update the relevant risk registers for each business unit annually.

The TRC performs an important stewardship function, enables executive accountability and demonstrates commitment to the responsible management of PanAust's facilities.

7.5.2 Tailings Independent Review Panel (TIRP)

The TIRP is an important element of PanAust's and FRL's governance program. The TIRP comprises eminent experts in the disciplines of tailings, geotechnical engineering and water who collectively provide independent review and advice on material risks that may arise during the design, construction, operations and closure of the company's facilities. The TIRP's membership is expanded, as needed, to draw on specialist expertise in disciplines such as hydropower generation.

The TIRP members must not have any conflict of interest issues and must not be involved in any other work for PanAust's operations that would require review by the TIRP. TIRP members must also be independent from the day-to-day operations and design activities.

The TIRP conduct annual facility inspections and provide independent confirmation to the Managing Director that the company's facilities are being managed appropriately. Recommendations arising from the TRIP's reports are transferred to action plans that are monitored by the TRC. Responsibility for acceptance and implementation of the TIRP's advice and recommendations remains with PanAust and its nominated design consultants and construction contractors.

7.5.3 ARD Review Committee

High level governance of acid rock drainage (ARD) management is provided through PanAust's ARD Review Committee which comprises internal management and specialist external consultants. The committee verifies that management strategies are effective in limiting the potential for generation of ARD during construction and waste placement and that these strategies will continue to be effective following mine closure. Functions of the committee include to:

- Provide technical support to evaluate risks of operation of tailing storage facilities using the PanAust Enterprise Risk Management criteria.
- Highlight any new risk issues identified during the review period and ensure the risks are appropriately captured on the site risk register.

- Provide guidance on procedures that ensure ARD management and closure planning conform with international good practice and standards, legal requirements and operating licenses.
- Review the geochemical aspects of the tailings, waste rock and construction materials, particularly with respect to ARD and the potential for metalliferous leaching.
- Provide input on design, construction, operational and closure activities that may have long-term stability or other critical performance implications on ARD management.
- Review health, safety, environmental and social risks associated with ARD management and ensure they are appropriately addressed in accordance with design, construction, operation and closure plans.

7.5.4 Engineer of Record

An Engineer of Record (EOR) is the approver of all designs, as-built construction, operations and performance monitoring of the FRHEP. The overarching responsibility of the EOR is to determine if the FRHEP meets applicable regulations, guidelines and standards. To execute this responsibility, the EOR must be completely familiar with the design, history and current conditions of the embankment. Where the EOR is also the designer of record, involved through construction and operations, this knowledge would be implicit in the design, as-built, monitoring and inspection reports. Given the complexity of the FRHEP, the EOR will need to rely on other qualified professional engineers to provide assurances of ancillary facilities related to the hydropower structures, including the diversion and spillway structures.

7.5.5 FRHEP Manager

The FRHEP Manager will be ultimately responsible for all day-to day operations of FRHEP and tailings and waste disposal, and ultimately decommissioning activities. All functional leads at the FRHEP will report to the FRHEP Manager, as well as the Tailings and Waste Leads from the mine.

7.5.6 Assurance

Independent qualified professionals provide assurances related to water management, tailings and waste stability, waste geochemistry and water quality.

Design Review

Facility designs are subject to a stage gated review and approval process. Designs are typically peer reviewed by a group of internal specialists and/or external independent experts to confirm that the design can be released to the next, more detailed, stage of work.

Routine Inspection and Monitoring

Daily, weekly and monthly inspections and monitoring is performed by trained employees reporting to the site based FRHEP Manager. Monitoring of dam seepage and embankment deformation is undertaken along with inspections and audit programs to ensure that monitoring equipment is operational and functioning correctly. The EOR reviews the inspection and monitoring reports monthly.

Quarterly inspections are performed by PanAust's corporate Principal Tailings Engineer and/or Senior Tailings Engineer.

Quality Control and Assurance

Site laboratories perform material testing for quality control and quality assurance of construction materials. The site laboratories are audited every two years by an independent auditor.

Independent testing activities are undertaken at an accredited external laboratory for validation of quality control activities.

Dam Safety Inspections

PanAust engages competent and experienced consulting organisations to perform the role of Design Engineer. The appointed Design Engineer has responsibility for preparing engineered designs, as directed by company representatives, for approval by the EOR. An annual audit of each facility is conducted and documented by an independent expert engineer.

Comprehensive Dam Safety Reviews

Comprehensive dam safety reviews (CDSRs) were recently initiated. These reviews will be performed at five-yearly intervals and other critical project milestones. The reviews are undertaken by a “suitably qualified and experienced person in relation to high risk tailings dams”, in accordance with the ANCOLD guidelines. The review is undertaken, as a minimum, based on the following key ANCOLD guidelines:

- Guidelines on Dam Safety Management (ANCOLD, 2003).
- Guidelines on the Consequence Categories for Dams (ANCOLD, 2012a).
- Guidelines on Tailings Dams, Planning, Design, Construction, Operation and Closure (ANCOLD, 2012b).

7.6 ISF Stewardship

The long-term stewardship of the ISF is a critical element of closure planning for the FRHEP and a key concern of stakeholders (the PNG Government, the owner of the FRHEP and the owner of the mine (FRL)).

FRL has already commenced this stewardship program through the development of the TIRP. This panel comprises preeminent international experts in the fields of tailings, hydropower and geotechnical engineering and has been established to provide FRL with independent advice regarding the design, construction, operation and closure of the ISF and other key features of the FRHEP. The panel The TIRP has recommended that:

- It is essential to apply the highest level of stewardship to the design, construction and operation of the ISF, including the appointment of a well-qualified and experienced design team and a well-qualified and experienced EOR.
- Provision be made for independent review of the design, construction and operation of the ISF by world class experts in the various critical disciplines, including geotechnical engineering, tailings management, seismicity and dynamic design analyses, hydrology, hydraulic design and embankment, powerhouse and tunnel construction.
- An operating protocol be developed to manage the interaction between, and the objectives of, the embankment construction team, the waste and tailings disposal teams and the power generation team.
- The management team for the ISF must have the appropriate level of experience.
- The monitoring, maintenance and oversight, which will be needed both during operations and after closure, is included in the stewardship plans.

FRL has addressed these recommendations and commenced an ISF stewardship program during the design of the ISF and independent expert review by the TIRP. The ISF stewardship program will continue through the life of the ISF and comprises:

- A dam safety program as described by the International Commission on Large Dams (ICOLD) and most of its associated national organisations, including the Australian National Committee on Large Dams (ANCOLD) and the Canadian Dams Association.
- Management and oversight structure for tailings and waste disposal from the mine operations and downstream water quality.
- A corporate governance and reporting structure (described above).

Critical elements of the corporate governance and reporting will include:

- Specific accountability for embankment construction, operation and safety at the Board and senior management and executive levels.
- Training at all levels, including senior management and executive management to ensure a full understanding that dam safety is fundamental to the business.
- Executive and senior management commitment to ensuring that a safety culture is established, monitored and continuously improved.
- Clear management accountabilities, reporting relationships and business systems that make dam safety part of the normal work flow and reward systems.
- At the Corporate and site level, a clear understanding of the scenarios that exist for post-mining operation of the hydroelectric power plant and ISF and systems for ensuring long term management of dam safety after closure need to be in place, together with a clear understanding of the risks involved.

External parties will also play an important role in ISF stewardship, particularly the PNG Government. FRL hosted a technical workshop with CEPA and MRA in Port Moresby (July 2016) to introduce the design of the ISF. During preparation of this EIS, FRL, HPL, SRK and the ITGRP held a technical workshop with CEPA and MRA in Port Moresby (September 2016) to present and further explain the ISF design and to answer any technical questions. A further workshop is planned during the latter half of 2018.

8. REHABILITATION

This section of the plan provides a summary of the rehabilitation principles that FRL intends to use during closure of the FRHEP.

8.1 Decommissioning

8.2.1 Demolition and Disposal

Once FRHEP operations have ceased, decommissioning will commence and will involve the removal of infrastructure and specific access roads, maintenance of other infrastructure, and considerations in terms of sedimentation processes. Following the cessation of operations, the following steps will be undertaken:

- Dismantle or demolish remaining equipment, infrastructure and services.
- Remove salvageable materials (e.g., steel, tanks) from site and sell as scrap for recycling where it is economic to do so. Such materials will probably include items such as steel pipework, framework, beams and sheeting.
- Remove and dispose of non-salvageable, non-contaminated materials in designated landfill/s.
- Fracture concrete structures and foundations to promote infiltration and then cover this with NAF material.
- Complete final profiling of rehabilitated landforms.
- Remove mobile equipment.

These steps will be subject to future modification based on further consultation with stakeholders, refinement undertaken by FRL's closure planning team and results of progressive rehabilitation.

8.2.2 Hazardous Materials

Incorrect disposal of potentially contaminating or hazardous materials and chemicals may cause pollution, health and social concerns for the employees and surrounding communities. Potentially contaminating and hazardous materials comprise items associated with powerhouse and power turbines. At decommissioning, hazardous materials will be managed in accordance with the environmental management system. Specific measures will include:

- Dispose industrial wastes in an on-site, CEPA-approved waste facility.
- Incinerate oil and oily waste material in the on-site, CEPA-approved incineration facility.
- Excavate any ground contaminated by hydrocarbons and remediate the land.
- Remove hazardous and industrial wastes from site by a licensed contractor, where appropriate.
- Non-hazardous wastes are assumed to be either disposed of underwater in the tailings facility or in a dedicated landfill on site. A contaminated land assessment of project components will be undertaken at the decommissioning stage of the FRHEP. In the event that contaminated soils remain at closure, their extent will be determined via a site investigation and they will be remediated accordingly. All contaminated materials will either be removed for off-site disposal or else treated prior to on-site disposal in landfill.

8.3 General Rehabilitation

Rehabilitation generally comprises two stages: landform design and the reconstruction of a stable land surface, and the revegetation or development of an alternative land use on the reconstructed landform. The main objectives of rehabilitation are to:

- Physically stabilise the land so that it is safe and erosion is controlled.
- Leave final landforms with a surface upon which vegetation can be successfully established.
- Revegetate landforms to meet the agreed final land use.
- Ensure that drainage is of acceptable quality.
- Protect adjacent undisturbed ecosystems.

8.3.1 Soil Management

Areas disturbed by the FRHEP include the FRHEP access road and quarries which will require some rehabilitation during FRHEP operations. Once the FRHEP is decommissioned, specific access roads will remain open for long-term monitoring and maintenance access. Natural revegetation will occur on all disturbed surfaces by scarification or ripping of compacted surfaces. A description of soil resources within the project area are outlined in Section 3.2.3.

8.3.2 Erosion and Sediment Control

A detailed erosion and sediment control management plan will be prepared as part of the FRHEP's environmental management and monitoring plan (EMMP) prior to the commencement of construction activities. This plan will describe measures to control and minimise soil erosion and sedimentation (and associated environmental impacts) due to FRHEP activities. This plan will be reviewed and updated 5 years prior to closure.

The primary objective for the erosion and sediment control management plan from the FRHEP EMMP will be to limit erosion and then to capture coarse sediment in drainage from disturbed areas. These principles will apply to the planning, design, construction, operation and decommissioning of the FRHEP. These measures are likely to focus on the natural sediments (source) that will continue to inundate the FRHEP post-closure and the sediment pathway (e.g., watercourses) to limit coarse sediment reaching the Frieda River and its tributaries. Further investigations of the long-term effects of sediments settling in the upper reaches of the ISF, and the potential for resuspension and transport through the FRHEP over the long term will need to be conducted.

Measures to reduce erosion and sediment transport during the decommissioning and closure of the FRHEP will include:

- Limiting the area of soil disturbed and exposed to erosion.
- Rehabilitating disturbed lands progressively, where practicable.
- Maintaining erosion and control measures during decommissioning earthworks.

8.3.3 Revegetation

Where appropriate, rehabilitation and revegetation strategies developed will aim to create conditions that favour the formation of vegetation communities through natural processes. Initial stabilisation of rehabilitation areas using quick-growing groundcovers will reduce the erosive impacts of rainfall and surface water flow. Once groundcover plants are established, shade trees will be established to develop a dense canopy since many native forest species require shade for successful colonisation.

9. CLOSURE STRATEGY

The PanAust Group internal processes require that projects commence planning for closure from the earliest stages of project development. Such planning aims to clearly identify the appropriate closure options and future land uses that limit long term environmental and socio-economic risks. Multi-disciplinary teams develop, review and implement closure plans. These teams typically include experts in environmental management, engineering, community affairs, human resources and finance. Closure plans increase in detail and understanding improves as the site progresses towards closure.

9.1 Overview

If developed, the Sepik Development Project will be the second largest capital investment in PNG and will attract significant local employment and foreign investment. As such there is a focus on creating the enabling environment for investment and economic participation through the construction and operation of infrastructure that provide a platform for other economic activities.

It is envisaged that the FRHEP will assist in supplying the power to northwest PNG and enable a reliable, long-term supply of energy long after the FRCGP has closed. As such, there is the possibility for the transfer of responsibility for containment of waste rock and tailings and also post closure open-pit water treatment associated with FRCGP after relinquishment of the mining tenements. Noting the conceptual nature of closure planning, it is envisaged that any handover of liabilities associated with FRCGP to FRHEP would need to be associated with a financial closure provision. Such a provision could take the form of a trust fund developed over the course of FRCGP operations to ensure financial surety to conduct the necessary monitoring and maintenance.

Prior to the relinquishment of mining tenements, opportunities to transfer liabilities associated with the FRCGP, including post closure open-pit water treatment and downstream water quality, will be investigated. These aspects have been considered in both the FRCGP closure plan and the FRHEP closure plan.

It is expected that the FRHEP will provide at least 100 years of hydroelectric power. Once decommissioned, the ISF will become a permanent stable landform. The ultimate objective that has informed the design is for embankment stability in perpetuity. The proposed conceptual closure plans are described in the following sections. It must be emphasised that these plans are notional and are subject to ongoing review during operation as the Closure Plan is progressively refined through consultation with relevant stakeholders, taking into account additional information obtained about environmental and other constraints as the FRHEP is developed.

Where infrastructure is no longer required or needs to be maintained the base case assumption is that it will be decommissioned and rehabilitated to the extent practicable.

9.2 Embankment and Reservoir

At closure, the ISF will consist of a large flow-through waterbody covering an area of about 12,400 ha, which will remain as a permanent landscape feature. The main embankment will reach a final crest elevation of RL 238.5 m with a maximum embankment wall height of 190.5 m. After closure, natural inflows from the river system will pass through the facility via the spillway. The spillway has been sized to allow flows from a PMF to be safely conveyed around the embankment. At closure, the spillway gates will be removed, with water continuing to flow into the facility via direct rainfall and inflow from the upstream catchment, with excess water passing over the ungated spillway.

Given the facility will be a permanent feature, appropriate standards will be applied for the design, construction and operation of the facility. The stewardship program outlined in Section 7.5 and on the following page will provide the greatest risk mitigation. These standards include:

- Using a FOS of 1.5 for embankment static stability in accordance with ANCOLD guidelines. The FOS describes the structural capacity of a system beyond the expected loads or actual loads. Essentially, the factor of safety is how much stronger the system is than it needs to be for an intended load.
- The embankment will be designed to meet embankment seepage loss criteria. Seepage cut-off infrastructure will be installed in the foundation and abutment. This included using an asphalt concrete core as the preferred embankment cut-off solution after a Multiple Accounts Analysis was undertaken.
- The spillway will be designed and constructed to pass a PMF event without causing damage to the spillway. A PMF event is defined as the largest flood that could conceivably occur at a particular location, usually estimated from probable maximum precipitation, coupled with the worst flood producing catchment conditions.
- Designing the embankment to withstand a MCE of 1.09 g. MCE is defined as the largest earthquake that appears capable of occurring under the known tectonic framework for a specific fault or seismic source, as based on geologic and seismologic data. This is based on the maximum earthquake from probabilistic and deterministic analyses.

The ISF will be designed as a flow-through facility and water downstream will need to meet water quality standards. At closure, it is expected that the facility will continuously fill with sediment which will progressively form a sediment layer over the tailings and waste. The ISF has been designed so that water in excess of 40 m depth will be maintained over the submerged waste material to preserve water quality during operation of the FRCGP. Over time, natural sediment will be deposited over the tailings and mine waste, gradually reducing this water depth. Maintaining the water cover will inhibit oxidation of tailings and waste rock and limit the potential for release of soluble contaminants.

The surrounding catchment will contribute significant sediment loads to the facility, and it is expected that the facility will eventually become completely silted. The sediments will reduce the storage capacity of the ISF reservoir, but will also result in the formation of a saturated cover over the tailings and mine waste. Landslides or other mass movement into the ISF reservoir will further reduce the available storage. Consequently, the spillway has been sized to pass flows in excess of the PMF.

9.3 Spillway

A gated spillway is included in the design. The spillway will comprise a nominally 30-m-long ogee crest on the east bank of the Frieda River with a reinforced concrete lined chute. A flip bucket and stilling basin at the toe of the chute will dissipate energy to reduce the erosive potential of water flowing down the spillway. A divider wall with four steel spillway radial gates will be installed into the spillway to permit partial and temporary closure of the spillway for maintenance activities.

At closure the operational spillway radial gates will be removed allowing the spillway to operate as an unregulated flow-through system.

9.4 Diversion Tunnels

Two diversion tunnels will be required during construction to divert river flows from the Frieda River away from the embankment while providing protection against 1:100 storm events. The diversion tunnels, approximately 1,300 m long, will consist of two 9 m x 9 m shotcrete-lined tunnels located on the eastern bank (i.e., the right abutment looking downstream) of the Frieda River.

Diversion structures of the FRHEP will be sealed and decommissioned prior to impoundment.

9.5 Hydroelectric Power Facility

In the event that infrastructure cannot be transferred to third parties, the hydroelectric power facility, and substation switchyard will be decommissioned and the area made safe. All services (i.e., electricity, water and sewage) will be disconnected prior to removal of power generation infrastructure. The powerhouse and associated electrical infrastructure will be demolished and removed. Hydropower conveyance tunnels and surge chambers will be plugged. Turbines will be dismantled and sent off site for sale to third parties if in a reusable condition, or recycled. Similarly, steel and other salvageable equipment and materials will be sold if usable, or recycled.

9.6 Quarries

There will be one quarry developed to support the construction of the embankment in addition to the use of material from spillway excavations. This quarry will be active during construction, and will be decommissioned during the filling of the reservoir will eventually be flooded. Portions of the quarry excavations will remain above the water level, which will be made safe e.g., by grading or installing an earthen safety bund.

9.7 Access Roads

At closure of the FRCGP, the mine access road and link road will be transferred to the FRHEP to allow continued access to the ISF and hydroelectric power facility. Hand-over of the road (including liabilities) to a third party will be explored.

9.8 Ancillary Infrastructure

The remainder of ancillary infrastructure including accommodation facilities will be decommissioned following the cessation of power generation. At decommissioning, electricity, water and sewage services will be disconnected and accommodation buildings will be demolished.

For the purposes of this plan, it has been conservatively assumed that buildings will not be dismantled for reuse and that controlled collapse of all structures will be undertaken. Where appropriate, steel will be sold for reuse or exported off site for recycling, while all other material will be disposed of in an appropriate manner.

All concrete footings, slabs and hardstand areas will be demolished and removed to the ground surface. For areas where infrastructure has been removed, the area will be ripped, shaped to be free draining and covered with topsoil, where available and rehabilitated to agreed standards.

Hand-over of the ancillary infrastructure including buildings, the Frieda River port and airstrip (including their liabilities) to a third party will be considered.

10. UNANTICIPATED CLOSURE

Best practice closure planning requires consideration to be given to closure actions in the unlikely event of sudden or unplanned closure, temporary closure as well as early permanent closure. In such circumstances, the CEPA and MRA (if during mining operations) will be notified as soon as possible that the FRHEP is being placed in care and maintenance. This chapter details the process to be followed for unplanned or temporary closure.

Closure scenarios, other than permanent closure of the FRHEP are summarised in Table 10.1. The relevance of each scenario is dependent on the long-term power supply requirements of the FRHEP including power generation for the FRCGP and PNG grid.

Table 10.1 Closure scenarios

Closure category	Potential closure scenarios
Unanticipated closure (early permanent closure or closure during construction)	• Early closure of the mine, with FRHEP supplying power for sole use of FRL. • ,Early closure of the mine, with FRHEP supplying power to FRL and PNG grid. • Mine closes prior to completion of the FRHEP construction; power supply to PNG grid is not required.
Temporary suspension	• Temporary suspension of mine operations, with FRHEP supplying power for sole use of FRL. • Temporary suspension of mine operations, with FRHEP supplying power to FRL and PNG grid.

With the placement of tailings and waste rock in the ISF, the general objective of closure is to ensure physical and chemical stability, with minimum requirements for active intervention and maintenance. As the water contained in the ISF reservoir cannot be drained and the embankment cannot be removed, the facility will require ongoing maintenance.

Specific objectives and requirements for unanticipated closure of the FRHEP are as follows:

- Prevent uncontrolled release of the tailings and waste rock.
- Prevent oxidation and contaminant release from the stored tailings and waste rock.
- Minimise the risk of failure of the embankment and/ or spillway.

To limit oxygen ingress and prevent solute generation from the waste rock and tailings, a water cover or water-saturated soil cover must be maintained over the waste and tailings in all closure scenarios. Specific measures for each closure scenario are discussed in the following sections.

10.1 Temporary Suspension

In the event of a temporary suspension, the critical requirement for the ISF is water flow and water quality management, including freeboard management. An active care-and-maintenance approach would need to be adopted to ensure that any potential risks associated with the ISF are managed and mitigated. A care and maintenance crew would be required on site to operate and maintain the spillway system, maintain freeboards, ensure water coverage of the waste and tailings, monitor and maintain embankments, and undertake water quality monitoring. Spillway gates may need to be completely opened and hydro tunnel outlet valves may need to be closed depending on the expected duration of suspension. Environmental flows would be maintained via the spillway.

Road maintenance will continue to ensure access when the FRHEP start-up commences.

Due to the FRHEP's remote location, temporary closure could leave the FRHEP exposed to a risk of unauthorised occupation because of reduced numbers of site personnel. This would require security control measures to be implemented.

Periods of temporary suspension are also ideal opportunities for maintenance of key mechanical and electrical equipment, to be carried out.

10.2 Unanticipated Closure

Sudden or unplanned closure would occur when operations suddenly ceases due to factors such as natural disaster or financial constraints. Some of the closure objectives described in Section 8.2 could be met after sudden closure, although it would not be possible to meet others.

In the event of sudden closure, an accelerated closure process will occur. A decommissioning plan based on the pre-existing closure plan will be prepared and implemented by FRL, taking into account the site's non-operational status.

Should FRHEP operations cease earlier than planned, the permanent closure measures are expected to be the same as for the planned permanent closure scenario.

The following general site requirements would be completed under a sudden unplanned closure:

- Prepare and leave mechanical, hydraulic, electrical systems in a 'no-load' condition, and ensure that they are effectively isolated so that they cannot be restarted or tampered with.
- Drain all pipelines.
- Safely contain all petroleum, chemicals and explosive products.
- Seal, secure and/or lock all buildings.
- Construct fences/barriers as required to restrict access to specific areas within the site.
- Notify the appropriate local and government authorities.
- Designate a contact person(s) for authorised access to the site.
- Establish a program for roadway maintenance to ensure that access to the site is maintained.
- Continue regular inspections.
- Establish a schedule for the monitoring of ground and surface water, including the ISF.
- Assign an appropriately qualified person to review and report all monitoring data collected. Prepare a trigger, action, response plan (TARP) based on risk assessment that considers the possible impacts on the surrounding environment(s).

Should the FRHEP cease during the embankment construction phase and prior to the impoundment of water, the following additional closure measures would be undertaken as required:

- Depending on the embankment construction progress, the embankment will either be breached, or a permanent spillway will be constructed around one of the abutments.
- Where practical, exposed bedrock within the footprint area will be covered with topsoil from the spoil storage area and the area revegetated.
- The spoil storage area will be re-graded to a stable landform and revegetated.
- The quarry will be re-graded or backfilled, as required, to prevent ponding of water.

- The diversion inlet tunnel will be plugged and the inlet area re-graded and/ or filled to prevent any surface water ponding.
- Stormwater diversion and silt collection channels, diversion bunds, and sediment ponds will be decommissioned once they are no longer required.

11. MONITORING AND MAINTENANCE

A comprehensive operations and maintenance manual will be developed prior to commissioning and will continue to be updated throughout the operating life of the ISF.

11.1 Monitoring and Reporting

The ISF embankment, spillway and water quality will continue to require long-term monitoring, inspection and maintenance. Detailed plans that establish post-closure maintenance and monitoring criteria will need to be developed prior to closure.

The post-closure maintenance and monitoring requirements are expected to include the following:

- Dam surveillance: continued inspections and monitoring as per the dam safety program developed in the later design stages, which is based on ANCOLD, CDA and ICOLD guidelines.
- Maintenance requirements: routine and event-driven maintenance of the ISF embankment and spillway.
- Post-closure monitoring requirements: sedimentation rates in the ISF, water depths over tailings and waste rock, performance of the embankment, performance of the spillway, and water chemistry in the ISF and at the embankment seepage outlet.

It has been assumed that closure monitoring will be required until completion criteria have been met. The duration of further closure monitoring will be determined on a risk-based basis, with additional monitoring and remediation activities being required if the monitoring results do not demonstrate that completion criteria have been achieved.

This plan will be regularly updated and refined to reflect changes in project development and operational planning, as well as the environmental and social conditions and circumstances.

A conceptual closure monitoring program is presented in Table 11.1. The financial means to conduct this program will be sufficiently provisioned. Detailed completion criteria and indicators, which will be central to the monitoring program, will be developed and outlined in the subsequent revisions of this plan. Similarly, monitoring locations will be determined in subsequent revisions of this plan and in consultation with relevant stakeholders.

Table 11.1 Conceptual decommissioning and closure monitoring program

Component	Variables/Agreed Outcomes	Timing/Frequency
Structural elements, including the embankment	Reviews of structural elements or components, which are situated in high-risk locations, by one or more qualified experts with relevant and recognised experience. Monitoring the structural integrity of the embankment.	Independent assessment reports submitted to relevant agency regularly until completion criteria have been met.
Meteorology	Basic parameters (e.g., wind, rainfall, temperature) to provide context for hydrology monitoring.	Continuation of operational program during and after decommissioning.
Hydrology	Water levels (stream gauging) to provide context to water quality and biological monitoring.	Continuation of operational program during and after decommissioning.
Stream sedimentation	Stream-bed cross sections to measure river bed aggradation or erosion and determine trends over time.	Continuation of operational program during and after decommissioning.

Component	Variables/Agreed Outcomes	Timing/Frequency
Hazardous materials	Records show that contaminated sites have been remediated appropriately.	Decommissioning.
Public safety	Visual inspection by the engineer to confirm that all excavations have either been backfilled or safety signage has been erected.	Decommissioning.
Geotechnical investigations for physical stability	To identify significant environmental or human safety risks during closure a visual inspection by geotechnical engineer will be undertaken to confirm that engineered structures have been completed as per design, and there are no signs of subsidence, slumping or slippage in the structure.	Decommissioning.
Water quality of ISF	Water quality measures to test for metal leaching due to exposure of material in the anoxic zone, and potential re-suspension of fine sediment due to deposition in the epilimnion zone, underwater landslides, and deposition of waste on top of tailings.	Annually until completion criteria have been met.
ISF monitoring	Pond elevation monitoring, sedimentation rates, depths of the pond over tailings and waste, performance of the ISF embankment, performance of the spillway.	Continuation of operational program during and after decommissioning until completion criteria have been met.
Soil	Soil parameters, i.e., physical and chemical characteristics including surface stability (e.g., resistance to erosion), capacity to accept rainfall, nutrient status and ability to support plant growth.	Monitored during and following rehabilitation activities and compared to pre-development conditions
Vegetation diversity and cover	Vegetation sampling to compare vegetation recovery during closure with baseline conditions and project-specific criteria.	Annually until two consecutive monitoring events indicate that criteria are being met or will likely be achieved.
Noxious weeds	Survey of noxious weeds surrounding disturbed areas prior to, during and following revegetation. To determine if weed control is required.	Annual until completion criteria have been met. If completion criteria are not met, continue to monitor annually until two consecutive monitoring events indicate that criteria are being met or will likely be achieved.

11.2 Maintenance

Ongoing management of the site will be required including maintenance of the embankment and spillway, maintenance of the access road to the embankment, maintenance of surface drainage system, and potentially repairs to any failed landforms. During this period a small maintenance workforce in the order of 20 people will be employed to conduct maintenance activities.

A funding and governance structure for post-closure maintenance and monitoring will be developed.

A detailed monitoring and maintenance plan will be developed in advance of closure of the FRHEP, however it is expected to include the elements outlined in the section below.

11.2.1 Embankment and Spillway

The embankment and spillway will require long-term monitoring, inspection and maintenance to ensure the facility remains stable. This will continue beyond the relinquishment of leases. Detailed plans will be developed in advance of closure and will establish post-closure maintenance and monitoring criteria.

Monitoring of the embankment and associated structures during construction, operations and closure will include (but are not limited to):

- Seepage flow rates, locations and water quality.
- Piezometric levels.
- Deformations.
- Earthquake accelerations.

Routine maintenance of the ISF more generally will include:

- Inspection and maintenance of the upstream and downstream shells of the embankment and removal of large vegetation.
- Maintenance of the closure spillway including keeping the spillway clear of debris as well as planned resurfacing as per design specifications. Stoplogs will be used to block the spillway when conducting any maintenance required.

External reviews of the integrity of the ISF embankment will also be conducted at intervals agreed with the PNG Government and as documented in the ISF stewardship program.

11.2.2 Site Access

Some routine maintenance of the access road between the FRHEP and Vanimo (via Green River) and supporting infrastructure such as road bridges may be required to enable access. This will include:

- Ongoing road maintenance such as grading, filling holes and repairing damage to water management infrastructure.
- Repair of any damage to bridges or the wharf at the Frieda River Port.

11.2.3 Geotechnical

Routine maintenance of landforms with regards to geotechnical aspects will include:

- Repair the landforms to maintain the integrity of the embankment.
- Repair of landforms should erosion rates exceed design specifications, for example after extreme rainfall events.

11.2.4 Rehabilitation

Rehabilitation maintenance may be required to:

- Control and prevent weed infestation while native vegetation becomes established.
- Improve soil nutrient levels where rehabilitation has failed.
- Control or repair erosion where rehabilitation has failed.

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